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The Water Safety Plan approach: elaboration, implementation and evaluation in rural contexts of sub-Saharan Africa

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List of acronyms

ASUFOR	Associations des Usagers des Forages (Associations of Rural Boreholes)
CFU	Colony-Forming Units
CGPE	Comité de Gestion des Points d'Eau (Water Management Committee)
CSPS	Centre de Santé et de Promotion Sociale (Health Care Centre)
DHA	Diourbel Hygiene Authority
EU	European Union
FCB	Fondazione della Comunità Bresciana (Brescia Community Foundation)
fCFA	Francs de la Communauté Financière Africaine (African Financial Community francs)
FonTov	Fondazione G. Tovini (G. Tovini Foundation)
GIE	Groupement d'Intérêt Economique (Association of farmers and traders)
HACCP	Hazard Analysis Critical Control Point
HDI	Human Development Index
HH	Household
HWTSS	Household Water Treatment and Safe Storage
IWA	International Water Association
JMP	Joint Monitoring Programme
LCA	Life Cycle Analysis
MDG	Millennium Development Goal
MMI	Medicus Mundi Italy
NGO	Non-Governmental Organisation
NTU	Nephelometric Turbidity Units
RCP	Rural Community of Patar
RPHC	Responsible for the Patar Health Centre
TW	Tubewell fitted with hand pump
UN	United Nations
UNICEF	United Children's Fund
UniDak	University of Dakar
WASH	Water, Sanitation and Hygiene
WHO	World Health Organisation
WSP	Water Safety Plan

Abstract (in Italian)

Introduzione

L'accesso all'acqua potabile è essenziale per la sopravvivenza umana e rappresenta uno dei fondamenti per garantire la prosperità e la salvaguardia delle popolazioni. Il 28 luglio 2010 l'Assemblea Generale delle Nazioni Unite ha ufficialmente riconosciuto a livello mondiale il diritto all'acqua potabile e a servizi igienico-sanitari come un **diritto umano** essenziale per il pieno godimento della vita e alla base di tutti gli altri diritti umani.

Secondo l'ultimo rapporto delle Nazioni Unite sugli Obiettivi di Sviluppo del Millennio, la popolazione mondiale senza un accesso sostenibile a fonti appropriate d'acqua potabile si è dimezzata dal 1990 ad oggi, passando dal 24 all'11% (nel 2011). Tuttavia rimane ancora estremamente elevato il numero di persone senza accesso a una fonte d'acqua sicura (circa 768 milioni di persone), in particolar modo nei Paesi a risorse limitate e, più precisamente, nell'Africa sub-Sahariana.

L'Organizzazione Mondiale della Sanità ha stimato che, a livello mondiale, le malattie diarroiche (che rappresentano la quota maggiore di malattie legate al consumo di acqua non potabile) sono responsabili della morte di circa 1.8 milioni di persone ogni anno. Nel 2011, infatti, tra le dieci principali cause di morte nel mondo, la diarrea si è classificata al quinto posto (dopo le malattie ischemiche cardiache, l'ictus, le infezioni delle vie respiratorie e le malattie polmonari croniche ostruttive), ponendola al di sopra dell'AIDS. I bambini di età inferiore ai cinque anni, in particolare, risultano particolarmente vulnerabili alla diarrea, detenendo infatti il 68% del carico totale di malattie diarroiche.

Molti degli agenti che veicolano le **malattie diarroiche** sono trasmessi attraverso il consumo di acqua microbiologicamente contaminata. Tuttavia, la maggior parte degli stessi agenti patogeni possono essere trasmessi per ingestione di alimenti contaminati e di altre bevande, per contatto da persona a persona e per contatto diretto o indiretto con feci infette. A causa di questa varietà nelle modalità di trasmissione, gli interventi per la prevenzione delle malattie diarroiche, quindi, non devono comprendere solo il miglioramento della qualità dell'acqua, ma anche misure per migliorare il corretto smaltimento delle feci umane, per aumentare la quantità e migliorare l'accesso ad acqua potabile, e per promuovere un corretto lavaggio delle mani e altre pratiche igieniche all'interno degli ambienti domestici, nonché comunitari. Sebbene la qualità dell'acqua possa anche essere influenzata negativamente da contaminanti di natura chimica (dovuti a cause naturali o antropiche), il tasso di malattie associate a metalli, nitrati, sostanze organiche e altre sostanze chimiche è solitamente inferiore rispetto a quello della diarrea.

Per tutte queste ragioni, l'approvvigionamento ad acqua potabile risulta una questione cruciale per l'esistenza e lo sviluppo dell'intera umanità.

A livello internazionale, l'approccio per garantire l'approvvigionamento d'acqua potabile è cambiato negli ultimi dieci anni. Fino all'inizio degli anni 2000, vi è stata la tendenza ad aggiungere un numero sempre maggiore di parametri (con limiti sempre più restrittivi) da rispettare per definire potabile un'acqua destinata al consumo umano, associandovi specifici requisiti per il numero e la frequenza di campionamento e d'analisi. Malgrado gli sforzi fatti in questa direzione, tale approccio si è rivelato fallimentare nella protezione delle comunità, perché, se il consumo d'acqua contaminata determina un immediato impatto negativo sulla salute, i consumatori si ammalano prima che il controllo analitico possa essere effettuato e prima che azioni correttive possano essere efficacemente adottate. Questo fenomeno è particolarmente acuto nelle aree rurali dei Paesi in Via di Sviluppo, a causa di laboratori non o poco attrezzati e protocolli di monitoraggio non ben definiti.

Negli ultimi dieci anni, si sono svolti due workshops a Bonn (in Germania) che hanno visto il coinvolgimento di esperti internazionali in materia di qualità dell'acqua potabile. Il primo si è tenuto nell'ottobre 2001, mentre il secondo nel febbraio 2004; l'obiettivo è stato quello di cercare un'alternativa utile per assicurare il consumo di acqua potabile per l'intera popolazione mondiale.

Questi incontri hanno portato alla stesura della Carta di Bonn (2004) prima e, in seguito, della nuova Edizione delle Linee Guida dell'Organizzazione Mondiale della Sanità (OMS) sulla qualità dell'acqua destinata al consumo umano (2004). Il principio fondamentale contenuto in questi documenti è di considerare l'intera filiera di approvvigionamento idrico, dalla sorgente al consumo, e di adottare un approccio di **gestione preventiva del rischio** attraverso lo sviluppo di piani di gestione e controllo della qualità dell'acqua potabile (i cosiddetti Water Safety Plans, WSPs).
Come detto, l'approccio WSP per la gestione preventiva della contaminazione idrica è stato ufficialmente introdotto nella terza Edizione delle Linee Guida dell'OMS sulla qualità dell'acqua potabile (2004). Questo nuovo approccio attinge molti dei principi e dei concetti da altri approcci di gestione del rischio, in particolare dall'approccio multibarriera e dall'HACCP (Hazard Analysis Critical Control Point), diffuso nell'industria alimentare.
I Water Safety Plans pongono l'accento sulla garanzia che i trattamenti di potabilizzazione siano efficaci e funzionino in modo tale che ogni possibile rischio di contaminazione sia escluso e che l'acqua consegnata al consumatore sia potabile. L'approccio WSP, infatti, prevede che ogni possibile causa di contaminazione dell'acqua destinata al consumo umano (a partire **dalla fonte fino al punto di consumo**) sia identificata e prevenuta attraverso l'applicazione di specifiche misure di controllo. Inoltre, deve essere prevista l'individuazione di limiti operativi che possano tempestivamente segnalare possibili anomalie e quindi l'applicazione di misure correttive, atte a impedire la distribuzione (e quindi il potenziale consumo) di acqua contaminata. A garanzia di tutto questo, pertanto, devono essere stilati dei piani di monitoraggio delle misure di controllo e dei piani di verifica per valutare l'efficacia del WSP elaborato.
L'obiettivo di un WSP è quello di assicurare il consumo di acqua potabile per mezzo di buone pratiche di gestione e di distribuzione, vale a dire:

- ✓ Prevenire la contaminazione dell'acqua alla fonte.
- ✓ Trattare l'acqua per ridurre o eliminare la contaminazione, permettendo il rispetto dei limiti di qualità delle acque.
- ✓ Evitare la ricontaminazione durante le fasi di distribuzione, trattamento e stoccaggio.

L'approccio WSP può variare in complessità in funzione del sistema di approvvigionamento idrico e può essere applicato a qualsiasi tipo di sistema, da estese e complesse reti di approvvigionamento, a piccoli sistemi comunitari, a sistemi a scala domestica.

Obiettivo della ricerca

L'**obiettivo principale** di questa ricerca è stato quello di applicare l'approccio WSP in due diversi contesti rurali dell'Africa sub-Sahariana, e precisamente in:

a. *Senegal*: dove il contesto era già noto a causa di un precedente progetto di cooperazione internazionale attuato dall'ONG "Fondazione G. Tovini", responsabile anche del progetto attraverso il quale è stato sviluppato il WSP. La Comunità Rurale coinvolta nelle attività del progetto era inoltre piuttosto popolosa (circa 15,000 abitanti) e il sistema di approvvigionamento idrico era piuttosto complesso.
b. *Burkina Faso*: dove il contesto era completamente sconosciuto e nessun altro progetto di cooperazione internazionale aveva mai coinvolto la comunità locale. I villaggi in cui è stato sviluppato l'approccio WSP, inoltre, erano popolati da circa 3,000 abitanti e il sistema di approvvigionamento idrico era piuttosto semplice.

Gli ambiziosi obiettivi che hanno caratterizzato e guidato questo lavoro sono stati:

1. Testare un approccio così complesso come quello del WSP in contesti rurali dell'Africa sub-Sahariana, considerando anche la limitata disponibilità di casi di studio nella letteratura scientifica. In particolare, l'obiettivo prefissato è stato di semplificare l'approccio WSP, garantendone tuttavia

la struttura e soprattutto l'efficacia, così da ridurre al minimo la contaminazione dell'acqua destinata al consumo umano (se impossibile da prevenire).

2. Identificare delle strategie di valutazione della sostenibilità dei WSPs sviluppati. In particolare con l'obiettivo principale di sviluppare strategie applicabili ai casi studio analizzati in questa ricerca, ma che risultino anche utili per essere impiegate in altri contesti (rurali) dei Paesi in Via di Sviluppo.

Gli aspetti fondamentali presi in considerazione durante l'elaborazione e l'attuazione dei WSPs sono stati l'applicabilità per contesti rurali, ovvero permettendo l'uso di materiali e il coinvolgimento di risorse umane locali, l'accettabilità da parte delle comunità locali, la facilità di gestione e la sostenibilità nel tempo. Inoltre, nel caso di studio relativo al Burkina Faso, si è sviluppata una ricerca integrata con una studentessa del curriculum sanitario di questo Dottorato di Ricerca, al fine di migliorare efficacemente la salute della comunità locale attraverso un'azione integrata dalla gestione dell'acqua potabile alle corrette norme igieniche e di accesso ai servizi sanitari.

Struttura della tesi

Il presente lavoro è organizzato come segue.

Nel *Capitolo 1* si illustra l'approccio Water Safety Plan (WSP) così come previsto dall'Organizzazione Mondiale della Sanità (OMS), descrivendo nel dettaglio ognuno degli 11 steps da sviluppare per la sua elaborazione. Si propone anche un approfondimento sullo sviluppo della strategia WSP per i piccoli sistemi di approvvigionamento, evidenziandone le semplificazioni e gli elementi chiave da prendere in considerazione quando il WSP è elaborato per questi particolari contesti. In seguito, vengono riportate alcune esperienze di sviluppo dei WSPs nei Paesi in Via di Sviluppo (relative sia a zone urbane che rurali), mettendo in luce le differenze rispetto all'approccio generale proposto dall'OMS.

Il *Capitolo 2* riporta il WSP elaborato nella Comunità di Patar, un contesto rurale del Senegal. In questo Capitolo è stata data particolare importanza alla presentazione dei dati raccolti durante la valutazione del rischio effettuata prima dell'elaborazione del WSP. Lo scopo è di presentare in modo chiaro tutti i possibili rischi di contaminazione dell'acqua potabile e le cattive pratiche di gestione, lungo l'intera filiera di approvvigionamento, che il WSP deve proporsi di minimizzare, o meglio, prevenire. A questo scopo, vengono presentati i risultati relativi alle analisi fisico-chimiche e microbiologiche delle fonti idriche, ai controlli igienico-sanitari e alle interviste ai Comitati locali di gestione dell'acqua. Per quanto riguarda le altre fasi della filiera di approvvigionamento idrico, vengono proposti i risultati sul grado di contaminazione microbiologica nei recipienti utilizzati per il trasporto e lo stoccaggio e le interviste condotte presso le famiglie locali in materia di gestione dell'acqua e di pratiche igieniche, così come in termini di condizioni di salute. Infine, si illustrano i risultati ottenuti dal monitoraggio di filtri a cenere d'ossa e dall'esecuzione di test di clorazione. La seconda parte di questo Capitolo è invece rivolta alla presentazione e all'analisi del WSP sviluppato. Vengono infatti analizzati nel dettaglio i rischi di contaminazione ritenuti più interessanti e / o importanti e le relative misure di controllo. In seguito, si riporta un confronto tra l'approccio generale WSP proposto dall'OMS e quello elaborato in loco.

Il *Capitolo 3*, invece, presenta il WSP elaborato nei villaggi di Fingla e Diarra, in un contesto rurale del Burkina Faso. Anche in questo caso di studio, grande enfasi è stata data alla valutazione dei rischi, effettuata durante il corso di una prima missione in loco al fine di raccogliere i dati essenziali per elaborare la strategia WSP più appropriata e sostenibile. Vengono quindi presentati i risultati forniti dalle analisi fisico-chimiche e microbiologiche condotte a livello delle fonti, dai controlli igienico-sanitari e dalle interviste ai Comitati di gestione dei punti d'acqua. Per quanto riguarda le fasi di trasporto e stoccaggio, si forniscono i risultati delle analisi microbiologiche dell'acqua campionata in diversi recipienti e delle interviste alle famiglie circa la gestione delle acque e le pratiche igieniche, come pure le condizioni di salute. Successivamente, si propongono e analizzano i WSPs sviluppati nei due villaggi di intervento, fornendo anche un confronto tra l'approccio generale e quello elaborato. Infine, si presentano i risultati ottenuti dalla valutazione della situazione in loco, 6 mesi dopo l'elaborazione dei WSPs. Tale valutazione è stata svolta prevedendo le stesse attività effettuate nel corso della prima missione in loco, in modo da ottenere informazioni utili a confrontare le condizioni prima e dopo l'implementazione dei WSPs.

Il *Capitolo 4* è infine dedicato alla presentazione di uno strumento di valutazione della sostenibilità dei WSPs elaborati in entrambi i casi di studio. Tale strumento si basa su una serie di domande (questionario) relative a cinque diversi elementi di sostenibilità: tecnici, economici, organizzativi e istituzionali, sociali e culturali, ambientali e sanitari. Questo questionario è stato proposto ai principali soggetti coinvolti nelle attività dei due progetti. I risultati ottenuti da questo strumento di valutazione della sostenibilità sono quindi presentati per entrambi i casi di studio e confrontati fra di loro. In seguito, la valutazione della sostenibilità dei WSPs prosegue con l'analisi del tempo necessario e dei relativi costi richiesti per l'elaborazione, l'implementazione e la gestione dei WSPs sviluppati in Senegal e in Burkina Faso. Infine, si propongono delle considerazioni circa l'influenza della complessità del sistema di approvvigionamento idrico sul tempo e i costi di sviluppo di un WSP.

Conclusioni

L'obiettivo principale di questa ricerca è stato quello di elaborare e implementare l'approccio Water Safety Plan (WSP) in contesti rurali dell'Africa sub-Sahariana, verificandone l'applicabilità, l'efficacia e la sostenibilità. La sfida principale è stata di semplificare l'approccio WSP, in quanto troppo complesso per essere applicato così come proposto dall'Organizzazione Mondiale della Sanità (OMS) nelle sue Linee guida per la qualità dell'acqua potabile. Pur prevedendo una semplificazione, si doveva tuttavia garantire la struttura del WSP e soprattutto consentire il conseguimento dell'obiettivo cardine della prevenzione, o almeno della riduzione, della contaminazione dell'acqua destinata al consumo umano.

L'approccio WSP è stato sviluppato in due contesti rurali dell'Africa sub-Sahariana.
La prima elaborazione è avvenuta in **Senegal** grazie a un progetto di cooperazione internazionale attuato dall'ONG Fondazione G. Tovini (Brescia, Italia), in una zona rurale piuttosto popolosa (circa 15,000 abitanti) e caratterizzata da un sistema di approvvigionamento idrico piuttosto complesso. Per quanto riguarda questo caso di studio, sono state effettuate due missioni sul campo: la prima (Luglio-Agosto 2012) è stata interamente dedicata ad un'analisi del rischio di contaminazione, mentre nella seconda (Febbraio-Marzo 2013) è stato elaborato il WSP, dopo averne individuato i membri del team. Nel contempo, sono stati anche sviluppati i programmi di supporto al WSP, basati su campagne di sensibilizzazione e corsi di formazione. A causa di ragioni economiche legate al progetto, non è stato possibile effettuare una terza missione di valutazione dopo l'attuazione del WSP.

Il secondo WSP è stato elaborato in **Burkina Faso**, grazie a un progetto di cooperazione internazionale coordinato dall'ONG Medicus Mundi Italia (Brescia, Italia), in una zona rurale abitata da circa 3,000 persone e dove il sistema idrico era piuttosto semplice. In questo caso, le missioni effettuate sul campo sono state tre: la prima (Novembre-Dicembre 2011) volta a effettuare una valutazione dei rischi, la seconda (Ottobre-Dicembre 2012) per l'elaborazione del WSP, in concomitanza con l'attuazione dei programmi di supporto, mentre la terza missione (Maggio-Giugno 2013) è stata completamente dedicata a valutare la situazione in loco (per quanto riguarda le pratiche di gestione dell'acqua potabile) dopo l'attuazione del WSP.

La ricerca sperimentale condotta in questa tesi ha portato alle seguenti considerazioni:

- ✓ L'approccio WSP è una strategia piuttosto complessa che richiede il coinvolgimento di figure tecniche esperte nel settore dell'acqua potabile, soprattutto se il WSP è applicato in Paesi a risorse limitate. In alternativa, la struttura del WSP deve essere semplificata se viene elaborato e gestito da non specialisti nel settore.

- ✓ Per quanto riguarda i due casi di studio analizzati, in Senegal l'approccio WSP è stato leggermente semplificato rispetto a quello proposto dall'OMS nelle Linee Guida per la qualità dell'acqua potabile, grazie alla presenza di gestori del servizio di approvvigionamento idrico e di rappresentanti di un Ente locale di controllo all'interno del team responsabile dell'elaborazione del WSP. Al contrario, in Burkina Faso, l'approccio WSP è stato fortemente semplificato, a causa dell'assenza di esperti locali. Infatti, in questo contesto, il WSP è stato sviluppato coinvolgendo i membri dei Comitati di gestione dei punti d'acqua e gli utenti locali.
- ✓ Un approccio WSP semplificato ha dimostrato di essere efficace anche come strumento di sensibilizzazione delle comunità locali. Infatti, nei villaggi rurali di Fingla e Diarra (Burkina Faso), il WSP è stato sviluppato durante il programma di sensibilizzazione sulle buone pratiche da adottare, a livello comunitario e domestico, per la gestione dell'acqua potabile. Alla comunità, infatti, è stato chiesto di elencare tutte le possibili cause di contaminazione dell'acqua lungo l'intera filiera di approvvigionamento e di individuare le misure di controllo più efficaci (contestualmente all'identificazione di un programma di monitoraggio) per prevenire, o almeno minimizzare, i rischi di contaminazione.
- ✓ In contesti come le aree rurali dei Paesi in Via di Sviluppo, la fase più importante nello sviluppo di un WSP è l'analisi del rischio, a causa della mancanza di sufficienti e / o affidabili dati di monitoraggio della qualità dell'acqua e di altre informazioni chiave relative alla gestione dell'acqua lungo l'intera filiera di approvvigionamento. Un protocollo di attività attuato in entrambi i casi di studio (che ha dimostrato d'essere efficace) e che dovrebbe essere svolto nel corso di una valutazione dei rischi è quello proposto nel seguito:
    - o *Fonti*: valutazione dei possibili rischi di contaminazione microbiologica attraverso controlli igienico-sanitari (come quelli suggeriti dall'OMS o anche rivisti a seconda delle caratteristiche specifiche dei punti d'acqua); esecuzione di un'intensa campagna di analisi della qualità dell'acqua, verificando tanto i principali parametri microbiologici quanto quelli chimici, e, se possibile, esecuzione anche di un monitoraggio della possibile fluttuazione stagionale della concentrazione degli inquinanti; realizzazione di interviste ai Comitati di gestione delle fonti d'acqua, al fine di raccogliere informazioni chiave sulla gestione dell'acqua potabile; raccolta di dati relativi alle fonti (in termini di qualità, quantità e struttura geomorfologica della fonte) a livello Istituzionale, vale a dire presso l'Ente di controllo locale delle risorse idriche o presso il Comune.
    - o *Trasporto e stoccaggio*: esecuzione di un'intensa campagna di controllo della qualità dell'acqua potabile in entrambi i recipienti (quindi lungo l'intera filiera di approvvigionamento) e, a livello dello stoccaggio, anche un'attenta valutazione dell'influenza sulla contaminazione da parte del bicchiere usato per bere; valutazione di tutte le possibili cause di contaminazione microbica mediante una serie di interviste alla popolazione locale, al fine di raccogliere dati sulle pratiche di gestione dell'acqua potabile (in particolare verificando le modalità con cui viene effettuato il trasporto e lo stoccaggio dell'acqua, tutti i tipi di recipienti utilizzati, etc.); valutazione delle pratiche igienico-sanitarie, verificando il corretto utilizzo delle latrine, la frequenza e le occasioni in cui viene effettuato il lavaggio delle mani, la presenza di detergenti all'interno delle abitazioni, etc.
    - o *Trattamento*: se una tecnologia di trattamento è già presente in loco o deve essere messa in atto, è indispensabile verificare la disponibilità locale di materiali per la sua realizzazione, le risorse umane disponibili per un coinvolgimento nella gestione e manutenzione, i fondi in grado di garantire un'autosufficienza della tecnologia, il supporto da parte sia dei beneficiari che delle Istituzioni locali / partner (ovvero i soggetti chiave per assicurarne la sostenibilità).
- ✓ L'analisi dei rischi, pur essendo una fase molto importante per l'elaborazione del WSP, si è rivelata essere anche la fase più costosa, secondo la valutazione dei costi sviluppata in questo lavoro. È infatti richiesta un'adeguata disponibilità economica per effettuare un'adeguata campagna di analisi

della qualità dell'acqua. Inoltre, deve essere presa in considerazione anche la presenza (fisica) e la disponibilità (lavorativa) di un laboratorio. Questo dovrebbe preferibilmente essere vicino alla zona di intervento, al fine di poter effettuare le analisi microbiologiche in un periodo di tempo adeguato, e dovrebbe essere ben attrezzato (in termini di strumentazione e reagenti) per l'esecuzione di analisi chimiche. Per queste ragioni, dovrebbe essere accuratamente effettuata un'analisi costi-benefici, al fine di valutare la quantità e il tipo di analisi che dovrebbero e / o potrebbero essere eseguite in funzione dei fondi disponibili.

- ✓ In Burkina Faso, la terza missione di valutazione ha permesso di verificare l'efficacia dell'approccio WSP. Infatti, la contaminazione microbiologica (in riferimento alla concentrazione di *E. coli*) è diminuita di circa il 60% a livello della fonte, del 75% nella fase di trasporto e circa dell'85% a livello dello stoccaggio. Inoltre, il livello di rischio calcolato seguendo l'approccio proposto dalla strategia WSP (ovvero come il prodotto della probabilità di accadimento per la gravità delle conseguenze dei pericoli identificati) si è ridotto, dopo l'implementazione del WSP, di circa il 33% a livello della fonte, del 21% nella fase di trasporto e del 22% in quella di stoccaggio. Tutti questi risultati sono stati ottenuti dopo solo 6 mesi dall'attuazione del WSP, dimostrando così la forte efficacia di questo strumento nel minimizzare la contaminazione dell'acqua potabile (pur essendo stato elaborato in modo semplificato).
- ✓ L'analisi costi-tempi effettuata in entrambi i casi di studio ha rivelato una forte dipendenza tra i costi e i tempi necessari per lo sviluppo di un WSP e la complessità del sistema di approvvigionamento idrico. Infatti, maggiore è la complessità del sistema, maggiore è la complessità del WSP e quindi maggiori sono i costi e il tempo necessari. La maggiore complessità del sistema idrico nella Comunità Rurale di Patar in Senegal ha fornito un WSP abbastanza complesso, che ha richiesto maggiori tempi e costi di elaborazione ed implementazione rispetto al caso di studio relativo al Burkina Faso. Relativamente ai costi di implementazione del WSP, ad esempio, in Senegal si sono stimati circa 140,000 €, mentre in Burkina Faso all'incirca 4,000 €, in entrambi i casi necessari per mettere in atto tutte le misure di controllo previste dal WSP.
- ✓ Lo strumento di valutazione della sostenibilità sviluppato in questo lavoro è risultato efficace per evidenziare la presenza di elementi di insuccesso all'interno del WSP (dal punto di vista tecnico, economico, organizzativo e Istituzionale, sociale e culturale o ancora ambientale e di salute). Anche se il solo questionario di valutazione non può essere ritenuto l'unico metodo per stimare la sostenibilità di un progetto, può comunque fornire una panoramica generale dal punto di vista dei diversi attori coinvolti nell'implementazione di un progetto. Per questo motivo, si ritiene sempre utile accompagnare questo questionario con un'indagine in loco.
- ✓ In entrambi i casi di studio, la valutazione della sostenibilità è stata condotta al termine del progetto. Tuttavia, una valutazione a lungo termine (dopo 1, 5 o 10 anni) dovrebbe essere eseguita per comprendere realmente l'efficacia nel tempo del WSP. Inoltre, il questionario per la valutazione dei cinque elementi di sostenibilità è stato ideato per essere utilizzato al termine dell'implementazione dei progetti, come detto, ma se riadattato può risultare utile anche per una valutazione prima e durante l'esecuzione di un progetto.
- ✓ La presenza di un forte partner locale (come un'ONG) si è rivelata un motivo di successo nell'implementazione e nella sostenibilità di un WSP, come evidenziato in questi due casi di studio. La collaborazione con l'ONG burkinabé Dakupa ha infatti permesso di implementare con successo le diverse attività previste dal progetto, e probabilmente ha anche permesso di guadagnare la fiducia nel progetto da parte delle comunità locali, assicurandone così la sua sostenibilità (e quindi indirettamente la sostenibilità del WSP implementato).

Introduction

Access to safe drinking water is essential for human survival and represents one of the fundamentals for a good and prosperous society. This was officially recognised worldwide the 28th of July 2010 when the UN General Assembly declared *the right to safe and clean drinking water and sanitation as a* ***human right*** *that is essential for the full enjoyment of life and all other human rights*[1].

Worldwide, an estimated 1.1 billion people lack access to improved water supplies, and diarrhoeal diseases (that represent the largest share of water-related diseases, due to the consumption of unsafe water) are responsible of an estimated 1.8 million people death each year[2].

Amongst the leading causes of death in the world, in 2011, diarrhoea ranks as fifth (after ischemic heart diseases, stroke, lower respiratory infections and chronic obstructive pulmonary diseases), placing it above HIV/AIDS[3]. Children less than five years of age are especially vulnerable, bearing 68% of the total burden of diarrhoeal disease[4].

Many of the **diarrhoegenic agents** are potentially waterborne, transmitted through the ingestion of contaminated water. However, most of the same pathogens can also be transmitted by ingestion of contaminated food and other beverages, by person-to-person contact, and by direct or indirect contact with infected faeces. Because of this variety of pathways, interventions for the prevention of diarrhoeal disease, hence, do not only include enhanced water quality, but even steps to improve the proper disposal of human faeces, increase the quantity and improve access to water, and promote hand washing and other hygiene practices within domestic and community settings.

Moreover, whilst water quality can also be adversely impacted by chemical contaminants, the level of disease associated with metals, nitrates, organics, and other chemicals is usually small relative to infectious diarrhoea[5].

For all these reasons, **providing safe drinking water is a crucial issue for human development**.

The emphasis on means of achieving safe drinking water has changed in the last decade. Until early 2000s, internationally, there had been a trend toward adding more and more parameters to drinking water standards, with an associated requirement for sampling and analysis. This approach is unlikely to increase protection of consumers because, if contaminated drinking water causes an immediate negative impact on health, people will become sick before the analysis is carried out and before remedial actions can be effectively taken. This is particularly true in rural areas of low and middle-income countries, where there are no competent laboratories or well established protocols.

In the past decade, two workshops involving key people concerned with drinking water quality were held in Bonn (Germany), one in October 2001 and the other in February 2004, to seek a better way of achieving safe drinking water. The direct output of these meetings was the Bonn Charter (2004) and, indirectly, the revised World Health Organisation (WHO) Drinking Water Guidelines (2004). The approach is encapsulated by the Bonn Charter structure given in Fig. 1. The key principle is to consider the entire supply chain from source to mouth, and to take a **risk management approach** through the development of drinking Water Safety Plans (WSP).

As stated, the WSP strategy has been officially recommended for preventive management of water supply in the third Edition of WHO Guidelines for drinking water quality (2004)[6]. This "new" approach draws on many of the principles and concepts from other risk management approaches, in

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[1] United Nations Human Rights - Office of the High Commissioner for Human Rights, The Right to Water, *Fact Sheet No. 35*, 2010.

[2] World Health Organisation, The World health report 2005 - Make every mother and child count, *WHO Library Cataloguing-in-Publication Data*, ISBN 92 4 156290 0, 2005.

[3] World Health Organisation, The top 10 causes of death, *Fact sheet No. 310*, 2013.

[4] J. Bartram, New water forum will repeat old message, *Bulletin of the World Health Organisation*, vol. 83, n. 3, 2003.

[5] T.F. Clasen, I.G. Roberts, T. Rabie, W.P. Schmidt and S. Cairncross, Interventions to improve water quality for preventing diarrhoea (Review), *The Cochrane Collaboration*, Published by John Wiley & Sons Ltd., 2009.

[6] World Health Organisation, Guidelines for drinking water quality. Third Edition - Volume 1: Recommendations, *WHO Library Cataloguing-in-Publication Data*, ISBN 92 4 154638 7, 2004.

particular the multiple-barrier approach and HACCP (Hazard Analysis Critical Control Point), used in the food industry. WSPs place an emphasis on ensuring that processes used to produce safe water are controlled and function in such a way that hazards are excluded or removed from water before it is delivered to the consumer. Thus, WSPs are a catchment-to-consumer approach, with actions taken from source protection through treatment (where applied), distribution (whether piped or manual) and household storage and use. The objectives of a WSP are to **ensure safe drinking water** by means of good water supply practice, that is:

- ✓ To prevent contamination of source waters.
- ✓ To treat the water to reduce or remove contamination in order to meet the water quality targets.
- ✓ To prevent re-contamination during storage, distribution and handling of drinking water.

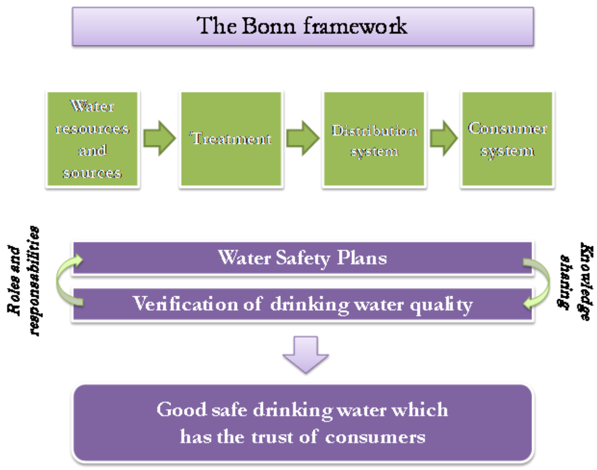

Fig. 1. *The Bonn Charter for safe drinking water*[7]

The **main goal** of this research has been to apply the WSP approach in two different rural contexts of sub-Saharan Africa:

a. *Senegal*: where the context was already known owing to a previous cooperation project implemented by G. Tovini Foundation NGO, responsible even for the project through which the WSP has been developed. Moreover, the Rural Community involved in the project activities was rather populated (some of 15,000 inh) and the water supply system was rather complex.
b. *Burkina Faso*: where the context was completely unknown and no other cooperation project was involving the local community in its activities. Moreover, the villages where the WSP approach was developed counted globally some of 3,000 inh and the water supply system was rather simple.

The **specific objectives** have been:

1. To test such a complex approach (as the WSP is) in rural contexts of sub-Saharan Africa, considering even the limited availability of case studies in the scientific literature. In particular, the main aim has been to simplify the WSP approach, guaranteeing its structure and above all its effectiveness, thus to minimise (if impossible to prevent) drinking water contamination.
2. To identify sustainability evaluation strategies of the WSPs developed. In this case, the main goal has been to developed strategies well applicable to the case studies analysed in this research, but even useful for being employed in other (rural) contexts of low or middle-income countries.

The key aspects considered during WSP elaboration and implementation have been the affordability for rural contexts, thus providing use of local materials and human resources, the acceptability of local communities, the easiness of management and maintenance, and the sustainability over time. In the Burkina Faso case study, a synergic collaboration with the PhD student of the health curriculum of my course has been provided, for effectively addressing the WSP to the improvement of people's health.

[7] International Water Association, The Bonn Charter for safe drinking water, *IWA*, 2004.

The work is organised as follow.

Chapter 1 illustrates the WSP approach as provided by the World Health Organisation (WHO), describing in detail each one of the 11 steps. A focus on the development of the WSP strategy for small systems is also proposed, highlighting simplifications and key elements to take into account when the WSP is elaborated for these particular contexts. Afterwards, some experiences of WSPs development in low and middle-income countries (both for urban and rural areas) are described, highlighting differences relative to the general WSP approach proposed by the WHO.

Chapter 2 reports the WSP elaborated in the Community of Patar, a rural context of Senegal. Great importance has been given to the presentation of data gathered during the risk assessment carried out before WSP elaboration, in order to make well understandable drinking water hazards and bad management practices which the WSP has to be addressed to. Results provided by physico-chemical and microbiological analyses of water sources, sanitary inspections and interviews to the local water management Committees are proposed. Regarding the other steps of the water supply chain, results on microbiological contamination in the transport and storage containers, interviews to households about water management and hygiene practices, as well as health conditions, are reported. Finally, data collected by means of monitoring some bone char-based filtration systems (at household level) and carrying out batch chlorination tests are presented. The second part of this Chapter is addressed to the presentation and analysis of the WSP developed, with an emphasis on the most interesting and / or important hazards, and related control measures, provided. Afterwards, a comparison between the general WSP approach proposed by WHO and the one elaborated is reported.

Chapter 3 presents the WSP elaborated in the villages of Fingla and Diarra, in a rural context of Burkina Faso. Even in this case study, great emphasis is given to the pre-assessment carried out in order to collect data for elaborating the most appropriate and sustainable WSP strategy. Results provided by physico-chemical and microbiological analyses, sanitary inspections and interviews to the water Committees of water points are proposed. Regarding transport and storage steps, results of microbiological analyses of water sampled in containers, interviews to households about water management and hygiene practices, as well as health conditions, are presented. Afterwards, the presentation of the WSPs developed in both the villages is proposed, jointly with the comparison between the general approach and the one elaborated. Finally, results provided by a post-assessment in loco, carried out 6 months after the WSP elaboration, are proposed. This assessment has been done carrying out the same activities of the pre-assessment, in order to be able to compare conditions before and after WSP implementation. Thus, a comparison amongst the two situations is proposed, highlighting improvements obtained thanks to the development of the WSP.

Chapter 4 is dedicated to the presentation of a sustainability evaluation tool, developed for evaluating the WSPs elaborated in both the case studies. The tool is based on a series of questions related to five sustainability elements: technical, economic, organisational and Institutional, social and cultural, environmental and health. Questions should be addressed to the main stakeholders involved in the project activities. Afterwards, an analysis of time consuming and costs related to WSP elaboration, implementation and management is proposed, based on the two case studies analysed. Considerations about the influence of the water supply system complexity on time consuming and costs of WSP development are finally proposed.

Conclusions report conclusive remarks of the work carried out, in view of further improvements or developments related to the implementation of the WSP strategy in rural contexts of low and middle-income countries.

Chapter 1. The Water Safety Plan approach

Abstract
Consumption of unsafe drinking water affects the health of communities and has a high impact on morbidity and mortality both in developing and developed countries. Access to safe drinking water is a basic need and is essential to health, without considering that since 2010 is become a human right. For decades, WHO Guidelines provided guidance on the parameters that can affect the quality of water and recommend safe guidelines values for a number of parameters. Whilst the first two Editions of the Guidelines emphasised monitoring and sanitary inspections by water and health authorities, since the third Edition published in 2004, WHO introduced a fundamental change in approach, suggesting a risk assessment and management strategy for water safety assurance, through Water Safety Plans (WSPs). WSP framework offers the most cost-effective and protective means of consistently assuring a supply of safe drinking water. WSP operates through a catchment to consumer risk assessment and management approach based on sound science and supported by confirmatory water quality testing. Its approach can be applied across a wide range of situations from household solutions to community water supply schemes or to large water supply utilities. The WSP framework is founded on the principles of Hazards Assessment Critical Control Point (HACCP), originating from the food industry.

1.1 Introduction

Whilst water has not been explicitly recognised as a self-standing human right in international treaties, international human rights law entails specific obligations related to access to safe drinking water. These obligations require States to ensure everyone's access to a sufficient amount of safe drinking water for personal and domestic uses (drinking, personal sanitation, washing of clothes, food preparation, and personal and household hygiene). States should prioritise these personal and domestic uses over other water uses and should take steps to ensure that this sufficient amount is of good quality, affordable for all and can be collected within a reasonable distance from a person's home [1].

In 2010, with the above declaration, United Nations (UN) stated access to safe drinking water as human right. Before this official and important identification, access to safe drinking water had already been taken as objective throughout the United Nations Millennium Development Goals (MDGs) elaboration. Indeed, from their first formulation, the MDGs included a specific target (designated Target 7c) for access to safe drinking water, *to reduce by half between 1990 and 2015 the proportion of population without sustainable access to safe drinking water and basic sanitation* [2].

The World Health Organisation (WHO) and the United Nations Children's Fund (UNICEF) report progress on this target by means of their Joint Monitoring Programme for Water Supply and Sanitation (JMP) [3]. Despite all efforts, MDGs and their pace of improvement are rather questioned as well as the appropriateness of some indicators used by the JMP to monitor access to safe drinking water [4-6]. A key concern is the use of the word *safe* in the target, and whether or not the data on water quality available are suitable for monitoring access to safe drinking water up to 2015, as well as for providing a retrospective estimate of access at baseline in 1990 [7].

To guarantee the safety of the water consumed is crucial, since unsafe water (as many outbreaks in both developing and developed countries have shown) has the potential to cause widespread illness and even death [8]. The latest estimates published by WHO state that diarrhoeal diseases are responsible for about 800,000 annual deaths of children under the age of 5, causing a higher number of under-age-5 deaths than malaria and HIV combined [9]. Contaminated water is in fact considered one of the main causes of diarrhoea [10-13]. Thus, in the last decades, Governments and donors took great efforts to promote access to safe drinking water, both in developing as well as developed countries (most particularly in Eastern Europe, but also in North America and elsewhere) [14, 15].

Prevention of drinking water contamination is, hence, a key issue in public health policies. Systematic preventive management plays an essential role in guaranteeing safe drinking water, whereas relying solely on end-testing appears to be too little and too late [16-18]. This is of particular concern in developing countries, where a multi-barrier approach to enhance drinking water safety is essential in order to minimise the (microbiological) contamination. The focus on sources (as in the MDGs and in the related JMP), moreover, is no more adequate because, as stated in several literature works [19-23], the major contamination is arising between the catchment and the point of use / consumption.

A first input in this direction was given by the International Water Association (IWA) with the Bonn Charter for Safe Drinking Water [24], based on the identification of key principles considered essential in creating a management framework for the reliable provision of good, safe drinking water. Then, in the third edition of the WHO Guidelines for Drinking Water Quality (GDWQ) in 2004 (and confirmed in the fourth edition in 2011), the World Health Organisation recommended the adoption of the Water Safety Plan (WSP) methodology for ensuring the safety of drinking water supplies [25]. The WSP approach, in fact, entails the comprehensive assessment of both the risk to health and risk management and should encompass all stages of the water supply system, from the catchment to the consumer, considering hazards within the system utilising a multi-barrier principle [26]. Thus, the concentration-based approach (considered until the second edition of the WHO GDWQ), which permitted to determine whether the end product (drinking water) complied with standards that ensure consumer safety, has been overcome with the risk-based approach of WSP strategy. This new approach takes into account parameters such as the level and duration of exposure to contaminants, their toxicity and the severity of the diseases they produce in assessing the need for mitigation [18]. As stated by international experts [17], the WSP approach permits to overcome the limitations of the end-product testing methodology, concerning the following aspects:

- There are several water-borne pathogens that cannot be detected or they can be insecurely detected with the classical indicators (*E. coli*, *Enterococci*, etc.).
- Monitoring results are almost always available out of time of intervention needed to maintain the safety of a supply system.
- End-product testing can be hardly considered a tough method for representative water quality status.
- End-product testing, finally, does not provide safety in itself.

The need to look at the entire drinking water supply chain (from the catchment to the consumer), in order to guarantee the respect of the quality's standards at the point of consumption, and the will to introduce a systematic risk-based approach (WSP) have brought the International Authorities to already think at the so-called post-2015 Agenda. This Agenda was desired in order to not frustrate all efforts made to date to ensure access to safe drinking water and aims to continue the work begun with the MGDs in 2000, introducing some changes. Indeed, "The World We Want 2015 Water Thematic Consultation", facilitated under the umbrella of UN-Water, co-led by the United Nations Department of Economic and Social Affairs (UN DESA) and the United Nations Children's Fund (UNICEF), and co-hosted by Jordan, Liberia, Mozambique, the Netherlands and Switzerland has helped define the role of water in the post-2015 development Agenda [27]. The Water Thematic Consultation reached a peak in March 2013 at a high level meeting in The Hague, which set a new course for concerted action and global direction, capturing water's importance to the post-2015 development framework in these key points [27]:

- Water is a key determinant in all aspects of social, economic and environmental development.
- Water, Sanitation and Hygiene, Water Resources Management and Wastewater Management and Water Quality are all indispensable elements for building a water-secure world.
- Water security will be of growing importance and should be addressed adequately in the Agenda, in order to prevent crises in the water as well as in the water-dependent sectors.

- Governments have to play a key role in securing water for competing demands, through cooperation at local, national, regional and global level and through partnerships with a multitude of stakeholders.

The experimental research carried out during the PhD course had the aim of developing an appropriate WSP to be implemented in rural areas of Africa and, at the same time, the aim of looking at the post-2015 development Agenda trying to identify / propose an appropriate approach and method to guarantee the safe consumption of drinking water, above all in stressed areas such as the ones of developing countries. In particular, this first Chapter aims at introducing the WSP approach and at highlighting pros and cons on its implementation, with a specific focus on developing countries.

1.2 The WHO Guidelines for drinking water quality and the origin of the WSP

Worldwide the main starting points for the setting of water quality standards are the World Health Organisation (WHO) Guidelines. These Guidelines are, in large part, health risk assessment and are based on scientific consensus, best available evidence and broad expert participation [26]. The first Edition of these Guidelines was published in middle '80s, the second in the late '90s (1997), the third one in 2004, whereas the fourth Edition was published in 2011.
The characteristic framework of the WHO Guidelines (Fig. 1.1) is an iterative cycle that encompasses assessment of public health concerns, risk assessment, the establishment of health-based targets and risk management. Feeding into this cycle is the determination of environmental exposure and the estimation of what constitutes an acceptable risk [28].

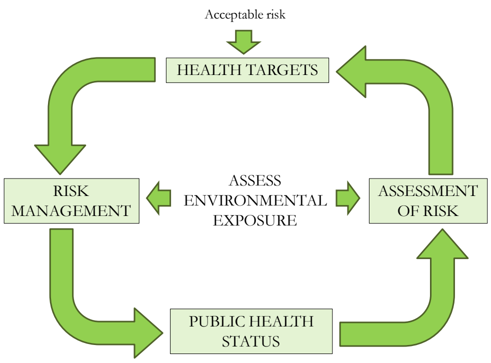

Fig. 1.1. *Simplified risk-based water cycle management framework showing health-based targets*

There are several chemical and microbiological contaminants that can be found in drinking water, some of which can have serious health effects on consumers (arsenic, fluorides, heavy metals, *E. coli*, *Vibrio cholera*, etc.). These can be derived from a large number of sources, including sometimes water treatment processes. Understanding the nature of sources of contamination and how these may enter the water supply is critical for assuring water safety [26]. A fundamental, but not decisive, strategy in providing safe drinking water for consumers is the multiple barrier approach, the application of which is often restricted to the actual water process. The consideration that testing water immediately prior to, or within, distribution (*end product testing*) can only highlight a potential health problem after the water has been consumed, has led to the recognition of the need to adopt additional approaches to assuring water quality and safety. Indeed, such practices are not timely enough to prevent consumption of contaminated water and do not give sufficient information to identify the source of contamination (when, why, and where it occurred) [29].
The most cost effective and protective means of consistently assuring a supply of acceptable drinking water is the application of some form of risk management, supported by appropriate monitoring. It is important that risk management is inclusive and, therefore, needs to cover the whole system, from the

catchment to the point of consumption [30]. A risk management approach such as this one has been already pointed out through the HACCP strategy (Hazard Analysis and Critical Control Point). The principles of HACCP (which is a preventive risk management system that has been used in the food manufacturing industry for a number of decades) are based on developing an understanding of the system, prioritising risks and ensuring that appropriate control measures are in place to reduce risks to an acceptable level.

These principles have been refined and tailored to the context of drinking water following the application of HACCP approach by several water utilities including in the USA [31] and Australia [32-34]. The experience of the application of HACCP by water utilities has informed the development of the Water Safety Plan approach [26].

WHO promoted water quality assurance through Water Safety Plans since the early 2000s, and formally recommended them in the third Edition of Guidelines for drinking water quality published in 2004. Indeed, this third Edition outlines a preventive management framework for safe drinking water that comprises five components (Fig. 1.2), three of which combine to form the WSP.

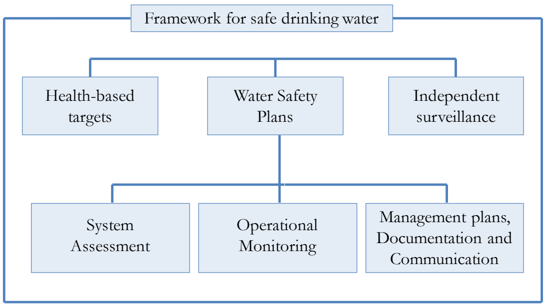

Fig. 1.2. *Simplified framework for safe drinking water*

A WSP, therefore, comprises three key components [25]:

- System assessment to determine whether the drinking water supply chain (up to the point of consumption) as a whole can deliver water of a quality that meets health-based targets.
- Identifying control measures in a drinking water system that will collectively control identified risks and ensure that the health-based targets are met. For each control measure identified, an appropriate means of operational monitoring should be defined that will ensure that any deviation from required performance is rapidly detected in a timely manner.
- Management plans describing actions to be taken during normal operation or incident conditions and documenting the system assessment, monitoring and communication plans and supporting programmes.

As clearly outlined, health-based targets provide the basis for the application of the Guidelines to all types of water supply. If water supplies cannot meet health-based targets, this does not mean that a WSP cannot be elaborated, but it should be defined providing an estimate made of current risk excess. Moreover, even for a supply system that cannot achieve desired health-based targets, the implementation of a WSP can assist in operating that system optimally, in order to minimise the incidence of disease attributable to that particular system.

1.3 The elaboration of a Water Safety Plan

As stated above, Water Safety Plans stand in contrast to conventional approaches. They introduce pro-active risk management that contributes to timely detection of contamination to prevent illness and rectify the problem through monitoring of critical points at the water source, treatment, distribution to the consumer, and end storage.

The primary objectives of a WSP in ensuring good drinking water supply practice are:

1. The ***minimisation*** of contamination of source waters.
2. The ***reduction or removal*** of contamination through treatment processes.
3. The ***prevention*** of (re-)contamination during storage, distribution and handling of drinking water.

Thus, the aim of a WSP is very straightforward: to consistently ensure the safety and acceptability of a drinking water supply.

The systematic nature of the WSP strategy should never be lost or forgotten during implementation, even because the great advantage of the WSP strategy is that it is applicable to ensuring the safety of water in all types and sizes of water supply systems, no matter how simple or complex. Indeed, the three objectives stated above are equally applicable to large piped drinking water supplies, small community supplies and household systems [25, 35].

There is not one way to undertake the WSP approach [35]. Indeed, WSPs can vary in complexity, as appropriate for the situation. They can also be quite simple, focusing only on the key hazards identified for the specific systems.

The WSP identifies credible risks in the water supply system from the source to the consumer, prioritise those risks, and put in place controls to mitigate them. They also include processes to monitor and validate the effectiveness of management control systems and the quality of the water produced. Globally, WHO has provided 11 different steps in order to elaborate a comprehensive WSP strategy (Fig. 1.3). Each of these steps will be deeply analysed in the following paragraphs.

Fig. 1.3. *Standard WSP approach suggested by WHO*

Since the amount of work necessary for the development of a WSP (as clearly outlined in steps of Fig. 1.3), WSP approach implementation requires both financial support and time availability.

The time it will take to establish a WSP will depend upon a number of factors. These include the experience of the staff, the amount of data available on the water supply, the size and complexity of the supply, and other systems that have already been adopted.

These factors are all inter-related and it is clearly difficult to define exactly what length of time is required to establish a WSP in all circumstances. The experience of the team is critical. The degree to which experience can reduce the time required to develop a plan will also depend on whether a dedicated individual or team are assigned to the project and how many other duties they must perform.

The amount of data available is also an important factor. In water supplies where there are a lot of data on the supply, particularly the distribution system, the WSP is not only more comprehensive but it can be prepared more rapidly. Where data are lacking, the quality of the WSP may be compromised, necessitating additional data collection. In such circumstances, draft plans may be developed and linked to an ongoing process of improvement and data collection. The size and complexity of the supply most obviously affects the time it is likely to take to put together a WSP. Large and complex systems, with more than one source, multiple treatment works and / or large and complex distribution systems will inevitably require a greater time input than small, simple systems.

Cost is another important factor in the implementation of any new approach or procedure. There seems to be a fear that risk-based approaches to water safety management, such as the Water Safety Plan, will increase costs of water production and distribution. There is, however, no solid reason why this should be so and it would be expected that some cost aspects would reduce. It would be expected that microbial testing would significantly decrease, but process monitoring would increase as a result of adopting a WSP strategy. This may offer opportunities for significant savings in countries where consumables for microbial testing are expensive [26]. Thus, financial and resource requirements need to be addressed at the outset but there should also be the understanding that proper implementation of the WSP approach can save money and better target resources in the longer term [35].

1.3.1 Assemble the WSP team

The first stage in developing a WSP is to assemble a multidisciplinary team of experts to develop the Water Safety Plan. This team should involve individuals from the utility, and also in some cases, from a wider group of stakeholders with the collective responsibility for understanding the water supply system and identifying hazards that can affect water quality and safety throughout the supply chain. The WSP team, hence, should include managers, engineers (operations, maintenance, design, capital investment), water quality controllers (microbiologists and chemists) and specialists, environmental or public health or hygienist professionals (even, if possible, members of professional organisations or universities), and technical staff involved in day-to-day operations. All members of the team should already have a good knowledge of the system. The team will be responsible for developing, implementing and maintaining the WSP as a core part of their day-to-day roles. It is essential that all involved play an active role in the development of the WSP and support the WSP approach. The team is vital to getting the WSP strategy understood and accepted by everyone connected with water safety within and outside the utility. Therefore, an inclusive team that works with everyone within a utility and outside is likely to be far more effective than an exclusive team who impose their WSP approach on the utility. Other desirable features of the WSP team include [26]:

- Knowledge of the water supply system and the types of drinking water safety hazards to be anticipated.
- Authority to implement any necessary changes to ensure that safe water is produced.
- Inclusion of people who are directly involved with the daily operations.
- Having sufficient people on the team to allow for a multidisciplinary approach, but not so many that the team has difficulty in making decisions.

Team numbers will vary according to the size of the organisation and complexity of process. The use of sub-teams is allowed and might for example include water harvesting, water treatment and distribution operations.

A vital early task of the team is to set out how the WSP approach is to be implemented and the methodology that will be used, particularly in assessing risks. Moreover, a team leader should be appointed to drive the project and ensure focus. The team leader should have the authority, organisational and interpersonal skills to ensure the project can be implemented. In situations where required skills are unavailable locally, the team leader should explore opportunities for external support. This can include benchmarking or partnering arrangements with other organisations and national or international assistance programmes. It is the team's responsibility to define the aim of the WSP. The scope should describe which part of the water supply chain is involved and the general classes of hazards to be addressed. The team should develop each step of the WSP in accordance with the steps outlined in Fig. 1.3. Finally, define and record roles and responsibilities of the individuals on the team are essential steps, in order to divide duties amongst team members, as well as define the time frame to develop the WSP, since the initial development of a WSP requires considerable time input [35].

Example

Table 1.1. *Example of WSP team details form*

Name	Affiliation	Title	Role in the team	Contact
Mr Bob Green	Blue Water Supply	Water Supply Operator	Catchment Liaison Officer	000-0101
Mr John Red	White surveillance Agency	Manager	President	111-2323
...	...	...	...	...

1.3.2 Describe the water supply system

The first task of the WSP team is to fully describe the water supply. Where utilities do not already have documentation of the water system, it is essential that field investigations are conducted. The objective is to ensure that subsequent documentation of the nature of the raw, interim, and finished water quality, and of the system used to produce water of that quality is accurate to allow risks to be adequately assessed and managed. This should cover the whole system from the source to the point of supply, covering the various types of source water, treatment processes and so on [26]. In most cases, consultation with public health and other sectors, including land and water users and all those who regulate activities in the catchment, will be required for the analysis of catchments. A structured approach is important to ensure that significant issues are not overlooked and that areas of greatest risk are identified [25].

A detailed description of the water supply system is required to support the subsequent risk assessment process. It should provide sufficient information to identify where the system is vulnerable to hazardous events, relevant types of hazards, and control measures. The following should be included in the description but it is not an exhaustive list, nor is every point relevant for each water supply system: relevant water quality standards; the sources of water including the runoff and / or recharge processes, and if applicable, alternative sources in case of incident; known or suspected changes in sources water quality relating to weather or other conditions; details of the land use in the catchment; information relating to the storage and the treatment of water; details of how the water is distributed including network, storage and tankers; description of the materials in contact with water; how well existing procedures are documented; information related to hygiene and sanitation conditions and devices; etc..

Hazard identification is facilitated through the conceptualism of the specific water supply system, through the construction of a flow diagram. Indeed, a flow diagram should be developed in order to capture all the elements of the water supply system in sufficient detail (from catchment to point-of-use). The flow diagram should be validated through on-site field checking and then used in the risk assessment process. An accurate flow diagram will help identify how risks can be transferred to consumers and where they are or can be controlled. Sometimes it may be helpful to divide the flow diagram for each or some of the basic elements (catchment, treatment, distribution and consumption) into discrete sections. Discrete flow diagrams could be produced, for example for more than one source in the catchment, for different treatment streams and service reservoirs, trunk and network mains in distribution [35].

Example

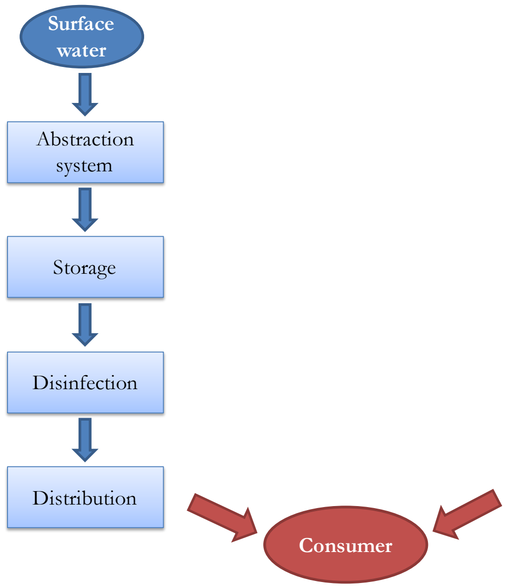

Fig. 1.4. *Basic water system diagram*

1.3.3 Identify hazards and hazardous events and assess the risks

For each step of the validated process flow diagram, the WSP team is required to assess what could go wrong at what point in the water supply system in terms of hazards and hazardous events. Effective risk management, therefore, requires identification of all potential hazards, their sources, possible hazardous events and an assessment of the risk presented by each. This process should [35]:

- Identify all potential biological, physical and chemical hazards associated with each step in the drinking water supply that can affect the safety of the water.
- Identify all hazards and hazardous events that could result in the water supply being, or becoming, contaminated, compromised or interrupted.
- Evaluate the risks identified at each point in the flow diagram previously prepared.

A hazardous event is an event or situation that could cause a hazard or fail to remove it from the water supply, whilst hazards to the water supply system can be defined as sources or agents of microbiological, chemical, physical or radiological nature that could be associated with the water supply and that may contain the potential to endanger the health of consumers (i.e.: heavy rainfall (hazardous event) may promote the introduction of microbial pathogens (hazards) into source water). Risk is measured by the probability of an event occurring and the danger of exposure to threats, which resulted in a period of time to consumers [29].

Biological hazards include pathogens such as bacteria, viruses, protozoa and helminths. Other non-pathogenic organisms that influence the acceptability of drinking water should also be considered. An important aspect is that it is not necessary or practical to completely eliminate microorganisms from drinking water supply systems. What is required is to keep numbers of pathogens below levels determined to represent an acceptable level of risk as outlined in the water quality targets.

A chemical hazard can be considered as any chemical agent that may compromise water safety or suitability. Chemicals from watersheds / catchments, reservoir storages, water treatment processes and distribution systems should be considered.

Physical hazards may affect water safety by posing a direct risk to health, through reducing the effectiveness of treatment and in particular residual disinfectants or because consumers find the water unacceptable and use alternative, maybe more contaminated water sources. The most common physical hazard in water is sediment within the water supply. Indeed, suspended or resuspended sediments can contain toxic chemicals or can have pathogens attached and can co-transport other hazards.

Radiological contamination of drinking water generally occurs as a result of contamination by man-made sources of radiation (mining industries, medical or industrial radioactive materials, etc.), but sometimes can even naturally occur [26].

The WSP team should consider factors that could introduce risks that are not readily obvious, for example the siting of a water treatment works in a flood plain or the ages of pipes in a distribution system. Identification of influencing factors like these will require the WSP team to think laterally and widely. Indeed, a number of hazards and related hazardous events may occur at any step in the water supply system [35].

Once potential hazards and their sources have been identified, the risk associated with each hazard or hazardous event should be compared so that priorities for risk management can be established and documented. Although there are several contaminants that can compromise drinking water quality, not every hazard will require the same degree of attention. The risk associated with each hazard may be described by identifying the likelihood of occurrence (e.g.: certain, possible, rare, etc.) and evaluating the severity of consequences if the hazard occurred (e.g.: insignificant, major, catastrophic, etc.). The potential impact on public health is the most important consideration, but other factors such as aesthetic effects, continuity and adequacy of supplies, and utility reputation should also be considered. The aim should be to distinguish between significant and less significant risks. When starting the risk assessment process, WSP team should draw up detailed definitions of what it means by possible, rare, major, etc.. These definitions should enable the risk assessment to avoid being too subjective. Of crucial importance, moreover, is the need to define in advance the definition or risk matrix score that identifies significant risk. The information that will inform the risk assessment will come from the experience, knowledge and judgement of the utility and the individual team members. When data are insufficient to determine whether a risk is high or low, risks should be considered significant until further investigations clarify the assessment.

The risk assessment process can involve a quantitative or semi-quantitative approach, comprising estimation of likelihood / frequency and severity / consequence (Table 1.2), or a simplified qualitative approach based on expert judgement of the WSP team. In any case, it is beneficial to record the basis of the decision to act as a reminder to the team and / or auditor or reviewer as to why the decision was taken. All risks should be documented in the WSP and be subjected to regular review even when the likelihood is rare and the risk rating low. This avoids risks being forgotten or overlooked and provides the water utility with a record of due diligence should incidents occur. An alternative to scoring risks based on the likelihood and severity of consequences model, is to undertake a simplified risk assessment process, drawing on the team's judgement. Risks may be ranked as significant, uncertain, or insignificant, based on an assessment of the hazards at each step in the process. Whatever method is applied, the WSP team needs to determine a cut off point above which all hazards will be retained for further consideration. Indeed, there is little value in expending a great deal of effort considering very small risks [35].

Table 1.2 shows an example of a risk scoring matrix for ranking risks, where total risk score is calculated multiplying likelihood per severity ratings. Examples of definitions of likelihood and severity categories that can be used in risk scoring are [25]:

Likelihood categories

Almost certain	Once per day
Likely	Once per week
Moderate	Once per month
Unlikely	Once per year
Rare	Once every 5 years

Severity categories

Catastrophic impact	Potentially lethal to large population
Major impact	Potentially lethal to small population
Moderate impact	Potentially harmful to large population
Minor impact	Potentially harmful to small population
Insignificant impact	No impact or not detectable

Table 1.2. *Semi-quantitative risk matrix approach, proposed by [34]*

		Severity or Consequence				
		Insignificant or no impact - Rating: 1	Minor compliance impact - Rating: 2	Moderate aesthetic impact - Rating: 3	Major regulatory impact - Rating: 4	Catastrophic public health impact - Rating: 5
Likelihood or frequency	Almost certain - Rating: 5	5	10	15	20	25
	Likely - Rating: 4	4	8	12	16	20
	Moderate - Rating: 3	3	6	9	12	15
	Unlikely - Rating: 2	2	4	6	8	10
	Rare - Rating: 1	1	2	3	4	5

Risk score	< 6	6-9	10-15	> 15
Risk rating	Low	Medium	High	Very high

Example

Table 1.3. *How to calculate the risk using the matrix [35]*

Element	Description
Hazard	Loss of network integrity through illegal connections results in the ingress of pathogens
Likelihood	2 – Plumbing controls are in place, but are ineffective (at least 2 outbreaks occurred in the past 5 years)
Severity	5 - Public health impact including disease and potentially death
Score	2 x 5 = 10 High risk
Outcome	Risk requires prioritising for action, including reviewing current controls and whether new controls could be implemented

1.3.4 Determine and validate control measures, reassess and prioritise the risks

Concurrently with identifying the hazards and evaluating the risks, the WSP team should document existing and potential control measures, which are those steps in supply that directly affect water quality and which, collectively, ensure that water consistently meets health-based targets. They are actions, activities and processes applied to prevent or minimise hazards occurring. Existing control measures should be determined for each of the identified hazards and hazardous events.

The WSP team should consider whether the existing controls are effective. Depending on the type of control, this could be done by site inspection or monitoring data. The risks should then be recalculated in terms of likelihood and consequence, taking into account all existing control measures. The reduction in risk achieved by each control measure will be an indication of its effectiveness. If the effectiveness of the control is not known at the time of the initial risk assessment, the risk should be calculated as though the control was not working.

Risks can only be reassessed and prioritised following validation of control measures. Validate the effectiveness of the controls will usually require an intensive programme of monitoring to demonstrate the performance of a control, under normal and exceptional circumstances. Technical data from scientific literature or data from studies at pilot drinking water treatment plants may be helpful in the

validation process, but care must be taken to check that the circumstances described or piloted are the same or very similar to the risks that have been identified as requiring controls.
After all the control measures have been taken into account, any remaining risks that the WSP team consider unacceptable should be investigated in terms of additional corrective actions.
The prioritisation of the risks should be carried out in terms of their likely impact on the capacity of the system to deliver safe water. High priority risks may require system modification or upgrade to achieve the water quality targets, whilst lower priority risks can often be minimised as part of routine good practice activities [35].

Example

Table 1.4. *Risk prioritisation and reassessment [35]*

Hazard	Hazardous event	Likelihood	Severity	Score	Risk rating	Control measure	Validation	Reassessment
Chemical	Formation of disinfection by-products exceeding Guideline values	3	3	9	Medium	Reducing water age through tanks downstream where possible in periods of low water demand	Consistent reduction in disinfection by-products under range of operating conditions	Low with appropriate operational monitoring
Microbial	Low chlorine residual in distribution and reticulation systems	4	4	16	Very high	Set point designed to achieve established target chlorine residual to achieve microbial standards at consumer premises linked to alarms	Alarms effective and demonstration of consistent removal of indicator organisms under range of operating conditions	Low with appropriate operational monitoring
Physical	Failure of pumps	4	3	12	High	Pressure measurement triggering back-up pumps	No controls in place	High - priority for mitigation
...	...	...	...	...	...	...	...	...

1.3.5 Develop, implement and maintain an improvement / upgrade plan

If the previous step identifies significant risks to the safety of water and demonstrates that existing controls are not effective or are absent, then an improvement / upgrade plan should be drawn up. Each identified improvement needs an owner to take responsibility for implementation and a target implementation date. In some instances, all that may be needed is to review, document and formalise the practices that are not working and address any areas where improvements are needed. In other cases, new or improved controls or a major infrastructure change may be needed. Significant resources may be needed and therefore a detailed analysis and careful prioritisation should be made in accordance with the system assessment. Generally, it should be taken into consideration that the introduction of new controls could introduce new risks to the system [35].
The assessment and planning of control measures should ensure that health-based targets will be met and should be based on hazard identification and assessment. The level of control applied to a hazard should be proportional to the associated ranking.
Control measures are identified by considering the hazards or the hazardous events that can cause contamination of water (both directly and indirectly) and the activities that can mitigate the risks from those events. Control measures need to be identified at the point of contamination as well as downstream, so that effects of multiple barriers can be assessed together [26]. Indeed, identification and implementation of control measures should be based on the multiple-barrier approach. The strength of

this approach is that a failure of one barrier may be compensated by effective operation of the remaining barriers, thus minimising the likelihood of contaminants passing through the entire system and being present in sufficient amounts to cause harm to consumers. Many control measures may contribute to control more than one hazard, whilst some hazards may require more than one control measure for effective control. Finally, each hazard / hazardous event / possible cause of contamination listed has to be prevented by means of an appropriate control measure.
All control measures are important and should be afforded ongoing attention. They should be subject to operational monitoring and control, with the means of monitoring and frequency of data collection based on the nature of the control measure and the rapidity with which change may occur [25].

Example

Table 1.5. *Drinking water quality improvement / upgrade plan actions and accountabilities [35]*

Action	Arising from	Improvement plan	Accountabilities	Due	Status
Implement measures to control risk arising from agricultural pesticides introduced into the water supply	Risk assessment process has identified a cocktail of pesticides from agricultural uses. Currently there is no confidence that these risks are adequately controlled	Install ozone and granular activated carbon filtration within the water treatment plan	e.g.: Engineer	e.g.: Date the action should be completed by	e.g.: Ongoing, not started, etc.
...	...	...	...	...	...

1.3.6 Define monitoring of the control measures

Operational monitoring includes supervising and validating the monitoring of control measures and establishing procedures to demonstrate that the controls continue to work. These actions should be documented in the management procedures. Defining the monitoring of the control measures also requires inclusion of the corrective actions necessary when operational targets are not met.
Indeed, the objectives of operational monitoring are for the drinking water supplier to monitor each control measure in a timely manner to enable effective system management and to ensure that health-based targets are achieved.
The number and type of control measures will vary for each system and will be determined by the type and frequency of hazards associated with the system. Monitoring of control points is essential for supporting risk management by demonstrating that the control measure is effective and that, if a deviation is detected, actions can be taken in a timely manner to prevent water quality targets from being compromised. Effective monitoring relies on establishing: what will be monitored, how it will monitored, the timing or frequency of monitoring, where it will be monitored, who will do the monitoring and the analysis and who receives the results of action (the so-called *what*, *how*, *when*, *where* and *who* principles). Parameters selected for operational monitoring should reflect the effectiveness of each control measure, provide a timely indication of performance, be readily measured and provide opportunity for an appropriate response [35].
Control measures need to have defined limits for operational acceptability (called operational limits) that can be applied to operational monitoring parameters. Operational limits should be defined for parameters applying to each control measure. If monitoring shows that an operational limit has been exceeded, predetermined corrective actions need to be applied. The detection of the deviation and implementation of corrective actions should be possible in a time frame adequate to maintain performance and water safety. For some control measures, a second series of so-called critical limits may also be defined, outside of which confidence in water safety would be lost. Deviations from critical limits will usually require urgent actions, including immediate notification of the appropriate health authority. Operational and critical limits can be upper limits, lower limits or a range of envelope of performance measures [25].

Not all measurable properties of control measures are suitable for this type of monitoring. Only where the following criteria are satisfied it is possible to define operational limits for control measures: limits for operational acceptability can be defined; these limits can be monitored, either directly or indirectly; a predetermined corrective response can be enacted when deviations are detected by monitoring; the corrective action will protect water safety by bringing the control measure back into specification, by enhancing the barrier or by implementing additional control measures; the process of detection of the deviation and completion of the corrective action can be completed in a time frame adequate to maintain water safety [26].

Routine monitoring is usually based on simple observations and tests, such as turbidity or structural integrity, rather than complex microbial or chemical tests. Monitoring data provide important feedback on how the water supply system is working and should be frequently assessed. Regularly assessed monitoring records are a necessary element of the WSP as they can be reviewed, through internal or external audit, to identify whether the controls are adequate and also to demonstrate adherence of the water system to the water quality targets [35].

Example

Table 1.6. *Monitoring requirements and corrective actions [35]*

Control measure	Critical limit	What	Where	When	How	Who	Corrective action
Chlorination at water treatment plant	Chlorine concentration leaving plant must be > 0.5 and < 1.5 mg/L	Disinfectant residual	At entry point to distribution system	On-line	Chlorine analyser	Water Quality Officer	Activate chlorine non-compliance protocol
…	…	…	…	…	…	…	…

1.3.7 Verify the effectiveness of the WSP

Verification provides a final check on the overall safety of drinking water supply chain by means of the use of methods, procedures or tests in addition to those used in monitoring to determine if the WSP is in compliance with the stated objectives outlined in the water quality standards and / or whether the WSP needs modification and revalidation [26].

Indeed, in addition to operational monitoring of the performance of the individual components of a drinking water system, it is necessary to undertake final verification for reassurance that the system as a whole is operating safely. Verification may be undertaken by the supplier, by an independent authority or by a combination of these, depending on the administrative regime in a given country. It typically includes testing for faecal indicator organisms and hazardous chemicals [25].

For microbial quality, approaches to verification include testing of source water, treatment end-point product and water in distribution systems or stored household water. Verification of microbial quality of drinking water includes testing for *Escherichia coli* as an indicator of faecal pollution. *E. coli* provides conclusive evidence of recent faecal pollution and should not be detected. The detection of thermotolerant coliform bacteria can be an acceptable alternative in many circumstances. Under certain circumstances it may be even desirable to include analysis for more resistant microorganisms, such as bacteriophages and / or bacterial spores.

Assessment of the adequacy of the chemical quality of drinking water relies on comparison of the results of water quality analysis with Guidelines values. Issues that need to be addressed in developing chemical verification include the availability of appropriate analytical facilities, the cost of analyses, the possible deterioration of samples, the stability of the contaminant, the likely occurrence of the contaminant in various supply, the most suitable point for monitoring and the frequency of sampling.

For both microbial and chemical quality's verification, frequencies of sampling should reflect the need to balance the benefits and costs of obtaining more information. Sampling frequencies are usually based

on the population served or on the volume of water supplied, to reflect the increased population risk. Frequency of testing for individual characteristics will also depend on variability. Generally, sampling and analysis are required more frequently for microbial than for chemical constituents [26].
The verification programme can also be outlined based on the so-called ***what***, ***how***, ***when***, ***where*** and ***who*** principles.

Example

Table 1.7. *Operational monitoring Vs verification monitoring plan [35]*

Unit process	Operational monitoring			Verification monitoring		
	What	When	Who	What	When	Who
Treatment works	On-line measurement: - pH - Chlorine	Daily	Water treatment operators / Analyst	*E. coli* Enterococci Record audit	Weekly Weekly Monthly	Analyst
	Jar testing records	Weekly		-	-	
	Turbidity	Daily				
	Dosing records	Monthly				
Distribution system	pH	Weekly		*E. coli*	Monthly	
	Turbidity	Weekly				
	Chlorine	Weekly		Turbidity	Monthly	
	Sanitary inspection	Weekly		Enterococci	Monthly	
...	...	...	...	...	...	...

1.3.8 Prepare management procedures

Clear management procedures documenting actions to be taken when the system is operating under normal conditions and when the system is operating in "incident" situations (where a loss of control of the system may occur) are an integral part of the WSP [35]. An incident is any situation in which there is reason to suspect that water being supplied for drinking purposes may be, or may become, unsafe. As part of a WSP, management procedures should be defined for response to predictable incidents as well as unpredictable incidents or emergencies. Management procedures should be documented alongside system assessment, monitoring plans, supporting programmes and communication required to ensure safe operation of the system [25].
Management staff have a responsibility to ensure procedures are kept up to date and in place to keep operators and management staff connected and involved, to make it easy for people to do the right thing, to provide adequate resources and to ensure that people are willing to come forward instead of withholding information for fear of reprisals. An efficient, regular review and updating cycle is also important.
Unforeseen events / incidents or deviations may occur for which there are no corrective actions in place. In this case, a generic emergency plan should be followed. This would have a protocol for situation assessment and identification of situations that require activation of the emergency response plan. It is also important that near misses are assessed as they could be an indicator of a likely future emergency. Following an emergency, an investigation should be undertaken involving all staff to discuss performance, assess if current procedures are adequate, and address any issues or concerns. Appropriate documentation and reporting of the emergency should also be established. Review of the cause of the emergency or near miss and the response to it may indicate that amendments to existing protocols, risk assessments and the WSP are necessary [35].

Example

Table 1.8. *Typical Standard Operating Procedures for a water utility [35]*

Category	Sub-category	Standard Operating Procedure
Facility operations overview	General tasks / information	Daily rounds
		Site security
		Record keeping
		Reporting procedures
		Cross contamination prevention for operators
	Sampling	Sampling procedure
	Emergency response	Power failure
Intake and pre-treatment	Raw water	Valve operation
		Screening
	Flow measurement	Meter calibration
...	...	...

1.3.9 Develop supporting programmes

Supporting programmes are activities that ensure the operating environment, the equipment used and the people themselves do not become an additional source of potential hazards to the drinking water supply. They have the aim of supporting the development of people's skills and knowledge, commitment to the WSP approach, and capacity to manage systems to deliver safe water. Programmes frequently relate to training, research and development. Supporting programmes may also entail activities that indirectly support water safety, for example those that lead to the optimisation of processes, like improving quality control in a laboratory. Programmes may already be in place, but are often forgotten or overlooked as important elements of the WSP [35].

Supporting programmes are often captured within Standard Operating Procedures (SOPs) or system operating rules. They can include, but are not limited to: hygienic working practices documented in maintenance SOPs; training and competence of personnel involved in water supply; tools for managing the action of staff, such as quality assurance systems; securing stakeholder commitment, at all levels, to the provision of safe water; education of communities whose activities may influence water quality; calibration of monitoring equipment; and record keeping.

Supporting programmes could specifically involve [26]:

- Controlling access of people into treatment plants, catchments and reservoirs, and implementation of the appropriate security measures to prevent transfer of hazards from people when they do enter source water.
- Development of verification protocols for the use of chemicals and materials used in water supply, for instance to ensure use of suppliers that participate in international quality assurance programmes.
- Use of designated equipment for attending to incidents such as mains bursts (e.g.: equipment should be designated for potable water work only and not for sewage work).
- Training and educational programmes for personnel involved in activities that could influence water safety. Training should be implemented as part of induction programmes and frequently updated.

Generally, in developing supporting programmes, it may not always be necessary to develop new programmes. Organisations should assess the programmes that are currently in place to identify any gaps that need to be addressed including updates of existing programmes.

<u>*Example*</u>

Table 1.9. *Types of supporting programmes that could be included in the WSP [35]*

Programme	Purpose	Examples
Training and awareness	To ensure organisation personnel understand water safety and the influence of their actions	WSP training Competency requirements Induction training Hygiene procedures
Research and development	To support decisions made to improve or maintain water quality	Understanding potential hazards Research into better indicators of contamination
Calibration	To ensure that critical limit monitoring is reliable and of acceptable accuracy	Calibration schedules Self-calibrating equipment
...	...	...

1.3.10 Plan and carry out periodic review of the WSP

The WSP team should periodically meet and review the overall plan (taking into account results obtained by the WSP implemented) and learn from experiences and new procedures. The review process is critical to the overall implementation of the WSP and provides the basis from which future assessments can be made. Following an emergency, incident or near miss, risk should be reassessed and may need to be fed into the improvement / upgrade plan. Indeed, regularly reviewing and revising the WSP ensures that new risks threatening the production and distribution of safe water are regularly assessed and addressed. An update, relevant WSP will in fact maintain the confidence and support of staff and stakeholders in the WSP approach.

A WSP can quickly become of out of date, owing to: catchment, treatment and distribution changes and improvement programmes, which can impact on process diagrams and risk assessments; revised procedures; staff changes; and stakeholder contact changes.

The WSP team should agree to meet regularly to review all aspects of the WSP to ensure that they are still accurate. In addition to the regular planned review, the WSP should also be reviewed when, for instance, a new water source is developed, major treatment improvements are planned and brought into use, or after a major water quality incident. During the regular review meeting, the date of the next review should be established [35]. Frequency and timing vary according to circumstances and local regulations [26].

<u>*Example*</u>

Checklist for WSP review [35]:

- ✓ Notes of last review meeting.
- ✓ Notes of any interim review.
- ✓ Changes to membership of the WSP team.
- ✓ Changes in catchment, treatment, distribution.
- ✓ Review of operational data trends.
- ✓ Validation of new controls.
- ✓ Review of verification.
- ✓ Internal and external audit reports.
- ✓ Stakeholders communication.
- ✓ Date of next review meeting.

1.3.11 Revise the WSP following an incident

As stated in paragraph 1.3.10, in order to ensure that a WSP covers emerging hazards and issues, it should be reviewed periodically by the WSP team. An important benefit derived from the development of the WSP approach is a likely reduction in the number and severity of incidents, emergencies or near misses affecting or potentially affecting drinking water quality. However, such events may still occur. For this reason, in addition to the periodic review, it is important that the WSP is reviewed following every emergency, incident or unforeseen event irrespective of whether new hazards were identified to ensure that, if possible, the situation does not recur and determine whether the response was sufficient or could have been handled better. A post-incident review is always likely to identify areas for improvement whether it is a new hazard or revised risk for the risk assessment, a revision for an operating procedure, a training issue or a communication issue, and the WSP must be revised to reflect the changes. In many cases, it will be necessary to include other stakeholders in this review process. It is important that water suppliers, within their WSP, have procedures in place to ensure that the WSP team is made aware of the circumstances and details of all incidents, emergencies, and near misses [35].

Example

Checklist of questions to be asked following an emergency, incident or near miss [35]:

- ✓ What was the cause of the problem?
- ✓ Was the cause a hazard already identified in the WSP risk assessment?
- ✓ How was the problem first identified or recognised?
- ✓ What were the most essential actions required and were they carried out?
- ✓ If relevant, was appropriate and timely action taken to warm consumers and protect their health?
- ✓ What communication problems arose and how were they addressed?
- ✓ What were the immediate and longer-term consequences of the emergency?
- ✓ How can risk assessment / procedures / training / communications be improved?
- ✓ How well did the emergency response plan function?

1.3.12 Documentation and communication

At the end of the WSP elaboration, documentation of all measures and programmes provided should be recorded. Documentation of a WSP should include [25]:

- Description and assessment of the drinking water system, including programmes to upgrade and improve existing water delivery.
- The plan for operational monitoring and verification of the drinking water system.
- Water safety management procedures for normal operation, incidents and emergency situations, including communication plans.
- Description of supporting programmes.

Even a communication strategy should be developed at the end of the WSP elaboration. This should include [25]:

- Procedures for promptly advising of any significant incidents within the drinking water supply, including notification of the public health authority.
- Summary information to be made available to consumers (e.g.: annual reports or documents available on-line in internet).
- Establishment of mechanisms to receive and actively address community complaints in a timely fashion.

The right of consumers to health-related information on the water supplied to them for domestic purposes is fundamental. In many communities, the simple right of access to information will not ensure that individuals are aware of the quality of the water supplied to them. Furthermore, the probability of consuming unsafe water may be relatively high.

The agencies responsible for monitoring should therefore develop strategies for disseminating and explaining the significance of health-related information [25].

1.4 Water Safety Plans for small systems

Small, community-managed water supplies can be found both in developed and developing countries worldwide. A wide range of technologies may be employed in such supplies, from relatively sophisticated treatment plans to single point sources, such as tubewells or boreholes fitted with a hand pump. The common feature of all such systems is that operation and maintenance is performed by members of the community with limited specialist skills, who can commit only limited amounts of time and who frequently receive little or no financial remuneration or formal training. Furthermore, the range of available equipment to identify and rectify faults may be limited as is access to water quality testing equipment.

The development of WSPs for such small systems should focus on the control of microbial quality and in particular in pathogens derived from faecal contamination [26]. Indeed, studies from both developed and developing countries highlighted the vulnerability of small systems to microbial contamination [36-38]. Chemical hazards are most likely to result from either natural sources or agricultural pollution. Of the natural chemicals, fluorides and arsenic are likely to be the most significant problems facing small systems. The WSP should propose control measures for chemical hazards where possible. However, in most cases, the control of these hazards must be addressed at the design stage rather than operational controls. Monitoring is unlikely to be feasible by the operators of small systems and therefore any water quality testing will necessarily devolve to the surveillance agency. This further supports the need for the WSP to focus on microbial quality in smaller systems [26].

For small or community-managed water supplies, the WSP is likely to be developed by a statutory body or accredited third-party organisation or surveillance agency. The implementation of the WSP will be highly dependent on the training and resource material made available to operators. This is also likely to require ongoing support in maintaining the WSP and providing periodic updating. Often this role has to be played by surveillance agencies, in addition to their role in independent assessment of water safety. Moreover, in these settings, guidance on household water storage, handling and use may also be required. Plans dealing with household water should be linked to a hygiene education programme and advice to households in maintaining water safety [25-26].

Hazard identification would ideally be on a case-by-case basis. In practice, for non-piped, community and household drinking water systems, reliance is typically placed on general assumptions of hazardous conditions that are relevant for technologies or system types. Even corresponding control measures depend on the characteristics of the source water and (human, material and financial) resources availability. Examples of hazards and controls potentially associated with various non-piped sources are presented in Table 1.10, as suggested by WHO in the fourth Edition of its Guidelines for drinking water quality [25].

Table 1.10. *Examples of hazards and controls for small water supply systems [25]*

Type of non-piped source	Possible hazards	Possible control measures
Tubewell fitted with a hand pump	✓ Ingress of contaminated water directly into the borehole ✓ Ingress of contaminants due to poor construction or damage to the lining ✓ Leaching of microbes into aquifer	✓ Proper wellhead completion measures ✓ Provide adequate set-back distances for contaminant sources such as latrines or animal husbandry
Protected spring	✓ Contamination directly through "backfill" area ✓ Contaminated water causes rapid recharge	✓ Maintain effective spring protection measures ✓ Establish set-back distance based on travel time
Open dug well	✓ Ingress of contaminants due to poor construction or damage to the lining ✓ Contamination introduced by buckets	✓ Proper construction and use of a mortar seal on lining ✓ Install and maintain hand pump or other sanitary means of abstraction
Rainwater collection	✓ Bird or other animal droppings found on roof or in guttering ✓ First flush of water can enter storage tank	✓ Cleaning of roof and gutters ✓ First-flush diversion unit

Generally, the greater the protection of the water source, the less the reliance on treatment or disinfection. Thus, water should be protected during storage and delivery to consumers by ensuring that the distribution and storage systems are enclosed; this applies to both piped systems and vendor-supplied water. For water stored in the home, protection from contamination can be achieved by use of enclosed or otherwise safely designed storage containers that prevent the introduction of hands, dippers or other extraneous sources of contamination.

Maintaining the quality of water during collection and manual transport is the responsibility of the household, good hygiene practices are required and should be supported through hygiene education. Hygiene education programmes should provide households and communities with skills to monitor and manage their water hygiene. Household treatment of water has proven to be effective in delivery of public health gains. Monitoring of treatment processes will be specific to the technology. When household treatment is introduced, it is essential that information (and, when appropriate, training) be provided to users to ensure that they understand basic operational monitoring requirements.

If the performance of a community drinking water system is to be properly evaluated, a number of factors should be considered. Usual practice would be to include the critical parameters for microbial quality (e.g.: *E. coli*, pH, turbidity and chlorine) and for a sanitary inspection to be carried out. It is recommended that field test kits be validated for performance against reference or standard methods and approved for use in verification testing. Periodic testing and sanitary inspection of community drinking water supplies should typically be undertaken by the surveillance agency and should assess microbial hazards and known problem chemicals. Frequent sampling is unlikely to be possible, and one approach is therefore a rolling programme of visits to ensure that each supply is visited once every 3-5 years. Comprehensive analysis of chemical quality of all sources is recommended prior to commissioning as a minimum and preferably every 3-5 years thereafter.

Community drinking water supplies worldwide are more frequently contaminated than larger drinking water supplies, may be more prone to operating discontinuously (or intermittently) and break down or fail more frequently. To ensure safe drinking water, the focus in small supplies should be on: informing the public; assessing the water supply to determine whether it is able to meet identified health-based targets; monitoring identified control measures and training operators to ensure that all likely hazards can be controlled and that risks are maintained at a tolerable level; operational monitoring of the drinking water system; implementing systematic water quality management procedures; establishing appropriate incident response protocols; developing programmes to upgrade and improve existing water delivery.

For point sources serving communities or individual households, the emphasis should be on selecting the best available quality source water and on protecting its quality by the use of multiple barriers and maintenance programmes. Whatever the source, communities and householders should assure themselves that the water is safe to drink. The parameters recommended for the minimum monitoring of a community supply are those that best establish the hygienic state of the water and thus the risk of waterborne disease [25].

1.5 Experiences of WSP development in low and middle income countries

Although WSP approach has been introduced by WHO Guidelines for drinking water quality since a decade, the spread of the WSP implementation is still limited. Worldwide WSP strategy is not already required by national legislations to drinking water suppliers (even European Union does not yet issue a Directive on drinking water quality requiring the adoption of the WSP approach, by water suppliers, for country members - the last reference Directive is dated 1998). Despite this limitation, the principle of risk assessment and preventive control measures, based on the strategy of the Hazard Analysis Critical Control Point (HACCP), which the WSP approach is referring to, has been put into regulation as a mandatory requirement in some countries, such as Australia, New Zealand, Iceland, Hungary, UK and

Uganda. Meanwhile, some experiences of WSP implementation in both urban and rural areas of low and middle-income countries have been carried out in the last decade, using the WSP approach in order to improve water quality consumed for drinking purposes.

1.5.1 Case study 1: WSP developed in Kampala, Uganda

The first implementation of the WSP approach in Africa is proposed by [39], referring to a research project funded by the Department for International Development (DFID) undertaken by the Water, Engineering and Development Centre (WEDC) in collaboration with the Uganda National Water and Sewerage Corporation (NWSC) and the Public Health and Environmental Engineering Department of Makerere University. The WSP framework was developed for a large utility system in Kampala, Uganda. The Kampala water supply network consists of 871 km of pipeline and serves over 40,000 households of approximately 700,000 people. Table 1.11 reports an example of the WSP developed.

The WSP team was composed by members of the NWSC (quality control manager, operations manager, chief engineer and principal analyst), the senior engineer of OSUL (Ondeo Services Uganda Ltd, the system operator) and a professor of environmental engineering of the Makerere University.

The WSP developed focused only on treatment works and distribution system. A future expansion of the Plan in order to cover actions within the source water and prevention of re-contamination post-collection from taps has been planned.

In the development of the WSP, it was decided to focus primarily on the microbiological contamination, considered the most serious in the local context compared to any kind of chemical contamination. The risk assessment was carried out using a quantitative method. Indeed, the definition of the probability of occurrence and the severity of consequences has been determined as a function of measurable quantities, such as slope of the land, population density and characteristics related to the pipe system (such as its length, age, discontinuity of supply and presence of infiltration phenomena). This approach allowed taking into account the spatial distribution of the risks associated with the same hazard, through the realisation of dedicated maps. Moreover, the risk assessment has been carried out considering directly the existing control measures. A distinction between critical and operational limits was not provided. Corrective actions consisted on activities able to bring the system to comply with reference water quality standards. An important role in the WSP was played by supporting programmes that were based on the mapping of the distribution system, the development of local sanitation and the training of both population and technical staff of the NWSC.

As shown in Table 1.11, the WSP framework developed in this case study was not in complete agree with the one proposed by WHO. Indeed, some steps were simplified or rearranged or even lacking.

Table 1.11. *WSP developed in Kampala, related to a service reservoir [39]*

Hazard event	Cause	Risk	Control measure	Critical limits		Monitoring			Corrective action	Verification
				Target	Action	What	When	Who		
Microbial contamination of service reservoir from birds	Birds faeces enter through vents because covers dislodged	Likely / Catastrophic	Vent covers remain in place	Vents covered	50% of vent support struts are damaged	Sanitary inspection	Weekly	Operations staff	Repair and replace damaged vents	*E. coli* and faecal streptococci; sanitary inspection
Microbial contamination of service reservoir from birds	Birds faeces enter through open inspection hatches	Moderate / Catastrophic	Inspection covers remain in place	Inspection covers locked in place	Inspection covers not in place or unlocked	Sanitary inspection and chlorine residual	Daily	Operating staff	Replace inspection cover and check chlorine consumption	*E. coli* and faecal streptococci; sanitary inspection
Animal and bird faecal	Animal and bird faecal material builds up on roof of service reservoir	Likely / Moderate	Trees do not overhang the reservoir and roofs kept clean	Tree branches 2m from reservoir roof; roof clean	Trees within 0.5m of roof; roof visibly dirty	Sanitary inspection	Quarterly	Operating staff	Cut back tree branches and clean roof	*E. coli* and faecal streptococci; sanitary inspection
Ingress of contamination at inlet valve	Inundation of inlet valve of surface water	Moderate / Major	Good drainage in valve box; covers on valve box; valve packing in good condition	Valve boxes covered and do not have standing water or organic material in base; packing dose not leak	Cover out of place, signs of material build-up; packing shows visible signs of damage	Sanitary inspection; washout drain tests	Monthly	Operating staff	Clean valve box and replace cover; clear washout drain; replace packing	*E. coli* and faecal streptococci; bacteriophage; sanitary inspection
Ingress of contamination at outlet / washout valve	Valve is inundated by surface water or waste water from reservoir	Almost certain / Major	Effective washout drains; covered valve box; good quality valve packing	Valve box covered and no visible signs or water or waste matter in box; washout drain functional; packing in good condition	Drainage around box blocked or damaged; washout drain blocked; water or waste build-up in valve box; packing showing signs of wear	Sanitary inspection; washout drain test	Monthly (sanitary inspection) and annual (drain test)	Operating staff	Make sure all boxes have washout drain that is jetted as part of regular maintenance; routine packing replacement	*E. coli* and faecal streptococci; bacteriophage; sanitary inspection
Microbial contamination from biofilm or sediment	Biofilm sloughs off or sediment is disturbed	Likely / Minor	Regular cleaning of service reservoir, drain-down of reservoir and clear sediment	Interior of reservoir is lean and sediment is minimised and undisturbed	Biofilm develops, increase in chlorine consumption	Sanitary inspection; chlorine residual; turbidity	Monthly	Operating staff	Take reservoir off-line and cleaned	Aeromonas; biofilm coupons; sanitary inspection

1.5.2 Case study 2: WSP developed in Spanish Town, Jamaica

Another case of WSP elaboration in an urban context is the one proposed by [40] and developed in Spanish Town, capital of the St. Catherine region, in Jamaica.

Spanish Town is supplied with potable water from a combination of wells and surface water from the Rio Cobre river that has a highly interconnected distribution network. 33,075 out of 37,656 households receive water from public sources. Of this number, 21,760 receive water from the public supply system directly to their dwelling, whereas the remaining 11,315 have access to water from the public supply system but into the yard, or from standpipes or from public tanks. The water distributed through the supply network is prior treated in a drinking water treatment plant, composed of: pre-treatment chlorination; primary settling tank; aluminium sulphate (alum) dosage; secondary settling tank; rapid gravity filtration; and chlorine disinfection.

In this case study the WSP was developed by a task force coordinated by the National Water Commission (NWC), in collaboration with the Water Quality Inspector for the Health Department. The WSP was developed for the catchment, the treatment plant and the piped distribution system. The hazard assessment was carried out following the scheme proposed by the WHO, thus evaluating hazards, identifying risks (by means of likelihood and severity scores), determining control measures and a monitoring programme. The last two steps (controls and monitoring) were developed only for hazards with a high or very high risk score (above 15, up to 25, risk score), thus determining a cut-off point and considering only the hazards above this value. Concerning critical limits, corrective actions and verification programmes, these were elaborated only for pre-identified critical control points on the NWC unit process at the treatment plant and wells. The aim was to focus on those critical steps in the process areas that, if not controlled, could pose a risk to the health and safety.

Table 1.12 reports a part of the WSP developed concerning the hazard assessment, where hazards were identified as biological (B) or chemical (C) or physical (P). Table 1.13 reports examples of controls and related monitoring programmes for some of the hazards highlighted in Table 1.12, whilst finally Table 1.14 shows critical limits, corrective actions and verification programmes of some of the pre-identified critical control points (CCPs).

Even in this case study, the WSP framework developed was not in complete agree with the approach proposed by WHO, due to some simplifications introduced during the elaboration of the Plan.

Table 1.12. *Hazard assessment carried out in the WSP of Spanish Town (Jamaica) [40]*

Hazard	Cause	Likelihood	Severity	Score	Risk
	CATCHMENT & INTAKE - RIVER				
B, C, P	Dumping of solid waste into rivers due to infrequent or non-existent garbage collection in watershed	5	2	10	Moderate
B, C, P	Informal residential settlements along canal prior to intake without sewage treatment & disposal systems	5	4	20	Very high
C	Pre-chlorination of raw water with elevated organics forming carcinogenic by-products	5	3	15	High
	CATCHMENT & INTAKE - WELL				
B, C	Sewage effluent, particularly nitrates, from systems which utilise on-site absorption pits	5	2	10	Moderate
B, C	Informal residential settlements without sewage treatment & disposal systems up gradient of groundwater resources	5	2	10	Moderate
	TREATMENT				
B	Under dosing of chlorine	4	4	16	High
C	Over dosing of chlorine	1	4	4	Low
C, P	Ineffective flocculation due to design limitations such as infrastructure and pH control	5	1	5	Moderate
	DISTRIBUTION SYSTEM				
B, C, P	Illegal connections to distribution system contributing to the high percentage of unaccounted for water	5	3	15	High
B, C, P	Low system pressure if one supply source is out of service	5	3	15	High
B, C, P	Check valves household - absent or ineffective	5	3	15	High

Table 1.13. *Controls and monitoring carried out in the WSP of Spanish Town (Jamaica) [40]*

Cause	Control measures	Priority	Responsible Agency	Time Frame	Monitoring
CATCHMENT & INTAKE - RIVER					
Informal residential settlements along canal prior to intake without sewage treatment & disposal systems	Implement an education campaign about sanitation, and prevent waste from reaching the canal	1	Health Department (Ministry of Health)	Start no later than March 2008	Central Health Committee, Water Quality Subcommittee will assess status in June 2008
	Upgraded WTP to effectively treat water with contaminants		NWC	4th quarter 2008	Water Quality Inspector (Health Department) checks on treatments monthly
Pre-chlorination of raw water with elevated organics forming carcinogenic by-products	Test treated water in the distribution system to determine the by-products formed and conduct a local risk assessment of the health implications of using chlorine	2	NWC	4th quarter 2008	Central Health Committee, Water Quality Subcommittee to assess status in December 2008
TREATMENT					
Under dosing of chlorine	New chlorination system designed for upgraded WTP	2	NWC	4th quarter 2008	Water Quality Inspector (Health Department) checks on treatments monthly
	Monitor residual chlorine throughout process		NWC	Ongoing	NWC T/P operator monitors Cl_2 residual levels hourly
DISTRIBUTION SYSTEM					
Illegal connections contributing to the high percentage of unaccounted for water	(1) Reduce pressure on distribution system supplying "Red Areas"; community outreach programmes (2) Enforce the law	2	NWC	Ongoing	Field operator monitors distribution system
Check valves household - absent or ineffective	Replace ineffective check valves and install missing; have sufficient uniformity within system to avoid large variety of different types of pumps in inventory	2	NWC	Ongoing	Water Production Manager and Field Operations personnel tracks percentage of households without or with defective check valves

Table 1.14. *Critical limits, corrective actions and verification programmes of some CCPs in the WSP [40]*

CCP	Critical Limits	Monitoring Procedures	Deviation Procedures	Verification Procedures	Records
Intake work	- 20 NTU Turbidity - pH 6.5-8.5	- Operator Guided by Standard Operating Procedures (SOPs) - Operator monitors pH and turbidity hourly	Shut down intake works when pH is trending towards the upper or lower limit and turbidity reaches limit	- Calibrate pH and turbidity meters monthly - Water Production Team Leader (WPTL) checks records weekly	- Hourly logs of pH and turbidity - Calibration records - Non-conformances and corrective actions - Records of Team Leader audits
	Chemical analysis of water	- NWC lab conducts twice per year full chemical analyses of raw water	Investigate source of chemicals and take necessary action to reduce or eliminate source	- Calibrate test equipment	- Water quality results - Calibration results
Pre-chlorination	2 mg/L residual on filter	- Operator Guided by SOPs - Operator checks every hour using chlorine comparator	- Manually adjust chlorine feed rate or water inflow rate	- Properly cleaned chlorine comparators - Check comparator against standard solution - WPTL checks records weekly	- Hourly logs of residual chlorine levels - Non-conformances and corrective actions - Calibration records - Log of chlorine feed rates
Alum dosing & mixing	- Dosed at 15-50 mg/L - Turbidity at < 1 NTU	- Operator Guided by SOPs - Operator doses within recommended range - Operator checks every hour turbidity	- Operator conducts system checks - Shut off booster pump and backwash filters - Manually adjust Alum feed rate or water inflow rate	- Calibrate turbidity meter in standard suspension - WPTL checks records weekly	- Logs of alum feed rates and turbidity readings - Non-conformances and corrective actions - Calibration records - Records of WPTL audits
Post-chlorination	- Total coliforms: 0 MPN/100 mL - *E. coli*: 0 MPN/100 mL	- Operator guided by SOPs check bacteria daily - Ministry of Health (MoH) checks distribution line at point of leaving the plant monthly	Activate early warning system	- Calibrate test equipment - National Public Health Lab conduct annual audit of labs doing water quality analysis	- Test equipment calibration records - Records of results - Results of lab audits - Non-conformances and corrective actions - MoH results

1.5.3 Case study 3: WSP developed in Bangladesh

In some low and middle-income countries (e.g. Bangladesh, India, Pakistan), a trend was to develop model WSPs for each technological option.

For instance, in Bangladesh, different WSP models have been developed for open dug wells, pond sand filters, deep tubewells, rainwater harvestings, small piped water systems from a tubewell or surface source, and small gravity piped system from a spring source [41]. These WSP models were elaborated by a team from the Arsenic Policy Support Unit (APSU) and the International Training Network Centre of the Bangladesh University of Engineering and Technology (ITN-BUET), in collaboration with the Environment and Population Research Centre (EPRC), the NGO Forum for Drinking Water Supply and Sanitation, the Dhaka Community Hospital (DCH), the Bangladesh Water Supply Program Project (BWSPP), and the DPHE-UNCIEF Arsenic Mitigation Project. Concerning these models, each one provided a general description of the supply system for which the Plan is expected, giving the opportunity to change the suggested structure case-by-case, based on the specific supply system. Each model was developed according to the structure described in the WHO Guidelines, starting from the definition of hazards up to the necessary corrective actions.

Tables 1.15 and 1.16 show part of a WSP related to a rainwater harvesting system [42].

Table 1.15. *Hazard risk assessment and related controls in the WSP developed in Bangladesh [42]*

Process Step	Hazardous Event	Hazard Type	Existing Control Measures	Risk	Additional Control Measures
Social exclusion	Poor members of community excluded from use of source because of income, gender to other social barriers	Social	Ensure that all members of the community involved in water supply development from start	Uncertain	Design of programmes and involvement of communities in water source development
Catchment	Rainfall insufficient	Quantity	Design based on expected rainfall, use of full roof catchment to collect water	Uncertain	Training of communities and households in water conservation
	Faecal contamination of roof from vermin and birds	Microbial	Regular cleaning of roof and gutter, at least before start of monsoon; remove all overhanging branches	Significant	Training of communities and households on roof catchment cleaning
	Leaching of chemicals from roof material	Zinc and lead	Selection of roofing sheets; age of sheet	Significant	Material specification
Rainwater tank	Contamination of tank from contaminated first flush	Microbial	First flush diversion system used to divert first rainwater away from tank	Significant	Installation of diversion system, training of households and communities in use of diversion system
	Rainwater collection tank becomes a breeding site for mosquitoes	Biological	Ensure vents have mosquito meshing in good condition	Significant	Ensure all vents have mesh in good condition
	Increased turbidity and biofilm development in tank due to poor cleaning	Turbidity and aesthetic quality	Tank to have an oval base inside and flushing outlet at the centre of the base of the tank; flushing outlet to have a cap	Significant	Training of households and communities in tank cleaning
Tap	Poorly maintained tap leads to leakage and wastage	Quantity	-	Significant	Ensure taps do not leak through use of proper materials in construction and regular maintenance; training of users in basic maintenance
Collection of water	Collected water becomes contaminated due to dirty container	Microbial	-	Significant	Vessel should be cleaned regularly with clean water and if possible soap; hygiene education in community
Transport of water	Water becomes contaminated during transport in an uncovered container	Microbial	-	Uncertain	Ensure vessel has a cover; hygiene education in community
Water stored at home	Water becomes contaminated from animals in home	Microbial	Water stored at elevated levels	Significant	Ensure vessel is covered at all times when water not being used; hygiene education in community
	Water becomes contaminated because users dip unclean fingers into the pot	Microbial	-	Significant	Use clean dipper or cup to withdraw water; tip water from container into drinking vessel; hygiene education in community
Use	Water contaminated before consumption because dirty drinking utensil used	Microbial	-	Significant	Use clean cup for drinking; hygiene education in community

***Table 1.16.** Monitoring and supporting programmes in the WSP developed in Bangladesh [42]*

Process Step	Performance Indicator	Monitoring		Critical Limit	Corrective Action		Supporting Programmes
Catchment	Roof catchment condition	What	Sanitary condition of the roof and guttering; proximity of branches to roof	No visible sign of dirt, leaves rust or algae on roof or in gutter; no branches close to roof or other sites for roosting or perching of birds	What	Clean roof and gutters, cut back branches	Maintenance and user education
		How	Sanitary inspection of the roof catchment and gutters		How	Clean roof with broom and clean water; cut back branches	
		When	Before monsoon and weekly intervals during monsoon		When	As soon as identified	
		Where	At the roof		Where	-	
		Who	Household or caretaker		Who	Household or caretaker	
Rainwater tank	Sanitary operation	What	Condition of the first flush diversion system	First foul flush diverter not blocked or damaged	What	Repair of diversion system and replace screen	Maintenance and user education
		How	Sanitary inspection		How	Replace joints or screen if damaged	
		When	Before monsoon, monthly during monsoon		When	As soon as identified	
		Where	At the tank		Where	-	
		Who	Household or caretaker		Who	Household or caretaker	
	Sanitary withdrawal system	What	Water withdrawal from tank	Single bucket used for collecting water	What	Sanitary withdrawal of water	Maintenance and user education
		How	Sanitary inspection		How	Install tap	
		When	On commissioning		When	Immediately	
		Where	At tank		Where	-	
		Who	Household or caretaker		Who	Household or caretaker	
	Protective maintenance	What	Prevention of mosquito breeding	No damage to mosquito mesh on vents	What	Repair damaged mesh on vents	Training of households and caretakers
		How	Sanitary inspection		How	Replacement of mesh	
		When	Monthly		When	Within 3 days	
		Where	Mesh of vents and inside the well		Where	-	
		Who	Household and caretaker		Who	Caretaker	
Tap	Condition of tap	What	Whether tap leaking or showing signs of wear	Tap does not leak	What	Repair or replace leaking tap	Training of caretakers and users
		How	Visual inspection		How	Replace with new tap using plumbers tape	
		When	Monthly		When	As soon as leaks notice	
		Where	Point of attachment to tank		Where	-	
		Who	User or caretaker		Who	User or caretaker	
Post source	Hygienic water use	What	Hygiene practice during collection, transport and storage	Water collection, transport and storage is hygienic	What	Key hygiene messages	Hygiene education materials and training of community hygiene promoters
		How	Hygiene inspection		How	Hygiene education	
		When	Regularly within community		When	Ongoing	
		Where	With households and in community		Where	-	
		Who	Community hygiene promoter		Who	Community hygiene promoter	

This example of WSP elaboration for a specific technology provided to be rather interesting. First of all, process steps where defined (highlighting the different steps of the supply chain), considering even the possible social exclusion of part of the community in the water supply. Amongst hazard types, traditional chemical and microbial hazards were considered, in addition to more specific dangers such as zinc and lead, turbidity and aesthetic, and unusual hazards such as quantity and social aspects. Conforming to the WHO proposed strategy, the definition of existing control measures and then the evaluation of risks was carried out. Regarding the contamination risk a simplified qualitative approach was used, evaluating only if the potential hazard was related to a significant or uncertain risk of contamination, thus without referring to the likelihood of occurrence and the severity of consequences. Additional control measures were always provided, independently on the presence of already existing measures. Sometimes these additional controls did not substantially differ from the existing ones.

Coming to the monitoring programme, performance indicators were immediately defined based on each process step rather than each hazard, then the monitoring was developed according to the WHO Guidelines, by means of the *what*, *how*, *when*, *where* and *who* principles. Generic critical limits (not easy to objectively evaluate) were then listed, accompanied by determined corrective actions that were defined through the *what*, *how*, *when* and *who* (without *where*) principles. As observed for the Kampala case study, corrective actions have been interpreted as restoration of control measures, without providing other interventions in order to effectively guarantee safe drinking water to consumers. Moreover, for each process step, a supporting programme was developed.

Even if not shown in Tables 1.15 and 1.16, a verification plan based on the *what*, *how*, *when*, *where* and *who* principles was elaborated, as well as a validation and an improvement plan.

1.5.4 Case study 4: WSP developed in India

Various agencies have been or are currently piloting the development of WSPs in the South Asia region [43]:

- In India, this includes UNICEF, WaterAid, and Action For Food Production (AFPRO) in rural areas, and WHO in urban centres.
- In Pakistan, the Pakistan Institute for Environment Development Action Research (PIEDAR) and Integrated Rural Support Program (IRSP) are working in rural areas in Punjab and Khyber-Pakhtunkhwa (KP), and the Earthquake Reconstruction and Rehabilitation Authority (ERRA) and UNICEF are supporting water quality management in emergencies and disasters (inclusive of water safety planning) in a number of areas such as Northern Areas and KP.

The work carried out by the Water and Sanitation Program in India has focused primarily on rural piped schemes, ranging from simple gravity-fed schemes for a group of houses to bulk supply for multivillage schemes. In India today, there is increasing demand for piped water supply as a result of both water scarcity and depletion of groundwater, and demand for higher levels of service. The work carried out for WSPs elaboration has been valuable in helping to set out what WSPs should look like at the scale of a single water supply system. The broader, institutional level, the assignment of roles and responsibilities for water quality management, the development of appropriate institutional incentives for stakeholders to undertake their assigned roles, and the critical role of individual and collective behaviour change are even considered. The Water and Sanitation Program in India has developed a simplified WSP framework to be used for the elaboration of WSPs in rural areas. This template should be used by the Village Water and Sanitation Committees for developing each own WSP. The approach proposed by the Water and Sanitation Program covers almost all the aspects proposed by WHO. After having analysed and listed all the possible hazards and related causes, an identification of the existing control measures has to be done. Then the framework requires verifying the level of risk (based on a semi-qualitative approach for which it is necessary to identify the likelihood of occurrence and the severity of consequences) and identifying further controls if necessary. For each control measure,

critical limits characterised by a target and an action level (as operational and critical limits provided by the WHO) should be determined. A monitoring programme has to be put in place according to the *what*, *when* and *who* (without *how* and *where*) principles, as well as the identification of corrective measures and a verification programme (characterised only by water quality analyses). Supporting programmes are characterised by community awareness campaigns based on proper water, sanitation and hygiene (WASH) practices carried out by local trainers, who have to be trained on these topics (within another supporting programme) by the National Institute of Rural Development.
The example of a WSP carried out locally by the Water and Sanitation Program is reported (in a simplified format) in Table 1.17.

Table 1.17. *Part of the WSP carried out in a rural area of India [43]*

Risk	Control measures	Who does it?	Who checks it is done?	Action if control fails	
				What to do?	Who does it?
HANDPUMPS					
- Livestock encroach on the well - Surface drainage getting into the well - Apron is muddy and poorly drained - Latrines are close to the well	- Fencing - Raise and repair the apron - Improve drainage - Ensure clean storage containers - Relocate latrines	- Handpump caretaker - Mechanic - Contractors	- Village Water and Sanitation Committees (VWSC) - Community	- Contact mechanic or contractor for maintenance and repair - Disinfect household water - Sampling and analysis	- Village Water and Sanitation Committees (VWSC)
SOURCE OF A PIPED WATER SUPPLY					
- Animal faeces - Garbage - Livestock effluents	- Fencing - Public awareness - Effluent pathway should be relocated	- Contract labourers - Barefoot Engineer and / or private fitter, community labour - VWSC with support from NGOs	- Regional Inspector with help from Barefoot Engineer and / or private fitter - VWSC - Community	- Clean up and repair - Disinfect household water using electro-chlorinator - H_2S vial test	- Barefoot Engineer and / or private fitter - VWSC - NGOs
DISTRIBUTION PIPELINE OF A PIPED WATER SUPPLY					
- Animal faeces - Garbage - Effluents - Poorly laid pipelines in public footpaths or drains - Leaking pipes	- Public awareness - Regular check up on pipes	- Barefoot Engineer and / or private fitter - VWSC with support of NGOs - Contractor	- Regional Inspector with help from Barefoot Engineer and / or private fitter - VWSC - Community	- Clean up - Disinfect household water using electro-chlorinator - H_2S vial test - Repair of leaking pipes	- Barefoot Engineer and / or private fitter - VWSC with support from NGOs - Contractor
HOUSEHOLD STORAGE AND PERSONAL HYGIENE					
- Unclean storage container - Absence of lid on storage container - No ladle to remove water - No hand washing with soap - Uncut nails	- Public awareness - Point-of-use treatment - Empower women groups to advocate personal hygiene	- VWSC - NGOs - Teachers - Health workers	- VWSC - Sanitary inspector	- Disinfect household water using electro-chlorinator - H_2S vial test	- VWSC - NGOs

1.5.5 Case study 5: WSP developed in Southern Sudan and Afghanistan

Concerning the elaboration of WSPs in rural areas of low and middle-income countries, an interesting approach to take into account is the one developed by the English NGO Tearfund [44], and already applied in different countries such as Southern Sudan and Afghanistan. Its approach is based on an extensive use of pictures and schematised sketches, becoming therefore extremely suitable for illiterate (or with a reduced level of schooling) communities. For example, the hazard identification is conducted by means of images representing the steps of the water supply chain, in order to involve communities to identify autonomously all the possible hazards (Fig. 1.5).

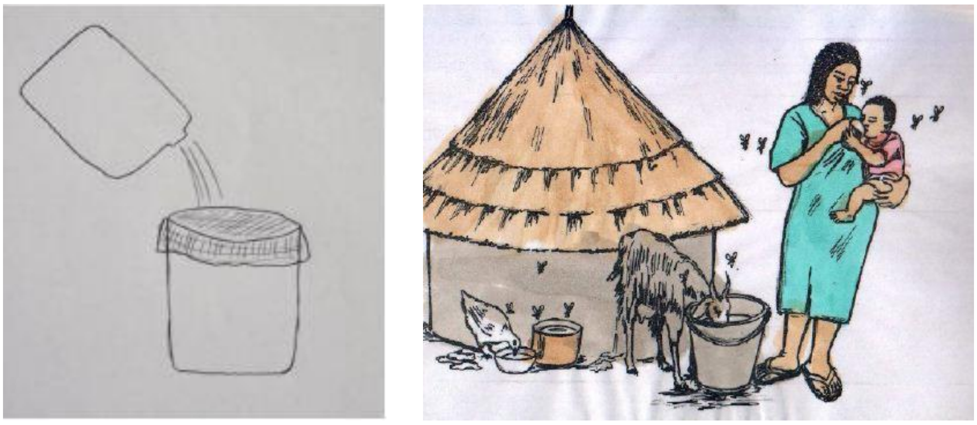

Fig. 1.5. *Sketch (on the left) and image (on the right) used for WSP elaboration in South Sudan [44]*

Through this approach, it is possible to drive the people themselves to develop their own WSP following a participatory mode. Moreover, to simplify the development of the WSP is proposed that the same person responsible for monitoring is even responsible for the implementation of corrective actions in cases of critical limits' exceeding. In order to simplify the WSP framework, the Tearfund approach did not consider the steps of verification and validation.

Table 1.18 reports part of the simplified WSP framework developed in Afghanistan by Tearfund in a rural community that counts some of 120 households.

Table 1.18. *Part of the WSP developed in Afghanistan [44]*

Hazard	Critical limits	Monitoring		Recommended further action
Dumping of children's faeces in streams	Any observed dumping of faeces in the stream	What	Raise awareness for women: stop dumping children's faeces in the stream	Elders have to be authorised by CDCs (Community Development Councils) to follow up and enforce this
		When	Friday congregational prayers and social gatherings; where there is a hygiene promotion session	
		Who	Mosque preachers; community health workers, water groups, government, NGOs	
Agricultural water overflows back to the stream (fertiliser may be washed into it)	Concentration of fertiliser waste in the stream water	What	Increase the depth of canals; control backflow or overflow from the field to the canals and then to the main stream	Use safe water source (borehole); CDCs have to discuss with the government to solve this problem
		When	Cultivation season	
		Who	Each farmer, community leaders	
Latrines close to the water source in the upstream villages	Observed location of latrines that continue to be used	What	Change the location of the latrines or construct sanitary latrine	Government enforcement should be there; CDCs need to advocate for the change
		When	Meeting is organised by the CDCs with the upstream community as soon as possible	
		Who	Village elders and CDCs	
Unsuitable pots for fetching and storage containers	Storage / consumption	What	Provision of suitable pots	-
		When	As soon as possible	
		Who	Heads of the households	
Lack of knowledge of proper water storage and consumption	Dirty or uncovered storage at point of use	What	Raising awareness of hygiene education in the community	Provision of storage containers and mugs
		When	Before or after cultivation season	
		Who	Water group members, community health workers, NGOs	

1.6 Conclusions

Water Safety Plans are an improved risk management tool designed to ensure the safety of drinking water through the use of a comprehensive risk assessment and risk management approach that encompasses all steps in water supply. The WSP approach has been developed to organise and systematise a long history of management practices applied to drinking water and to ensure the applicability of these practices to the management of drinking water quality. The main goal of WSPs is to identify and eliminate all the possible risks in the water supply system, from the catchment throughout the distribution network to the consumers' taps.

The following list aims at summarising the main advantages and disadvantages of the WSP approach:

+ WSP is a holistic approach to ensure safe drinking water from catchment to consumers.
+ Water supply system managers and operators will be able to understand their system and the risks that must be managed.
+ WSP enables operators identifying and controlling risks rather than just analysing them.
+ WSP fosters team work, planning, coordination and documentation.
+ WSP increases reliance on actual field sanitary inspection rather than relying just on water quality testing at laboratory.
- WSP requires technical expertise in the team which may not be available in all water supply systems particularly in rural areas.
- WSP requires additional training and capacity building initiatives.
- WSP may require huge capital investment for large water supply systems.
- WSP needs thorough and systematic monitoring, supervision and validation process which may be time consuming and tedious.

± Overall cost reduction in the management of the supply system can be obtained, above all due to lab analyses and maintenance decrease, but maybe after a relevant investment.

Finally, a fundamental aspect is that the WSP in itself has no value, without an appropriate and accurate implementation and without adequate people who implement it.

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Chapter 2. Water Safety Plan implementation in a rural area of Senegal

Abstract
In 2012, the G. Tovini Foundation (Brescia, Italy), together with the Universities of Brescia (Italy) and Dakar (Senegal), started a cooperation project in the Rural Community of Patar (Diourbel Region, Senegal). The aim of the project was to improve the living conditions of the village people by implementing the Water Safety Plan (WSP) approach, in order to prevent the drinking water contamination along the supply chain, from the catchment to the point of consumption. A first mission in the field has been conducted in July-August 2012, in order to carry out hazard assessment and risk characterisation of drinking water. Identified the main criticalities and source of pollution (strong lack of hygiene in handling drinking water; natural fluoride contamination at source level; managers of drinking water supply not aware of their key role and responsibilities, etc.), the Water Safety Plan approach has been developed in order to minimise / prevent the water contamination. The WSP team was set up involving managers of the drinking water supply, some local Authorities and representatives of the local population. The scheme adopted in the WSP approach had the same framework of the one proposed by the World Health Organisation, except for few elements.

2.1 Introduction

The most important aspect in improving people's health is to provide users with safe and clean water. It is estimated that 1.1 billion people worldwide still do not have access to safe potable water, and a large percentage of these people comes from developing countries, especially in the rural areas and low-income communities [1-4]. Consequently an estimated 5 million people lose their lives to water-related diseases each year [5, 6]. An important proportion of water-related diseases is directly linked to poor water quality, characterised by chemical or microbiological contamination (Table 2.1) [7].

Table 2.1. *Disease groups related to water quality [7]*

Group	Example of diseases
Water-borne diseases (caused by consumption of biologically contaminated drinking water)	Cholera Typhoid Infectious hepatitis Giardiasis, Amoebiasis
Water-based diseases	Schistosomiasis Dracunculiasis (Guinea worm)
Diseases caused by consumption of chemically contaminated drinking water	Fluorisis (fluoride) Skin cancer (arsenic) Lead poisoning

Lack of hygiene and sanitation is one of the main factors of diarrhoea's transmission routes. In fact, drinking water contaminated by human and animal faeces contributes significantly to diarrhoeal diseases (transmitted by pathogens in faeces via the faecal-oral route), one of the major causes of death in developing countries [8]. Bacterial pathogens in water, generally, tend to cause gastrointestinal infections: not only diarrhoea but even dysentery, typhoid shigellosis and human enteritis [3, 9, 10]. Another common cause of illness and death in developing countries related to unsafe water is cholera [11], caused by the pathogen bacteria *Vibrio cholerae*. Several other water and sanitation -related diseases are not considered in this scheme since are vector-borne diseases, such as malaria or Japanese encephalitis [12]. The World Health Organisation (WHO) estimated that improving water, sanitation and hygiene practices could prevent approximately the 9.1% of the global burden of disease and avoid the 6.3% of all deaths [13]. It is for all these reasons that, during the last two decades, the WHO, together with United Children's Fund (UNICEF), encouraged the improvement of drinking water sources to gain, in short-terms and with little investments, the health gaps associated with unsafe drinking water consumes [14]. Moreover, it has to be highlighted that there is widespread consensus that one of the past mistakes in tackling infectious diseases has been to give priority to water over sanitation and to sanitation over hygiene. In reality it is keeping faecal matter away from hands, food and water that it is possible to reduce the burden of infectious diseases [12].

Drinking water is not only exposed to microbiological contamination, but can contain also organic or inorganic chemical compounds [15]. However, chemical contamination of drinking water provides risks to a smaller global population, even if is a serious human health hazard for those affected [16]. The most common and dangerous chemical compounds characterising drinking water are arsenic and fluoride [17], which are geogenic compounds (both in developed as in developing countries).

In developing countries, point-of-use or household treatment technologies can be used to improve the drinking water quality in situations where there is not a central / community treatment plant or where the treated water supply system is compromised. The most appropriate technology depends on the situation, the quality of water, the availability of the required materials and equipment, the time frame in which it is to be used, the customs, preferences and education levels as well as cultural acceptance of the local population and the availability of personnel to provide the necessary training and monitoring for the technology to be successfully implemented [15]. The scientific international literature presents several studies on household water treatment and safe storage (HWTSS) [17-20], and most of them prove as simple and relatively cheap HWTSS methods can strongly improved the microbial quality of drinking water, thus reducing risks of illness and death [21-23]. In particular, treatment devices and safe storage technologies such as solar or chemical disinfection, filtration, distillation and reverse osmosis have been reported to decrease endemic diarrhoea caused by waterborne pathogens and to improve the microbial and chemical quality of drinking water [4, 14, 24].

In order to gain health gaps associated with unsafe drinking water consumption, the Water Safety Plan (WSP) approach seems to be the best solution. Indeed, the WSP methodology for ensuring the safety of drinking water from the point of catchment to the point of consumption is an approach based on the systematic preventive management and risk assessment. Its methodology is more comprehensive than conventional approaches to drinking water safety, addressing the whole water system with the goal of preventing contamination at each stage [25]. The objectives of a WSP are threefold: (1) to prevent or to minimise the contamination of source waters, (2) to reduce or to remove the contamination through treatment processes and (3) to prevent the contamination during storage, distribution and handling of drinking-water. The final aim is to protect public health through system assessment, operational monitoring and management plans, guided by health-based targets and overseen by surveillance [26].

Thus, WSP approach takes into account and wants to prevent (or to minimise) all the possible contaminations which the drinking water can be subjected to along the entire supply chain, from the catchment through the treatment, transport, storage and handling until the consumption.

In this second Chapter, the elaboration of a revised WSP approach carried out in a rural area of Senegal is presented. The case study is interesting and relevant for several reasons: the presence of microbiological and chemical contamination directly at the source level; the presence of different type of sources, managed by different authorities; the direct involvement of these authorities in the WSP elaboration; the WSP carried out in the study area has the same framework of the one proposed by WHO (and presented in Chapter 1), except for few elements; the population / community beneficiary of the WSP implementation is quite high (some of 15,000 inh).

2.2 The Senegal context

Senegal is ranked 154th out of 187 countries in the 2012 United Nations (UN) Human Development Index (HDI)[8]. Senegal's HDI value for 2012 was 0.470 (amongst the low human development category countries). Between 1980 and 2012, Senegal's HDI value increased from 0.322 to 0.470, a global increase of 46% or average annual increase of about 1.2%. Senegal's 2012 HDI of 0.470 is above the average of 0.466 for countries in the low human development group and slightly below the average of 0.475 for countries in sub-Saharan Africa. From sub-Saharan Africa, countries which are close to Senegal in 2012 HDI rank and population size are Rwanda and Burkina Faso, which have HDIs ranked 167 and 183 respectively [27].

According to the data published by the Joint Monitoring Program (JMP) of WHO and UNICEF, which reports progress on target 7c (concerning the sustainable access to safe drinking water and basic sanitation) of the Millennium Development Goals (MDGs), in 2011, Senegal did not meet yet the specific target concerning the access to safe drinking water, even if it is on track to meet it by 2015. Indeed, at national level, the proportion of population without sustainable access to safe drinking water was not already halved, since it decreased from the 40% of 1990 up to the 27% of 2011 (this means that 7% more of the population needs to be covered). In any case, more efforts are required to improve the access for rural population, which for the 41% has not access to improved sources (on the contrary, the urban population is estimated at 7%) [28], and since, globally, WHO has estimated about 15,000 deaths each year caused by diarrhoea only, owning to poor water, sanitation and hygiene [29].

Senegal began reforming its water supply and sanitation sector in 1996 and since then has made substantial improvements in coverage and sector organisation. Institutional reforms have improved the overall management of the sector in terms of quality of service delivery, efficiency of operations, and cost recovery. Indeed, the Senegal experience is regarded as a model of public-private partnership in sub-Saharan Africa and has been replicated in other African countries. Key attributes of the reform program included: ensuring autonomy of the management and a rational organisation of the sector; supporting improvements in commercial management and cost effectiveness; establishing a new rate policy for improving cost recovery; and reaching financial equilibrium of the urban water sub-sector. The urban water sector reached a financial equilibrium at the end of 2003 due to a gradual decrease in subsidies and a gradual increase in tariffs over several years. In 2005, Senegal developed a programmatic approach to coordinate water supply stakeholders and donor programs, called PEPAM (Millennium Water and Sanitation Program). PEPAM has been instrumental in setting Senegal's progressive policy and investment program. Whilst the urban water outlook is generally positive, further progress is needed in rural areas. The Management Reform Projects of Rural Boreholes (REGEFOR) has been successful in implementing an innovative management approach to water, creating the User Associations of Rural Boreholes (ASUFOR) for borehole management, and putting them under private management contracts. As part of the reform, the national water company SONES was created, and operations were contracted out to a private operating company SDE. In urban areas, the primary institutions involved with water include the Ministry of Agriculture and Water Resources and the Ministry of Economy and Finance; then, there are the Higher Water Council (including its Water Technical Committee), which sets policy, SONES, which holds the concession for urban water resources, and SDE that manages the urban water service. SONES, in particular, is responsible for managing sector assets, planning and financing investments, and for quality of service regulation. Concerning the rural areas, water is managed under the Water Directorate (DHY), which handles programming and implementation of new works, the Operation and Maintenance Directorate (DEM), which manages the operation and maintenance of motorized rural boreholes, and the Water Resources Management and Planning Directorate (DGPRE) that is responsible for water resources planning and water quality monitoring. Under reforms instituted by REGEFOR and using the ASUFOR model,

[8] The Human Development Index (HDI) is a summary measure for assessing long-term progress in three basic dimensions of human development: a long and healthy life, access to knowledge and a decent standard of living.

communities are pricing water by volume and contracting out maintenance of boreholes to the private sector. To ensure progress is maintained, borehole committee management requires training. Until March 2009, 178 ASUFORs had been created, including the training of masons, operators, primary school teachers and women.

During the last 20 years, Senegal has received significant support in the water supply sector under two notable multi-donor projects led by The World Bank's Water Sector Project and the Long-Term Water Project. In addition, France, Germany and Belgium have allocated funding to technical assistance under PEPAM [30].

The Italian NGO Fondazione Giuseppe Tovini (Brescia) developed two cooperation projects in a rural area of Senegal. The first one, titled "Support to training and management in the field of drinking water in the Diourbel region – Senegal", co-funded by Lombardy region (Italy) and CeTAmb (Research Centre on Appropriate Technologies for Environmental Management in Developing Countries, of the University of Brescia, Italy), was implemented between 2008 and 2009. The aim of that project was the design and diffusion of household bone char-based filters in order to reduce the fluoride content in the groundwater consumed by people. The second one, titled "Contribution to the improvement of drinking water quality in the Diourbel region – Senegal", co-funded by Fondazione della Comunità Bresciana (Italy) and CeTAmb, was implemented between 2012 and 2013. The aim of this project was the elaboration and implementation of a Water Safety Plan approach in order to prevent or at least minimise the drinking water contamination along the entire supply chain, from the catchment until the point of consumption.

The experimental research proposed in this paper was conducted during the second project carried out by Fondazione Giuseppe Tovini NGO in Senegal. In the following paragraphs the work done in the field and the WSP elaborated will be presented.

2.3 Materials and methods

The cooperation project, elaborated by Fondazione Giuseppe Tovini (FonTov) in Senegal, was carried out in the Rural Community of Patar (RCP), and in particular in Sambé and Dabel Bara villages, which were considered representative of the entire Community. The RCP is part of the District of Ndoulo, Region of Diourbel (Fig. 2.1).

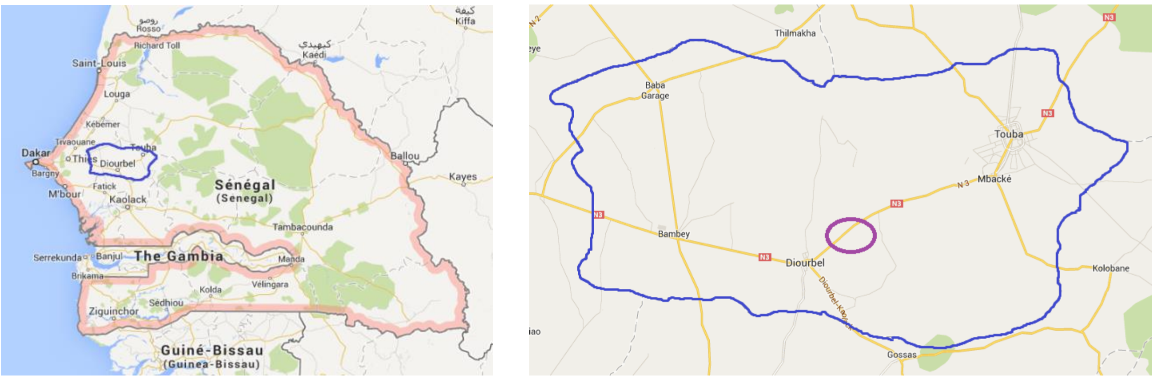


Fig. 2.1. *The Diourbel Region in Senegal (on the left) and the Rural Community of Patar in the Region (on the right)*

The Diourbel Region is divided into 3 Departments (Bambey, Diourbel and Mbacké), 8 Districts (Baba Garage, Lambaye and Ngoye in Bambey Dep.; Ndindy and Ndoulo in Diourbel Dep.; Kael, Ndame and Taif in Mbacké Dep.), 36 Rural Communities and 3 Municipalities. Globally, the Region has an estimated population of 1,315,202 inh and an area of 4,769 km². The population density is approximately 200 inh/km² and reaches a maximum of 323 inh/km² in Mbacké Department. The Region is populated by three main ethnic groups: Peulh, Wolof and Sérére (the more consistent one). Agriculture and livestock are the main activities of the population of the Region (more than 90%).

Agricultural production is primarily based on cereals (i.e.: millet, sorghum, corn, peanuts, etc.) and other products as sesame, cassava and watermelon. Livestock is consisting of cattle, goats, sheep, horse, donkey and poultry. Craft and trade are also important activities, owing to the geographical position of the area, midway between the major centre of production of agricultural and livestock resources and the major consumption centres of the Centre-West Senegal (Dakar, Thies and Kaolack) [31-33].

The Rural Community of Patar is divided into 52 villages, counting globally about 15,000 inhabitants. Amongst these villages, those of Sambé and Dabel Bara (about 4 km away) were chosen as the first one was involved in the previous project implemented by FonTov and people were already aware about good practices in manage and handling drinking water, whereas the second one was never involved in a cooperation project (not even by local Associations or NGOs), thus people were not made aware about good management practices.

In the RCP, there are 12 elementary schools and 1 middle / high school. However, the rate of education is still low (21%). The Rural Community has 5 Health Centres; the one of Patar village is the biggest and is equipped with a maternity ward. The main economic activity is agriculture, followed by farming and trade, as in the regional context.

The experimental activities carried out in this research were conducted during two missions in the field. The first one was done at the beginning of the project, between July and August 2012. The aim of this mission was to gather all the information required in order to develop an appropriate WSP for the local area. Despite the first project implemented in Sambé by FonTov had already provided to collect important information about the sources present in the area and the level of drinking water management, it has been necessary to carry out a specific mission in order to evaluate the entire context, as this second project aimed at implementing a WSP valid for all the RCP villages. It is for this reason that another village (Dabel Bara) has been involved in the research, in order to better assess the characteristics of the entire Rural Community.

The second and final mission was conducted at the end of the project, between February and March 2013, and was aimed at elaborating and developing the WSP. Unfortunately, the funds available from the project did not permit to carry out a third mission, which would have been extremely useful for verifying the level of drinking water management after the implementation of the WSP approach.

In the following sub-paragraphs, the detailed activities carried out in each field mission are proposed.

2.3.1 Pre-assessment

The aim of the first mission was to collect as much information as possible in order to carry out a proper hazard assessment and risk characterisation regarding the drinking water supply.

<u>Drinking water sources: identification and risk assessment</u>

The first activity was to <u>identify all the water sources' type</u> available and used by the population. Jointly with this, a sanitary survey of each water point was conducted according to the standardised forms suggested by WHO [34]. <u>Sanitary inspections</u> of water systems and resources are useful for identifying the potential risks of contamination in the long term and which interventions are eventually required. A sanitary inspection includes: hazard factors, which are the sources of faeces in the environment; pathway factors, which are factors that allow microbiological contamination to enter into the supply chain but that are not direct sources of contamination; and indirect factors that enhance the development of pathway factors, but do not directly allow contamination of the supply and are not a source of faeces. A sanitary inspection alone can provide a reasonable idea of the bacteriological quality of the water and its vulnerability to pollution, but it is always recommended to complement this information with water-quality analyses [7]. Indeed, <u>microbiological analyses</u>, through the determination of *Escherichia coli*, faecal coliforms, total coliforms and faecal streptococci, were conducted. The membrane filtration (MF) method was applied for microbiological analyses, in accordance with [34-36], by means of a TRAWAS laboratory (Sandberg and Schneidewind) consisting in a portable incubator, a membrane filtration system and a steriliser device. TRAWAS test kits for *E. coli*, faecal coliforms, total coliforms and faecal streptococci determination, based on Nutrient Pad Sterile (NPS) Membrane and dry nourishing (in sterile Petri dishes), were employed. The analyses were performed on-site, with field instrumentation (Fig. 2.2), brought from Italy.

Fig. 2.2. *TRAWAS laboratory installed in the field for microbiological analyses of drinking water*

Regarding the water sources, an intense campaign of physico-chemical analyses was conducted. The parameters evaluated were: temperature, pH, conductivity, turbidity, TDS, fluorides, chlorides, sodium, lead, ammonium, nitrates, nitrites and free chlorine. These analyses were also carried out by means of field instrumentation: multi-parameter Delta Ohm, model HD98569, was used for temperature, pH and conductivity determination; ionometer WTW, model pH/ION 340i, for fluorides concentration; photometer WTW, model PhotoflexTurb Set, for turbidity and all the other chemical parameters (Fig. 2.3).

Fig. 2.3. *Multi-parameter (on the left), ionometer WTW (in the middle) and photometer WTW (on the right)*

Another activity carried out during the first mission, concerning the water sources where a water Committee was established, was an interview (Annexe 1) of the own members, in order to understand the management level of the source (if there is in place a periodic water quality control, how is the financial management, what is the frequency with which meetings between members take place, which is the role and the duty of each member, etc.).

Transport and storage steps: identification and risk assessment

Investigated the management and the water quality of the sources, the analysis of the supply chain moved to the following steps. The first activity was to identify the supply chain, trying to understand how people were collecting, transporting and storing water. In order to gather all the necessary information, interviews with local families were carried out (Annexe 2). Thanks to the help of students of the University of Dakar, 45 questionnaires were collected amongst Sambé and Dabel Bara villages. These interviews had a dual purpose: on one hand to gather information related to drinking water

(which source and which container for transport and storage are used, frequency of cleaning of these containers, type of treatment carried out, etc.), and secondly to collect information on hygiene and sanitation (type of defecation, frequency of use and cleaning of latrines, hand-washing, etc.) and on health conditions (type of diseases contracted in recent months, frequency and level of access to the Health Centres, etc.). The elaboration of collected data was then carried out by means of the software Epi Info™ 3.5.1, which is a tool usually used by epidemiologists for elaborating and investigating health data. The particular and "friendly" layout of the software permits to well analyse data such as the ones collected by interviews.
The investigation of the water quality in the supply chain was provided by the conduction of microbiological analyses (*E. coli*, faecal coliforms, total coliforms and faecal streptococci). During the interview, twenty families were required to take samples of water from the transport and storage containers in order to conduct a quality analysis and thus evaluate the microbiological contamination. Analyses were performed on-site, as previously stated, with a field instrumentation (Fig. 2.2) brought from Italy.

Drinking water treatments: bone char-based filtration and chlorination
Since during the mission arose that the household bone char-based filters distributed during the first project implemented in the area by FonTov were no more in-operation, an investigation of the causes and a restoration of the filters took place. First of all, the business relation with the slaughterhouse was restored, in order to be able to furnish again the beneficiaries of the bones necessary for the filtration system. Secondly, the bone calcination and the crushing and sieving treatments for the bone char production were restored and supervised (Fig. 2.4). After the restoration of the bone char-based filters, a monitoring of water quality after the filtration treatment was carried out. The same four microbiological parameters were analysed on water samples after the filtration treatment, whereas, regarding the physico-chemical characteristics, only fluorides, chlorides, conductivity and pH were investigated (before and after the filtration treatment).

Fig. 2.4. *Bones selection (on the left) and calcination (on the right) carried out by the local technicians*

The last activity carried out in the field was the execution of batch analyses in order to identify the correct dosage of chlorine for the disinfection treatment. Using the chlorine solution available in loco, four different dosages of disinfectant were investigated in terms of pathogen removal and free residual chlorine concentrations.

2.3.2 WSP approach elaboration

The elaboration of the WSP approach to be implemented in the Rural Community of Patar was conducted according to the results obtained from the first mission in the field. The first activity carried out was the composition of the WSP team, responsible for the Plan elaboration. The managers of the different water sources, some representatives of the RCP population, the Responsible for the Patar Health Centre (RPHC) and some representatives of the Diourbel Hygiene Authority (DHA) were engaged. Despite the impossibility to involve important political authorities as the President of the RCP, owing to the election campaign who was developing in those months, and important technical institutions as the Water Directorate, because the person in charge of drinking water management was strongly occupied in several other activities, the involvement of local authorities was however guaranteed, thanks to the presence of RPHC and DHA.

A specific WSP was developed for the different drinking water sources (3 globally) available and used by the local people. Moreover, a WSP for the transport and storage steps was developed. The meetings of the team for the WSP elaboration were divided in 5 days: the first three days dedicated to examine all the possible contamination's risks, the related control measures and the monitoring and verification plans referred to the three different water sources; the fourth one to analyse the transport step; whereas, the fifth day had the aim to investigate the storage and consumption point. Table 2.2 shows the WSP steps, suggested by WHO, carried out and not in the elaboration of the WSPs for the Rural Community of Patar.

It has to be highlighted that the validation of control measures step was not provided since there were not control measures already in place at the time of WSP elaboration. For all the other specific details, see paragraph 2.5.

Table 2.2. *Steps carried out during the WSP elaboration*

WSP step	Provided
Assemble the WSP team	V
Describe the water supply system	V
Identify hazards and hazardous events and assess the risks	V
Determine and validate control measures, reassess and prioritize the risks	/
Develop, implement and maintain an improvement/upgrade plan	V
Define monitoring of the control measures	V
Verify the effectiveness of the WSP	V
Prepare management procedures	/
Develop supporting programmes	V
Plan and carry out periodic review of the WSP	V
Revise the WSP following an incident	/

2.4 Hazard assessment and risk characterisation

In this section the assessment carried out in the first mission in the field is presented. The identification and evaluation of the drinking water supply chain characterising the villages of Sambé and Dabel Bara are provided, focusing on the contamination hazards, drinking water management (by water Committees and users) and physico-chemical and microbiological quality analyses. Moreover results obtained by bone char-based filters monitoring and batch chlorination analyses are provided.

2.4.1 The drinking water sources

2.4.1.1 Identification

The survey carried out in Sambé and Dabel Bara villages permitted to identify three different water sources used by the population for drinking purposes:

1. Groundwater distribution system
2. Protected wells network
3. Open dug wells

The first one was identified in a pipe network (Fig. 2.5) that caught water from a confined aquifer 266 m in depth.

Fig. 2.5. *Confined aquifer's pipe network characterised by feed tanks (on the left), public taps (in the middle) and private taps (on the right)*

By means of a pumping system (powered by electrical energy, and in case of failure or lack of current through a diesel generator), water was stored into two feed tanks of 100 and 150 m^3 capacity respectively. A pipe distribution system about 38 km long reached 32 out of 52 villages of the Rural Community of Patar (Sambé included, but not Dabel Bara) and distributed water by means of 229 private taps, 97 public taps and other 13 scholastic taps. This first water source was managed by a water Association (ASUFOR) responsible for technical and economic management.

Another water source was represented by a small pipe network (Fig. 2.6) that caught water from an unconfined aquifer 36 m in depth.

Fig. 2.6. *Unconfined aquifer's pipe network characterised by protected caption wells (on the left), tanks (in the middle) and public taps (on the left)*

By means of a pumping system (powered by solar energy), water was extracted from four protected wells and stored into two feed tanks of 16 m^3 capacity. A pipe distribution system of few meters distributed water through 4 public taps (for drinking purposes) and 24 reservoirs used for irrigation purposes. Indeed, this type of water source was located only in the village of Sambé, inside the agricultural plot owned by an Association of local farmers and traders (GIE), also responsible for the management of this source.

The last and most common water point was represented by open dug wells (Fig. 2.7). The unconfined aquifer, which water was extracted from by means of ropes and buckets, was on average 30 m in depth. These sources were located in all the 52 villages of the Rural Community of Patar, in particular some of 10 in Sambé and only 2 in Dabel Bara.

Fig. 2.7. *Open dug wells of Sambé (on the left and in the middle) and Dabel Bara (on the right)*

2.4.1.2 Sanitary inspections

Jointly with the identification of the sources, a sanitary inspection was carried out in order to evaluate their vulnerability to pollution. According to the standardised forms provided by WHO [34], the groundwater distribution system, the protected wells network and four open dug wells (three located in Sambé and one in Dabel Bara) were investigated.

Table 2.3 shows aspects evaluated and related answers of the groundwater distribution system. This source provided a low risk of contamination, as expected, due only to two reasons: the improper fence around the installation, thus permitting animals or unauthorised people to enter into the perimeter of the pumping system and feed tanks, and the inadequate chlorination system, since no disinfectant was dosed into the pipe network for protecting water from a possible microbiological contamination during the distribution till the scholastic / public / private taps.

Table 2.3. *Sanitary inspection used for groundwater evaluation*

Questions	Yes / No
1. Is there a latrine or sewer within 15–20 m of the pump?	N
2. Is the nearest latrine a pit latrine that percolates to soil, i.e. unsewered?	N
3. Is there any other source of pollution (e.g. animal excreta, rubbish) within 10 m of the borehole?	N
4. Is there an uncapped well within 15–20 m of the borehole?	N
5. Is the drainage area around the pump faulty? Is it broken, permitting ponding to ground?	N
6. Is the fencing around the installation damaged in any way which would permit any unauthorised entry or allow animals access?	Y
7. Is the floor of the pump permeable to water?	N
8. Are extraction pipes unsanitary?	N
9. Is the chlorination functioning improperly?	Y
10. Are feed tanks unsanitary?	N
Total	2 / 10

Table 2.4 presents the form used for the protected wells network's sanitary inspection with related results. In this case the criticalities arisen were more, 7 out of 12, thus classifying with a high risk of contamination this kind of source. The only aspects that did not contribute to the risk of water pollution were the absence of latrines close to the pumping system, the structural integrity of extraction pipes and wells' parapet, and the proper seal of well's walls.

Table 2.4. *Sanitary inspection used for protected wells evaluation*

Questions	Yes / No
1. Is there a latrine or sewer within 15–20 m of the pump?	N
2. Is the nearest latrine a pit latrine that percolates to soil, i.e. unsewered?	N
3. Is there any other source of pollution (e.g. animal excreta, rubbish) within 10 m of the borehole?	Y
4. Is the drainage poor, causing stagnant water within 2 m of the pump?	Y
5. Is the extraction pipe loose at the point of attachment to the well so that water could enter the casing?	N
6. Is the wall (parapet) around the well inadequate, allowing water to enter the well?	N
7. Is the fencing around the installation damaged in any way which would permit any unauthorized entry or allow animals access?	Y
8. Is the concrete floor less than 1 m wide all around the well?	Y
9. Are the walls of the well inadequately sealed?	N
10. Is the cover of the well unsanitary?	Y
11. Is the chlorination functioning properly?	Y
12. Are feed tanks unsanitary?	Y
Total	7 / 12

Regarding inspections carried out on open dug wells, results are provided in Fig. 2.8. Distinctions amongst Sambé and Dabel Bara wells were not pointed out owing to the same results obtained.

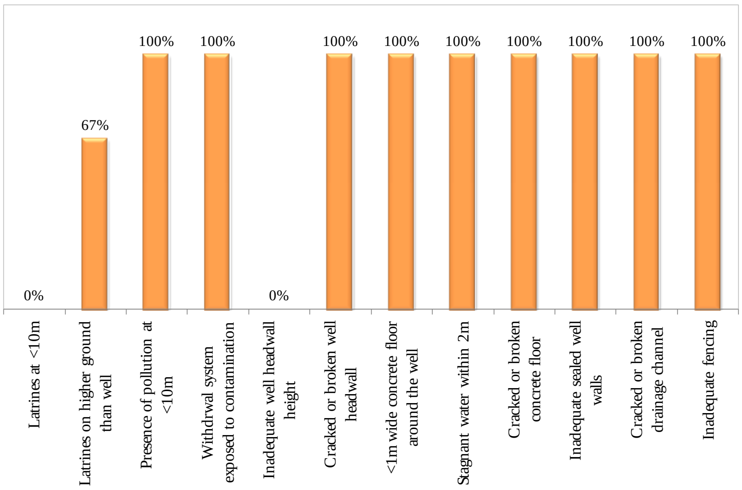


Fig. 2.8. *Results of the sanitary inspections carried out on open dug wells*

The investigations fulfilled on 3 wells located in Sambé and 1 in Dabel Bara demonstrated how many risks of contamination characterised these water sources, since about all the factors questioned during the inspections were positive. All the wells provided an extremely high risk of contamination, since all the three wells located in Sambé had 10 out of 12 hazard properties and the well in Dabel Bara was characterised by 9 out of 12.

2.4.1.3 Hazard evaluation

Most of the hazards were evaluated carrying out sanitary inspections, but site surveys permitted to highlight even other criticalities to take then into account during WSP elaboration.

Regarding the groundwater distribution system, two main criticalities were given from the valves (Fig. 2.9). The first one was related to the control valve located inside the pumping system and feed tanks installation, since it was connected with a rubber hose exposed to contamination. Moreover a drainage system to avoid stagnant water, when this valve was used, was not installed. The other hazard evaluated was concerning the presence of animals inside the pumping system and feed tanks installation, as well as close to public and private taps. Even if their presence did not contribute directly to possible water pollution, animals contributed to the presence of contamination vectors that could contaminate water during its withdrawal from taps.

Fig. 2.9. *Possible hazards for water contamination highlighted in the groundwater distribution system*

Hazards pointed out during site surveys at the protected wells network installation were related to the structural integrity of the well's cover that (as shown in Fig. 2.10) in one case was cracked and broken and in another was even open. Moreover, regarding this water source, valves of public taps were connected to rubber hoses exposed to contamination, thus contributing to possible water pollution.

Finally the presence of agricultural plots in the surroundings of the protected wells did not guarantee safe water, since pesticides and other chemicals were typically employed in cultivation practices.

Fig. 2.10. *Hazards due to the improper structural integrity of well's covers*

Regarding open dug wells (Fig. 2.11), the major sources of pollution were the inadequate structural protection of the well (absence of appropriate concrete aprons, drainage channels, covers, etc.), the improper integrity of parapets and walls, the improper hygiene conditions due to the exposition to contamination of buckets and ropes (withdrawal system), presence of stagnant water, rubbish, excreta and animals in the surroundings of the wells (sometimes rubbish were even found on the surface layer of water).

Fig. 2.11. *Hazards of contamination related to open dug wells*

2.4.1.4 Water quality analyses

At source level, water quality analyses covered both physico-chemical and microbiological parameters. Regarding the latter ones, *Escherichia coli*, faecal coliforms, total coliforms and faecal streptococci were investigated. Results present in the following section referred particularly on *E. coli* and faecal streptococci, which are the ones suggested by WHO and European Union (EU) guidelines for drinking water quality determination. Other results will be presented in section 2.4.2, focused on the supply chain (all data collected are reported in Annexe 3). Water samples were always collected in sterilise containers, stored in ice boxes and analysed within 4 hours from sampling.

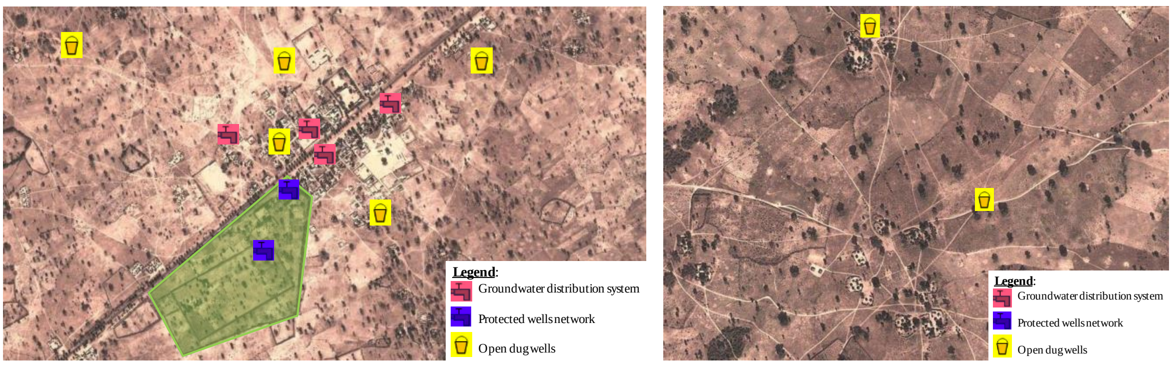


Fig. 2.12. *Sampling points of water sources in Sambé (on the left) and in Dabel Bara (on the right)*

Fig. 2.12 reports sampling points referred to the different sources available in loco, for the villages of Sambé and Dabel Bara. The green area highlighted in Sambé village corresponds to the agricultural plot owned by GIE. At each sampling point, a comprehensive characterisation of physico-chemical and microbiological parameters was carried out.

2.4.1.4.1 Physico-chemical parameters

For each of the physico-chemical parameters analysed, comparisons were carried out between mean values observed for each of the sources available in the villages of Sambé and Dabel Bara (groundwater distribution system, protected wells network and open dug wells). In each graph, the standard deviation has been reported.

Fig. 2.13 shows as only water caught from the groundwater distribution system provided concentrations of lead (<0.01 mg/L) under the limit set by WHO and EU guidelines (10 μg/L), whereas protected wells network and open dug wells were characterised by an average concentration (0.1 mg/L) of one order of magnitude more. This means that only the unconfined aquifer (where these two sources caught water) was contaminated by this pollutant.

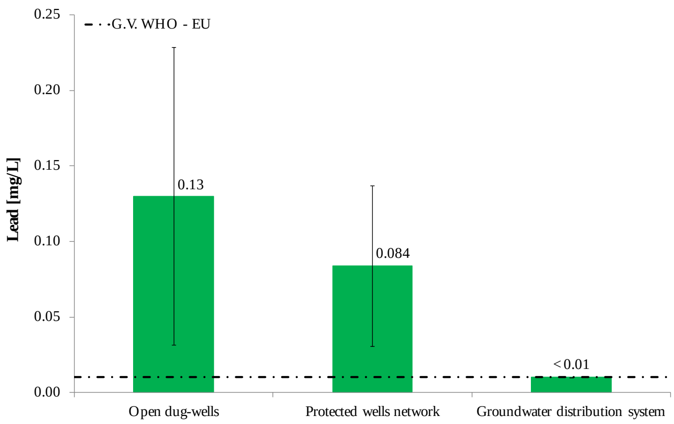


Fig. 2.13. *Average lead concentration in the different water sources*

These results were rather unexpected, since in the previous project implemented in the area, only few open dug wells provided a concentration of lead above the standard limit for drinking purposes and with values lower than the ones obtained in this assessment. The reason of this contamination was then investigated, and local Authorities and communities were promptly informed of the hazard. Information gathered with local partners and Authorities and site inspections conducted in the close city of Diourbel brought to suppose two possible causes of contamination: the first one was related to the presence of several underground storage tanks of leaded gasoline in the near city of Diourbel (above all in the suburbs toward the Community of Patar), which could release leaded gasoline if cracked or not well sealed, whereas the second one was referred to the presence (always in the close Diourbel) of uncontrolled deposits of abandoned vehicles that even in this case could release lead (above all through engines) into the soil and thus into the shallow aquifer.

Fluorides concentrations in the different water sources are provided in Fig. 2.14. As expected, extremely high values were obtained in water caught from the confined aquifer, where fluoride was naturally released by rocks. If protected wells network did not provide any value above the standard limit, fluorides concentrations varied widely in open dug wells. However, from this latter type of source, a seasonal variation has been highlighted comparing results provided from this assessment with values collected during previous monitoring campaigns. Indeed, in this case study analyses were carried out in the month of February, during the dry season, whereas the other data were collected in correspondence of the months of July (when rainy season was beginning) and November (when rainy season was just ended). Average fluorides concentrations obtained were respectively equal to 0.30 mg/L in November, 1.20 mg/L in July and 1.80 mg/L in February, clearly highlighting the dilution effect that rains practiced on fluorides.

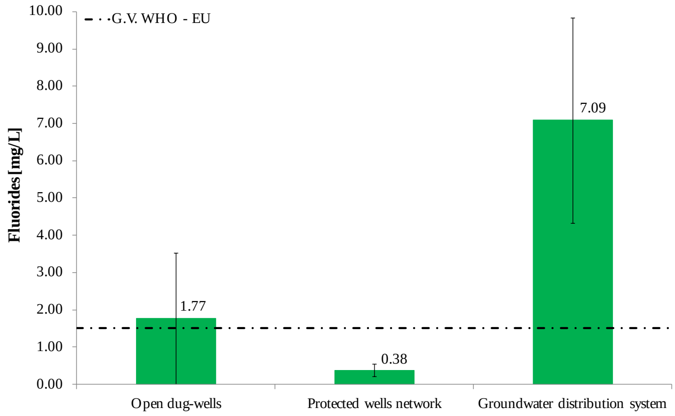


Fig. 2.14. *Average fluorides concentration in the different water sources*

Similarly for chlorides and sodium (Fig. 2.15 and Fig. 2.16 respectively), the source providing values always above the standard limits was the groundwater distribution system, owing to the natural release of these two elements from rocks. Conversely, protected wells network and open dug wells pointed out concentrations always lower than limit values. Variability was recorded for both parameters regarding unprotected wells, due to the higher concentrations measured at a well of Dabel Bara that drew water from an aquifer at an intermediate depth (about 70 m) between that of groundwater (266 m) and shallow aquifer (some of 30 m).

Even if chlorides and sodium did not represent a healthy hazard, they conferred a strong salty taste to water, bringing communities to prefer the other water sources (above all protected wells network) for drinking purposes.

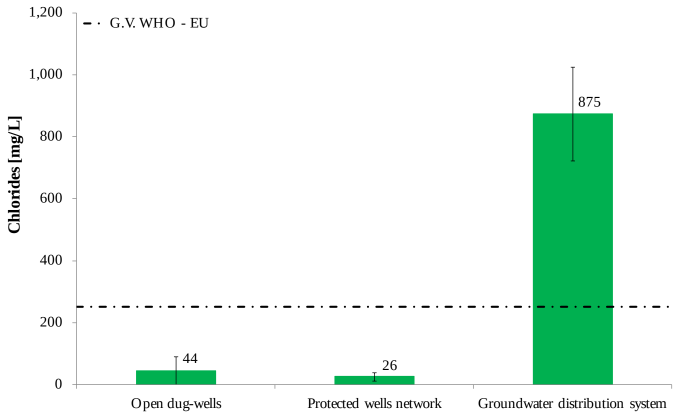


Fig. 2.15. *Average chlorides concentration in the different water sources*

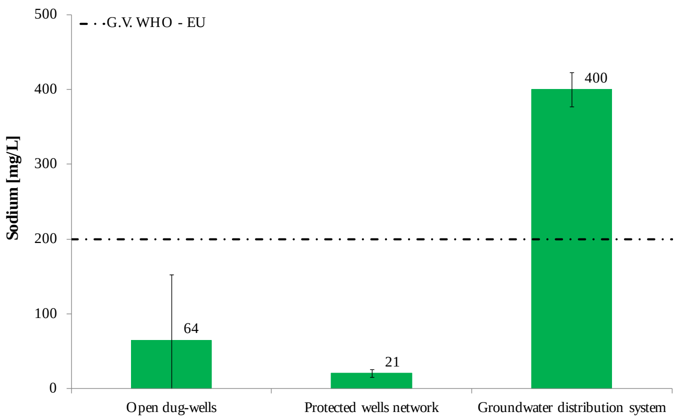


Fig. 2.16. *Average sodium concentration in the different water sources*

Analysing the nitrogen forms, such as ammonia, nitrates and nitrites (respectively shown in Fig. 2.17, Fig. 2.18 and Fig. 2.19), it is possible to notice how, for both protected wells and groundwater distribution system, concentrations were very low (for ammonia and nitrites) or equal to zero (for nitrates). Slightly higher concentrations were obtained considering open dug wells, even if still far from the standard limits set or suggested for drinking water (i.e.: 0.5 mg/L for nitrites and 50 mg/L for nitrates). Results highlighted as open dug wells were more vulnerable to this type of contamination, due to faecal vectors or chemicals used in agriculture (such as pesticides).

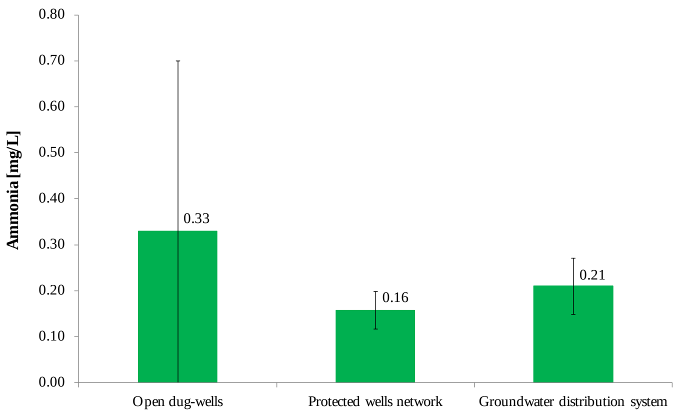


Fig. 2.17. *Average ammonia concentration in the different water sources*

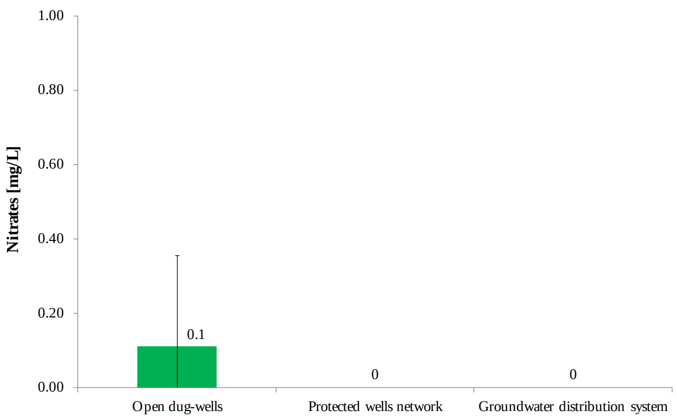


Fig. 2.18. *Average nitrates concentration in the different water sources*

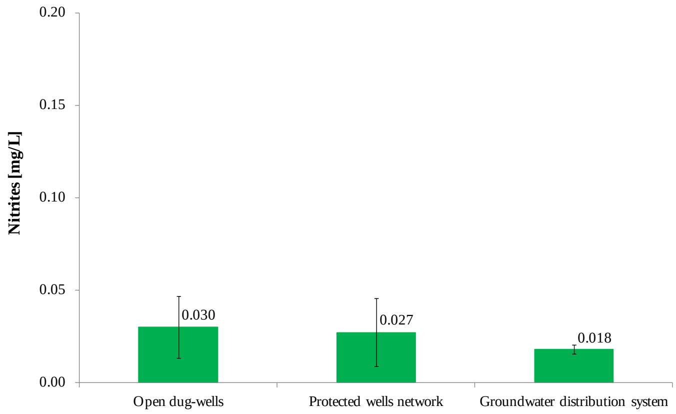


Fig. 2.19. *Average nitrites concentration in the different water sources*

<u>Free chlorine</u> was completely absent in unprotected wells, but present in trace in the other two sources (Fig. 2.20). This indicated that in protected wells network and groundwater distribution system, chlorination treatments have been carried out, probably in correspondence of repairs or feed tanks washing. The concentrations of free residual chlorine obtained from these analyses, however, were absolutely insufficient to ensure adequate and secure coverage from microbial contamination along the distribution network.

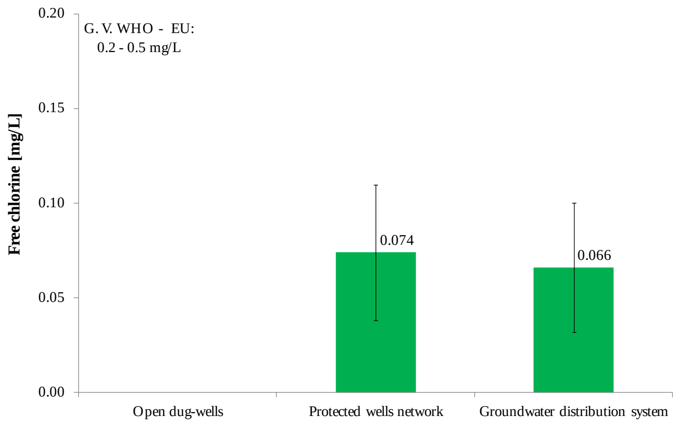


Fig. 2.20. *Average free chlorine concentration in the different water sources*

<u>Conductivity</u> provided values slightly above the limit set by WHO (2,500 μS/cm) for waters caught from the confined aquifer (Fig. 2.21), whilst much lower values were observed for the unprotected wells (891 μS/cm) and for the protected wells network (619 μS/cm).
Since electric current is transported by ions in solution, conductivity increases with the concentration of ions. Thus conductivity increases with the ionic species in solution, and this is the reason of the higher values obtained from the confined aquifer, being reach of ions such as fluorides, chlorides and sodium.
The different sources investigated provided rather constant values of <u>temperature</u> (Fig. 2.22) and <u>pH</u> (Fig. 2.23). This latter parameter was also maintained in the range of values suggested by WHO guidelines for drinking water quality.

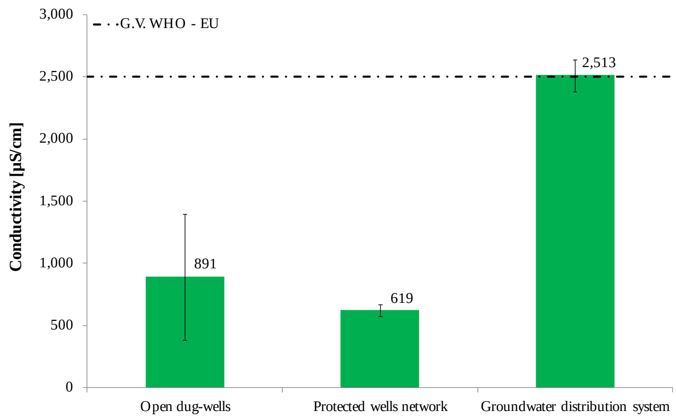


Fig. 2.21. *Average conductivity values in the different water sources*

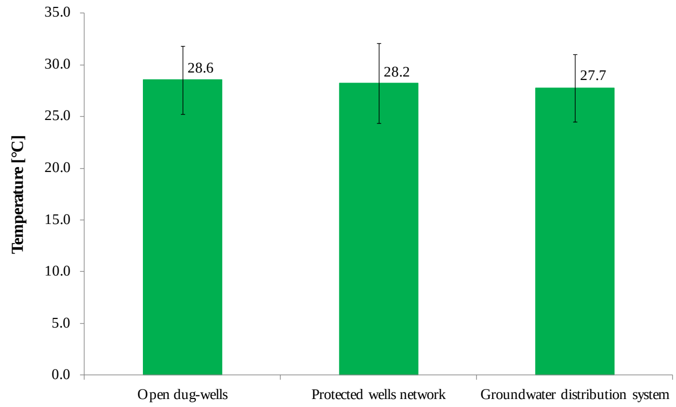


Fig. 2.22. *Average temperature values in the different water sources*

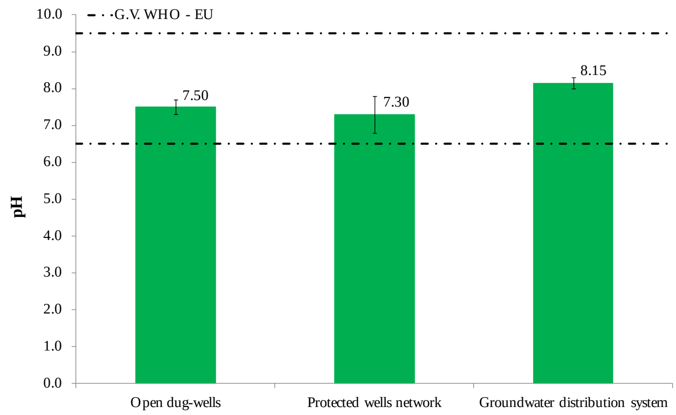


Fig. 2.23. *Average pH values in the different water sources*

Turbidity provided relevant values (on average 14.6 NTU, out of a limit of 5) only referring to open dug wells (Fig. 2.24). The reason of these high values could be the great number of dirty ropes and buckets come into contact with water, thus increasing the amount of solids inside the wells, or even the high exploitation of the wells sampled, owing to the recalling of a greater number of solid particles in suspension. The other two supply sources were instead always below the limit value.

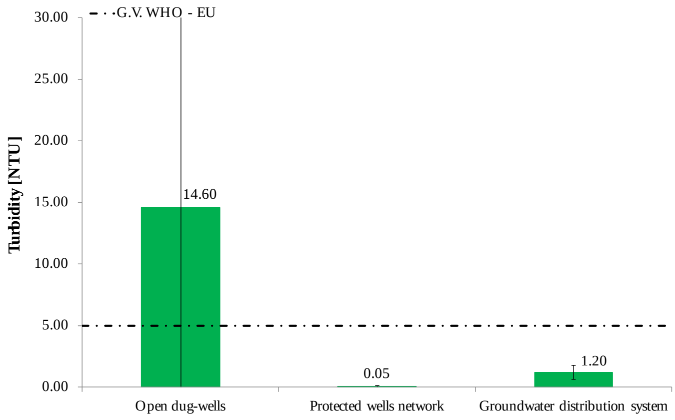


Fig. 2.24. *Average turbidity values in the different water sources*

<u>2.4.1.4.2 Microbiological parameters</u>

Regarding microbiological quality, the three sources available in loco showed a clear distinction (Fig. 2.25). All the four parameters investigated highlighted how water caught from the confined aquifer had the best microbial quality, as expected (the few faecal coliforms provided were probably due to a contamination of the sampling valves), whilst the worst one was identified in water from open dug wells. Even in this latter case results were quite expected, owing to the great number of hazards identified for this kind of source during the risk assessment. Regarding finally water distributed from the protected wells network, its quality was quite acceptable. The greater contamination in comparison with the groundwater distribution system was probably due to the worse hygiene conditions of public taps of this supply system. Generally, higher values of <u>faecal streptococci</u> were obtained compared to <u>*Escherichia coli*</u>, index of a more ancient contamination (all data collected are reported in Annexe 3).

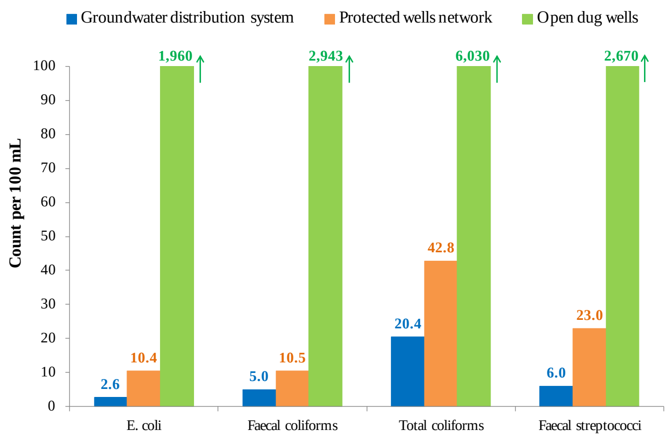


Fig. 2.25. *Microbiological contamination of the different water sources*

Results of microbiological analyses were compared with contamination risks provided by sanitary inspections (Fig. 2.26). A relationship of direct proportionality was clearly observed: higher the risk score, higher the microbial contamination. A slight anomaly was provided by the protected wells network, since a greater microbiological contamination was expected owing to the high risk score obtained during the sanitary inspection.

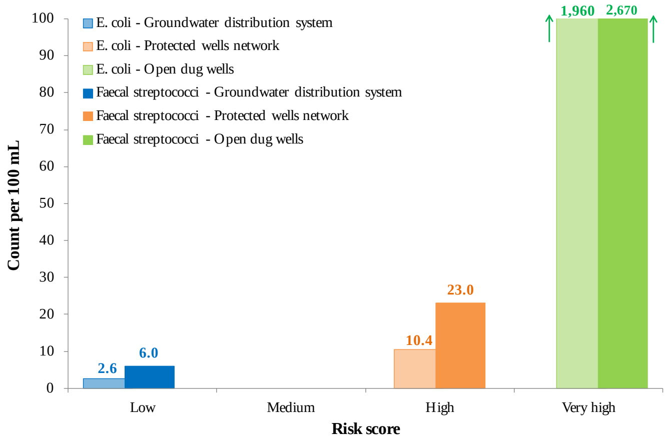


Fig. 2.26. *Comparison between contamination risk scores and microbiological quality of the different water sources*

2.4.1.5 Water points management

During the first mission, an interview of the members of the water point Committees was carried out in order to understand the management level of the sources. First of all, it has to be highlighted that only the groundwater distribution system and the protected wells network had in place a water Committee (respectively named ASUFOR and GIE), whereas open dug wells were not managed by an Association of users.

<u>The water Committee ASUFOR</u>

The pipe distribution network was based in the village of Patar and was realised by GTZ (German National Cooperation) during 80s, the reception was made on 1st May 1986 and the final commissioning in December 1986. At the beginning, the <u>water supply system</u> was characterized by two feed tanks and 3 km of pipes. In 2007, thanks to PARPEBA (Project for the Improvement and Strengthening of Water Points in the Groundnut Basin) project funded by Belgium National Cooperation, there was a rehabilitation of the network: the two tanks were rehabilitated (since one was completely out of service) and the length of the network was increased, with the construction of private and public taps. ASUFOR was set up as responsible for the drilling system and the pipe network. The <u>composition of ASUFOR Association</u> is: a Steering Committee of 78 people, 9 of which made up the Bureau and 1 person was the Manager. The 9 people composing the Bureau had the following roles:

- A President, who was responsible for and coordinates all the activities of the Committee;
- Two vice-Presidents, who were supporting the President in its activities;
- A Treasury, who was responsible for the economic management;
- An Assistant Treasury, who was supporting the Treasury activities;
- A Secretary-General, who had to report at each meeting of the Committee and was responsible for the relations with the users;
- An Assistant Secretary-General, who was supporting the Secretary-General activities;
- A Supervisor-General, who had to supervise the activities of the Committee; and
- An Assistant Supervisor-General, who was supporting the Supervisor-General.

A <u>key role</u> was played by the <u>Manager</u>, who was responsible for managing the drilling system and the pipe network. The importance of this role is nationally recognised, since to become manager of a pipe distribution system it is necessary to own official certificates of participation in courses on financial management and drinking water and hygiene issues.

Every 2 years, <u>elections</u> are carried out amongst RCP villages for the election of the 78 representatives. Last elections were made in 2007, between that date and 2012 there were 4 different Presidents.

Each month a <u>meeting between ASUFOR members</u> was carried out in order to:

- Take stock of financial resources: payments received by users (for the consumption of household and public taps' water) and expenses made (electricity for the pumping system, diesel for the generator, pumps' filters and oil, etc.);
- Present technical data on the pipe network: volume of water extracted and distributed, average monthly flow, repairs provided, etc.;
- Present general information: representatives who had direct contact with users reported any problem, request or advice; and
- Present and discuss the technical and financial report that the ASUFOR must submit monthly to the Regional Directorate of Water, to the President of the RCP and to the Sub-Prefect of the District.

The ASUFOR had a management register used for indicating the number of private, public and scholastic taps, number and names of people served by private taps, and users' payments. Indeed, monthly, the collection of money amongst users took place. Cost of water was 300 fCFA (some of 0.46 €) per m^3 consumed. After reading counters, ASUFOR issued an invoice for each tap and each user had about two weeks to pay. At the moment of the interview, ASUFOR had a bank account at the *Crédit Mutuel du Sénégal* with a total amount of money of 4,700,000 fCFA (some of 7,165 €), which according to the Treasury, was not enough for a proper management considering that in 6 months the average bill for electricity was 4 million fCFA (about 6,100 €) and for diesel generator 550 thousands (about 840 €).
Regarding drinking water quality control and management, ASUFOR did not provide periodic analysis owing to the lack of money availability. Conversely, to prevent microbiological quality deterioration during pipe distribution, twice per year a cleaning of the feed tanks and a chlorination treatment were carried out. Disinfection treatment was made with liquid bleach of 2.4% active chlorine (a bottle of 0.9 L cost 1,200 fCFA, about 1.83 €), dosing 8 bottles in the feed tank of 150 m^3 capacity and 6 bottles in the one of 100 m^3. Other treatments for fluorides, chlorides and sodium removal were not in place.

The water Committee GIE

The protected wells network was managed by GIE, which, as already stated, was an Association representing agricultural producers and shop managers of the Sambé village. The entire network (wells, feed tanks, pipes and taps) was built and started to be managed by GIE in 1994.
The composition of GIE Association is: a Steering Committee of 31 people (21 men and 10 women), 6 of which made up the Bureau, 3 are accounting Commissioners, 7 are part of the agricultural Committee and 15 of the trade and water delivery Committee. The 6 members of the Bureau had similar roles as the ones of ASUFOR: a President, a vice-President, a Treasury, an Assistant Treasury, a Secretary-General and an Assistant Secretary-General. Every two years a general meeting of the population of Sambé took place in order to elect GIE members. Last elections were carried out in 2011. Extraordinary meetings were organised if problems in GIE Committee arose, may deciding to substitute members. Meetings amongst GIE members took place about every two months, in order to take stock of financial resources. Other meetings were made only in case of problems or other urgent matters.
Regarding specifically drinking water, GIE had not a management register, taking notice of volumes of water delivered, average number of users per day, users' payments, etc.. Every time someone drew water from public taps, an amount of money must be paid. The price was fixed based on the volume of water drawn: 20 L (1 jerry can) cost 15 fCFA (some of 0.023 €), whereas 40 L (2 jerry cans) 25 fCFA (some of 0.061 €). Money was collected by people responsible of each public tap and was given to GIE during meetings that took place every two months, but management registers and counters were not provided, thus making difficult to control the volume of water distributed and verify the amount of money collected. At the moment of the interview, GIE had a bank account at the *Banque Agricole du Sénégal* with a total amount of money of 600,000 fCFA (some of 915 €), which according to the

Treasury, was not enough for a proper management considering that every 2 months the average bill for electricity was 700,000 fCFA (about 1,067 €).
Regarding drinking water quality control and management, GIE did not provide periodic analyses owing to the lack of money availability. Feed tanks were never cleaned or disinfected since their construction (they were made in reinforced concrete), and disinfection in the supply network was even never provided. Chlorine was dosed only in case of repairs.

2.4.2 The drinking water supply chain

After the evaluation of the three water sources, the focus moved on the supply chains, by means of their identification and hazard assessment, interviews to local people for understanding management and handling practices and drinking water quality analyses.

2.4.2.1 Identification

The identification of the drinking water supply chain consisted in identifying how local people transported, stored and consumed drinking water (which kind of container they were using for each step). Few differences amongst Sambé and Dabel Bara villages were provided, referred only to distances between households and water sources and to types of water point available. Figg. 2.27, 2.28 and 2.29 show the three different supply chains related to the three different water sources.

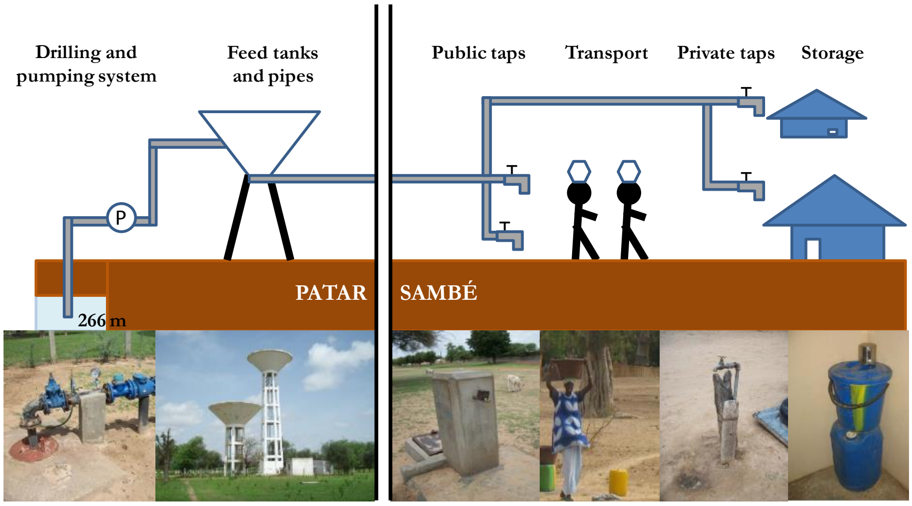


Fig. 2.27. *Drinking water supply chain related to groundwater distribution system as water point*

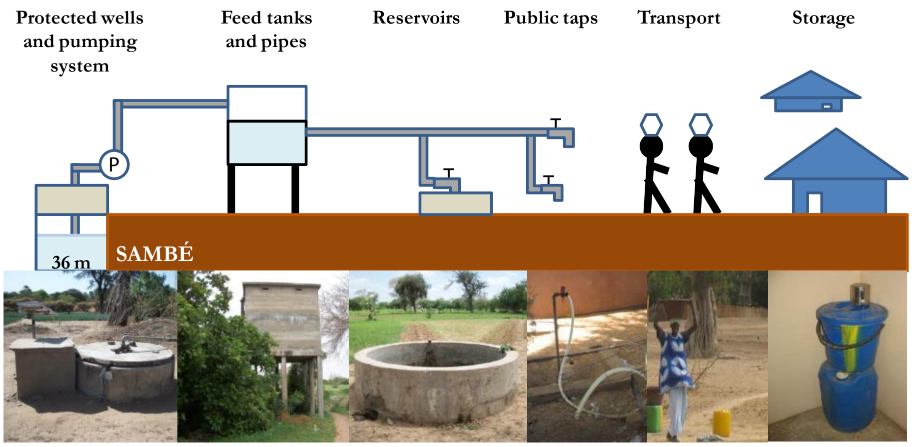


Fig. 2.28. *Drinking water supply chain related to protected wells network as water point*

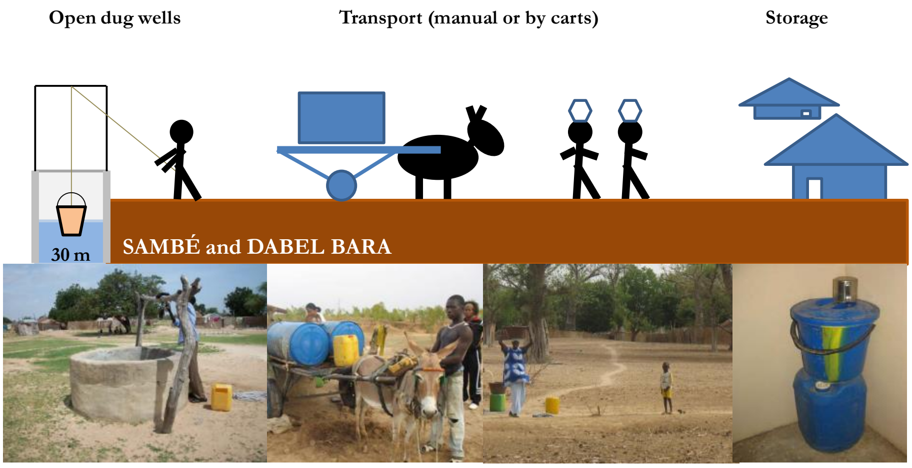


Fig. 2.29. *Drinking water supply chain related to open dug wells as water point*

Regarding transport step, people were used to carry home drinking water by means of plastic basins or jerry cans of, on average, 20 L capacity (Fig. 2.30). Plastic basins were rather always open / unprotected, loaded on head and transported on foot till home, whereas jerry cans were always closed / protected and loaded on head or bicycles or carts. The type of container did not depend on drinking water source, meaning that containers were indifferently used in each one of the three water supply chains.

Fig. 2.30. *Plastic basin (on the left) and jerry cans (on the right) used for drinking water transportation*

The only exception was highlighted in the village of Dabel Bara, where some families were used to go to Sambé by carts for catering water from the protected wells network. In these cases, plastic barrels of about 200 L capacity were employed (Fig. 2.31).

Fig. 2.31. *Plastic barrels used for drinking water transportation by some families of Dabel Bara*

Regarding storage step, families were used to store water in earthen jars, jerry cans, plastic barrels or plastic cans with valve (Fig. 2.32). These latter types of container were the ones spread during the first project implementation, for the fulfilment of bone char-based filtration. The main difference amongst them was the place and the way of storing: inside or outside home, with the container open or closed. Between the two villages, there were not differences in the use of the different containers, except for the plastic cans with valve that were not employed in Dabel Bara, since this village was not involved in the first project implemented in loco by FonTov.

Fig. 2.32. *Earthen jar (on the left), jerry cans (in the middle-left), plastic barrel (in the middle-right) and plastic can with valve (on the right) used for storing water at the dwelling*

Finally, regarding the consumption point of the supply chain, it was possible to notice that people were consuming water by means of plastic-cups (the most common ones) or aluminium-cups (Fig. 2.33). The only differences provided by the families were the place of storing of these containers: inside the storage tank, left on the ground close to the storage tank, on the lid of the tanks with the side to drink upwards or downwards (in this latter configuration, sometimes the drinking cup was also protected with a piece of tissue).

Fig. 2.33. *Plastic- and aluminium-cups used for drinking*

2.4.2.2 Hazard evaluation

Identifying the drinking water supply chain, some hazards already arose: plastic basins transported open, allowing contamination vectors (dust, sand, microbes, flies, etc.) to enter in contact with water; storage containers left open outside the home, and even in this case permitting the contact between pollution sources and water; and cups used for the consumption left on the ground or stored on the lid of the tanks without any protection. But carefully analysing all the possible other sources of pollution, it was clearly evident how the already identified ones represented only a part, since it has also to be considered:

- Buckets and ropes used for drawing water from open dug wells were dirty and rather always left on the ground in contact with contamination vectors;
- Rubber hoses attached to taps (of both protected wells network and groundwater distribution system) were usually characterised by an algal formation inside the hoses, due to the improper hygiene and cleanliness, and with the extremity used for filling transport containers left on the ground in contact with contamination vectors;
- Animals were easily in contact with water containers and, sometimes, had access to the basins or the jars for drinking (if left open without any surveillance);
- Rubbish were often present close to the storage containers and attracted flies and other insects (vectors of contamination) facilitating their contact with drinking water;

- Use of dirty hands, since people extracted water inserting hands (almost in all the cases not properly washed before) and the cups into the storage containers;
- Presence of algal formations inside the containers, owing to the improper or not frequent cleansing (as shown in Fig. 2.34 for jerry cans and earthen jars respectively).

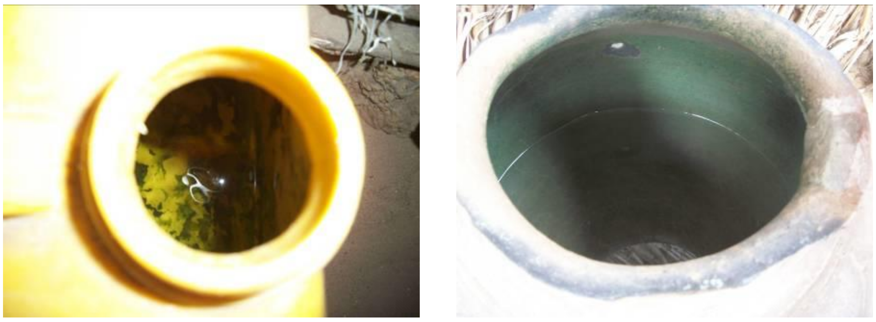


Fig. 2.34. *Algal formations inside the jerry cans (on the left) and the earthen jars (on the right)*

Generally, the village of Dabel Bara that was not involved in the first project implemented in loco by FonTov (as well as any another cooperation project) highlighted a worse situation compared to Sambé, regarding the possible hazards of drinking water contamination. Amongst the families of Sambé surveyed during this assessment, the ones directly involved into the first project implementation showed more proper hygiene and drinking water management practices compared to the others.

2.4.2.3 Drinking water management practices

Interviewing the families of Sambé and Dabel Bara villages, it has been possible to gather important information about the local drinking water management practices. 30 out of 45 interviews were developed in Sambé (the biggest village), whereas the remaining 15 in Dabel Bara.

Regarding first of all water consumption, it has been highlighted that, at Sambé, amongst people interviewed, 22 families collected water at the protected wells network, 22 at the private taps and 9 at the public ones of the groundwater distribution system, 12 at open dug wells and 13 used rain water. At Dabel Bara, 13 families collected water at open dug wells, 9 went till Sambé at the protected wells network and 5 used rain water. For drinking purposes, at Sambé, 22 families used water drawn from protected wells network, 12 from open dug wells and, when available, 1 family used to drink rain water. Regarding Dabel Bara, 9 families drank water caught from open dug wells, 6 from protected wells network and, when feasible, 1 family used rain water.

The average distance between households and water points was evaluated in 16 minutes walking. Detailed distances between water points and households per each village are proposed in Table 2.5.

Table 2.5. *Distances between water points and households in Sambé and Dabel Bara villages*

Water point	Sambé (min)	Dabel Bara (min)
Private taps of drilling water	1.0	-
Public taps of drilling water	6.5	-
Protected wells network	9.7	61.0
Open dug wells	10.4	20.5
AVERAGE	6.4	44.5

The average distance between the sources in both villages resulted statistically significant ($p=10^{-12}$). Then, even the single ones related to protected wells network and open dug wells were statistically significant (respectively $p=0.0023$ and $p=0.013$), thus not due to chance, but proving the greater distance between households and sources in the two villages. These results are in line with the different water sources' distribution between the villages, as clearly shown in Fig. 2.12, and considering that the two villages are about 4 km far. Analyzing the supply frequency, its average was equal to 1.3 times per

day. Even in this case, differentiating between the villages, it has been obtained that, at Sambé, people went on average 1.4 times per day, whereas at Dabel Bara 0.96 times.
Processing data collected from the interviews, it was also possible to estimate the amount of water available for drinking purposes per capita (based on the number of containers collected and their capacity). Results showed that, on average, 59.44 L per family were available daily exclusively for drinking, which means about 4.41 L daily per person.
Focusing on drinking water management practices, elaborated for both villages together, results showed that to transport water in 26 cases was used a jerry can, in 15 a plastic barrel whilst in 19 a plastic basin (global amount of tanks is over the total number of families interviewed because someone of them used both the types). Most of the jerry cans and barrels were always closed during transport (95.1%), whilst the basins were generally left open (94.7%). Table 2.6 reports the different transport containers used in the different villages.

Table 2.6. *Transport containers employed in the villages surveyed*

Water point	Sambé	Dabel Bara
Jerry cans	17	9
Plastic barrels	1	14
Plastic basins	19	0

On average, jerry cans were cleaned 0.9 times per day, plastic barrels 0.77, whereas basins 1.38 times. Analysing the cleaning frequency of jerry cans in Sambé and Dabel Bara, results highlighted a statistical significance ($p=0.0058$) since in Sambé the cleanliness was conducted 1.06 times per day, whilst in Dabel Bara 0.58 times. Moreover, amongst the people of Sambé, a statistical significance ($p=0.0093$) arose between families that had followed awareness campaigns and were directly involved into the first project implementation and families that did not participate. Indeed the first category carried out the cleanliness of transport containers 3.5 times per day whereas the second 1.1.
On average, the cleansing of the containers was carried out by means of chlorine jointly with soap in 30 cases, only chlorine in 3 cases, only soap in 25 and only water in 4 cases.
Moved to the storage tanks, results highlighted that 13 families used jerry cans, 40 barrels, 19 plastic cans with valve and 17 an earthen jar. Table 2.7 reports the different storage containers used in the different villages.

Table 2.7. *Storage containers employed in the villages surveyed*

Water point	Sambé	Dabel Bara
Jerry cans	10	3
Plastic barrels	25	15
Plastic cans with valve	19	0
Earthen jars	14	3

During the survey, it was possible to notice how all the cans with valve, the jerry cans and the jars were closed, whilst 27 out of 40 barrels were open. On average, the cleansing of these containers was carried out 1.1 times per day and water was stored for 1.2 days. A statistical significance ($p=0.0016$) was provided in the different storage time between Sambé (0.98 days) and Dabel Bara (1.68 days), clearly showing how much water sources' distance in Dabel Bara influenced the water storage. Regarding the way of cleaning, in 61 cases families said to use chlorine, in 71 soap (only in 2 families of Sambé soap was not found in the house at the moment of the interview) and in 9 only water. Fig. 2.35 shows the use of the different storage tanks identified in the interviewed families.
Water collection was mainly a duty of women (53%), followed by girls (31%) and guys (10%); 18% of interviewed people (all coming from the village of Dabel Bara) declared that water collection was carried out by all the family's components, highlighting major difficulties in water provision.

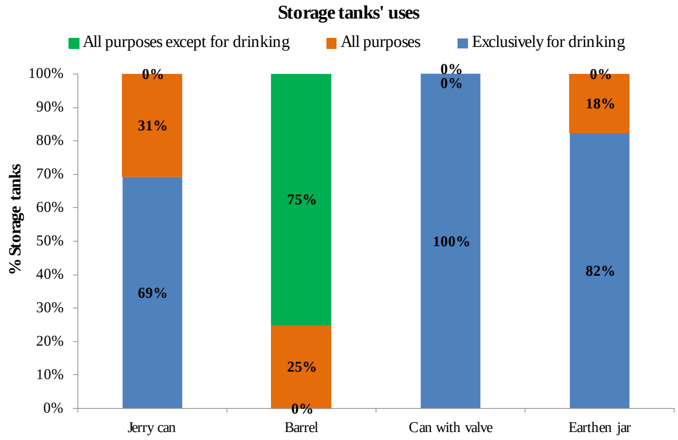


Fig. 2.35. *Final purpose of the different storage tanks*

On average, time dedicated to collect water necessary for the family's daily needs (defined as the time to go to the water point, fill the transport containers and return water at the household, within a day) was 96.6 minutes. In the village of Sambé, on average, 69.3 minutes were used to collect water, whilst at Dabel Bara some of 161.5 minutes were necessary. A statistical significance was provided for this difference ($p=10^{-6}$), thus not due to a chance, but really present in loco, highlighting again the difficulties on water supply for the inhabitants of Dabel Bara.
Concerning water treatment, results showed as 11 families out of 45 did not carry out any disinfection treatment. Amongst the others, 20 made disinfection with chlorine, 22 filtration on tissue and 5 sedimentation. Interviewed from Sambé declared most to make a water treatment: 16 families treated water with chlorine, 16 made a filtration on tissue, 5 a sedimentation and only 6 out of 30 did not carry out any treatment. Regarding Dabel Bara, 4 disinfected with chlorine, 6 filtrated with a piece of tissue and 5 (out of 15) admitted to not carry out any treatment.
At the end of the interview, two main aspects were investigated directly by the interviewer: the place where drinking water and the cup used for drinking were stored. Water was stored outside the dwelling and accessible to every potential source of pollution in 7 cases, in 6 was outside the house but covered with a lid, in 2 was inside the house but in potential contact with contaminants and in 30 cases was inside the house and protected. Regarding the cup used for drinking, in 2 cases was left inside the storage tank, in 5 deposited on the lid with the side to drink upwards, in 16 with the side to drink upside down, whilst in 21 cases has not been seen around the storage tank. In none of the cases, however, cups were not found left on the ground. Differences amongst Sambé and Dabel Bara villages were not highlighted for these issues.
Finally, a variable called "attitude" was created in order to define the level of good practices in water management. A score of 0, 0.25, 0.50, 0.75 or 1 was assigned to the possible answers to questions related to water management (frequency and type of cleansing of the transport and storage tanks, residence time of the stored water, place of storage of drinking water and cup used for drinking). The suitability to the responses has been identified taking into account both the international guidelines on good practices and the real possibilities of implementing them in this specific context. Then, 4 categories of the level of "attitude", on the basis of scores obtained, were also fixed: extremely poor, poor, adequate and good. The average score obtained from the 45 households surveyed was equal to 7.8 that corresponds to a level of attitude adequate (Table 2.8).

Table 2.8. *Categories of attitude to the good practices in drinking water management*

Attitudes	Categories	Households
Extremely poor	0 - 2	0
Poor	2 - 4	3
Adequate	4 - 8	26
Good	> 8	16

The average level of "attitude" of interviewed from Sambé was good and precisely equal to 8.3, whilst families from Dabel Bara have achieved on average an adequate level (equal to 6.6). This difference between levels of "attitude" was statistically significant (p=0.0023), suggesting that awareness campaigns carried out during the previous project, on good water management practices, determined the difference in the level of "attitude" between the two villages.
Concerning questions related to hygiene and health conditions, some important aspects arose related to drinking water quality and management.
Investigating which detergent was used for washing hands, all the 45 families surveyed indicated the soap (in the 93% of those, soap was really present at home during the interview) and 20 families declared to use even chlorine. Circumstances in which detergents were used are proposed in Table 2.9.

Table 2.9. *Different uses of detergents and the observed/declared ratios*

Situation	Declared	Real presence of detergent at home	Observed/declared ratio
Before eating	37	34	92%
After eating	5	5	100%
After defecation	29	26	90%
Washing tanks	5	5	100%
After works	6	5	83%
Before cooking	3	3	100%
After waking	3	3	100%
When hands are dirty	1	1	100%

Regarding health conditions, questions on the number of diarrhoea cases in the family in the last few months, actions to be taken in case of diarrhoea, causes of diarrhoea, methods to avoid diarrhoea and signs of severe diarrhoea were asked to people interviewed. The elaboration of these answers provided that 60% of interviewed families had a good knowledge about the diarrhoea disease, whilst the remaining 40% an adequate level of consciousness.

2.4.2.4 Water quality analyses

Drinking water quality analyses in the supply chain were carried out evaluating the four microbiological parameters already investigated at source level (*Escherichia coli*, faecal coliforms, total coliforms and faecal streptococci). Samples were collected from transport (when possible) and storage containers of 20 households, put in sterilise containers, stored in ice boxes and analysed within 4 hours from sampling. Samples from transport tanks were taken directly from the containers, whereas, regarding storage tanks, cups for drinking were employed for sampling, in order to evaluate the microbiological contamination of the water effectively drunk by the population (so to not lead to an underestimation).
The sources taken into consideration were only protected wells network and open dug wells, since (as already stated in the previous paragraph) none of the families surveyed used water coming from the groundwater distribution system for drinking purposes, owing to its salty taste.

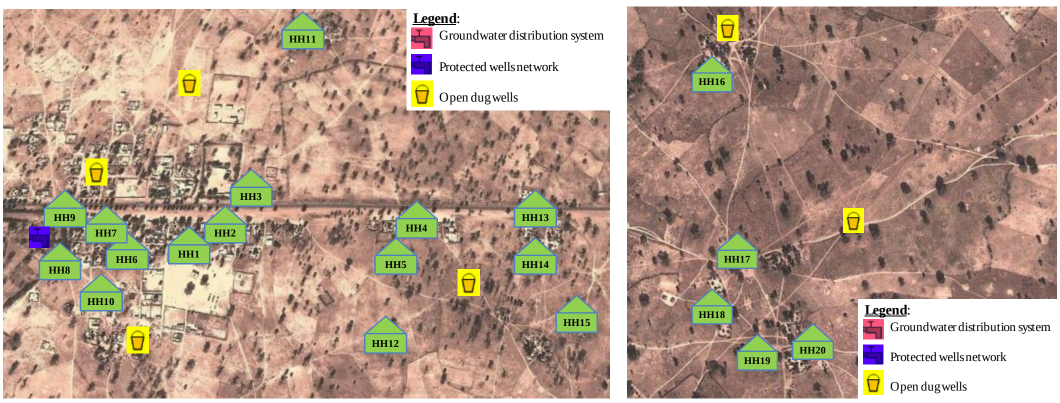


Fig. 2.36. *Households surveyed and water's sampled, jointly with related water points, in Sambé (on the left) and Dabel Bara (on the right)*

Fig. 2.36 shows the location in the villages of Sambé and Dabel Bara of the households where an interview was carried out jointly with the sampling of specimens from transport and storage containers for the microbial quality determination of drinking water, and related water points.
Half of the households where water samples were collected used to catch drinking water at public taps of the protected wells network, whilst the other half at open dug wells. From this latter "category" of families, drinking water samples were collected only in storage containers, since transport tanks where always found empty at the moment of the survey. For this reason, the supply chain deeply analysed was the one characterised by protected wells network as water source. However, in order to evaluate even the microbiological quality of water sampled in households that used to catch water at open dug wells, a comparison of microbial quality at storage level, between the two different supply chains highlighted, was carried out. Fig. 2.37 pointed out the difference on colonies for the four parameters investigated. Results clearly highlighted the major microbiological contamination in water samples related to open dug wells as source, for all the four parameters investigated. Relevant differences were provided above all regarding *E. coli* and faecal coliforms. The worst microbiological quality of open dug wells reported previously was the cause of these results (all data are reported in Annexe 3).
Carefully analysing data obtained at source and storage level (referred to open dug wells), it was possible to highlight a decrease of microbial contamination rather consistent (about 1 order of magnitude). This reduction may be due, on one hand, to the sedimentation of bacteria adhering to solid particles [37] and, on the other, to an endogenous decay owing to the exposure to solar radiations and to the consequent increase of the water temperature [38]. High values of turbidity obtained, on average, for these water sources (some of 15 NTU) and high temperatures characterising the season when investigations in the field where carried out strengthen this hypothesis.

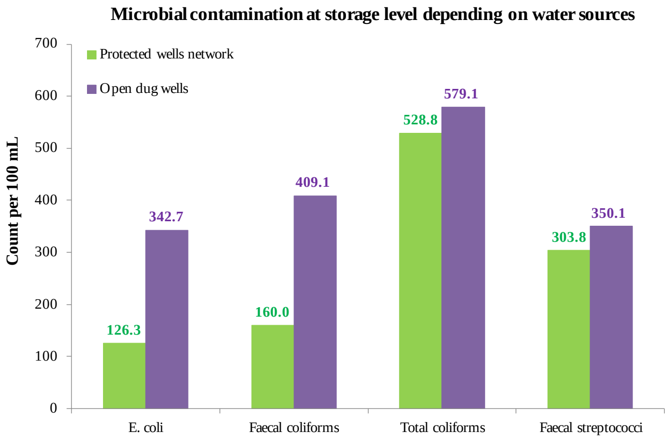


Fig. 2.37. *Microbiological quality at storage level of the two different supply chains highlighted in the villages*

Focusing on the supply chain characterised by protected wells network as drinking water source, a trend of microbiological contamination's increase along the entire supply chain (from source, through transport to storage) was highlighted for all the parameters investigated, as shown in Fig. 2.38. The worst result was obtained from total coliforms, which were present on average with 530 CFU/100mL and with a peak that reached 1,500 colonies. Amongst *E. coli* and faecal streptococci, the latter ones were increasing the most along the supply chain reaching an average value of 300 CFU/100mL. This was probably due to the improper cleaning of the containers that permitted the growth of algal formations, favouring bacterial pathogens' increase [39]. However, even *E. coli* contamination cannot be ignored since it reached an average concentration of about 130 colonies.

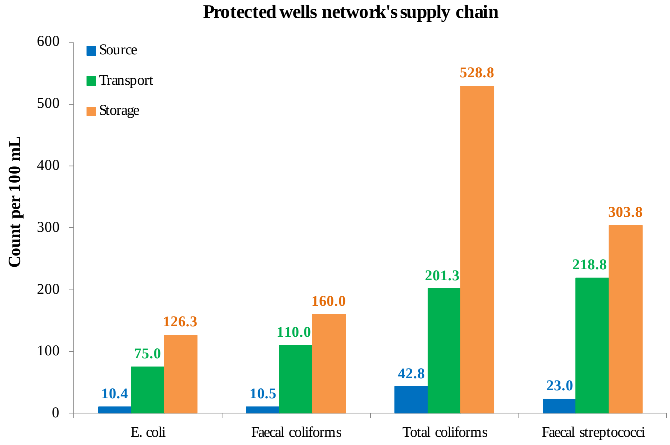


Fig. 2.38. *Microbiological quality along the protected wells network's supply chain*

Since interviews highlighted that some of 45% households made a chlorination treatment at storage level for water disinfection, a distinction on microbiological quality amongst families that made and did not make water disinfection was carried out. Results are reported in Fig. 2.39.

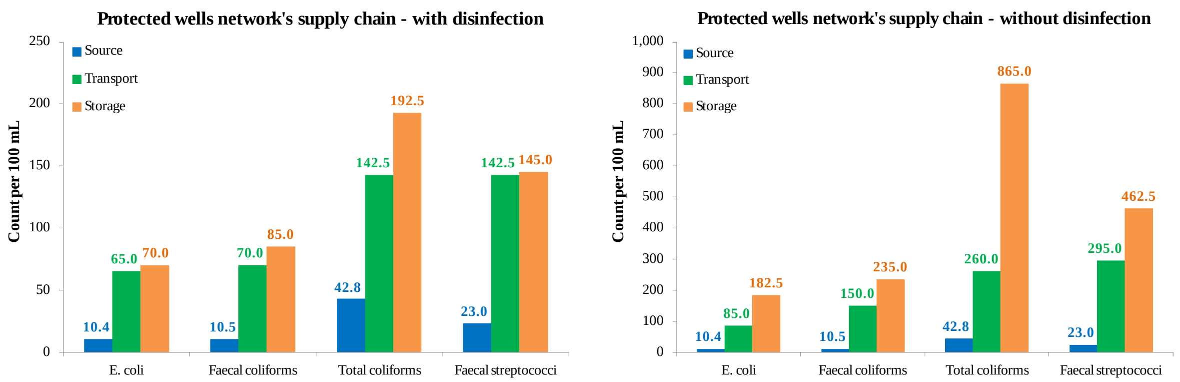


Fig. 2.39. *Microbiological quality along the supply chain amongst families that made (on the left) and did not make (on the right) water disinfection*

Analysing the average contamination along the supply chain of families that did not carry out the chlorination treatment (Fig. 2.39, graph on the right), for all the microbiological parameters, a significant increase in colonies was observed for each step of the supply chain. In particular, *E. coli* and total coliforms provided a more significant increase between transport and storage, whilst for faecal coliforms and faecal streptococci the greatest increase occurred between source and transport steps. Families who have instead stated to perform a disinfection treatment (Fig. 2.39, graph on the left) provided a contamination substantially constant, for all the parameters, between transport and storage, except for total coliforms for which a slight increase was noticed. The chlorination treatment, despite having prevented a significant increase in the contamination (on average three times less for all the parameters), did not allow ensuring a complete microbial removal, owing to the improper disinfection treatment carried out by the community. Indeed, the interviews carried out amongst families highlighted that chlorine doses applied (only few drops for a container of on average 40 L capacity) were not sufficient to ensure a proper disinfection. However, the more proper behaviour in water handling and management provided by these families permitted to obtain better results even in specimens sampled from transport containers (where disinfection was not yet carried out).
In order to release the dependence of the storage's contamination on the number of colonies provided at transport level, contamination's percentage increase between transport and storage has been considered, as shown in Fig. 2.40. Results clearly highlighted how disinfection treatment, on average, permitted to obtain a decrease of contamination, despite a significant increase provided by households

that did not carry out chlorination. If important results were obtained referring to *E. coli* (some of 20% colonies less), faecal streptococci still provided an increase in the number of colonies (some of 8% colonies more), owing to their longer survival in water environments and more resistance to chlorination [40].

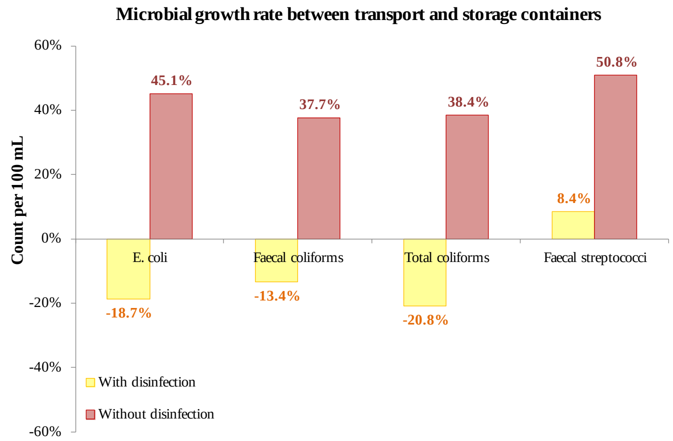


Fig. 2.40. *Percentage increases of contamination between transport and storage*

Finally, analysing the influence of the storage container on the microbiological contamination (without considering the presence or not of a disinfection treatment), for the families that used to collect water from the protected wells network with the same transport container (jerry can), interesting results were obtained (Fig. 2.41).

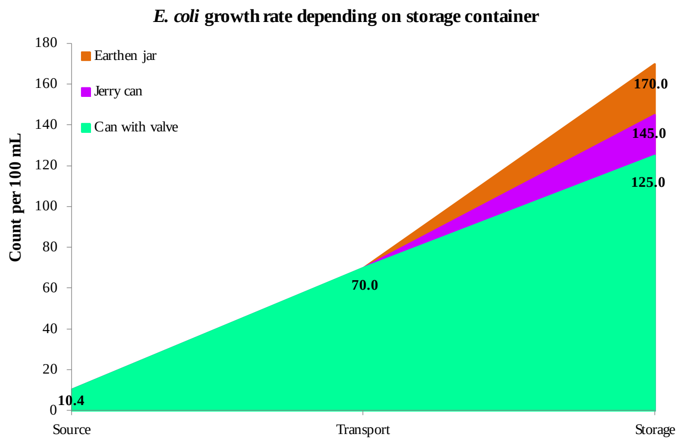


Fig. 2.41. *Microbiological contamination (E. coli) along the supply chain with the employment of different storage containers*

The storage container, which higher contamination was observed for, was the earthen jar that provided an increase up to 170 CFU/100mL. In addition to the fact that often this type of container was not well covered, the high porosity of the clay helped the nest of microorganisms and their proliferation. Conversely, the type of container, for which the minor contamination was highlighted, was the can with valve, with an average number of colonies equal to 125 CFU/100mL. In this case, the presence of a valve avoided an increase of *E. coli*, owing to the less contact between drinking water and hands (usually improperly cleaned) during the consumption. An average increase up to 145 CFU/100mL was instead provided by jerry cans that owing to their conformation avoided contacts between water and hands, but resulted more difficult to be properly cleaned.

2.4.3 Bone char-based filters' monitoring

After the restoration of four bone char-based filters (as previously stated), a monitoring of water quality after the filtration treatment was carried out. The same microbiological parameters were analysed on water filtered, whereas, regarding the physico-chemical characteristics, only fluorides, chlorides, conductivity and pH were investigated (before and after the filtration treatment).

During the interviews carried out amongst people living in Sambé, households that received filters during the first project implementation were asked to give a feedback on the use of these filters. 13 out of 25 families interviewed in Sambé received a bone char-based filter. The management of the filter was judged simple from 10 families and complicated according to 3, all 13 respondents felt useful the use of the filter, and 5 families believed expensive in terms of time its use, whereas the other 8 not. Regarding technical / management problems of the filtration system, 8 families have stated to have not found any, whilst 5 declared that filtration was too slow and 2 claimed to have had problems with the deterioration of the valve. The water treated by the filter was considered better than the untreated one by all the 13 families interviewed. In particular, the quality of the treated water was considered better from 11 families, clearer from 6 and saltier from 2. However, all 13 families were available to use again the filter for water treatment.

Water collected from (private and public) taps of the groundwater distribution system was employed for the filtration treatment, owing to its higher fluorides concentration and better quality (for the absence of lead and the minor microbiological contamination). The monitoring of 4 filters restored was carried out for 2 months. Figg. 2.42, 2.43, 2.44 and 2.45 report fluorides concentrations in water samples before and after the filtration treatment. Results are reported based on the volume of water filtered, which was on average 20 L daily (all data collected are reported in Annexe 3).

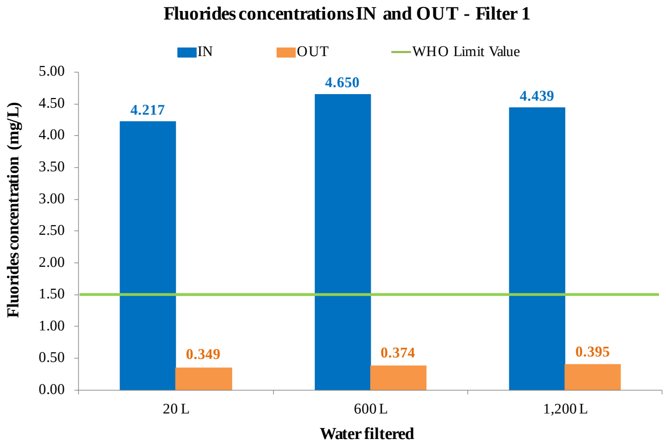


Fig. 2.42. *Fluorides concentration inlet and outlet the first bone char-based filter*

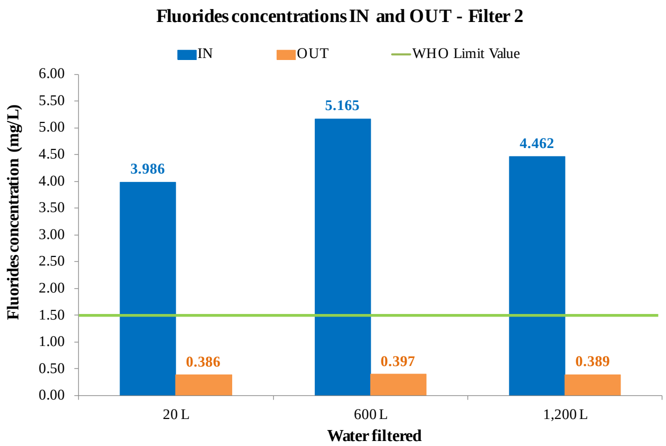


Fig. 2.43. *Fluorides concentration inlet and outlet the second bone char-based filter*

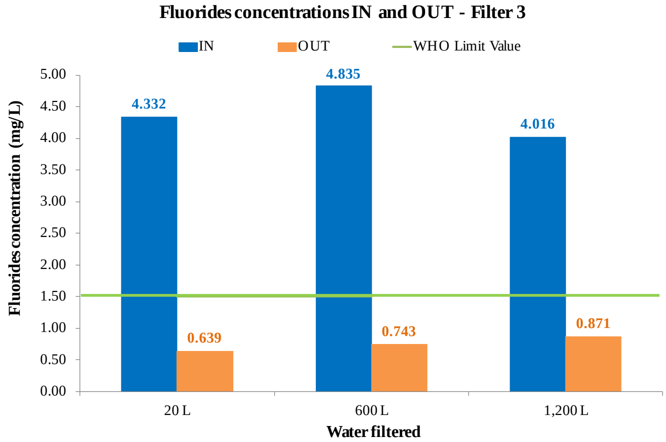


Fig. 2.44. *Fluorides concentration inlet and outlet the third bone char-based filter*

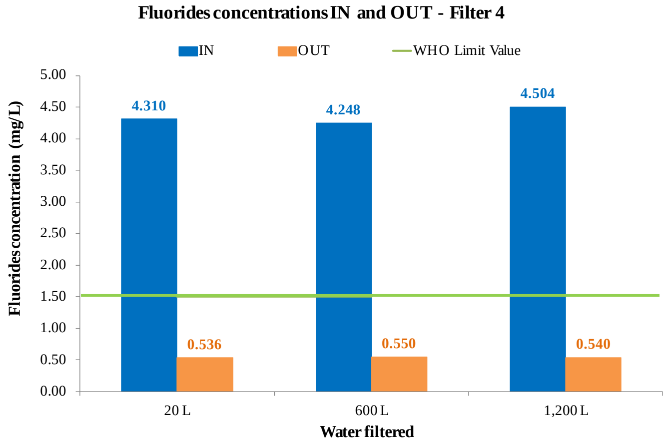


Fig. 2.45. *Fluorides concentration inlet and outlet the fourth bone char-based filter*

For each of the four filters monitored, an effective fluorides removal was obtained. Indeed, starting from initial concentrations included between 4 and 5 mg/L, final concentrations always below the limit of 1.5 mg/L established by the WHO and UE were provided (between 0.3 and 0.8 mg/L). In particular, it has to be noticed that these values were on average retained even at higher volumes filtered, regardless of the progressive exhaustion (adsorption capacity) of the filter.
Table 2.10 reports the fluorides removal per each filter, according to the different water treated volumes. On average, better removals were obtained from filter 1 and filter 2, whilst the worst ones from filter 3. The removal slightly decreased along the time, even if on average, after two months, was still equal to 87%.

Table 2.10. *Fluorides removal per each filter and water treated volume*

Water filtered	Fluorides removal				
	Filter 1	Filter 2	Filter 3	Filter 4	*Mean*
20 L	91.7%	90.3%	85.2%	87.6%	*88.7%*
600 L	92.0%	92.3%	84.6%	87.1%	*89.0%*
1,200 L	91.1%	91.3%	78.3%	88.0%	*87.2%*

Analysing the influence of the filtration on other chemical parameters, on average, a variable trend of all the parameters analysed was observed (Tables 2.11, 2.12 and 2.13, respectively referred to chlorides concentrations, conductivity and pH values). The filter, at the beginning of its functioning (20 L), tended to release chlorides (characterising both raw water and bone char), thus increasing conductivity and pH. Subsequently, after the treatment of some of 600 L, chlorides decreased as well as conductivity and pH. Finally, during the last monitoring when about 1,200 L were filtered, the concentration of chlorides found in the raw water was substantially equal to the one in the water treated, whereas a decrease of conductivity and an increase of pH were determined.

Table 2.11. *Chlorides concentrations in raw and treated waters per each filter, along the monitoring period*

Chlorides [mg/L]	20 L		600 L		1,200 L	
	In	Out	In	Out	In	Out
Filter 1	480	540	560	555	490	510
Filter 2	650	400	520	510	490	510
Filter 3	510	770	590	400	480	500
Filter 4	470	440	540	490	570	520
Mean	*527*	*537*	*552*	*488*	*507*	*510*

Table 2.12. *Conductivity values in raw and treated waters per each filter, along the monitoring period*

Conductivity [μS/cm]	20 L		600 L		1,200 L	
	In	Out	In	Out	In	Out
Filter 1	2,620	3,270	2,620	2,700	3,490	3,380
Filter 2	2,700	3,270	2,640	2,410	3,240	3,170
Filter 3	2,610	3,600	2,320	1,450	3,360	3,320
Filter 4	2,640	2,670	2,450	2,260	3,380	3,280
Mean	2,642	3,202	2,507	2,205	3,367	3,287

Table 2.13. *pH values in raw and treated waters per each filter, along the monitoring period*

pH	20 L		600 L		1,200 L	
	In	Out	In	Out	In	Out
Filter 1	8.47	8.49	7.64	7.65	7.65	8.04
Filter 2	8.37	8.49	7.64	6.99	7.90	8.50
Filter 3	8.47	8.50	7.84	6.78	7.82	8.31
Filter 4	8.36	8.46	7.61	6.98	7.96	8.14
Mean	8.41	8.48	7.69	7.10	7.83	8.24

Results of microbiological analyses conducted on samples extracted from filters highlighted, for all the parameters, a significant increase of microbiological contamination in the time. Fig. 2.46 and Fig. 2.47 show respectively *E. coli* and faecal streptococci concentrations in the four filters surveyed.
In particular *E. coli* concentration doubled between the filtration of 600 and 1,200 L, passing from an average value of 10 CFU/100mL to 25. Faecal streptococci provided an even more marked increase in concentrations, which were 5 times more between the filtration of 600 and 1,200 L, passing from an average value of 10 CFU/100mL to 45. The increases observed could be due to the proliferation of microorganisms present in the water supplied on the filter (jointly perhaps with no optimal handling and management of the filter) and the presence of high temperatures characterising the season when monitoring occurred.

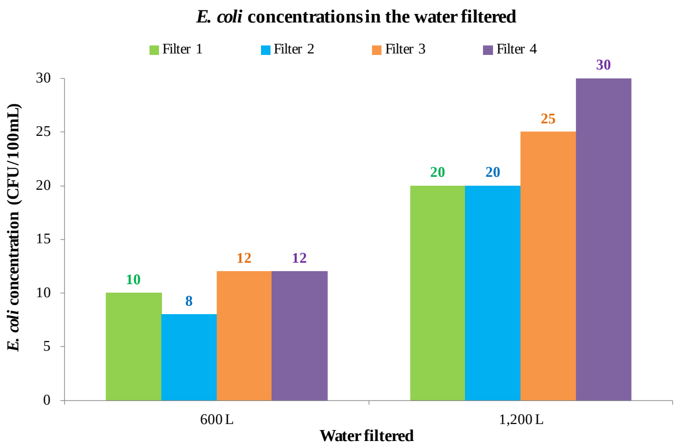


Fig. 2.46. *E. coli concentrations' trend, in the time, for the four filters monitored*

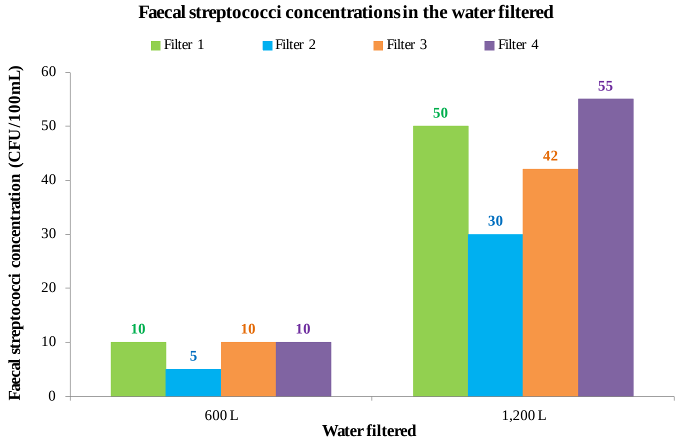


Fig. 2.47. *Faecal streptococci concentrations' trend, in the time, for the four filters monitored*

2.4.4 Batch chlorination tests

Batch chlorination analyses were performed on samples collected from open dug wells that, as already observed, were characterised by the highest level of microbiological contamination. A fixed contact time of 30 minutes was set and different doses of chlorine were added in a volume of 1.5 L, corresponding to different values of the parameter C*Tc (0.10, 0.15, 0.20 and 0.25 mg/L*min) according to the scientific literature [41]. Figg. 2.48 and 2.49 report concentrations of free chlorine and *E. coli* and faecal streptococci respectively, based on the different doses of chlorine added (all data are reported in Annexe 3).

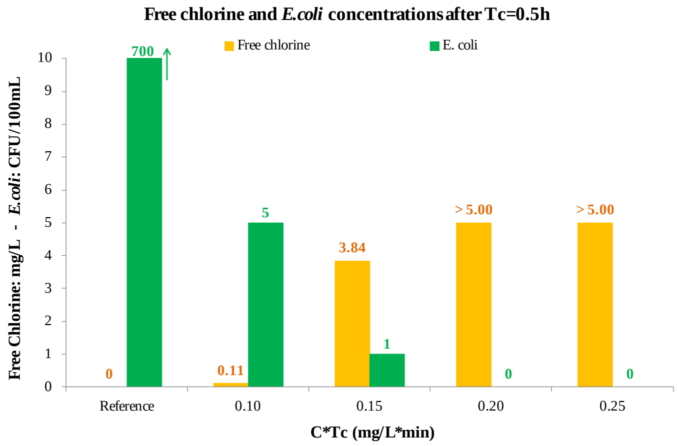


Fig. 2.48. *E. coli and free chlorine concentrations' trend for the different values of C*Tc used in the test*

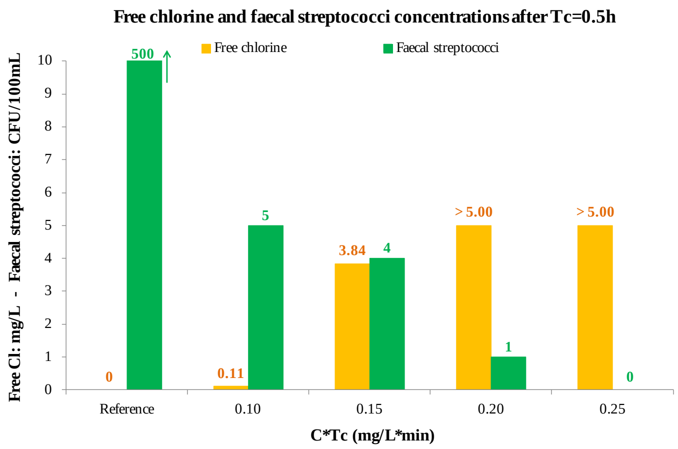


Fig. 2.49. *Faecal streptococci and free chlorine concentrations' trend for the different values of C*Tc used in the test*

For both *E. coli* and faecal streptococci, with a value of C*Tc equal to 0.1 mg/L*min, the contamination was reduced till 5 CFU/100mL. Although the reduction provided to be significant, it was insufficient to ensure a complete killing of bacteria. Moreover, with that value of C*Tc, the concentration of free residual chlorine was too low, indicating its strong use for the microbiological contamination removal. Increasing values of C*Tc and so the amount of chlorine dosed in each batch container, *E. coli* concentration was completely null whilst faecal streptococci slightly decreased till become null only with the highest value of C*Tc, thus highlighting again their more resistance to chlorination. Increasing the values of C*Tc, moreover, the free residual chlorine highlighted to be extremely high in concentration.

In order to identify and suggest to the communities the best dosage of chlorine able to kill all the bacteria and, at the same time, to provide an adequate residual for further contaminations (0.2-0.5 mg/L), an average dose between the doses corresponding to values of C*Tc of 0.10 and 0.15 was taken as a reference. Thus, the optimal dosage of chlorine was determined in 1 cap of chlorine bottle per each container of 20 L capacity poured in the storage container.

2.5 Water Safety Plan development

The Water Safety Plan (WSP) approach to develop in the Rural Community of Patar (RCP) had to take into consideration all the criticalities provided by the drinking water supply chain, analysed during the preliminary assessment in two representative villages as Sambé and Dabel Bara, and the arrangement of local Authorities and water management Committees. Briefly, the following highlights aim at synthesising all the major aspects:

- ❖ At source level, open dug wells provided an extremely high microbiological contamination, confirmed by the very high risk of contamination highlighted by means of sanitary inspections, whereas the other two drinking water sources (groundwater distribution system and protected wells network) were characterised by a low microbiological contamination, due mostly to the improper management of distribution taps. Structural and management interventions are thus required for all the water points, even if more deeply for open dug wells.
- ❖ At source level, from a physico-chemical point of view, all the sources provided some criticalities. The groundwater distribution system was characterised by high concentrations of fluorides, chlorides and sodium (all above the limits set by WHO and EU). For these reasons, bone char-based filters were restored in order to treat water for reducing fluorides content, and dilution with rain water (or shallow aquifer when rain water was not available) for decreasing the salinity was suggested. Regarding the other water sources, problems related to high concentrations of lead, and in some cases even of fluorides, have been discovered. Appropriate solutions able to cover all the inhabitants of the RCP and in order to solve all these criticalities have to be put in place.
- ❖ The water management Committees, ASUFOR and GIE, were not well organised (above all GIE) and they did not take properly care of water points. The WSP elaboration had also to be aimed at increasing the level of consciousness of their role and duties.
- ❖ Local technical (Water Directorate) and political (President of the RCP) Authorities could not be involved in the WSP development due to several reasons.
- ❖ The major microbiological contamination of drinking water took place along the supply chain, during transport and storage steps, due to improper hygiene practice and management. The main sources of contamination were: containers dirty; cups for drinking and hands in contact with water not properly cleaned; presence of microbial vectors in the surrounding of drinking water containers (animals, excreta, rubbish, etc.).

The development of the WSP approach in this case study occurred as intended by WHO drinking water guidelines, as a tool for creating a drinking water management approach able to minimise or prevent the microbial contamination. At the same time, meetings organised for the WSP elaboration were used for training members of ASUFOR and GIE, in order to increase their awareness level about good practices in the management of water points.

In order to reach these objectives, a WSP composed by five different sub-Plans was developed for all the RCP: the first one specific for the groundwater distribution system, the second one for the protected wells network, the third one for the open dug wells and the last two for transport step and storage and consumption point.

The development of the WSPs was carried out with the technical support of a Diourbel Hygiene Authority (DHA) technician and the ASUFOR Manager. WSP team was created in order to involve all the responsible of water catchment, distribution and management and in agreement with the Director of DHA and the President of the RCP. WSP team was composed by 12 people: 2 representatives of ASUFOR (the President and the General Supervisor), 2 representatives of GIE (the Secretary-general and a technician), 2 representatives of DHA (the Responsible of water, sanitation and hygiene monitoring and a technician), the Responsible for the Patar Health Centre (RPHC) and 5 students of the University of Dakar, who lived in the RCP, as representatives of the community.

The WSP team, on one hand, created the WSP and on the other, was made aware on how manage and handle drinking water along the entire supply chain in order to minimise and / or prevent the microbiological and chemical contamination. In order to develop each specific sub-Plan, five different meeting days were organised (Fig. 2.50).

Fig. 2.50. *WSP elaboration for the Rural Community of Patar*

Based on a slightly simplified WSP approach elaborated in collaboration with the DHA Director, the WSP team put in place was asked to list all the possible hazards that could pollute water, to define the related risks and control measures, to plan a monitoring programme for evaluating the efficacy and the respect of control measures adopted on the minimisation and / or prevention of the different hazards, to identify operational limits and corrective actions in order to guarantee the consumption of safe water and, finally, to plan a verification programme able to evaluate the efficacy of all the WSP. If a hazard, a control measure or any other aspect were not significant or were not taken into account, the team's members were leading in reasoning in order to bring them individually to identify the best solution.

Awareness campaigns on water, sanitation and hygiene were also organised involving the population of Sambé and Dabel Bara, in particular 100 women and 100 students (the most important and more involved in drinking water management). The aim of this supporting programme was to make aware local people on the correct behaviour to have during water handling and management, but also on good sanitation and hygiene practices, in order to minimise all the possible contaminations of drinking water that, in rural areas such as the one where the project was implemented, were one of the main criticalities. Moreover, 5 Hygienists (each one coming from a different village of the RCP) were trained about good practices in water, sanitation and hygiene issues. The aim of this training course was to form local people able to continue the awareness campaigns of the local community even after the end of the cooperation project and, thus, guaranteeing the sustainability of the WSP implemented and the improvement of drinking water management and quality.

All these awareness campaigns and training courses were aimed at supporting and favouring the implementation of the WSP approach.

2.5.1 WSP elaboration

In this section, the different sub-Plans elaborated by the WSP team are analysed separately.

Before elaborating the WSP, all components connected to the water supply system were described and analysed, in order to assure the clarity of the water supply chain and thus better identify all the possible hazards for drinking water.

WSP team was preliminarily asked to list all the possible hazards that could contribute to drinking water contamination. Then, a risk assessment was carried out according to the semi-quantitative method, based on the definition of both the frequency of occurrence (likelihood) and the severity of the consequences of contamination. After explaining the whole process of evaluation, definitions used for each frequency and severity categories have been discussed and decided. Tables 2.14 and 2.15 show respectively the frequencies of occurrence and the severities of the consequences used in this case study.

Table 2.14. *Likelihood or frequency of occurrence of contamination*

Likelihood	Risk score
Rare: once every 5-10 years	1
Unlikely: once a year	2
Moderate: once a month	3
Likely: once a week	4
Almost sure: every day	5

Table 2.15. *Severity of consequences of contamination*

Severity	Risk score
Insignificant: no water pollution	1
Minor: unlikely water pollution	2
Moderate: likely water pollution	3
Major: very likely water pollution	4
Catastrophic: certain water pollution	5

For all the possible causes of contamination listed, first of all the evaluation of likelihoods took place and subsequently the levels of severity. In this way it was possible to better compare the values progressively attributed to the different causes of contamination. Each score was assigned according to the result of the debate amongst the team.

After having identified the global risk (likelihood x severity), specific control measures for each hazard were carried out, providing also a dedicated monitoring programme establishing which action will be monitored, how it will be monitored, the frequency or timing of monitoring, where (spatially) actions will be monitored and finally who will do the monitoring or will be responsible for it.

Then, operational limits outside of which confidence in water safety would diminish were established as well as corrective actions, which have to be put in place when operational limits will be exceeded (corrective actions should be predetermined in order to enable their rapid implementation).

Finally, a specific verification programme was established to ensure that WSP was working properly. Thus actions to be monitored, how they will be monitored, the frequencies or timing of monitoring, where should be monitored and who will be the responsible were planned.

At the end of the fifth day of work (when the WSP was completed), amongst the team, a Responsible for the whole WSP was designated. Its role is fundamental for verifying that all the actions / control measures have been correctly put into practice and for coordinating the responsibilities of the different people involved in the WSP management.

In Annexe 4, all the Water Safety Plan elaborated is proposed. The following sections aim at presenting the different sub-Plans and showing the most interesting / relevant aspects.

2.5.1.1 The groundwater distribution system

The first sub-Plan elaborated was related to the groundwater distribution system, which, as already stated, was considered comprehensive of catchment, storage in feed tanks and distribution till taps (private / public / scholastic). A key role in this sub-Plan was played by ASUFOR. Indeed, during the WSP elaboration, the attention was focused on its role and duties.

Before the elaboration of the WSP, the groundwater distribution system was schematised in order to better identify all the possible causes of contamination and to be sure that all team members could have a clear idea of the system (Fig. 2.51).

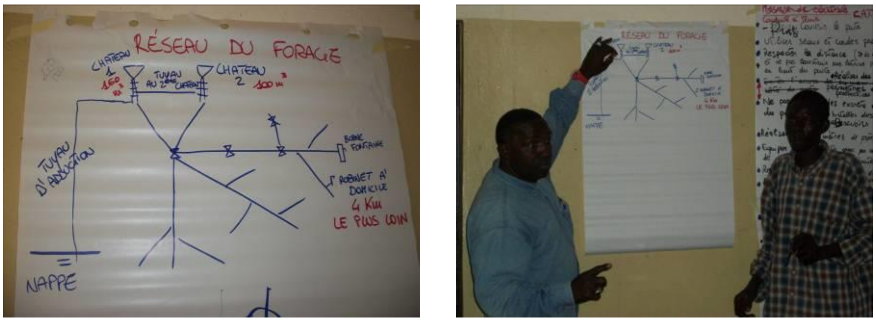


Fig. 2.51. *Diagram of the groundwater distribution system (on the left) and a moment of the discussion between WSP team's members (on the right)*

After this preliminary step, WSP elaboration began. Table 2.16 shows some of the hazards, causes and risk scores provided. The hazardous event considered was always drinking water contamination.

Table 2.16. *Some of the hazards, causes and risk scores provided for the sub-Plan concerning the groundwater distribution system*

Hazard	Cause	Risk		
		Likelihood	Severity	Score
Microbial	Animals enter through open inspection hatches of tanks	1	5	5
	Improper hygiene practices during feed tanks' cleansing	2	4	8
	Rupture of a water supply distribution pipe	3	5	15
	Lack of pressure in the supply system	4	3	12
	Dirty taps	5	5	25
	Improper fence around the installation enabling animals or unauthorised people entering	1	2	2
Chemical	Corrosion of iron pipes and valves	3	5	15
	Chlorine overdose	1	3	3
Geological	High concentrations of fluorides, chlorides and sodium	5	5	25

Three different types of hazards were identified by the team: microbial, chemical and geological. This latter one was justified by the fact that water contamination due to fluorides, chlorides and sodium occurred naturally. Regarding microbiological contaminations, a long list of causes was provided and only some examples are reported in Table 2.16. Of particular concern were the possible entrance of animals or other sources of pollution from inspection hatches of feed tanks, if not well sealed, the rupture of distribution pipes and dirty taps. Regarding chemical contaminations, the corrosion of iron pipes and valves was listed (even if mostly of the distribution system was made of PVC, polyvinyl chloride, some sections and some valves were realised in iron) as well as the chlorine overdose during water treatment. The possible causes of contamination could be divided into three categories: technical, where contamination could be due to technical and not "voluntary" reasons, such as the rupture or the corrosion of a pipe; management, where contamination could be due to the improper management of the system, such as lack of hygiene during the cleaning of feed tanks, the lack of pressure and dirty taps; natural, where contamination naturally occurred, such as the high concentrations of fluorides, chlorides and sodium.

The risk assessment, with the identification of the likelihood and the severity of consequences, was individually carried out by WSP team. Interesting and intense debates were characterising this step. No suggestions or decisions were given to the participants, in order to freely determine the frequencies and severities of risk. This decision was due to the fact that the perception of likelihood and severity of the possible causes of contamination had to be really felt by team members, who will be tasked to conduct the annual review of the Plan. Outside interventions (although maybe improving the correct interpretation of the level of risk) could lead to a lack of understanding by participants, especially during the revision / update of the Plan.

If likelihood was variable within the causes, higher values of severity were provided and above all set equal to 5 (certain water pollution). An exception was the severity score provided for the improper fencing system, which was set equal to 2 (unlikely water pollution) since presence of animals could unlikely determine water contamination as well as unlikely unauthorised people entered to the installation with the intent of manipulate or damage the distribution system. The highest risk scores were finally assigned to dirty taps and presence of natural pollutants in the aquifer.

Identified the total risk, participants were asked to identify the most proper control measure to put in place in order to prevent / minimise every possible cause of drinking water contamination. Some of the actions provided are listed in Table 2.17 and referred to each specific cause.

Table 2.17. *Some of the causes and related control measures provided for the sub-Plan concerning the groundwater distribution system*

Cause	Control measure
Animals enter through open inspection hatches of tanks	Ensure the hermetic closing of inspection hatches
Improper hygiene practices during feed tanks' cleansing	Observe the good hygiene practices during the cleaning
Rupture of a water supply distribution pipe	Check, during the installation, the quality of pipes Install correctly the pipes
Lack of pressure in the supply system	Ensure the presence of the watchman 24h/24
Dirty taps	Disinfect regularly the taps
Improper fence around the installation enabling animals or unauthorised people entering	Ensure the suitability of the fence
Corrosion of iron pipes and valves	Replace periodically the iron pipes and valves and use the rust preventer onto the iron elements
Chlorine overdose	Dose the correct quantity of chlorine
High concentrations of fluorides, chlorides and sodium	Spread the use of bone char-based filtration systems and the dilution with rain-water or wells-water Launch an experimental research of appropriate solutions at community level for decreasing fluorides, chlorides and sodium concentrations

WSP team tried to identify the easiest and most effective control measures. Of particular concern, amongst possible microbiological causes of contamination, was to ensure the presence of the watchman 24h/24 at the system's installation. Indeed, its presence was essential when lack of electricity happened since it had to immediately switch the functioning of the system from electricity to diesel generator, in order to avoid absence of pressure in the distribution system, causing possibly water contamination. This control measure was particularly important since lack of electricity was rather frequent (even several times per day) as well as the absence of the watchman (its likelihood in the risk assessment was in fact set equal to 4, at least once per week). Another interesting aspect was the identification of two control measures for the rupture of a distribution pipe, since the Manager of the system highlighted as these ruptures were frequently due on one hand to the low quality of the pipes and on the other to the improper installation.

Amongst chemical hazards, particularly interesting was the control measure related to the corrosion of iron pipes and valves. Since the Manager of the system clearly knew the location of these pipes, proposed to replace them periodically in order to prevent the presence of rust.

Finally, regarding the contamination of fluorides, chlorides and sodium, since immediate preventive actions could not be put in place, WSP team decided to increase the use of bone char-based filters amongst the entire RCP (because the first FonTov project was involving only the village of Sambé) and jointly to launch an experimental research at the University of Dakar, in order to identify a possible community technology (appropriate for the local context) able to remove those pollutants.

Table 2.18. *Some control measures and related monitoring programme provided for the sub-Plan concerning the groundwater distribution system*

Control measure	Monitoring programme				
	What	How	When	Where	Who
Ensure the hermetic closing of inspection hatches	The hermetic closing of hatches	Control of the hatches	Every 2 months	At the borehole installation	President of ASUFOR (Mr Issa Faye) and DHA
Observe the good hygiene practices during the cleaning	Respect of good hygiene practices	Inspection during cleansing	Every 6 months	At the borehole installation	President of ASUFOR (Mr Issa Faye) and DHA
Check, during the installation, the quality of the pipes Install correctly the pipes	The pipes' state and the installation method	Inspection before, during and after the installation	During the installation	At the borehole installation	General supervisor of ASUFOR (Mrs Tening Pouye)
Ensure the presence of the watchman 24h/24	The presence of the watchman	Site inspections	Weekly	At the borehole installation	President of ASUFOR (Mr Issa Faye)
Disinfect regularly the taps	The healthiness of the taps	Inspections	Weekly Monthly	At the taps	Members ASUFOR and RPHC DHA
Ensure the suitability of the fence	The suitability of the fence	Inspections	Monthly	At the borehole installation	President of ASUFOR (Mr Issa Faye)
Replace periodically the iron pipes and valves and use the rust preventer onto the iron elements	The state of the iron pipes and valves	Inspections	Every 5 years	At the borehole installation and along the distribution system	President and Manager of ASUFOR
Dose the correct quantity of chlorine	The disinfection treatment	Inspections	Every 6 months	At the borehole installation	President of ASUFOR (Mr Issa Faye) and DHA
Spread the use of bone char-based filtration systems and the dilution with rain-water or wells-water	The utilisation level of filters and dilution operations	Inspections	Every 6 months	At the dwellings	Student representative (Mr Mamadou Séne); Secretary-general GIE (Mr Moustapha Sagne); General supervisor ASUFOR (Mrs Tening Pouye); RPHC
Launch an experimental research of appropriate solutions at community level for decreasing fluorides, chlorides and sodium concentrations	The research progress	Meetings with the partners	Every 6 months	At the University of Dakar	Student representative (Mr Cheikh Kama) and DHA

After having identified the control measures, WSP team elaborated a dedicated monitoring programme (Table 2.18). The action to monitor (*what*) was always the put into practice of the specific control measures identified of each possible cause of contamination. Even when the check referred to behavioural change (such as the adoption of good hygiene practices during feed tanks cleaning), the aim was to verify that old and bad practices were abandoned for more proper behaviours, able to guarantee the prevention / minimisation of contamination. The monitoring approach adopted (*how*) was always referred to direct inspections, in order to effectively verify the realisation / putting into practice of the different control measures. The only exception was characterised by the experimental research at the University of Dakar, for which meetings amongst partners were provided. The different monitoring frequencies (*when*) have been determined based on several factors, such as the level of risk previously assigned, the availability of those responsible for monitoring amongst team members and the times that were deemed necessary for the implementation of control measures. Regarding the monitoring place (*where*), this was rather always represented by the distribution system (at the borehole installation or along the distribution pipes), except for taps (to monitor in the place where they were located), bone char-based filters (to monitor at the dwellings of beneficiaries) and research progress (to monitor directly at the University of Dakar). Regarding people responsible for the monitoring of each control measure (*who*), above all representatives of ASUFOR, with the support of DHA, were involved. The level of use of bone char-based filters was assigned to the monitoring of several people, representatives of each category of people composing the WSP team, whereas the progress in the research at the University of Dakar was asked to be monitored by students and DHA (as supervisor).
The following step in the WSP elaboration was the identification of operational limits and corrective measures able to control water contamination, so to prevent, when possible, the consumption of unsafe water. Table 2.19 reports part of the WSP concerning this step.

Table 2.19. *Some control measures and related operational limits and corrective actions provided for the sub-Plan concerning the groundwater distribution system*

Control measure	Operational limit	Corrective measure
Ensure the hermetic closing of inspection hatches	Hermetic closing of inspection hatches	Drinking water disinfection Ensure the hermetic closing of hatches
Observe the good hygiene practices during the cleaning	Failure of only 1 hygiene practice	Drinking water disinfection
Check, during the installation, the quality of the pipes	More than 1 broken pipe in 6 months	Drinking water disinfection Verify rigorously the pipes quality before the installation
Install correctly the pipes		Verify rigorously the installation operations Change the supplier
Ensure the presence of the watchman 24h/24	2 absences per month	1 warning (after 3 warnings, there will be dismissal)
Disinfect regularly the taps	More than 1 dirty tap per month	Disinfection of taps Awareness campaigns for the community
Ensure the suitability of the fence	Fence damaged	Repair the fence Training of the watchman on good management practices
Replace periodically the iron pipes and valves and use the rust preventer onto the iron elements	Water red-coloured more than once per year	Replace the rusty elements Drinking water disinfection Increase of the replacement frequency
Dose the correct quantity of chlorine	High taste and odour of chlorine	Interruption of drinking water disinfection
Spread the use of bone char-based filtration systems and the dilution with rain-water or wells-water	In 1 year, at least 10% of yards of each CRP village with bone char-based filters (some of 300 filters)	Research of financial partners
Launch an experimental research of appropriate solutions at community level for decreasing fluorides, chlorides and sodium concentrations	In 1 year, first proposal of community drinking water treatment	Research of other technical and financial partners

For each of the control measures monitored, the WSP team identified critical limits that, if exceeded, provided the application of immediate corrective measures to prevent water contamination. Some operational limits were characterised by two or even more corrective measures, in order to minimise the possibility of distributing contaminated water. Interesting operational limits were set regarding good hygiene practices during the cleaning of feed tanks and the pipes quality and way of installation. For the first control measure, the failure of only one hygiene practice was determined as sufficient to not guarantee safe water quality, whereas for the second one the WSP team decided to fix a limit of one pipe broken every 6 months for considering not safe water distributed (and meaning that quality of pipes and way of installation were not guaranteed). In both the cases, drinking water disinfection at feed tanks was provided as well as, for the second control measure, a more rigorous control by ASUFOR staff of the pipes' quality and of the way they were installed. Regarding another control measure related to microbiological contamination, to ensure the presence of the watchman 24h/24 at the borehole installation, two absences per month were set as operational limit. As corrective measure, the WSP team decided to warn once the watchman arriving maximum at three warnings, thereafter dismissal will be required. Regarding finally the geological hazards, since contamination was already in place, and immediate effective measures could not be provided, the WSP team determined two objectives to reach: the equipment of at least 10% of the families of each RCP village with a borne char-based filter and the proposal of a community drinking water treatment for pollutants' removal within 1 year. If these objectives would not be reached, the research of other technical and financial partners will be provided in order to assure the consumption of safe drinking water to the whole RCP as soon as possible.

The last step of this sub-Plan was the elaboration of a verification programme, necessary for verifying the effectiveness of the Plan (Table 2.20). For this reason, and as suggested by WHO guidelines, amongst activities (*what*) to verify, even drinking water quality was provided, at least for the check of control measures related to direct causes of water contamination (such as dirty taps or entrance of pollution from feed tanks' hatches). In the other cases the environmental hygiene and the management register (suggested and introduced as a practice in the routine work of the Manager) were set. The verification approach adopted (*how*) was referred to microbiological analyses, conduction of sanitary inspections and control of the register respectively. A meeting amongst partners and the evaluation of a research report were instead provided for the measures related to the drinking water natural contamination. Frequencies of verification (*when*) were varied: every 6 months or monthly, depending on the action to verify. Verification place (*where*) was rather always set to be the borehole installation for the control of the management register, the sanitary inspection for the control of the environmental hygiene and the water quality analyses for the verification of the microbiological parameters (this latter action was also accompanied by the laboratory of the DHA located in the close Diourbel). Finally, regarding people responsible for the verification of each action (*who*), above all representatives of DHA and, secondly, ASUFOR were involved. The reason of this choice was due to the fact that DHA had routinely the role and the duty of drinking water quality and environmental hygiene control, whereas ASUFOR was the body responsible of the whole system. Regarding the spread of bone char-based filters, even the President of the RCP and the RPHC were involved since they were daily in contact with all the inhabitants of the entire Rural Community.

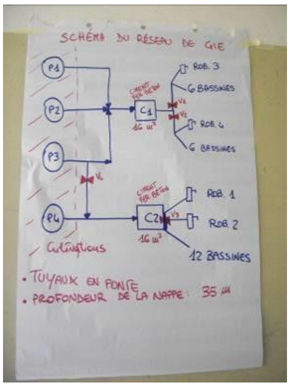
Table 2.20. *Some control measures and related verification programme provided for the sub-Plan concerning the groundwater distribution system*

Control measure	Verification programme				
	What	How	When	Where	Who
Ensure the hermetic closing of inspection hatches Observe the good hygiene practices during the cleaning	*E. coli* < 1 CFU/100 mL Faecal streptococci < 1 CFU/100 mL	Microbiological analyses	Every 6 months	At the borehole installation and at the laboratory	DHA
Check, during the installation, the quality of the pipes Install correctly the pipes Ensure the presence of the watchman 24h/24	Management register	Control of the register	Monthly	At the borehole installation	DHA and ASUFOR
Disinfect regularly the taps	*E. coli* < 1 CFU/100 mL Faecal streptococci < 1 CFU/100 mL	Microbiological analyses	Every 6 months	At the borehole installation and at the laboratory	DHA
Ensure the suitability of the fence	Proper environmental hygiene	Sanitary inspections WHO	Every 6 months	At the borehole installation	DHA and ASUFOR
Replace periodically the iron pipes and valves and use the rust preventer onto the iron elements	Management register	Control of the register	Monthly	At the borehole installation	DHA and ASUFOR
Dose the correct quantity of chlorine	Proper environmental hygiene	Sanitary inspections WHO	Every 6 months	At the borehole installation	DHA and ASUFOR
Spread the use of bone char-based filtration systems and the dilution with rain-water or wells-water	Financial conditions	Meetings with partners	Monthly	RCP	President RCP; RPHC; Students' representative (Mr Kama Cheikh); Secretary-general of GIE (Mr Moustapha Sagne); President of ASUFOR (Mr Issa Faye); DHA (Mr Talla Diack)
Launch an experimental research of appropriate solutions at community level for decreasing fluorides, chlorides and sodium concentrations	Research progress	Research report evaluation	Every 6 months	RCP	University students

2.5.1.2 The protected wells network

The second sub-Plan elaborated was related to the protected wells network, which, as already stated, was considered comprehensive of catchment from protected wells, storage in feed tanks and distribution till public taps. A key role in this sub-Plan was played by GIE. Indeed, during the WSP elaboration, the attention was focused on its role and duties.

Before the elaboration of the WSP, the protected wells network was schematised in order to better identify all the possible causes of contamination and to be sure that all team members could have a clear idea of the system (Fig. 2.52).



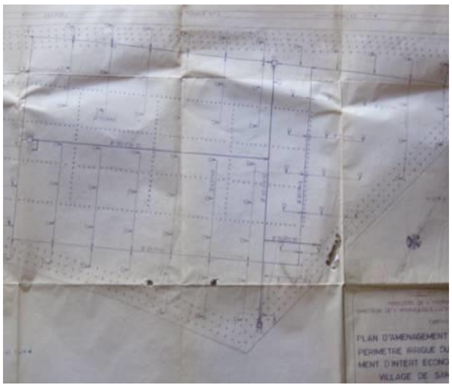


Fig. 2.52. *Diagram of the protected wells network (on the left) and cartography of the system's installation (on the right)*

After this preliminary step, WSP elaboration began. Table 2.21 shows some of the hazards, causes and risk scores provided. The hazardous event considered was always drinking water contamination.

Table 2.21. *Some of the hazards, causes and risk scores provided for the sub-Plan concerning the protected wells network*

Hazard	Cause	Risk		
		Likelihood	Severity	Score
Microbial	Presence of latrines or open defecation places < 10 m from wells	1	4	4
	Cracks or holes in the attachment between extraction pipes and wells	5	4	20
	Dirty taps	5	5	25
	Improper hygiene practices during feed tanks' cleansing	5	5	25
	Presence of stagnant water around the wells	2	4	8
	Improper fence around the installation enabling animals or unauthorised people entering	3	2	6
	Rupture of water supply distribution pipes and / or valves	1	4	4
Chemical	Use of chemicals in the wells surroundings (pesticides, fertilisers, etc.)	2	4	8
	High concentrations of lead	5	5	25

Two types of hazards were identified by the team: microbial and chemical. This latter one was justified by the fact that water extracted and distributed was contaminated by lead and sometimes pesticides were used in the wells surroundings thus permitting the possible contamination of the shallow aquifer. Regarding microbiological contaminations, a long list of causes was provided and only some examples are reported in Table 2.21. Of particular concern were the possible presence of latrines or open defecation places close to the wells, the presence of cracks in the attachment between extraction pipes and wells (as highlighted during the hazard assessment) and dirty taps. Regarding chemical contaminations, as stated, the use of pesticides in the wells surroundings and the high concentrations of lead were highlighted. The possible causes of contamination could be divided into two categories: technical, where contamination could be due to technical and not "voluntary" reasons, such as the rupture of a pipe or valve; management, where contamination could be due to the improper management of the system, such as lack of hygiene during the cleaning of feed tanks, the use of chemicals close to the water source and dirty taps.

The risk assessment, with the identification of the likelihood and the severity of consequences, was individually carried out by the WSP team, by means of intense debates. As for the elaboration of the previous sub-Plan, no suggestions or decisions were given to the members.
If likelihood was variable within the causes, higher values of severity were provided and above all set equal to 4 (very likely water pollution) and 5 (certain water pollution). An exception was the severity score provided for the improper fencing system, which was set equal to 2 (unlikely water pollution) since unlikely unauthorised people entered to the installation with the intent of manipulate or damage the distribution system. Highest risk scores were finally assigned to dirty taps, improper hygiene during the cleaning of feed tanks (since they have never been cleaned) and presence of lead in the aquifer.
Identified the total risk, participants were asked to identify the most proper control measure to put in place in order to prevent / minimise every possible cause of drinking water contamination. Some of the actions provided are listed in Table 2.22 and referred to each specific cause.

Table 2.22. *Some of the causes and related control measures provided for the sub-Plan concerning the protected wells network*

Cause	Control measure
Presence of latrines or open defecation places < 10 m from wells	Respect the distance (> 10 m) and do not build latrines on higher ground than wells
Cracks or holes in the attachment between extraction pipes and wells	Ensure the hermetic closing amongst extraction pipes and wells (walls or covers)
Dirty taps	Disinfect regularly the taps
Improper hygiene practices during feed tanks' cleansing	Observe the good hygiene practices during the cleaning
Presence of stagnant water around the wells	Build drainage channels conducting waters to absorbing wells
Improper fence around the installation enabling animals or unauthorised people entering	Ensure the suitability of the fence
Rupture of water supply distribution pipes and / or valves	Replace periodically (at least every 5 years) valves and pipes
Use of chemicals in the wells surroundings (pesticides, fertilisers, etc.)	Respect the standard precautions of the chemicals used
High concentrations of lead	Spread the use of bone char-based filtration systems Launch an experimental research of appropriate solutions at community level for decreasing lead concentrations

WSP team tried to identify the easiest and most effective control measures. Of particular concern, amongst possible microbiological causes of contamination, was to build drainage channels conducting waters to absorbing wells, in order to avoid the presence of stagnant water in the wells' surroundings, thus permitting its infiltration and the possible contamination of the aquifer. Another interesting aspect was the periodic replacement of valves and pipes. Since the lifetime estimated for these elements was no longer than 5 years, the suggestion of the WSP team was to replace them at least every 5 years.
Regarding chemical hazards, for the use of pesticides close to the wells, the WSP team decided to set the respect of the standard precautions present in the chemicals' label as control measure. However, the two representatives of GIE, members of the WSP team, took the responsibility to immediately inform all the farmers present in their Association about this possible cause of contamination. Concerning high concentrations of lead, two control measures were adopted: on one hand, the launch of an experimental research at the University of Dakar, in order to identify a possible community technology (appropriate for the local context) able to remove this pollutant, and, on the other, the use of bone char-based filtration systems (the same for the fluorides removal) in order to decrease lead concentrations. Some scientific literature works, indeed, demonstrated the ability of this material to adsorb even heavy metals including lead [42-46]. The University of Dakar and the DHA were directly involved in this experimental research and in the monitoring of the bone char-based filters in order to evaluate the lead removals.
The following step in the WSP development was the elaboration of a monitoring programme in order to control all the measures put in place. Table 2.23 reports part of the WSP concerning this step.

Table 2.23. *Some control measures and related monitoring programme provided for the sub-Plan concerning the protected wells network*

Control measure	Monitoring programme				
	What	How	When	Where	Who
Respect the distance (> 10 m) and do not build latrines on higher ground than wells	The respect of latrine installation rules	Inspections	Every 6 months	GIE	Secretary-general GIE (Mr Moustapha Sagne) and DHA
Ensure the hermetic closing amongst extraction pipes and wells (walls or covers)	The tightness of the junctions	Inspections	Every 6 months	GIE	Secretary-general GIE (Mr Moustapha Sagne) and DHA
Disinfect regularly the taps	The healthiness of the taps	Inspections	Weekly Monthly	At the taps	Technician GIE (Mr Birame N'Diaye) and RPHC DHA
Observe the good hygiene practices during the cleaning	The cleansing of tanks The respect of good hygiene practices	Inspections	Annually	GIE	Technician GIE (Mr Birame N'Diaye)
Build drainage channels conducting waters to absorbing wells	The presence of drainage channels	Inspections	Every 6 months	GIE	Secretary-general GIE (Mr Moustapha Sagne) and DHA
Ensure the suitability of the fence	The suitability of the fence	Inspections	Every 6 months	GIE	Technician GIE (Mr Birame N'Diaye)
	The presence of animals	Inspections	Daily	GIE	Technician GIE (Mr Birame N'Diaye) and RPHC
Replace periodically (at least every 5 years) valves and pipes	The valves and pipes' state	Inspections	Annually	GIE	Technician GIE (Mr Birame N'Diaye)
Respect the standard precautions of the chemicals used	The knowledge level of the use of chemicals	Meetings with GIE Committee	Every 6 months	GIE	DHA
Spread the use of bone char-based filtration systems	The utilisation level of filters and dilution operations	Inspections	Every 6 months	At the dwellings	Student representative (Mr Mamadou Séne); Secretary-general GIE (Mr Moustapha Sagne); General supervisor ASUFOR (Mrs Tening Pouye); RPHC
Launch an experimental research of appropriate solutions at community level for decreasing lead concentrations	The research progress	Meetings with partners	Every 6 months	At the University of Dakar	Student representative (Mr Cheikh Kama) and DHA

The action to monitor (*what*) was always the put into practice of the specific control measures identified for each possible cause of contamination. Even when the check referred to behavioural change (such as the adoption of good hygiene practices during feed tanks cleaning), the aim was to verify that old and bad practices were abandoned for more proper behaviours, able to guarantee the prevention / minimisation of contamination. The monitoring approach adopted (*how*) was always referred to direct inspections, in order to effectively verify the realisation / putting into practice of the different control measures. The only exceptions were characterised by the respect of the standard precautions for chemicals' use and the experimental research at the University of Dakar, for which meetings amongst partners were provided. The different monitoring frequencies (*when*) have been determined based on several factors, such as the level of risk previously assigned, the availability of those responsible for monitoring amongst team members and the times that were deemed necessary for the implementation of control measures. In this case, frequencies were extremely varied, passing from daily to annually. Regarding the monitoring place (*where*), this was rather always represented by the distribution network (at the GIE plot or along the distribution pipes), except for the bone char-based filters (to monitor at the dwellings of beneficiaries) and the research progress (to monitor directly at the University of Dakar). Regarding people responsible for the monitoring of each control measure (*who*), above all representatives of GIE, with the support of DHA, were involved. The level of use of bone char-based filters was assigned to the monitoring of several people, representatives of each category of people composing the WSP team, whereas the progress in the research at the University of Dakar was asked to be monitored by students and DHA (as supervisor).

After the planning of the monitoring programme, the identification of operational limits and corrective measures able to control water contamination was carried out. Measures provided by the WSP team are listed in Table 2.24.

Table 2.24. *Some control measures and related operational limits and corrective actions provided for the sub-Plan concerning the protected wells network*

Control measure	Operational limit	Corrective measure
Respect the distance (> 10 m) and do not build latrines on higher ground than wells	Presence of a latrine < 10 m	Interruption of the latrines' use and emptying of pits Drinking water disinfection Verify the pollution weekly for at least 3 months
Ensure the hermetic closing amongst extraction pipes and wells (walls or covers)	Presence of cracks / holes	Repair the damage Drinking water disinfection
Disinfect regularly the taps	More than 1 tap dirty per week	Disinfection of taps
Observe the good hygiene practices during the cleaning	Annual cleaning Failure of only 1 hygiene practice	Drinking water disinfection
Build drainage channels conducting waters to absorbing wells	Absence of drainage channel	Awareness campaigns addressed to GIE Committee Build the drainage channels
Ensure the suitability of the fence	Fence damaged	Repair the fence
Replace periodically (at least every 5 years) valves and pipes	More than 1 broken valve and pipe in 5 years	Replace the valves and the pipes Drinking water disinfection
Respect the standard precautions of the chemicals used	1 improper use every 2 years	Interruption of water supply Chemical analyses weekly per at least 1 month
Spread the use of bone char-based filtration systems	In 1 year, at least 10% of yards of each CRP village with bone char-based filters (some of 300 filters)	Research of financial partners
Launch an experimental research of appropriate solutions at community level for decreasing lead concentrations	In 1 year, first proposal of community drinking water treatment	Research of other technical and financial partners

Operational limits, as already stated, were useful in order to provide the application of immediate corrective measures to prevent water contamination, if exceeded. Some operational limits were characterised by two or even more corrective measures, in order to minimise the possibility of distributing contaminated water. An interesting sequence of actions was provided for the possible presence of latrines or open defecation places close to the protected wells. Even if the operational limit set was quite ordinary (as the presence at a distance less than 10 m), corrective measures were relevant: first of all the interruption of the latrines' use and the emptying of pits was set, than an immediate water disinfection and finally it was highlighted the necessity to verify the soil pollution and the drinking water quality weekly for at least 3 months. Regarding the necessity to build a drainage channel able to conduct waters to an absorbing well, its absence was provided as operational limit, whereas as corrective actions its realisation and the organisation of training / awareness courses to the GIE Committee were determined. Often the WSP team (as clearer in the following sub-Plans) decided to accompany the realisation of an infrastructure with awareness campaigns able to help in the behavioural change of the people involved in that activity.

Regarding finally the chemical hazard due to the presence of high concentrations of lead, since contamination was already in place and immediate effective measures could not be provided, the WSP team determined two objectives to reach: the equipment of at least 10% of the families of each RCP village with a borne char-based filter and the proposal of a community drinking water treatment for lead's removal within 1 year. If these objectives would not be reached, the research of other technical and financial partners will be provided in order to assure the consumption of safe drinking water to the whole RCP as soon as possible.

The last step of this sub-Plan was the elaboration of a verification programme, necessary for verifying the effectiveness of the Plan (Table 2.25). Amongst activities to verify (*what*), for the ones related to direct causes of water contamination (such as dirty taps, presence of latrines or open defecation places or entrance of pollution from feed tanks' hatches), drinking water quality analyses were provided. In the other cases the environmental hygiene and the management register (suggested and introduced as a practice in the routine work of the GIE Committee) were set. The verification approach adopted (*how*) was referred to microbiological analyses, conduction of sanitary inspections and control of the register respectively. A meeting amongst partners and the evaluation of a research report were instead provided for the measures related to the drinking water contamination. Frequencies of verification (*when*) were varied: every 6 months or monthly, depending on the action to verify. Verification place (*where*) was rather always set to be the protected wells installation (GIE plot), in order to: control the management register; conduct sanitary inspections, for the control of the environmental hygiene; and carry out water quality analyses, for the verification of the microbiological parameters (this latter action was also accompanied by the laboratory of the DHA located in the close Diourbel). Finally, regarding people responsible for the verification of each action (*who*), above all representatives of DHA and, secondly, GIE were involved. The reason of this choice was due to the fact that DHA had routinely the role and the duty of drinking water quality and environmental hygiene control, whereas GIE was the body responsible of the whole system. Regarding the spread of bone char-based filters, even the President of the RCP and the RPHC were involved since they were daily in contact with all the inhabitants of the entire Rural Community (as already set in the previous sub-Plan).

Table 2.25. *Some control measures and related verification programme provided for the sub-Plan concerning the protected wells network*

Control measure	Verification programme				
	What	How	When	Where	Who
Respect the distance (> 10 m) and do not build latrines on higher ground than wells Ensure the hermetic closing amongst extraction pipes and wells (walls or covers) Disinfect regularly the taps Observe the good hygiene practices during the cleaning	*E. coli* < 1 CFU/100 mL Faecal streptococci < 1 CFU/100 mL	Microbiological analyses	Every 6 months	At the GIE taps and at the laboratory	DHA
Build drainage channels conducting waters to absorbing wells Ensure the suitability of the fence	Proper environmental hygiene	Sanitary inspections WHO	Every 6 months	GIE	DHA
Replace periodically (at least every 5 years) valves and pipes	Management register	Control of the register	Monthly	GIE	DHA and Secretary-general of GIE (Mr Moustapha Sagne)
Respect the standard precautions of the chemicals used	Drinking water chemical quality	Chemical analyses	Every 6 months	GIE and at the laboratory	DHA
Spread the use of bone char-based filtration systems	Financial conditions	Meetings with partners	Monthly	RCP	President RCP; RPHC; Students' representative (Mr Kama Cheikh); Secretary-general of GIE (Mr Moustapha Sagne); President of ASUFOR (Mr Issa Faye); DHA (Mr Talla Diack)
Launch an experimental research of appropriate solutions at community level for decreasing lead concentrations	Research progress	Research report evaluation	Every 6 months	RCP	University students

2.5.1.3 The open dug wells

The third sub-Plan elaborated (and the last one regarding drinking water sources) was related to open dug wells, which were considered comprehensive of the catchment by means of ropes and buckets. A key role in this sub-Plan was played by the RPHC and the University students (representatives of the entire population), since they were the members more in contact with the community. During the WSP elaboration, the attention was also focused on the role of village leaders.

Due to their simplicity and well known structure, open dug wells were not schematised before WSP elaboration. Table 2.26 shows some of the hazards, causes and risk scores provided. The hazardous event considered was always drinking water contamination.

Table 2.26. *Some of the hazards, causes and risk scores provided for the sub-Plan concerning open dug wells*

Hazard	Cause	Risk		
		Likelihood	Severity	Score
Microbial	Wells open (without cover)	5	5	25
	Dirty ropes and buckets	5	5	25
	Wells without proper parapets	1	5	5
	Absence of proper concrete aprons around the wells	5	2	10
	Presence of animals around the wells	4	3	12
	Presence of rubbish around the wells	3	4	12
Chemical	Presence of rubbish around the wells	3	4	12
	Use of chemicals in the wells surroundings (pesticides, fertilisers, etc.)	2	4	8
Geological and chemical	High concentrations of fluorides and lead	5	5	25
Vandalism	Presence of rubbish inside the wells	1	5	5
	Suicide	1	5	5
Suspended solids	Improper drawing	5	5	25

Five different types of hazards were identified by the team: microbial, chemical, geological and chemical, vandalism and suspended solids. The geological and chemical hazard was justified by the fact that water contamination due to fluorides occurred naturally, whereas lead pollution was a chemical contamination likely due to anthropic causes. Regarding microbiological contaminations, a long list of causes was provided and only some examples are reported in Table 2.26. Most of these causes were related to structural deficiencies of the wells, as the absence of covers, proper parapets, sealed walls, concrete aprons and drainage channels. On the other hand, several causes were related to environmental hygiene, thus concerning the presence of rubbish, animals and excreta in the wells' surroundings. Regarding chemical contaminations, the use of pesticides in the wells surroundings and the high concentrations of lead were highlighted. Strictly referred to the geological hazard was the presence of high concentrations of fluorides in the water (even if this problem was not pointed out for all the wells of the RCP, as stated in section 2.4.1.4.1). Two interesting hazards and related causes of contamination were vandalism, with the presence of rubbish inside the wells and suicide (the WSP team wanted to add even this cause since in the neighbourhood of the RCP, already happened that someone decided to commit suicide by jumping into a well), and suspended solids, which characterised this water source as already highlighted in section 2.4.1.4.1. In this sub-Plan, the possible causes of contamination could be divided into two categories: management, where contamination could be due to the improper management of the source, such as improper structure, lack of hygiene during the drawing, lack of environmental hygiene; natural, where contamination naturally occurred, such as the high concentrations of fluorides. Thus, "technical" category was not characterising this source.

The risk assessment, with the identification of the likelihood and the severity of consequences, was individually carried out by the WSP team. If likelihood was variable within the causes, higher values of severity were provided and above all set equal to 5 (certain water pollution). The highest risk scores

were finally assigned to four causes: wells without a proper cover, use of dirty ropes and buckets, high concentrations of fluorides and lead in the aquifer, and improper drawing that generated high turbidity.
Identified the total risk, participants were asked to identify the most proper control measure to put in place in order to prevent / minimise every possible cause of drinking water contamination. Some of the actions provided are listed in Table 2.27 and referred to each specific cause.

Table 2.27. *Some of the causes and related control measures provided for the sub-Plan concerning open dug wells*

Cause	Control measure
Wells open (without cover)	Cover the wells
Dirty ropes and buckets	Use clean and proper ropes and buckets
Wells without proper parapets	Build parapets of at least 1 m height
Absence of proper concrete aprons around the wells	Build concrete aprons of 1-2 m width
Presence of animals around the wells	Build drinking troughs
	Build proper fences
Presence of rubbish around the wells	
Presence of rubbish around the wells	
Use of chemicals in the wells surroundings (pesticides, fertilisers, etc.)	Avoid farming around the wells
High concentrations of fluorides and lead	Spread the use of bone char-based filtration systems and the dilution with rain water Launch an experimental research of appropriate solutions at community level for decreasing fluorides and lead concentrations
Presence of rubbish inside the wells	Cover the wells
Suicide	
Improper drawing	
	Use clean and proper ropes and buckets

WSP team tried to identify the easiest and most effective control measures. Of particular concern, amongst possible microbiological causes of contamination, was the construction of several structural parts able to protect drinking water, such as covers, concrete aprons, parapets, drainage channels, drinking troughs for animals and adequate fences. Regarding chemical hazards, for the use of pesticides close to the wells, the WSP team imposed to avoid cultivations close to open dug wells. Finally, concerning high concentrations of fluorides and lead, two control measures were adopted, as already provided for the other two drinking water sources: on one hand, the launch of an experimental research at the University of Dakar, and, on the other, the use of bone char-based filtration systems.
The following step in the WSP development was the elaboration of a monitoring programme in order to control all the measures put in place. Table 2.28 reports part of the WSP concerning this step.
The action to monitor (*what*) was always the put into practice of the specific control measures identified for each possible cause of contamination. The monitoring approach adopted (*how*) was always referred to direct inspections, in order to effectively verify the realisation / putting into practice of the different control measures. The only exceptions were characterised by awareness campaigns regarding the use of proper drawing systems, in order to maximise the population rate with proper behaviours, and meetings amongst partners, regarding the experimental research at the University of Dakar. Monitoring frequencies (*when*) were rather always set equal to 6 months, owing to the necessity of realise important structural parts of the wells that required a relevant mobilisation of funds and resources. Conversely, for the monitoring of a behavioural change, such as the use of proper ropes and buckets, a weekly frequency was provided, in order to assure the putting into practice of this control measure. Regarding the monitoring place (*where*), this was rather always represented by the wells, except for the bone char-based filters (to monitor at the dwellings of beneficiaries) and the research progress (to monitor directly at the University of Dakar). Regarding people responsible for the monitoring (*who*), as stated above, representatives of students, the RPHC and village leaders were involved the most, even if all the WSP team's members were implicated somehow.

Table 2.28. *Some control measures and related monitoring programme provided for the sub-Plan concerning open dug wells*

Control measure	Monitoring programme				
	What	How	When	Where	Who
Cover the wells	Wells covering	Inspections	Every 6 months	At the wells	RPHC; Village leaders; DHA; Secretary-general GIE (Mr Moustapha Sagne); Student representative (Mr Cheikh Kama)
Use clean and proper ropes and buckets	Use of proper drawing tools	Inspections	Weekly	At the wells	RPHC; Student representative (Mr Cheick Kama); Village leaders
		Awareness campaigns for the users		At the wells and at the dwellings	RPHC
Build parapets of at least 1 m height	The presence of adequate parapets	Inspections	Every 6 months	At the wells	RPHC; Village leaders; DHA; Secretary-general GIE (Mr Moustapha Sagne); Student representative (Mr Cheikh Kama)
Build concrete aprons of 1-2 m width	The presence of concrete aprons	Inspections	Every 6 months	At the wells	RPHC; Village leaders; DHA; Secretary-general GIE (Mr Moustapha Sagne); Student representative (Mr Cheikh Kama)
Build drinking troughs	The presence of drinking troughs	Inspections	Every 6 months	At the wells	Student representative (Miss Ndeye Séne); Secretary-general GIE (Mr Moustapha Sagne)
Build proper fences	The presence of proper fences	Inspections	Every 6 months	At the wells	Student representative (Miss Ndeye Séne); Secretary-general GIE (Mr Moustapha Sagne)
Avoid farming around the wells	Absence of farming	Inspections	Every 6 months	At the wells	DHA
Spread the use of bone char-based filtration systems and the dilution with rain water	The utilisation level of filters and dilution operations	Inspections	Every 6 months	At the dwellings	Student representative (Mr Mamadou Séne); Secretary-general GIE (Mr Moustapha Sagne); General supervisor ASUFOR (Mrs Tening Pouye); RPHC
Launch an experimental research of appropriate solutions at community level for decreasing fluorides and lead concentrations	The research progress	Meetings with partners	Every 6 months	At the University of Dakar	Student representative (Mr Cheikh Kama); DHA

After the planning of the monitoring programme, the identification of operational limits and corrective measures able to control water contamination was carried out. Measures provided by the WSP team are listed in Table 2.29. Some operational limits were characterised by two or even more corrective measures, in order to minimise the possibility of distributing contaminated water. Generally, as operational limit, the absence of the control measure provided by the WSP team was set. This was justified by the presence of several structural interventions required for guaranteeing safe water, thus their absence was considered a strict limit. Each operational limit was characterised by at least two different corrective measures: the first one was the realisation of the infrastructure and the second one was the organisation of awareness campaigns amongst users, in order to highlight the need to mobilise funds and resources for avoiding a further water contamination. In some cases, drinking water disinfection was provided (even if the effectiveness of a chlorination treatment at the well was debated). Regarding finally the chemical and geological hazards, the same operational limits and corrective measures provided in the previous sub-Plans were adopted.

Table 2.29. *Some control measures and related operational limits and corrective actions provided for the sub-Plan concerning open dug wells*

Control measure	Operational limit	Corrective measure
Cover the wells	Open wells	Drinking water disinfection Awareness campaigns for the users Provide the well cover
Use clean and proper ropes and buckets	More than 1 dirty rope and bucket per week	Awareness campaigns for the users Control of the drawing tools weekly per 2 months
Build parapets of at least 1 m height	Absence of parapet	Awareness campaigns for the users Build the parapet
Build concrete aprons of 1-2 m width	Absence of concrete apron	Awareness campaigns for the users Build the concrete apron
Build drinking troughs	Absence of drinking trough	Awareness campaigns for the users Build the drinking trough
Build proper fences	Absence of fence	Awareness campaigns for the users Build the fence
Avoid farming around the wells	Presence of a farming	Awareness campaigns for the herdsmen Prohibition of the use of chemicals
Spread the use of bone char-based filtration systems and the dilution with rain-water	In 1 year, at least 10% of yards of each CRP village with bone char-based filters (some of 300 filters)	Research of financial partners
Launch an experimental research of appropriate solutions at community level for decreasing fluorides and lead concentrations	In 1 year, first proposal of community drinking water treatment	Research of other technical and financial partners

The last step was the elaboration of a verification programme, necessary for verifying the effectiveness of the Plan (Table 2.30). Amongst activities to verify (*what*), for the ones related to direct causes of water contamination (such as wells' covers and use of proper drawing systems), drinking water quality analyses were provided. In the other cases, related to the realisation of structural elements, the environmental hygiene was set. The verification approach adopted (*how*) was referred to microbiological analyses and conduction of sanitary inspections respectively. Frequencies of verification (*when*) were almost set every 6 months. Verification places (*where*) were the sites of open dug wells and the entire RCP, concerning chemical and geological hazards. Finally, regarding people responsible for the verification of each action (*who*), representatives of DHA were involved. The reason of this choice was due to the fact that DHA, as stated, had routinely the role and the duty of drinking water quality and environmental hygiene control. Regarding the spread of bone char-based filters and the research progress, the same people of the previous verification programmes were involved.

Table 2.30. *Some control measures and related verification programme provided for the sub-Plan concerning open dug wells*

Control measure	Verification programme				
	What	How	When	Where	Who
Cover the wells Use clean and proper ropes and buckets	*E. coli* < 1 CFU/100 mL Faecal streptococci < 1 CFU/100 mL	Microbiological analyses	Every 6 months	At the wells and at the laboratory	DHA
Build parapets of at least 1 m height Build concrete aprons of 1-2 m width Build drinking troughs Build proper fences Avoid farming around the wells	Proper environmental hygiene	Sanitary inspections WHO	Every 6 months	At the wells	DHA
Spread the use of bone char-based filtration systems and the dilution with rain-water	Financial conditions	Meetings with partners	Monthly	RCP	President RCP; RPHC; Students' representative (Mr Kama Cheikh); Secretary-general of GIE (Mr Moustapha Sagne); President of ASUFOR (Mr Issa Faye); DHA (Mr Talla Diack)
Launch an experimental research of appropriate solutions at community level for decreasing fluorides and lead concentrations	Research progress	Research report evaluation	Every 6 months	RCP	University students

2.5.1.4 The transport

The sub-Plan related to the transport step of the supply chain aimed at identifying all the possible causes of contamination and the related control measures, concerning drinking water from the catchment (independently from the type of water source used) until the storage at home. Even in this phase, as previously stated during the preliminary assessment, some criticalities arose. Table 2.26 shows the hazards, causes and risk scores provided. The hazardous event considered was always drinking water contamination.

Table 2.31. *Hazards, causes and risk scores provided for the sub-Plan concerning the transport*

Hazard	Cause	Risk		
		Likelihood	Severity	Score
Microbial	Containers open	5	5	25
	Containers dirty	5	5	25
	Use of dirty utensils	5	5	25
	Hands dirty in contact with water	5	5	25
Chemical	Use of containers previously employed for chemicals	4	4	16

In this sub-Plan only microbial and chemical hazards were identified. Regarding microbiological contamination, all the possible improper behaviours that could cause water pollution were listed in the WSP, whereas for chemical contamination only the use of containers previously employed for the transport or storage of chemicals was identified. An interesting cause of contamination was the contact between dirty hands and drinking water, since people had the habit to not wash properly hands with soap before supplying water. The poor hygiene level in the area and the rather diffusion of open defecation (a quarter of the households interviewed admitted to practice open defecation) did not guarantee the appropriateness of hands and, consequently, the safety of drinking water.

Comparing risk scores provided in this sub-Plan with the ones determined for water points, it is possible to notice how values were increasing, above all regarding likelihood. Bad practices in drinking water management during transport were recognised by the WSP team, who fixed mostly 5 (once a day) in frequencies. Thus, all the microbial causes of contamination obtained the maximum risk score. Identified the total risk, the WSP team listed the most proper control measures to put in place (Table 2.32), referred to each specific cause.

Table 2.32. *Causes and related control measures provided for the sub-Plan concerning the transport*

Cause	Control measure
Containers open	Use containers closed Awareness campaigns for the users
Containers dirty	Wash properly the containers Awareness campaigns for the users
Use of dirty utensils	Use proper utensils Awareness campaigns for the users
Hands dirty in contact with water	Avoid the contact between hands and water Awareness campaigns for the users
Use of containers previously employed for chemicals	Wash properly containers previously dedicated to transport or store chemicals Awareness campaigns for the users

In this sub-Plan, the WSP team decided to set two different control measures for each possible cause of contamination. On one hand, the action was the application of the correct behaviour's practices, such as close the containers, wash them properly with soap, etc., but on one other, each of these proper behaviours was accompanied by awareness campaigns of the users. The aim of this choice was to try to reach the maximum number of people, in order to improve not only drinking water quality, but even health conditions, of the majority of RCP inhabitants.

Table 2.33 reports the monitoring programme elaborated for this sub-Plan.

Table 2.33. *Control measures and related monitoring programme provided for the sub-Plan concerning the transport*

Control measure	Monitoring programme				
	What	How	When	Where	Who
Use containers closed Awareness campaigns for the users	Use of adequate containers	Controlling containers and people behaviour	Weekly	At the sources and at the dwellings	RPHC; Student representative (Mr Kama Cheick); Village leaders
Wash properly the containers Awareness campaigns for the users	Use of proper containers				
Use proper utensils Awareness campaigns for the users	Use of proper utensils				
Avoid the contact between hands and water Awareness campaigns for the users	Absence of contact between hands and water				
Wash properly containers previously dedicated to transport or store chemicals Awareness campaigns for the users	Use of proper containers				GIE and DHA

Even in this case, actions to monitor (*what*) were always the putting into practice of the specific control measures identified. The monitoring approach adopted (*how*) was to directly inspect the transport containers and contextually to control people's practices and behaviours. Regarding monitoring frequencies (*when*), these were extremely different compared with the previous sub-Plans. Since the likelihood of the different causes of contamination was rather always equal to the maximum, meaning that more or less every day these causes of contamination happened, the need to set a monitoring frequency quite high was highlighted by the team. The debate amongst the members brought to fix a weekly control. Regarding monitoring place (*where*), both the sources and the dwellings were considered. Responsible of the control (*who*) were identified in the people more in contact with the whole community, as the RPHC, the University students and the village leaders. The only chemical hazard highlighted was decided to be monitored by DHA and GIE, since this cause was more frequent in the vendors using tanker trucks that were used to collect water at the protected wells network managed by GIE (DHA was, since its role, put alongside GIE as supervisor).
Table 2.34 reports all the control measures with the related objectives and corrective measures. Indeed, in this sub-Plan, objectives have been identified, instead of critical limits, to be achieved in a given period of time. The WSP team adopted this strategy deeming it necessary in view of the inability to comply with (at the entry into force of the WSP) of the acceptable limits of drinking water, at least for the microbiological parameters, in the short term. The objectives set for the WSP, defined in both the short (6 months) and medium term (1 year), were expressed as the percentage of observations complying with control measures. The idea of introducing objectives was established in order to begin a change in the behaviour of the population, laying the groundwork to get the introduction of critical limits during the next revision of the WSP. Regarding corrective measures, the WSP team decided to strengthen the awareness campaigns (if objectives would not be reached), deeming it the only possible solution for improving hygiene and behavioural change.

Table 2.34. *Control measures and related objectives and corrective actions provided for the sub-Plan concerning the transport*

Control measure	Objectives	Corrective measure
Use containers closed	70% closed containers in 6 months	Strengthen the awareness campaigns
Awareness campaigns for the users	90% closed containers in 1 year	Spur on people to use jerry tanks instead of aluminium basins
Wash properly the containers	90% proper containers in 6 months	Strengthen the awareness campaigns
Awareness campaigns for the users	100% proper containers in 1 year	
Use proper utensils	90% proper utensils in 6 months	
Awareness campaigns for the users	100% proper utensils in 1 year	
Avoid the contact between hands and water	70% people without contacts hands/water in 6 months	Strengthen the awareness campaigns
Awareness campaigns for the users	90% people without contacts hands/water in 1 year	Spur on people to use jerry tanks instead of aluminium basins
Wash properly containers previously dedicated to transport or store chemicals	None uses these containers	Application of the expected hygiene sanctions
Awareness campaigns for the users		

The last step was the elaboration of a verification programme (Table 2.35). Amongst activities to verify (*what*), all the ones related to microbiological causes were characterised by drinking water quality analyses, whereas regarding the chemical hazard the evaluation of organoleptic parameters was decided. The verification approach adopted (*how*) was referred to drinking water analyses for all the control measures. Frequencies of verification (*when*) were set every 6 months for microbiological causes and monthly for the chemical one. Verification places (*where*) were set at the dwellings (before the storage), during the transport and at the laboratory. Finally, representatives of DHA were involved as people responsible for the verification of each action (*who*).

Table 2.35. *Control measures and related verification programme provided for the sub-Plan concerning the transport*

Control measure	Verification programme				
	What	How	When	Where	Who
Use containers closed	*E. coli* < 1 CFU/100 mL Faecal streptococci < 1 CFU/100 mL	Drinking water analyses	Every 6 months	At the dwellings (before the storage), during the transport and at the laboratory	DHA
Awareness campaigns for the users					
Wash properly the containers					
Awareness campaigns for the users					
Use proper utensils					
Awareness campaigns for the users					
Avoid the contact between hands and water					
Awareness campaigns for the users					
Wash properly containers previously dedicated to transport or store chemicals	Organoleptic parameters		Monthly		
Awareness campaigns for the users					

2.5.1.5 The storage and consumption

The last part of the WSP developed in the RCP was related to storage and consumption at household level, so from storage containers' filling until the moment of drinking. Table 2.36 lists all the contamination causes provided by the team during the WSP elaboration, with the related risk scores. As for the other sub-Plans, the hazardous event considered was always drinking water contamination.

Table 2.36. *Hazards, causes and risk scores provided for the sub-Plan concerning the storage and consumption*

Hazard	Cause	Risk		
		Likelihood	Severity	Score
Microbial	Containers open	5	5	25
	Containers dirty	5	5	25
	Hands dirty	5	5	25
	Dirty environment nearby the containers	5	5	25
	High drinking water storage time (> 24h)	4	3	12
	Filtration with dirty tissues	3	5	15
	Cups used for drinking dirty	5	5	25
Chemical	Use of containers previously employed for chemicals	2	3	6
	Chlorine overdose	1	3	3

Even in this sub-Plan, only microbial and chemical hazards were identified. Regarding microbiological contamination, all the possible improper behaviours that could cause water pollution were listed in the WSP, whereas for chemical contamination only the use of containers previously employed for the transport or storage of chemicals and chlorine overdose were identified. If almost all the microbiological causes were characterised by the maximum risk score, meaning that happened every day and with a certain water pollution, some exceptions were highlighted regarding in particular the high drinking water storage time and the use of dirty tissues for filtration. If the first had a higher likelihood but a lower severity of consequences, conversely the second one was characterised by the maximum severity and a lower frequency. Comparing risk scores provided in this sub-Plan with the ones determined for water points, as for the sub-Plan concerning transport step, higher values were provided. Indeed, worse practices in drinking water management during storage and consumption were recognised by the WSP team. Identified the total risk, the WSP team listed the most proper control measures to put in place (Table 2.37), referred to each specific cause.

Table 2.37. *Causes and related control measures provided for the sub-Plan concerning the storage and consumption*

Cause	Control measure
Containers open	Use containers closed Awareness campaigns for the community
Containers dirty	Wash properly the containers Awareness campaigns for the community
Hands dirty	Avoid the contact between hands and water Awareness campaigns for the community
Dirty environment nearby the containers	Guarantee a proper environmental hygiene
High drinking water storage time (> 24h)	Change drinking water daily
Filtration with dirty tissues	Use a proper piece of tissue
Cups used for drinking dirty	Use proper cups for drinking purposes Promote the use of containers with valves
Use of containers previously employed for chemicals	Wash properly containers previously dedicated to transport or store chemicals
Chlorine overdose	Dose the correct quantity of chlorine

Control measures identified in this sub-Plan were the application of the correct hygiene and water management practices. The first three (and probably most important) causes were characterised even by the presence of awareness campaigns of the users, in order to reach the maximum number of people. Regarding the correct dosage of chlorine, the team was made aware that the optimal dosage was 1 cap of chlorine bottle per each container of 20 L capacity poured in the storage container.

Table 2.38. *Control measures and related monitoring programme provided for the sub-Plan concerning the storage and consumption*

Control measure	Monitoring programme				
	What	How	When	Where	Who
Use containers closed	Containers closed	Inspections and awareness campaigns	Weekly	At the dwellings	RPHC and DHA
Awareness campaigns for the community					
Wash properly the containers	Healthiness of the containers				
Awareness campaigns for the community					
Avoid the contact between hands and water	Absence of contact between hands and water				
Awareness campaigns for the community					
Guarantee a proper environmental hygiene	Environmental hygiene				
Change drinking water daily	Water changed daily				
Use a proper piece of tissue	Proper tissues				
Use proper cups for drinking purposes	Healthiness of the cups				
Promote the use of containers with valves	Level of spread				
Wash properly containers previously dedicated to transport or store chemicals	Healthiness of the containers		Every 3 months		
Dose the correct quantity of chlorine	Quantity of chlorine dosed		Weekly		

Table 2.38 concerns the monitoring programme elaborated for this sub-Plan. Even in this case, actions to monitor (*what*) were always the putting into practice of the specific control measures identified. In particular, for the use of proper storage containers with valve (suggested in order to decrease the contact between drinking water and contamination vectors and because the preliminary assessment demonstrated that the use of this container was an effective method to reduce microbial contamination), the action to monitor was the level of spread of these tanks amongst the RCP people. The monitoring approach adopted (*how*) was to directly inspect the containers and contextually to control people's practices and behaviours by means of continue awareness campaigns. Regarding monitoring frequencies (*when*), these were set weekly according to the decision taken for the transport sub-Plan. The only exception was represented by the use of containers previously dedicated to chemicals, for which the frequency was set every three months, due to the low likelihood provided during the risk assessment. Regarding monitoring place (*where*), only the dwellings were considered. Responsible of the control (*who*) were identified in the RPHC and DHA, since they were the only subjects with the authority for checking habits and behaviours inside the dwellings.
Table 2.30 highlights the control measures with the related objectives and corrective actions.

Table 2.39. *Control measures and related objectives and corrective actions provided for the sub-Plan concerning the storage and consumption*

Control measure	Objectives	Corrective measure
Use containers closed	95% closed containers in 6 months	Strengthen the awareness campaigns and increase the numbers of village trainers
Awareness campaigns for the community	99% closed containers in 1 year	
Wash properly the containers	70% proper containers in 6 months	
Awareness campaigns for the community	85% proper containers in 1 year	
Avoid the contact between hands and water	20% containers with valve in 6 months	
Awareness campaigns for the community	50% containers with valve in 1 year	
Guarantee a proper environmental hygiene	50% containers stored in a proper environment in 6 months	
	70% containers stored in a proper environment in 1 year	
Change drinking water daily	70% people changing water daily in 6 months	
	80% people changing water daily in 1 year	
Use a proper piece of tissue	60% proper tissues in 6 months	
	75% proper tissues in 1 year	
Use proper cups for drinking purposes	60% proper cups for drinking in 6 months	
	75% proper cups for drinking in 1 year	
Promote the use of containers with valves	20% containers with valve in 6 months	
	50% containers with valve in 1 year	
Wash properly containers previously dedicated to transport or store chemicals	95% proper containers in 6 months	
	99% proper containers in 1 year	
Dose the correct quantity of chlorine	60% people disinfecting drinking water in 6 months	
	75% people disinfecting drinking water in 1 year	

Even in this sub-Plan, objectives have been identified, instead of critical limits. For the actions that the WSP team considered easier to be achieved, as the cover of containers and their proper cleaning, really high percentages up to 99% were set. Regarding the use of containers with valve, instead, since beyond the behavioural change even money should be brought into play, a low coverage of people (up to 50% in one year) was provided. Regarding corrective measure, the WSP team decided to strengthen the awareness campaigns (if objectives would not be reached), deeming it the only possible solution for improving hygiene and behavioural change, accompanied by an increase of the number of village trainers that could make aware people amongst the 52 villages of the RCP.
The last step was the elaboration of a verification programme (Table 2.40).

Table 2.35. *Control measures and related verification programme provided for the sub-Plan concerning the storage and consumption*

Control measure	Verification programme				
	What	How	When	Where	Who
Use containers closed Awareness campaigns for the community Wash properly the containers Awareness campaigns for the community Avoid the contact between hands and water Awareness campaigns for the community Guarantee a proper environmental hygiene Change drinking water daily Use a proper piece of tissue Use proper cups for drinking purposes Promote the use of containers with valves	*E. coli* < 1 CFU/100 mL Faecal streptococci < 1 CFU/100 mL	Drinking water analyses	Every 6 months	At the dwellings and at the laboratory	DHA
Wash properly containers previously dedicated to transport or store chemicals	Organoleptic parameters		Monthly		
Dose the correct quantity of chlorine	Free chlorine [0.2-0.5 mg/L]		Every 6 months		

Amongst activities to verify (*what*), all the ones related to microbiological causes were characterised by drinking water quality analyses, whereas regarding the chemical hazard the evaluation of organoleptic parameters and the check of free residual chlorine were decided. The verification approach adopted (*how*) was referred to drinking water analyses for all the control measures. Frequencies of verification (*when*) were set every 6 months for microbiological causes and the correct dosage of chlorine, whereas a monthly frequency was decided for the other chemical one. Verification places (*where*) were set at the dwellings and at the laboratory. Finally, representatives of DHA were involved as people responsible for the verification of each action (*who*).

At the end of the fifth day of work, the WSP team was asked to designate a Responsible of the whole WSP, in order to coordinate all the activities and supervise all the members responsible of the monitoring of a specific control measure. The designation of the Responsible was made by votes that at unanimity elected the DHA Responsible of water, sanitation and hygiene monitoring, owing to its role and its optimal competences.

Once the work was completed, the WSP was presented during an extraordinary open meeting at the RCP Hall to all the community and in particular to village leaders. During the meeting, the Water Safety Plan has been explained, emphasizing its importance as a tool to ensure the supply of safe drinking water. A printed version of the WSP was subsequently posted in the Hall of the Rural Community, so that everyone could access it (Fig. 2.53). Team members were engaged, from as early as following weeks, in the implementation of the Plan, starting from control measures not yet existing.

Fig. 2.53. *Presentation of the WSP to the whole RCP (on the left), speech of the WSP Responsible (in the middle) and WSP printed version posted in the Hall of the Rural Community (on the right)*

2.5.2 Supporting programmes

Several actions are important in ensuring water safety, but do not affect water quality directly, supporting programmes fall into this category. They incorporate the principles of good process control that underpin the WSP. Codes of good operating, management and hygienic practices are essential elements of supporting programmes, which can include education of communities whose activities may influence water quality [26].

In this case study, two supporting programmes were developed. The first one was concerning training courses to 5 Hygienists, coming from five different villages of the RCP, in order to transfer the knowledge of the WSP approach and all the important good practices to take into account when managing and handling drinking water, even related to hygiene and sanitation. The second supporting programme was addressed to the local community, in particular 100 women and 100 students coming from the villages of Sambé and Dabel Bara (where the FonTov project was focused on). Awareness campaigns on water, sanitation and hygiene were organised in order to minimise all the possible contaminations of drinking water. This latter activity was carried out in collaboration with DHA.

Training courses addressed to form the 5 Hygienists were provided by means of simple but explicative pictures, highlighting bad and proper behaviours. A copy of these pictures was left to each Hygienist in order to be able to carry out alone the awareness of local communities, even after the end of the project (Fig. 2.54).

Fig. 2.54. *Bad and good practices in drinking water management related to the storage at dwelling (on the top) and at school (on the bottom)*

At the end of the training session, the Hygienists were asked to simulate an awareness campaign in a yard of the RCP, in order to become familiar as a trainer and to clarify any doubt that maybe arose during the simulation (Fig. 2.55).

Fig. 2.55. *A moment of the training course (on the left) and the simulation of an awareness campaign by a Hygienist (on the right)*

The second supporting programme, based on awareness campaigns for the local community, was developed in several sessions, owing to the high number of people to cover. By means of the use of pictures (as the ones shown in Fig. 2.54), participants were made aware on bad and good practices in hygiene, sanitation and drinking water management (Fig. 2.56).

Fig. 2.56. *Awareness campaigns addressed to women (on the left) and students (on the right) of Sambé and Dabel Bara villages*

Awareness campaigns were always organised with a participative approach, meaning that participants were asked to explain what they were seeing from the pictures shown and to comment what was wrong and what was right, according to their point of view. Then, open debates were organised in order to share the different opinions and to clarify, if necessary, important or unclearly aspects arisen from the discussion. At the end of each session, the summary of all the bad and good practices was carried out.
These campaigns were considered fundamental for the success and the sustainability of the WSP elaborated, and it was for this reason that a great effort was put in this activity.

2.5.3 WSP approach elaborated Vs WSP approach proposed by WHO

In this section a comparison between the WSP approach developed by the local team for the Rural Community of Patar and the standard framework proposed by the WHO (and described in Chapter 1) is proposed. Fig. 2.57 shows the conformities according to the WSP approach suggested by WHO.

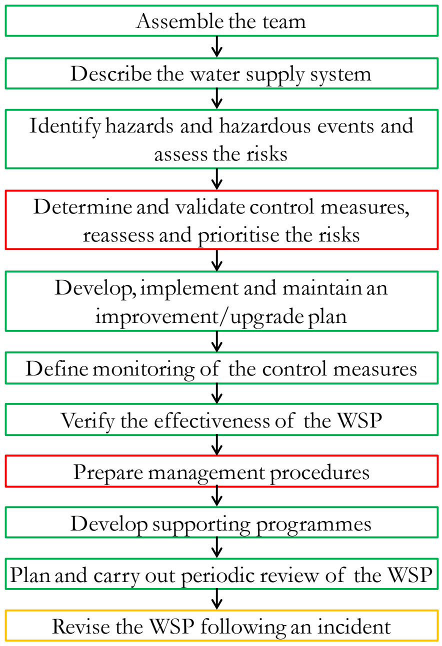


Fig. 2.57. *Conformities of the WSP approach carried out in the RCP in comparison with the standard approach (boxes highlighted in green report steps completely carried out, in red the ones not developed and in yellow the ones partially elaborated)*

An aspect that differed from the standard proposed by the WHO was the determination and validation of control measures, with the reassessment and the prioritisation of the risks. This step was completely not carried out, since already planned control measures for preventing or at least minimising drinking water contamination were not in place. For this reason it was impossible to validate the already existing control measures and reassess and prioritise risks. Moreover, a prioritisation of the risks (with a cut-off score, under which, theoretically, causes of contamination can be even neglected) was not carried out, since it has been considered significantly important to assess and provide control measures for each possible cause of contamination. The reason is that even a low minimisation or prevention in the contamination can improve the quality of drinking water, and therefore the potential improvement of health conditions of the local population.
The monitoring of control measures was correctly developed, including the definition of operational limits and corrective actions. The only simplification has been to not consider separately operational and critical limits, as instead suggested by WHO, in order to not complicate further the WSP.
The management procedures aimed at documenting actions to be taken when the system is operating under normal and “incident” conditions were neglected, because there were no differences between

normal and incident conditions (water delivered and consumed was already and always microbiologically and chemically contaminated). Regarding the development of supporting programmes and the planning of periodic review of the Plans, these steps were accordingly provided.
The last step suggested by WHO was the revision of the Plan following every emergency, incident or unforeseen event. This step was not carried out since every day local people were in emergency situation (concerning drinking water quality), but at least the WSP team was informed about the necessity to provide control measures, monitoring programmes, operational limits and corrective measures, and verification programmes for each new hazard identified.

2.6 Conclusions

This Chapter aimed at presenting the Water Safety Plan elaborated in a rural area of Senegal. Local conditions did not permit to develop a WSP approach in strict conformity with the one suggested by WHO, thus a slight revised framework was carried out. Community, managers of water points, Responsible of the local Health Centre and members of the local Hygiene Authority were involved as WSP team. In order to guarantee the consumption of safe drinking water, disinfection with chlorine at the point of consumption, the use of improved water containers (cans with valve) and the installation of household water treatment technologies (bone char-based filtration systems) were promoted amongst the population.
The following highlights summarise the main conclusions of this experimental research:

- ✓ A WSP was elaborated for the whole Rural Community of Patar, composed of 5 sub-Plans related to the three sources of drinking water available in loco (groundwater distribution system, protected wells network and open dug wells), the transport and the storage levels. The WSP team (put in place in agreement with the local political and technical Authorities) elaborated this Plan during 5 days of work, one for each sub-Plan.
- ✓ Members of the WSP team were made aware of all the measures to put into practice in order to prevent or at least minimise drinking water contamination along the entire supply chain. Moreover, they were directly involved in the monitoring and verification programme of control measures, in order to guarantee the sustainability of the WSP.
- ✓ As stated, the use of a storage container with valve that permits to minimise the contact between drinking water and contamination vectors was suggested and promoted, as well as water treatments at the point of consumption. This latter intervention was mandatory for trying to assure the consumption of safe drinking water, on one hand due to the microbiological contamination provided during the pre-assessment at household level and on the other due to the high concentrations of fluorides and lead in the water sources.
- ✓ Microbiological quality of drinking water was more acceptable amongst households that carried out a chlorination treatment at the storage point. The majority of these households followed the awareness campaigns, carried out during the first cooperation project implemented in loco by FonTov, regarding proper hygiene and correct management behaviours of drinking water.
- ✓ The use of bone char-based filters demonstrated the effectiveness in the reduction of fluorides concentration, naturally present in drinking water. The combination of this treatment with a chlorination (in order to remove microbes that highlighted to growth during the use of the filter) will permit to respect the drinking water quality standards.
- ✓ An unexpected high concentration of lead was determined in protected and unprotected wells, due probably to anthropic causes. Scientific works demonstrated the effectiveness of bone char-based filters for removing this pollutant. Experimental tests should carry out to effectively verify this solution, using the bone char-based filtration system spread in loco.
- ✓ Many efforts and energies must be put in the RCP for assuring the consumption of safe drinking water and, thus, the implementation of the WSP. Local partners (University of Dakar, Diourbel

Hygiene Authority and Rural Community of Patar) will have to be the reference point for all the actors involved in this change, in order to guarantee the sustainability of the work carried out in loco.

Unfortunately, the funds available from the project did not permit to carry out a third mission, which would have been extremely useful for verifying the level of drinking water management after the implementation of the WSP approach and the level of putting into practice of all the control measures listed into the WSP.

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Chapter 3. Water Safety Plan implementation in a rural area of Burkina Faso

Abstract

In 2011, the Italian NGO Medicus Mundi Italy, together with the University of Brescia (Italy) and the Burkinabe NGO Dakupa, started a cooperation project in the Municipality of Béguédo (Boulgou Province, Burkina Faso). The main aim of the project was to improve the health conditions of the local people. Amongst the activities of the project, in order to achieve this goal, there was the implementation of the Water Safety Plan (WSP) approach. Three missions were conducted in the field, in order to: assess the drinking water management and the main criticalities; elaborate and implement the WSP methodology; evaluate the drinking water management, handling and contamination level after the WSP implementation. The WSP carried out in the study area had a really simplified framework compared to the one proposed by the World Health Organisation and was used as a tool for the awareness campaigns of the local communities, regarding good practices to take into account in order to improve drinking water quality along the entire supply chain. Results showed as the WSP approach can be strongly effective in minimise / prevent the microbiological contamination, in terms of microbial growth during transport, storage and handling steps. Local people and drinking water supply managers were aware about all the possible sources of contamination and put in practice the control measures provided (according to the WSP elaborated), in order to avoid drinking water pollution.

3.1 Introduction

Drinking water supply is one of the key natural resource bases that are inevitable for sustainability of human and environment health [1]. Safe drinking water, sanitation and good hygiene are fundamental to the health, survival, growth and development of humanity [2]. The World Health Organisation (WHO) and the United Children's Fund (UNICEF) stated that these basic necessities are still a luxury for many of the world's poor people, highlighting even the strong link between socio-economic development and access to safe drinking water [3].

A large proportion of the world's people do not have access to improved or microbiologically safe drinking water sources. The Joint Monitoring Programme for Water Supply and Sanitation (JMP) of WHO and UNICEF [4] estimated that, in 2011, 768 million people relied on unimproved drinking water sources. Thus, water-related diseases, due to the consumption of unsafe water, continue to be one of the major health problems globally. Diarrhoea represents the largest share of this disease burden, causing an estimated 4 billion cases and about 2 million deaths each year, mostly in children under 5 years in developing countries [5-9]. A state-of-the-art literature review of 144 researches revealed that the expected reduction in diarrhoeal disease morbidity from improvements in water quality (alone) and water quantity (alone) can be 15 and 20% respectively [10-11].

Current estimates of the number of people using microbiologically unsafe water, however, are probably low. This is because the assumptions about the safety or quality of water based on its source, extent of treatment or consumer handling do not take into consideration several problems. The first one is that so-called protected or improved sources can still be fecally contaminated and deliver microbially unsafe water. Another problem contributing to the underestimation of the population served by unsafe water is contamination of water by the time it reaches the home (collection, transport and storage) and is consumed [5, 6, 9, 12-15]. Generally, post-supply water quality deterioration has been assumed to result from contamination through contact with hands or utensils used in domestic water management (Fig. 3.1). Another possibility that has rarely been considered is that bacterial growth is involved in water quality deterioration [16, 17].

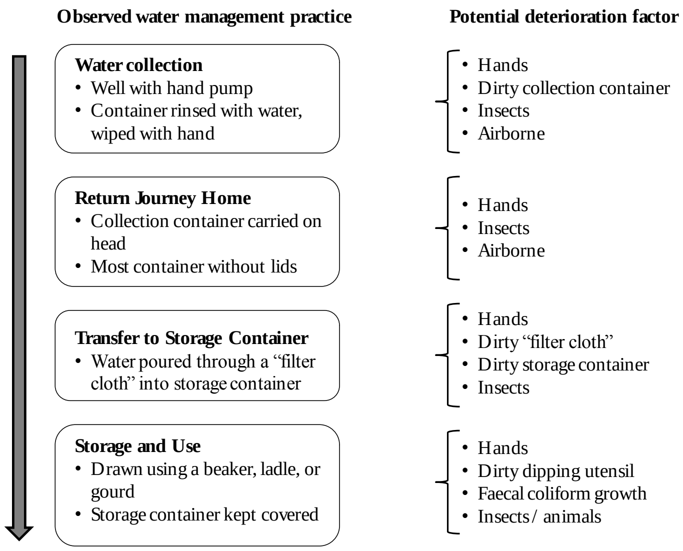

Fig. 3.1. *Conceptual framework showing the main characteristics of domestic water management, and the potential factors involved in water quality deterioration [17]*

A growing concern has therefore emerged that recontamination of water from safe sources has diminished or completely negated the expected positive health effects of providing access to improved drinking water sources. Indeed, there is only limited evidence that the provision of improved public water points reduces diarrhoea morbidity [6, 18-20]. These findings led to an increased interest in promoting water treatment technologies at point-of-use, such as chlorine addition, ceramic or biosand filters, cooking and / or solar disinfection. Results in the scientific literature have shown a potential 17-85% reduction of diarrhoeal diseases from the use of disinfection-based water treatment at household level [11]. Although all of these water treatments considerably improve water quality and help to gain worldwide public health, both usage rates and sustainability of measured effects remain low [19, 21]. The main reason is that all of these interventions require a behavioural change that not always is simple to achieve. Beyond treatments at household level, a positive effect on water quality can be done by improved water containers that require little in terms of behavioural change and they are often easier to use than traditional water transport and storage vessels. Obviously, improved water containers do not purify contaminated water, but they might be able to keep clean water clean [16]. The most interesting effectiveness is possible to achieve combining improved water containers with treatment at household level [22, 23].

As stated, drinking water quality deteriorates during collection, transport, storage and in distribution networks, so it becomes mandatory to prevent water contamination and to monitor water quality at each stage of delivery till the consumption [24]. The Water Safety Plan (WSP) approach is looking in this direction, implementing a systematic preventive management and risk assessment in order to avoid the consumption of contaminated drinking water. The objective of the WSP is to supply drinking water of a quality that will allow health-based targets to be met. The success of the WSP approach is assessed through drinking water supply surveillance [25]. The three key components of a WSP are:

- System assessment, which involves assessing the capability of the drinking water supply chain to deliver water of a quality that meets the identified targets, and assessing design criteria for new systems.
- Identification of control measures in a drinking water system that will collectively control identified risks and ensure that health-based targets are met. For each control measure identified, an appropriate means of operational monitoring should be defined that will ensure that any deviation from required performance is rapidly detected in a timely manner (before the consumption of the contaminated drinking water).

- Management plans that describe actions to be taken during normal operation or extreme and incident conditions, and that document system assessment, monitoring, communication plans and supporting programs.

In this third Chapter, the elaboration and implementation of a simplified WSP approach carried out in a rural area of Burkina Faso are presented. The case study is interesting and relevant for several reasons: the presence of microbiological contamination directly at the source level; the WSP carried out in the study area has a really simplified framework compared to the one proposed by WHO (and presented in Chapter 1); the population / community beneficiary of the WSP implementation is quite low (some of 3,000 inh); the WSP elaboration was used as a tool in order to aware local community and sources' managers on the correct practices for drinking water management and handling.

3.2 The Burkina Faso context

Burkina Faso is one of the poorest countries in the world, ranking 183th out of 187 countries in the 2012 United Nations (UN) Human Development Index (HDI)[9]. Burkina Faso's HDI value for 2012 was equal to 0.343 (in the low human development category). Between 2005 and 2012, Burkina Faso's HDI value increased from 0.301 to 0.343, a total increase of 14% or average annual increase of about 1.9%. Burkina Faso's 2012 HDI of 0.343 is below the average of 0.466 for countries in the low human development group and below the average of 0.475 for countries in sub-Saharan Africa. From sub-Saharan Africa, countries which are close to Burkina Faso in 2012 HDI rank and population size are Mali and Chad, which have HDIs ranked 182 and 184 respectively [26].

According to the data published by JMP, in 2011, Burkina Faso already met the Millennium Development Goal (MDG), concerning the access to safe drinking water. Indeed, at national level, the proportion of population without sustainable access to safe drinking water was more than halved, decreasing from the 56% of 1990 up to the 20% of 2011. However, more efforts are required for improving this condition, since rural population without access to improved sources still represents the 26% (on the contrary, the urban population is estimated at 4%) [4], and since, globally, WHO has estimated about 25,000 deaths each year caused by diarrhoea only, owning to poor water, sanitation and hygiene [27].

Government ministries and directorates, the public water utility, and municipal / local communities each play a role in managing the drinking water sector. The Ministry of Agriculture, Hydraulics, and Fishery Resources has overall responsibility. The General Directorate of Water Resources (water management department within the Ministry) and the National Office of Water and Sanitation (ONEA) share responsibilities for infrastructure and water supply and sanitation projects. Lastly, there are a total of 49 urban municipalities and 302 rural towns, which the government is transferring authority to for the management of water supply and sanitation services, as part of a broad decentralisation strategy. Moreover, in 2006, Burkina Faso adopted a National Water Supply and Sanitation Program (PN-AEPA) that includes a comprehensive set of water supply and sanitation policies and strategies for the sector as a whole.

Theoretically, the rural sector should benefit the most from national reforms in water supply and sanitation policies, decentralisation, and expansion of sustainable service, owing to the local control over water supply services provided by water Committees or users Associations (CGPEs). The problem is that, often, CGPEs are not been aware about their role and responsibilities and regarding the best practices to put in place in order to guarantee safe water (at least) at the source level. Thus, with little support from the General Directorate of Water Resources, community service providers have relied upon support from international donors and local and international Non-Governmental Organisations (NGOs), in addition to a growing sector of private water supply service providers. Typically, water

[9] The Human Development Index (HDI) is a summary measure for assessing long-term progress in three basic dimensions of human development: a long and healthy life, access to knowledge and a decent standard of living.

supply service management capacity is higher in areas where rural providers are supported by outside organisations like a NGO or international donors. Major donors to Burkina Faso's water supply sector include the World Bank, the Water and Sanitation Program for Africa, the African Development Bank, the European Union, WaterAid NGO, and the governments of Denmark, Germany and Japan [28].
Between 2011 and 2013, Medicus Mundi Italy NGO developed in Burkina Faso a cooperation project titled "Water, health, hygiene and socio-economic development in the rural area of Béguédo (Burkina Faso)", co-funded by the Municipality of Brescia, Rotary Club Milano Sempione, Fondazione della Comunità Bresciana and CeTAmb (Research Centre on Appropriate Technologies for Environmental Management in Developing Countries, University of Brescia, Italy). The project has been developed with the technical collaboration and support of Dakupa, a local NGO, who was responsible for the activities' implementation. This project was aimed at improving the health conditions of people by means of: the prevention of major infectious diseases' spread and the improvement of health services' hygiene and quality; the improvement of hygiene in the primary schools; the increase and improvement of access to safe drinking water and sanitation devices.
The experimental research proposed in this paper, which is the elaboration and implementation of a Water Safety Plan approach in order to prevent or at least minimise the drinking water contamination along the entire supply chain, was carried out within the latter project activity listed above. In the following paragraphs the work done in the field and the WSP elaborated will be presented.

3.3 Materials and methods

The cooperation project, elaborated by Medicus Mundi Italy (MMI) in Burkina Faso, was carried out in two rural villages, Fingla and Diarra, which are part of the Municipality of Béguédo, Health District of Garango, Boulgou Province (Fig. 3.2).
The Province of Boulgou has a population of 542,286 inhabitants (of which 54% women), an area of 6,692 km^2, a population density of 81.03 inh/km^2 and is located in the Centre-East region of the country, crossed by the second national river, called Nakambé. This Province is populated by three main ethnic groups: Peulh, Mossi and Bissa (the more consistent one). The population is mostly young: about 80% is under 40 years of age. The Province of Boulgou has 5 departments and includes:

- 6 urban municipalities: Tenkodogo (the provincial capital, located about 180 km south-east of the national capital, Ouagadougou), Koupela, Pouytenga, Bittou, Ouargaye and Garango;
- 24 rural municipalities;
- 676 villages.

Agriculture and livestock are the main activities of the population of the Province (97%). Agricultural production is focused mainly on the cultivation of cereals during the rainy season (i.e.: millet, sorghum, corn, peanuts, etc.), whereas the dry season is characterized by the cultivation of onions, aubergines and tomatoes. Even farming is very important in the Province; livestock is consisting of cattle, goats, sheep, pigs and poultry. On the contrary, craft and trade are poorly developed.
The Health District of Garango, created in 2007 by division of the District of Tenkodogo, includes an urban municipality (Garango) and four rural municipalities (Béguédo, Boussouma, Komtoèga and Niaogho), covers 55 villages, for a global area of 1,994 km^2, with a population of approximately 182,439 inh. The population of the District of Garango is served by a district's hospital and 20 rural Health Centres [29].

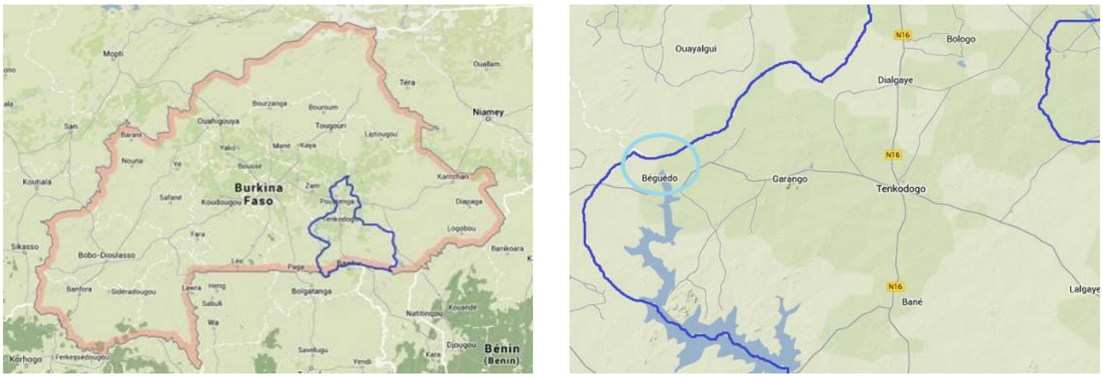

Fig. 3.2. *The Province of Boulgou in Burkina Faso (on the left) and the Municipality of Béguédo in the Province (on the right)*

The villages of Fingla and Diarra, as a whole, count about 3,000 inh and are located approximately 3 km far from Béguédo. Fingla has a Health Centre (CSPS), built in 2008, serving the people of both villages Fingla and Diarra. It should be noticed that at least 80% of the population lives less than 5 km from the CSPS and that Diarra village is inaccessible during the rainy season, owing to the presence of a branch of Nakambé river.

The project implemented by MMI NGO was the first one carried out in Fingla and Diarra villages, not even local Associations or NGOs worked in that area before.

The experimental activities carried out in this research were conducted during three missions in the field. The first one was done at the beginning of the project, between November and December 2011. The aim of this mission was to gather all the information required in order to develop an appropriate WSP for the local area. The second mission in the field was conducted between October and December 2012 and was aimed at elaborating and developing the WSP. The third and final mission has been done at the end of the project, between May and June 2013, with the aim of verifying the level of drinking water management after the implementation of the WSP approach.

In the following sub-paragraphs, the detailed activities carried out in each field mission are proposed.

3.3.1 Pre-assessment

Since at the beginning of the project, the data available on Fingla and Diarra villages were not sufficient to develop a WSP, the intent of the first mission was to collect as much information as possible in order to carry out a proper hazard assessment and risk characterisation regarding the drinking water supply.

<u>Drinking water sources: identification and risk assessment</u>

One of the first activities was to <u>identify all the water sources' type</u> available and used by the population. Jointly with this, a sanitary survey of each water point was conducted according to the standardised forms suggested by WHO [30]. <u>Sanitary inspections</u> of water systems and resources regard the ongoing status of the water supply and the potential risks of contamination in the long term. They are useful to identify what interventions are required and they are a tool that can be used by water-point committees to be able to monitor their water supply. Three main types of risk factor are included in sanitary inspections:

- *hazard factors*: these are sources of faeces in the environment (e.g. pit latrines, sewers, solid waste dumps and animal husbandry);
- *pathway factors*: these are factors that allow microbiological contamination to enter the water supply, but that are not direct sources of contamination (e.g. leaking pipes, eroded catchment areas and damaged protection works);

- *indirect factors*: these are factors that enhance the development of pathway factors, but do not directly allow contamination of the supply and are not a source of faeces (e.g. lack of fencing, faulty surface-water diversion drainage).

In the majority of cases, a sanitary survey on its own can provide a reasonable idea of the bacteriological quality of the water and its vulnerability to pollution, but it is important to complement this information with water-quality analyses [31]. Indeed, microbiological (through the determination of *E. coli*, faecal coliforms, total coliforms and faecal streptococci) and physico-chemical (temperature, pH, conductivity, TDS, COD, BOD_5, iron, manganese, fluorides, ammonium, nitrates and nitrites) analyses of water points were conducted. The membrane filtration (MF) method was applied for microbiological analyses, as described in [30, 32, 33], by means of a TRAWAS laboratory (Sandberg and Schneidewind) consisting in a portable incubator, a membrane filtration system and a steriliser device. TRAWAS test kits for *E. coli*, faecal coliforms, total coliforms and faecal streptococci determination, based on Nutrient Pad Sterile (NPS) Membrane and dry nourishing (in sterile Petri dishes), were employed. The analyses were performed on-site, with field instrumentation (Fig. 3.3), brought from Italy.


Fig. 3.3. *TRAWAS laboratory installed in the field for microbiological analyses of drinking water*

Physical analyses were also carried out by means of field instrumentation: ECO testr EC low for the conductivity analysis, ECO testr pH 1 for the pH analysis and Digital Thermometer 30.1018 for temperature determination. On the contrary, chemical analyses were provided by the laboratory of 2iE Foundation (International Institute for Water and Environmental Engineering) based at Ouagadougou.
Another activity carried out during the first mission, concerning water points where a water Committee (CGPE) was established, was an interview of the own members (Annexe 5), in order to understand the management level of the source (if there is in place a periodic water quality control, how is the financial management, what is the frequency with which meetings between members take place, which is the role and the duty of each member, etc.).

Transport and storage steps: identification and risk assessment

Identified the positive aspects and the criticalities at the source level, the focus moved to the supply chain. The first activity was to identify the supply chain, trying to understand how people were collecting, transporting and storing water. In order to gather all the necessary information, interviews with local families were also carried out. Thanks to the help of Dakupa NGO, 200 questionnaires (Annexe 6) were collected amongst the Fingla and Diarra villages (an interview for each yard[10]). These interviews had a dual purpose: on one hand to gather information related to drinking water (which source and which container for transport and storage were used, frequency of cleaning of these containers, type of treatment carried out, etc.), and secondly collect information on hygiene and sanitation (type of defecation, frequency of use and cleaning of latrines, hand-washing, etc.) and on health conditions (type of diseases contracted in recent months, frequency and level of access to the

[10] In Burkina Faso, villages are composed by yards (in French *concessions*) lived by members of the same family (in the majority of cases) or also by members of different families.

CSPS, etc.). The elaboration of collected data was then carried out by means of the software Epi Info™ 3.5.1, which is a tool usually used by epidemiologists for elaborating and investigating health data. The particular and "friendly" layout of the software permitted to well analyse data such as the ones collected by interviews.
The investigation of the water quality in the supply chain was provided by the conduction of microbiological analyses (*E. coli*, faecal coliforms, total coliforms and faecal streptococci). During the interview, twenty families were required to take samples of water from the transport and storage containers in order to conduct a quality analysis and thus evaluate the microbiological contamination. Analyses were performed on-site, as previously stated, with a field instrumentation (Fig. 3.3) brought from Italy. Then, using the software Quantum GIS 1.7.3, it was possible to represent the results of microbiological analyses in maps of Fingla and Diarra villages, in order to identify possible correlations between the contamination rate and the location of the investigated samples.

3.3.2 WSP approach elaboration

The elaboration of the WSP approach to be implemented in Fingla and Diarra villages was conducted according to the results obtained from the first mission in the field. Since the awareness level of local people on good practices in managing and handling drinking water was deeply low as well as the global educational level, the idea was to develop a simplified WSP approach that could be used as a tool for consciousness campaigns. The impossibility to involve neither local political authorities (the Municipality of Béguédo), owing to the election campaign that was developing in those months and that was particularly intense (opposite political parties arrived to fight each other), nor local technical institutions (the General Directorate of Water Resources based in Tenkodogo), because the person in charge of drinking water management and quality control changed job before the beginning of the project and a new manager was assigned only after the WSP implementation, were also two reasons to implement a simplified WSP directly elaborated with the local population.
Even if local authorities were not involved, a key role on WSP elaboration was played by the NGO Dakupa who was the supervisor of the Plan and helped in the engagement of the population.
A specific WSP was developed for each improved source (tubewells with hand pump) present in both villages (11 globally). The people involved in the WSP elaboration were the CGPE and the source's users. The awareness campaigns were divided in 3 days: the first one dedicated to examine all the possible contamination's risks and the related control measures referred to the water point; the second one to analyse the transport step; whereas, the third day had the aim to investigate the storage and consumption point. Table 3.1 shows the WSP steps, suggested by WHO, carried out and not in the elaboration of the WSPs for Fingla and Diarra.

Table 3.1. *Steps carried out during the WSP elaboration*

WSP step	Provided
Assemble the WSP team	/
Describe the water supply system	V
Identify hazards and hazardous events and assess the risks	V
Determine and validate control measures, reassess and prioritise the risks	/
Develop, implement and maintain an improvement/upgrade plan	V
Define monitoring of the control measures	V
Verify the effectiveness of the WSP	/
Prepare management procedures	/
Develop supporting programmes	V
Plan and carry out periodic review of the WSP	V
Revise the WSP following an incident	/

It has to be highlighted that the WSP team was not put in place in advance (as expected by the WHO guidelines and manuals and deeply illustrated in Chapter 1), but after the WSP elaboration. This is due to the fact that the WSP team for each water point is composed by the people responsible for each control measure identified during the elaboration of the Plan (more details will be given in paragraph 3.5). Regarding the validation of control measures, this step was not provided since there were not control measures already in place at the time of WSP elaboration.

3.3.3 Post-assessment

Six months after the elaboration and primary implementation of the WSPs for each improved source, a mission in the field took place in order to verify the management and the quality of drinking water along the entire supply chain. Thus, the aim of this post-assessment was to evaluate the control measures provided by the WSPs and to check the effectiveness of the Plan.

The first activity, as for the pre-assessment, was to conduct a <u>sanitary inspection for each source</u> and to complement this information with <u>water quality analyses</u>. Since results of physico-chemical analyses carried out during the first mission did not highlight any pollution (see paragraph 3.4), only microbiological analyses were conducted. The instrumentation used and the parameters investigated were the same of the pre-assessment.

Even the <u>interviews at household level</u> were conducted, in order to evaluate if the bad practices underlined in the first mission, regarding management and handling of drinking water from the catchment to the point of consumption, were changed. With the support of Dakupa NGO, 200 families were again interviewed for gathering information related to drinking water, hygiene and sanitation, and health conditions (as in the pre-assessment, the elaboration of interview's data were conducted by means of the software Epi Info™ 3.5.1). During the interview, twenty-four families were required to take samples of water from the transport and storage containers in order to conduct a <u>quality analysis</u> and thus evaluate the <u>microbiological contamination</u>.

Finally, a <u>check of all the control measures</u> identified during the WSPs elaboration as well as the role of each member of the WSP teams was carried out through field surveys and informal interviews.

3.4 Hazard assessment and risk characterisation

In this section the results of the local situation's assessment are presented. The first paragraph shows the hazard evaluation, the quality and the management of the drinking water sources identified, whereas in the second paragraph the analysis of other steps of the drinking water supply chain (transport and storage) is provided.

3.4.1 The drinking water sources

3.4.1.1 Identification

The survey carried out in Fingla and Diarra villages permitted to identify three different water sources used by the population for drinking purposes (Fig. 3.4): (1) tubewells fitted with hand pump, (2) open dug wells and (3) river.

Fig. 3.4. *Tubewells (on the left), open dug wells (in the middle) and river (on the right) used for drinking purposes by local communities*

The first ones were protected tubewells with hand-pump, realised by enterprises drilling the soil after a careful hydrogeological analysis. Water is extracted by a hand-pump through a pipe that reaches the aquifer about 60 m in depth. These wells are characterised by the presence of concrete aprons, walls and drainage channels that canalize (waste)water to an absorbing well. The second water sources identified were open dug wells, hand-dug directly by local population since the unconfined aquifer was already reached at about 8 m in depth. These wells, except for a wellhead (not always built with a proper height, like the one showed in Fig. 3.4), are usually not equipped with concrete aprons, drainage channels and cover slabs. Only few wells were identified with these equipments but they were always improper or broken. The third source of drinking water was the river (a branch of Nakambé river) that separates the villages of Fingla and Diarra. This source was obviously used only during, or the months after, the rainy season.

Water sources presented above are not equally distributed between the two rural villages (Fig. 3.5). Indeed, Fingla has 9 tubewells (2 of which realised by the project implemented by MMI and 1 built by the National Government, during the MMI project implementation, for serving the CSPS of Fingla) and 16 open dug wells, whereas Diarra, due to the presence of the seasonal river and the deeper water level of the unconfined aquifer, has only 2 tubewells (1 of which realised by the project implemented by MMI). This means that Fingla has one tubewell per some of 240 people, whereas Diarra one per about 400 people. Only tubewells are counted in this estimation since they are the only improved drinking water sources.

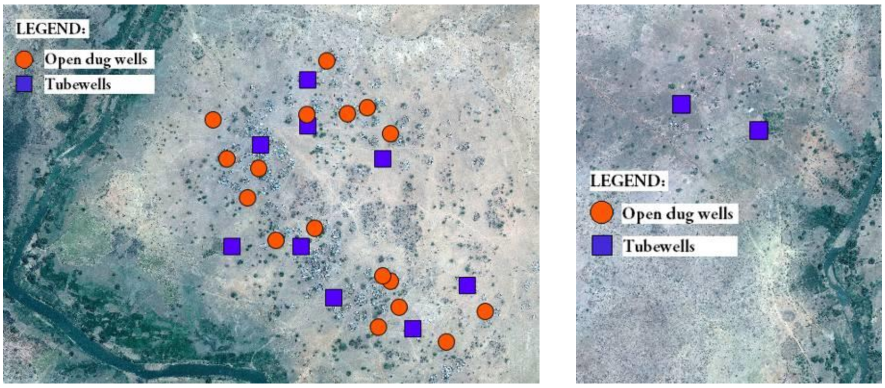

Fig. 3.5. *Water sources distribution in Fingla (on the left) and in Diarra (on the right) villages*

3.4.1.2 Sanitary inspections

Jointly with the identification of each source, a sanitary inspection was carried out in order to have a reasonable idea of the bacteriological water quality and its vulnerability to pollution. According to the standardised forms provided by WHO, the tubewells of Fingla and Diarra were evaluated (in total 9, since 2 out of 4 new wells were not realised yet) (Fig. 3.6).

Results showed that none of the tubewells had neither a proper environment around them, owing to the presence of pollution (excreta, rubbish, animals, etc.), nor an adequate fencing in order to keep away animals. Some of them, moreover, were characterised by ponding on the concrete floor or presence of stagnant water or inadequate concrete aprons. For these reasons, 5 tubewells were classified with a low risk of contamination, since they were characterised by 1 or 2 (out of 10) hazards according to the sanitary inspection, whereas the other 4 tubewells provided a medium risk of contamination, since they had from 3 to 5 hazard properties.

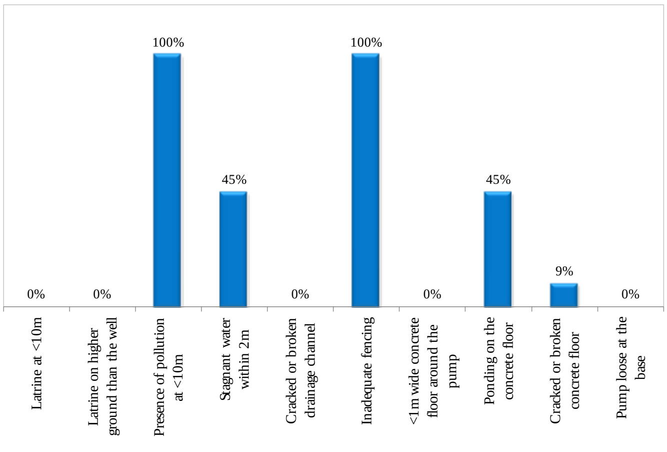

Fig. 3.6. *Results of the sanitary inspections carried out on tubewells*

Even the 16 open dug wells identified at Fingla were investigated (Fig. 3.7). The analyses demonstrated how many risks of contamination characterised these water sources, since about all the factors questioned during the inspection were positive. 8 wells provided a high risk of contamination, since they had from 6 to 9 (out of 12) hazard properties, whereas the remaining 8 were classified with a very high risk, because they were characterised by more than 9 hazards.

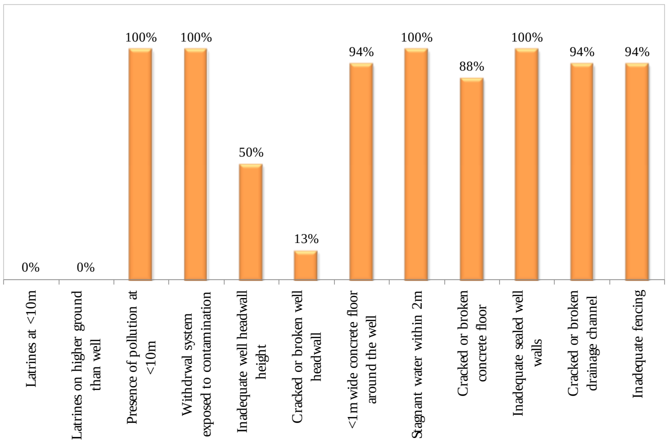

Fig. 3.7. *Results of the sanitary inspections carried out on open dug wells*

3.4.1.3 Hazard evaluation

Most of the hazards were evaluated during the sanitary inspection, when the presence of stagnant water, rubbish, excreta and animals around the water sources were identified in both well types (Fig. 3.8).

Fig. 3.8. *Hazards of pollution at water points: stagnant water (on the left), presence of animals (in the middle) and presence of rubbish (on the right)*

Even integrity problems of tubewells' structure arose in some cases, as well as the inadequate cleaning of the drainage channel that sometimes was responsible for the stagnant water's presence around the well. Rubbish and food residues on the concrete floor of tubewells represented another source of pollution. Related to this type of water source, an important risk factor was identified in the improper hygiene condition of the water extraction pipe, owing to the presence of algal formation inside (Fig. 3.9).

Fig. 3.9. *Algal formation into the water extraction tube*

Regarding open dug wells, the major sources of pollution were the inadequate structural protection of the well (absence of appropriate concrete aprons, drainage channels, etc.), the improper hygiene condition, due to the exposition to contamination of buckets and ropes (withdrawal system) used for water extraction, and the presence of rubbish and other sources of contamination inside the well, on the surface layer of water.

3.4.1.4 Water quality analyses

At source level, water quality analyses covered both physico-chemical and microbiological parameters. Regarding the latter ones, *Escherichia coli*, faecal coliforms, total coliforms and faecal streptococci were investigated. Results present in the following section referred particularly on *E. coli* and faecal streptococci, which are the ones suggested by WHO and European Union (EU) guidelines for drinking water quality determination. Other results will be presented in section 3.4.2, focused on the supply chain. Water samples were always collected in sterilise containers, stored in ice boxes and analysed within 4 hours from sampling (all data collected are reported in Annexe 7).
Fig. 3.10 provides results on *E. coli* determination both in tubewells and open dug wells. Referring to the categories suggested by WHO on the count of bacteria per 100 mL of sample analysed, it is possible to notice the extremely high concentrations of *E. coli* in open dug wells, since they all provided values above 1,000 CFU (Colony Forming Units) per 100 mL. On the contrary, tubewells were characterised above all by 1 to 10 CFU per 100 mL.

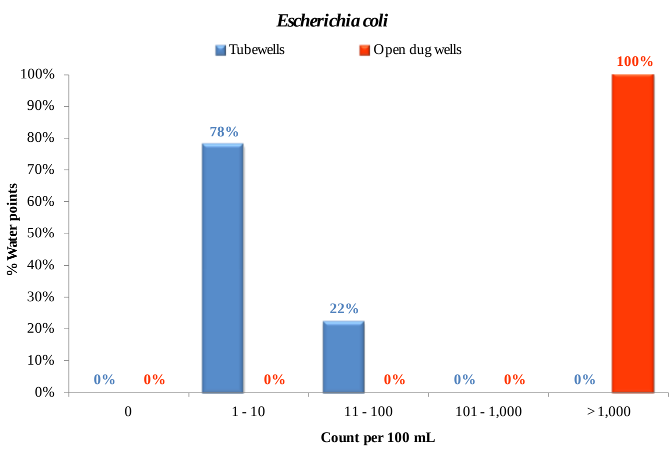

Fig. 3.10. *E. coli in tubewells and open dug wells*

Regarding the faecal streptococci (Fig. 3.11), comparable results were obtained. All the tubewells provided a contamination between 1 and 10 CFU per 100 mL, whereas open dug wells were characterised mainly by 100 to 1,000 CFU.

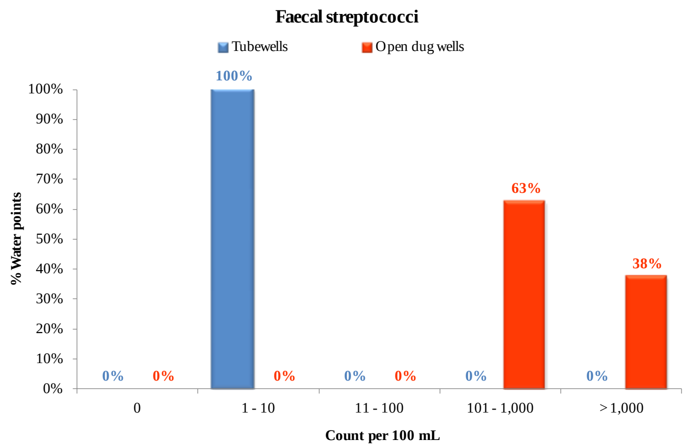

Fig. 3.11. *Faecal streptococci in tubewells and open dug wells*

Results obtained from the microbiological analyses were compared with the contamination risks provided by sanitary inspections. Fig. 3.12 and Fig. 3.13 show these correlations for tubewells and open dug wells respectively.

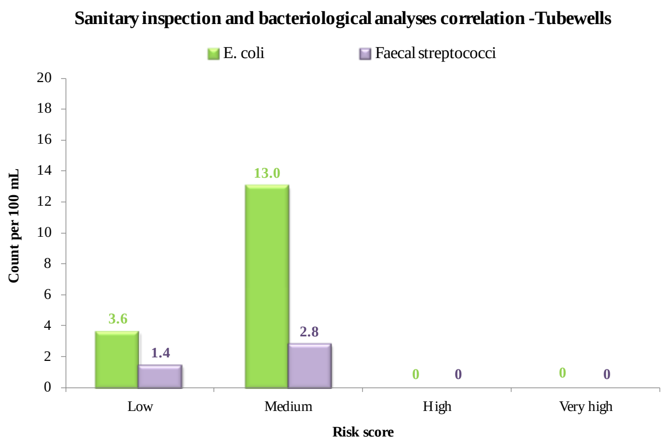

Fig. 3.12. *Sanitary inspection risk score Vs microbiological analyses for tubewells*

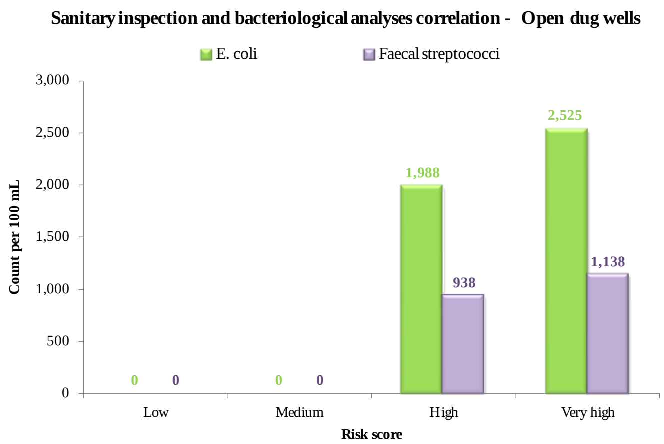

Fig. 3.13. *Sanitary inspection risk score Vs microbiological analyses for open dug wells*

It is self evident that *E. coli* and faecal streptococci content increases according to a higher number of detected risk factors: in particular, it can be highlighted that values detected in low and medium risk classes (tubewells) are significantly lower than the ones obtained in the two higher classes (open dug wells). The good correlation between concentration of bacteria and contamination risk score is one of the proofs that appropriate configuration and correct management of wells are basically important to guarantee a safer water supply.

One of the hazards identified in the tubewells, in the previous step of the research, was the presence of algal formation inside the pipe. For this reason, samples collected before and after the cleaning of the pipes were microbiologically analysed. The cleaning was done with a proper piece of tissue soaked with chlorine, in order to remove the algal formation and to disinfect the tube (Fig. 3.9).

Fig. 3.14 and Fig. 3.15 show, respectively, *E. coli* and faecal streptococci concentrations before and after the disinfection. It is possible to clearly notice how much efficient was this simple treatment that permitted to enhance water quality at the source level. The average contamination due to *E. coli* moved from 7.2 to 0.8 CFU per 100 mL, whereas faecal streptococci from 2.0 to 0.3 CFU per 100 mL.

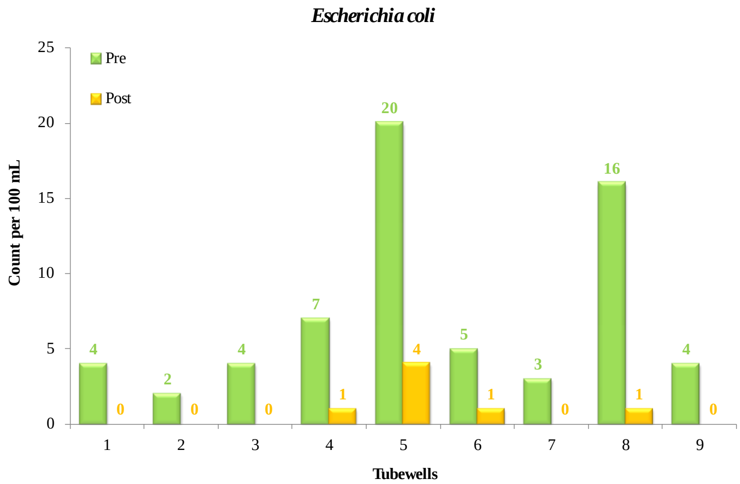

Fig. 3.14. *E. coli concentration pre- and post-disinfection treatment in tubewells*

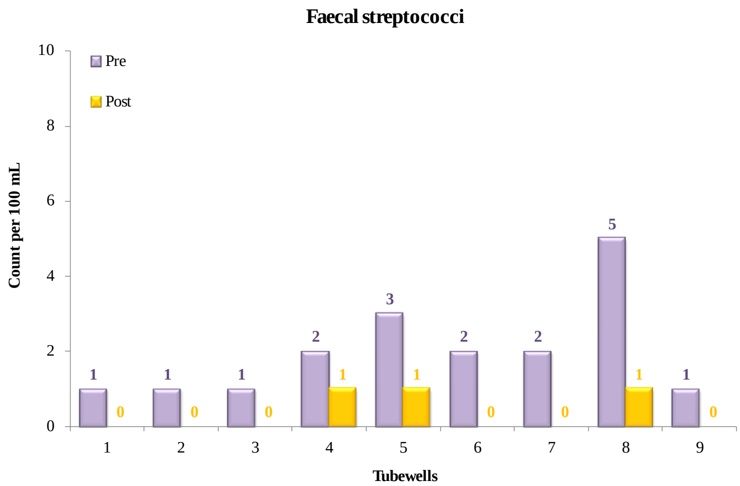

Fig. 3.15. *Faecal streptococci concentration pre- and post-disinfection treatment in tubewells*

Microbiological parameters' concentration was also evaluated in the river water. Results of the same order of magnitude of the ones provided by open dug wells were obtained: 2,000 CFU of *E. coli* and faecal streptococci per 100 mL. Indeed, bacterial pathogens naturally occur and are able to persist and grow in biofilms of drinking water [34].

Jointly with the microbiological characterisation, water samples for chemical analyses were collected from some open dug wells and tubewells. Samples for the determination of iron and manganese were stabilised with acid, before carrying them to the laboratory. Table 3.2 shows the results obtained. No contamination was highlighted for both the sources, except for the values above the limit (set by WHO and EU) of nitrites in 2 out of 3 open dug wells. Higher concentrations of the other nitrogen forms were also provided by these water points, highlighting a problem of faecal contamination. These results were perfectly in line with the extremely high values obtained with the microbiological analyses.

Table 3.2. *Results of the chemical analyses*

Parameter	Unit	Open dug wells			Tubewells					Limits of WHO / EU
		1	2	3	1	2	3	4	5	
pH	-	7.6	7.1	7.1	7.1	6.7	6.8	6.8	6.9	6.5 - 9.5
Temperature	°C	28.1	28.1	27.3	26.9	30.0	27.1	30.6	30.1	-
Conductivity	μS/cm	660	805	930	620	350	330	284	400	2,500
Iron	mg/L	0.04	0	0.04	0.15	0.01	0.09	0.01	0.04	0.20
Manganese	mg/L	0.008	0.001	0.031	-	0.012	-	0.050	0.050	0.050
Fluorides	mg/L	1.33	1.25	0.79	-	1.09	-	0.60	0.78	1.50
Ammonium	mg/L	0.34	0	0.22	0.14	0	0.19	0	0	0.50
Nitrates	mg/L	25.52	17.82	20.28	13.64	6.77	4.78	1.77	6.20	50.00
Nitrites	mg/L	3.300	0	3.300	0.017	0	0.003	0	0	3.000
BOD_5	mg/L	<1	<1	<1	-	<1	-	<1	<1	-
COD	mg/L	23	2	23	-	6	-	2	3	-
TDS	mg/L	0	0	0	-	2	-	0	0	-

3.4.1.5 Water point management

During the first mission, an interview of the members of the water point Committees was carried out in order to understand the management level of the sources. First of all, it has to be highlighted that only tubewells have in place a water Committee, whereas for the open dug wells there is not an Association of users that takes care of them. The composition of water Committees (CGPEs) of the different tubewells is:

- A President, who is responsible for and coordinates all the activities of the CGPE;
- A Treasury, who is responsible for the economic management;
- A Secretary-General, who has to report at each meeting of the CGPE and is responsible for the relations with the users;
- A Technician, who has to manage (practically) the water point in terms of repairing minor breakdowns; and
- One or two Hygienists, who are responsible for the users' awareness on good management practices and are also responsible for the cleaning of tubewells.

Members of the CGPEs were democratically elected by the users only in 4 cases out of 9. According to the National Regulation, members of a CGPE should be changed by means of new elections every 6 years. None of the CGPEs interviewed has ever changed members.

The frequency, which the meetings between the members take place with, is not regular amongst the different CGPEs: in 2 cases monthly, in 2 cases each three months, in 1 case each four months, in 1 case two times per year, in 1 case "when necessary" and 2 CGPEs do not organise meetings between the members. When members organise these meetings, the topics include the update on community monetary contributions, the need to repair a fault / breakdown, the organisation of awareness-raising sessions for the users and the need to clean the structural parts of the well (apron, drainage channel, etc.). It has to be considered that National Regulation requires monthly meetings of the members, in order to assure a good management of the water point and well coordinate the activities amongst the members.

The use of each tubewell is subject to the payment of an annual contribution from the users. All the wells present in Fingla and Diarra require a contribution of 500 or 600 fCFA (about 0.76 or 0.91 €

respectively) to every woman of a family. The financing management is regularly reported on registers only by 4 CGPEs. This means that the other 5 do not have a proper management of finances, because they do not know the exact number of women who cater to their well and if they have actually paid the annual fee for the use. On average, the CGPEs dispose of about 108,106 fCFA (about 165 €) in their bank account. As referred by 4 CGPEs, the amount of money available is sufficient to pay the costs of any small breakdown and in one case also of great faults. For the other 5 CGPEs, it is estimated that the money available in their bank account is insufficient to cover any repair cost.
5 CGPEs declared to carry out disinfection with chlorine routinely, each time a breakdown of the tubewell happen. Regarding water quality control, only 1 Committee said to have made it before, but without specifying which kind of parameters was evaluated and which were the results. Finally, all the CGPEs, except for one, organise common meetings with the users in order to aware them on good hygiene practices to adopt when managing the tubewell.

3.4.2 The drinking water supply chain

The assessment of the drinking water sources already provided one important result: open dug wells were characterised by an extremely high contamination, which did not allow consuming that water for drinking purposes. Thus, one of the first aspects that the Water Safety Plan elaboration will have to take into account will be the exclusive use of tubewells as safe drinking sources. For these reasons, during the survey along the supply chain, only tubewell sources were taken into consideration (even if transport, storage and consumption steps were carried out in the same way, independently from the source type).

3.4.2.1 Identification

The identification of the drinking water supply chain consisted in identifying how local people transported, stored and consumed drinking water (which kind of container they were using for each step). Differences amongst Fingla and Diarra villages were not provided (as for the drinking source). For this reason, the presentation of the drinking water supply chain will not take into consideration separately the habits between the villages.
Regarding the transport step, people were used to carry home drinking water by means of aluminium basins (Fig. 3.16) or jerry cans (Fig. 3.17). The aluminium basins were always open / unprotected, loaded on the head and transported on foot till home, whereas jerry cans were always closed / protected and loaded on the head or bicycles or carts. Concerning this latter type of container, it has to be underlined that its filling was carried out in two alternative ways: on one hand using a plastic funnel that allowed to convey water out of the tubewell pipe within the jerry can, on the other by inserting the tubewell pipe directly inside the opening of the jerry can (as shown in the first two images of Fig. 3.17).

Fig. 3.16. *Aluminium basins used for transporting drinking water*

Fig. 3.17. *Jerry cans used for transporting drinking water*

Regarding the storage step, most of the families were used to store water in earthen jars (Fig. 3.18), some others in the same jerry cans used for the transport and only few in plastic buckets. The main difference amongst them was the place and the way of storing: inside or outside home, with the container open or closed.

Fig. 3.18. *Earthen jars for storing drinking water*

Finally, regarding the consumption point of the supply chain, it was possible to notice that people were consuming water by means of plastic-cups (the most common ones) or small metal barrels (Fig. 3.19). The only differences provided by the families were the place of storing of these containers: inside the storage tank, left on the ground close to the storage tank, on the lid of the tanks with the side to drink upwards or downwards (in this latter configuration, sometimes the drinking cup was also protected with a piece of tissue).

Fig. 3.19. *Plastic-cup (on the left) and small metal barrel (on the right) used for the consumption of drinking water*

3.4.2.2 Hazard evaluation

Identifying the drinking water supply chain, some hazards already arose: aluminium basins transported open, allowing contamination vectors (dust, sand, microbes, flies, etc.) to enter in contact with water; storage containers left open outside the home, and even in this case permitting the contact between pollution sources and water; and cups used for the consumption left on the ground or stored on the lid of the tanks without any protection. But carefully analysing all the possible other sources of pollution, it was clearly evident how the already identified ones represented only a part, since it has also to be considered:

- Funnels, left on the concrete apron or on the ground outside the tubewells;
- Animals, which are easily in contact with the water containers and, sometimes, they have access to the basins or the jars for drinking (if left open without any surveillance);
- Rubbish, which is often present close to the storage containers and attracts flies and other insects (vectors of contamination) facilitating their contact with drinking water;
- Dirty hands, since people extract water inserting the hands (almost in all the cases not properly washed before) and the cups into the storage containers;
- Algal formations inside the containers, owing to the improper or not frequent cleansing of the containers (as shown in Fig. 3.20 for jerry cans and earthen jars respectively).

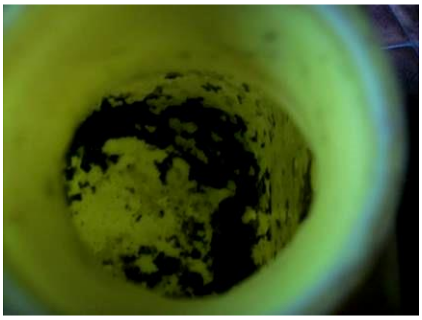

Fig. 3.20. *Algal formations inside the jerry cans (on the left) and the earthen jars (on the right)*

3.4.2.3 Drinking water management practices

Interviewing the families of Fingla and Diarra villages, it has been possible to gather important information about the local drinking water management practices. 175 out of 200 interviews were developed in Fingla (the biggest village), whereas the remaining 25 in Diarra.

Regarding first of all water consumption, it has been highlighted that, at Fingla, amongst people interviewed, 129 families collected water at tubewells, 64 at open dug wells, 2 at the river and 19 used rain water. The rate of access to "safe" water (in other words to tubewells, which were the only improved source in loco) was about 76%, in line with the national accessibility in rural areas which is some of 74% [4]. At Diarra, 19 families collected water at tubewells, whereas 8 at the river. Globally, 148 families, for drinking purposes, used water from tubewells, 56 from open dug wells (about 25% of the population of Fingla and Diarra) and, when available, 8 families used rain water and 5 river water.

The average distance between households and water points was evaluated in 10.8 minutes walking. Detailed distances between water points and households per each village are proposed in Table 3.3.

Table 3.3. *Distances between water points and households in Fingla and Diarra villages*

Water point	Fingla (min)	Diarra (min)
Tubewell	9.7	18.9
Open dug well	4.3	-
River	15.0	59.7
AVERAGE	8.5	27.2

The average distance between the sources in both villages resulted statistically significant ($p=10^{-9}$). Then, even the one related to tubewells was statistically significant ($p=0.0027$). These results are in line with the different water sources' distribution between the villages, as clearly shown in Fig. 3.5.

Analyzing the supply frequency, it resulted that its average was equal to 5.1 times per day. Even in this case, differentiating between the villages, it has been obtained that, at Fingla, people went on average 5.2 times per day, whereas at Diarra 4.3 times. The average supply frequency at the different sources, in the two villages, was statistically significant ($p=0.043$), thus not due to chance, but proving that the greater distance between households and sources, the lowers the supply frequency.
Processing data collected from the interviews, it was also possible to estimate the amount of water available for drinking purposes per capita (based on the number of containers collected and their capacity). Results showed that, on average, 33.35 L per family were available daily exclusively for drinking, which means about 4.50 L daily per person.
Focusing on drinking water management practices, elaborated for both villages together (since no differences were highlighted in this topic, as already stated above), results showed that transport tanks were generally discovered open at the moment of the interview in 99 cases and closed in the other 134 (global amount of tanks is over the total number of families interviewed because someone of them used both the types). In particular, all the 128 jerry cans were closed, whereas aluminium basins were open in 98 cases out of 105. On average, the cleansing of these containers was carried out 1.7 times per day (minimum every 4 days, maximum 10 times per day). In 9 cases families said to use chlorine, in 174 soap (even if only in 83 cases soap was found in the house, whereas in the remaining 91 was absent), in 23 only water, in 58 a sponge, in 28 sand and in 2 cases leaves. Moved to the storage tanks, results highlighted that 217 were closed and 11 open. In particular, all the 30 jerry cans were closed as all the 11 plastic buckets, whereas earthen jars were found closed in 176 cases out of 187. On average, the cleansing of these containers was carried out 1.1 times per day (minimum every 4 days, maximum 3 times per day). In 12 cases families said to use chlorine, in 127 soap (even if only in 65 cases soap was found in the house, whereas in the remaining 62 was absent), in 28 only water, in 77 a sponge and in 23 sand. The average time of water storage in the home was identified in 1.01 days. Fig. 3.21 shows the use of the different storage tanks identified in the interviewed families.

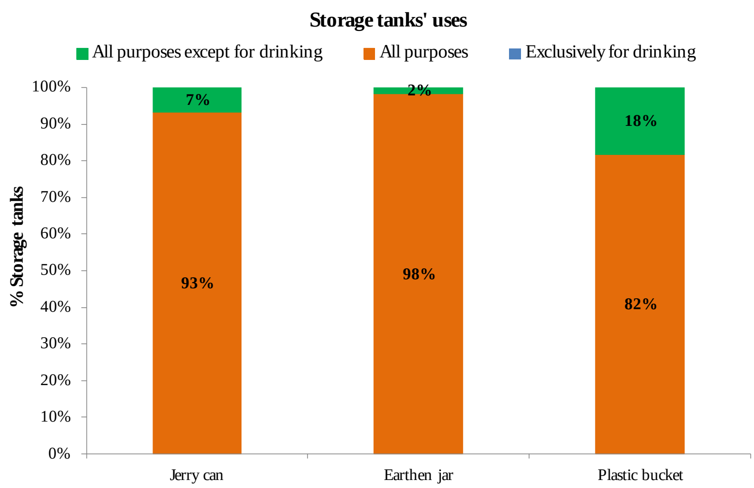

Fig. 3.21. *Final purpose of the different storage tanks*

Water collection was mainly a duty of women (97%), followed by girls (20%) and men and guys (globally 2%). Concerning water treatment, interviews' results were discouraging since 158 families out of 200 did not carry out any disinfection treatment. Amongst the others, 8 made disinfection with chlorine and 34 filtration on tissue. The 8 families that carried out disinfection with chlorine came from Fingla and they were used to collect water from tubewells in 4 cases and from open dug wells in the remaining 4, whereas the filtration on tissue was carried out by 30 families coming from Fingla (on water collected from tubewells in 7 cases and 23 from open dug wells) and 4 from Diarra (treating water collected at the river).

At the end of the interview, two main aspects were investigated directly by the interviewer: the place where drinking water and the cup used for drinking were stored. Water was stored outside the dwelling and accessible to every potential source of pollution in 42 cases, in 140 was outside the house but covered with a lid, in 8 was inside the house but in potential contact with contaminants and in 10 cases was inside the house and protected. Regarding the cup used for drinking, in 74 cases was left on the ground, in 13 inside the storage tank, in 56 deposited on the lid with the side to drink upwards and in 53 with the side to drink upside down.

Finally, a variable called "attitude" was created in order to define the level of good practices in water management. A score of 0, 0.25, 0.50, 0.75 or 1 was assigned to the possible answers to questions related to water management (frequency and type of cleansing of the transport and storage tanks, residence time of the stored water, place of storage of drinking water and cup used for drinking). The suitability to the responses has been identified taking into account both the international guidelines on good practices and the real possibilities of implementing them in this specific context. Then, 4 categories of the level of "attitude", on the basis of scores obtained, were also fixed: extremely poor, poor, adequate and good. The average score obtained from the 200 households surveyed was equal to 5.6 that corresponds to a level of attitude adequate (Table 3.4).

Table 3.4. *Categories of attitude to the good practices in drinking water management*

Attitudes	Categories	Households
Extremely poor	0 - 2	4
Poor	2 - 4	18
Adequate	4 - 8	172
Good	> 8	6

Concerning the questions related to hygiene and health conditions, some important aspects arose related to drinking water quality and management.

Investigating which detergent was used for washing hands, 148 families indicated soap (but only in the 46% of those, soap was really present at home during the interview), 7 chlorine, 48 only water and 6 admitted not to use any detergent. The situations in which detergents were used are proposed in Table 3.5.

Table 3.5. *Different uses of detergents and the observed/declared ratios*

Situation	Declared	Real presence of detergent at home	Observed/declared ratio
Before eating	103	56	54%
After eating	14	8	57%
After defecation	108	66	61%
After touching animals	2	1	50%
Washing tanks	35	6	17%
After greetings	1	0	0%
Before praying	7	5	71%
After touching dirty objects	2	1	50%
Before cooking	2	2	100%
Washing kids	1	1	100%
Laundry	5	1	20%
Cleaning	2	1	50%
When hands are dirty	6	2	33%
Washing dishes	1	0	0%
Toilette	22	6	27%
Always	1	1	100%
Never	2	0	0%

Regarding health conditions, questions on the number of diarrhoea cases in the family in the last few months, actions to be taken in case of diarrhoea, causes of diarrhoea, methods to avoid diarrhoea and signs of severe diarrhoea were asked to people interviewed. After the elaboration of these answers, a variable called "enteritis" was created in order to determine possible relations between the water-borne diseases and the drinking water management practices. Households that have highlighted at least a case of enteritis were 57. Statistically significant correlations were obtained with the following variables: drinking cup left on the lid with the side to drink upwards (p=0.01), drinking cup deposited on the ground (p=0.0005), presence of animals close to the storage tanks (p=0.001).

3.4.2.4 Water quality analyses

Drinking water quality analyses in the supply chain (transport and storage steps) were carried out evaluating the four microbiological parameters already investigated at source level (<u>*Escherichia coli*, faecal coliforms, total coliforms and faecal streptococci</u>). Samples were collected from 20 households, 10% of the total households interviewed by means of questionnaires. Results present in the first part of this section referred particularly on *E. coli* and faecal streptococci (suggested by WHO and EU), further in the discussion even results related to faecal and total coliforms will be introduced (all data are reported in Annexe 7). The sources taken into consideration were only tubewells, since (as already stated) they were the most used one and because the aim of the Water Safety Plan elaboration will be discouraged local people to use water from open dug wells for drinking purposes (due to the extremely high faecal contamination).

Water samples were always collected in sterilise containers, stored in ice boxes and analysed within 4 hours from sampling. As shown in Fig. 3.22, samples from transport tanks were taken directly from the containers, whereas, regarding storage tanks, cups for drinking were used for sampling, in order to evaluate the microbiological contamination of the water effectively drunk by the population (so to not lead to an underestimate of contamination).

Fig. 3.22. *Water sampling from transport (on the left) and storage (on the right) containers*

Fig. 3.23 provides results on *E. coli* determination along the entire supply chain.

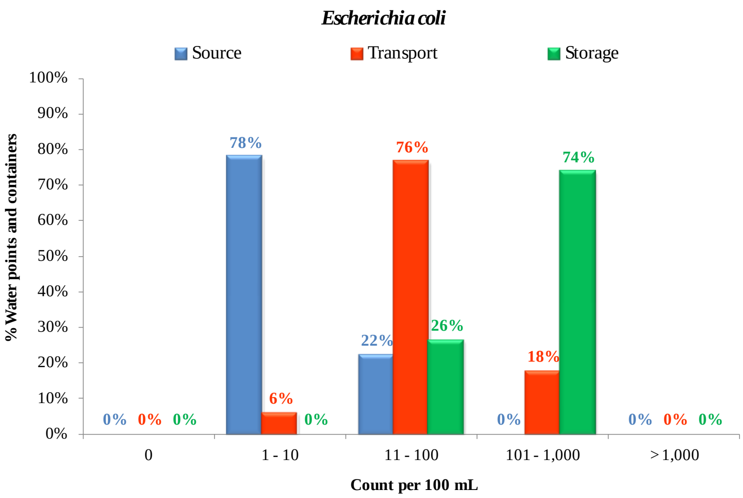

Fig. 3.23. *E. coli trend along the supply chain*

Referring to the categories suggested by WHO on the count of bacteria per 100 mL of sample analysed, it is evident how *E. coli* contamination increases along the supply chain's steps. The average contamination at the source level was in the range 1-10 CFU/100mL (78% of the samples), at the transport step was between 11 and 100 CFU (76%), whereas storage was characterised by 101-1,000 CFU (74%).

A similar trend was obtained analysing faecal streptococci (Fig. 3.24). All the sources analysed had faecal streptococci between 1 and 10 CFU/100mL, 65% of the samples in the range 11-100 during the transport step, whereas in the storage tanks the average values obtained from analyses were between 101 and 1,000 CFU/100mL (74%).

It is clear from these results how improper hygiene practices, related to water management, influence negatively on microbiological water quality.

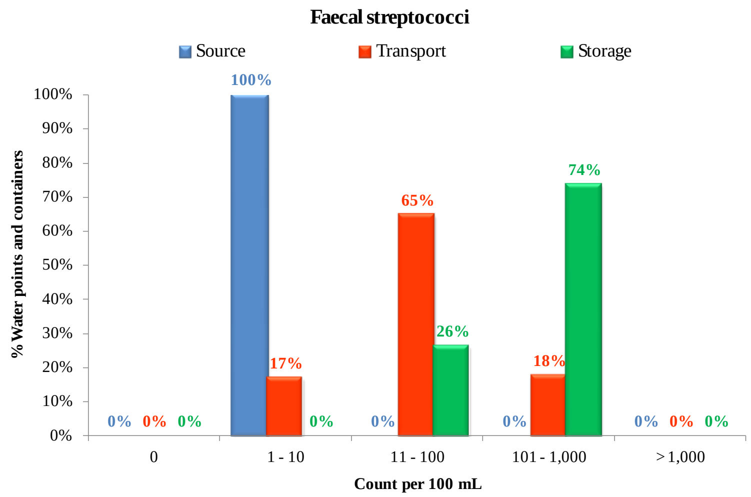

Fig. 3.24. *Faecal streptococci trend along the supply chain*

The graph shown in Fig. 3.25 is related to *E. coli* and faecal streptococci average concentrations in the three steps of the supply chain. The increasing trend of the contamination seems even clearer. If at source level a higher average contamination from *E. coli* was provided (thus indicating a more recent faecal pollution), in transport and storage steps higher values of faecal streptococci were obtained. These bacteria increased of two orders of magnitude from source (2.6 CFU/100mL) to storage (276.8 CFU/100mL) steps. This was mainly due to the improper cleaning of the containers that permitted the growth of algal formations, favouring bacterial pathogens increase [34]. However, even *E. coli* contamination cannot be ignored since it reached an average concentration of 179.5 CFU/100mL.

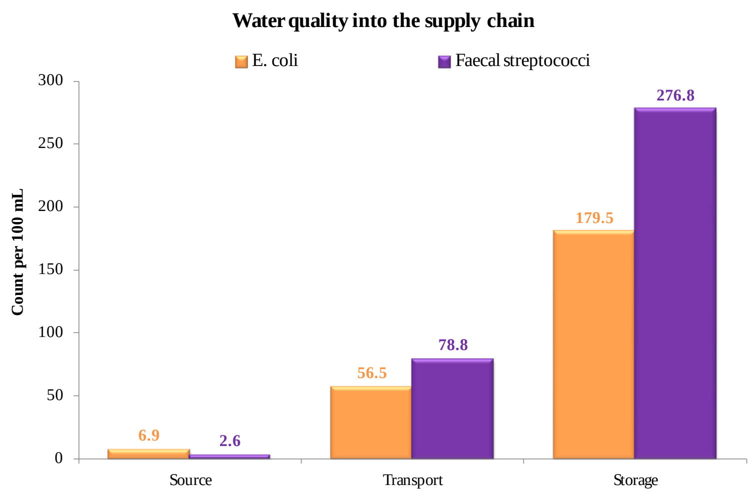

Fig. 3.25. *Average E. coli and faecal streptococci concentrations along the steps of the supply chain*

Figg. 3.26, 3.27, 3.28 and 3.29 show results obtained from this assessment, related to *E. coli*, faecal coliforms, total coliforms and faecal streptococci respectively at source, transport and storage level. From all the graphs, it is possible to see how the contamination strongly increased from source to storage, owing to the use of earthen pitchers, which contribute to bacterial growth [35], and to contamination through unwashed hands, containers and utensils [36]. The worst results were provided by total coliforms, which reached an average concentration at the end of the supply chain of 536.3 CFU/100mL and with a peak of 1,360. As already highlighted, even faecal streptococci did not provide encouraging results reaching, at the storage level, a concentration peak of 830 CFU/100mL.

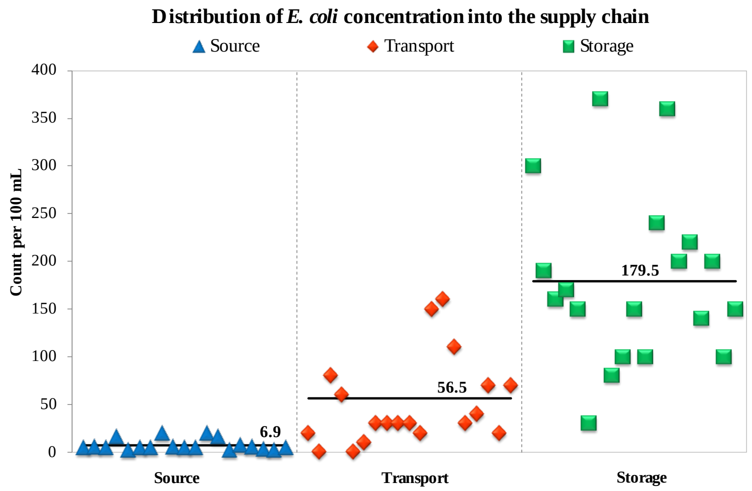

Fig. 3.26. *E. coli concentration of all samples analysed in the different supply chain's steps*

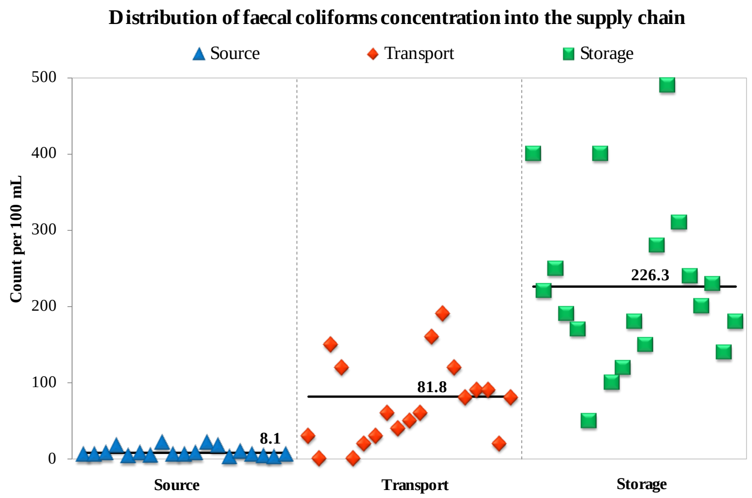

Fig. 3.27. *Faecal coliforms concentration of all samples analysed in the different supply chain's steps*

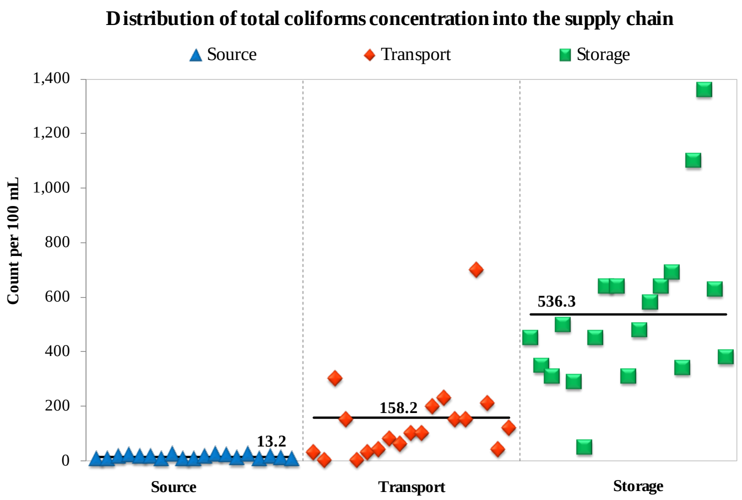

Fig. 3.28. *Total coliforms concentration of all samples analysed in the different supply chain's steps*

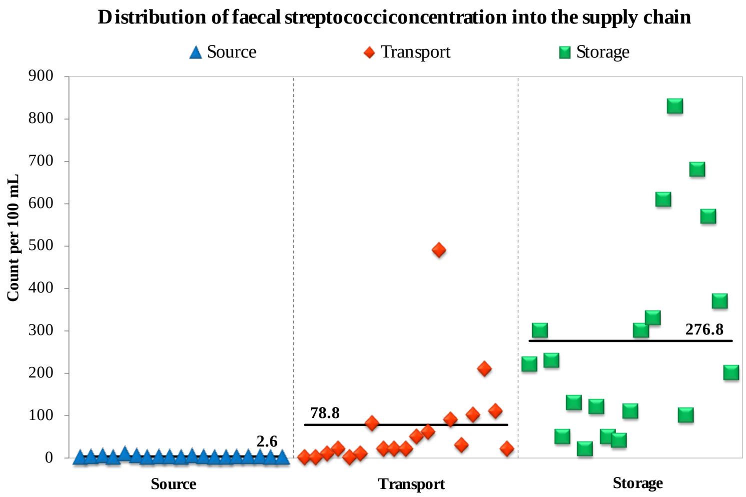

Fig. 3.29. *Faecal streptococci concentration of all samples analysed in the different supply chain's steps*

During data elaboration, by means of Quantum GIS 1.7.3 software, a correlation between drinking water microbiological contamination and location of investigating samples was researched. Figg. 3.30, 3.31, 3.32 and 3.33 report *E. coli* and faecal streptococci contamination comparing source and transport level, and source and storage level. Results obtained show that there was a uniform spatial distribution of the contamination between sources, and transport and storage containers. Differences between Fingla and Diarra have not even been highlighted. Finally, it clearly appears that better microbiological quality of water at source level did not correspond to better quality neither in the transport nor in the storage containers.

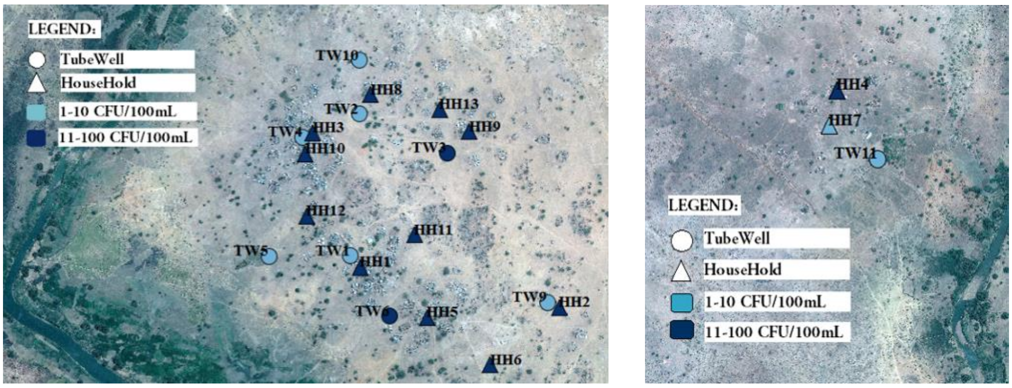

Fig. 3.30. *E. coli concentration in tubewells and households (transport containers) in Fingla (on the left) and Diarra (on the right)*

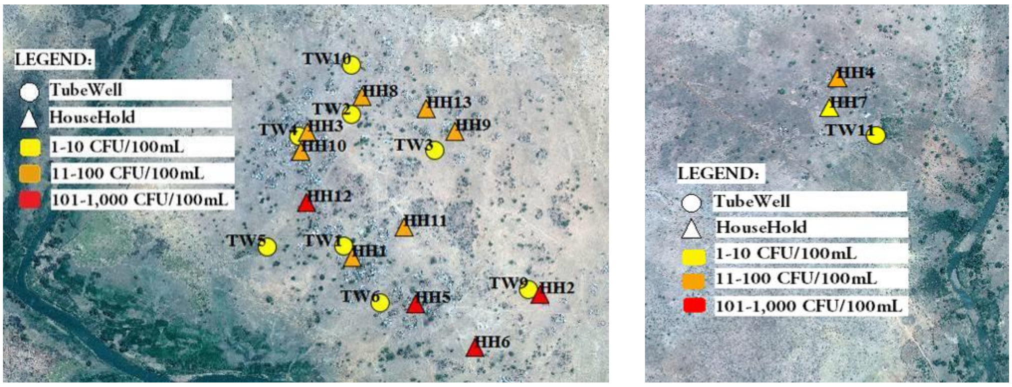

Fig. 3.31. *Faecal streptococci concentration in tubewells and households (transport containers) in Fingla (on the left) and Diarra (on the right)*

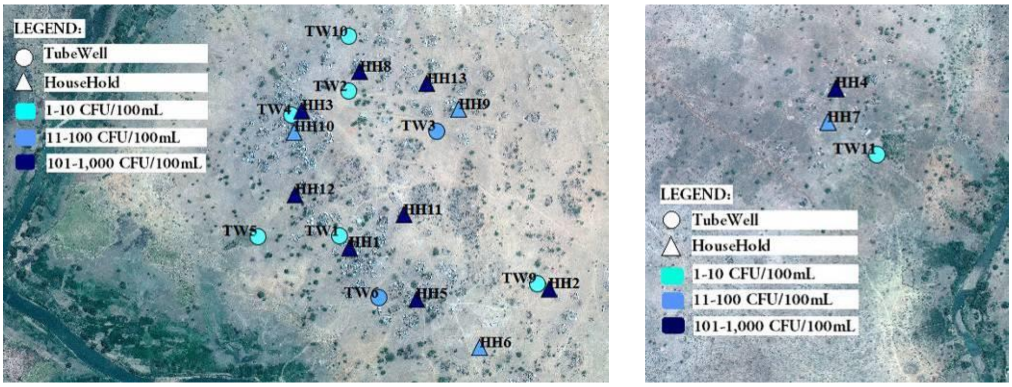

Fig. 3.32. *E. coli concentration in tubewells and households (storage containers) in Fingla (on the left) and Diarra (on the right)*

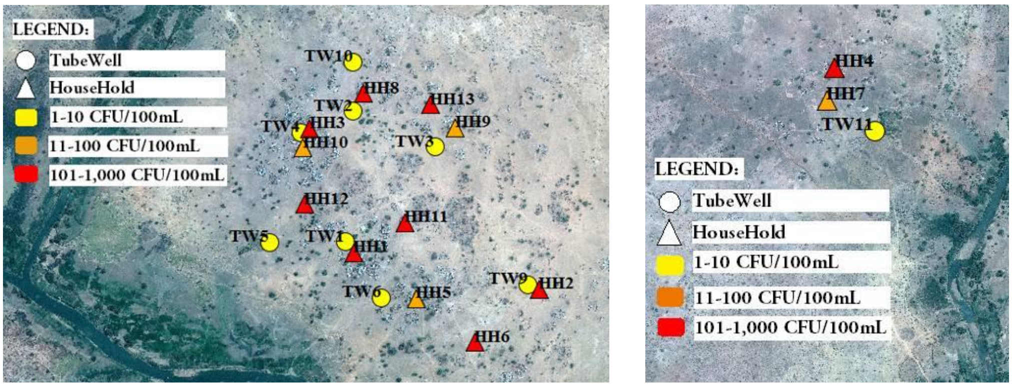

Fig. 3.33. *Faecal streptococci concentration in tubewells and households (storage containers) in Fingla (on the left) and Diarra (on the right)*

3.5 Water Safety Plan development

The Water Safety Plan (WSP) approach to develop in Fingla and Diarra villages had to take into consideration all the criticalities provided by the drinking water supply chain, analysed during the preliminary assessment, and the arrangement of local Authorities and water management Committees. Briefly, the following highlights aim at synthesising all the major aspects:

- The use of open dug wells and river has to be discouraged as drinking water sources, due to the extremely high microbial pollution (and even chemical regarding dug wells).
- Tubewells with hand pump, although they present some critical characteristics (absence of fencing systems, improper surrounding environments, contaminated pipes, etc.), are the only possible sources for drinking purposes.
- The water management Committees (CGPEs) of tubewells are not well organised and they do not take properly care of water points.

- Local technical and political Authorities cannot be involved in the WSP development due to several reasons.
- The major drinking water contamination takes place along the supply chain, during transport and storage steps, due to improper hygiene practice and management. The main sources of contamination are: containers open and dirty; utensils (funnels and cups for drinking) polluted; presence of microbial vectors in the surrounding of drinking water containers (animals, excreta, rubbish, etc.).

The original idea in the development of the WSP approach for this case study has been to use the WSP approach, as intended by WHO drinking water guidelines, as a tool for creating a drinking water management approach able to minimise or prevent the microbial contamination, on one hand, whereas on the other for the awareness of local people on the issues of good hygiene practices, management and handling of drinking water from the catchment at the tubewells till the consumption at the dwelling.

In order to reach these objectives, 11 different WSPs were developed comprehensive of both Fingla and Diarra villages. WSPs were elaborated based on the 11 tubewells with hand pump available in loco (9 in Fingla and 2 in Diarra). Each WSP was composed by three different sub-Plans: the first one specific for the tubewell, one for the transport step and the last one for the storage and consumption level.

The development of the WSPs was carried out with the technical support of Dakupa NGO and the 7 local hygienists (of Fingla and Diarra) involved into and made aware by the project on the issues related to water, sanitation and hygiene (see paragraph 3.5.2). The CGPE and the users of each tubewell were involved in the WSP elaboration: on one hand, they created the WSP and on the other, they were made aware on how manage and handle drinking water along the entire supply chain in order to minimise and / or prevent the microbiological and chemical contamination. In order to develop the specific WSP for source, transport and storage steps respectively, three different days of "awareness sessions" were organised per each tubewell (Fig. 3.34).

Fig. 3.34. *WSP elaboration in Fingla and Diarra villages*

Based on a simplified WSP approach elaborated in collaboration with Dakupa NGO, the CGPEs and the users were asked to list all the possible hazards that could pollute water, to define the relative risks and control measures and, finally, to plan a monitoring programme for evaluating the efficacy and the respect of control measures adopted on the minimisation and / or prevention of the different hazards. If a hazard or a control measure were not significant or were not taken into account, participants were leading in reasoning in order to bring them individually to identify the best solution / proposal.

In order to have a support during the WSP implementations and to guarantee its sustainability even after the end of the project, before developing the WSPs for each tubewell the 7 hygienists of Fingla and Diarra (already identified by MMI project) were made aware of the WSP approach, in particular of its fundamental aim of preventing contamination and its structure.

Awareness campaigns on water, sanitation and hygiene were also organised involving all the population of the villages: the community, the members of the Health Centre (CSPS), the teachers, students and parents' representatives of the primary schools. The aim of this supporting programme was to aware local people on the correct behaviour to have during water handling and management, but also on good sanitation and hygiene practices, in order to minimise all the possible contaminations of drinking water that, in rural areas such as the one where the project was implemented, are one of the main criticalities. These awareness campaigns aimed at supporting the implementation of the WSP approach.

3.5.1 WSP elaboration

In this section, the different steps of the drinking water supply chain are analysed separately, since three sub-Plans, one per each step, were elaborated in loco for each of the 11 tubewells.

Before elaborating the WSP, all components connected to the water supply system were described and analysed with the population, in order to assure the clarity of the water supply chain and thus better identify all the possible hazards for drinking water.

CGPEs and users were preliminarily asked to list all the possible hazards that could contribute to drinking water contamination. Then, a risk assessment was carried out according to the semi-quantitative method, based on the definition of both the frequency of occurrence (likelihood) and the severity of the consequences of contamination. After explaining the whole process of evaluation, the definitions used for each frequency and severity categories have been discussed, decided and shared amongst the participants. Tables 3.6 and 3.7 show respectively the frequencies of occurrence and the severities of the consequences used in this case study.

Table 3.6. *Likelihood or frequency of occurrence of contamination*

Likelihood	Risk score
Rare: once every 5-10 years	1
Unlikely: once a year	2
Moderate: once a month	3
Likely: once a week	4
Almost sure: every day	5

Table 3.7. *Severity of consequences of contamination*

Severity	Risk score
Insignificant: no water pollution	1
Minor: unlikely water pollution	2
Moderate: likely water pollution	3
Major: very likely water pollution	4
Catastrophic: certain water pollution	5

For all the possible causes of contamination listed, first of all the evaluation of likelihoods took place and subsequently the levels of severity. In this way it was possible to better compare the values progressively attributed to the different causes of contamination. Each score was assigned according to the result of the debate amongst participants.

After having identified the global risk (likelihood x severity), specific control measures for each hazard were carried out, providing also a dedicated monitoring programme establishing which action will be monitored, how it will be monitored, the frequency or timing of monitoring, where (spatially) actions will be monitored and finally who will do the monitoring or will be responsible for it.

At the end of the third day of work (when the WSP was completed), amongst the participants and in particular amongst the people responsible for action / control measure monitoring, a Responsible for the whole WSP was designated. Its role is fundamental for verifying that all the actions / control measures have been correctly put into practice and for coordinating the responsibilities of the different people involved in the WSP management.

In Annexe 8, all the 11 Water Safety Plans elaborated are proposed. The following sections aim at presenting the different sub-Plans and showing the most interesting / relevant aspects.

3.5.1.1 The source

The first WSPs elaborated were related to tubewells. A key role in these sub-Plans was played by water Committees (CGPEs), which were lacking in tubewells' management. Indeed, during the WSP elaboration, the attention was focused on their role and duties. Table 3.8 shows the hazards, causes and risk scores provided by the different WSPs related to tubewells. The hazardous event considered was always drinking water contamination.

Table 3.8. *Hazards, causes and risk scores provided for the sub-Plans concerning water points (tubewells)*

Hazard	Cause	Risk		
		Likelihood	Severity	Score
Microbial	Improper hygiene and cleaning of the tubewell	2	3	6
	Use of dirty shoes inside the tubewell structure	2	5	10
	Do the laundry close to the tubewell	5	5	25
	Presence of excreta and rubbish close to the tubewell	3	4	12
	Presence of animals around the tubewell	5	4	20
	Presence of latrines within 10m	1	5	5
	Presence of cemeteries within 10m	1	5	5
	Presence of stagnant water around the tubewell's walls	2	3	6
	Tubewell's pipe dirty	2	4	8
	Reparation of the tubewell during breakdowns	2	4	8
	Presence of children with an improper behaviour and hygiene	3	2	6
	Presence of water showers from the yards close to the tubewell	3	4	12
	Flood of the river	2	5	10
Chemical	Use of pesticides close to the tubewell	4	4	16
	Lubrication of the tubewell chain	2	3	6

The causes listed in Table 3.8 were identified in almost all the WSPs, except for three of them that were provided only by two tubewells:

- *Presence of children with an improper behaviour and hygiene*: this possible cause of microbial contamination was highlighted by TW10, a tubewell close to the primary school. This cause was particularly interesting, since effectively children that play around tubewells (or sometimes even on concrete aprons) can favour drinking water contamination. The proposal to insert this possible cause was made by the President of the CGPE, particularly attentive to the protection of the tubewell, so that was taken over personally to distance children in case of crowding on or in the surroundings of the tubewell for playing.
- *Presence of water showers from the yards close to the tubewell*: even this cause of contamination was provided by TW10. This was due to the presence of water showers close to the tubewell that were determining continuously stagnant water. Only this tubewell has considered this cause since it was the only one suffering from this problem.
- *Flood of the river*: TW5 is annually interested in river's flood, since it is located quite close to the river bed. For this reason, the necessity to include this possible cause of contamination arose.

Amongst all the causes of contamination, one of those was not highlighted during the preliminary assessment carried out in the villages, and was provided by CGPEs members during the WSP elaboration. The possible cause was the lubrication of the tubewell chain, which was typically carried out twice a month and could contribute with the grease on the chemical contamination of drinking water, if the operation is not carried out properly (and particularly if the old grease is not well removed before the new lubrication). Conversely, the cause that was never provided by CGPEs and users, and for which was necessary to begin reasoning in order to bring participants to identify that cause, was the presence of algal formation into the pipe of tubewells (*tubewell's pipe dirty*). Regarding all other causes listed in Table 3.8, they were already identified as potential sources of contamination of drinking water

during the preliminary assessment and were also individually provided by participants during WSP elaboration.
The risk assessment, with the identification of the likelihood and the severity of consequences, was individually carried out by CGPEs members and users. Interesting and intense debates were always characterising the identification of the risk score. No suggestions or decisions were given to the participants, in order to freely determine the frequencies and severities of risk. This decision was due to the fact that the perception of likelihood and severity of the possible causes of contamination had to be really felt by local population, who will be tasked to conduct the annual review of the Plan. Outside interventions (although maybe improving the correct interpretation of the level of risk) could lead to a lack of understanding by participants, especially during the revision / update of the Plan. For this reason the risk scores identified for each cause of contamination were quite different amongst different Plans.
If likelihood was variable within the causes, high values of severity were rather always provided, and set equal to 4 (very likely water pollution) or 5 (certain water pollution). An exception was the severity score provided for the presence of children close to the tubewell, which was correctly set equal to 2 (unlikely water pollution).
Identified the total risk, participants were asked to identify the most proper control measure to put in place in order to prevent / minimise every possible cause of drinking water contamination. Actions provided by the 11 sub-Plans are listed in Table 3.9, referring to each specific cause.

Table 3.9. *Causes and related control measures provided for the sub-Plans concerning water points (tubewells)*

Cause	Control measure
Improper hygiene and cleaning of the tubewell	Clean properly the concrete apron Awareness campaigns for the users
Use of dirty shoes inside the tubewell structure	Remove shoes before entering the tubewell's apron
Do the laundry close to the tubewell	Avoid doing the laundry close to the tubewell
Presence of excreta and rubbish close to the tubewell	Avoid littering and the presence of excreta close to the tubewell
Presence of animals around the tubewell	Build an adequate fence around the tubewell Awareness campaigns for the herdsmen
Presence of latrines within 10m Presence of cemeteries within 10m	Avoid realising latrines and cemeteries close to the tubewell Distance the cemetery from the tubewell
Presence of stagnant water around the tubewell's walls	Fill the tubewell's border with stones Empty daily the tank for watering the animals
Tubewell's pipe dirty	Clean properly the pipe
Reparation of the tubewell during breakdowns	Clean properly all the tubewell parts before putting them back
Presence of children with an improper behaviour and hygiene	Awareness campaigns for the children
Presence of water showers from the yards close to the tubewell	Construction of absorbing wells
Flood of the river	Close the tubewell for some time (till water has not retreated)
Use of pesticides close to the tubewell	Prohibition of the use of pesticides around the tubewell
Lubrication of the tubewell chain	Remove properly the old grease and take care during the lubrication operation

Within the control measures provided by participants, of particular concern were the awareness campaigns of tubewells' users, herdsmen and children. Even if they cannot be considered as a "real" control measure (and in fact they were always associated with more practical actions), they still represented an important and effective activity in order to prevent / minimise the respective causes of contamination.
Build an adequate fence around the tubewell was considered as an effective measure in order to control the possible contamination due to the presence of excreta, rubbish or animals in the surroundings of the tubewells. Since the construction of a traditional fence made of wooden stakes could be too much

expensive and onerous, the solution provided by CGPEs members and tubewells' users was to plant the *Jatropha curcas*, which being quite invasive and toxic to animals can contribute to distance them from tubewells. This solution, moreover, was appropriate for the local context, since already used as a fence for protecting a tubewell in a village close to Fingla and Diarra (Fig. 3.35).

Fig. 3.35. *Fence around the tubewell of a Health Centre in Dièrma (village close to Fingla and Diarra)*

If for the presence of latrines (or open defecation areas) and cemeteries in the surroundings of the tubewell the control measure typically highlighted was to not realise these structures (or to not make open defecation in those areas), in a case (tubewell TW5) the presence of a cemetery pretty close to the water point required to provide a more severe control measure, as distance it, in order to avoid possible further contamination of drinking water.

Another interesting control measure proposed by participants was to fill the tubewell's border with stones, owing to the presence of stagnant water around the water point. This solution seemed appropriate, since stones can better drain water into the soil avoiding the excessive stagnation of water, thus favouring the presence of microbial vectors.

Regarding water river flood, the only possible control measure identified was to interrupt the supply to the tubewell (TW5) until water has not retreated. The President of the CGPE has taken the task of finding an agreement with the CGPE of the nearest tubewell (TW4), which was not annually affected by river flooding, thus permitting to users to supply water from that water point for the period covered by river flood.

The last step in the WSP elaboration was to identify a <u>monitoring programme</u> able to supervise the application of each control measure (Table 3.10).

The action to be monitored (*what*) was always the putting into practice of the specific control measures identified for each possible cause of contamination. Even when the check referred to behavioural change, the aim was to verify that old and bad practices were abandoned for more proper behaviours (recommended by the WSP) able to guarantee the prevention / minimisation of contamination.

The monitoring approach adopted (*how*) was always referred to direct inspections, in order to effectively verify the realisation / putting into practice of the different control measures. This kind of approach was often accompanied by awareness campaigns carried out and organised between users themselves, in order to favour the adoption of correct practices and actions planned to the whole population.

Regarding the monitoring frequency (*when*), this was rather varied. If for actions more easily to be controlled, and more related to the everyday use of the tubewell, daily or weekly monitoring frequencies have been adopted, to control the execution of structures such as the fence, the frequency became annual (for the fence realisation annually, starting from August 2013, the period most favourable in terms of environmental conditions for the plantation of the *Jatropha curcas*). In other cases, the check has been fixed at the time of potential violation of control measures, as in the case of the construction of latrines or cemeteries or in the flooding of the tubewell due to the river or even during the lubrication of the tubewell chain.

Table 3.10. *Control measures and related monitoring programme provided for the sub-Plans concerning water points (tubewells)*

Control measure	Monitoring programme				
	What	How	When	Where	Who
Clean properly the concrete apron	Regular washing / cleanliness of the tubewell	Awareness campaigns and inspections	Weekly	At the tubewell	Dabré Sapoura, Bayiré Salamatou
Remove shoes before entering the tubewell's apron	Behavioural change	Awareness campaigns and inspections	Daily	At the tubewell	Guébré Mariam
Avoid doing the laundry close to the tubewell	Behavioural change	Awareness campaigns and inspections	Daily	At the tubewell	Guébré Mariam
Avoid littering and the presence of excreta close to the tubewell	Behavioural change	Awareness campaigns and inspections	Weekly	At the tubewell	Zoumbaré Fatoumata
Build an adequate fence around the tubewell	Construction of the fence	Inspections	August 2013 and then annually	At the tubewell	Guébré Seydou
Awareness campaigns for the herdsmen	Behavioural change	Inspections	January 2013 and then annually	At the tubewell	Guébré Issa
Avoid realising latrines and cemeteries close to the tubewell	Absence of latrines and cemeteries close to the tubewell	Awareness campaigns and inspections	During latrines and cemeteries realisation	At the tubewell	Guébré Mariam, Zandé Mariam
Fill the tubewell's border with stones	Presence of stones at the tubewell's border	Inspections	Annually	At the tubewell	Guébré Fati
Clean properly the pipe	Regular washing / cleanliness of the tubewell's pipe	Awareness campaigns and inspections	Weekly	At the tubewell	Dabré Sapoura, Bayiré Salamatou
Clean properly all the tubewell parts before putting them back	Cleanliness of all the tubewell's parts	Inspections	During the reparation of breakdowns	At the tubewell	Guébré Issa
Awareness campaigns for the children	Absence of children close to the tubewell	Awareness campaigns and inspections	Daily	At the tubewell	The President of the CGPE
Construction of absorbing wells	Presence of absorbing wells	Awareness campaigns and inspections	January 2013 and then annually	At the yards close to the tubewell	Bara Habibou
Close the tubewell for some time (till water has not retreated)	Tubewell close	Inspections	When flood happens	At the tubewell	Dabré Issaka
Prohibition of the use of pesticides around the tubewell	Behavioural change	Awareness campaigns and inspections	Before the rainy season (when pesticides are used)	At the tubewell	Guébré Seydou
Remove properly the old grease and take care during the lubrication operation	Behavioural change	Awareness campaigns and inspections	Twice a month	At the tubewell	Guébré Issa

The monitoring place (*where*) was always represented by the tubewell, since this specific sub-Plan concerned the water point. The only exception was provided by the control at the yards close to the tubewell in relation to the presence of stagnant water due to improper water showers.
Finally, regarding people responsible for the monitoring of each control measure (*who*), representatives of CGPEs members or users were involved (in 90% of cases, voluntarily).
In the monitoring programme, as suggested by WHO, were not provided analyses of water quality. This is due to the fact that they are not useful during monitoring, and secondly because they were not feasible at the time of WSP elaboration. Indeed, the Authority responsible for water quality control was not provided with the technical specialist and, moreover, the laboratory for conducting analyses was abandoned at that moment. In any case, in loco, there are several problems to carry out a water quality control owing to the distance existing between the villages of Fingla and Diarra and the city where laboratory is located (Tenkodogo, almost 50 km far, with some of 35 km of dirt road).

3.5.1.2 The transport

The sub-Plans related to the transport step of the supply chain aimed at identifying all the possible causes of contamination and the related control measures, concerning drinking water from the moment of caption at tubewells until the storage at home. As previously stated, even in this phase, some criticalities arose during the preliminary assessment. Table 3.11 lists the contamination causes provided by CGPEs members and tubewells' users during the WSP elaboration, with the relative risk score. As for the sub-Plans of the sources, the hazardous event considered was always drinking water contamination.

Table 3.11. *Hazards, causes and risk scores provided for the sub-Plans concerning the transport*

Hazard	Cause	Risk		
		Likelihood	Severity	Score
Microbial	Containers dirty	5	5	25
	Containers open	4	5	20
	Hands dirty	5	5	25
	Utensils (funnel) dirty	5	5	25
	Lay down the container's lid on the ground and then put it again on the container	3	5	15
Chemical	Jerry cans that contained chemicals	1	5	5

The potential causes of contamination listed above were provided by all of the 11 WSPs, except for the laying down of container's lid that was highlighted only for few tubewells. This cause was particularly interesting since leaving on the ground lids in contact with potential hazards can strongly affect water quality (above all from the microbiological point of view).
In this case, the causes were identified by participants, even the use of jerry cans previously containing chemicals that can contaminate chemically drinking water if improperly washed and managed. Of particular concern was the identification of dirty hands as cause of contamination, since people had the habit to not wash properly with soap hands before supplying drinking water. The inadequate hygiene level in the area and the large diffusion of open defecation (from the interviews carried out locally was estimated to be about 85%) did not guarantee the appropriateness of hands and, consequently, the safety of drinking water.
Comparing risk scores provided in these Plans with the ones determined for water points, it is possible to notice how values were increasing, above all regarding likelihood. Bad practices in drinking water management during transport were recognised by users and members of CGPEs, who fixed mostly 5 (every day) in frequencies. Regarding severity scores, values were always equal to the maximum, meaning the almost certain water contamination, owing to the direct contact between drinking water and pollution vectors.
Table 3.12 presents causes and related control measures provided during WSP elaborations.

Table 3.12. *Causes and related control measures provided for the sub-Plans concerning the transport*

Cause	Control measure
Containers dirty	Wash properly the containers with soap
Containers open	Use containers closed
Hands dirty	Wash properly the hands with soap
Utensils (funnel) dirty	Use of proper funnels
Lay down the container's lid on the ground and then put it again on the container	Avoid laying down the lids on the ground
Jerry cans that contained chemicals	Prohibition of the use of these containers

Control measures identified in these sub-Plans were the application of the correct hygiene and water management practices, in order to prevent / minimise all the possible causes of contamination. These actions were characterising all the WSPs elaborated in Fingla and Diarra.

The monitoring programme comprehensive of all the 11 WSPs is presented in Table 3.13. Even in this case, actions to be monitored (*what*) were always the putting into practice of the specific control measures identified. The monitoring approach adopted (*how*) was partially referred to direct inspections combined with awareness campaigns carried out and organised between users themselves, with specific monitoring frequencies, locations and responsible. On the other hand, the sharing of information was also required, in order to obtain the highest coverage of people with proper water management behaviours. These two different monitoring approaches were not provided for all the tubewells. The majority of the WSPs had only considered the site inspections with awareness campaigns. Regarding the monitoring frequencies (*when*), these were extremely different between different approaches and even between different WSPs. In the case of the presence of sharing information as way of monitoring, the frequency established was every time, meaning that every occasion had to be used to make aware other people on the use of proper hygiene practices. Inspections and awareness campaigns were characterised by daily, weekly or monthly frequencies, depending on the different sub-Plans. Even monitoring places (*where*) depended on the approaches considered. In the case of sharing information, the location established was everywhere, in order to maximise people involved in the good practices. Inspections and awareness campaigns were set at the tubewell, in order to verify people behaviours and practices. Representatives of CGPEs members or tubewell's users were involved in the monitoring of each control measure (*who*). In this case, moreover, each yard had to designate a woman responsible for the behaviour control of the other women leaving in the same yard. This is particularly important, above all under the social and anthropological point of view, since women belonging to the same yard have a more confidential relation and can better accept criticisms from people who know and have a connection with (perhaps even of family). The identification of these women was provided immediately after the end of the joint session for the WSP elaboration.

Table 3.13. *Control measures and related monitoring programme provided for the sub-Plans concerning the transport*

Control measure	Monitoring programme				
	What	How	When	Where	Who
Wash properly the containers with soap	Verify the use of well cleaned containers	Share the information	At every moment	Everywhere	Bara Salamatou, Zabré Assétou
		Awareness campaigns and inspections	Monthly	At the tubewell	1 woman/yard
Use containers closed	Use of closed containers	Share the information	At every moment	Everywhere	Bara Salamatou, Zabré Assétou
		Awareness campaigns and inspections	Monthly	At the tubewell	1 woman/yard
Wash properly the hands with soap	Hands well washed	Share the information	At every moment	Everywhere	Bara Salamatou, Zabré Assétou
		Awareness campaigns and inspections	Monthly	At the tubewell	1 woman/yard
Use of proper funnels	Behavioural change	Share the information	At every moment	Everywhere	Bara Salamatou, Zabré Assétou
		Awareness campaigns and inspections	Monthly	At the tubewell	1 woman/yard
Avoid laying down the lids on the ground	Behavioural change	Share the information	At every moment	Everywhere	Bara Salamatou, Zabré Assétou
		Awareness campaigns and inspections	Monthly	At the tubewell	1 woman/yard
Prohibition of the use of these containers	None uses these containers	Share the information	At every moment	Everywhere	Bara Salamatou, Zabré Assétou, The Hygienists of Fingla
		Awareness campaigns and inspections	Monthly	At the tubewell	1 woman/yard

3.5.1.3 The storage and consumption

The last part of the WSPs developed in Fingla and Diarra were related to storage and consumption at household level, so from storage containers' filling until the moment of drinking. As previously stated, even in this phase, several criticalities arose during the preliminary assessment. Table 3.14 lists all the contamination causes provided by CGPEs members and tubewells' users during the WSP elaboration, with the related risk scores. As for the other sub-Plans, the hazardous event considered was always drinking water contamination.

Table 3.14. *Hazards, causes and risk scores provided for the sub-Plans concerning the storage and consumption*

Hazard	Cause	Risk		
		Likelihood	Severity	Score
Microbial	Cups used for drinking dirty	5	5	25
	Containers dirty	4	5	20
	High drinking water storage time (>1d)	3	5	15
	Containers open	2	5	10
	Hands dirty	5	5	25
	Containers stored outside the dwelling	5	5	25
	Dirty environment nearby the containers	3	5	15
Chemical	Chlorine overdose	1	5	5
	Storage containers and cups for drinking used also for chemicals	5	5	25
	Cups used for drinking rusty	2	5	10

Dirty cups used for drinking were recognised to be one of the major causes of contamination, as resulted also in the preliminary assessment carried out during the first mission, due to the statistical correlation between place of storage of these cups and incidence of enteritis amongst the population. Even containers stored outside the dwelling have been recognised as an important cause of contamination providing the maximum risk score, as highlighted in the pre-assessment where 91% of the households investigated had drinking water containers stored outside. An interesting cause proposed directly by participants was the high storage time, which have been considered not too frequent (likelihood=3) but very dangerous (severity=5). The same risk score resulted for the unwholesome environment surrounding drinking water containers. Regarding chemical hazards, by means of reasoning, users and members of CGPEs provided chlorine overdose as a possible cause of contamination, which a high severity score was assigned for but with an extremely low likelihood since almost none did disinfection with chlorine in the villages (from interviews to households arose that only 8 out of 200 people disinfected drinking water). Even for rusty cups used for drinking, proposed by participants, low likelihood (2) and high severity (5) were assigned. As provided for sub-Plans concerning the transport, total risk scores obtained in this Plan were rather higher than the one assigned to the contamination causes related to water points, since even in this case the direct contact between contamination vectors and drinking water represents a major risk factor.

Table 3.15 presents causes and related control measures provided during WSP elaborations.

Table 3.15. *Causes and related control measures provided for the sub-Plans concerning the storage and consumption*

Cause	Control measure
Cups used for drinking dirty	Wash properly the cups for drinking with soap
Containers dirty	Wash properly the containers with soap
High drinking water storage time (>1d)	Change regularly drinking water (daily)
Containers open	Use containers closed
Hands dirty	Wash properly the hands with soap before drinking
Containers stored outside the dwelling	Use dedicated containers for drinking water and store them inside the dwelling
Dirty environment nearby the containers	Clean properly the environment nearby the containers
Chlorine overdose	Dose the correct quantity of chlorine
Storage containers and cups for drinking used also for chemicals	Clean properly containers and cups before using them for drinking purposes
Cups used for drinking rusty	Prohibition of the use of these cups

Control measures identified in these sub-Plans were the application of the correct hygiene and water management practices, in order to prevent / minimise all the possible causes of contamination. These actions were characterising all the WSPs elaborated in Fingla and Diarra. Regarding in particular the correct dosage of chlorine, all the participants at the WSPs elaboration were made aware that the optimal dosage was 1 cap of chlorine bottle per each container of 20 L capacity poured in the storage container (calculations that brought to this suggestion were made locally by means of experimental tests based on chlorine solutions available in the villages). Moreover, concerning the dedicated containers for drinking water, the use of plastic cans with valve was suggested and promoted (Fig. 3.36).

Fig. 3.36. *Plastic cans with valve (on the left) and a woman beneficiary (on the right)*

Two of these containers were offered to two women amongst the participants of each WSP elaboration groups (in total 22). The beneficiaries were identified between people who showed to be more participant and involved in the WSP elaboration. The promotion of the use of these containers was strengthened by the 7 hygienists of Fingla and Diarra who set a good example buying themselves the plastic cans with valve.

The use of these storage containers appeared to be an effective solution for preventing microbial contamination at the point of consumption, due to the absence of contact between cups used for drinking (highlighted to be a cause of enteritis problems) and drinking water stored, and the absence of continuous openings of the storage containers to withdraw water. Furthermore, plastic containers are not porous such as earthen jars used in loco, thus avoiding promoting microbial growth (as highlighted in section 3.4.2.4). From the economic point of view, the price of the container (already with the valve installed) was equal to 4,500 fCFA (some of 6.5 €), an amount accessible from the majority of the inhabitants according also to Dakupa NGO that well knew the local reality.

The monitoring programme synthesising all the 11 WSPs is presented in Table 3.16. Even in this case, actions to be monitored (*what*) were always the putting into practice of the specific control measures identified. The monitoring approach adopted (*how*) was different amongst sub-Plans. If some of them were referred to direct inspections and awareness campaigns combined, some others were clearly separated (as shown in Table 3.16). In these latter cases, awareness campaigns were characterised by specific frequency, place and people responsible for the monitoring, different from the ones provided for site inspections. Awareness campaigns were typically carried out weekly (*when*), at the tubewells (*where*) and by two people (*who*) identified from the specific sub-Plan, whereas inspections were set daily, at the dwelling and provided by a woman per each of the yards present in the villages. As in the case of sub-Plans related to transport, women responsible for the monitoring at each yard were identified immediately after the end of the joint session for the WSP elaboration.

Generally, in these sub-Plans, frequencies of monitoring were higher, since there were greater possibilities to contaminate drinking water (higher scores related to likelihood) and, as stated in the risk assessment, severities of contamination were higher compared to the other sub-Plans.

Furthermore, it has to be highlighted that for each WSP the 7 hygienists of Fingla and Diarra were designated responsible for the control and verification of chlorine dosage. Since this treatment was of particular concern, it has been decided to involve these people as supervisors.

Table 3.16. *Control measures and related monitoring programme provided for the sub-Plans concerning the storage and consumption*

Control measure	Monitoring programme				
	What	How	When	Where	Who
Wash properly the cups for drinking with soap	Behavioural change	Awareness campaigns	Weekly	At the tubewell	Bara Mariam Dabré Damata
		Inspections	Daily	At the dwelling	1 woman/yard
Wash properly the containers with soap	Behavioural change	Awareness campaigns	Weekly	At the tubewell	Bara Mariam, Dabré Damata
		Inspections	Daily	At the dwelling	1 woman/yard
Change regularly drinking water (daily)	Behavioural change	Awareness campaigns	Weekly	At the tubewell	Bara Mariam, Dabré Damata
		Inspections	Daily	At the dwelling	1 woman/yard
Use containers closed	Behavioural change	Awareness campaigns	Weekly	At the tubewell	Bara Mariam, Dabré Damata
		Inspections	Daily	At the dwelling	1 woman/yard
Wash properly the hands with soap before drinking	Behavioural change	Awareness campaigns	Weekly	At the tubewell	Bara Mariam, Dabré Damata
		Inspections	Daily	At the dwelling	1 woman/yard
Use dedicated containers for drinking water and store them inside the dwelling	Behavioural change	Awareness campaigns	Weekly	At the tubewell	Bara Mariam, Dabré Damata
		Inspections	Daily	At the dwelling	1 woman/yard
Clean properly the environment nearby the containers	Behavioural change	Awareness campaigns	Weekly	At the tubewell	Bara Mariam, Dabré Damata
		Inspections	Daily	At the dwelling	1 woman/yard
Dose the correct quantity of chlorine	Check the dosed quantity	Awareness campaigns	Weekly	At the tubewell	Bara Mariam, Dabré Damata
		Inspections	Daily	At the dwelling	1 woman/yard
Clean properly containers and cups before using them for drinking purposes	Behavioural change	Awareness campaigns	Weekly	At the tubewell	Bara Mariam, Dabré Damata
		Inspections	Daily	At the dwelling	1 woman/yard
Prohibition of the use of these cups	None uses these cups	Awareness campaigns	Weekly	At the tubewell	Bara Mariam, Dabré Damata
		Inspections	Daily	At the dwelling	1 woman/yard

At the end of the third joint session, each group that had elaborated the WSP was asked to designate a person Responsible for the entire WSP in terms of coordinate all the activities and supervise all the members responsible for the monitoring of a specific control measure. The designation of the Responsible was made by votes, even if sometimes someone of the people responsible for a control measure's monitoring asked to be made Responsible itself, strengthened the idea of the effective participation to the WSP elaboration. People made Responsible for the WSPs were chosen amongst the more active participants and with a certain level of authority between the users (owing to their important role and duty). Indeed, the Responsible for the Plan will also have the responsibility to coordinate the revision / update of the WSP, after one year from its implementation (at the beginning of 2014).

3.5.2 Supporting programmes

Supporting programmes are activities that support the development of people's skills and knowledge, commitment to the WSP approach, and capacity to manage systems to deliver safe water. Programmes frequently relate to training, research and development [37].

In this case study, two supporting programmes were developed. The first one was concerning training courses to the 7 hygienists of Fingla and Diarra, in order to transfer the knowledge of the WSP approach and all the important good practices to take into account when managing and handling drinking water (even related to hygiene and sanitation). The second programme involved local community, from the inhabitants till the teachers, students and parents' representatives of the primary schools (one per each village), and was related to WASH issues (WAter, Sanitation and Hygiene).

<u>Training courses of hygienists</u> were carried out in collaboration with Dakupa NGO (Fig. 3.37).

Fig. 3.37. *The Hygienists (on the left) and the trainer of Dakupa NGO (on the right)*

A first series of training courses was provided in order to make aware hygienists on the good hygiene and drinking water management practices. By means of simple but explicative pictures (Fig. 3.38), bad and proper behaviours were highlighted.

These first courses were intended to form local figures (hygienists) able to clearly recognise good and bad hygiene and water management practices, in order to later sensitize local population through "door to door" campaigns. For this reason a copy of the pictures showed during the training were gave to the participants.

Fig. 3.38. *Bad and good practices in drinking water management related to source, transport and storage steps*

Regarding the second series of training courses, starting from the explanation of the WSP concept and its purposes, the structure of the WSP elaborated for the villages of Fingla and Diarra has been step-by-step reconstructed. Possible causes of contamination, definition of the likelihood and severity scores, control measures and monitoring programme were presented and discussed singularly. A great debate arose at the moment of the likelihood and severity scores classification, in order to identify the best definitions for the local context. In this moment, the decision to not refer severity of consequences to the potential impact on public health but to the potential contamination of drinking water was taken, in order to make more useful and understandable by people the meaning of this score. At the end of the training, the important role and duty that the hygienists will have in the WSP management, revision and update was explained to them.

The importance to make aware local experts (outside Dakupa NGO) able to manage the Water Safety Plans developed in the villages was considered extremely relevant.

The second supporting programme, based on <u>awareness campaigns for all the local community</u>, was developed in several sessions, owing to the high number of people to cover. By means of the use of pictures (as the ones shown in Fig. 3.38), people were made aware on bad and good practices in hygiene and drinking water management (Fig. 3.39).

Fig. 3.39. *Awareness campaigns addressed to the community (on the left), students (at the centre) and teachers (on the right)*

Awareness campaigns were always organised with a participative approach, meaning that participants were asked to explain what they were seeing from the pictures shown and to comment what was wrong and what was right, according to their point of view. Then open debates were organised in order to share the different opinions and to clarify, if necessary, important or unclearly aspects arisen from the discussion. At the end of each session, the summary of all the bad and good practices was carried out. These campaigns were considered fundamental for the success and the sustainability of the WSPs elaborated in Fingla and Diarra, and it was for this reason that a great effort was put in this activity.

3.5.3 WSP approach elaborated Vs WSP approach proposed by WHO

The WSP approach elaborated in this case study was rather simplified compared to the one proposed by WHO, as already stated in Paragraph 3.3.2.
Fig. 3.40 shows the conformities according to the WSP approach suggested by WHO.

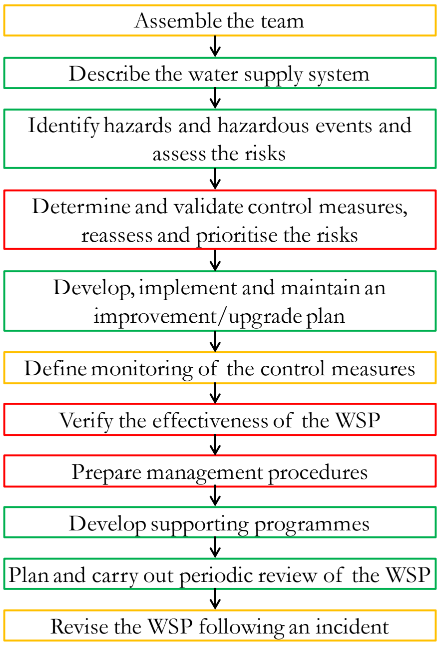

Fig. 3.40. *Conformities of the WSP approach carried out in Fingla and Diarra in comparison with the standard approach (boxes highlighted in green report steps completely carried out, in red the ones not developed and in yellow the ones partially elaborated)*

Even if the establishment of a qualified and dedicated team is one of the prerequisite of the WSP approach, local conditions did not permit to rigorously carry out the first step of the WSP, as suggested by the WHO drinking water guidelines. Technical and political authorities were not available to participate at the WSP elaboration, and moreover qualified experts have not been identified in the area. Thus, the WSP team was composed by users and water Committees' members, who at least are fundamental figures in the drinking water management along the supply chain.
Another aspect that differed from the standard proposed by the WHO was the determination and validation of control measures, with the reassessment and the prioritisation of the risks. This step was completely not carried out, since already planned control measures for preventing or at least minimising drinking water contamination were not in place. For this reason it was impossible to validate the already existing control measures and reassess and prioritise risks. Moreover, a prioritisation of the risks (with a cut-off score, under which, theoretically, causes of contamination can be even neglected) was not carried out, since it has been considered significantly important to assess and provide control measures for each possible cause of contamination because even a low minimisation or prevention in the contamination can contribute to improving the quality of drinking water, and therefore the potential improvement of health conditions of the local population.
The monitoring of control measures was correctly developed, except for the definition of operational and critical limits and corrective actions. Even the verification of the WSP effectiveness was not

provided. The reason behind these decisions was to not excessively complicate the WSP, since it has been elaborated as a prevention tool to manage by ordinary people, without a technical expertise in the field.
The management procedures aimed at documenting actions to be taken when the system is operating under normal and "incident" conditions were neglected. On one hand because there were no differences between normal and incident conditions (water delivered and consumed was already and always microbiologically contaminated), on the other the high amount of illiterate people did not permit to draw up a management document.
Regarding the development of supporting programmes and the planning of periodic review of the Plans, these steps were accordingly provided.
The last step suggested by WHO on the WSP elaboration was the revision of the Plan following every emergency, incident or unforeseen event. This step was not carried out since every day local people were in emergency situation (concerning drinking water quality), but at least the members of the WSPs were informed about the necessity to provide control measures and monitoring programmes for each new hazard identified.

3.6 Final evaluation

In this last section, the results of the assessment carried out about 6 months after the WSP implementation are provided. The first paragraph is focused on drinking water sources evaluation, whereas the second one is regarding the drinking water supply chain.

3.6.1 The drinking water sources

3.6.1.1 Sanitary inspections

One of the first activities carried out in this post-WSP implementation assessment was the survey of tubewells with hand pump. Thus, sanitary inspections were provided for each of the 11 water points. Fig. 3.41 shows the comparison between results obtained before and after the WSP implementation.

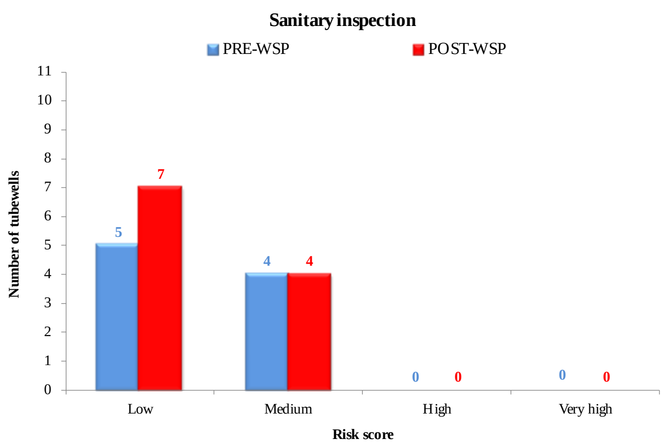

Fig. 3.41. *Comparison of the sanitary inspection results before and after the WSP implementation*

It is possible to highlight how the situation was substantially unchanged, since the same number of tubewells provided a medium risk score. The tubewells in the low risk score category increased from 5 to 7, owing to the presence of the 2 new tubewells realised during the project implementation. But analysing carefully the risk scores obtained, it was possible to notice an interesting result. The 4 tubewells with a medium risk of contamination, highlighted during the pre-assessment, had in one case a score of 5 out of 10 (where "medium" is the category for scores between 3 and 5) and the other three a score of 4. Conversely, sanitary inspections carried out on the same tubewells after the WSP

implementation provided one water point with a risk score of 4 and the other three with a value of 3, meaning that an improvement was taking place. Regarding the tubewells in the low category of risk, the situation was almost unvaried, since at the beginning all the five sources had a score of 2, whereas in the final assessment 6 out of 7 provided a risk score of 2 and the remaining tubewell a value of 1.
The major factor that determined the improvement in these results was the absence of stagnant water within 2 m from the tubewell, meaning that the control measure included in the WSP was able to manage this problem. One aspect that needs to be highlighted was the absence in all the tubewells (except for one) of a proper fence able to protect the water source (from animals, excreta, etc.), even if required by the WSP. The reason was that the survey was carried out during May and June, whereas fences were scheduled to be put in place in August, since (as already stated) it is the better month for the *Jatropha curcas* plantation. An important possible cause of contamination noticed in all the tubewells and unvaried in comparison with the pre-assessment, was the presence of excreta, rubbish, etc. close to the water points. Above all the presence of rubbish was rather consistent in both the surveys. Indeed, waste management was absent in loco, because local people abandoned outdoors each kind of garbage and just sometimes burned it. Moreover, the constant presence of wind did not help to keep away the rubbish from the tubewells and even in spite of the efforts of women in the cleaning of the wells' surrounding, this possible source of contamination was still present in each water point.
Although the strict aspects that were possible to evaluate according to the sanitary inspection forms, the management of water points was considerably improved (Fig. 3.42). The amount of rubbish close to the surroundings decreased, as the presence of stagnant water. The concrete aprons were better cleaned and washed and rarely drainage channels were occluded. Shoes were always kept out of concrete aprons. Control measures provided by the WSPs, in fact, were correctly put into practice and effective.

Fig. 3.42. *Dirty and cleaned concrete aprons before and after WSP implementation (on the left and at the centre respectively), and shoes outside the tubewell apron (on the right)*

3.6.1.2 Water quality analyses

At source level, water quality analyses covered only microbiological parameters. *Escherichia coli*, faecal coliforms, total coliforms and faecal streptococci were investigated. Results present in the following section referred particularly on *E. coli* and faecal streptococci, which are the ones suggested by WHO and European Union (EU) guidelines for drinking water quality determination. Other results will be presented in section 3.6.2, focused on the supply chain. Water samples were always collected in sterilise containers, stored in ice boxes and analysed within 4 hours from sampling (all data collected are reported in Annexe 7).
Fig. 3.43 provides results on *E. coli* determination. Referring to the categories suggested by WHO on the count of bacteria per 100 mL of sample analysed, it is possible to notice the improvement between pre and post WSP implementation. One tubewell did not provide any colony of *E. coli*, whereas all the other ten had a contamination below the 10 units. None of the wells have therefore reported a presence of *E. coli* between 11 and 100, as pointed out instead by some of them during the first assessment.
As shown in Fig. 3.44, comparable results were obtained concerning faecal streptococci. If before the WSP implementation all the water points provided a contamination between 1 and 10 CFU/100mL,

during the final assessment 36% highlighted no contamination whereas the remaining provided always a contamination between 1 and 10.

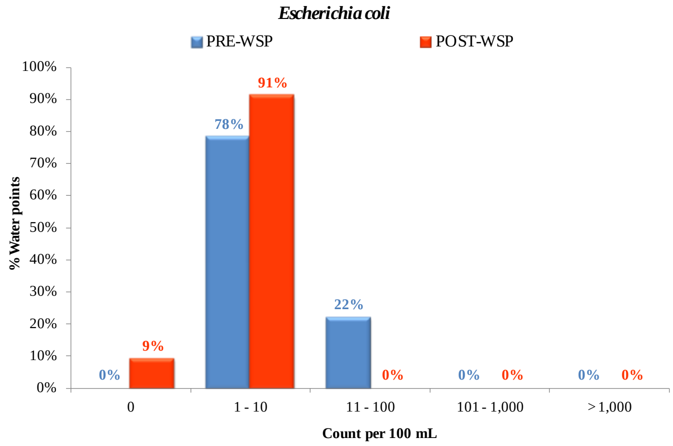

Fig. 3.43. *E. coli contamination at the sources before and after the WSP implementation*

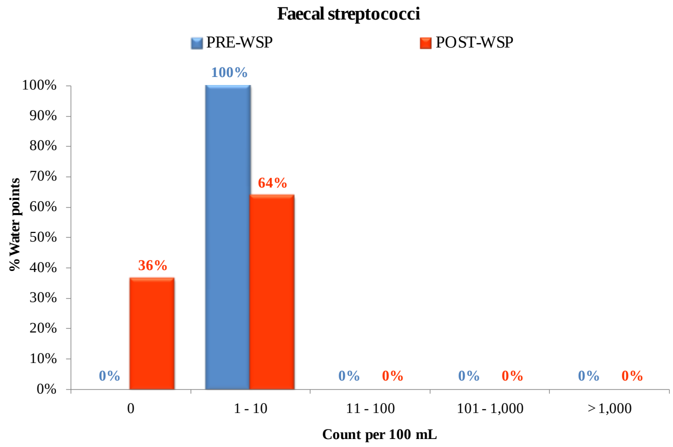

Fig. 3.44. *Faecal streptococci contamination at the sources before and after the WSP implementation*

Fig. 3.45 reports the *E. coli* concentrations at the different tubewells, with a comparison between the pre and post WSP implementation. As pointed out with the previous graph, the sources' contamination decreased quite strongly at the end of the project. Indeed, the average presence of *E. coli* in the pre-assessment was equal to 6.9 CFU/100mL, whereas in the post-assessment 3, thus more than halved (seasonal fluctuations due to the different period of sampling - 3 months after a (feeble) rainy season during the pre-assessment and 1 month before a rainy season during the post-assessment - should also be taken into account).

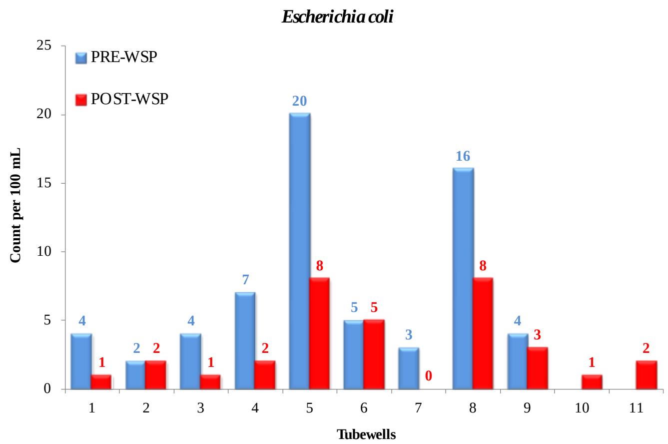

Fig. 3.45. *Count of E. coli at the sources before and after the WSP implementation*

Comparable and even better results were obtained regarding faecal streptococci concentrations, as reported in Fig. 3.46. The average concentration obtained during the first survey in loco was equal to 2.6 CFU/100mL, whereas after the WSP implementation the mean was 0.8, about three times less.

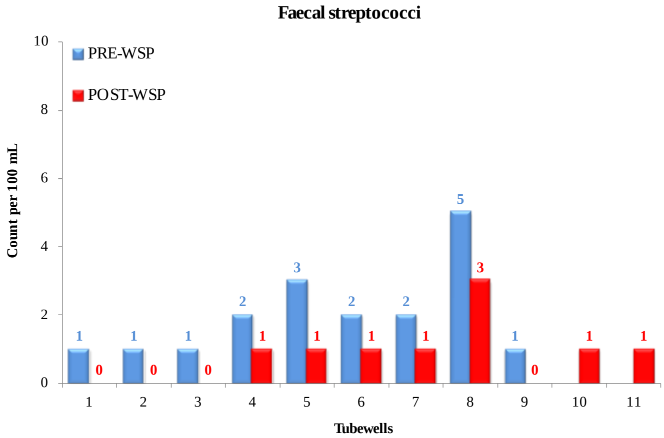

Fig. 3.46. *Count of faecal streptococci at the sources before and after the WSP implementation*

All the results provided until this moment highlight how the WSP approach permitted to improve the management of water points and thus drinking water quality. Greater efforts must be made to ensure that tubewells are delivering safe drinking water, but these results only 6 months after the WSP implementation are to think of being on the right direction.

3.6.1.3 WSP control measures evaluation

The evaluation at the source level was also carried out concerning the Water Safety Plan. In particular, control measures provided by each Plan were evaluated. To perform this check, the frequencies of occurrence of all possible causes of drinking water contamination listed in the WSP were verified. This methodology permitted to determine, on one hand, the effectiveness of the control measures provided per each Plan and on the other if these measures were actually put into practice. Therefore, unvarying the risk scores related to the severity of contamination, likelihoods have been reformulated and then the overall risks (likelihood x severity) recalculated. Thus, means of the global risk scores of each Plan (only referring to the sources sub-Plans) were determined both with the new and old frequencies. Fig. 3.47 shows results obtained from this evaluation. It has to be highlighted that the average risk score of each Plan can assume values between 1 and 25: 1 is related to the best situation, in which all the likelihoods and severities are equal to 1 (so, causes of contamination that happen once every 5-10 years and no water pollution); 25 is related to the worst situation, in which all the likelihoods and severities are equal to 5 (so, causes of contamination that happen daily and certain water pollution).

Results showed as the average risk score decreased 6 months after the WSP implementation. The global risk score provided by WSPs had an average value of 15.2, whereas the “new” global risk score, obtained by the reformulation of the occurrence’s frequencies of contamination, assumed an average value of 9.9. Moreover, some sub-Plans determined really high risk scores at the moment of the WSP elaboration, rather close to the maximum value of 25, respectively equal to 21.2, 20.6 and 23.5. Conversely, already in the first draft of the Plan, two tubewells provided a global risk score quite low and equal to 7.2 and 9.6. These values were related to the two new tubewells realised during the project implementation, when people was already made aware on the good practices for drinking water management. For this reason likelihoods set in these WSPs were lower.

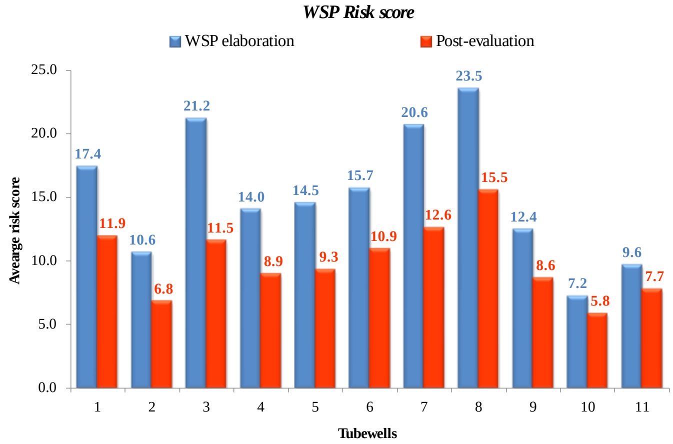

Fig. 3.47. *Means of the global risk scores of each WSP (sources sub-Plans)*

Regarding the average values of the "new" global risk scores, it is possible to highlight how the maximum value reached 15.5 whereas the minimum 5.8, both in correspondence to the maximum and minimum value, respectively, of the first WSP draft.
Fig. 3.48 shows the risk reduction obtained for each tubewell. The average decrease was equal to 33%, with a peak of 45%. The two new tubewells built were the ones with the lesser reduction, respectively of 19 and 20%.

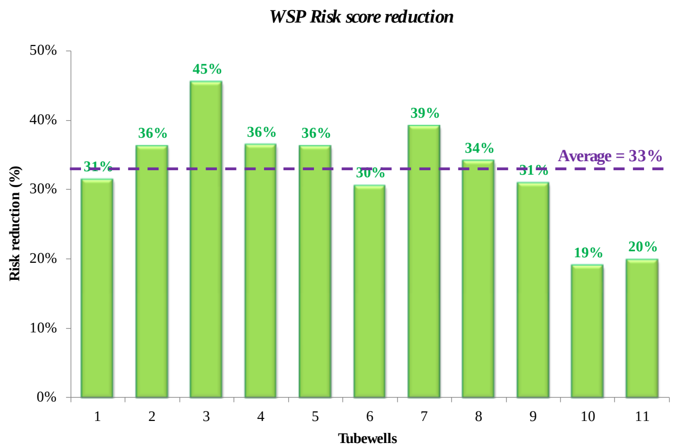

Fig. 3.48. *Reductions on global risk scores 6 months after WSPs elaboration (sources sub-Plans)*

The frequencies of almost all the possible causes of contamination were contributing to the global risk reduction. The ones that decreased more likelihoods have been the improper hygiene and cleaning of the tubewell, the use of dirty shoes on the concrete aprons, the doing the laundry close to the tubewell, the presence of stagnant water around the tubewell's walls and the use of pesticides close to the tubewell. Conversely the causes still almost unvaried (for the reasons already stated above) were the presence of animals, excreta and rubbish around / close to the tubewell and the presence of latrines and cemeteries within 10m (already with an extremely low frequency, due to their absence, set during the WSPs elaboration).

3.6.2 The drinking water supply chain

An evaluation of the entire drinking water supply chain (tubewells-transport-storage and consumption) was carried out 6 months after the WSP elaboration. The drinking water management practices of the local population were verified by means of interviews, moreover water quality analyses in the transport and storage containers of 24 families and the evaluation of WSP control measures were provided.

3.6.2.1 Drinking water management practices

The interviews carried out amongst families of Fingla and Diarra permitted to gather essential information about drinking water management practices. 175 out of 200 interviews were developed in Fingla, whereas the remaining 25 in Diarra.

Regarding first of all water consumption, at Fingla, 173 families collected water at tubewells, 38 at open dug wells, 26 at the river and 19 used rain water. The rate of access to "safe" water (in other words to tubewells, which are the only improved source in loco) was about 92%, higher compared to the national accessibility in rural areas which is some of 74% [4]. At Diarra, 18 families collected water at tubewells, whereas 8 at the river. Globally, 191 families, for drinking purposes, used water from tubewells, 8 from open dug wells and, when available, 1 family used rain water and 10 river water.

Tab. 3.17 reports data on drinking water supply before and after the WSP implementation, highlighting how consumption of drinking water from tubewells increased in spite of the reduction of water supplied by open dug wells (used for drinking purposes only by 9 out of 200 families interviewed).

***Table 3.17.** Water sources used for drinking purposes before and after WSP implementation*

Tubewells			Open dug wells		
Pre-WSP	Post-WSP	*Variation**	Pre-WSP	Post-WSP	*Variation**
148	191	*+22%*	56	9	*- 24%*

* Calculated based on the 200 households surveyed

The average distance between households and water points was evaluated in 9.3 minutes walking. Considering separately the two villages, it appeared as at Fingla the average distance tubewell / household has been reduced compared to the beginning of the project ($p=0.0191$), going from 9.7 minutes walking to the current 7.0, thanks to the three new tubewells built during MMI project implementation. Even analysing the frequency of supply, it was possible to notice that at Fingla the average frequency was reduced ($p=0.0004$), going from 5.2 to 4.3 times per day.

Regarding the village of Diarra, the average distance tubewell / household decreased from 18.9 to 12.1 minutes walking (even if not with a statistical significance), whereas the average frequency of supply was substantially unvaried (4.3 at the beginning of the project and 4.6 at the end).

Processing data collected from the interviews, it was also possible to estimate the amount of water available for drinking purposes per capita (based on the number of containers collected and their capacity). Results showed that, on average, 54.14 L per family were available daily exclusively for drinking, which means about 5.7 L daily per person, thus providing a higher amount compared with the previous value of 4.5 L obtained in the first assessment.

Focusing on drinking water management practices, elaborated for both villages together, results showed that transport tanks were generally discovered closed at the moment of interviews in 203 cases and open in the other 21 (global amount of tanks is over the total number of families interviewed because someone of them used both the types). In particular, all the 191 jerry cans were closed, whereas aluminium basins were open in 21 cases out of 33. Globally, 34% more containers resulted closed compared with the pre-WSP implementation assessment. An interesting aspect highlighted during the survey and confirmed by data elaboration, was the strong decrease in the use of aluminium basins for collecting drinking water (from 105 to 33), in spite of the increase of jerry cans (from 128 to 191). On average, the cleansing of these containers was carried out once per day (Fig. 3.49). In 32 cases families said to use chlorine, in 178 soap, in 6 only water, in 4 a sponge, in 4 sand and in 49 cases gravel.

Fig. 3.49. *Interior of jerry cans proper cleaned*

Tab. 3.18 shows the variance on cleaning practices of these containers before and after the WSP implementation, highlighting a relevant increase in the use of chlorine and a reduction in the use of only water, sand and leaves. A new cleansing method appeared (as suggested during the WSP elaboration), by means of the use of gravel. The use of this material jointly with water and soap (or better chlorine) was incentivised for cleaning jerry cans, in order to easier remove the possible algal formation that grew inside this kind of containers.

Table 3.18. *Cleansing methods of transport containers before and after WSP implementation*

Detergents	Pre-WSP	Post-WSP	*Variation**
Chlorine	9	32	*+ 12%*
Soap	174	178	*+ 2%*
Only water	23	6	*- 9%*
Sponge	58	4	*- 27%*
Sand	28	4	*- 12%*
Gravel	0	49	*+ 25%*
Leaves	2	0	*- 1%*

* Calculated based on the 200 households surveyed

Moved to the <u>storage tanks</u>, results highlighted that 377 were closed and 9 open. In particular, all the 172 jerry cans were closed as all the 13 plastic cans with valve (Fig. 3.50), whereas earthen jars were found closed in 175 cases out of 179 and plastic buckets in 17 out of 22.

Fig. 3.50. *Plastic cans with valve used by two families (stored inside the dwelling)*

On average, the <u>cleansing</u> of these containers was carried out once per day. In 38 cases families said to use chlorine, in 162 soap, in 19 only water, in 12 a sponge and in 17 sand. Tab. 3.19 shows the variance on cleaning practices of these containers before and after the WSP implementation, highlighting an increase in the use of chlorine and soap and a reduction in the use of only water, sponge and sand.

Table 3.19. *Cleansing methods of storage containers before and after WSP implementation*

Detergents	Pre-WSP	Post-WSP	*Variation**
Chlorine	12	38	*+ 13%*
Soap	127	162	*+ 18%*
Only water	28	19	*- 5%*
Sponge	77	12	*- 33%*
Sand	23	17	*- 3%*

* Calculated based on the 200 households surveyed

The average time of water storage in the home was identified in 1 day. Fig. 3.51 shows the use of the different storage containers identified in the interviewed families, before and after the WSPs implementation. Results highlighted that something changed in comparison with the situation pre-WSP elaboration, since the use of dedicated containers only for drinking purposes arose. However, further efforts need to be put in place in order to increase the percentage of containers used exclusively for this purpose.

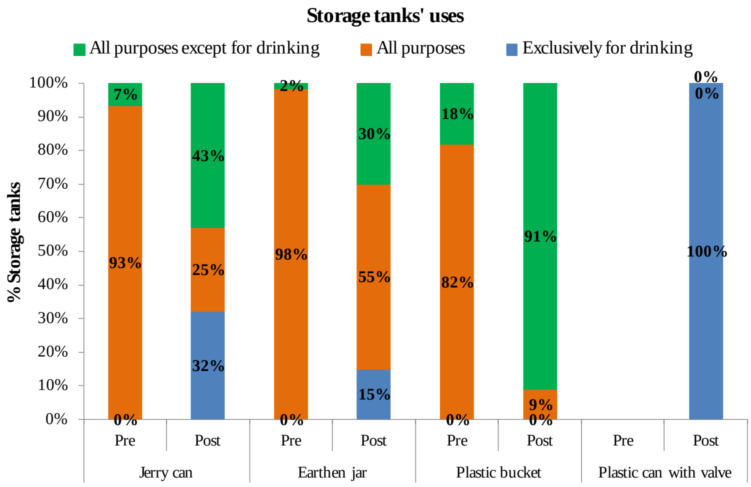

Fig. 3.51. *Final purpose of the different storage containers before and after WSP implementation*

Concerning water treatment, interviews' results were still discouraging since 156 families out of 200 did not carry out any disinfection treatment. Amongst the others, 37 made disinfection with chlorine (some of 15% more compared to the pre-WSP implementation), 6 filtration on tissue and 1 decanting.
At the end of the interviews, two main aspects were investigated directly by the interviewer: the place where drinking water and the cup used for drinking were stored. Water was stored outside the dwelling and accessible to every potential source of pollution in 9 cases, in 70 was outside the house but covered with a lid, in 2 was inside the house but in potential contact with contaminants and in 119 cases was inside the house and protected. Tab. 3.20 shows the variance on storage's places of containers used for drinking purposes before and after the WSP implementation, pointing out an extremely high increase of the storage inside the dwelling in a protected place, jointly with a strong reduction of all the other possible places of storage.

Table 3.20. *Storage's place of containers used for drinking purposes before and after WSP implementation*

Place	Pre-WSP	Post-WSP	*Variation**
Outside unprotected	42	9	*- 17%*
Outside protected	140	70	*- 35%*
Inside unprotected	8	2	*- 3%*
Inside protected	10	119	*+ 55%*

* Calculated based on the 200 households surveyed

Regarding the cup used for drinking, in 11 cases was left on the ground, in 20 inside the storage tank, in 100 deposited on the lid with the side to drink upwards and in 53 with the side to drink upside down, in

9 cases was left upside down on the container's lid but protected with a tissue and in 7 cases was stored in a protected place.

Table 3.21. *Storage's place of containers used for drinking purposes before and after WSP implementation*

Place	Pre-WSP	Post-WSP	*Variation**
Left on the ground	74	11	*- 32%*
Inside the container	13	20	*+ 4%*
On the lid upwards	56	100	*+ 22%*
On the lid downwards	53	53	*0%*
On the lid downwards and protected	0	9	*+ 5%*
In a protected place	0	7	*+ 4%*

* Calculated based on the 200 households surveyed

Tab. 3.21 shows the variance on storage's places of cups used for drinking purposes before and after the WSP implementation, pointing out a decrease of the storage on the ground but an increase inside the containers and on the lid upwards. Even if the storage on the lid downwards was unchanged, new safe places of storage arose as on the lid downwards but protected with a piece of tissue and in a protected place. Conversely to the place of storage of drinking water containers that provided relevant improvements, regarding cups used for drinking more efforts have to be put in place.

Finally, a <u>variable called "attitude"</u> was again created in order to define the level of good practices in water management. A score of 0, 0.25, 0.50, 0.75 or 1 was assigned to the possible answers to questions related to water management (frequency and type of cleansing of the transport and storage tanks, residence time of the stored water, place of storage of drinking water and cup used for drinking). The suitability to the responses has been identified taking into account both the international guidelines on good practices and the real possibilities of implementing them in the specific context. Then, 4 categories of the level of "attitude", on the basis of scores obtained, were also fixed: extremely poor, poor, adequate and good. The average score obtained from the 200 households surveyed was equal to 7.4 (the pre-WSP elaboration assessment provided an average attitude of 5.6) that corresponds to a level of attitude adequate. Table 3.22 reports the levels of attitude of households interviewed before and after WSP implementation. Relevant results were obtained, since the extremely poor and poor attitudes decreased strongly, whereas good attitudes were highlighted by 21% more interviewed people. On average, the level of attitude on drinking water management practices increased of 32%.

Table 3.22. *Categories of attitude to the good practices in drinking water management, before and after WSP implementation*

Attitudes	Categories	Pre-WSP	Post-WSP	*Variation**
Extremely poor	0 - 2	4	0	*- 2%*
Poor	2 - 4	18	7	*- 6%*
Adequate	4 - 8	172	145	*- 14%*
Good	> 8	6	48	*+ 21%*
AVERAGE	-	5.6	7.4	*+ 32%*

* Calculated based on the 200 households surveyed

Concerning the questions related to <u>hygiene and health conditions</u>, some important aspects arose related to drinking water quality and management.

Investigating which detergent was used for washing hands, 154 families indicated soap (but only in the 82% of those, soap was really present at home during the interview), 10 chlorine, 72 only water and 3 admitted not to use any detergent. An increase of the people that really had in the household the soap used for washing hands was provided, the percentages of people passed from 46 to 82%, respectively before and after WSP elaboration.

Regarding health conditions, questions on the number of diarrhoea cases in the family in the last few months, actions to be taken in case of diarrhoea, causes of diarrhoea, methods to avoid diarrhoea and signs of severe diarrhoea were asked to people interviewed. After the elaboration of these answers, a variable called "enteritis" was again created in order to determine possible relations between the waterborne diseases and the drinking water management practices. Households that have highlighted at least a case of enteritis were 24 (58% less than the first assessment). Cases of enteritis were statistically significantly prevented when cups for drinking were left on the lid with the side to drink downwards (p=0.037), drinking cups deposited in a protected place (p=0.029) and the distance between households and tubewells was less than 5 minutes walking (p=0.0092).

3.6.2.2 Water quality analyses

Drinking water quality analyses in the supply chain (transport and storage steps) were carried out evaluating *Escherichia coli*, faecal coliforms, total coliforms and faecal streptococci. Samples were collected from 24 households (12% of the households interviewed), half of which had received or purchased a plastic can with valve, as a storage container, whereas the other half was using traditional earthen jars. Water samples were always collected in sterilise containers, stored in ice boxes and analysed within 4 hours from sampling. Samples from transport tanks were taken directly from the containers, whereas, regarding storage tanks, samples opening valves were provided for the first type of containers and by means of cups for drinking for jars. Results present in the first part of this section referred particularly on *E. coli* and faecal streptococci (suggested by WHO and EU), further in the discussion even results related to faecal and total coliforms will be introduced. All data collected are reported in Annexe 7.

Fig. 3.52 provides results on *E. coli* determination along the entire supply chain, independently from the storage container. Referring to the categories suggested by WHO on the count of bacteria per 100 mL of sample analysed, it is evident how *E. coli* contamination increases along the supply chain's steps. The contamination at the source level was predominantly in the range 1-10 CFU/100mL (91% of the samples), even if the 9% of the samples analysed was characterised by the complete absence of *E. coli*. Transport step presented typically between 11 and 100 CFU (63%), whereas storage was characterised by 11-100 CFU/100mL for the 50% and by 101-1,000 for the other half.

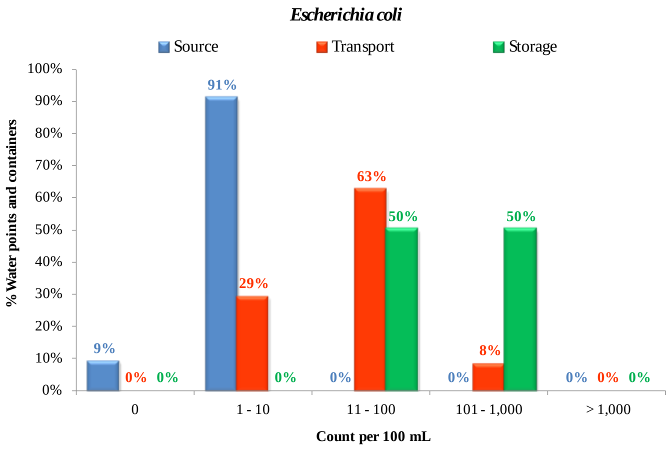

Fig. 3.52. *E. coli trend along the supply chain*

Table 3.23 reports the comparison between the *E. coli* trend into the supply chain before and after the WSP approach elaboration. As already stated in section 3.6.1.2, *E. coli* contamination at source level was decreasing after the WSP implementation. A 22% reduction of sources with a contamination above 11 CFU/100mL was provided, with an increase of the 9% of sources without *E. coli* colonies. Regarding the transport step, it has to be noticed the increase of the 23% of samples with a contamination between 1 and 10 colonies, to the detriment of the 10% decrease in the higher category highlighted during the pre-assessment (101-1,000 CFU/100mL), which now characterises only the 8% of the samples analysed. Concerning finally the storage step, a 24% decrease of the contamination in the range

101-1,000 CFU/100mL was provided, with the consequent increase of the 24% in the lower category (11-100 colonies).

Table 3.23. *Comparison between the E. coli trend into the supply chain before and after the WSP elaboration*

Escherichia coli		Count per 100 mL				
		0	1 - 10	11 - 100	101 – 1,000	> 1,000
Source	Pre-WSP	0%	78%	22%	0%	0%
	Post-WSP	9%	91%	0%	0%	0%
	Variation	*+ 9%*	*+ 13%*	*- 22%*	0%	0%
Transport	Pre-WSP	0%	6%	76%	18%	0%
	Post-WSP	0%	29%	63%	8%	0%
	Variation	*0%*	*+ 23%*	*- 13%*	*- 10%*	*0%*
Storage	Pre-WSP	0%	0%	26%	74%	0%
	Post-WSP	0%	0%	50%	50%	0%
	Variation	*0%*	*0%*	*+ 24%*	*- 24%*	*0%*

Fig. 3.53 provides results on faecal streptococci determination along the entire supply chain, even in this case independently from the storage container. The contamination at the source level was above all in the range 1-10 CFU/100mL (64% of the samples), even if the 36% of the samples analysed was characterised by the complete absence of *E. coli*. Referring to transport and storage steps, interesting results were pointed out. In transport containers, even if 63% of samples were characterised by the presence of 11-100 colonies, 12% of these did not present faecal streptococci and 25% only in the range 1-10 CFU/100mL. A similar trend was obtained for the storage step, where 53% of samples had a contamination between 101 and 1,000 colonies, but an 8% was characterised by the complete absence of faecal streptococci and another 8% in the range 1-10 CFU/100mL.

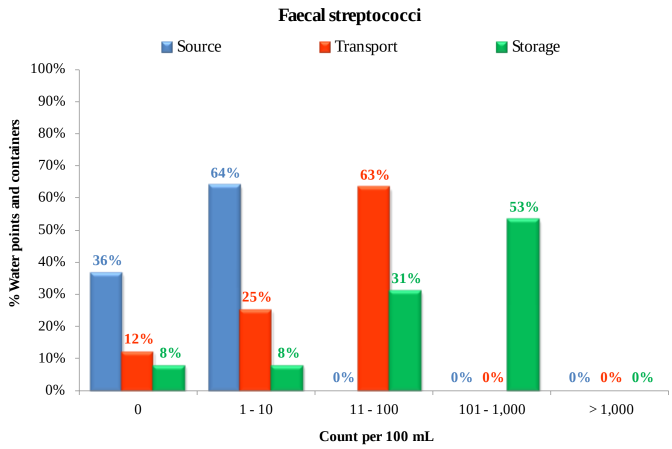

Fig. 3.53. *Faecal streptococci trend along the supply chain*

Table 3.24 reports the comparison between the faecal streptococci trend into the supply chain before and after the WSP approach elaboration. As already stated in section 3.6.1.2, faecal streptococci contamination at source level was decreasing after the WSP implementation. A reduction of the 36% of sources with a contamination in the range 1-10 CFU/100mL was provided, with a consequent increase of the 36% of sources without faecal streptococci colonies. Regarding the transport step, it has to be noticed the increase of the 8% of samples with a contamination between 1 and 10 colonies, and above all the 12% of samples without faecal streptococci. Consequently samples characterised by 101-1,000 CFU/100mL were annulled. Concerning the storage containers analysed, a 21% decrease of the contamination in the range 101-1,000 CFU/100mL was provided, with the consequent increase of the 8% in the categories 0 and 1-10 CFU/100mL.

Table 3.24. *Comparison between the faecal streptococci trend into the supply chain before and after the WSP elaboration*

Faecal streptococci		Count per 100 mL				
		0	1 - 10	11 - 100	101 – 1,000	> 1,000
Source	Pre-WSP	0%	100%	0%	0%	0%
	Post-WSP	36%	64%	0%	0%	0%
	Variation	*+ 36%*	*- 36%*	*0%*	*0%*	*0%*
Transport	Pre-WSP	0%	17%	65%	18%	0%
	Post-WSP	12%	25%	63%	0%	0%
	Variation	*+ 12%*	*+ 8%*	*- 2%*	*- 18%*	*0%*
Storage	Pre-WSP	0%	0%	26%	74%	0%
	Post-WSP	8%	8%	31%	53%	0%
	Variation	*+ 8%*	*+ 8%*	*+ 5%*	*- 21%*	*0%*

After having highlighted the average contamination along the entire supply chain, a focus on the two main supply chains that differed only for the storage container was made. Indeed, sources were identified in tubewells, transport containers in jerry cans and storage tanks in plastic cans with valve in one case and in earthen jars in the other.
Fig. 3.54 shows results obtained for *Escherichia coli* concentration into the two different supply chains.

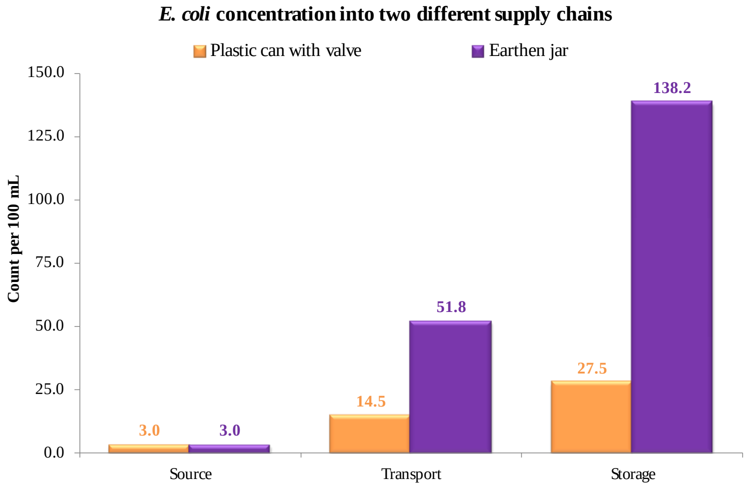

Fig. 3.54. *Average E. coli concentrations along the steps of the two supply chains*

Starting from the same average value of *E. coli* at source level, high differences in the contamination along the other two steps were provided. If lower values in cans with valve's storage containers were due to the lower contact between drinking water and pollution vectors (contact with dirty hands, dirty cups used for drinking, continue openings of the containers during the day, etc.), lower values in the jerry cans' transport containers were explained by more proper hygiene practices in water handling and management (mainly, better cleansing of containers) from households that used cans with valve. Fig. 3.55 shows the different level of cleansing of the two supply chains.

Fig. 3.55. *Level of cleansing in the traditional supply chain (on the top) and in the "new" one (on the bottom)*

Generally and on average the level of cleansing was improved amongst the population (as partially highlighted by data obtained from interviews). More proper water management practices were however highlighted in the households that benefited from cans with valve. In fact, these containers were donated to people who showed to be more participant and involved in the WSP elaboration, thus more receptive about proper water management.
Even better results were obtained referring to faecal streptococci, as shown in Fig. 3.56. This is probably due to the fact that faecal streptococci represent an ancient contamination, thus applying more proper cleaning practices in containers' management, it is possible to avoid a high increase of these colonies.

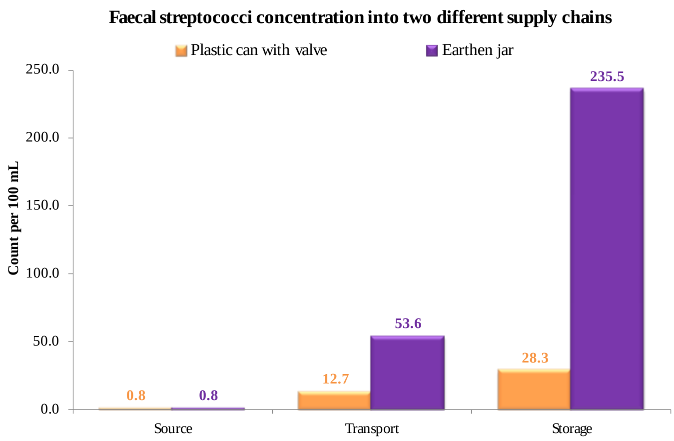

Fig. 3.56. *Average faecal streptococci concentrations along the steps of the two supply chains*

Figg. 3.57, 3.58, 3.59 and 3.60 show results obtained from this assessment, related to *E. coli*, faecal coliforms, total coliforms and faecal streptococci respectively at source, transport and storage level. Transport and storage values, referred to the supply chain characterised by the use of cans with valve, are the ones highlighted with a black edge. From all the graphs, it is possible to see how analyses carried out along the "new" supply chain provided values always lower the average contamination. Some high peaks of contamination in transport and above all in storage step were provided by some households.

These referrers to families that did not ever follow awareness campaigns organised during the project implementation, regarding both good practices in water handling and management and WSP elaboration.

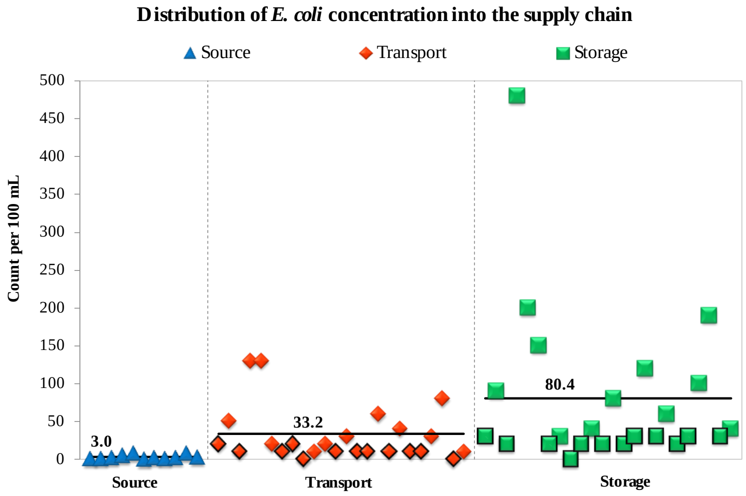

Fig. 3.57. *E. coli concentration of all samples analysed in the different supply chains' steps*

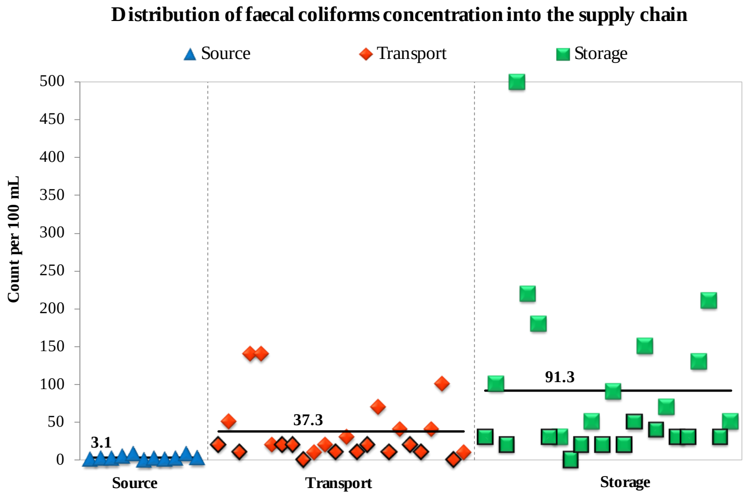

Fig. 3.58. *Faecal coliforms concentration of all samples analysed in the different supply chains' steps*

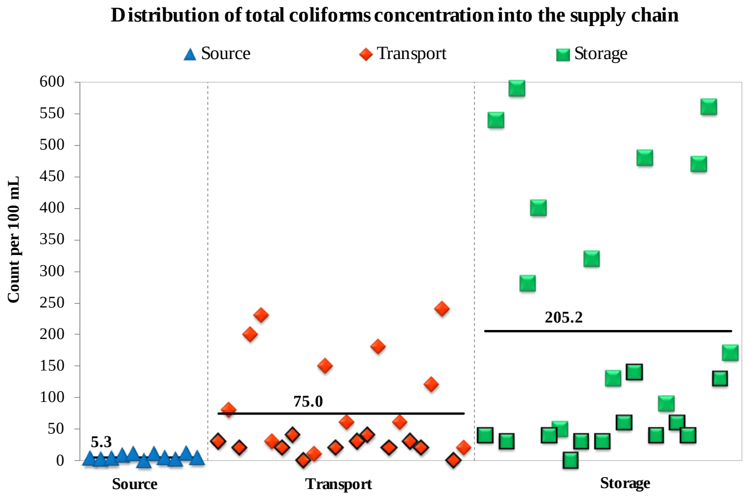

Fig. 3.59. *Total coliforms concentration of all samples analysed in the different supply chains' steps*

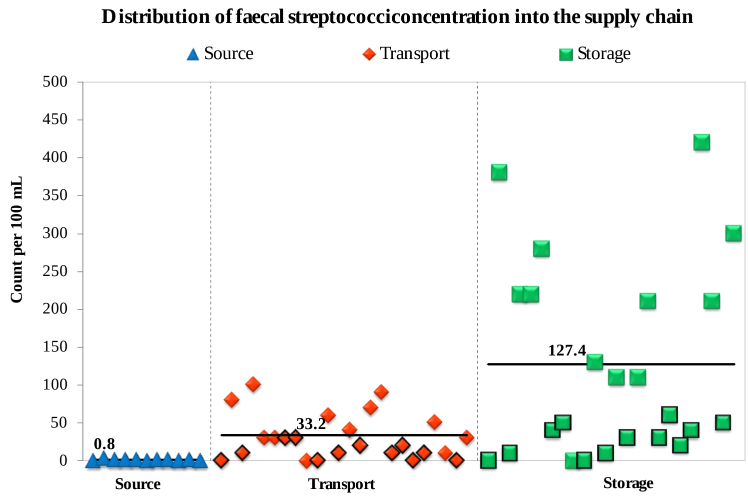

Fig. 3.60. *Faecal streptococci concentration of all samples analysed in the different supply chains' steps*

In order to evaluate the possible improvement in drinking water quality after the implementation of the WSP approach, a comparison between the average concentrations of all the four parameters analysed along the entire supply chain has been carried out. As reported in an experimental study present in the scientific literature [38], the comparison of bacteriological analyses pre- and post-WSP elaboration can be an indicator of the WSP effectiveness. Table 3.25 shows results obtained from this data elaboration. Results on the post-WSP implementation assessment were divided into two categories, according to the two drinking water supply chains. In order to evaluate the difference in the contamination before and after the WSP elaboration, a statistical analysis by means of the t-test (statistical tool used for comparing two means) was provided. Statistical significance was set as two tail and at 5% (p=0.05).

Table 3.25. *Average drinking water quality along the entire supply chain before and after the WSP implementation*

Parameter	Supply chain's point	Pre-WSP	Post-WSP (Can with valve)	*P (t-test)*	Pre-WSP	Post-WSP (Earthen jar)	*P (t-test)*
E. coli *(CFU/100mL)*	Source	6.9	3.0	*0.0734*	6.9	3.0	*0.0734*
	Transport	56.5	14.5	*0.0039*	56.5	51.8	*0.7793*
	Storage	179.5	27.5	*< 0.0001*	179.5	138.2	*0.2908*
Faecal coliforms *(CFU/100mL)*	Source	8.1	3.1	*0.0339*	8.1	3.1	*0.0339*
	Transport	81.8	16.4	*0.0001*	81.8	58.2	*0.2082*
	Storage	226.3	30.8	*< 0.0001*	226.3	157.3	*0.1199*
Total coliforms *(CFU/100mL)*	Source	13.2	5.3	*0.0044*	13.2	5.3	*0.0044*
	Transport	158.2	27.3	*0.0085*	158.2	122.7	*0.4815*
	Storage	536.3	53.3	*< 0.0001*	536.3	370.9	*0.0891*
Faecal streptococci *(CFU/100mL)*	Source	2.6	0.8	*0.0258*	2.6	0.8	*0.0258*
	Transport	78.8	12.7	*0.0650*	78.8	53.6	*0.4772*
	Storage	276.8	28.3	*0.0012*	276.8	235.5	*0.5739*

The decrease in the microbiological contamination of sources has been highlighted statistically significant for all the four parameters analysed, except for *E. coli* that provided a value of 0.07 when the statistical significance was set at 0.05.

The microbiological quality of drinking water improved in a statistically significant way between the pre- and post-WSP elaboration (for all the four parameters investigated), in relation with the supply chain characterised by the use of plastic cans with valve. Although the drinking water microbiological quality related to the traditional supply chain was also improved after the WSP implementation, the comparison of the average concentrations did not show any statistical significance.

These results lead therefore to the conclusion that the development of the WSP as a tool for the prevention / minimization of contamination and at the same time for raising awareness amongst the population on good water management practices, jointly with the use of storage containers equipped with a valve, allows a statistically significant reduction of the drinking water's microbiological contamination along the entire water supply chain.

3.6.2.3 WSP control measures evaluation

The evaluation of the drinking water supply chain was also carried out referring to the Water Safety Plan. In particular, control measures provided by each sub-Plan were evaluated. To perform this check, the frequencies of occurrence of all possible causes of drinking water contamination listed in the WSP were verified, as for source sub-Plans. Therefore, unvarying the risk scores related to the severity of contamination, likelihoods have been reformulated and then the overall risks (likelihood x severity) recalculated. Then, means of the global risk scores of each sub-Plan (referring to both transport and storage and consumption sub-Plans) were determined referring to the new and old frequencies. Fig. 3.61 shows results obtained from the evaluation of transport sub-Plans. Each Plan can always assume values between 1 and 25: 1 is related to the best situation, in which all the likelihoods and severities are equal to 1, whereas 25 is related to the worst situation, in which all the likelihoods and severities are equal to 5. Results showed as the average risk score decreased 6 months after the WSP implementation. The global risk score provided by WSPs had an average value of 17.2, whereas the "new" global risk score, obtained by the reformulation of the occurrence's frequencies of contamination, assumed an average value of 13.3. Some sub-Plans determined already high risk scores at the moment of the WSP elaboration, rather close to the maximum value of 25 (i.e. 20.8). Conversely, already in the first draft of the Plan, a tubewell (a new one) provided a global risk score quite low and equal to 6.6. Regarding the average values of the "new" global risk scores, it is possible to highlight how the maximum value reached 15.0 whereas the minimum 5.8.

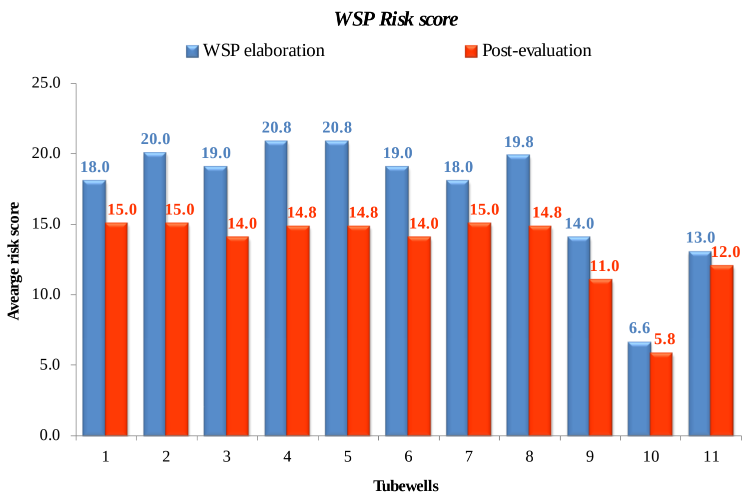

Fig. 3.61. *Means of the global risk scores of each WSP (transport sub-Plans)*

Fig. 3.62 shows the risk reduction obtained for each WSP developed in the area. The average decrease was equal to 21%, with a peak of 29%. The two new tubewells built were the ones with the lesser reduction, respectively of 12 and 8%. It has to be noticed how the reduction was more significant in the Plans with a higher risk score set during the WSP elaboration, whereas the ones with an already lower global risk value provided a minor risk reduction (due to the minor decrease of the likelihoods referred to the different causes of contamination).

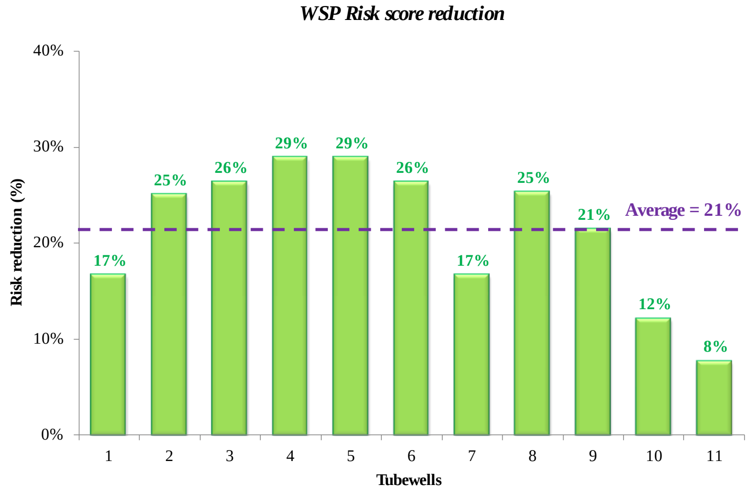

Fig. 3.62. *Reductions on global risk scores 6 months after WSPs elaboration (transport sub-Plans)*

The frequencies that more contributed to the global risk reduction, by means of the decrease of likelihoods, have been related to open containers.

Fig. 3.63 shows results obtained from the evaluation of storage and consumption sub-Plans. Results showed as the average risk score decreased 6 months after the WSP implementation. The global risk score provided by WSPs had an average value of 16.0, whereas the "new" global risk score, obtained by the reformulation of the occurrence's frequencies of contamination, assumed an average value of 12.4. Some Plans determined already high risk scores at the moment of the WSP elaboration (i.e. 19.5), even if lower compared with the ones provided by source and transport sub-Plans. Regarding the average values of the "new" global risk scores, it is possible to highlight how the maximum value reached 13.8 whereas the minimum 8.8.

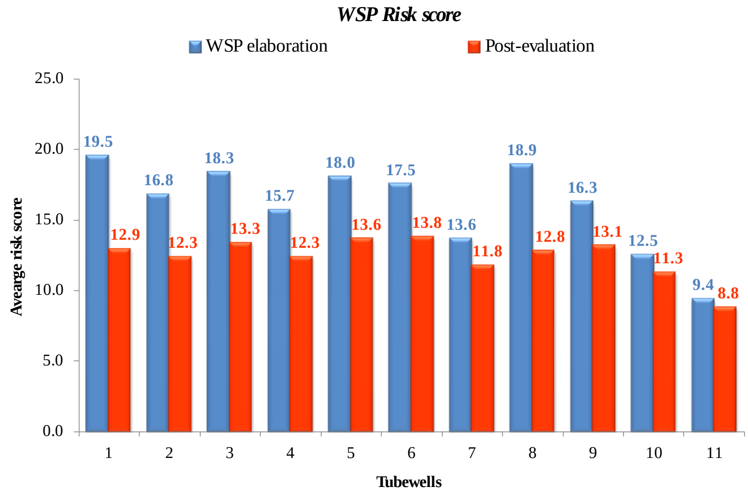

Fig. 3.63. *Means of the global risk scores of each WSP (storage and consumption sub-Plans)*

Fig. 3.64 shows the risk reduction obtained for each WSP developed in the area. The average decrease was equal to 22%, with a peak of 34%. The two new tubewells built were the ones with the lesser reduction, respectively of 10 and 7%. Even in this case, the reduction was more significant in the Plans with a higher risk score set during the WSP elaboration.

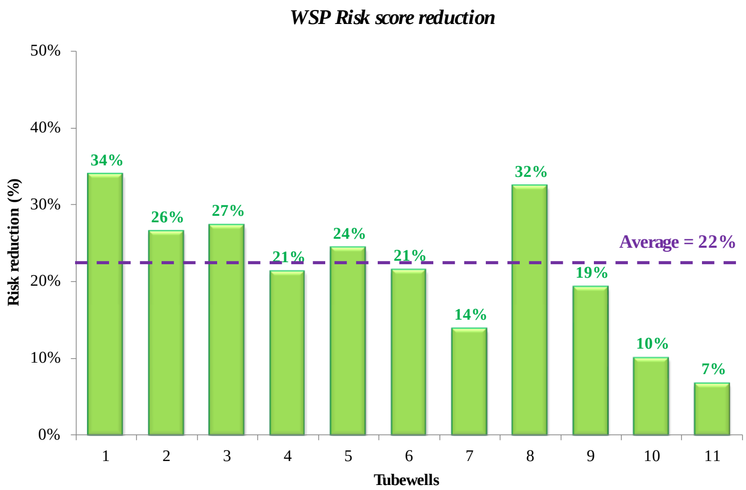

Fig. 3.64. *Reductions on global risk scores 6 months after WSPs elaboration (storage and consumption sub-Plans)*

The frequencies of almost all the possible causes of contamination were contributing to the global risk reduction. The ones that decreased more likelihoods have been the containers open, the containers stored outside the dwelling, the high drinking water storage time, the dirty environment nearby the containers and the storage containers and cups for drinking used also for chemicals. Conversely the causes still almost unvaried were the cups used for drinking dirty, the containers dirty and the hands dirty, since not all the households were putting into practice all the proper hygiene behaviours recommended during the WSP elaboration. As highlighted by some results of microbiological analyses, people that did not participate to awareness campaigns and WSP elaboration still provided high microbial contamination of drinking water.

3.7 Conclusions

This Chapter aimed at presenting the Water Safety Plan elaborated and implemented in a rural area of Burkina Faso. Local conditions did not permit to develop a WSP approach as suggested by WHO, thus a simplified and revised framework was carried out. The community and the managers of water points were involved as WSP team and, at the same time of the WSP elaboration, were made aware about good practices to take into account when managing and handling drinking water, from the catchment to the point of consumption. In order to guarantee the consumption of safe drinking water, disinfection with chlorine at the point of consumption and the use of improved water containers (cans with valve) were promoted amongst the population.

The following highlights summarise the main conclusions of this experimental research:

- ✓ 11 WSPs were elaborated amongst the villages of Fingla and Diarra, each composed of 3 sub-Plans related to hazard evaluation, control measures' identification and monitoring programming of source, transport and storage levels respectively. Each WSP was develop in correspondence of an improved water point (tubewells), thus it will be valid and of reference for the specific water Committee and the users of each tubewell.
- ✓ Water Committees and users who elaborated the WSPs (in collaboration with 7 local hygienists and Dakupa NGO) were made aware of all the possible causes of drinking water contamination along the entire supply chain and thus of all the good behaviours to put into practice in order to prevent microbiological and chemical contamination. Moreover these people were directly involved in the monitoring programme of control measures, in order to guarantee the sustainability of the WSP.
- ✓ As stated, the use of a storage container with valve that permits to minimise the contact between drinking water and contamination vectors was suggested and promoted, as well as water treatment

at the point of consumption. This latter intervention was mandatory for trying to assure the consumption of safe drinking water and because burkinabé national Regulation forbade the disinfection of drinking water at source level by communities (only Institutions nationally recognized had the authorization for the treatment of water at point of capture).

- ✓ Microbiological quality of drinking water improved drastically after WSP implementation along all the supply chain. The most significant improvements, both at transport and storage level, were highlighted amongst people who received or purchased the improved storage container. These families provided a statistical significant reduction of drinking water contamination. In these supply chains, for instance and on average, *E. coli* decreased in transport containers of 42 colonies and in storage containers of 152. The final average contamination at the point of consumption was some of 25 CFU/100mL.
- ✓ Control measures provided by WSPs were mostly put into practices. Some of them were not yet carried out at the moment of the final evaluation since they were already scheduled to develop after that period (e.g.: *Jatropha curcas* plantation). Some others were not yet routinely adopted by local people (e.g.: water disinfection). The main reason is that all of the interventions provided by WSPs required a behavioural change that is not simple to achieve, above all in a short time as the one intervened between WSP elaboration and final evaluation (6 months).

Therefore, it is possible to conclude that Water Safety Plan approach revealed to be an effective tool for improving drinking water quality along the whole supply chain, even if elaborated and developed with a really simplified framework compared to the one proposed by WHO. Lots of efforts are however still required for improving local conditions and reach the water quality standards (complete absence of faecal microbes). The time and the support of the local NGO, as a supervisor of the WSP, will strongly contribute to achieve this aim.

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Chapter 4. Evaluation of the Water Safety Plans sustainability

Abstract

In developing countries, drinking water supply is still an open issue. In sub-Saharan Africa, coverage of improved water supply gains only the 63%. Some regions are affected by geogenic contaminants (e.g. fluorides and arsenic) and the lack of access to sanitation facilities and hygiene practices causes a high microbiological contamination of water in the supply chain. The responses to these problems are the several projects on drinking water supply that aim at improving the water availability and quality all over the world. But, how interventions of cooperation projects on water supply can be really sustainable? Can implemented technologies still work after the end of the projects? These are questions that every NGO / Association should answer during project elaboration and implementation. The main factors that can be a source of failure for water supply projects are: complexity and costs of technologies (even if implemented at domestic scale), technical management, level of acceptance by the beneficiary community (that, if does not clearly recognize the technology benefits, can make hardly sustainable the entire project) and level of support by the local and / or national Institutions. In order to gain the interventions' sustainability, the activities should be clearly focused after a rigorous assessment in the study area, regarding local availability of human and material resources for the technology implementation, awareness level of the community in terms of technology need and acceptance, and several other aspects.

4.1 Introduction

According to the last update of the WHO / UNICEF Joint Monitoring Programme (JMP) for the water supply and sanitation progress towards the MDGs achievement, drinking water coverage in 2011 still remained at 89% (even if 1% above the MDG drinking water target). Thus, 768 million people relied on unimproved drinking water sources. Moreover, it has to be considered an uncountable amount of people that, whilst disposing of an improved source, consumes drinking water of poor quality (above all concerning the microbiological quality) due to the lack of proper handling and hygiene during transport and storage steps. Meanwhile, sanitation coverage (in 2011) was 64%, off track to meet the MDG sanitation target of 75%. If current trends continue, it is set to miss the target by more than half a billion people. By the end of 2011, there were 2.5 billion people who still did not use an improved sanitation facility. The number of people practising open defecation decreased to a little over 1 billion, but this still represents 15% of the global population [1].

The worst situation is highlighted to be in the sub-Saharan Africa, where the coverage of improved water supply gains only the 63% and the coverage of sanitation facilities reaches the 48% (improved and shared facilities) [1].

Despite several decades of development aid and thousands of international cooperation projects implemented all over the world, the worldwide situation remains critical, as stated above. More efforts have to be put in place in order to overcome these conditions. But every NGO / Association that has worked or is working or will work in this direction should carefully reflect if development aids or cooperation projects are really sustainable according to the local context. Indeed, it is only through a coherent focus on sustainability that interventions made by international cooperation projects can reach the objectives stated by the MDGs, at least in relation to water supply and sanitation. But what does sustainability mean in development projects? According to the World Commission on Environment and Development and other scientific experts, the most widely accepted concept of sustainability is development that meets the needs of the present without compromising the ability of future generations to meet their own needs [2-8]. In 1993, in *Agenda 21* (document that provides a general

framework for investigating sustainability in water and sanitation), UN declared that sustainability is the integration of environmental and development concerns for the fulfilment of basic needs and improved living standards for all [9].
From a water supply perspective, sustainability can be defined as the utilisation of water sources whilst ensuring that the ability of future generations to use the same sources are not affected [10] or as the ability of an ecosystem to maintain ecological processes, functions, biodiversity and productivity water resources into the future [11]. Whereas a sustainable sanitation can be defined as sanitation technically manageable, socio-politically appropriate, systematically reliable and economically affordable that utilises minimal amount of energy and resources with the least negative impacts, recovery of useable matters [11]. Regardless of the definitions, in order to evaluate and sustain water and sanitation supplies in developing countries, the international literature offers some proposals as: create a "sustainability chain", consisting of motivation, maintenance, cost recovery and continuing support [12], divide water and sanitation projects in sequential steps as needs assessment, conceptual design, design and action planning, implementation, operation and maintenance [13], or base the project sustainability on three components: effective community demand, local financing and cost recovery, dynamic operation and maintenance [14]. According to the scientific literature [15-17], sustainability is higher when demand is expressed directly by household members and not through traditional leaders or community representatives such as water Committees or local Government. Therefore to achieve sustainability, water supply and sanitation development requires effective complementary inputs such as community participation, community capacity development and community training.
Sustainability evaluation tools already proposed by international researchers are: LCA (Life Cycle Analysis) framework to inventory a holistic set of primary sustainability indicators across the supply chain of a water system, thus considering technical, environmental and economic parameters [6]; a guiding set of questions covering different sustainability elements (technology, social aspects, economy, institutions, and environment), related to solid waste management [18]; interviews to the main stakeholders of the project (beneficiaries, government representatives, project staff) in order to assess health, water, and sanitation interventions (checklists and rating scales were also developed for use in documenting the results of observations about infrastructure status and sustainability) [19].
This Chapter aims at presenting two different methodologies that can be used in order to evaluate the sustainability of the WSPs: on one hand, the use of a questionnaire based on five different sustainability elements and to address to the main stakeholders involved in the WSP strategy development, and, on the other, costs and time consuming evaluations, since these two fundamental parameters should also be considered when developing a WSP in order to guarantee its effective and sustainable implementation. These two different approaches were applied both in Senegal and Burkina Faso.

4.2 Sustainability evaluation: methodologies

4.2.1 Development of a tool based on five sustainability elements

According to the research experience carried out during this PhD course, five sustainability elements to solve environmental problems should be sought: *(1) technical sustainability*, in terms of use of local material and human resources and in terms of adopting appropriate technologies with an affordable and simple operation and maintenance need, *(2) economic sustainability*, which means the adoption of technologies or facilities with low costs of investment and operation, trying to create local trade / business opportunities that can guarantee a self-reliance, *(3) organisational and institutional sustainability*, in terms of acceptance by the local Institutions (from the lowest to the highest) and in terms of creating a strong partnership between local stakeholders (with a key-role of a local NGO / Association) that can guarantee the continuance of the project after its "official" end, *(4) social and cultural sustainability*, which means develop projects and implement technologies really felt by the local people and that can rapidly show an improvement in the everyday life and / or in the health status, and *(5) environmental (and health)*

sustainability, in terms of minimising the use of natural resources by acting on the reuse or recovery of waste or other resources and in terms of avoiding any kind of environmental impact (possibly improving, or at least not worsening, the local people health). Moreover, the concept of sustainability clearly requires a long-term view of the infrastructure / facility / technology implemented or of the behaviour change in the lifestyle generated by the project.
On the base of the elements above mentioned, and suggested also in the scientific literature [10, 11, 18, 20-22], the two case studies presented in Chapter 2 and 3 were evaluated at the end of the project implementation.

4.2.1.1 The tool

For each of the five sustainability elements identified (technical, economic, organisational and institutional, social and cultural, environmental and health) a series of questions were listed and addressed to the main stakeholders of the project (NGOs, local Authorities, beneficiaries, etc.). The aim of this methodology was to collect as more information as possible about all the likely reasons of success or failure of the projects, and in particular of the WSPs. Table 4.1 reports, for each sustainability element, the questions provided.

Table 4.1. *Sustainability elements and related questions*

Sustainability element	Question
Technical	Are there locally knowledge and technical expertise necessary for the elaboration and development of a WSP?
	Are there locally knowledge and technical expertise necessary for the management and update of a WSP?
	Are there locally knowledge and technical expertise necessary for the design and construction of a technology for drinking water treatment?
	Are there locally knowledge and technical expertise necessary for the operation and maintenance of a technology for drinking water treatment?
	Is there locally the availability of people and material resources for the WSP implementation?
	Is there locally the availability of people and material resources for the construction and management of the technology used for drinking water treatment?
	Is the WSP performing as it was designed to perform?
	Is the technology used for drinking water treatment performing as it was designed to perform?
Economic	Is there locally economic availability necessary for the elaboration and development of a WSP?
	Is there locally economic availability necessary for the design and construction of a technology for drinking water treatment?
	Is there locally economic availability necessary for the management and update of a WSP?
	Is there locally economic availability necessary for the operation and maintenance of a technology for drinking water treatment?
Organisational and Institutional	Has the WSP team been adequately trained for the implementation and management of the WSP?
	Have the managers and operators been adequately trained for the construction, operation and maintenance of the technology used for drinking water treatment?
	Are the WSP managers supported by the local community?
	Are the adopted technology managers supported by the local community?
	Are the WSP managers supported by the local Institutions (political and technical Institutions)?
	Are the adopted technology managers supported by the local Institutions (political and technical Institutions)?
Social and Cultural	Has the community been informed about the WSP implementation and its benefits?
	Has the community been informed about the technology used for drinking water treatment and its benefits?
	Is the community favourable to the WSP implementation?
	Is the community favourable to the use of a technology for drinking water treatment?
	Does the community contribute and encourage the WSP elaboration and implementation?
	Does the community contribute and encourage the use of the technology for drinking water treatment?
Environmental and Health	Has the WSP implementation improved local people health?
	Has the WSP implementation permitted to guarantee the drinking water quality according to the WHO standards?
	Are the adopted technology managers well equipped to assure well-being and health?
	Have adequate measures been adopted in order to safety dispose of any residues produced by the technology for drinking water treatment?
	Has the WSP implementation prevented the arising of any negative impact on the environment?

As clearly evident from Table 4.1, questions were related not only to the Water Safety Plan, but also to the treatment technology implemented in loco (in Senegal bone char-based filtration and chlorination, whilst in Burkina Faso only chlorination). This approach has been chosen in order to highlight contingent deficiencies of sustainability related specifically to the drinking water treatment, since this requires a relevant behavioural change in the daily life of the communities (difficult to gain in a short period) and, hence, can strongly affect the sustainability of the WSP (which includes water treatment).
Each question could be answered with: "absolutely yes", "rather yes", "rather no", "absolutely no" and "not applicable to the project". This latter option was considered in order to elaborate a questionnaire as general as possible and feasible also by other researchers; indeed, some questions could not be pertinent for all the projects. At each answer a score between 0 and 1 has been established, in order to assign a numerical value at the sustainability level. Table 4.2 reports scores related to each possible answer.

Table 4.2. *Scores assigned at each answer*

Possible answer	Score / Sustainability level
Absolutely yes	1
Rather yes	0.75
Rather no	0.25
Absolutely no	0
Not applicable to the project	Not considered

This tool was originally proposed by [18] in a previous research, but applied for the sustainability evaluation of waste management projects. Questions adopted in this evaluation process were elaborated and adapted to water supply projects, in particular to the ones concerning WSP implementation.

4.2.1.2 The methodology applied in Senegal

Regarding the Senegal case study (proposed in Chapter 2), the sustainability evaluation was carried out at the end of the second project. Questions listed in Table 4.1 were addressed to the main stakeholders involved into the project implementation (all data are reported in Annexe 9):

- Two volunteers of the G. Tovini Foundation NGO (FonTov NGO), who worked directly in the field.
- Four representatives of the local partners, University of Dakar and Diourbel Hygiene Authority (UniDak & DHA).
- The WSP team, composed by 4 managers of the different water sources, 3 people of the local Institutions and 5 representatives of the community.
- The most relevant people of the Rural Community of Patar (RCP) involved into the project activities, such as the President of the RCP, the President of the Women Association and the President of the Young People Association.

The choice of these people categories has been done in order to collect information from different subjects (each one involved in a different way into the implementation of the project activities) and, hence, to compare different points of view related to the sustainability of the WSP.

4.2.1.3 The methodology applied in Burkina Faso

Regarding the Burkina Faso case study (presented in Chapter 3), the sustainability evaluation was carried out at the end of the project, during the last field mission. Questions listed in Table 4.1 were addressed to the main stakeholders involved into the project implementation (see Annexe 9):

- Two volunteers of Medicus Mundi Italy NGO (MMI NGO), who were working in the field for almost the entire period of the project implementation.
- Three representatives of the local NGO Dakupa, and responsible for the implementation of the project activities.

- The team of 7 hygienists of Fingla and Diarra villages (Local Hygienists), who has actively worked on the elaboration and implementation of the WSP.

Even in this case, the choice of these people categories has been done in order to collect information from different subjects and to compare different points of view related to the WSP sustainability.

4.2.2 Complementary evaluation based on costs and time consuming

WSP approach implementation requires both financial support and time availability.
The time it will take to establish a WSP will depend upon a number of factors. These include the experience of the staff, the amount of data available on the water supply, the size and complexity of the supply, and other systems that have already been adopted. These factors are all inter-related and it is clearly difficult to define exactly what length of time is required to establish a WSP in all circumstances.
Cost is another important factor in the implementation of any new approach or procedure. Risk-based approaches to water safety management, such as the WSP, aim at significantly decreasing costs due to microbial testing, even if process monitoring tends to increase as a result of adopting this strategy. This may offer opportunities for significant savings in countries where consumables for microbial testing are expensive [23]. Thus, financial and resource requirements need to be addressed at the outset but there should also be the understanding that proper implementation of the WSP approach can save money and better target resources in the longer term [24].
This complementary evaluation of the WSP sustainability was carried out estimating, for both the case studies, costs and times of the three different stages of a WSP approach: elaboration, implementation and management. Regarding the elaboration step, the real amount of money and time spent in loco for the development of each step of the WSP was considered. Concerning the two other steps, where more focus was addressed to costs, the real price of the different resources and materials was considered as well as the hypothesis that all the people of the different villages (the whole 52 villages of the RCP in Senegal, and both the villages of Fingla and Diarra in Burkina Faso) were putting into practice the measures provided by the WSPs. Indeed, estimations were carried out based on the control measures provided by each WSP for all the steps of the supply chain: source, transport, storage and treatment (regarding the Senegal case study, the evaluation was provided for each of the three different water sources present in loco). Finally, based on the results obtained from these two case studies and the experience gained in this topic, considerations on the factors that can influence cost, time and complexity of a WSP development are proposed.
This complementary evaluation was carried out since, as even outlined by WHO, time and costs are two fundamental parameters to consider when developing a WSP, in order to guarantee its effective and sustainable implementation.

4.3 Sustainability evaluation: results

4.3.1 Appraisal tool output

The results obtained from the sustainability evaluation are provided separately for each case study, in order to clearer determine the possible reasons of success or elements of failure. Then, a comparison of the global sustainability level amongst the two case studies is provided.

4.3.1.1 The WSP sustainability in Senegal

The sustainability evaluation of the Senegal case study started from the assessment of the local situation at the beginning of the second project implementation, in order to evaluate the effective or failing activities carried out during the first project.
One of the first tasks carried out in the field has been to visit the household bone char-based filtration systems. This survey permitted to rapidly highlight that none of the 22 filters distributed was in-

operation, owning to the unavailability of bone char. Further meetings with people responsible for the drinking water treatment, local Institutions and local partners outlined the problem of bones supply from the slaughterhouse situated in Dakar (approximately 150 km far from the RCP), and which the agreement was taken with. Due to the lack of the raw material, filtration systems and all the equipment for the production of bone char were abandoned and subjected to degradation. The absence of a leader local partner (as an NGO can be) likely caused the interruption in the bones supply and, hence, water treatment. To strengthen this idea was the intervention of the FonTov NGO volunteers, who restored the business relation with the slaughterhouse and were able to furnish again the beneficiaries of the bones necessary for the filtration system. The enthusiasm of the filters' owners and the still present ability of the technicians to produce the bone char were even more strengthening the idea of a lack of efforts by local partners.

Regarding water quality along the supply chain, it was clearly evident from the first analyses how chemical contaminants provided substantially unvaried concentrations compared to the previous project (or better, no improvements were highlighted). On the other hand, results from microbiological analyses provided interesting causes for reflection. High concentrations of *E. coli* and faecal streptococci were found in transport and storage containers of the families that did not follow the awareness campaigns on good hygiene practices, proper methods of drinking water management and attitudes to prevent diseases due to polluted water consumption. Indeed, the lack of hygiene in handling drinking water was determined as the primary reason of contamination. Conversely, families that received a bone char-based filtration system or that had actively participated to the awareness campaigns during the first project provided microbial concentrations in the different containers lower than the other families. Even the awareness campaigns on the consequences that the consumption of water rich in fluorides can determine to health were successfully. The confirmation was given by the change of drinking water source by beneficiaries of the filtration system, when the supply of bones was interrupted. Indeed, most of them preferred to go farther at the public taps of the protected wells network, rather than consume the household tap water from groundwater distribution system (the source with the highest concentration of fluorides). All these considerations lead to the conclusion that awareness campaigns carried out amongst the population during the first project implementation were extremely useful and sustainable, whilst lack of efforts in guaranteeing the supply of bones for the filtration systems caused the failure of the treatment technology introduced.

At the end of the second project, a comprehensive evaluation through the questionnaire related to the sustainability elements was carried out. As stated in section 4.2.1, specific questions concerning the WSP and the treatment technology (which is included in the WSP, but that was explicitly analysed separately in order to evaluate the treatment technology influence on the entire WSP sustainability) were addressed to the main stakeholders. In this case study, treatment technology was covering both the bone char-based filtration and the chlorination treatment.

Fig. 4.1 reports results obtained for the **<u>technical elements</u>**.

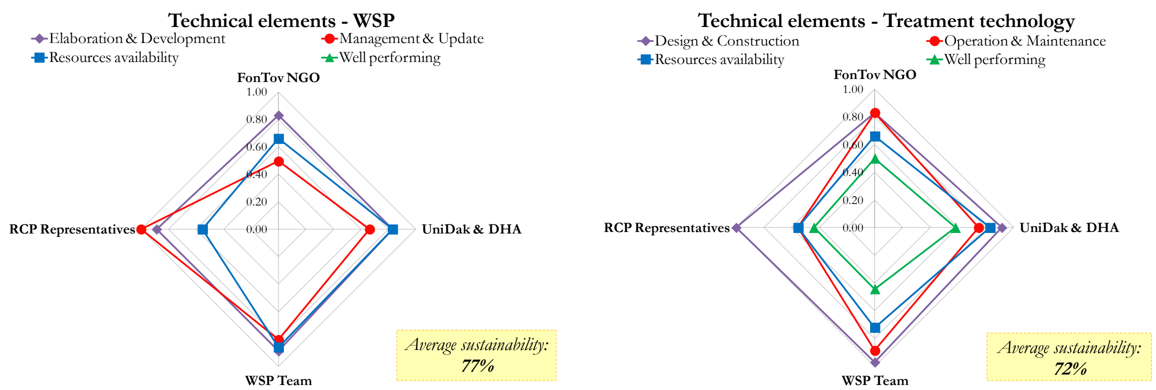


Fig. 4.1. *Technical sustainability related to the WSP (on the left) and to the treatment technology (on the right)*

Regarding the technical sustainability of the WSP, the question related to the well performing of the Plan (as designed to perform) was not posed since, at the moment of the assessment, the WSP was not already implemented but only elaborated. Generally, the sustainability level assigned by the four stakeholder categories to the different questions was rather uniform. An exception was provided by the RCP representatives that outlined a lower sustainability value related to the human and material resources available in loco for the WSP implementation. Conversely, regarding the technical sustainability of the treatment technology, a major difference in the answers was obtained. The well performing (as designed to be) of the technology provided a lower sustainability level from all the stakeholders interviewed, owing to the reasons previously highlighted, whilst the availability of expertise for designing and constructing the treatment was recognised by all the stakeholders, since this aspect provided a high sustainability level (on average equal to 93%). In fact, local technicians for the bone char production were still able to carry out treatment activities (calcination, grinding and sieving), proving that they were well trained during the first project implementation. Globally, the average sustainability (calculated as the mean value obtained by each stakeholder category from the different questions) was higher for the WSP (77%) compared to the one of the treatment technology (72%). Thus, controls provided by the WSP were considered more technically sustainable than the single treatment technology, probably owing to the difficulties met to guarantee a constant / periodic supply of bones.

Fig. 4.2 shows the results concerning the **economic sustainability elements**.

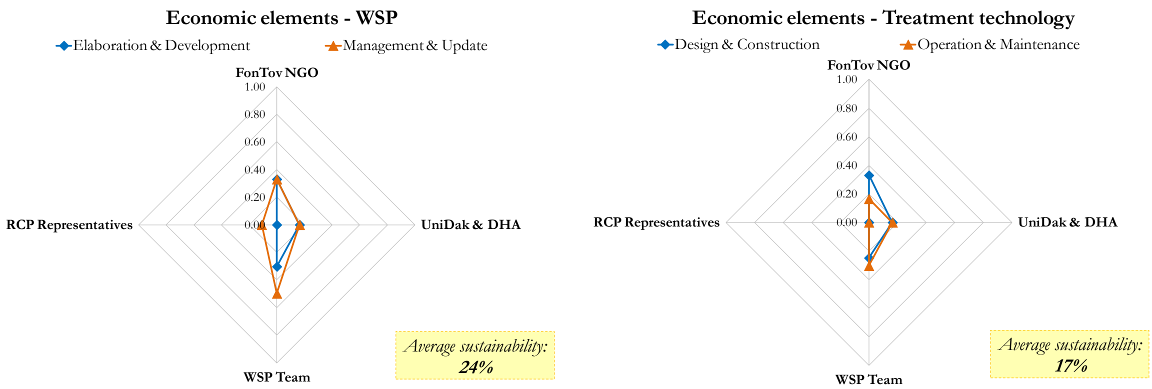


Fig. 4.2. *Economic sustainability related to the WSP (on the left) and to the treatment technology (on the right)*

As clearly evident from both graphs of Fig. 4.2, the economic sustainability of the WSP and the treatment technology was extremely low. Regarding the WSP, above all elaboration and development of the Plan were critical (obtaining an average value of 20%). Indeed, in order to put in place all the control measures provided by the WSP, a great amount of funds was needed, since it was not directly available in the RCP community (above all regarding structural interventions required to put in safety all the open dug wells). Concerning the treatment technology, the low sustainability values were likely justified by two reasons: on one hand by the necessity to equip all the RCP households of a bone char-based filter, and, on the other, by the costs required for guaranteeing a constant supply of bones. Indeed, the unit cost of each filter was not high (without bone char, cost was estimated equal to 5,000 fCFA, some of 7.60 €) or at least it was affordable by the majority of the families (according to the specific study carried out in the previous project and the opinion of all the local people who, during the interviews, were also willing to pay in return for a filtration system). These factors of no-sustainability were already somehow expected, and this is the reason why the research of contacts / partnerships for collecting funds (in order to guarantee the self-reliance of the activities / technologies required by the WSP after the end of the project) was one of the control measures provided by the WSP for improving drinking water quality. Globally, the average sustainability was higher for the WSP (24%) compared to the one of the treatment technology (17%), even if both were extremely low.

Fig. 4.3 shows the results concerning the **organisational and Institutional sustainability elements**.

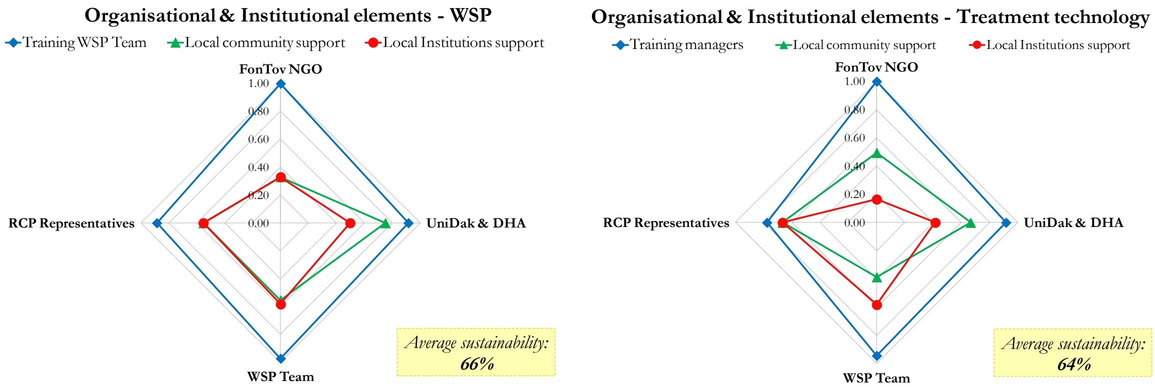


Fig. 4.3. *Organisational and Institutional sustainability related to the WSP (on the left) and to the treatment technology (on the right)*

The average sustainability level concerning these elements was substantially equal between WSP (66%) and treatment technology (64%). In both cases, training activities carried out for the WSP team and the technicians and managers of the filtration treatment have been recognised to be effective (average sustainability level of 94 and 91% respectively) for guaranteeing the sustainability. Conversely, both the cases highlighted a low sustainability level related to the community and Institutions support. In fact, during the supporting programmes related to the WSP elaboration, where people were asked to participate at the awareness campaigns, great difficulties were met regarding their mobilisation. Meanwhile, technical and political Institutions did not provide their availability for being involved in the WSP elaboration, and their support was strongly lacking for guaranteeing the bones supply for the water treatment.
Fig. 4.4 reports results related to the **social and cultural sustainability elements**.

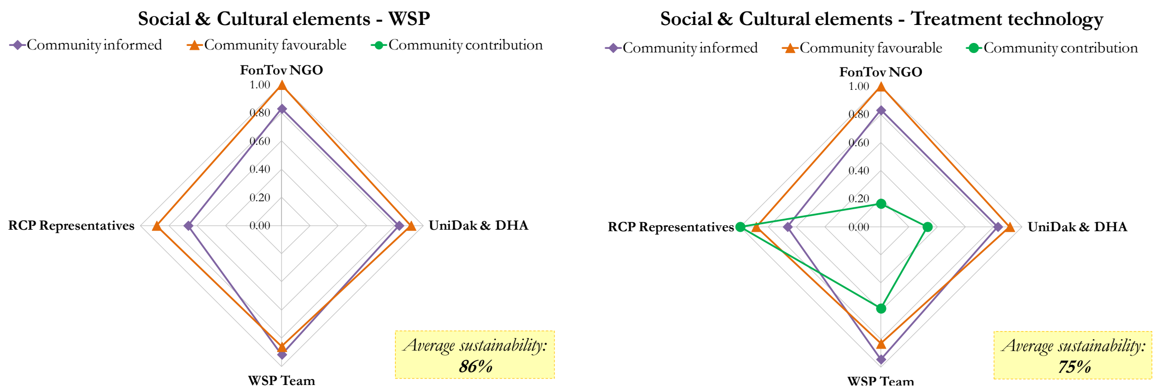


Fig. 4.4. *Social and Cultural sustainability related to the WSP (on the left) and to the treatment technology (on the right)*

Regarding the sustainability of the WSP, the question related to the community contribution for the WSP implementation was not posed since, at the moment of the assessment, the WSP was not already implemented but only elaborated. High values were obtained concerning the sustainability of the WSP, where both the level of information of the community about the WSP implementation and its benefits and the level of acceptance of the new drinking water management strategy proposed were positively recognised by the different stakeholders involved in this assessment (81 and 92% respectively). Concerning the treatment technology, both the levels of information and acceptance of the RCP community were well evaluated, whilst the community contribution to the technology adoption and diffusion was not provided to be sustainable by the majority of the stakeholders interviewed. The only exception was given by the RCP representatives that, instead, outlined an optimal mobilisation of the community for this purpose. Globally, the average sustainability was higher for the WSP (86%) compared to the one of the treatment technology (75%).

The last sustainability element, related to **environment and health**, was evaluated only for the treatment technology, since questions concerning these topics and related to the WSP evaluation assume that the WSP has already been implemented (whereas in this case study was only elaborated at the moment of the sustainability assessment). Indeed, these questions aim at verifying if improvements in people health conditions and in drinking water quality and if absences of negative impacts on the environment are gained by means of the WSP implementation.

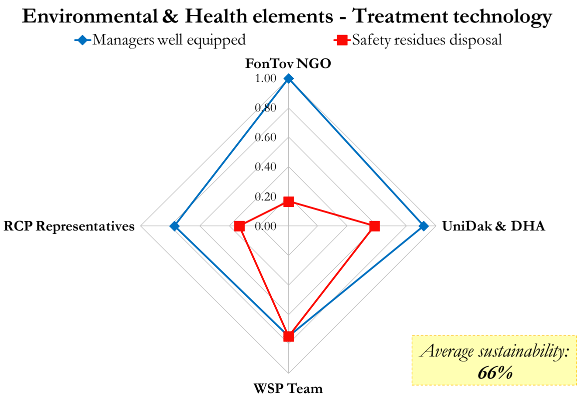


Fig. 4.5. *Environmental and Health sustainability related to the treatment technology*

Fig. 4.5 shows results obtained by the treatment technology. If the equipment provided to the technicians and managers of the bone char-based filters was considered appropriate and a related high value of sustainability was assigned (on average 86%), the safety disposal of the residues produced by the filtration treatment (represented by the exhausted bone char) provided a much lower value (on average 46%). In fact, a safety residues disposal was not applied during the bone char-based filters implementation, even because in loco there is not an organised system of waste management and safe disposal. Indeed, open burning of waste is usually carried out. In order to avoid water and soil pollution, however, during the restoring of the bone char-based filters, managers and technicians were made aware about the necessity of a safety disposal. Thus, exhausted chars were suggested to be disposed of far from wells and agricultural plots, and buried under the ground. Globally, the average sustainability level was equal to 66%.

Despite all the efforts that a lot of people have put in these two projects, many elements of failure have been provided. Probably the main reason was the absence of a strong leader as local partner that could help to mobilise human and material resources and try to find funds for the self-reliance of the projects. Indeed, activities were carried on only during the projects implementation, when an external support (FonTov NGO) in terms of funds and human resources was provided. As also stated in the scientific literature [22], a project that solves a problem but forever links the beneficiary to an external support is a failed project because it does not create real development, but rather further dependency. The aim of international cooperation projects should be to increase sustainability, meaning the autonomy of the project and its efficiency.

4.3.1.2 The WSP sustainability in Burkina Faso

The sustainability evaluation of the Burkina Faso case study started from the assessment of the local situation 6 months after the WSP implementation, in order to evaluate the effectiveness of the control measures provided by the Plan. As deeply analysed in Chapter 3, the evaluation of the activities carried out during the project implementation was mainly focused on the behavioural change in drinking water handling and management due to the introduction of several control measures by means of the WSP.

Results of this final risk assessment highlighted a relevant improvement at source, transport and storage level, where a risk reduction (based on the risk score assigned by means of the semi-quantitative method of the WSP) of 33, 21 and 22% respectively has been provided.

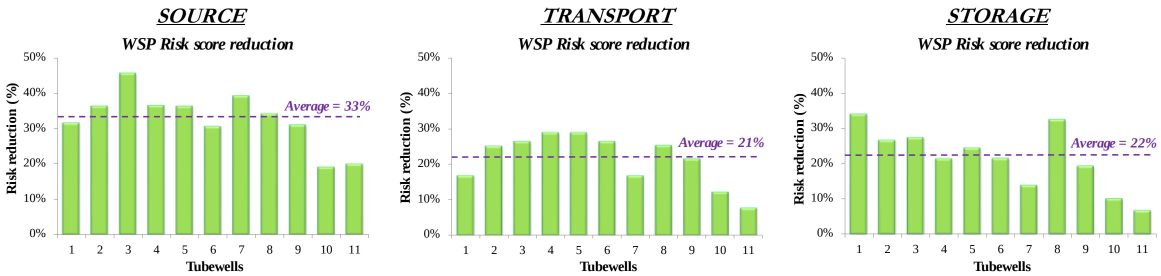


Fig. 4.6. *WSP risk score reduction in the different steps of the supply chain*

This result, as well as the decrease of the microbial contamination in all steps of the supply chain and the improvement in drinking water handling and management outlined by the local community, has permitted to highlight the effectiveness of the WSP and of all the control measures applied. However, this effectiveness has to be guaranteed along the time, in order to make sustainable the WSP. Thus, a comprehensive evaluation through the questionnaire related to the sustainability elements was carried out. As stated in section 4.2.1, specific questions concerning the WSP and the treatment technology (that for this case study was related to the chlorination treatment, comprehensive of the improved storage container spread locally - plastic can with valve) were addressed to the main stakeholders.
Fig. 4.7 reports results obtained for the **technical elements**.

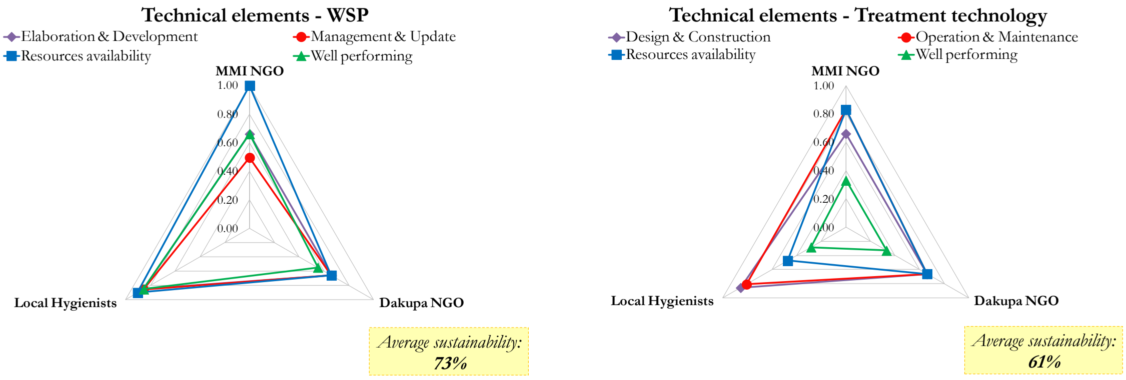


Fig. 4.7. *Technical sustainability related to the WSP (on the left) and to the treatment technology (on the right)*

Regarding the technical sustainability of the WSP, Dakupa NGO and local Hygienists provided, on average, rather uniform values for the four elements investigated, and respectively equal to 63 and 87%. This rather high sustainability level provided by the local Hygienists can be justified by the fact that those people are inhabitants of Fingla and Diarra villages and, hence, considered most sustainable (from the technical point of view) the implementation of all the control measures provided by the WSP. Conversely, MMI NGO assigned a lower sustainability value to the four technical elements, on average equal to 70%. In particular, the question related to the availability of human and material resources necessary for the implementation of the WSP was considered guaranteed (100% of sustainability), whereas the presence of local expertise for the management and update of the WSP provided a lower value, equal to 50%. Indeed, the high number of illiterate people (or at least with a low level of schooling) requires the technical support of both local Hygienists and Dakupa NGO, in order to guarantee the sustainability of the Plan. Considering instead the technical sustainability of the treatment technology, a major difference in the answers was obtained amongst the different stakeholders interviewed. All of them considered well technically sustainable the design and construction, the operation and maintenance, and the human and material resources local availability (except for the local Hygienists, concerning this latter element). Conversely, the well performing of the treatment technology (as designed to perform) was considered quite low sustainable from all the subjects. On average this element provided a sustainability level of 31%, likely due to the slow diffusion of the improved storage containers and the extremely low number of households carrying out chlorination at the point-of-use (demonstrating again how behavioural change is not easy to obtained, above all in a short period of time as that between the implementation and evaluation of the WSP). However, the support guaranteed by Dakupa NGO and local Hygienists is a positive element for the sustainability. Globally, the average sustainability (calculated as the mean value obtained by each stakeholder category from the different questions) was higher for the WSP (73%) compared to the one of treatment technology (61%). Thus, controls provided by the WSP were considered more technically sustainable than the single treatment technology.

Fig. 4.8 shows results concerning the **economic sustainability elements**.

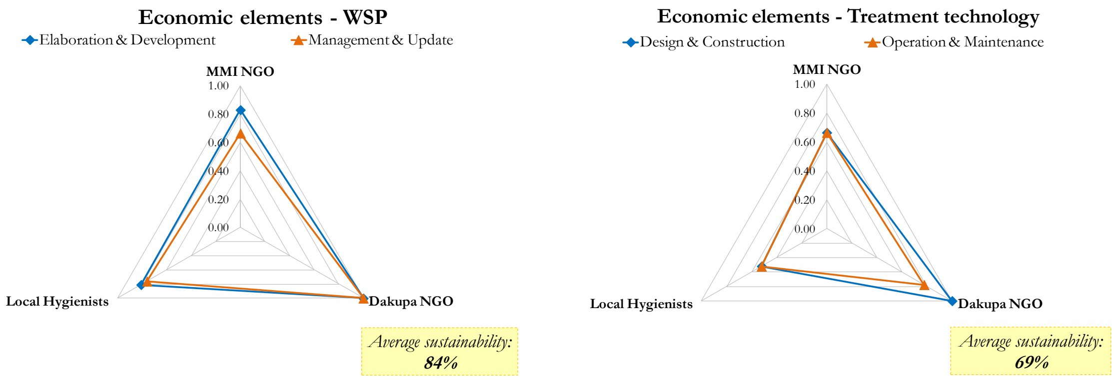


Fig. 4.8. *Economic sustainability related to the WSP (on the left) and to the treatment technology (on the right)*

Regarding the economic elements related to the WSP, Dakupa NGO expressed complete confidence on their level of sustainability (100%), whilst the other two stakeholders involved in this survey provided average values of 75 and 78%, related to MMI NGO and local Hygienists respectively. Almost all the controls provided by the WSPs, in fact, did not require a relevant amount of money for being put in place and this has definitively supported the economic sustainability of the Plans. Regarding the economic sustainability of the treatment technology, the rather high sustainability values were likely justified by two reasons: on one hand by the local availability of chlorine for the disinfection treatment, whose cost is absolutely affordable (a bottle of 250 mL capacity: 300 fCFA, some of 0.46 €), even because it was already used by the community for the laundry, and, on the other, the low cost of the improved storage container (estimated equal to 5,000 fCFA, some of 7.60 €) that was already bought by some households and, however, whose cost was considered affordable both from Dakupa NGO and local people. Despite these latter considerations, however, the economic sustainability of the single WSP was considered, globally, higher (84%) compared to the one of the treatment technology (69%).

Fig. 4.9 shows the results concerning the **organisational and Institutional sustainability elements**.

As clearly figured out by both the graphs of Fig. 4.9, the lack of support from local Institutions was considered a relevant aspect that can not surely guarantee the sustainability of both WSPs and treatment technology. Even if Dakupa NGO and local Hygienists have considered that, related to the chlorination treatment, a support could come by the Municipality of Béguédo, the average sustainability level was however extremely low (equal to 22%). Conversely, the aspects related to the level of training of both the WSP teams and the managers of the treatment technology, and the local community support were considered favouring elements for the sustainability. Regarding the WSPs, the level of sustainability related to the adequate level of training of the WSP team and to the community support was, on average, equal to 100 and 91% respectively. Considering instead the treatment technology, the level of sustainability related to the training of the treatment managers and to the community support was, on average, equal to 89 and 80% respectively. These values were lower compared to the ones related to the WSPs, owing to the lower sustainability values provided by MMI NGO, due to the doubts expressed by its volunteers about the possible spread of the chlorination treatment amongst the community, as a routinely operation. Globally, the average sustainability was the same for both WSPs and treatment technology (64%).

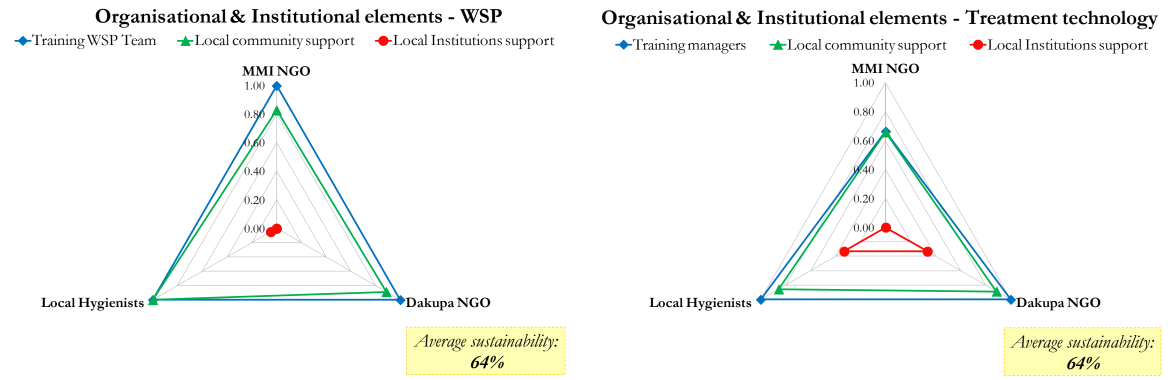


Fig. 4.9. *Organisational and Institutional sustainability related to the WSP (on the left) and to the treatment technology (on the right)*

Fig. 4.10 reports results related to the **social and cultural sustainability elements**.

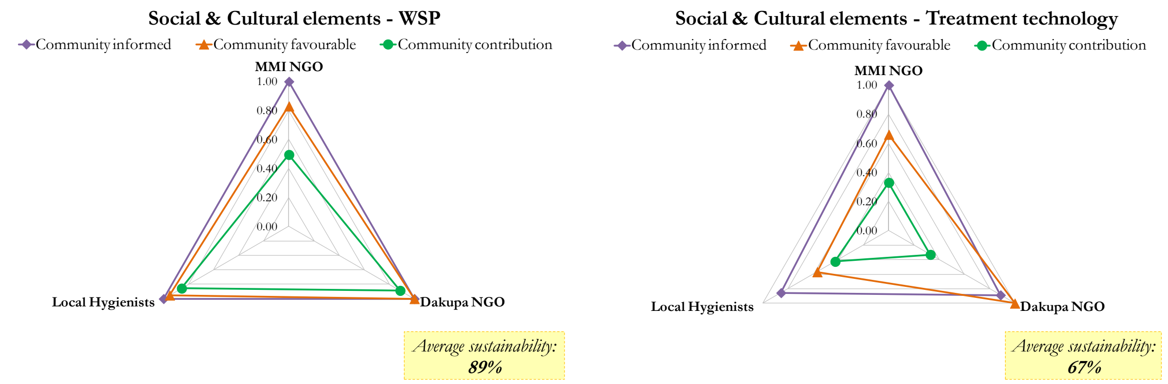


Fig. 4.10. *Social and Cultural sustainability related to the WSP (on the left) and to the treatment technology (on the right)*

Regarding the sustainability of the WSP, high values were obtained concerning the sustainability of the WSP, where both the level of information of the community about the WSP implementation and its benefits, and the level of acceptance of the new drinking water management strategy proposed were positively recognised by the different stakeholders involved in this assessment (100 and 93% respectively). Concerning the contribution of the population, the sustainability level was quite lower (on average 75%), likely due to the difficulties sometimes observed for the mobilisation of the population to elaborate the WSP. Regarding the treatment technology, the level of information and acceptance of the community was well evaluated (on average 91%), whilst the community acceptance and contribution provided lower sustainability values, 74 and 36% respectively. Even in this case, the rather low value obtained for the community contribution is justified by the slow diffusion of the improved storage containers and the extremely low number of households carrying out chlorination at the point-of-use, mainly owing to the behavioural change unlikely achievable in a short period of time. Globally, the average sustainability was higher for the WSP (89%) compared to the one of the treatment technology (67%).

Fig. 4.11 reports results obtained for the **environmental and health elements**.

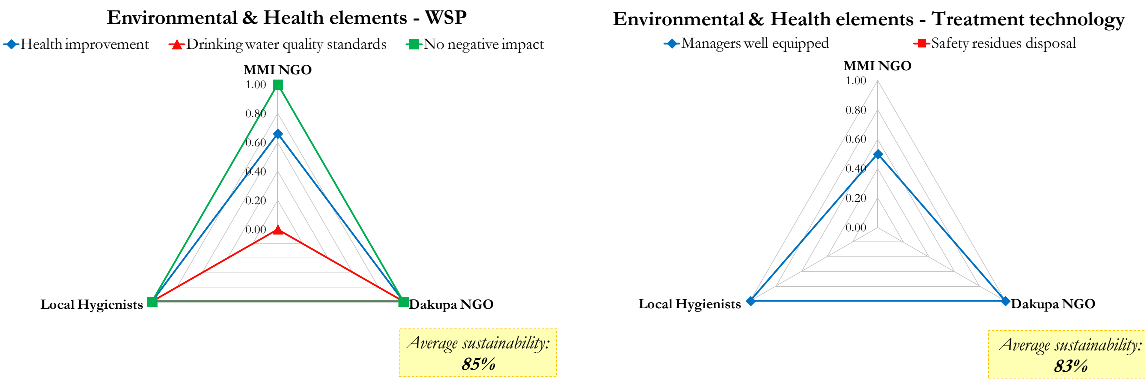


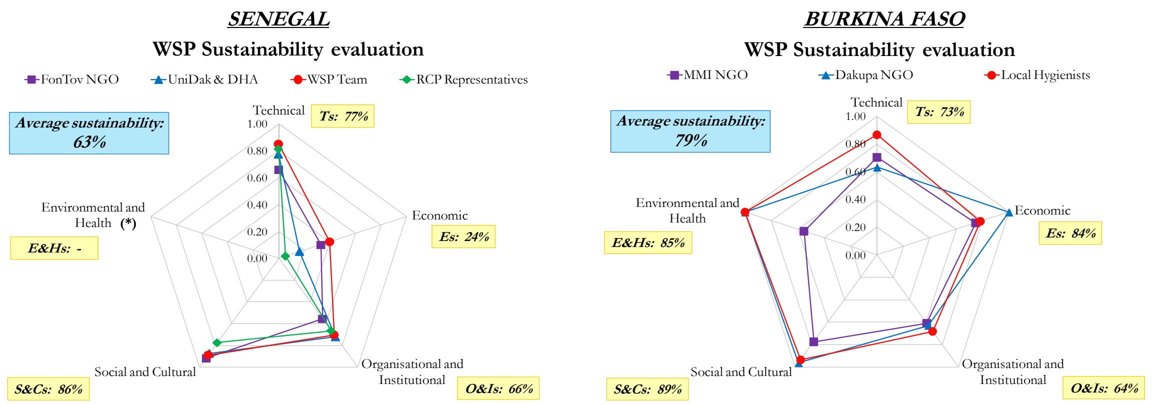
Fig. 4.11. *Environmental and Health sustainability related to the WSP (on the left) and to the treatment technology (on the right)*

Concerning the treatment technology, only the equipment level of the treatment managers was evaluated, since the technology (chlorination and improved storage container) did not provide any residual. The aspect investigated provided an average sustainability level of 83%, owing to the lower value assigned by MMI NGO. Regarding the WSPs, the absence of negative impacts from the WSP implementation was recognised as a positive element of sustainability (100%), whilst health improvements and drinking water quality standards' respect obtained lower values, equal to 89 and 67% respectively. In both the cases, this was due to the lower values of sustainability provided by MMI NGO, above all regarding the respect of the drinking water standards (0%). Actually, water standards (as shown in Chapter 3) were met neither at source nor at storage level. Despite this result, Dakupa NGO and local Hygienists, however, assigned positive values to the sustainability level of this element, owing to the decreasing trend obtained from the microbiological analyses of drinking water, along the entire supply chain, during the final assessment. Indeed, this was considered as a proof that drinking water quality standards will be achieved in a short period of time. Globally, the average sustainability was almost the same for both WSPs and treatment technology.
The final assessment of the project has permitted to positively evaluate its sustainability. A lot of efforts were put in place by all the subjects involved into the project implementation, and above all by the local NGO Dakupa.

4.3.1.3 Comparison amongst Senegal and Burkina Faso case studies

In this section, a comparison between the sustainability evaluation carried out in Senegal and Burkina Faso is proposed. Firstly, regarding the evaluation of the WSP elaborated in both case studies, it is important to highlight that the environmental and health element was not analysed due to the reasons previously provided (Paragraph 4.3.1.1).
Fig. 4.12 proposes the comparison amongst the two case studies, focused on the WSP sustainability evaluation. Concerning the technical sustainability, a higher value was obtained in Senegal compared to Burkina Faso, likely owing to the different members of the WSP team. Indeed, in Senegal, WSP team was composed also by members of the different water suppliers, who (even if not completely properly) had major technical competencies and expertises in relation with the inhabitants of Fingla and Diarra villages in Burkina Faso (who represented the WSP team). However, these sustainability elements did not significantly differ amongst the two case studies: 77% in Senegal and 73% in Burkina Faso. Conversely, the economic sustainability element changed strongly in the two different contexts. The high number of significant structural improvements provided by the WSP in Senegal deeply affected this element, which obtained a final average value of 24%. In Burkina Faso, the final sustainability was equal to 84%, mostly due to the cheaper measures required by the WSP. Indeed, this latter Plan was

characterised more by behavioural changes than structural improvements. Regarding the organisational and Institutional element, the final average value provided by Senegal case study was slightly higher (66%) than in Burkina Faso (64%). Actually, in both contexts, an important cause of the quite low sustainability value obtained was the absence of support provided by local Institutions, both technical and political. Values related to the social and cultural sustainability were, as for the previously element, quite similar amongst them, even if slightly lower in Senegal (86%) than in Burkina Faso (89%). However, both results were encouraging and local communities demonstrated to be participative and to support the WSP elaboration and implementation. Regarding the final element connected to the environmental and health sustainability, comparisons were not possible due to the lack of information related to the Senegal case study.



(*): this element has not been assessed since WSP evaluation assumes that the WSP has already been implemented, but in the Senegal case study was only elaborated before the sustainability evaluation

Fig. 4.12. *WSP sustainability's comparison between Senegal (on the left) and Burkina Faso (on the right) case studies*

Globally, the WSP developed in Senegal appeared to be less sustainable than the one implemented in Burkina Faso. Indeed, the average sustainability (comprehensive of all the stakeholders interviewed and all the five sustainability elements evaluated) obtained a final value of 63 and 79% for Senegal and Burkina Faso case studies respectively.

The comparison of the sustainability evaluation, related to the treatment technology between both case studies, can be carried out for all the five sustainability elements identified (Fig. 4.13).

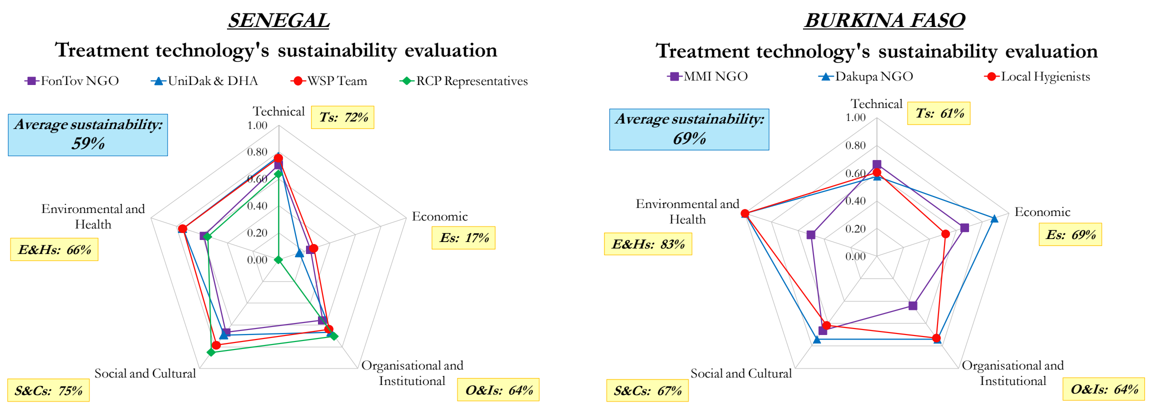


Fig. 4.13. *Treatment technology sustainability's comparison between Senegal (on the left) and Burkina Faso (on the right) case studies*

The technical element provided a higher sustainability value in Senegal (72%) compared to Burkina Faso (61%), likely due to the poor diffusion of the chlorination treatment amongst the community as well as the use of improved storage containers. As in the evaluation of the WSP sustainability, the

economic element was particularly critical in Senegal (17%) compared to Burkina Faso (69%), mostly due to the need of periodic and constant bones' supply. Even in the case of the organisational and Institutional element, the sustainability value was not high (64% in both case studies), owing to the lack of support obtained by local political and technical Institutions. Concerning the social and cultural sustainability, the survey provided higher results for the Senegal case study (75%) in comparison with the Burkina Faso one (67%). In this latter experience, the most critical aspect was related to the community acceptance of the treatment process, since only few households surveyed highlighted to carry out the disinfection with chlorine. Conversely, regarding the environmental and health element, better results were obtained in Burkina Faso (83%) than in Senegal (66%), above all owing to the lack of a safe disposal for the exhausted bone char. The absence of residues from the water treatment introduced in Burkina Faso strongly contributed to the higher sustainability values.
Globally, the treatment technology developed in Senegal appeared to be less sustainable than the one implemented in Burkina Faso. Indeed, the average sustainability provided a final value of 59 and 69% for Senegal and Burkina Faso case studies respectively.
The work carried out in the field permitted to highlight as the support from the local partner was completely different in the two case studies: if in Burkina Faso Dakupa NGO was constantly present in the elaboration and implementation of the WSP and was actively involved in the development of the supporting programmes, in Senegal UniDak and DHA did not provide the same support. This is an aspect extremely relevant in order to guarantee the sustainability of the activities carried out in both case studies, even because local partners represent the only reference for local communities after the end of the project implementation. Probably this different behaviour influenced also the results of the survey concerning sustainability evaluation, where a higher value was obtained in Burkina Faso for both the aspects (WSP and treatment technology) analysed.

4.3.2 Time and costs analysis

This second sustainability evaluation started with the consideration of the time needed for the development of the WSP in both the case studies. This analysis was carried out only regarding the first two steps of the WSP development (elaboration and implementation), without considering the management that, obviously, lasts in an unlimited period of time.

<u>WSP elaboration: time consuming</u>

Fig. 4.14 reports the time needed for the elaboration of the WSPs in Senegal and Burkina Faso, referring to the different steps that characterised this phase: assemble the WSP team, identify the water supply system (the whole supply chain), evaluate all the possible hazards along the supply chain and elaborate the Plans.

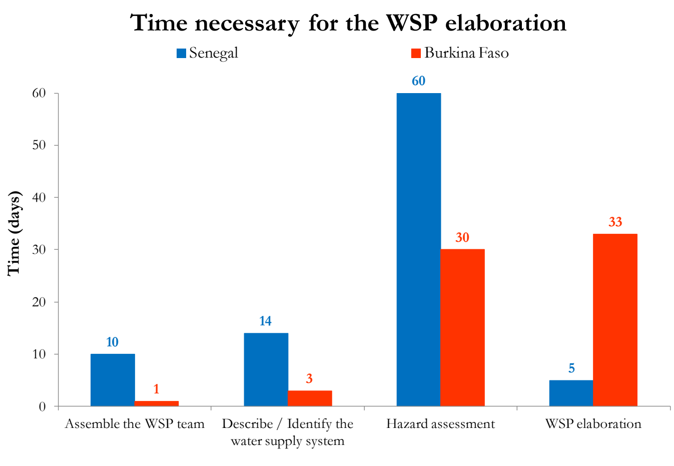


Fig. 4.14. *Time required for the elaboration of the WSPs in Senegal and Burkina Faso*

As clearly evident from Fig. 4.14, the step more time consuming of this phase has been the identification and evaluation of hazards along the entire drinking water supply chain.
In Senegal, for assembling the team, the time required was some of 10 days, due to the complexity of the water system (three different water sources, two of which with a specific management Committee) and the different stakeholders with confront which (political and technical authorities, surveillance agencies, water Committees and representatives of the community). All this time was used in order to assemble a WSP team with the maximum level of (technical and management) competencies, due to the impossibility to involve local political and technical authorities, but minimising the number of members to avoid difficulties in making decisions. Conversely in Burkina Faso, the time needed was 1 day. Indeed, owing to the absence of political and technical authorities, the decision to involve each CGPE (water Committee of a tubewell) and related users for the development of the WSPs did not require a long period of time.
For the identification of the entire drinking water supply chain, the Senegal case study revealed to be more time consuming. Even in this case the reason was the complexity of the water system and, more generally, of the local context. The survey carried out in loco covered only 2 of the 52 villages forming the Rural Community of Patar (owing to technical and economic project's reasons), thus a lot of time was spent for verifying that water sources and transport and storage steps identified in Sambé and Dabel Bara were effectively representatives of the entire RCP. In Burkina Faso the time spent for this step of the WSP development was lower (3 days) compared to the one in Senegal (14 days). The reason was the extremely simplified water system present in loco. Considering the difficulties to access at the village of Diarra (due to the presence of the river), time needed could also be less than the one effectively spent.
As already stated, the hazard assessment represented the step more time consuming. Indeed, the identification and evaluation of all the possible hazards that can compromise drinking water quality, along the entire supply chain, require a lot of time. In this step, the following activities have to be considered: identification of water points with related sanitary inspections and drinking water quality analyses (physico-chemical and microbiological); identification of all the vessels employed for transporting and storing water and related drinking water quality analyses; interviews addressed to water Committees and local communities. Considering all these aspects, the time required in Burkina Faso was some of 30 days, whilst in Senegal was doubled. Reasons have to be found in the more complexity of the water system and in the larger and more populated area to assess in Senegal.
The last step of this evaluation process was the WSP elaboration, considered as the time required for developing by the WSP team the Plan. In Senegal 5 days were used for its elaboration (the first three for the water points and the last two for transport and storage steps respectively), whilst in Burkina Faso 33 days were needed, even if for a single WSP no more than 3 days were required. As stated in Chapter 3, indeed, in Fingla and Diarra villages a dedicated WSP was developed for each of the 11 tubewells present in loco.

<u>WSP implementation: time consuming</u>

Regarding the evaluation of the time required for the implementation of the WSPs, two different aspects were considered. The first one is related to the time needed for putting into practice all the control measures provided by the WSPs. In Senegal, during the elaboration of the Plan, the WSP team considered that at least 1 year was necessary for adopting all the controls, even because most of them required a structural intervention on water sources or a strongly behavioural change, thus solutions not easy to be reached in a short period of time. It is also for this reason that objectives stated in the sub-Plans related to transport and storage steps were referred both to 6 and 12 months. Conversely, in Burkina Faso, the time required for implementing the WSP was lower (some of 1 week) owing to the fact that control measures identified in each Plan were more focused on better management practices and not related to structural interventions to put in safety water points. The second aspect considered was the time needed for carrying out supporting programmes. In this case, a comparison amongst the two case studies is more difficult owing to the different activities required by each cooperation projects. Indeed, the project developed in Senegal was exclusively aimed at elaborating and implementing a WSP strategy, thus supporting programmes were carried out in terms of awareness campaigns addressed to the communities of Sambé and Dabel Bara (lasting some of 10 days) and of training of local people (lasting 2 days) in order to form subjects with the competencies for making themselves community awareness campaigns after the end of the project. Conversely in Burkina Faso, the cooperation project had several purposes and covered not only the drinking water quality improvement (by means of the development of a WSP strategy), but even hygiene and sanitation, health and development of income-generating activities. For this reason, the time required strictly for awareness campaigns concerning drinking water was about 1 week, but even health, hygiene and sanitation issues debated in other campaigns (covering some of 3 months) can be considered as useful for improving drinking water management practices.

Costs analysis, developed for both the case studies, was carried out for all the three steps of the WSP development (elaboration, implementation and management). Costs were estimated based on the control measures provided by each WSP and taking into account materials and resources' prices present in loco, both in Senegal and Burkina Faso.

Fig. 4.15 outlines costs of the three different steps of the WSP development. In Senegal, the most expensive phase revealed to be the implementation, although costs are not that lower even during the routine management (referred to 1 year). Despite costs were similar in the elaboration phase in both the case studies, during the other steps, in Burkina Faso, these are tending to decrease.

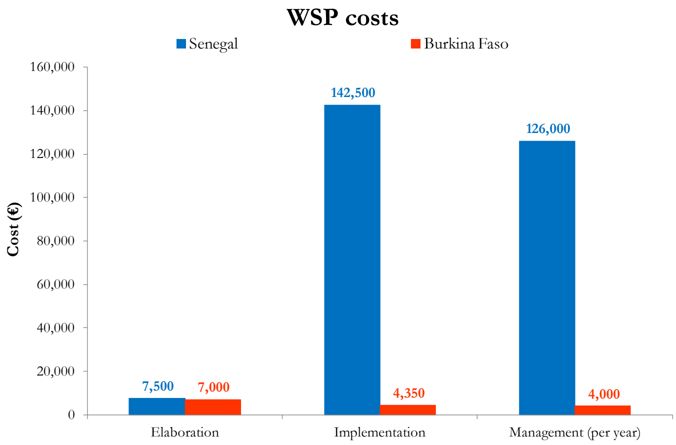


Fig. 4.15. *Costs related to the different steps of the WSP development for both case studies*

In the following, each step is analysed separately in order to better highlight differences between the two case studies and which element has the greatest effect in the definition of the total cost of each step.

<u>WSP elaboration: costs</u>

Fig. 4.16 reports costs evaluated for the WSP elaboration, divided for the three different elements in which this step was characterised: hazard assessment, supporting programmes and WSP team's pay.

Costs related to the hazard assessment were higher in Senegal (some of 5,000 €) compared to Burkina Faso (some of 2,000 €). The amount of money spent for this phase in Senegal is related to chemical reagents and microbiological cultures used for drinking water analyses. In this cost were not counted all the instruments needed for tests, since already available from the previous cooperation project implemented by FonTov in loco (they were left at the DHA headquarter). Concerning the Burkina Faso case study, costs are related to cultures and portable incubator used for drinking water microbiological tests and chemical analyses carried out by 2iE Foundation. These costs are strictly related to the case studies of Senegal and Burkina Faso, thus cannot be generalised for all the projects aimed at implementing a WSP in a rural area of sub-Saharan Africa. Most depends on drinking water quality, number of water sources and complexity of the water system, size of the communities involved into the project, and even size and financial availability of the project.

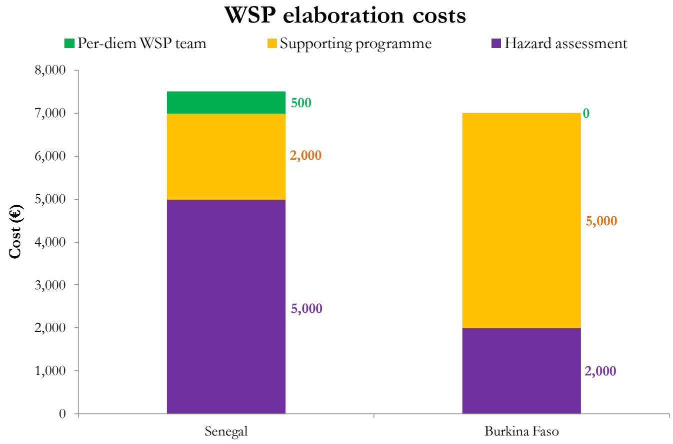


Fig. 4.16. *Costs related to the WSP elaboration step*

Conversely, costs related to the supporting programmes were higher in Burkina Faso (some of 5,000 €) compared to Senegal (some of 2,000 €). These costs include pays of the local people supporting awareness campaigns and training courses (owing to the necessity of language translations), and costs of pictures, photos, notebooks, pens and all the other material required. As already stated regarding time consuming, supporting programmes were more consistent in Burkina Faso, and this is the reason of the highest costs.
Finally, WSP team's per-diem was provided only in Senegal for a global amount of some of 500 €.

<u>WSP implementation: costs</u>
Fig. 4.17 reports costs related to the WSP implementation step, where four different elements were defined: sources, transport, storage and treatment. Implementation costs are strictly related to the specific control measures provided by each WSP in both the case studies.

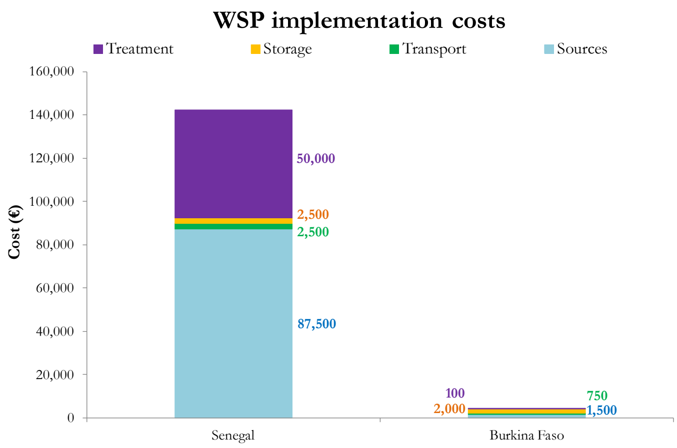


Fig. 4.17. *Costs related to the WSP implementation step*

As already clear from Fig. 4.15, Senegal's WSP implementation costs provided to be strongly higher (some of 30 times more) than the ones related to Burkina Faso's WSPs. Taking into account controls set for each water source in Senegal, a total amount of 87,500 € was estimated, divided as follow:

- 7,500 € referred to the groundwater distribution system, in which replacement of valves, disinfection of public and private taps, improvement of the disinfection treatment in the feed tanks, replacement of iron pipes and valves were included.
- 12,500 € referred to the protected wells network and including disinfection of public taps, construction of concrete aprons and drainage channels for the four protected wells, replacement of pipes and valves.
- 67,500 € referred to open dug wells, where most of the controls were related to structural improvements of wells, such as the realisation of covers, appropriate parapets, concrete aprons, drainage channels and drinking troughs for animals.

This latter element revealed to be the most consistence one, but it is necessary to specify that is referred to all the about 200 wells present in loco. Indeed, each open dug well was estimated to need some of 350 € for putting into practice control measures provided by the WSP.
Regarding transport and storage steps, a global amount of 5,000 € (for both of them) was estimated. This amount of money should be necessary for equipping each household of detergents and disinfectants (soap, sponges, chlorine, etc.) useful for the proper management of drinking water vessels.
Finally, for the implementation of the WSP controls related to the treatment of drinking water, 50,000 € were estimated to be necessary. This amount of money refers to the equipment of each RCP household (some of 1,500) of a bone char-based filtration system, considering the need of improved storage containers (cans with valve), plates for supporting the filtration material, bones' supply and treatment (calcination, grinding and sieving). Each filtration system should need an investment of money equal to about 40 €.
In Burkina Faso, WSP implementation costs, as stated, were strongly lower. Concerning water sources, it has to be recalled that only tubewells were involved in the WSP and that control measures were mostly referred to improved management practices than structural interventions. For this reason, some of 1,500 € were estimated to be needed for the remedial of some tubewells and for the equipment of each CGPE of detergents and disinfectants (for the cleaning of the tubewell).
Transport step needed some of 750 € of investment. This rather low amount of money was necessary exclusively for the equipment of each household (about 200, comprehensive of both Fingla and Diarra villages) of the detergents and disinfectants required for improving drinking water management. Control measures related to the storage sub-Plans required a higher amount of money for being implemented (about 2,000 €), owing to the need of equipping each household of an improved storage container (plastic can with valve) in addition to detergents for improving cleaning habits.
Since in this case study, referring to the water treatment, only chlorine has been required by WSPs, related costs were extremely low (100 € globally), although they include the equipment of each household of the chlorine necessary for the treatment.
This analysis clearly showed as costs are unlikely sustainable for the RCP in Senegal, whereas in the rural villages of Burkina Faso they seem to be affordable. Nevertheless, analysing several possible solutions, the distribution of all the costs amongst local population appears to be an interesting alternative. Fig. 4.18 shows results obtained by this elaboration.
Implementation costs related to all the four elements composing this step were distributed amongst the 1,500 households of the RCP in Senegal and the 200 present globally in Fingla and Diarra villages. Costs distribution required households to contribute with a total amount of money equal to 95.00 and 21.75 € respectively for the Senegal and Burkina Faso case studies. Considering the average annual revenue of each household in both communities (calculated on the base of the information collected during interviews), equal to 1,400 and 480 € per household in Senegal and Burkina Faso respectively,

the amount of money required for the implementation of the WSPs represents the 7.0 and 4.5% of the average annual revenue respectively.

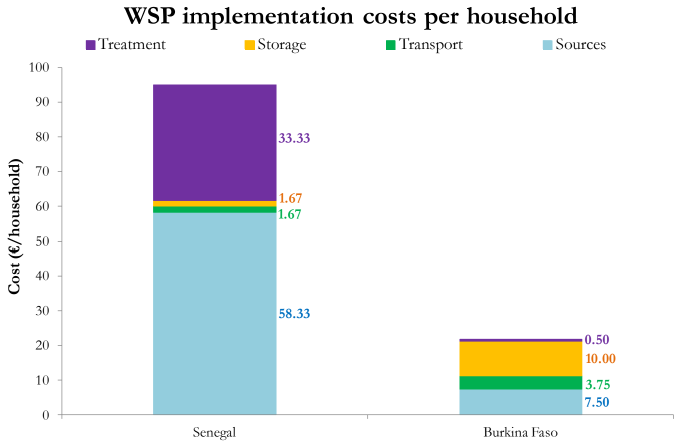


Fig. 4.18. *Costs related to the WSP implementation, distributed amongst local communities*

<u>WSP management: costs</u>

Fig. 4.19 reports WSP management costs, detailed for each of the four steps identified. These costs are strictly related to the specific control measures provided by each WSP in both the case studies, and were estimated based on the costs necessary annually for the management of all the supply chain.

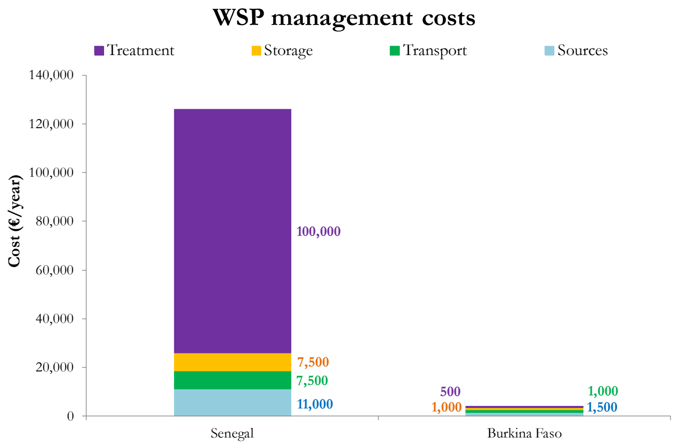


Fig. 4.19. *Costs related to the WSP management step*

As already clear from Fig. 4.15, Senegal's WSP management costs provided to be strongly higher (some of 30 times more) than the ones related to Burkina Faso's WSPs. Taking into account controls set for each water source in Senegal, a total amount of 11,000 € was estimated, divided as follow:

- 3,500 € referred to the groundwater distribution system, for the management of all the controls already highlighted for the WSP implementation step.
- 2,500 € referred to the protected wells network.
- 5,000 € referred to open dug wells.

This latter element revealed to be again the most consistence one, owing to the high number of open wells present in loco. Management costs related to this type of source consider remedial interventions and disinfection treatment (some of 25 € per each open dug well).

Regarding transport and storage steps, a global amount of 15,000 € (for both of them) was estimated. As for the previous WSP step, this amount of money should be necessary for equipping each household of detergents and disinfectants (soap, sponges, chlorine, etc.) for the proper management of

drinking water vessels. Costs are quite high owing to the need to provide households of the material necessary for an entire year.
Finally, for the implementation of the WSP controls related to the treatment of drinking water, 100,000 € were estimated to be necessary. This amount of money refers to bones' supply and to slight remedial interventions on containers (above all on valves). Indeed, it has to be considered that each household needs to change bone char at least twice a year (during the previous project implementation, it was estimated that the bone char exhausts its adsorption capacity of fluorides approximately 6 months after installation), reaching a global amount of about 60 € per household per year.
In Burkina Faso, WSP management costs, as stated, were strongly lower. Some of 1,500 € were estimated to be needed annually for the remedial of some tubewells and for the equipment of each CGPE of detergents and disinfectants (as for the implementation step).
Transport and storage steps were rather more expensive than the previous step, since the need to provide households of the material (detergents, disinfectants and possible remedial interventions on the improved storage containers) necessary for an entire year was taking into account.
Treatment was again quite cheap, since composed by costs required for equipping all the 200 households of chlorine for water treatment, during an entire year.
By means of the same methodology used in the previous step (WSP implementation), a distribution of all the costs amongst local population was carried out. Results obtained from this analysis are shown in Fig. 4.20.

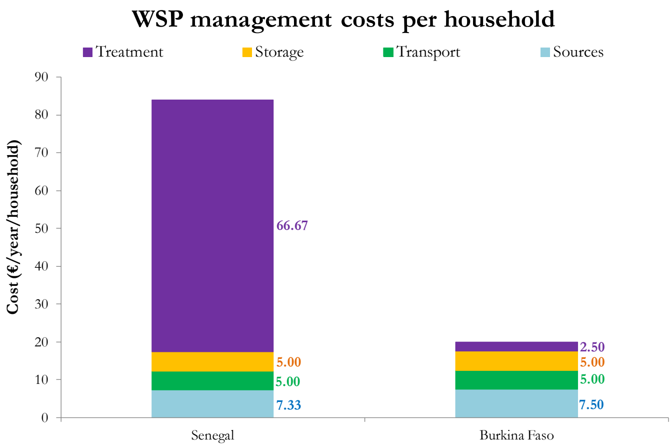


Fig. 4.20. *Costs related to the WSP management, distributed amongst local communities*

Management costs related to all the four elements composing this step, hence, were equally distributed amongst the 1,500 households of the RCP in Senegal and the 200 present globally in Fingla and Diarra villages. Costs distribution required households to contribute with a total amount of money equal to 84.00 and 20.00 € respectively for the Senegal and Burkina Faso case studies. Considering the average annual revenue of each household in both communities, the amount of money required for the management of the WSPs represents the 6.0 and 4.0% of the average annual revenue respectively.
To distribute costs amongst local people appears to be a better solution regarding this latter type of costs (WSP management costs), since contributions are required along an entire year. In this way, the economic weight on people's life is lower (contributions are spread along the year). Conversely, WSP implementation costs should be collected immediately after the WSP elaboration, in a time as short as possible in order to fulfil the drinking water quality requirements, and this does not guarantee its feasibility (owing to the lack of availability by the local community).
Referring to this time and costs analysis, the WSP developed in Burkina Faso appeared to be more sustainable than the one in Senegal, as also resulted from the elaboration of data related to the five sustainability elements previously proposed (Paragraph 4.3.1).

How the complexity of the water system can influence on costs and time consuming

A key element that likely brought to obtain these results was the complexity of the water system in the Rural Community of Patar. Indeed, this experimental research permitted to highlight as more complex is the water system in a low or middle-income country, more complex is the related WSP development and, hence, time and costs.

In the following, some highlights are listed in order to better clarify which elements can bring (based on these experiences) to retain complex a water system (and consequently the related WSP), thus increasing costs and time consuming:

- *Number of water points available in loco and used by communities for drinking purposes*: higher the number of water sources, higher the sub-Plans to elaborate and, hence, higher costs of control measures' implementation and management.
- *Complexity of each water point*: since more complex the water system (presence of pipes interconnections, tanks, valves, taps, etc.) and more possible causes of contamination can contribute to water pollution, thus more controls should be identified, implemented and managed.
- *Number of unimproved water points without controls already in place*: in this case, the complexity of the WSP increases and above all costs of WSP implementation, in order to put in safety the water point.
- *Complexity of the transport and storage steps*: similarly to the complexity of the water system, higher the complexity, more the possible causes of contamination and more the controls required (even in costs and time consuming way).
- *Type of drinking water contamination*: controls required for a drinking water microbiologically contaminated are more related to changes in management behaviour (thus less expensive) compared to the ones necessary to minimise or prevent a chemical contamination (extremely more time consuming and costly).
- *Technical competencies and skills of water Committees*: high technical competences could bring to already adopt controls in order to prevent drinking water contamination (thus minimising global costs), or at least can permit to minimise time consuming in both WSP elaboration and implementation steps.
- *Characteristics of the local context*: obviously the local context strongly influences the WSP development and consequently its sustainability. Main factors that should be taking into account in this "category" are:
  - Number of inhabitants: greater the community, more complex (and costly) the WSP development.
  - Social-cultural and political structure: a simple political authorities' structure and a socially-culturally availability contribute positively to WSP sustainability.
  - Support of local authorities (from technical and political point of view): WSP more sustainable if support is available.
  - Presence / absence of water Committees: already in place water Committees make simpler WSP development.
  - Presence / absence of control measures already in place in order to prevent / minimise drinking water contamination: already in place control contribute positively to WSP sustainability and strongly help to minimise costs and time.
  - Drinking water management (use of more or less appropriate practices): more the spread of good practices, simpler, cheaper, less time consuming and thus more sustainable the WSP.

4.4 Conclusions

This Chapter aimed at presenting two complementary methodologies for WSP sustainability evaluation, tested in both case studies (Senegal and Burkina Faso).

The first method lies on a series of questions related to five sustainability elements: technical, economic, organisational and Institutional, social and cultural, environmental and health. The questionnaire should be addressed to the main stakeholders involved in the WSP development. The tool aims at collecting information necessary in order to highlight all the likely reasons of success or failure of projects.
The second method, instead, lies on a time consuming and costs analysis. Based on the three different steps of a WSP development (elaboration, implementation and management), an estimation of time needed and costs to cover should be carried out (based on control measures provided by the WSP), in order to better evaluate WSP sustainability.
The following highlights summarise the main conclusions of this experimental research:

- ✓ In both the projects, the sustainability evaluation by means of the experimental tool was carried out at the end of the activities, but a long-term assessment (after 1, 5 or 10 years) should also be provided in order to really understand the projects' effectiveness.
- ✓ The questionnaire for the evaluation of the sustainability elements was applied at the end of the projects' implementation, but if revised can be useful also for an evaluation before and during the activities.
- ✓ This questionnaire alone cannot be the only method to investigate the sustainability of a project, but it can provide a general overview from the standpoint of the different stakeholders. Indeed, as shown by the results of the two case studies, the application of the questionnaire alone would not have allowed the understanding of important aspects (appreciated thanks to a survey in loco).
- ✓ The presence of a strong local partner (as an NGO) can be a reason of success, as highlighted in these two case studies. The partnership with the NGO Dakupa in Burkina Faso has permitted to easily implement the different activities of the project, and probably to gain the reliance of the local communities into the project, assuring its sustainability.
- ✓ Time needed for the development of a WSP is not negligible. The WSP step characterised by more time consuming has provided to be the hazard assessment. WSP implementation, in terms of time, can vary depending on water system complexity.
- ✓ WSP costs demonstrated to be strongly dependent on water system complexity. Indeed, the easy structure of the water supply system in Burkina Faso provided rather acceptable costs of implementation and management of the WSP, whilst the more complex structure in Senegal was associated with extremely high costs.
- ✓ An interesting solution for making sustainable costs of a WSP management is to divide them amongst local community. Regarding WSP implementation, the need of external funds is mandatory, since costs that need to be covered are not affordable for rural communities.
- ✓ During the WSP development, the complexity of the water system under investigation has to be carefully considered. Time and costs, in fact, provided to be strongly dependent on this factor.

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Conclusions

The main goal of this research was to elaborate and implement a Water Safety Plan (WSP) approach in rural contexts of sub-Saharan Africa, verifying its applicability, effectiveness and sustainability. The major challenge was to simplify the WSP approach, since too much complex for being applicable as proposed by the World Health Organisation (WHO) in its Guidelines for drinking water quality. Nevertheless, the simplification had to ensure intact the structure of the WSP and above all had to enable the achievement of the final objective of prevention or minimisation of drinking water contamination.
The WSP approach was developed in two rural contexts of sub-Saharan Africa.

The first one in **Senegal**, by means of the cooperation project carried out by G. Tovini Foundation NGO (Brescia, Italy), in a rural area rather populated (some of 15,000 inh) and characterised by a quite complex water system. Regarding this case study, two missions in the field took place: the first one (July-August 2012) was entirely dedicated to the risk assessment, whilst in the second one (February-March 2013) the WSP has been elaborated after having identified the members of the WSP team. Meanwhile, supporting programmes based on awareness campaigns and training courses were developed.

The second WSP was elaborated in **Burkina Faso**, thanks to the cooperation project coordinated by Medicus Mundi Italy NGO (Brescia, Italy), in a rural area where lived about 3,000 inh and where the water system was quite simple. In this case, the missions in the field were three: the first one (November-December 2011) aimed at carrying out the risk assessment, in the second one (October-December 2012) the elaboration of the WSP took place, jointly with the implementation of the supporting programmes, whilst the third mission (May-June 2013) was entirely dedicated to evaluate the local situation (regarding drinking water management and handling practices) after the WSP implementation.

The experimental research carried out in this thesis has brought to the following considerations:

- ✓ The WSP approach is a rather complex strategy that requires involving technical experts in the drinking water sector, above all if applied in developing countries. Alternatively, the WSP structure needs to be strongly simplified if elaborated and managed by non specialists in the water sector.
- ✓ Regarding the two case studies analysed, in Senegal the WSP approach has been slightly simplified relative to the WSP framework proposed by the WHO, due to the presence of water supply managers and representatives of a local surveillance agency involved in the elaboration of the Plan, whilst in Burkina Faso the WSP approach has been strongly simplified owing to the absence of local experts. Indeed, in this context, the Plan has been developed involving Committees of water points and local users.
- ✓ A simplified WSP strategy has demonstrated to be effective as awareness tool of local communities. Indeed, in the rural villages of Fingla and Diarra (Burkina Faso), the WSP has been developed during the awareness campaigns' programme on good practices for drinking water management. Communities were asked to list all the possible causes of water contamination along the entire supply chain and to identify the best control measures (and a related monitoring programme) for effectively preventing or at least minimising hazards.
- ✓ In contexts such as rural areas of developing countries, the most important step of WSP development is the risk assessment, owing to the lack or complete absence of drinking water quality's monitoring data and other key information relative to water management along the entire

supply chain. A protocol of activities that should be carried out during a hazard assessment (implemented in these case studies and demonstrated to be effective) is the one proposed in the follow:

- *Water sources*: evaluation of the possible risks of microbiological contamination through the use of sanitary inspection forms (as the ones suggested by WHO or even revised depending on the specific characteristics of the water points); execution of an exhaustive campaign of water quality analysis, verifying both microbial and chemical parameters, and, if possible, monitoring the possible seasonal fluctuation of contaminants' concentration; carrying out interviews addressed to water Committees in order to gather key information about drinking water management; collection of data about drinking water sources (in terms of quality, quantity and geomorphologic structure of the source) at Institutional level, that is at the local water Directorate or at the Municipality.
- *Transport and storage*: execution of an exhaustive campaign of drinking water analysis in both the containers and, at storage level, careful evaluation of the influence on the contamination of the cup used for drinking purposes; evaluation of all the possible causes of microbial contamination by means of an intense campaign of interviews, in order to collect data on the practices of drinking water management and handling (in particular looking at the way people transport and store water, at all the possible types of containers employed, etc.); evaluation of the hygiene and sanitation practices, verifying the proper use of latrines, the frequency and occasions of hand washing, the presence of detergents in the households, etc.
- *Treatment*: if a treatment technology is already in place or needs to be put in place, it is fundamental to verify the local availability of materials to implement it, human resources available to be involved in the management and surveillance, funds able to guarantee a self-reliance of the technology, support both from beneficiaries and local Institutions / partners that are the key subjects for assuring its sustainability.

✓ The hazard assessment, although being extremely important, during the cost analysis developed in this work, revealed to be the most expensive step of the WSP elaboration. Indeed, it requires a proper economic availability for carrying out an adequate drinking water quality analysis campaign. Moreover, the presence and availability of a laboratory has to be taken into account. This should be close to the area of investigation, in order to carry out microbiological analysis in a suitable time frame, and should be well outfitted (in terms of both equipments and reagents) for the execution of chemical analysis. For these reasons, a cost-benefit analysis should be carefully carried out, in order to evaluate the amount and which kind of analyses could be feasible to provide depending on funds available.

✓ In Burkina Faso, the third evaluation mission permitted to verify the effectiveness of the WSP approach. Indeed, microbiological contamination (particularly referred to the concentration of *E. coli*) decreased of about 60% at source level, 75% at the transport step and some of 85% at storage level. Moreover, the hazard risk score calculated following the approach suggested by the WSP strategy (as the product of the likelihood of occurrence and the severity of consequences of the hazards identified) was reduced, after the WSP development, of some of 33% at source level, 21% at the transport step and 22% at the storage one. All these results were obtained only 6 months after the WSP implementation, demonstrating the strong effectiveness of this tool in minimising drinking water contamination, although it was rather strongly simplified.

✓ Time consuming and costs analysis revealed as their magnitude strictly depend on the complexity of the water system. Indeed, higher the complexity of the water supply system, higher the complexity of the WSP to be developed and thus higher the costs and more the time needed. This consideration clearly arose from the two case studies analysed in this research work. The higher complexity of the water system in the Rural Community of Patar in Senegal provided a quite complex WSP with higher time and costs of elaboration and implementation compared to the Burkina Faso case study. For instance, total costs of WSP implementation were equal to some of 140,000 € in Senegal relative to about 4,000 € in Burkina Faso.

- ✓ The sustainability evaluation tool developed in this work revealed to be effective for highlighting the presence of failure elements (technical, economic, organisational and Institutional, social and cultural, environmental and health) in the WSP. Even if the questionnaire alone cannot be the only method to investigate the sustainability of a project, it can provide a general overview from the standpoint of the different stakeholders. For this reason it would always be better to support this questionnaire with a survey in loco.
- ✓ In both the case studies, the sustainability evaluation was carried out at the end of the projects, but a long-term assessment (after 1, 5 or 10 years) should also be provided in order to really understand the WSP effectiveness. Moreover, the questionnaire for the evaluation of the five sustainability elements was designed to be used at the end of the projects' implementation, but if revised can be useful also for an evaluation before and during the activities.
- ✓ The presence of a strong local partner (as an NGO) can be a reason of success of a WSP implementation, as highlighted in these two case studies. The partnership with the NGO Dakupa in Burkina Faso permitted to easily implement the different activities of the project, and probably to gain the reliance of the local communities into the project, assuring its sustainability.

Annexes

Annexe 1. Questionnaire addressed to water Committees in Senegal

1) IDENTIFICATION DU QUESTIONNAIRE

1.1) Date du questionnaire:____________________ Nom de l'enquêteur___________________

1.2) Village et/ou quartier:_______________________

2) INFORMATIONS SUR LE COMITES DE GESTION DE L'EAU DE BOISSON

2.1) Combien de personnes composent le Comité de gestion? Indiquer le nombre:____________

2.2) Quelle est la fonction de chaque personne? Spécifier:_____________________________________

____

____

____

2.3) Modalité de mise en place du Comité de gestion de l'eau:

__ Il y a eu des élections __ Il y a eu des volontaires

2.4) Depuis combien d'année le Comité a été formé? Spécifier:_____________________________

2.5) Durée du mandate du Comité. Indiquer: ans____

2.6) Le Comité prévoit des réunions chaque mois? __ Oui __ Non

Spécifier la fréquence, si n'est pas mensuelle:____

Dans quel but ces réunions sont faites? Spécifier:____

____

____

2.7) Combien de francs les utilisateurs payent pour puiser l'eau?

Robinet à domicile: CFA/litre____________________

Borne fontaine: CFA/litre____________________

Puits protégés du village de Sambé: CFA/litre____________________

2.8) Toutes les familles payent pour puiser l'eau? __ Oui __ Non

Vous avez un registre? __ Oui __ Non

Si une famille ne paye pas, vous leur interdisez de puiser l'eau? __ Oui __ Non

Si Non, qu'est-ce que vous faites?Spécifier:____

____

2.9) Le Comité a un son compte (par exemple en banque)? __ Oui __ Non

Combien de francs le Comité a dans son compte/trésorerie? Indiquer: CFA_________________

Est-ce que vous pensez qu'ils soient suffisants pour payer quelques réparations du réseau?

__ Oui __ Non

Si Oui, pour quel type de réparation? Spécifier:_____________________________________

____

____

Si l'argent est utilisé pour autres buts, spécifier lesquels:_______________________________

____

____

2.10) Avez-vous reçu une formation spécifique sur la gestion de l'eau potable et/ou sur la gestion d'un réseau d'eau? __ Oui __ Non

Si Oui, par qui vous avez reçu cette formation? Spécifier:___________________________

Il y a mises à jour périodiques? Spécifier:____

2.11) Est-ce que le Comité a déjà tenu quelque réunion avec la population afin de la sensibiliser sur le bon usage de l'eau? __ Oui __ Non

Si Oui, combien de fois? Indiquer le nombre:_____________________________________

Avec l'aide de quelque autre Organisation? __ Oui __ Non

Si Oui, quel Organisation? Spécifier:____

2.12) Est-ce que le Comité a une coopération avec la population? Il tient compte des demandes qui viennent de la population? Spécifier:____

____

____

3) INFORMATIONS SUR LE RÉSEAU D'EAU

3.1) Combien de villages dans la communauté de Patar le réseau d'eau sert? Nombre_____________

Pour combien de ménages et/ou personnes? Nombre__________________________________

Combien ce réseau d'eau mesure-t-il en longueur? Kilomètre_______________

Savez-vous indiquer le nombre de fontaines publiques, robinets à domicile, etc. servis par le réseau?

Robinets à domicile:_______________

Fontaines publiques:_______________

Fontaines scolaires:________________

Autre à spécifier:____

3.2) En quell'année le réseau d'eau a été réalisé? Spécifier:___________________

Quand est été la dernière réhabilitation? Spécifier:______________________

Pour quelle raison la dernière réhabilitation a été faite? Spécifier:_________________________

____

____

3.3) Combien de fois le réseau d'eau a eu des dysfonctionnements/ruptures? Spécifier:_____________

Quel type de dysfonctionnement/rupture il y a eu? Spécifier:__________________________

____

____

3.4) D'habitude, est-ce que vous (ou quelque autre organisation) faites quelque contrôle périodique de la qualité de l'eau? __ Oui __ Non

Si Oui, combien de fois par année? Indiquer: fois/année________________________

Pour quels paramètres? Spécifier:____

Dans quel laboratoire? Spécifier:____

D'habitude, combien de francs vous payez pour ces analyses? Indiquer: CFA_____________

3.5) D'habitude, est-ce que vous ajoutez de l'eau de javel (ou quelque autre désinfectant) dans le réseau d'eau pour la désinfection? __ Oui __ Non

Si Oui…

Lequel?

Spécifier:____

Quand? Spécifier:____

Dans quel point du réseau? Spécifier:____

Quand est été la dernière fois? Spécifier:____

Est-ce que vous pouvez indiquer la quantité et le type (liquide ou solide; % de chlore actif; coût)? Spécifier:____

____

Selon quel critère, vous ajoutez l'eau de javel? Il ya des règles nationales/régionales?

Spécifier:____

____

Si Non…

Est-ce que vous faites quelque autre traitement? __ Oui __ Non

Lequel? Spécifier:____

3.6) En saison sèche, est-ce que l'extraction d'eau travaille régulièrement? __ Oui __ Non

Et en saison pluvieuse? __ Oui __ Non

3.7) Est-ce que les réservoirs de stockage de l'eau, avant de la distribution, ont été jamais nettoyés?
__ Oui __ Non
Depuis combien de temps a été la dernière fois? Spécifier:____________________________________
Quelle est la modalité de nettoyage? Spécifier:____
____
____

3.8) Quel type de relation il y a entre le Comité et les chefs des villages/le Président de la communauté de Patar/la Direction Régionale de l'Hydraulique/la population? Spécifier:________________________
____
____

<u>QUESTIONS TECHNIQUES</u>

Profondeur de l'eau:____
Diamètre du tuyau de captation:____
Débit extrait:____
Alimentation de la pompe:____
Coût d'extraction de l'eau:____
En général, coût annuel de gestion du réseau:_____________________________
Gain annuel du réseau:____

Annexe 2. Questionnaire addressed to households in Senegal

1) IDENTIFICATION DU QUESTIONNAIRE

1.1) Date du questionnaire:___________________ Nom de l'enquêteur:_________________

1.2) Village et/ou quartier:_______________________ ID nombre:_________________

1.3) Âge de la personne interrogée:_________________________

1.4) Sexe de la personne interrogée: __ Masculin __ Féminin

1.5) Nom de la personne interrogée:____

2) INFORMATIONS SOCIO-DÉMOGRAPHIQUES

2.1) Nombre des ménages dans la concession:____________________

2.2) Nombre des personnes dans le ménage interrogé:______________

Sexe	**Âge**				
	0-5 ans	**6-15 ans**	**16-45 ans**	**46-60 ans**	**plus de 61 ans**
Masculin					
Féminin					

2.3) Nombre des personnes qui ont atteint (ou fréquenté) le niveau supérieur:________________

2.4) Nombre des personnes qui ont atteint (ou fréquenté) le niveau secondaire:_______________

2.5) Nombre des personnes qui ont atteint (ou fréquenté) le niveau premier:_________________

2.6) Nombre des personnes qui savent parler et comprendre la langue française:______________

3) INFORMATIONS SUR LES MODES D'UTILISATION DE L'EAU

3.1) Où vous puisez l'eau en fonction de la saison et de la destination d'emploi (boire-cousiner-toilette-lessive-animaux-tout-autre à préciser)?

Source	**Saison sèche**	**Saison pluvieuse**	**Destination d'emploi**
Robinet à domicile			
Borne fontaine			
Puits protégés			
Puits non protégés			
Eau de pluie			
Eau en bouteille/sachet			
Autre à préciser:			

3.2) À quelle distance est votre source d'approvisionnement en eau et la fréquence à la quelle vous allez?

Source	**Distance (heures)***	**Fréquence (fois par jour)**
Robinet à domicile		
Borne fontaine		
Puits protégés		
Puits non protégés		
Eau de pluie		
Eau en bouteille/sachet		
Autre à préciser:		

*: pour aller de la maison au point d'approvisionnement en eau

3.3) Quelle est la quantité d'eau consommée par jour selon l'usage?

Usage	**Nombre récipients**	**Volume récipients**	**Litres**
Boisson			
Cuisine			
Toilette			
Lessive			
Nettoyage			
Animaux			
Autre à préciser:			

3.4) Quel est le récipient que vous utilisez pour le <u>transport</u> de l'eau? Pouvez-vous indiquer le volume, la fréquence de nettoyage et si le récipient est fermé?

Récipient	**Volume (litres)**	**Fréquence de nettoyage (jours)**	**Fermé (Oui/Non)**
1-Canaris			
2-Bassine			
3-Bidon			
4-Fût			
5-Seau			
6-Autre à préciser:			

3.5) Qu'est-ce que vous utilisez pour nettoyer les récipients de <u>transport</u> de l'eau?
__ Eau de javel __ Savon __ Eau simple __ Aucun
__ Autre____

3.6) Quel est le récipient que vous utilisez pour le <u>stockage</u> de l'eau? Pouvez-vous indiquer le volume, la fréquence de nettoyage, si le récipient est fermé et le temps de stockage de l'eau?

Récipient	**Volume (litres)**	**Fréquence de nettoyage (jours)**	**Fermé (Oui/Non)**	**Temps de stockage (jours)**
a-Canaris				
b-Bassine				
c-Bidon				
d-Fût				
e-Jarre				
f-Autre à préciser:				

3.7) Qu'est-ce que vous utilisez pour nettoyer les récipients de <u>stockage</u> de l'eau?
__ Eau de javel __ Savon __ Eau simple __ Aucun
__ Autre____

3.8) Comment vous utilisez l'eau stockée?

Récipient	**Boisson**	**Cuisine**	**Toilette**	**Lessive**	**Nettoyage**	**Animaux**	**Tout**
Canaris							
Bassine							
Bidon							
Fût							
Jarre							
Autre à préciser:							

4) INFORMATIONS SUR LA QUALITÉ DE L'EAU

4.1) Dans le ménage, qui s'occupe de la collecte de l'eau?

__ La femme __ L'homme __ Les filles __ Les garçons

__ Autre à spécifier: ________________________________

4.2) Combien de temps vous utilisez pour collecter et transporter l'eau?

Indiquer: heures: ___________________

4.3) Consommez-vous l'eau telle quel vous l'avez prélevée ou bien la soumettez-vous à quelque traitement? Lequel?

__ Aucun __ Désinfection avec eau de javel __ Filtration sur tissu

__ Bouillir __ Filtration sur cendre d'os __ Autre: _______________________

4.4) Cotisez-vous pour l'approvisionnement en eau? Combien et pour quelle source d'eau?

Source d'eau: __________________________ Coût (par mois): ____________________________

Source d'eau: __________________________ Coût (par mois): ____________________________

Source d'eau: __________________________ Coût (par mois): ____________________________

4.5) Selon vous, le coût de l'eau est-il élevé? __ Oui __ Non

4.6) Aimez-vous l'eau que vous disposez? __ Oui __ Non

Si Non…

Pourquoi?

__ Mauvais goût __ Salée __ Sale

__ Autre: ____

4.7) Êtes-vous satisfait de:

la qualité de l'eau: __ Oui __ Non

la quantité de l'eau: __ Oui __ Non

la distance de l'eau: __ Oui __ Non

Si Non…

Quelle amélioration aimeriez-vous? Spécifier: ____

____

Seriez-vous disposés à cotiser de plus en échange d'une amélioration? __ Oui __ Non

Si Oui, indiquez la somme maximale que vous êtes disposés à cotiser: CFA __________________

5) UTILISATION DES FILTRES EN CENDRE D'OS

5.1) D'habitude, vous utilisez les filtres pour le traitement de l'eau? __ Oui __ Non

Si OUI…

5.2) Combien de fois par jour?

__ Jamais __ 1 __ 2 __ 3 __ Autre à préciser______

5.3) Quelle eau vous introduisez dans le filtre?

__ Eau du forage __ Eau de puits __ Tous les deux

__ Autre à préciser_____________________________________

5.4) Comment vous jugez l'emploi du filtre?

__ Simple __ Compliqué

__ Utile __ Pas utile

__ Pas dispendieux en termes de temps __ Dispendieux en termes de temps

5.5) Quels problèmes techniques vous avez eu pendant l'emploi du filtre?

__ Aucun __ Perte d'eau du robinet __ Perte de cendre dans le robinet

__ Disponibilité limitée d'os __ Filtration trop lente

__ Autre à préciser____

5.6) Avez-vous quelque conseil pour améliorer l'emploi du filtre?

____

____

5.7) Quelles différences vous avez relevé entre l'eau traitée et l'eau pas traitée?
__ Aucun __ Meilleur __ Pire

5.8) Comment vous jugez la qualité de l'eau traitée?
__ Bonne __ Claire __ Trouble __ Salée
__ Mauvais goût __ Mauvais couleur __ Mauvais odeur

Si NON…

5.9) Pourquoi?
__ Disponibilité limitée d'os
__ Gestion du filtre trop compliquée
__ Trop compliquée la combustion d'os
__ Perte d'eau dans le robinet
__ Trop compliqué le déchiquetage d'os
__ Perte des cendres dans le robinet
__ Filtration trop lente
__ Filtre cassé
__ Eau salée après le traitement
__ Eau trouble après le traitement
__ Dispendieux en termes de temps
__ Pas utile
__ Autre à préciser____

5.10) Avez-vous quelque conseil pour améliorer l'emploi du filtre?
____
____

5.11) Après des améliorations, seriez-vous disposés à utiliser le filtre? __ Oui __ Non

6) HYGIENE ET ASSAINISSEMENT

6.1) D'habitude, où vous faites vos besoins?
__ Latrine personnelle __ Latrine familiale __ Latrine publique
__ À l'air libre __ Autres lieux: ______________________

6.2) Si vous utilisez une latrine, vous sauriez indiquer le type?
__ Traditionnelle __ Chasse d'eau __ VIP
__ Je ne sais pas __ Autre:__________________

6.3) Quel type de détergent vous utilisez pour vous laver les mains?
__ Savon __ Eau de javel __ Les deux __ Aucun
__ Autre: ________________________________

6.4) À quel occasion vous utilisez le savon? ***(LAISSER REPONDRE)***
__ Se laver les mains avant de manger
__ Se laver les mains après avoir fait les besoins
__ Se laver les mains après avoir mangé
__ Se laver les mains après avoir touché les animaux
__ Nettoyer les récipients de transport et stockage de l'eau
__ Rien
__ Autre: ________________________________

6.5) Savez-vous quels sont les avantages d'un bon système d'assainissement?
__ La discrétion __ La réduction de l'odeur __ Je ne sais pas
__ Se débarrasser des mouches et des moustiques __ L'amélioration de la santé
__ La sécurité __ Autre: __________________________

7) INFORMATIONS SUR L'ECONOMIE FAMILIALE

7.1) Quelle est la source de revenu de la famille?
__ Activités professionnelles __ Soutien extérieur __ Les deux

7.2) Quelles activités professionnelles?
__ Artisanat __ Commerce __ Agriculture __ Élevage __ Pêche
__ Fonctionnaire __ Autre__________________________________

7.3) Quel est le niveau de revenu de la famille?
Indiquer: CFA/année: ______________ **ou** CFA/mois: ______________

8) ASPECTS SANITAIRES

8.1) Est-ce que quelqu'un dans le ménage a eu des troubles de santé dans ce dernier mois?

__ Oui __ Non

Lesquels? ***(Indiquer le nombre)***

	Masculin			Féminin		
	0-5 ans	**6-15 ans**	**Plus de 15 ans**	**0-5 ans**	**6-15 ans**	**Plus de 15 ans**
Diarrhée						
Dysenterie						
Vomissement						
Maux de ventre						
Fièvre						
Toux						
Autre						

8.2) Est-ce que dans le ménage il y a des cas de fluorose? __ Oui __ Non

Si Oui, qui a été touché? ***(Indiquer le nombre)***

	Masculin			Féminin		
	0-5 ans	**6-15 ans**	**Plus de 15 ans**	**0-5 ans**	**6-15 ans**	**Plus de 15 ans**
Fluorose dentaire						
Fluorose osseuse						

8.3) Qu'est-ce que vous faites habituellement lorsque quelqu'un d'entre vous a la diarrhée?
(LAISSER REPONDRE)

__ Rien
__ Donner à boire beaucoup de liquides
__ Utiliser les tisanes
__ Aller chez le guérisseur dans un village
__ Donner la solution de réhydratation / eau avec sel / aliments salés
__ Prendre des médicaments de la rue
__ Donner des médicaments de la pharmacie
__ Aller au Poste de santé / clinique / visite médicale
__ Autre: ____

8.4) Selon vous, pourquoi les gens ont la diarrhée? Parce que: ***(LAISSER REPONDRE)***

__ L'eau est souillée __ Il y a des microbes __ Les mains sont sales __ Je ne sais pas
__ Les aliments ne sont pas lavés et/ou bien cuits __ Autre: ____________________

8.5) Selon vous, comment peut-on empêcher la diarrhée? ***(LAISSER REPONDRE)***

__ Se laver régulièrement les mains avec du savon
__ Ne pas utiliser de l'eau souillée
__ Bien laver les fruits avant de les manger
__ Bien cuire les aliments avant de les manger
__ Couvrir les récipients de stockage de l'eau
__ Je ne sais pas
__ Autre: __________________________________

8.6) Connaissez-vous quelque signe de diarrhée sévère? __ Oui __ Non

Si Oui, lequel? ***(LAISSER REPONDRE)***

__ Sang dans les selles __ Diarrhée et vomissement __ Incapacité à boire
__ Diarrhée et une forte fièvre __ Aller beaucoup de fois aux selles
__ Autre: ____

8.7) Selon vous, c'est important de se laver les mains? __ Oui __ Non __ Je ne sais pas
Si Oui, pourquoi? ***(LAISSER REPONDRE)***
__ Ça évite la diarrhée et d'autres maladies __ Ça empêche la contamination des aliments
__ Ça élimine les microbes __ Autre: ____

8.8) Selon vous, quand est important de se laver les mains? ***(LAISSER REPONDRE)***
__ Avant de faire les besoins __ Après avoir fait les besoins
__ Avant de cuisiner __ Avant de manger
__ Après avoir mangé __ Après avoir touché les animaux
__ Avant de toucher les animaux __ Jamais
__ Autre: ____

8.9) Est-ce que quelqu'un dans le ménage est allé au Poste de santé dans ce dernier mois?
__ Oui __ Non
Si Oui, qui et pour quelle raison? ***(Indiquer le nombre)***

	Masculin			Féminin		
	0-5 ans	**6-15 ans**	**Plus de 15 ans**	**0-5 ans**	**6-15 ans**	**Plus de 15 ans**
Diarrhée						
Dysenterie						
Vomissement						
Maux de ventre						
Fièvre						
Toux						
Autre						

8.10) Où achetez-vous un médicament quand vous avez besoin?
__ Poste de santé __ Marché __ Pharmacie __ Autre____________

8.11) Combien d'argent vous avez dépensé dans le dernier mois pour les questions de santé du ménage?
Indiquer le coût: ________________________

8.12) La prochain fois, irez-vous encore au Poste de santé si quelqu'un est malade? __ Oui __ Non

8.13) Avez-vous déjà participé à une séance de sensibilisation à l'hygiène? __ Oui __ Non
Si Oui, qui vous a fait cette séance de sensibilisation?
__ Une personne de l'ASUFOR __ Une personne du Poste de Santé
__ 1er projet FonTov __ Autre:____________________________

8.14) Avez-vous déjà participé à une séance de sensibilisation sur la bonne gestion de l'eau potable?
__ Oui __ Non
Si Oui, qui vous a fait cette séance de sensibilisation?
__ Une personne de l'ASUFOR __ Une personne du Poste de Santé
__ 1er projet FonTov __ Autre:____________________________

<u>Avant de terminé le questionnaire, voir les choses suivantes</u>

1. Faire une photo dans l'extérieur et l'intérieur des récipients de transport et stockage de l'eau.
2. Contrôler l'état des récipients de transport et stockage de l'eau.
3. Le lieu de conservation du récipient de stockage de l'eau est:
   __ À l'extérieur non protégé __ À l'extérieur protégé
   __ À l'intérieur non protégé __ À l'intérieur protégé
   __ Au contact avec les animaux __ À l'abri des animaux
   __ Autre_____________

4. Le gobelet de puisage de l'eau de boisson est:
   __ Inexistant __ Par terre
   __ Posé sur le couvercle du récipient __ Posé inversé sur le couvercle du récipient
5. Y a t'il des animaux près des récipients de stockage de l'eau? __ Oui __ Non
6. Contrôler si dans le ménage il y a du savon pour le lavage des mains.
   __ Oui __ Non
7. Voir les latrines et indiquer l'état:
   __ Accessible __ Fermé avec un cadenas
   __ Utilisée souvent __ Utilisée rarement
   __ Bien entretenue et propre __ Mal entretenue et sale
   __ Présence d'une porte __ Absence d'une porte
   __ Présence d'une toiture __ Absence d'une toiture
   __ Présence d'une fenêtre __ Absence d'une fenêtre
   __ Présence d'un tuyau d'aération __ Absence d'un tuyau d'aération
   __ Trou de défécation couvert __ Trou de défécation ouvert
   __ Présence d'eau prés de la cabine __ Absence d'eau prés de la cabine
   __ Présence de savon prés de la cabine __ Absence de savon prés de la cabine
8. Indiquer le type des latrines?
   __ Traditionnelle __ Chasse d'eau __ VIP
   __ Autre:____
9. Faire une photo du système utilisé pour cuisiner.

Annexe 3. Water quality analyses in Senegal

A.3.1 Physico-chemical analyses at source level

The groundwater distribution system

Parameter	November 2008	July 2009	July 2012	28-02-2013	07-03-2013	14-03-2013	18-03-2013
Lead (mg/L)	n.a.	n.a.	n.a.	< 0.01	< 0.01	< 0.01	< 0.01
Fluorides (mg/L)	4.75	7.98	n.a.	6.22	11.04	8.89	3.63
Chlorides (mg/L)	872	910	n.a.	1,100	940	650	780
Sodium (mg/L)	n.a.	n.a.	n.a.	400	404	426	371
Ammonia (mg/L)	n.a.	n.a.	0.28	0.20	0.26	0.13	0.18
Nitrates (mg/L)	n.a.	n.a.	0	0	0	0	0
Nitrites (mg/L)	n.a.	n.a.	n.a.	0.020	0.020	0.018	0.015
Free chlorine (mg/L)	n.a.	n.a.	0.08	0.08	0.10	0.06	0.01
Conductivity (µS/cm)	2,630	2,750	2,503	2,410	2,420	2,440	2,440
Temperature (°C)	25.7	27.2	31.6	27.9	22.8	32.1	26.8
pH	8.20	8.15	8.03	7.88	8.30	8.21	8.28
Turbidity (NTU)	0.98	0.65	n.a.	0.49	1.50	1.84	1.71

n.a.: not available

The protected wells network

Parameter	November 2008	July 2009	July 2012	28-02-2013	07-03-2013	14-03-2013	18-03-2013
Lead (mg/L)	n.a.	0.13	n.a.	0.06	0.14	0.01	0.08
Fluorides (mg/L)	0.14	0.46	n.a.	0.35	0.37	n.a.	0.58
Chlorides (mg/L)	40	34	n.a.	25	34	10	10
Sodium (mg/L)	n.a.	n.a.	n.a.	14	19	25	25
Ammonia (mg/L)	n.a.	n.a.	0.11	0.20	0.20	0.13	0.15
Nitrates (mg/L)	n.a.	n.a.	n.a.	0	0	0	0
Nitrites (mg/L)	n.a.	n.a.	0.060	0.020	0.020	0.020	0.016
Free chlorine (mg/L)	n.a.	n.a.	0.02	0.11	0.08	0.10	0.06
Conductivity (µS/cm)	627	631	565	715	593	602	602
Temperature (°C)	25.0	33.0	31.9	27.1	22.6	31.1	26.9
pH	7.5	7.6	6.3	7.1	7.7	7.6	7.6
Turbidity (NTU)	0.19	n.a.	n.a.	0.01	0.01	0.01	0.01

n.a.: not available

The open dug wells

Lead (mg/L)

Dug well	November 2008	July 2009	July 2012	February 2013
Sambé école	n.a.	0.08	n.a.	0.08
Sambé centre	n.a.	0.21	n.a.	0.04
Diam Tine	n.a.	n.a.	n.a.	0.14
Sambé Cheikh	n.a.	n.a.	n.a.	0.14
Sambé Sene	n.a.	n.a.	n.a.	0.09
Dabel Bara centre	n.a.	n.a.	n.a.	0.35
Dabel Bara	n.a.	n.a.	n.a.	0.04

n.a.: not available

Fluorides (mg/L)

Dug well	November 2008	July 2009	July 2012	February 2013
Sambé école	0.30	0.95	n.a.	2.40
Sambé centre	0.33	0.99	0.85	n.a.
Diam Tine	0.36	1.22	n.a.	5.40
Sambé Cheikh	n.a.	2.18	n.a.	5.54
Sambé Sene	n.a.	n.a.	n.a.	0.49
Dabel Bara centre	n.a.	n.a.	n.a.	2.86
Dabel Bara	n.a.	n.a.	n.a.	0.86

n.a.: not available

Chlorides (mg/L)

Dug well	November 2008	July 2009	July 2012	February 2013
Sambé école	30	37	n.a.	26
Sambé centre	31	33	n.a.	10
Diam Tine	n.a.	39	n.a.	59
Sambé Cheikh	n.a.	n.a.	n.a.	66
Sambé Sene	n.a.	n.a.	n.a.	10
Dabel Bara centre	n.a.	n.a.	n.a.	180
Dabel Bara	n.a.	n.a.	n.a.	12

n.a.: not available

Sodium (mg/L)

Dug well	November 2008	July 2009	July 2012	February 2013
Sambé école	n.a.	n.a.	n.a.	19
Sambé centre	n.a.	n.a.	n.a.	29
Diam Tine	n.a.	n.a.	n.a.	32
Sambé Cheikh	n.a.	n.a.	n.a.	30
Sambé Sene	n.a.	n.a.	n.a.	31
Dabel Bara centre	n.a.	n.a.	n.a.	265
Dabel Bara	n.a.	n.a.	n.a.	39

n.a.: not available

Ammonia (mg/L)

Dug well	November 2008	July 2009	July 2012	February 2013
Sambé école	n.a.	n.a.	0.58	0.20
Sambé centre	n.a.	n.a.	0.11	0.16
Diam Tine	n.a.	n.a.	n.a.	0.20
Sambé Cheikh	n.a.	n.a.	n.a.	0.20
Sambé Sene	n.a.	n.a.	n.a.	0.17
Dabel Bara centre	n.a.	n.a.	n.a.	1.24
Dabel Bara	n.a.	n.a.	n.a.	0.09

n.a.: not available

Nitrates (mg/L)

Dug well	November 2008	July 2009	July 2012	February 2013
Sambé école	n.a.	n.a.	0.00	0.00
Sambé centre	n.a.	n.a.	n.a.	0.00
Diam Tine	n.a.	n.a.	n.a.	0.20
Sambé Cheikh	n.a.	n.a.	n.a.	0.70
Sambé Sene	n.a.	n.a.	n.a.	0.01
Dabel Bara centre	n.a.	n.a.	n.a.	0.00
Dabel Bara	n.a.	n.a.	n.a.	0.00

n.a.: not available

Nitrites (mg/L)

Dug well	November 2008	July 2009	July 2012	February 2013
Sambé école	n.a.	n.a.	n.a.	0.020
Sambé centre	n.a.	n.a.	n.a.	0.032
Diam Tine	n.a.	n.a.	n.a.	0.025
Sambé Cheikh	n.a.	n.a.	n.a.	0.038
Sambé Sene	n.a.	n.a.	n.a.	0.063
Dabel Bara centre	n.a.	n.a.	n.a.	0.022
Dabel Bara	n.a.	n.a.	n.a.	0.012

n.a.: not available

Conductivity (µS/cm)

Dug well	November 2008	July 2009	July 2012	February 2013
Sambé école	715	732	724	681
Sambé centre	636	718	732	686
Diam Tine	782	775	n.a.	619
Sambé Cheikh	n.a.	n.a.	n.a.	712
Sambé Sene	n.a.	n.a.	n.a.	616
Dabel Bara centre	n.a.	n.a.	2,000	2,350
Dabel Bara	n.a.	n.a.	n.a.	783

n.a.: not available

Temperature (°C)

Dug well	November 2008	July 2009	July 2012	February 2013
Sambé école	26.0	32.0	31.9	28.1
Sambé centre	26.0	32.0	31.5	29.8
Diam Tine	n.a.	32.0	n.a.	22.2
Sambé Cheikh	n.a.	n.a.	n.a.	23.5
Sambé Sene	n.a.	n.a.	n.a.	27.9
Dabel Bara centre	n.a.	n.a.	31.5	26.5
Dabel Bara	n.a.	n.a.	n.a.	27.4

n.a.: not available

pH

Dug well	November 2008	July 2009	July 2012	February 2013
Sambé école	7.3	7.4	7.2	7.4
Sambé centre	7.6	7.4	7.8	7.4
Diam Tine	7.3	7.3	n.a.	7.6
Sambé Cheikh	n.a.	n.a.	n.a.	7.6
Sambé Sene	n.a.	n.a.	n.a.	7.4
Dabel Bara centre	n.a.	n.a.	7.5	7.9
Dabel Bara	n.a.	n.a.	n.a.	7.7

n.a.: not available

Turbidity (NTU)

Dug well	November 2008	July 2009	July 2012	February 2013
Sambé école	1.0	n.a.	n.a.	13.8
Sambé centre	0.7	n.a.	n.a.	5.1
Diam Tine	0.5	2.6	n.a.	6.3
Sambé Cheikh	n.a.	n.a.	n.a.	21.8
Sambé Sene	n.a.	n.a.	n.a.	2.8
Dabel Bara centre	n.a.	n.a.	n.a.	98.6
Dabel Bara	n.a.	n.a.	n.a.	7.9

n.a.: not available

A.3.2 Microbiological analyses at source level

The groundwater distribution system

Date	Sampling point	*E. coli*	Faecal coliforms	Total coliforms	Faecal streptococci
28/02/2013	Public tap	3	3	6	5
07/03/2013	Feed tanks	1	1	12	2
07/03/2013	Public tap	3	7	64	6
14/03/2013	Public tap	5	7	12	8
14/03/2013	Feed tanks	0	4	8	9
18/03/2013	Public tap	4	5	5	4
18/03/2013	Private tap	5	6	8	4
19/03/2013	Public tap	5	7	67	10

The protected wells network

Date	*E. coli*	Faecal coliforms	Total coliforms	Faecal streptococci
July 2012	14	n.a.	38	8
28/02/2013	6	8	42	17
07/03/2013	2	2	5	19
14/03/2013	16	17	100	29
18/03/2013	14	15	29	42

The open dug wells

Date	Sampling point	*E. coli*	Faecal coliforms	Total coliforms	Faecal streptococci
July 2012	Dabel Bara centre	900	n.a.	2,500	4,000
July 2012	Sambé école	400	n.a.	700	100
July 2012	Sambé centre	300	n.a.	2,000	1,000
28/02/2013	Sambé école	1,500	1,500	8,000	1,200
07/03/2013	Sambé Cheikh	700	1,000	6,900	500
07/03/2013	Diam Tine	1,600	2,000	9,000	5,000
14/03/2013	Sambé centre	1,700	2,400	8,400	3,800
18/03/2013	Sambé Sene	9,500	9,500	11,400	5,400
19/03/2013	Dabel Bara centre	2,200	2,300	7,900	2,900
19/03/2013	Dabel Bara	800	1,900	3,500	2,800

A.3.3 Microbiological analyses along the supply chain

HH	Transport				Storage			
	E. coli	Faecal coliforms	Total coliforms	Faecal streptococci	*E. coli*	Faecal coliforms	Total coliforms	Faecal streptococci
1	50	130	260	150	170	220	370	420
2	30	30	120	90	80	140	320	140
3	120	230	330	110	240	320	1360	430
4	100	260	400	210	60	240	150	320
5	n.a.	n.a.	n.a.	n.a.	150	370	420	110
6	100	110	200	100	70	70	150	90
7	50	60	150	250	30	30	180	230
8	80	80	100	130	100	100	120	120
9	130	200	260	880	100	180	1500	730
10	40	40	190	40	220	220	230	270
12	n.a.	n.a.	n.a.	n.a.	730	730	1080	240
13	n.a.	n.a.	n.a.	n.a.	650	650	800	380
14	n.a.	n.a.	n.a.	n.a.	770	770	1140	240
15	n.a.	n.a.	n.a.	n.a.	340	340	910	180
16	110	180	550	260	410	410	590	390
17	n.a.	n.a.	n.a.	n.a.	110	110	140	710
18	n.a.	n.a.	n.a.	n.a.	80	380	530	260
19	n.a.	n.a.	n.a.	n.a.	70	70	110	40
20	300	300	410	70	400	430	500	220

HH: HouseHold; n.a.: not available

A.3.4 Monitoring of bone char-based filters

Filter 1

Parameter	20 L		600 L		1,200 L	
	IN	OUT	IN	OUT	IN	OUT
Fluorides (mg/L)	4.220	0.349	4.650	0.374	4.440	0.395
Chlorides (mg/L)	480	540	560	555	490	510
pH	8.47	8.49	7 .64	7.65	7.65	8.04
Conductivity (mS/cm)	2.62	3.27	2.62	2.70	3.49	3.38
E. coli	n.a.	n.a.	n.a.	10	n.a.	20
Faecal coliforms	n.a.	n.a.	n.a.	10	n.a.	20
Total coliforms	n.a.	n.a.	n.a.	120	n.a.	250
Faecal streptococci	n.a.	n.a.	n.a.	10	n.a.	50

n.a.: not available

Filter 2

Parameter	20 L		600 L		1,200 L	
	IN	OUT	IN	OUT	IN	OUT
Fluorides (mg/L)	3.986	0.386	5.165	0.397	4.462	0.389
Chlorides (mg/L)	650	400	520	510	490	510
pH	8.37	8.49	7.64	6.99	7.90	8.50
Conductivity (mS/cm)	2.70	3.27	2.64	2.41	3.24	3.17
E. coli	n.a.	n.a.	n.a.	8	n.a.	20
Faecal coliforms	n.a.	n.a.	n.a.	12	n.a.	22
Total coliforms	n.a.	n.a.	n.a.	90	n.a.	160
Faecal streptococci	n.a.	n.a.	n.a.	5	n.a.	30

n.a.: not available

Filter 3

Parameter	20 L		600 L		1,200 L	
	IN	OUT	IN	OUT	IN	OUT
Fluorides (mg/L)	4.332	0.639	4.835	0.743	4.016	0.871
Chlorides (mg/L)	510	770	590	400	480	500
pH	8.47	8.50	7.84	6.78	7.82	8.31
Conductivity (mS/cm)	2.61	3.60	2.32	1.45	3.36	3.32
E. coli	n.a.	n.a.	n.a.	12	n.a.	25
Faecal coliforms	n.a.	n.a.	n.a.	15	n.a.	36
Total coliforms	n.a.	n.a.	n.a.	40	n.a.	200
Faecal streptococci	n.a.	n.a.	n.a.	10	n.a.	42

Filter 4

Parameter	20 L		600 L		1,200 L	
	IN	OUT	IN	OUT	IN	OUT
Fluorides (mg/L)	4.310	0.536	4.248	0.550	4.504	0.540
Chlorides (mg/L)	470	440	540	490	570	520
pH	8.36	8.46	7.61	6.98	7.96	8.14
Conductivity (mS/cm)	2.64	2.67	2.45	2.26	3.38	3.28
E. coli	n.a.	n.a.	n.a.	12	n.a.	30
Faecal coliforms	n.a.	n.a.	n.a.	12	n.a.	34
Total coliforms	n.a.	n.a.	n.a.	100	n.a.	180
Faecal streptococci	n.a.	n.a.	n.a.	10	n.a.	55

A.3.5 Batch chlorination tests

Free chlorine concentrations

Free chlorine			Contact time (hours)				
Test	$C*T_C$ (mg/L*min)	Dosage (mL)	0.5	1	2	3	4
a	0.10	0.21	0.11	0.86	1.29	2.31	0.20
b	0.15	0.31	3.84	2.99	2.25	1.68	2.48
c	0.20	0.42	5.00	5.00	3.61	3.73	3.49
d	0.25	0.52	5.00	5.00	5.00	5.00	4.99

Microbiological parameters' concentrations

Test	$C*T_C$ (mg/L*min)	*E. coli*	Faecal coliforms	Total coliforms	Faecal streptococci
Reference	-	700	1,000	6,900	500
a	0.10	5	5	6	5
b	0.15	1	1	2	4
c	0.20	0	0	0	1
d	0.25	0	0	0	0

Annexe 4. The WSP developed in Senegal

A.4.1 The groundwater distribution system

Hazardous event	Hazard	Cause	Risk			Control measure
			Likelihood	Severity	Score	
Drinking water contamination	Microbial	Animals enter through open inspection hatches of tanks	1	5	5	Ensure the hermetic closing of inspection hatches
		Improper hygiene practices during feed tanks' cleansing	2	4	8	Observe the good hygiene practices during the cleaning
		Ingress of contaminated water through damaged valves	1	4	4	Replace periodically (at least every 5 years) the valves
		Rupture of a water supply distribution pipe	3	5	15	Check, during the installation, the quality of the pipes
						Install correctly the pipes
		Improper hygiene practices during pipe repairs	3	5	15	Employ qualified personnel for repairs
		Lack of pressure in the supply system	4	3	12	Ensure the presence of the watchman 24h/24
		Dirty taps	5	5	25	Disinfect regularly the taps
		Improper fence around the installation enabling animals or unauthorised people entering	1	2	2	Ensure the suitability of the fence
		Free chlorine residue insufficient	5	4	20	Improve the disinfection at the feed tanks
	Chemical	Corrosion of iron pipes and valves	3	5	15	Replace periodically the iron pipes and valves and use the rust preventer onto the iron elements
		Free chlorine overdose	1	3	3	Dose the correct quantity of chlorine
	Geological	High concentrations of fluorides, chlorides and sodium	5	5	25	Spread the use of bone char-based filtration systems and the dilution with rain-water or wells-water
						Launch an experimental research of appropriate solutions at community level for decreasing fluorides, chlorides and sodium concentrations

Continue...

...Continue

Control measure	Monitoring programme				
	What	How	When	Where	Who
Ensure the hermetic closing of inspection hatches	The hermetic closing of hatches	Control of the hatches	Every 2 months	At the borehole installation	President of ASUFOR (Mr Issa Faye) and DHA
Observe the good hygiene practices during the cleaning	Respect of good hygiene practices	Inspection during cleansing	Every 6 months	At the borehole installation	President of ASUFOR (Mr Issa Faye) and DHA
Replace periodically (at least every 5 years) the valves	The valves' state	Check that no water leaks	Monthly	At the borehole installation and along the distribution system	President and manager of ASUFOR
Check, during the installation, the quality of the pipes	The pipes' state and the installation method	Inspection before, during and after the installation	During the installation	At the borehole installation	General supervisor of ASUFOR (Mrs Tening Pouye)
Install correctly the pipes					
Employ qualified personnel for repairs	The qualification level of employees	Inspection during repairs	At each repair / installation	At the borehole installation and along the distribution system	General supervisor of ASUFOR (Mrs Tening Pouye)
Ensure the presence of the watchman 24h/24	The presence of the watchman	Site inspections	Weekly	At the borehole installation	President of ASUFOR (Mr Issa Faye)
Disinfect regularly the taps	The healthiness of the taps	Inspections	Weekly	At the taps	Members ASUFOR and RPHC
			Monthly		DHA
Ensure the suitability of the fence	The suitability of the fence	Inspections	Monthly	At the borehole installation	President of ASUFOR (Mr Issa Faye)
Improve the disinfection at the feed tanks	The disinfection treatment	Inspections	Every 6 months	At the borehole installation	President of ASUFOR (Mr Issa Faye) and DHA
Replace periodically the iron pipes and valves and use the rust preventer onto the iron elements	The state of the iron pipes and valves	Inspections	Every 5 years	At the borehole installation and along the distribution system	President and manager of ASUFOR
Dose the correct quantity of chlorine	The disinfection treatment	Inspections	Every 6 months	At the borehole installation	President of ASUFOR (Mr Issa Faye) and DHA
Spread the use of bone char-based filtration systems and the dilution with rain-water or wells-water	The utilisation level of filters and dilution operations	Inspections	Every 6 months	At the dwellings	Student representative (Mr Mamadou Séne); Secretary-general GIE (Mr Moustapha Sagne); General supervisor ASUFOR (Mrs Tening Pouye); RPHC
Launch an experimental research of appropriate solutions at community level for decreasing fluorides, chlorides and sodium concentrations	The research progress	Meetings with the partners	Every 6 months	At the University of Dakar	Student representative (Mr Cheikh Kama) and DHA

Continue...

...Continue

Control measure	Operational limit	Corrective measure
Ensure the hermetic closing of inspection hatches	Hermetic closing of inspection hatches	Drinking water disinfection
		Ensure the hermetic closing of hatches
Observe the good hygiene practices during the cleaning	Failure of only 1 hygiene practice	Drinking water disinfection
Replace periodically (at least every 5 years) the valves	More than 1 broken valve in 5 years	Replace of valves
		Drinking water disinfection
		Increase of the frequency of valves' replacement (5 → 4 years)
Check, during the installation, the quality of the pipes	More than 1 broken pipe in 6 months	Drinking water disinfection
		Verify rigorously the pipes quality before the installation
Install correctly the pipes		Verify rigorously the installation operations
		Change the supplier
Employ qualified personnel for repairs	1 employee not qualified	Change the employee
Ensure the presence of the watchman 24h/24	2 absences per month	1 warning (after 3 warnings, there will be dismissal)
Disinfect regularly the taps	More than 1 dirty tap per month	Disinfection of taps
		Awareness campaigns for the community
Ensure the suitability of the fence	Fence damaged	Repair the fence
		Training of the watchman on good management practices
Improve the disinfection at the feed tanks	Absence of the taste and odour of chlorine	Drinking water disinfection
Replace periodically the iron pipes and valves and use the rust preventer onto the iron elements	Water red-coloured more than once per year	Replace the rusty elements
		Drinking water disinfection
		Increase of the replacement frequency
Dose the correct quantity of chlorine	High taste and odour of chlorine	Interruption of drinking water disinfection
Spread the use of bone char-based filtration systems and the dilution with rain-water or wells-water	In 1 year, at least 10% of yards of each CRP village with bone char-based filters (some of 300 filters)	Research of financial partners
Launch an experimental research of appropriate solutions at community level for decreasing fluorides, chlorides and sodium concentrations	In 1 year, first proposal of community drinking water treatment	Research of other technical and financial partners

Continue...

...Continue

Control measure	Verification programme				
	What	How	When	Where	Who
Ensure the hermetic closing of inspection hatches	*E. coli* < 1 CFU/100 mL Faecal streptococci < 1 CFU/100 mL	Microbiological analyses	Every 6 months	At the borehole installation and at the laboratory	DHA
Observe the good hygiene practices during the cleaning					
Replace periodically (at least every 5 years) the valves	Management register	Control of the register	Monthly	At the borehole installation	DHA and ASUFOR
Check, during the installation, the quality of the pipes					
Install correctly the pipes					
Employ qualified personnel for repairs					
Ensure the presence of the watchman 24h/24					
Disinfect regularly the taps	*E. coli* < 1 CFU/100 mL Faecal streptococci < 1 CFU/100 mL	Microbiological analyses	Every 6 months	At the borehole installation and at the laboratory	DHA
Ensure the suitability of the fence	Proper environmental hygiene	Sanitary inspections WHO	Every 6 months	At the borehole installation	DHA and ASUFOR
Improve the disinfection at the feed tanks					
Replace periodically the iron pipes and valves and use the rust preventer onto the iron elements	Management register	Control of the register	Monthly	At the borehole installation	DHA and ASUFOR
Dose the correct quantity of chlorine	Proper environmental hygiene	Sanitary inspections WHO	Every 6 months	At the borehole installation	DHA and ASUFOR
Spread the use of bone char-based filtration systems and the dilution with rain-water or wells-water	Financial conditions	Meetings with partners	Monthly	RCP	President RCP; RPHC; Students' representative (Mr Kama Cheikh); Secretary-general of GIE (Mr Moustapha Sagne); President of ASUFOR (Mr Issa Faye); DHA (Mr Talla Diack)
Launch an experimental research of appropriate solutions at community level for decreasing fluorides, chlorides and sodium concentrations	Research progress	Research report evaluation	Every 6 months	RCP	University students

A.4.2 The protected wells network

Hazardous event	Hazard	Cause	Risk: Likelihood	Risk: Severity	Risk: Score	Control measure
Drinking water contamination	Microbial	Presence of latrines or open defecation places < 10 m from wells	1	4	4	Respect the distance (> 10 m) and do not build latrines on higher ground than wells
		Cracks or holes in the attachment between extraction pipes and wells	5	4	20	Ensure the hermetic closing amongst extraction pipes and wells (walls or covers)
		Dirty taps	5	5	25	Disinfect regularly the taps
		Animals enter through open inspection hatches of feed tanks	1	5	5	Ensure the hermetic closing of inspection hatches
		Improper hygiene practices during feed tanks' cleansing	5	5	25	Observe the good hygiene practices during the cleaning
		Absence of proper concrete aprons around the wells	5	2	10	Build concrete aprons of 1-2 m width
		Presence of stagnant water around the wells	2	4	8	Build drainage channels conducting waters to absorbing wells
		Improper fence around the installation enabling animals or unauthorised people entering	3	2	6	Ensure the suitability of the fence
		Presence of animals around the wells	3	3	9	
		Presence of animal excreta around the wells	3	4	12	
		Rupture of water supply distribution pipes and / or valves	1	4	4	Replace periodically (at least every 5 years) valves and pipes
		Improper hygiene practices during repair operations	1	5	5	Employ qualified personnel for repairs
	Chemical	Use of chemicals in the wells surroundings (pesticides, fertilisers, etc.)	2	4	8	Respect the standard precautions of the chemicals used
		High concentrations of lead	5	5	25	Spread the use of bone char-based filtration systems
						Launch an experimental research of appropriate solutions at community level for decreasing lead concentrations

Continue...

...Continue

Control measure	Monitoring programme				
	What	**How**	**When**	**Where**	**Who**
Respect the distance (> 10 m) and do not build latrines on higher ground than wells	The respect of latrine installation rules	Inspections	Every 6 months	GIE	Secretary-general GIE (Mr Moustapha Sagne) and DHA
Ensure the hermetic closing amongst extraction pipes and wells (walls or covers)	The tightness of the junctions	Inspections	Every 6 months	GIE	Secretary-general GIE (Mr Moustapha Sagne) and DHA
Disinfect regularly the taps	The healthiness of the taps	Inspections	Weekly	At the taps	Technician GIE (Mr Birame N'Diaye) and RPHC
			Monthly		DHA
Ensure the hermetic closing of inspection hatches	The hermetic closing of hatches	Inspections	Every 2 months	GIE	Technician GIE (Mr Birame N'Diaye)
Observe the good hygiene practices during the cleaning	The cleansing of tanks	Inspections	Annually	GIE	Technician GIE (Mr Birame N'Diaye)
	The respect of good hygiene practices				
Build concrete aprons of 1-2 m width	The presence of concrete aprons	Inspections	Every 6 months	GIE	Secretary-general GIE (Mr Moustapha Sagne) and DHA
Build drainage channels conducting waters to absorbing wells	The presence of drainage channels	Inspections	Every 6 months	GIE	Secretary-general GIE (Mr Moustapha Sagne) and DHA
Ensure the suitability of the fence	The suitability of the fence	Inspections	Every 6 months	GIE	Technician GIE (Mr Birame N'Diaye)
	The presence of animals	Inspections	Daily	GIE	Technician GIE (Mr Birame N'Diaye) and RPHC
Replace periodically (at least every 5 years) valves and pipes	The valves and pipes' state	Inspections	Annually	GIE	Technician GIE (Mr Birame N'Diaye)
Employ qualified personnel for repairs	The suitability of the repair	Inspections	During repairs	GIE	Technician GIE (Mr Birame N'Diaye)
Respect the standard precautions of the chemicals used	The knowledge level of the use of chemicals	Meetings with GIE Committee	Every 6 months	GIE	DHA
Spread the use of bone char-based filtration systems	The utilisation level of filters and dilution operations	Inspections	Every 6 months	At the dwellings	Student representative (Mr Mamadou Séne); Secretary-general GIE (Mr Moustapha Sagne); General supervisor ASUFOR (Mrs Tening Pouye); RPHC
Launch an experimental research of appropriate solutions at community level for decreasing lead concentrations	The research progress	Meetings with partners	Every 6 months	At the University of Dakar	Student representative (Mr Cheikh Kama) and DHA

Continue...

...Continue

Control measure	Operational limit	Corrective measure
Respect the distance (> 10 m) and do not build latrines on higher ground than wells	Presence of a latrine < 10 m	Interruption of the latrines' use and emptying of pits
		Drinking water disinfection
		Verify the pollution weekly for at least 3 months
Ensure the hermetic closing amongst extraction pipes and wells (walls or covers)	Presence of cracks / holes	Repair the damage
		Drinking water disinfection
Disinfect regularly the taps	More than 1 tap dirty per week	Disinfection of taps
Ensure the hermetic closing of inspection hatches	Hermetic closing of inspection hatches	Drinking water disinfection
		Ensure the hermetic closing of hatches
Observe the good hygiene practices during the cleaning	Annual cleaning	Drinking water disinfection
	Failure of only 1 hygiene practice	
Build concrete aprons of 1-2 m width	Absence of concrete apron	Awareness campaigns addressed to GIE Committee
		Build the concrete aprons
Build drainage channels conducting waters to absorbing wells	Absence of drainage channel	Awareness campaigns addressed to GIE Committee
		Build the drainage channels
Ensure the suitability of the fence	Fence damaged	Repair the fence
Replace periodically (at least every 5 years) valves and pipes	More than 1 broken valve and pipe in 5 years	Replace the valves and the pipes
		Drinking water disinfection
Employ qualified personnel for repairs	1 improper repair	Replace the employee
		Drinking water disinfection
Respect the standard precautions of the chemicals used	1 improper use every 2 years	Interruption of water supply
		Chemical analyses weekly per at least 1 month
Spread the use of bone char-based filtration systems	In 1 year, at least 10% of yards of each CRP village with bone char-based filters (some of 300 filters)	Research of financial partners
Launch an experimental research of appropriate solutions at community level for decreasing lead concentrations	In 1 year, first proposal of community drinking water treatment	Research of other technical and financial partners

Continue...

...*Continue*

Control measure	Verification programme				
	What	**How**	**When**	**Where**	**Who**
Respect the distance (> 10 m) and do not build latrines on higher ground than wells	*E. coli* < 1 CFU/100 mL Faecal streptococci < 1 CFU/100 mL	Microbiological analyses	Every 6 months	At the GIE taps and at the laboratory	DHA
Ensure the hermetic closing amongst extraction pipes and wells (walls or covers)					
Disinfect regularly the taps					
Ensure the hermetic closing of inspection hatches					
Observe the good hygiene practices during the cleaning					
Build concrete aprons of 1-2 m width	Proper environmental hygiene	Sanitary inspections WHO	Every 6 months	GIE	DHA
Build drainage channels conducting waters to absorbing wells					
Ensure the suitability of the fence					
Replace periodically (at least every 5 years) valves and pipes	Management register	Control of the register	Monthly	GIE	DHA and Secretary-general of GIE (Mr Moustapha Sagne)
Employ qualified personnel for repairs					
Respect the standard precautions of the chemicals used	Drinking water chemical quality	Chemical analyses	Every 6 months	GIE and at the laboratory	DHA
Spread the use of bone char-based filtration systems	Financial conditions	Meetings with partners	Monthly	RCP	President RCP; RPHC; Students' representative (Mr Kama Cheikh); Secretary-general of GIE (Mr Moustapha Sagne); President of ASUFOR (Mr Issa Faye); DHA (Mr Talla Diack)
Launch an experimental research of appropriate solutions at community level for decreasing lead concentrations	Research progress	Research report evaluation	Every 6 months	RCP	University students

A.4.3 The open dug wells

Hazardous event	Hazard	Cause	Risk: Likelihood	Risk: Severity	Risk: Score	Control measure
Drinking water contamination	Microbial	Wells open (without cover)	5	5	25	Cover the wells
		Dirty ropes and buckets	5	5	25	Use clean and proper ropes and buckets
		Presence of latrines or open defecation places < 10 m from wells	1	4	4	Respect the distance (> 10 m) and do not build latrines on higher ground than wells
		Wells without proper parapets	1	5	5	Build parapets of at least 1 m height
		Absence of proper concrete aprons around the wells	5	2	10	Build concrete aprons of 1-2 m width
		Presence of stagnant water around the wells	5	4	20	Build drainage channels conducting waters to absorbing wells
		Presence of animals around the wells	4	3	12	Build drinking troughs
		Presence of rubbish around the wells	3	4	12	Build proper fences
		Presence of animal corpses around the wells	2	4	8	
		Presence of animal and human excreta around the wells	4	4	16	
	Chemical	Presence of rubbish around the wells	3	4	12	
		Use of chemicals in the wells surroundings (pesticides, fertilisers, etc.)	2	4	8	Avoid farming around the wells
	Geological and chemical	High concentrations of fluorides and lead	5	5	25	Spread the use of bone char-based filtration systems and the dilution with rain-water
						Launch an experimental research of appropriate solutions at community level for decreasing fluorides and lead concentrations
	Vandalism	Presence of rubbish inside the wells	1	5	5	Cover the wells
		Suicide	1	5	5	
High turbidity	Suspended solids	Improper drawing	5	5	25	Use clean and proper ropes and buckets

Continue...

...Continue

Control measure	Monitoring programme				
	What	**How**	**When**	**Where**	**Who**
Cover the wells	Wells covering	Inspections	Every 6 months	At the wells	RPHC; Village leaders; DHA; Secretary-general GIE (Mr Moustapha Sagne); Student representative (Mr Cheikh Kama)
Use clean and proper ropes and buckets	Use of proper drawing tools	Inspections	Weekly	At the wells	RPHC; Student representative (Mr Cheick Kama); Village leaders
		Awareness campaigns for the users		At the wells and at the dwellings	RPHC
Respect the distance (> 10 m) and do not build latrines on higher ground than wells	The respect of latrine installation rules	Inspections	Every 6 months	At the wells	DHA
Build parapets of at least 1 m height	The presence of adequate parapets	Inspections	Every 6 months	At the wells	RPHC; Village leaders; DHA; Secretary-general GIE (Mr Moustapha Sagne); Student representative (Mr Cheikh Kama)
Build concrete aprons of 1-2 m width	The presence of concrete aprons	Inspections	Every 6 months	At the wells	RPHC; Village leaders; DHA; Secretary-general GIE (Mr Moustapha Sagne); Student representative (Mr Cheikh Kama)
Build drainage channels conducting waters to absorbing wells	The presence of drainage channels	Inspections	Every 6 months	At the wells	RPHC; Village leaders; DHA; Secretary-general GIE (Mr Moustapha Sagne); Student representative (Mr Cheikh Kama)
Build drinking troughs	The presence of drinking troughs	Inspections	Every 6 months	At the wells	Student representative (Miss Ndeye Séne); Secretary-general GIE (Mr Moustapha Sagne)
Build proper fences	The presence of proper fences	Inspections	Every 6 months	At the wells	Student representative (Miss Ndeye Séne); Secretary-general GIE (Mr Moustapha Sagne)
Avoid farming around the wells	Absence of farming	Inspections	Every 6 months	At the wells	DHA
Spread the use of bone char-based filtration systems and the dilution with rain-water	The utilisation level of filters and dilution operations	Inspections	Every 6 months	At the dwellings	Student representative (Mr Mamadou Séne); Secretary-general GIE (Mr Moustapha Sagne); General supervisor ASUFOR (Mrs Tening Pouye); RPHC
Launch an experimental research of appropriate solutions at community level for decreasing fluorides and lead concentrations	The research progress	Meetings with partners	Every 6 months	At the University of Dakar	Student representative (Mr Cheikh Kama); DHA

Continue...

...Continue

Control measure	Operational limit	Corrective measure
Cover the wells	Open wells	Drinking water disinfection
		Awareness campaigns for the users
		Provide the well cover
Use clean and proper ropes and buckets	More than 1 dirty rope and bucket per week	Awareness campaigns for the users
		Control of the drawing tools weekly per 2 months
Respect the distance (> 10 m) and do not build latrines on higher ground than wells	Presence of a latrine < 10 m	Interruption of the latrines' use and emptying of pits
		Drinking water disinfection
		Verify the pollution weekly for at least 3 months
Build parapets of at least 1 m height	Absence of parapet	Awareness campaigns for the users
		Build the parapet
Build concrete aprons of 1-2 m width	Absence of concrete apron	Awareness campaigns for the users
		Build the concrete apron
Build drainage channels conducting waters to absorbing wells	Absence of drainage channel	Awareness campaigns for the users
		Build the drainage channel
Build drinking troughs	Absence of drinking trough	Awareness campaigns for the users
		Build the drinking trough
Build proper fences	Absence of fence	Awareness campaigns for the users
		Build the fence
Avoid farming around the wells	Presence of a farming	Awareness campaigns for the herdsmen
		Prohibition of the use of chemicals
Spread the use of bone char-based filtration systems and the dilution with rain-water	In 1 year, at least 10% of yards of each CRP village with bone char-based filters (some of 300 filters)	Research of financial partners
Launch an experimental research of appropriate solutions at community level for decreasing fluorides and lead concentrations	In 1 year, first proposal of community drinking water treatment	Research of other technical and financial partners

Continue...

...Continue

Control measure	Verification programme				
	What	**How**	**When**	**Where**	**Who**
Cover the wells	*E. coli* < 1 CFU/100 mL Faecal streptococci < 1 CFU/100 mL	Microbiological analyses	Every 6 months	At the wells and at the laboratory	DHA
Use clean and proper ropes and buckets					
Respect the distance (> 10 m) and do not build latrines on higher ground than wells					
Build parapets of at least 1 m height	Proper environmental hygiene	Sanitary inspections WHO	Every 6 months	At the wells	DHA
Build concrete aprons of 1-2 m width					
Build drainage channels conducting waters to absorbing wells					
Build drinking troughs					
Build proper fences					
Avoid farming around the wells					
Spread the use of bone char-based filtration systems and the dilution with rain-water	Financial conditions	Meetings with partners	Monthly	RCP	President RCP; RPHC; Students' representative (Mr Kama Cheikh); Secretary-general of GIE (Mr Moustapha Sagne); President of ASUFOR (Mr Issa Faye); DHA (Mr Talla Diack)
Launch an experimental research of appropriate solutions at community level for decreasing fluorides and lead concentrations	Research progress	Research report evaluation	Every 6 months	RCP	University students

A.4.4 The transport

Hazardous event	Hazard	Cause	Risk			Control measure
			Likelihood	Severity	Score	
Drinking water contamination	Microbial	Containers open	5	5	25	Use containers closed
						Awareness campaigns for the users
		Containers dirty	5	5	25	Wash properly the containers
						Awareness campaigns for the users
		Use of dirty utensils	5	5	25	Use proper utensils
						Awareness campaigns for the users
		Hands dirty in contact with water	5	5	25	Avoid the contact between hands and water
						Awareness campaigns for the users
	Chemical	Use of containers previously employed for chemicals	4	4	16	Wash properly containers previously dedicated to transport or store chemicals
						Awareness campaigns for the users

Continue...

...Continue

Control measure	Monitoring programme				
	What	How	When	Where	Who
Use containers closed	Use of adequate containers	Controlling containers and people behaviour	Weekly	At the sources and at the dwellings	RPHC; Student representative (Mr Kama Cheick); Village leaders
Awareness campaigns for the users					
Wash properly the containers	Use of proper containers				
Awareness campaigns for the users					
Use proper utensils	Use of proper utensils				
Awareness campaigns for the users					
Avoid the contact between hands and water	Absence of contact between hands and water				
Awareness campaigns for the users					
Wash properly containers previously dedicated to transport or store chemicals	Use of proper containers				GIE and DHA
Awareness campaigns for the users					

Continue...

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Control measure	Objectives	Corrective measure
Use containers closed	70% closed containers in 6 months	Strengthen the awareness campaigns
Awareness campaigns for the users	90% closed containers in 1 year	Spur on people to use jerry tanks instead of aluminium basins
Wash properly the containers	90% proper containers in 6 months	Strengthen the awareness campaigns
Awareness campaigns for the users	100% proper containers in 1 year	
Use proper utensils	90% proper utensils in 6 months	
Awareness campaigns for the users	100% proper utensils in 1 year	
Avoid the contact between hands and water	70% people without contacts hands/water in 6 months	Strengthen the awareness campaigns
Awareness campaigns for the users	90% people without contacts hands/water in 1 year	Spur on people to use jerry tanks instead of aluminium basins
Wash properly containers previously dedicated to transport or store chemicals	None uses these containers	Application of the expected hygiene sanctions
Awareness campaigns for the users		

Continue...

...Continue

Control measure	Verification programme				
	What	How	When	Where	Who
Use containers closed	*E. coli* < 1 CFU/100 mL Faecal streptococci < 1 CFU/100 mL	Drinking water analyses	Every 6 months	At the dwellings (before the storage), during the transport and at the laboratory	DHA
Awareness campaigns for the users					
Wash properly the containers					
Awareness campaigns for the users					
Use proper utensils					
Awareness campaigns for the users					
Avoid the contact between hands and water					
Awareness campaigns for the users					
Wash properly containers previously dedicated to transport or store chemicals	Organoleptic parameters		Monthly		
Awareness campaigns for the users					

A.4.5 The storage and consumption

Hazardous event	Hazard	Cause	Risk: Likelihood	Risk: Severity	Risk: Score	Control measure
Drinking water contamination	Microbial	Containers open	5	5	25	Use containers closed
						Awareness campaigns for the community
		Containers dirty	5	5	25	Wash properly the containers
						Awareness campaigns for the community
		Hands dirty	5	5	25	Avoid the contact between hands and water
						Awareness campaigns for the community
		Dirty environment nearby the containers	5	5	25	Guarantee a proper environmental hygiene
		High drinking water storage time (> 24h)	4	3	12	Change drinking water daily
		Filtration with dirty tissues	3	5	15	Use a proper piece of tissue
		Cups used for drinking dirty	5	5	25	Use proper cups for drinking purposes
						Promote the use of containers with valves
	Chemical	Use of containers previously employed for chemicals	2	3	6	Wash properly containers previously dedicated to transport or store chemicals
		Chlorine overdose	1	3	3	Dose the correct quantity of chlorine

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<table>
<tr><th rowspan="2">Control measure</th><th colspan="5">Monitoring programme</th></tr>
<tr><th>What</th><th>How</th><th>When</th><th>Where</th><th>Who</th></tr>
<tr><td>Use containers closed</td><td rowspan="2">Containers closed</td><td rowspan="12">Inspections and awareness campaigns</td><td rowspan="10">Weekly</td><td rowspan="12">At the dwellings</td><td rowspan="12">RPHC and DHA</td></tr>
<tr><td>Awareness campaigns for the community</td></tr>
<tr><td>Wash properly the containers</td><td rowspan="2">Healthiness of the containers</td></tr>
<tr><td>Awareness campaigns for the community</td></tr>
<tr><td>Avoid the contact between hands and water</td><td rowspan="2">Absence of contact between hands and water</td></tr>
<tr><td>Awareness campaigns for the community</td></tr>
<tr><td>Guarantee a proper environmental hygiene</td><td>Environmental hygiene</td></tr>
<tr><td>Change drinking water daily</td><td>Water changed daily</td></tr>
<tr><td>Use a proper piece of tissue</td><td>Proper tissues</td></tr>
<tr><td>Use proper cups for drinking purposes</td><td>Healthiness of the cups</td></tr>
<tr><td>Promote the use of containers with valves</td><td>Level of spread</td></tr>
<tr><td>Wash properly containers previously dedicated to transport or store chemicals</td><td>Healthiness of the containers</td><td>Every 3 months</td></tr>
<tr><td>Dose the correct quantity of chlorine</td><td>Quantity of chlorine dosed</td><td>Weekly</td></tr>
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Control measure	Objectives	Corrective measure
Use containers closed	95% closed containers in 6 months	Strengthen the awareness campaigns and increase the numbers of village trainers
Awareness campaigns for the community	99% closed containers in 1 year	
Wash properly the containers	70% proper containers in 6 months	
Awareness campaigns for the community	85% proper containers in 1 year	
Avoid the contact between hands and water	20% containers with valve in 6 months	
Awareness campaigns for the community	50% containers with valve in 1 year	
Guarantee a proper environmental hygiene	50% containers stored in a proper environment in 6 months	
	70% containers stored in a proper environment in 1 year	
Change drinking water daily	70% people changing water daily in 6 months	
	80% people changing water daily in 1 year	
Use a proper piece of tissue	60% proper tissues in 6 months	
	75% proper tissues in 1 year	
Use proper cups for drinking purposes	60% proper cups for drinking in 6 months	
	75% proper cups for drinking in 1 year	
Promote the use of containers with valves	20% containers with valve in 6 months	
	50% containers with valve in 1 year	
Wash properly containers previously dedicated to transport or store chemicals	95% proper containers in 6 months	
	99% proper containers in 1 year	
Dose the correct quantity of chlorine	60% people disinfecting drinking water in 6 months	
	75% people disinfecting drinking water in 1 year	

Continue...

...Continue

Control measure	Verification programme				
	What	**How**	**When**	**Where**	**Who**
Use containers closed					
Awareness campaigns for the community					
Wash properly the containers					
Awareness campaigns for the community					
Avoid the contact between hands and water					
Awareness campaigns for the community	*E. coli* < 1 CFU/100 mL Faecal streptococci < 1 CFU/100 mL		Every 6 months		
Guarantee a proper environmental hygiene		Drinking water analyses		At the dwellings and at the laboratory	DHA
Change drinking water daily					
Use a proper piece of tissue					
Use proper cups for drinking purposes					
Promote the use of containers with valves					
Wash properly containers previously dedicated to transport or store chemicals	Organoleptic parameters		Monthly		
Dose the correct quantity of chlorine	Free chlorine [0.2-0.5 mg/L]		Every 6 months		

Annexe 5. Questionnaire addressed to water Committees in Burkina Faso

1) IDENTIFICATION DU QUESTIONNAIRE

1.1) Date du questionnaire:____________________ Nom de l'enquêteur____________
1.2) Commune:________________________________ ID nombre:__________________
1.3) Village et/ou quartier:______________________
1.4) Rôle dans le CGPE de la personne interrogée:____
1.5) Nom de la personne interrogée:____

2) INFORMATIONS PRINCIPALES

2.1) Type: __ Forage __ Puits
2.2) Dans quell'année le point d'eau a été réalisé? Spécifier:___________________________
2.3) Combien de fois le point d'eau a eu des ruptures? Spécifier:____________________
Quel type de rupture il y a eu? Spécifier:____
____
2.4) D'habitude, est-ce que vous faites quelque contrôle périodique de la qualité de l'eau?
__ Oui __ Non
Si Oui, combien de fois par année? Indiquer: fois/année________________________
Pour quels paramètres? Spécifier:____
Dans quel laboratoire? Spécifier:____
D'habitude, combien de francs vous payez pour ces analyses? Indiquer: CFA_____________
2.5) En saison sèche, est-ce que le point d'eau travaille régulièrement? __ Oui __ Non
Et en saison pluvieuse? __ Oui __ Non
2.6) Combien d'argent les familles cotisent par mois pour la gestion du point d'eau?
Indiquer: CFA/mois__________________
Toutes les familles cotisent pour l'utilisation du point d'eau? __ Oui __ Non
Vous avez un registre? __ Oui __ Non
2.7) Si une famille ne cotise pas, vous leur interdisez de puiser l'eau? __ Oui __ Non
Si Non, qu'est-ce que vous faites? Spécifier:____
2.8) Combien de personnes utilisent le point d'eau? Indiquer:
Saison sèche:
Nombre de personnes:_____________ **ou** Nombre de familles:_____________
Saison pluvieuse:
Nombre de personnes:_____________ **ou** Nombre de familles:_____________

3) INFORMATIONS SUR LES MODALITES DE GESTION DU POINT D'EAU

3.1) Combien de personnes composent le CGPE? Indiquer le nombre:___________________
3.2) Quelle est la fonction de chaque personne? Spécifier:__________________________________
____
____
3.3) Modalité de mise en place du CGPE: __ Il y a des élections __ Il y a des volontaires
3.4) Depuis combien d'année vous êtes dans le CGPE? Spécifier:___________________________
3.5) Durée du mandate du CGPE. Indiquer: année__________________________
3.6) Le CGPE prévoit des réunions chaque mois? __ Oui __ Non
Spécifier la fréquence, si n'est pas mensuelle:____________________
Dans quel but ces réunions sont faites? Spécifier:___________________________________

3.7) D'habitude, est-ce que vous ajoutez de l'eau de javel (ou quelque autre désinfectant) dans le point d'eau pour la désinfection? __ Oui __ Non

Si Oui…

Lequel? Spécifier:______________________________

Quand? Spécifier:______________________________

Quand est été la dernière fois?______________________________

Est-ce que vous pouvez indiquer la quantité? Spécifier:______________________________

3.8) Combien de francs le CGPE a dans son compte? Indiquer: CFA________________

Est-ce que vous pensez qu'ils soient suffisants pour payer quelque réparation du point d'eau?
__ Oui __ Non

Si Oui, pour quel type de réparation? Spécifier:______________________________
____

Si l'argent est utilisé pour autres buts, spécifier lesquels:______________________________
____

3.9) Avez-vous reçu une formation spécifique sur l'eau potable et/ou sur la gestion technique du point d'eau? __ Oui __ Non

Si Oui, par qui vous avez reçu cette formation? Spécifier:______________________________

3.10) Est-ce que le CGPE a déjà tenu quelque réunion avec la population afin de la sensibiliser sur le bon usage de l'eau? __ Oui __ Non

Si Oui, combien de fois? Indiquer le nombre:______________________________

Avec l'aide de quelque autre Organisation? __ Oui __ Non

Si Oui, quel Organisation? Spécifier:______________________________

Annexe 6. Questionnaire addressed to households in Burkina Faso

1) IDENTIFICATION DU QUESTIONNAIRE

1.1) Date du questionnaire:________________ Nom de l'enquêteur:______________
1.2) Commune:________________________
1.3) Village et/ou quartier:____________________
1.4) Âge de la personne interrogée:____________________
1.5) Sexe de la personne interrogée: __ Masculin __ Féminin
1.6) Nom de la personne interrogée:____

2) INFORMATIONS SOCIO-DÉMOGRAPHIQUES

2.1) Nombre des ménages dans la concession:________________
2.2) Nombre des personnes dans le ménage interrogé:

Sexe	**Âge**				
	0-5 ans	**6-15 ans**	**16-45 ans**	**46-60 ans**	**plus de 61 ans**
Masculin					
Féminin					

2.3) Nombre des personnes qui ont atteint (ou fréquenté) le niveau supérieur:_____________
2.4) Nombre des personnes qui ont atteint (ou fréquenté) le niveau secondaire:____________
2.5) Nombre des personnes qui ont atteint (ou fréquenté) le niveau premier:_____________
2.6) Nombre des personnes qui savent parler et comprendre la langue française:___________

3) INFORMATIONS SUR LES MODES D'UTILISATION DE L'EAU

3.1) Où vous puisez l'eau en fonction de la saison et de la destination d'emploi (boire-cousiner-toilette-lessive-animaux-tout-autre à préciser)?

Source	**Saison sèche**	**Saison pluvieuse**	**Destination d'emploi**
Eau de pluie			
Forages			
Puits moderne			
Eau du surface			
Eau en bouteille/sachet			
Autre à préciser:			

3.2) À quelle distance est votre source d'approvisionnement en eau et la fréquence à la quelle vous allez?

Source	**Distance (heures)***	**Fréquence (fois par jour)**
Eau de pluie		
Forages		
Puits moderne		
Eau du surface		
Eau en bouteille/sachet		
Autre à préciser:		

*: pour aller de la maison au point d'approvisionnement en eau

3.3) Quelle est la quantité d'eau consommée par jour selon l'usage?

Usage	**Litres consumés***
Boisson	
Cuisine	
Toilette	
Lessive	
Nettoyage	
Animaux	
Autre à préciser:	

*: Ou nombre des récipients avec un certain volume

3.4) Quel est le récipient que vous utilisez pour le transport de l'eau? Pouvez-vous indiquer le volume, la fréquence de nettoyage et si le récipient est fermé?

Récipient	**Volume (litres)**	**Fréquence de nettoyage (jours)**	**Fermé (Oui/Non)**
1-Canaris			
2-Bassine			
3-Bidon			
4-Fût			
5-Seau			
6-Autre à préciser:			

3.5) Qu'est-ce que vous utilisez pour nettoyer les récipients de transport de l'eau?

__ Javel __ Savon en boule __ Savon en poudre __ Savon liquide

__ Eau simple __ Aucun __ Autre________________________________

3.6) Quel est le récipient que vous utilisez pour le stockage de l'eau? Pouvez-vous indiquer le volume, la fréquence de nettoyage, si le récipient est fermé et le temps de stockage de l'eau?

Récipient	**Volume (litres)**	**Fréquence de nettoyage (jours)**	**Fermé (Oui/Non)**	**Temps de stockage (jours)**
a-Canaris				
b-Bassine				
c-Bidon				
d-Fût				
e-Jarre				
f-Autre à préciser:				

3.7) Qu'est-ce que vous utilisez pour nettoyer les récipients de stockage de l'eau?

__ Javel __ Savon en boule __ Savon en poudre __ Savon liquide

__ Eau simple __ Aucun __ Autre________________________________

3.8) Comment vous utilisez l'eau stockée?

Récipient	**Boisson**	**Cuisine**	**Toilette**	**Lessive**	**Nettoyage**	**Animaux**	**Tout**
Canaris							
Bassine							
Bidon							
Fût							
Jarre							
Autre à préciser:							

4) INFORMATIONS SUR LA QUALITÉ DE L'EAU

4.1) Dans le ménage, qui s'occupe de la collecte de l'eau?
__ La femme __ L'homme __ Les filles __ Les garçons
__ Autre à spécifier: ______________________________

4.2) Combien de temps vous utilisez pour collecter et transporter l'eau?
Indiquer: heures: __________________

4.3) Consommez-vous l'eau telle quel vous l'avez prélevée ou bien la soumettez-vous à quelque traitement? Lequel?
__ Aucun __ Désinfection avec eau de javel __ Filtration sur tissu
__ Bouillir __ Canaris __ Autre: ________________________________

4.4) Cotisez-vous pour l'approvisionnement en eau? Combien et pour quelle source d'eau?
Source d'eau: _________________________ Coût: ____________________________
Source d'eau: _________________________ Coût: ____________________________
Source d'eau: _________________________ Coût: ____________________________

4.5) Selon vous, le coût de l'eau est-il élevé? __ Oui __ Non

4.6) Aimez-vous l'eau que vous disposez? __ Oui __ Non

Si Non…

Pourquoi?
__ Mauvais goût __ Salée __ Sale __ Autre: __________________________

4.7) Êtes-vous satisfait de:
la qualité de l'eau: __ Oui __ Non
la quantité de l'eau: __ Oui __ Non
la distance de l'eau: __ Oui __ Non

Si Non…

Quelle amélioration aimeriez-vous? Spécifier: ____
____

Seriez-vous disposés à cotiser de plus en échange d'une amélioration? __ Oui __ Non
Si Oui, indiquez la somme maximale que vous êtes disposés à cotiser: CFA ___________________

5) HYGIENE ET ASSAINISSEMENT

5.1) D'habitude, où vous faites vos besoins?
__ Latrine personnelle __ Latrine familiale __ Latrine publique
__ À l'air libre __ Autres lieux: _________________________________

5.2) Si vous utilisez une latrine familiale, combien de latrines il y a et combien de personnes les utilisent?
Indiquer le nombre des latrines: ________ Indiquer le nombre des personnes: _________

5.3) Si vous utilisez une latrine, vous sauriez indiquer le type?
__ Traditionnelle __ Chasse d'eau __ VIP
__ Je ne sais pas __ Autre:__________________________

5.4) Si vous utilisez une latrine, indiquer:
Qui s'occupe du nettoyage: ____
Fréquence du nettoyage: fois/semaine ____
Qui s'occupe de la vidange: ____
Système de vidange utilisé: ____
Fréquence de vidange: fois/année ____
Si présent, le coût pour le vidange: ____
Destination finale des excréta et de l'eau à la sortie: _____________________________
Problèmes plus fréquents dans la gestion de la latrine et éventuelles solutions adoptées: __________
____

5.5) Quel type de détergent vous utilisez pour vous laver les mains?
__ Savon __ Eau de javel __ Les deux __ Aucun
__ Autre: ____

5.6) À quel occasion vous utilisez le savon? ***(LAISSER REPONDRE)***
__ Se laver les mains avant de manger __ Se laver les mains après avoir fait les besoins
__ Se laver les mains après avoir mangé __ Se laver les mains après avoir touché les animaux
__ Nettoyer les récipients de transport et stockage de l'eau __ Rien
__ Autre: ____

5.7) Savez-vous quels sont les avantages d'un bon système d'assainissement?
__ La discrétion __ La réduction de l'odeur __ Je ne sais pas
__ Se débarrasser des mouches et des moustiques __ L'amélioration de la santé
__ La sécurité __ Autre: _____________________________________

6) INFORMATIONS SUR L'ECONOMIE FAMILIALE

6.1) Quelle est la source de revenu de la famille?
__ Activités professionnelles __ Soutien extérieur __ Les deux

6.2) Quelles activités professionnelles?
__ Artisanat __ Commerce __ Agriculture __ Élevage __ Pêche
__ Fonctionnaire __ Autre____

6.3) Quel est le niveau de revenu de la famille?
Indiquer: CFA/année: ______________ **ou** CFA/mois: _______________

7) ASPECTS SANITAIRES

7.1) Est-ce que quelqu'un dans le ménage a eu des troubles de santé dans ce dernier mois?
__ Oui __ Non
Lesquels? __ Diarrhée __ Dysenterie __ Vomissement
__ Maux de ventre __ Fièvre __ Toux
__ Autre: ____________________________ __ Je ne sais pas

7.2) Qui a été touché par ces maladies? __ La femme __ L'homme __ Les enfants __ Autre: ______

7.3) Qu'est-ce que vous faites habituellement lorsque quelqu'un d'entre vous a la diarrhée?
(LAISSER REPONDRE)
__ Rien
__ Donner à boire beaucoup de liquides
__ Utiliser les tisanes
__ Aller chez le guérisseur dans un village
__ Donner la solution de réhydratation / eau avec sel / aliments salés
__ Prendre des médicaments de la rue
__ Donner des médicaments de la pharmacie
__ Aller au Centre de santé / clinique / visite médicale
__ Autre: ____

7.4) Selon vous, pourquoi les gens ont la diarrhée? Parce que: ***(LAISSER REPONDRE)***
__ L'eau est souillée __ Il y a des microbes __ Les mains sont sales __ Je ne sais pas
__ Les aliments ne sont pas lavés et/ou bien cuits __ Autre: _________________________

7.5) Selon vous, comment peut-on empêcher la diarrhée? ***(LAISSER REPONDRE)***
__ Se laver régulièrement les mains avec du savon
__ Ne pas utiliser de l'eau souillée __ Bien laver les fruits avant de les manger
__ Bien cuire les aliments avant de les manger __ Couvrir le récipient de stockage de l'eau
__ Je ne sais pas __ Autre: ____

7.6) Connaissez-vous quelques signes de diarrhée sévère? __ Oui __ Non
Si Oui, lesquels? ***(LAISSER REPONDRE)***
__ Sang dans les selles __ Diarrhée et vomissement __ Incapacité à boire
__ Diarrhée et une forte fièvre __ Aller beaucoup de fois aux selles
__ Autre: ____________________

7.7) Selon vous, c'est important de se laver les mains? __ Oui __ Non __ Je ne sais pas
Si Oui, pourquoi? ***(LAISSER REPONDRE)***
__ Ça évite la diarrhée et d'autres maladies __ Ça empêche la contamination des aliments
__ Ça élimine les microbes __ Autre: ____________________

7.8) Selon vous, quand est important de se laver les mains? ***(LAISSER REPONDRE)***
__ Avant de faire les besoins __ Après avoir fait les besoins
__ Avant de cuisiner __ Avant de manger
__ Après avoir mangé __ Après avoir touché les animaux
__ Avant de toucher les animaux __ Jamais
__ Autre: ____________________

7.9) Est-ce que quelqu'un dans le ménage a eu la toux dans ce dernier mois? __ Oui __ Non
Si Oui, qui l'a eu? __ La femme __ L'homme __ Les enfants __ Autre: ____________
La toux a été:
__ Sèche __ Avec glaire __ Seulement le matin __ Toute la journée
__ Avec la fièvre __ Avec une perte de poids __ Autre____________
Est-ce que vous êtes allés au Centre de santé pour ça toux? __ Oui __ Non
Si Oui, avez-vous reçu un médicament? __ Oui __ Non

7.10) Est-ce que quelqu'un dans le ménage est allé au Centre de santé dans ce dernier mois?
__ Oui __ Non
Si Oui, qui est allé? __ La femme __ L'homme __ Les enfants __ Autre: ___________
Pourquoi? __ Diarrhée __ Paludisme __ Pneumonie __ Accouchement
__ Traumatisme Autre:____________ __ Je ne sais pas

7.11) Où achetez-vous un médicament quand vous avez besoin?
__ Centre de santé __ Marché __ Pharmacie __ Autre____________

7.12) Combien d'argent vous avez dépensé dans le dernier mois pour les questions de santé du ménage?
Indiquer le coût: ____________________

7.13) La prochain fois, irez-vous encore au Centre de santé si quelqu'un est malade? __ Oui __ Non

7.14) Avez-vous déjà participé à une séance de sensibilisation à l'hygiène? __ Oui __ Non
Si Oui, qui vous a fait cette séance de sensibilisation?
__ Une personne du CGPE __ Une personne de l'Association DAKUPA
__ Une personne du CSPS __ Autre:____________________

Avant de terminé le questionnaire, voir les choses suivantes

1. Faire une photo dans l'extérieur et l'intérieur des récipients de transport et stockage de l'eau.
2. Contrôler l'état des récipients de transport et stockage de l'eau.
3. Le lieu de conservation du récipient de stockage de l'eau est:
   __ À l'extérieur non protégé __ À l'extérieur protégé
   __ À l'intérieur non protégé __ À l'intérieur protégé
   __ Au contact avec les animaux __ À l'abri des animaux
   __ Autre____________
4. Le gobelet de puisage de l'eau de boisson est:
   __ Inexistant __ Par terre
   __ Posé sur le couvercle du récipient __ Posé inversé sur le couvercle du récipient
5. Y a t'il des animaux près des récipients de stockage de l'eau? __ Oui __ Non

6. Contrôler si dans le ménage il y a du savon pour le lavage des mains.
   __ Oui __ Non
7. Voir les latrines et indiquer l'état:

__ Accessible	__ Fermé avec un cadenas
__ Utilisée souvent	__ Utilisée rarement
__ Bien entretenue et propre	__ Mal entretenue et sale
__ Présence d'une porte	__ Absence d'une porte
__ Présence d'une toiture	__ Absence d'une toiture
__ Présence d'une fenêtre	__ Absence d'une fenêtre
__ Présence d'un tuyau d'aération	__ Absence d'un tuyau d'aération
__ Trou de défécation couvert	__ Trou de défécation ouvert
__ Présence d'eau prés de la cabine	__ Absence d'eau prés de la cabine
__ Présence de savon prés de la cabine	__ Absence de savon prés de la cabine

8. Indiquer le type de latrine?
   __ Traditionnelle __ Chasse d'eau __ VIP
   __ Autre:____
9. Faire une photo du système utilisé pour cuisiner.

Annexe 7. Water quality analyses in Burkina Faso

A.7.1 Pre-assessment

A.7.1.1 Microbiological analyses at source level

Data concerning tubewells are referred to water samples collected before extraction pipe's disinfection.

Source	*E. coli*	Faecal coliforms	Total coliforms	Faecal streptococci
TW1	4	5	6	1
TW2	2	2	10	1
TW3	4	4	6	1
TW4	7	9	25	2
TW5	20	22	24	3
TW6	5	5	7	2
TW7	3	3	15	2
TW8	16	18	20	5
TW9	4	7	14	1
TW10	n.a.	n.a.	n.a.	n.a.
TW11	n.a.	n.a.	n.a.	n.a.
ODW1	1,500	1,900	2,800	1,200
ODW2	2,000	2,500	6,300	1,800
ODW3	2,800	3,000	3,300	3,000
ODW4	1,500	1,700	1,900	1,200
ODW5	1,900	2,000	2,100	600
ODW6	1,700	2,000	2,400	400
ODW7	2,600	3,000	4,500	1,200
ODW8	4,300	5,000	5,700	3,000
ODW9	1,200	1,600	6,000	300
ODW10	3,500	3,800	4,000	400
ODW11	1,500	1,600	1,600	300
ODW12	1,900	2,000	2,200	500
ODW13	1,600	2,400	3,200	600
ODW14	4,700	5,000	5,700	900
ODW15	1,600	1,600	3,900	500
ODW16	1,800	2,100	3,700	700

TW: TubeWell; ODW: Open Dug Well; n.a.: not available

Data are referred to water samples collected after extraction pipe's disinfection.

Source	*E. coli*	Faecal coliforms	Total coliforms	Faecal streptococci
TW1	0	0	1	0
TW2	0	0	1	0
TW3	0	0	1	0
TW4	1	1	7	1
TW5	4	4	5	1
TW6	1	1	3	0
TW7	0	0	2	0
TW8	1	1	3	1
TW9	0	0	2	0
TW10	n.a.	n.a.	n.a.	n.a.
TW11	n.a.	n.a.	n.a.	n.a.

TW: TubeWell; n.a.: not available

A.7.1.2 Microbiological analyses along the supply chain

HH	TRANSPORT				STORAGE			
	E. coli	Faecal coliforms	Total coliforms	Faecal streptococci	*E. coli*	Faecal coliforms	Total coliforms	Faecal streptococci
1	20	30	30	0	300	400	450	220
2	n.a.	n.a.	n.a.	n.a.	190	220	350	300
3	80	150	300	10	160	250	310	230
4	60	120	150	20	170	190	500	50
5	n.a.	n.a.	n.a.	n.a.	150	170	290	130
6	10	20	30	10	30	50	50	20
7	30	30	40	80	370	400	450	120
8	30	60	80	20	80	100	640	50
9	30	40	60	20	100	120	640	40
10	30	50	100	20	150	180	310	110
11	20	60	100	50	100	150	480	300
12	150	160	200	60	240	280	580	330
13	160	190	230	490	360	490	640	610
14	110	120	150	90	200	310	690	830
15	30	80	150	30	220	240	340	100
16	40	90	700	100	140	200	1100	680
17	70	90	210	210	200	230	1360	570
18	20	20	40	110	100	140	630	370
19	70	80	120	20	150	180	380	200

HH: HouseHold; n.a.: not available

A.7.2 Post-assessment

A.7.2.1 Microbiological analyses at source level

Source	*E. coli*	Faecal coliforms	Total coliforms	Faecal streptococci
TW1	1	1	3	0
TW2	2	2	2	0
TW3	1	2	2	0
TW4	2	2	10	1
TW5	8	8	10	1
TW6	5	5	8	1
TW7	0	1	1	1
TW8	8	8	12	3
TW9	3	3	4	0
TW10	1	1	4	1
TW11	2	2	3	1

TW: TubeWell

A.7.2.2 Microbiological analyses along the supply chain

HH	Storage container	TRANSPORT				STORAGE			
		E. coli	Faecal coliforms	Total coliforms	Faecal streptococci	*E. coli*	Faecal coliforms	Total coliforms	Faecal streptococci
1	Improved	20	20	30	0	30	30	40	0
2	Traditional	50	50	80	80	90	100	540	380
3	Improved	10	10	20	10	20	20	30	10
4	Traditional	130	140	200	100	480	500	590	220
5	Traditional	130	140	230	30	200	220	280	220
6	Traditional	20	20	30	30	150	180	400	280
7	Improved	10	20	20	30	20	30	40	40
8	Improved	20	20	40	30	30	30	50	50
9	Traditional	n.a.	n.a.	n.a.	n.a.	120	130	160	90
10	Improved	10	10	10	0	20	20	30	0
11	Traditional	20	20	150	60	40	50	320	130
12	Improved	10	10	20	10	20	20	30	10
13	Traditional	30	30	60	40	80	90	130	110
14	Improved	10	10	30	20	20	20	60	30
15	Traditional	10	20	40	70	30	50	140	110
16	Traditional	60	70	180	90	120	150	480	210
17	Improved	10	10	20	10	30	40	40	30
18	Improved	40	40	60	20	60	70	90	60
19	Improved	10	20	30	0	20	30	60	20
20	Improved	10	10	20	10	30	30	40	40
21	Traditional	30	40	120	50	100	130	470	420
22	Traditional	80	100	240	10	190	210	560	210
23	Improved	n.a.	n.a.	n.a.	n.a.	30	30	130	50
24	Traditional	10	10	20	30	40	50	170	300

Annexe 8. The WSPs developed in Burkina Faso

A.8.1 Tubewell 1. The source

Hazardous event	Hazard	Cause	Risk			Control measure
			Likelihood	Severity	Score	
Drinking water contamination	Microbial	Improper hygiene and cleaning of the tubewell	2	5	10	Clean properly the concrete apron
		Use of dirty shoes inside the tubewell structure	3	5	15	Remove shoes before entering the tubewell's apron
		Presence of animals around the tubewell	4	5	20	Build an adequate fence around the tubewell
		Do the laundry close to the tubewell	5	5	25	Avoid doing the laundry close to the tubewell
		Presence of latrines and cemeteries within 10m	5	5	25	Avoid realising latrines and cemeteries close to the tubewell
		Presence of excreta and rubbish close to the tubewell	5	5	25	Avoid littering and the presence of excreta close to the tubewell
		Presence of stagnant water around the tubewell's walls	2	5	10	Fill the tubewell's border with stones
		Tubewell's pipe dirty	4	5	20	Clean properly the pipe
		Reparation of the tubewell during breakdowns	2	5	10	Clean properly all the tubewell parts before putting them back
	Chemical	Use of pesticides close to the tubewell	5	5	25	Prohibition of the use of pesticides around the tubewell
		Lubrication of the tubewell chain	2	3	6	Remove properly the old grease and take care during the lubrication operation

Continue...

Continue...

Control measure	Monitoring programme				
	What	**How**	**When**	**Where**	**Who**
Clean properly the concrete apron	Regular washing / cleanliness of the tubewell	Awareness campaigns and inspections	Weekly	At the tubewell	Nonni Salamata, Bancé Binta
Remove shoes before entering the tubewell's apron	Behavioural change	Awareness campaigns and inspections	Daily	At the tubewell	Bara Awa, Bangagné Damata
Build an adequate fence around the tubewell	Construction of the fence and absence of animal excreta / rubbish	Awareness campaigns and inspections	August 2013	At the tubewell	Guébré Baureima, Guébré Anassé
Avoid doing the laundry close to the tubewell	Behavioural change	Awareness campaigns and inspections	Daily	At the tubewell	Guébré Alimatou, Guébré Mamatou
Avoid realising latrines and cemeteries close to the tubewell	Absence of latrines and cemeteries close to the tubewell	Awareness campaigns and inspections	During latrines and cemeteries construction	At the tubewell	President of the CGPE
Avoid littering and the presence of excreta close to the tubewell	Behavioural change	Awareness campaigns and inspections	Daily	At the tubewell	President of the CGPE, Yoda Alimatou
Fill the tubewell's border with stones	Presence of stones at the tubewell's border	Inspections	Annually	At the tubewell	Guébré Abdoulayé
Clean properly the pipe	Regular washing / cleanliness of the tubewell's pipe	Awareness campaigns and inspections	Weekly	At the tubewell	Nonni Salamata, Bancé Binta
Clean properly all the tubewell parts before putting them back	Cleanliness of all the tubewell's parts	Inspections	During the reparation of breakdowns	At the tubewell	Guébré Ibrahim
Prohibition of the use of pesticides around the tubewell	Behavioural change	Awareness campaigns and inspections	Before the rainy season (when pesticides are used)	At the tubewell	President of the CGPE
Remove properly the old grease and take care during the lubrication operation	Behavioural change	Awareness campaigns and inspections	During the lubrication operations	At the tubewell	Guébré Ibrahim

Tubewell 1. The transport

Hazardous event	Hazard	Cause	Risk			Control measure
			Likelihood	Severity	Score	
Drinking water contamination	Microbial	Containers open	2	5	10	Use containers closed
		Hands dirty	5	5	25	Wash properly the hands with soap
		Containers dirty	5	5	25	Wash properly the containers with soap
		Utensils (funnel) dirty	5	5	25	Use of proper funnels
	Chemical	Jerry cans that contained chemicals	1	5	5	Prohibition of the use of these containers

Continue...

...Continue

Control measure	Monitoring programme				
	What	**How**	**When**	**Where**	**Who**
Use containers closed	Use of the correct containers and behavioural change	Awareness campaigns and inspections	Weekly	At the tubewell	1 woman/yard, Nonni Alizéta
Wash properly the hands with soap	Behavioural change	Awareness campaigns and inspections	Weekly	At the tubewell	1 woman/yard, Nonni Alizéta
Wash properly the containers with soap	Behavioural change	Awareness campaigns and inspections	Weekly	At the tubewell	1 woman/yard, Nonni Alizéta
Use of proper funnels	Behavioural change	Awareness campaigns and inspections	Weekly	At the tubewell	1 woman/yard, Nonni Alizéta
Prohibition of the use of these containers	The monitoring programme was not developed since the "WSP team" was sure that none could use this kind of containers.				

Tubewell 1. The storage and consumption

Hazardous event	Hazard	Cause	Risk: Likelihood	Risk: Severity	Risk: Score	Control measure
Drinking water contamination	Microbial	Cups used for drinking dirty	5	5	25	Wash properly the cups for drinking with soap
		Containers dirty	5	5	25	Wash properly the containers with soap
		Containers open	2	5	10	Use containers closed
		Hands dirty	5	5	25	Wash properly the hands with soap before drinking
		Containers stored outside the dwelling	5	5	25	Use dedicated containers for drinking water and store them inside the dwelling
		High drinking water storage time (>1d)	5	5	25	Change regularly drinking water (daily)
		Dirty environment nearby the containers	5	5	25	Clean properly the environment nearby the containers
	Chemical	Chlorine overdose	1	5	5	Dose the correct quantity of chlorine
		Storage containers and cups for drinking used also for chemicals	5	4	20	Clean properly containers and cups before using them for drinking purposes
		Cups used for drinking rusty	2	5	10	Prohibition of the use of these cups

Continue...

...Continue

Control measure	Monitoring programme				
	What	How	When	Where	Who
Wash properly the cups for drinking with soap	Behavioural change	Awareness campaigns	Weekly	At the tubewell	Bara Mariam, Dabré Damata
		Inspections	Daily	At the dwelling	1 woman/yard
Wash properly the containers with soap	Behavioural change	Awareness campaigns	Weekly	At the tubewell	Bara Mariam, Dabré Damata
		Inspections	Daily	At the dwelling	1 woman/yard
Use containers closed	Behavioural change	Awareness campaigns	Weekly	At the tubewell	Bara Mariam, Dabré Damata
		Inspections	Daily	At the dwelling	1 woman/yard
Wash properly the hands with soap before drinking	Behavioural change	Awareness campaigns	Weekly	At the tubewell	Bara Mariam, Dabré Damata
		Inspections	Daily	At the dwelling	1 woman/yard
Use dedicated containers for drinking water and store them inside the dwelling	Behavioural change	Awareness campaigns	Weekly	At the tubewell	Bara Mariam, Dabré Damata
		Inspections	Daily	At the dwelling	1 woman/yard
Change regularly drinking water (daily)	Behavioural change	Awareness campaigns	Weekly	At the tubewell	Bara Mariam, Dabré Damata
		Inspections	Daily	At the dwelling	1 woman/yard
Clean properly the environment nearby the containers	Behavioural change	Awareness campaigns	Weekly	At the tubewell	Bara Mariam, Dabré Damata
		Inspections	Daily	At the dwelling	1 woman/yard
Dose the correct quantity of chlorine	Check the dosed quantity	Awareness campaigns	Weekly	At the tubewell	Bara Mariam, Dabré Damata
		Inspections	Daily	At the dwelling	1 woman/yard
Clean properly containers and cups before using them for drinking purposes	Behavioural change	Awareness campaigns	Weekly	At the tubewell	Bara Mariam, Dabré Damata
		Inspections	Daily	At the dwelling	1 woman/yard
Prohibition of the use of these cups	None uses these cups	Awareness campaigns	Weekly	At the tubewell	Bara Mariam, Dabré Damata
		Inspections	Daily	At the dwelling	1 woman/yard

Responsible for the WSP: Mrs Dabré Fatimata

A.8.2 Tubewell 2. The source

Hazardous event	Hazard	Cause	Risk: Likelihood	Risk: Severity	Risk: Score	Control measure
Drinking water contamination	Microbial	Improper hygiene and cleaning of the tubewell	5	5	25	Clean properly the concrete apron
		Use of dirty shoes inside the tubewell structure	5	5	25	Remove shoes before entering the tubewell's apron
		Do the laundry close to the tubewell	5	5	25	Avoid doing the laundry close to the tubewell
		Presence of rubbish close to the tubewell	5	5	25	Avoid littering close to the tubewell and, if not, clean the environment around the tubewell
		Presence of latrines within 10m	1	5	5	Avoid realising latrines close to the tubewell
		Presence of cemeteries within 10m	1	5	5	Avoid realising cemeteries close to the tubewell
		Presence of excreta close to the tubewell	3	5	15	Build an adequate fence around the tubewell
		Tubewell's pipe dirty	5	5	25	Clean properly the pipe
		Presence of animals around the tubewell	5	5	25	Build an adequate fence around the tubewell
		Reparation of the tubewell during breakdowns	5	5	25	Clean properly all the tubewell parts before putting them back
		Presence of stagnant water around the tubewell's walls	5	5	25	Fill the tubewell's border with stones
	Chemical	Lubrication of the tubewell chain	5	5	25	Remove properly the old grease and take care during the lubrication operation
		Use of pesticides close to the tubewell	5	5	25	Prohibition of the use of pesticides around the tubewell

Continue...

...Continue

Control measure	Monitoring programme				
	What	**How**	**When**	**Where**	**Who**
Clean properly the concrete apron	Regular washing / cleanliness of the tubewell	Awareness campaigns and inspections	Weekly	At the tubewell	Guébré Bintou
Remove shoes before entering the tubewell's apron	Behavioural change	Awareness campaigns and inspections	Weekly	At the tubewell	Guébré Bintou
Avoid doing the laundry close to the tubewell	Behavioural change	Awareness campaigns and inspections	Daily	At the tubewell	Bencé Zénoubou
Avoid littering close to the tubewell and, if not, clean the environment around the tubewell	Behavioural change	Awareness campaigns and inspections	Weekly	At the tubewell	Dabré Amina
Avoid realising latrines close to the tubewell	Absence of latrines close to the tubewell	Awareness campaigns and inspections	During latrines construction	At the tubewell	Guébré Dramane
Avoid realising cemeteries close to the tubewell	Absence of cemeteries close to the tubewell	Awareness campaigns and inspections	During cemeteries construction	At the tubewell	Guébré Dramane
Build an adequate fence around the tubewell	Construction of the fence and absence of animals	Awareness campaigns and inspections	Monthly	At the tubewell	Guébré Dramane
Clean properly the pipe	Regular washing / cleanliness of the tubewell's pipe	Awareness campaigns and inspections	Weekly	At the tubewell	Guébre Bintou
Clean properly all the tubewell parts before putting them back	Cleanliness of all the tubewell's parts	Inspections	During the reparation of breakdowns	At the tubewell	Guébré Zakaria
Fill the tubewell's border with stones	Presence of stones at the tubewell's border	Inspections	Annually	At the tubewell	Guébré Dramane
Remove properly the old grease and take care during the lubrication operation	Behavioural change	Awareness campaigns and inspections	At each lubrication operation	At the tubewell	Guébré Dramane
Prohibition of the use of pesticides around the tubewell	Behavioural change	Awareness campaigns and inspections	Before the rainy season (when pesticides are used)	At the tubewell	Guébré Dramane

Tubewell 2. The transport

Hazardous event	Hazard	Cause	Risk			Control measure
			Likelihood	**Severity**	**Score**	
Drinking water contamination	Microbial	Containers open	4	5	20	Use containers closed
		Lay down the container's lid on the ground and then put it again on the container	3	5	15	Avoid laying down the lids on the ground
		Hands dirty	5	5	25	Wash properly the hands with soap
		Containers dirty	5	5	25	Wash properly the containers with soap
		Utensils (funnel) dirty	5	5	25	Use of proper funnels
	Chemical	Jerry cans that contained chemicals	1	4	4	Prohibition of the use of these containers

Continue...

...Continue

Control measure	Monitoring programme				
	What	**How**	**When**	**Where**	**Who**
Use containers closed	Use of closed containers	Share the information	At every moment	Everywhere	Bara Salamatou, Zabré Assétou
		Awareness campaigns and inspections	Monthly	At the tubewell	1 woman/yard
Avoid laying down the lids on the ground	Behavioural change	Share the information	At every moment	Everywhere	Bara Salamatou, Zabré Assétou
		Awareness campaigns and inspections	Monthly	At the tubewell	1 woman/yard
Wash properly the hands with soap	Behavioural change	Share the information	At every moment	Everywhere	Bara Salamatou, Zabré Assétou
		Awareness campaigns and inspections	Monthly	At the tubewell	1 woman/yard
Wash properly the containers with soap	Verify the use of well cleaned containers	Share the information	At every moment	Everywhere	Bara Salamatou, Zabré Assétou
		Awareness campaigns and inspections	Monthly	At the tubewell	1 woman/yard
Use of proper funnels	Behavioural change	Share the information	At every moment	Everywhere	Bara Salamatou, Zabré Assétou
		Awareness campaigns and inspections	Monthly	At the tubewell	1 woman/yard
Prohibition of the use of these containers	None uses these containers	Share the information	At every moment	Everywhere	Bara Salamatou, Zabré Assétou, The Hygienists of Fingla
		Awareness campaigns and inspections	Monthly	At the tubewell	1 woman/yard

Tubewell 2. The storage and consumption

Hazardous event	Hazard	Cause	Risk			Control measure
			Likelihood	Severity	Score	
Drinking water contamination	Microbial	Cups used for drinking dirty	5	5	25	Wash properly the cups for drinking with soap
		Containers dirty	4	5	20	Wash properly the containers with soap
		High drinking water storage time (>1d)	3	5	15	Change regularly drinking water (daily)
		Containers open	2	5	10	Use containers closed
		Hands dirty	5	5	25	Wash properly the hands with soap before drinking
		Containers stored outside the dwelling	5	5	25	Use dedicated containers for drinking water and store them inside the dwelling
		Dirty environment nearby the containers	3	5	15	Clean properly the environment nearby the containers
	Chemical	Chlorine overdose	1	5	5	Dose the correct quantity of chlorine
		Storage containers and cups for drinking used also for chemicals	5	5	25	Clean properly containers and cups before using them for drinking purposes

Continue...

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Control measure	Monitoring programme				
	What	**How**	**When**	**Where**	**Who**
Wash properly the cups for drinking with soap	Behavioural change	Awareness campaigns and inspections	Daily	At the dwelling	1 woman/yard
Wash properly the containers with soap	Behavioural change	Awareness campaigns and inspections	Daily	At the dwelling	1 woman/yard
Change regularly drinking water (daily)	Behavioural change	Awareness campaigns and inspections	Daily	At the dwelling	1 woman/yard
Use containers closed	Behavioural change	Awareness campaigns and inspections	Daily	At the dwelling	1 woman/yard
Wash properly the hands with soap before drinking	Behavioural change	Awareness campaigns and inspections	Daily	At the dwelling	1 woman/yard
Use dedicated containers for drinking water and store them inside the dwelling	Behavioural change	Awareness campaigns and inspections	Daily	At the dwelling	1 woman/yard
Clean properly the environment nearby the containers	Behavioural change	Awareness campaigns and inspections	Daily	At the dwelling	1 woman/yard
Dose the correct quantity of chlorine	Check the dosed quantity	Awareness campaigns and inspections	Daily	At the dwelling	1 woman/yard
Clean properly containers and cups before using them for drinking purposes	Behavioural change	Awareness campaigns and inspections	Daily	At the dwelling	1 woman/yard

Responsible for the WSP: Mr Guébré Draman

A.8.3 Tubewell 3. The source

Hazardous event	Hazard	Cause	Risk: Likelihood	Risk: Severity	Risk: Score	Control measure
Drinking water contamination	Microbial	Improper hygiene and cleaning of the tubewell	4	4	16	Clean properly the concrete apron Awareness campaigns for the users
		Use of dirty shoes inside the tubewell structure	4	4	16	Remove shoes before entering the tubewell's apron
		Do the laundry close to the tubewell	4	4	16	Avoid doing the laundry close to the tubewell
		Presence of stagnant water around the tubewell's walls	4	4	16	Fill the tubewell's border with stones
		Presence of excreta close to the tubewell	4	4	16	Build an adequate fence around the tubewell
		Presence of rubbish close to the tubewell	5	4	20	
		Presence of animals around the tubewell	5	5	25	Awareness campaigns for the herdsmen
		Presence of latrines and cemeteries within 10m	1	5	5	Avoid realising latrines and cemeteries close to the tubewell
		Tubewell's pipe dirty	4	4	16	Clean properly the pipe
		Reparation of the tubewell during breakdowns	2	4	8	Clean properly all the tubewell parts before putting them back
	Chemical	Use of pesticides close to the tubewell	2	5	10	Prohibition of the use of pesticides around the tubewell
		Lubrication of the tubewell chain	2	5	10	Remove properly the old grease and take care during the lubrication operation

Continue...

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Control measure	Monitoring programme				
	What	**How**	**When**	**Where**	**Who**
Clean properly the concrete apron	Regular washing / cleanliness of the tubewell	Awareness campaigns and inspections	Weekly	At the tubewell	Dabré Sapoura, Bayiré Salamatou
Awareness campaigns for the users	Behavioural change	Awareness campaigns and inspections	Daily	At the tubewell	Zéba Zénabou, Nanni Asseto
Remove shoes before entering the tubewell's apron	Behavioural change	Awareness campaigns and inspections	Daily	At the tubewell	Guébré Mariam
Avoid doing the laundry close to the tubewell	Behavioural change	Awareness campaigns and inspections	Daily	At the tubewell	Guébré Mariam
Fill the tubewell's border with stones	Presence of stones at the tubewell's border	Inspections	Annually	At the tubewell	Guébré Fati
Build an adequate fence around the tubewell	Construction of the fence	Inspections	August 2013 and then annually	At the tubewell	Guébré Seydou
Awareness campaigns for the herdsmen	Behavioural change	Inspections	January 2013 and then annually	At the tubewell	Guébré Issa
Avoid realising latrines and cemeteries close to the tubewell	Absence of latrines and cemeteries close to the tubewell	Awareness campaigns and inspections	During latrines and cemeteries realisation	At the tubewell	Guébré Mariam, Zandé Mariam
Clean properly the pipe	Regular washing / cleanliness of the tubewell's pipe	Awareness campaigns and inspections	Weekly	At the tubewell	Dabré Sapoura, Bayiré Salamatou
Clean properly all the tubewell parts before putting them back	Cleanliness of all the tubewell's parts	Inspections	During the reparation of breakdowns	At the tubewell	Guébré Issa
Prohibition of the use of pesticides around the tubewell	Behavioural change	Awareness campaigns and inspections	Before the rainy season (when pesticides are used)	At the tubewell	Guébré Seydou
Remove properly the old grease and take care during the lubrication operation	Behavioural change	Awareness campaigns and inspections	Twice a month	At the tubewell	Guébré Issa

Tubewell 3. The transport

Hazardous event	Hazard	Cause	Risk			Control measure
			Likelihood	Severity	Score	
Drinking water contamination	Microbial	Containers open	5	5	25	Use containers closed
		Containers dirty	5	5	25	Wash properly the containers with soap
		Hands dirty	5	5	25	Wash properly the hands with soap
		Utensils (funnel) dirty	5	5	25	Use of proper funnels
	Chemical	Jerry cans that contained chemicals	1	4	4	Prohibition of the use of these containers

Continue...

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Control measure	Monitoring programme				
	What	**How**	**When**	**Where**	**Who**
Use containers closed	Use of the correct containers and behavioural change	Awareness campaigns and inspections	Daily	At the tubewell and at the dwelling	1 woman/yard
Wash properly the containers with soap	Behavioural change	Awareness campaigns and inspections	Daily	At the tubewell	Bancé Assetou, Déné Alimatou
Wash properly the hands with soap	Behavioural change	Awareness campaigns and inspections	Daily	At the tubewell	Bancé Assetou, Déné Alimatou
Use of proper funnels	Behavioural change	Awareness campaigns and inspections	Daily	At the tubewell	Bancé Assetou, Déné Alimatou
Prohibition of the use of these containers	Absence of these containers	Awareness campaigns and inspections	Weekly	At the tubewell and at the dwelling	Guébré Mariam, Guébré Massouki, Zandé Mariam

Tubewell 3. The storage and consumption

Hazardous event	Hazard	Cause	Risk			Control measure
			Likelihood	Severity	Score	
Drinking water contamination	Microbial	Containers open	4	5	20	Use containers closed
		Cups used for drinking dirty	5	5	25	Wash properly the cups for drinking with soap
		Containers dirty	5	5	25	Wash properly the containers with soap
		Dirty environment nearby the containers	3	3	9	Clean properly the environment nearby the containers
		Containers stored outside the dwelling	5	5	25	Use dedicated containers for drinking water and store them inside the dwelling
		High drinking water storage time (>1d)	2	5	10	Change regularly drinking water (daily)
		Hands dirty	5	5	25	Wash properly the hands with soap before drinking
	Chemical	Chlorine overdose	1	5	5	Dose the correct quantity of chlorine

Continue...

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Control measure	Monitoring programme				
	What	**How**	**When**	**Where**	**Who**
Use containers closed	Behavioural change	Awareness campaigns and inspections	Weekly	At the dwelling	1 woman/yard
Wash properly the cups for drinking with soap	Behavioural change	Awareness campaigns and inspections	Daily	At the dwelling	1 woman/yard
Wash properly the containers with soap	Behavioural change	Awareness campaigns and inspections	Daily	At the dwelling	1 woman/yard
Clean properly the environment nearby the containers	Proper environment close to the container	Awareness campaigns and inspections	Daily	At the dwelling	1 woman/yard
Use dedicated containers for drinking water and store them inside the dwelling	Drinking water containers stored inside the dwelling	Awareness campaigns and inspections	Monthly	At the dwelling	1 woman/yard
Change regularly drinking water (daily)	Behavioural change	Awareness campaigns and inspections	Daily	At the dwelling	1 woman/yard
Wash properly the hands with soap before drinking	Behavioural change	Awareness campaigns and inspections	Daily	At the dwelling	1 woman/yard
Dose the correct quantity of chlorine	Check the dosed quantity	Awareness campaigns and inspections	Daily	At the dwelling	1 woman/yard 2 Hygienists of Fingla

Responsible for the WSP: Mrs Guébré Fati

A.8.4 Tubewell 4. The source

Hazardous event	Hazard	Cause	Risk: Likelihood	Risk: Severity	Risk: Score	Control measure
Drinking water contamination	Microbial	Use of dirty shoes inside the tubewell structure	5	5	25	Remove shoes before entering the tubewell's apron
		Do the laundry close to the tubewell	1	5	5	Avoid doing the laundry close to the tubewell
		Improper hygiene and cleaning of the tubewell	4	5	20	Awareness campaigns for the users
						Clean properly the concrete apron
		Presence of excreta and rubbish close to the tubewell	3	5	15	Avoid littering and the presence of excreta close to the tubewell
		Tubewell's pipe dirty	5	5	25	Clean properly the pipe
		Presence of animals around the tubewell	5	5	25	Awareness campaigns for the herdsmen
						Build an adequate fence around the tubewell
		Presence of stagnant water around the tubewell's walls	3	5	15	Empty daily the tank for watering the animals
						Fill the tubewell's border with stones
		Presence of latrines within 10m	1	5	5	Avoid realising latrines close to the tubewell
	Chemical	Lubrication of the tubewell chain	2	3	6	Remove properly the old grease and take care during the lubrication operation

Continue...

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Control measure	Monitoring programme				
	What	**How**	**When**	**Where**	**Who**
Remove shoes before entering the tubewell's apron	Behavioural change	Awareness campaigns and inspections	Daily	At the tubewell	Guébré Salam
Avoid doing the laundry close to the tubewell	Behavioural change	Awareness campaigns and inspections	Daily	At the tubewell	Guébré Salam
Awareness campaigns for the users	Behavioural change	Awareness campaigns and inspections	Weekly	At the tubewell	Bara Safiatou
Clean properly the concrete apron	Regular washing / cleanliness of the tubewell	Awareness campaigns and inspections	Weekly	At the tubewell	Bara Safiatou
Avoid littering and the presence of excreta close to the tubewell	Behavioural change	Awareness campaigns and inspections	Weekly	At the tubewell	Bancé Amina, Bambore Salamatou
Clean properly the pipe	Regular washing / cleanliness of the tubewell's pipe	Awareness campaigns and inspections	Weekly	At the tubewell	Bara Safiatou
Awareness campaigns for the herdsmen	Behavioural change	Inspections	Annually	At the tubewell	Guébre Salam, Bancé Amina
Build an adequate fence around the tubewell	Construction of the fence and absence of animal excreta / rubbish	Awareness campaigns and inspections	August 2013	At the tubewell	Bara Safiatou
Empty daily the tank for watering the animals	Behavioural change	Inspections	Daily	At the tubewell	Guébre Salam, Bancé Amina
Fill the tubewell's border with stones	Presence of stones at the tubewell's border	Inspections	Weekly	At the tubewell	Guébre Salam, Bancé Amina
Avoid realising latrines close to the tubewell	Absence of latrines close to the tubewell	Awareness campaigns and inspections	During latrines realisation	At the tubewell	Bancé Amina, Bambore Salamatou
Remove properly the old grease and take care during the lubrication operation	Behavioural change	Awareness campaigns and inspections	During the lubrication operations	At the tubewell	Bara Safiatou

Tubewell 4. The transport

Hazardous event	Hazard	Cause	Risk			Control measure
			Likelihood	Severity	Score	
Drinking water contamination	Microbial	Containers open	5	5	25	Use containers closed
		Containers dirty	3	5	15	Wash properly the containers with soap
		Hands dirty	5	5	25	Wash properly the hands with soap
		Utensils (funnel) dirty	5	5	25	Use of proper funnels
	Chemical	Jerry cans that contained chemicals	1	5	5	Wash properly these containers with soap, sponge and chlorine

Continue...

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Control measure	Monitoring programme				
	What	**How**	**When**	**Where**	**Who**
Use containers closed	Behavioural change	Awareness campaigns	Weekly	At the tubewell	1 woman/yard
Wash properly the containers with soap	Behavioural change	Awareness campaigns	Weekly	At the tubewell	1 woman/yard
	Use of containers well washed	Inspections	Daily	At the dwelling	1 woman/yard
Wash properly the hands with soap	Behavioural change	Awareness campaigns	Weekly	At the tubewell	1 woman/yard
	Hands well washed	Inspections	Daily	At the dwelling	1 woman/yard
Use of proper funnels	Behavioural change	Awareness campaigns	Weekly	At the tubewell	1 woman/yard
Wash properly these containers with soap, sponge and chlorine	Cleanliness of these containers	Awareness campaigns and inspections	Monthly	At the dwelling	1 woman/yard

Tubewell 4. The storage and consumption

Hazardous event	Hazard	Cause	Risk			Control measure
			Likelihood	Severity	Score	
Drinking water contamination	Microbial	Containers open	1	5	5	Use containers closed
		Containers dirty	5	5	25	Wash properly the containers with soap
		Hands dirty	5	5	25	Wash properly the hands with soap before drinking
		Cups used for drinking dirty	5	5	25	Wash properly the cups for drinking with soap
		Dirty environment nearby the containers	3	5	15	Clean properly the environment nearby the containers
		Containers stored outside the dwelling	3	5	15	Use dedicated containers for drinking water and store them inside the dwelling
		High drinking water storage time (>1d)	5	5	25	Change regularly drinking water (daily)
	Chemical	Chlorine overdose	1	5	5	Dose the correct quantity of chlorine

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Control measure	Monitoring programme				
	What	**How**	**When**	**Where**	**Who**
Use containers closed	Behavioural change	Awareness campaigns and inspections	Daily	At the dwelling	1 woman/yard
Wash properly the containers with soap	Behavioural change	Awareness campaigns and inspections	Daily	At the dwelling	1 woman/yard
Wash properly the hands with soap before drinking	Behavioural change	Awareness campaigns and inspections	Daily	At the dwelling	1 woman/yard
Wash properly the cups for drinking with soap	Behavioural change	Awareness campaigns and inspections	Daily	At the dwelling	1 woman/yard
Clean properly the environment nearby the containers	Behavioural change	Awareness campaigns and inspections	Daily	At the dwelling	1 woman/yard
Use dedicated containers for drinking water and store them inside the dwelling	Drinking water containers stored inside the dwelling	Awareness campaigns and inspections	Daily	At the dwelling	1 woman/yard
Change regularly drinking water (daily)	Behavioural change	Awareness campaigns and inspections	Daily	At the dwelling	1 woman/yard
Dose the correct quantity of chlorine	Check the dosed quantity	Awareness campaigns and inspections	Daily	At the dwelling	1 woman/yard

<u>Responsible for the WSP</u>: Mrs Bara Safiatou

A.8.5 Tubewell 5. The source

Hazardous event	Hazard	Cause	Risk: Likelihood	Risk: Severity	Risk: Score	Control measure
Drinking water contamination	Microbial	Improper hygiene and cleaning of the tubewell	5	5	25	Clean properly the concrete apron
		Presence of rubbish close to the tubewell	5	5	25	Avoid littering close to the tubewell and, if not, clean the environment around the tubewell
		Use of dirty shoes inside the tubewell structure	5	5	25	Remove shoes before entering the tubewell's apron
		Do the laundry close to the tubewell	5	5	25	Avoid doing the laundry close to the tubewell
		Flood of the river	2	5	10	Close the tubewell for some time (till water has not retreated)
		Presence of stagnant water around the tubewell's walls	5	5	25	Fill the tubewell's border with stones
		Presence of excreta close to the tubewell	5	5	25	Build latrines
		Tubewell's pipe dirty	3	5	15	Clean properly the pipe
		Reparation of the tubewell during breakdowns	3	3	9	Clean properly all the tubewell parts before putting them back
		Presence of latrines within 10m	1	5	5	Avoid realising latrines close to the tubewell
		Presence of cemeteries within 10m	5	5	25	Distance the cemetery from the tubewell
		Presence of animals around the tubewell	5	5	25	Build an adequate fence around the tubewell
	Chemical	Use of pesticides close to the tubewell	5	5	25	Prohibition of the use of pesticides around the tubewell
		Lubrication of the tubewell chain	5	5	25	Remove properly the old grease and take care during the lubrication operation

Continue...

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Control measure	Monitoring programme				
	What	How	When	Where	Who
Clean properly the concrete apron	Regular washing / cleanliness of the tubewell	Awareness campaigns and inspections	Weekly	At the tubewell	Bancé Boussiratou
Avoid littering close to the tubewell and, if not, clean the environment around the tubewell	Behavioural change	Awareness campaigns and inspections	Weekly	At the tubewell	Bancé Boussiratou
Remove shoes before entering the tubewell's apron	Behavioural change	Awareness campaigns and inspections	Weekly	At the tubewell	Bancé Boussiratou
Avoid doing the laundry close to the tubewell	Behavioural change	Awareness campaigns and inspections	Daily	At the tubewell	Dabré Issaka
Close the tubewell for some time (till water has not retreated)	Tubewell close	Inspections	When flood happens	At the tubewell	Dabré Issaka
Fill the tubewell's border with stones	Presence of stones at the tubewell's border	Inspections	Annually	At the tubewell	Bancé Habibou, Nonni Fayem
Build latrines	Presence of latrines in every yard close to the tubewell	Awareness campaigns and inspections	Monthly	At the yards of each user	Dabré Issaka
Clean properly the pipe	Regular washing / cleanliness of the tubewell's pipe	Awareness campaigns and inspections	Weekly	At the tubewell	Bancé Boussiratou
Clean properly all the tubewell parts before putting them back	Cleanliness of all the tubewell's parts	Inspections	During the reparation of breakdowns	At the tubewell	Dabré Hamidou
Avoid realising latrines close to the tubewell	Absence of latrines close to the tubewell	Awareness campaigns and inspections	During latrines construction	At the tubewell	Dabré Issaka
Distance the cemetery from the tubewell	Absence of cemeteries	Awareness campaigns and inspections	Every time someone dies	At the tubewell	Dabré Adama
Build an adequate fence around the tubewell	Construction of the fence and absence of animals	Awareness campaigns and inspections	Weekly	At the tubewell	Bancé Boussiratou
Prohibition of the use of pesticides around the tubewell	Behavioural change	Awareness campaigns and inspections	Annually	At the tubewell	Dabré Adama
Remove properly the old grease and take care during the lubrication operation	Behavioural change	Awareness campaigns and inspections	Every three weeks	At the tubewell	Dabré Hamadou

Tubewell 5. The transport

Hazardous event	Hazard	Cause	Risk			Control measure
			Likelihood	Severity	Score	
Drinking water contamination	Microbial	Containers open	2	5	10	Use containers closed
		Hands dirty	5	5	25	Wash properly the hands with soap
		Containers dirty	5	5	25	Wash properly the containers with soap
		Utensils (funnel) dirty	5	5	25	Use of proper funnels
	Chemical	Jerry cans that contained chemicals	1	5	5	Prohibition of the use of these containers

Continue...

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Control measure	Monitoring programme				
	What	**How**	**When**	**Where**	**Who**
Use containers closed	Verify the use of closed containers	Awareness campaigns and inspections	Weekly	At the tubewell	Déné Assetou, Bara Safiatou
		Share the information	At every moment	Everywhere	1 woman/yard
Wash properly the hands with soap	Behavioural change	Awareness campaigns and inspections	Weekly	At the tubewell	Déné Assetou, Bara Safiatou
		Share the information	At every moment	Everywhere	1 woman/yard
Wash properly the containers with soap	Behavioural change	Awareness campaigns and inspections	Weekly	At the tubewell	Déné Assetou, Bara Safiatou
		Share the information	At every moment	Everywhere	1 woman/yard
Use of proper funnels	Behavioural change	Awareness campaigns and inspections	Weekly	At the tubewell	Déné Assetou, Bara Safiatou
		Share the information	At every moment	Everywhere	1 woman/yard
Prohibition of the use of these containers	Cleanliness of these containers	Awareness campaigns and inspections	Weekly	At the tubewell	Déné Assetou, Bara Safiatou, 2 Hygienists of Fingla

Tubewell 5. The storage and consumption

Hazardous event	Hazard	Cause	Risk			Control measure
			Likelihood	Severity	Score	
Drinking water contamination	Microbial	Containers open	1	5	5	Use containers closed
		Containers stored outside the dwelling	2	5	10	Use dedicated containers for drinking water and store them inside the dwelling
		Containers dirty	3	5	15	Wash properly the containers with soap
		Cups used for drinking dirty	3	5	15	Wash properly the cups for drinking with soap
		Hands dirty	5	5	25	Wash properly the hands with soap before drinking
		Dirty environment nearby the containers	3	3	9	Clean properly the environment nearby the containers
		High drinking water storage time (>1d)	5	5	25	Change regularly drinking water (daily)
	Chemical	Chlorine overdose	1	5	5	Dose the correct quantity of chlorine

Continue...

...Continue

Control measure	Monitoring programme				
	What	How	When	Where	Who
Use containers closed	Behavioural change	Awareness campaigns and inspections	Daily	At the dwelling	1 woman/yard
Use dedicated containers for drinking water and store them inside the dwelling	Drinking water containers stored inside the dwelling	Awareness campaigns and inspections	Daily	At the dwelling	1 woman/yard
Wash properly the containers with soap	Behavioural change	Awareness campaigns and inspections	Daily	At the dwelling	1 woman/yard
Wash properly the cups for drinking with soap	Behavioural change	Awareness campaigns and inspections	Daily	At the dwelling	1 woman/yard
Wash properly the hands with soap before drinking	Behavioural change	Awareness campaigns and inspections	Daily	At the dwelling	1 woman/yard
Clean properly the environment nearby the containers	Proper environment close to the container	Awareness campaigns and inspections	Daily	At the dwelling	1 woman/yard
Change regularly drinking water (daily)	Behavioural change	Awareness campaigns and inspections	Daily	At the dwelling	1 woman/yard
Dose the correct quantity of chlorine	Check the dosed quantity	Awareness campaigns and inspections	Daily	At the dwelling	2 Hygienists of Fingla

<u>Responsible for the WSP</u>: Mrs Nonni Fayem

A.8.6 Tubewell 6. The source

Hazardous event	Hazard	Cause	Risk: Likelihood	Risk: Severity	Risk: Score	Control measure
Drinking water contamination	Microbial	Improper hygiene and cleaning of the tubewell	4	5	20	Awareness campaigns for the users
						Clean properly the concrete apron
		Presence of rubbish close to the tubewell	4	5	20	Avoid littering close to the tubewell and, if not, clean the environment around the tubewell
		Use of dirty shoes inside the tubewell structure	4	5	20	Remove shoes before entering the tubewell's apron
		Do the laundry close to the tubewell	5	5	25	Avoid doing the laundry close to the tubewell
		Presence of animals around the tubewell	5	5	25	Awareness campaigns for the herdsmen
						Build an adequate fence around the tubewell
		Presence of latrines within 10m	5	5	25	Avoid realising latrines close to the tubewell
		Presence of cemeteries within 10m	5	5	25	Avoid burying close to the tubewell
		Presence of excreta close to the tubewell	5	5	25	Avoid the presence of excreta close to the tubewell
		Tubewell's pipe dirty	5	5	25	Clean properly the pipe
	Chemical	Use of pesticides close to the tubewell	5	5	25	Prohibition of the use of pesticides around the tubewell

Continue...

...Continue

Control measure	Monitoring programme				
	What	How	When	Where	Who
Awareness campaigns for the users	Behavioural change	Awareness campaigns and inspections	Weekly	At the tubewell	Guébré Fatimata
Clean properly the concrete apron	Regular washing / cleanliness of the tubewell	Awareness campaigns and inspections	Weekly	At the tubewell	Guébré Fatimata
Avoid littering close to the tubewell and, if not, clean the environment around the tubewell	Behavioural change	Awareness campaigns and inspections	Weekly	At the tubewell	Guébré Fatimata
Remove shoes before entering the tubewell's apron	Behavioural change	Awareness campaigns and inspections	Weekly	At the tubewell	Guébré Fatimata
Avoid doing the laundry close to the tubewell	Behavioural change	Awareness campaigns and inspections	Weekly	At the tubewell	Dabré Saratou
Awareness campaigns for the herdsmen	Absence of animals close to the tubewell	Awareness campaigns and inspections	Daily	At the tubewell	Guébré Salam, Guébré Soumaila
Build an adequate fence around the tubewell	Construction of the fence and absence of animal excreta	Awareness campaigns and inspections	August 2013 and daily	At the tubewell	Guébre Soumaila
Avoid realising latrines close to the tubewell	Absence of latrines close to the tubewell	Awareness campaigns and inspections	During latrines realisation	At the tubewell	Bidiga Fatimata, Hygienists of the CGPE
Avoid burying close to the tubewell	Absence of the cemeteries	Awareness campaigns and inspections	Every time someone dies	At the tubewell	Guébre Soumaila
Avoid the presence of excreta close to the tubewell	Absence of excreta	Awareness campaigns and inspections	Weekly	At the tubewell	Bidiga Fatimata, Hygienists of the CGPE
Clean properly the pipe	Regular washing / cleanliness of the tubewell's pipe	Awareness campaigns and inspections	Weekly	At the tubewell	Guébré Fatimata
Prohibition of the use of pesticides around the tubewell	Behavioural change	Awareness campaigns and inspections	Annually	At the tubewell	Guébré Soumaila

Tubewell 6. The transport

Hazardous event	Hazard	Cause	Risk			Control measure
			Likelihood	**Severity**	**Score**	
Drinking water contamination	Microbial	Containers open	4	5	20	Use containers closed
		Containers dirty	5	5	25	Wash properly the containers with soap
		Hands dirty	5	5	25	Wash properly the hands with soap
		Utensils (funnel) dirty	5	5	25	Use of proper funnels
	Chemical	Jerry cans that contained chemicals	1	4	4	Prohibition of the use of these containers

Continue...

...Continue

Control measure	Monitoring programme				
	What	**How**	**When**	**Where**	**Who**
Use containers closed	Verify the use of closed containers	Awareness campaigns and inspections	Daily	At the tubewell	Bara Safiatou, 1 woman/yard
Wash properly the containers with soap	Behavioural change	Awareness campaigns and inspections	Daily	At the tubewell	Guébré Fatimatou, 1 woman/yard
Wash properly the hands with soap	Behavioural change	Awareness campaigns and inspections	Daily	At the tubewell	Guébré Fatimatou, 1 woman/yard
Use of proper funnels	Behavioural change	Awareness campaigns and inspections	Daily	At the tubewell	Guébré Fatimatou, 1 woman/yard
Prohibition of the use of these containers	Cleanliness of these containers	Awareness campaigns and inspections	Weekly	At the tubewell	Bancé Inoussa

Tubewell 6. The storage and consumption

Hazardous event	Hazard	Cause	Risk			Control measure
			Likelihood	Severity	Score	
Drinking water contamination	Microbial	Containers dirty	5	5	25	Wash properly the containers with soap
		Containers open	1	5	5	Use containers closed
		Hands dirty	5	5	25	Wash properly the hands with soap before drinking
		Cups used for drinking dirty	5	5	25	Wash properly the cups for drinking with soap
		Dirty environment nearby the containers	5	5	25	Clean properly the environment nearby the containers
		High drinking water storage time (>1d)	5	5	25	Change regularly drinking water (daily)
		Containers stored outside the dwelling	5	5	25	Use dedicated containers for drinking water and store them inside the dwelling
	Chemical	Cups used for drinking rusty	2	5	10	Prohibition of the use of these cups
		Chlorine overdose	1	5	5	Dose the correct quantity of chlorine

Continue...

...Continue

Control measure	Monitoring programme				
	What	**How**	**When**	**Where**	**Who**
Wash properly the containers with soap	Behavioural change	Awareness campaigns and inspections	Weekly	At the dwelling	1 woman/yard
Use containers closed	Behavioural change	Awareness campaigns and inspections	Weekly	At the dwelling	1 woman/yard
Wash properly the hands with soap before drinking	Behavioural change	Awareness campaigns and inspections	Weekly	At the dwelling	1 woman/yard
Wash properly the cups for drinking with soap	Behavioural change	Awareness campaigns and inspections	Weekly	At the dwelling	1 woman/yard
Clean properly the environment nearby the containers	Behavioural change	Awareness campaigns and inspections	Weekly	At the dwelling	1 woman/yard
Change regularly drinking water (daily)	Behavioural change	Awareness campaigns and inspections	Weekly	At the dwelling	1 woman/yard
Use dedicated containers for drinking water and store them inside the dwelling	Behavioural change	Awareness campaigns and inspections	Weekly	At the dwelling	1 woman/yard
Prohibition of the use of these cups	Behavioural change	Awareness campaigns and inspections	Weekly	At the dwelling	1 woman/yard
Dose the correct quantity of chlorine	Check the dosed quantity	Awareness campaigns and inspections	Weekly	At the dwelling	Guébré Mariam, Guébré Inoussa

Responsible for the WSP: Mrs Dabré Saratou

A.8.7 Tubewell 7. The source

Hazardous event	Hazard	Cause	Risk			Control measure
			Likelihood	Severity	Score	
Drinking water contamination	Microbial	Presence of latrines and cemeteries within 10m	1	5	5	Avoid realising latrines and cemeteries close to the tubewell
		Presence of excreta and rubbish close to the tubewell	1	5	5	Avoid littering and the presence of excreta close to the tubewell
		Improper hygiene and cleaning of the tubewell	1	4	4	Clean properly the concrete apron
		Presence of animals around the tubewell	2	4	8	Build an adequate fence around the tubewell
						Awareness campaigns for the herdsmen
		Use of dirty shoes inside the tubewell structure	1	5	5	Remove shoes before entering the tubewell's apron
		Do the laundry close to the tubewell	1	5	5	Remove shoes before entering the tubewell's apron
		Tubewell's pipe dirty	2	5	10	Clean properly the pipe
		Reparation of the tubewell during breakdowns	1	3	3	Clean properly all the tubewell parts before putting them back
		Presence of stagnant water around the tubewell's walls	2	3	6	Fill the tubewell's border with stones
	Chemical	Lubrication of the tubewell chain	2	4	8	Remove properly the old grease and take care during the lubrication operation
		Use of pesticides close to the tubewell	4	5	20	Prohibition of the use of pesticides around the tubewell

Continue...

...Continue

Control measure	Monitoring programme				
	What	**How**	**When**	**Where**	**Who**
Avoid realising latrines and cemeteries close to the tubewell	Absence of latrines and cemeteries close to the tubewell	Awareness campaigns and inspections	During latrines and cemeteries realisation	At the tubewell	Bancé Boukaré
Avoid littering and the presence of excreta close to the tubewell	Behavioural change	Awareness campaigns and inspections	Weekly	At the tubewell	Bara Awa
Clean properly the concrete apron	Behavioural change	Awareness campaigns and inspections	Weekly	At the tubewell	Bara Awa
Build an adequate fence around the tubewell	Fence in place	Inspections	August 2013	At the tubewell	Bancé Ilyassa
Awareness campaigns for the herdsmen	Behavioural change	Awareness campaigns and inspections	Annually	At the tubewell	Bancé Ilyassa
Remove shoes before entering the tubewell's apron	Behavioural change	Awareness campaigns and inspections	Daily	At the tubewell	Bara Awa
Remove shoes before entering the tubewell's apron	Behavioural change	Awareness campaigns and inspections	Daily	At the tubewell	Saba Aminata
Clean properly the pipe	Behavioural change	Awareness campaigns and inspections	Weekly	At the tubewell	Bara Awa
Clean properly all the tubewell parts before putting them back	Cleanliness of all the tubewell's parts	Inspections	During the reparation of breakdowns	At the tubewell	Bancé Salif
Fill the tubewell's border with stones	Presence of stones at the tubewell's border	Inspections	Annually	At the tubewell	Sambaré Awa
Remove properly the old grease and take care during the lubrication operation	Behavioural change	Awareness campaigns and inspections	When lubrication operations are carried out	At the tubewell	Bancé Salif
Prohibition of the use of pesticides around the tubewell	Behavioural change	Awareness campaigns and inspections	Before the rainy season (when pesticides are used)	At the tubewell	Bancé Boukaré

Tubewell 7. The transport

Hazardous event	Hazard	Cause	Risk			Control measure
			Likelihood	Severity	Score	
Drinking water contamination	Microbial	Containers open	1	5	5	Use containers closed
		Hands dirty	2	5	10	Wash properly the hands with soap
		Containers dirty	2	4	8	Wash properly the containers with soap
		Utensils (funnel) dirty	1	5	5	Use of proper funnels Each user provides its funnel (never again community funnels)
	Chemical	Jerry cans that contained chemicals	1	5	5	Prohibition of the use of these containers

Continue...

...Continue

Control measure	Monitoring programme				
	What	**How**	**When**	**Where**	**Who**
Use containers closed	Verify the use of closed containers	Awareness campaigns and inspections	Daily	At the tubewell and at the dwelling	1 woman/yard, Everyone at the tubewell
Wash properly the hands with soap	Behavioural change	Awareness campaigns and inspections	Daily	At the tubewell and at the dwelling	1 woman/yard, Everyone at the tubewell
Wash properly the containers with soap	Verify the use of well cleaned containers	Awareness campaigns and inspections	Daily	At the tubewell and at the dwelling	1 woman/yard, Everyone at the tubewell
Use of proper funnels	Behavioural change	Awareness campaigns and inspections	Daily	At the tubewell and at the dwelling	1 woman/yard, Everyone at the tubewell
Each user provides its funnel (never again community funnels)	Behavioural change	Awareness campaigns and inspections	Daily	At the tubewell	Bancé Aminata
Prohibition of the use of these containers	None uses these containers	Awareness campaigns and inspections	Monthly	At the tubewell	Bancé Aminata

Tubewell 7. The storage and consumption

Hazardous event	Hazard	Cause	Risk			Control measure
			Likelihood	Severity	Score	
Drinking water contamination	Microbial	Containers open	2	5	10	Use containers closed
		Containers dirty	2	5	10	Wash properly the containers with soap
		Cups used for drinking dirty	4	5	20	Wash properly the cups for drinking with soap
		Hands dirty	5	5	25	Wash properly the hands with soap before drinking
		Dirty environment nearby the containers	3	5	15	Clean properly the environment nearby the containers
		High drinking water storage time (>1d)	1	5	5	Change regularly drinking water (daily)
		Containers stored outside the dwelling	2	5	10	Use dedicated containers for drinking water and store them inside the dwelling
	Chemical	Chlorine overdose	1	5	5	Dose the correct quantity of chlorine

Continue...

...Continue

Control measure	Monitoring programme				
	What	**How**	**When**	**Where**	**Who**
Use containers closed	Behavioural change	Awareness campaigns and inspections	Daily	At the dwelling	1 woman/yard
Wash properly the containers with soap	Behavioural change	Awareness campaigns and inspections	Daily	At the dwelling	1 woman/yard
Wash properly the cups for drinking with soap	Behavioural change	Awareness campaigns and inspections	Daily	At the dwelling	1 woman/yard
Wash properly the hands with soap before drinking	Behavioural change	Awareness campaigns and inspections	Daily	At the dwelling	1 woman/yard
Clean properly the environment nearby the containers	Behavioural change	Awareness campaigns and inspections	Daily	At the dwelling	1 woman/yard
Change regularly drinking water (daily)	Behavioural change	Awareness campaigns and inspections	Daily	At the dwelling	1 woman/yard
Use dedicated containers for drinking water and store them inside the dwelling	Behavioural change	Awareness campaigns and inspections	Daily	At the dwelling	1 woman/yard
Dose the correct quantity of chlorine	Behavioural change	Awareness campaigns and inspections	Daily	At the dwelling	1 woman/yard

<u>Responsible for the WSP</u>: Mrs Bara Awa

A.8.8 Tubewell 8. The source

Hazardous event	Hazard	Cause	Risk			Control measure
			Likelihood	Severity	Score	
Drinking water contamination	Microbial	Do the laundry close to the tubewell	2	5	10	Avoid doing the laundry close to the tubewell
		Use of dirty shoes inside the tubewell structure	3	5	15	Remove shoes before entering the tubewell's apron
		Improper hygiene and cleaning of the tubewell	3	4	12	Clean properly the concrete apron
		Presence of excreta close to the tubewell	1	5	5	Build an adequate fence around the tubewell
		Presence of animals around the tubewell	5	5	25	Awareness campaigns for the herdsmen
		Presence of rubbish close to the tubewell	4	4	16	Avoid littering close to the tubewell and, if not, clean the environment around the tubewell
		Presence of stagnant water around the tubewell's walls	5	5	25	Fill the tubewell's border with stones
		Tubewell's pipe dirty	2	5	10	Clean properly the pipe
		Presence of latrines and cemeteries within 10m	1	5	5	Avoid realising latrines and cemeteries close to the tubewell
		Reparation of the tubewell during breakdowns	1	4	4	Clean properly all the tubewell parts before putting them back
	Chemical	Use of pesticides close to the tubewell	2	5	10	Prohibition of the use of pesticides around the tubewell
		Lubrication of the tubewell chain	4	3	12	Remove properly the old grease and take care during the lubrication operation

Continue...

...Continue

Control measure	Monitoring programme				
	What	How	When	Where	Who
Avoid doing the laundry close to the tubewell	Behavioural change	Awareness campaigns and inspections	Daily	At the tubewell	Déné Adissa
Remove shoes before entering the tubewell's apron	Behavioural change	Awareness campaigns and inspections	Daily	At the tubewell	Bara Assana
Clean properly the concrete apron	Regular washing / cleanliness of the tubewell	Awareness campaigns and inspections	Each Friday	At the tubewell	Zoumbaré Fatoumata
Build an adequate fence around the tubewell	Construction of the fence and absence of animal excreta	Awareness campaigns and inspections	Monthly	At the tubewell	Déné Adissa
Awareness campaigns for the herdsmen	Behavioural change	Inspections	Annually	At the tubewell	Bara Adjara
Avoid littering close to the tubewell and, if not, clean the environment around the tubewell	Behavioural change	Awareness campaigns and inspections	Each Friday	At the tubewell	Zoumbaré Fatoumata
Fill the tubewell's border with stones	Presence of stones at the tubewell's border	Inspections	Annually	At the tubewell	Guébré Inoussa
Clean properly the pipe	Regular washing / cleanliness of the tubewell's pipe	Awareness campaigns and inspections	Each Friday	At the tubewell	Zoumbaré Fatoumata
Avoid realising latrines and cemeteries close to the tubewell	Absence of latrines and cemeteries close to the tubewell	Awareness campaigns and inspections	During latrines and cemeteries realisation	At the tubewell	Guébré Inoussa
Clean properly all the tubewell parts before putting them back	Cleanliness of all the tubewell's parts	Inspections	During the reparation of breakdowns	At the tubewell	Guébré Inoussa
Prohibition of the use of pesticides around the tubewell	Behavioural change	Awareness campaigns and inspections	Before the rainy season (when pesticides are used)	At the tubewell	Guébré Inoussa
Remove properly the old grease and take care during the lubrication operation	Behavioural change	Awareness campaigns and inspections	During the lubrication operations	At the tubewell	Guébré Inoussa

Tubewell 8. The transport

Hazardous event	Hazard	Cause	Risk			Control measure
			Likelihood	**Severity**	**Score**	
Drinking water contamination	Microbial	Containers dirty	4	5	20	Wash properly the containers with soap
		Hands dirty	4	5	20	Wash properly the hands with soap
		Containers open	1	5	5	Use containers closed
		Utensils (funnel) dirty	4	5	20	Use of proper funnels
	Chemical	Jerry cans that contained chemicals	1	5	5	Prohibition of the use of these containers

Continue...

...Continue

Control measure	Monitoring programme				
	What	**How**	**When**	**Where**	**Who**
Wash properly the containers with soap	Behavioural change	Awareness campaigns and inspections	Every Friday	At the tubewell	1 woman/yard
Wash properly the hands with soap	Behavioural change	Awareness campaigns and inspections	Every Friday	At the tubewell	1 woman/yard
Use containers closed	Behavioural change	Awareness campaigns and inspections	Every Friday	At the tubewell	1 woman/yard
Use of proper funnels	Behavioural change	Awareness campaigns and inspections	Every Friday	At the tubewell	1 woman/yard
Prohibition of the use of these containers	None uses these containers	Awareness campaigns and inspections	Every Friday	At the tubewell	1 woman/yard

Tubewell 8. The storage and consumption

Hazardous event	Hazard	Cause	Risk			Control measure
			Likelihood	Severity	Score	
Drinking water contamination	Microbial	Containers dirty	4	5	20	Wash properly the containers with soap
		Containers open	4	5	20	Use containers closed
		Containers stored outside the dwelling	4	5	20	Use dedicated containers for drinking water and store them inside the dwelling
		High drinking water storage time (>1d)	3	5	15	Change regularly drinking water (daily)
		Cups used for drinking dirty	3	5	15	Wash properly the cups for drinking with soap
		Hands dirty	5	5	25	Wash properly the hands with soap before drinking
		Dirty environment nearby the containers	2	5	10	Clean properly the environment nearby the containers
	Chemical	Chlorine overdose	1	5	5	Dose the correct quantity of chlorine

Continue...

...Continue

Control measure	Monitoring programme				
	What	**How**	**When**	**Where**	**Who**
Wash properly the containers with soap	Cleanliness of the containers	Awareness campaigns and inspections	Daily	At the dwelling	1 woman/yard
Use containers closed	Use of containers close	Awareness campaigns and inspections	Daily	At the dwelling	1 woman/yard
Use dedicated containers for drinking water and store them inside the dwelling	Drinking water containers are stored inside the dwelling	Awareness campaigns and inspections	Daily	At the dwelling	1 woman/yard
Change regularly drinking water (daily)	Behavioural change	Awareness campaigns and inspections	Daily	At the dwelling	1 woman/yard
Wash properly the cups for drinking with soap	Behavioural change	Awareness campaigns and inspections	Daily	At the dwelling	1 woman/yard
Wash properly the hands with soap before drinking	Behavioural change	Awareness campaigns and inspections	Daily	At the dwelling	1 woman/yard
Clean properly the environment nearby the containers	Behavioural change	Awareness campaigns and inspections	Daily	At the dwelling	1 woman/yard
Dose the correct quantity of chlorine	Check the dosed quantity	Awareness campaigns and inspections	Daily	At the dwelling	1 woman/yard Guébré Inoussa

Responsible for the WSP: Mrs Zoumbaré Fatoumata

A.8.9 Tubewell 9. The source

Hazardous event	Hazard	Cause	Risk: Likelihood	Risk: Severity	Risk: Score	Control measure
Drinking water contamination	Microbial	Improper hygiene and cleaning of the tubewell	2	5	10	Clean properly the concrete apron
		Do the laundry close to the tubewell	2	5	10	Avoid doing the laundry close to the tubewell
		Use of dirty shoes inside the tubewell structure	1	5	5	Remove shoes before entering the tubewell's apron
		Presence of excreta close to the tubewell	1	4	5	Build an adequate fence around the tubewell
		Presence of rubbish close to the tubewell	2	3	6	Avoid littering close to the tubewell and, if not, clean the environment around the tubewell
		Presence of animals around the tubewell	4	5	20	Awareness campaigns for the herdsmen
		Tubewell's pipe dirty	1	4	4	Clean properly the pipe
		Presence of latrines and cemeteries within 10m	1	5	5	Avoid realising latrines and cemeteries close to the tubewell
		Presence of stagnant water around the tubewell's walls	2	4	8	Fill the tubewell's border with stones
	Chemical	Lubrication of the tubewell chain	2	4	8	Remove properly the old grease and take care during the lubrication operation
		Use of pesticides close to the tubewell	5	5	25	Prohibition of the use of pesticides around the tubewell

Continue...

...Continue

Control measure	Monitoring programme				
	What	How	When	Where	Who
Clean properly the concrete apron	Regular washing / cleanliness of the tubewell	Awareness campaigns and inspections	Weekly	At the tubewell	Bara Minata, The Hygienists of Fingla
Avoid doing the laundry close to the tubewell	Behavioural change	Awareness campaigns and inspections	Daily	At the tubewell	Bancé Awa
Remove shoes before entering the tubewell's apron	Behavioural change	Awareness campaigns and inspections	Daily	At the tubewell	Bara Minata
Build an adequate fence around the tubewell	Fence in place	Awareness campaigns and inspections	Monthly	At the tubewell	Bara Minata
Avoid littering close to the tubewell and, if not, clean the environment around the tubewell	Behavioural change	Awareness campaigns and inspections	Daily	At the tubewell	Bara Minata
Awareness campaigns for the herdsmen	Behavioural change	Awareness campaigns and inspections	Daily	At the tubewell	Guébré Mamoudou
Clean properly the pipe	Regular washing / cleanliness of the tubewell's pipe	Awareness campaigns and inspections	Weekly	At the tubewell	Bara Minata
Avoid realising latrines and cemeteries close to the tubewell	Absence of latrines and cemeteries close to the tubewell	Awareness campaigns and inspections	During latrines and cemeteries construction	At the tubewell	Guébré Mamoudou
Fill the tubewell's border with stones	Presence of stones at the tubewell's border	Awareness campaigns and inspections	Annually	At the tubewell	Bara Minata
Remove properly the old grease and take care during the lubrication operation	Behavioural change	Awareness campaigns and inspections	Monthly	At the tubewell	Guébré Mamoudou
Prohibition of the use of pesticides around the tubewell	Behavioural change	Awareness campaigns and inspections	Annually	At the tubewell	Guébré Mamoudou

Tubewell 9. The transport

Hazardous event	Hazard	Cause	Risk			Control measure
			Likelihood	Severity	Score	
Drinking water contamination	Microbial	Containers open	3	5	15	Use containers closed
		Containers dirty	3	5	15	Wash properly the containers with soap
		Hands dirty	3	5	15	Wash properly the hands with soap
		Utensils (funnel) dirty	3	5	15	Use of proper funnels
	Chemical	Jerry cans that contained chemicals	1	5	5	Prohibition of the use of these containers

Continue...

...Continue

Control measure	Monitoring programme				
	What	**How**	**When**	**Where**	**Who**
Use containers closed	Use of closed containers	Awareness campaigns and inspections	Daily	At the tubewell and at the dwelling	1 woman/yard
Wash properly the containers with soap	Behavioural change	Awareness campaigns and inspections	Daily	At the tubewell	1 woman/yard
Wash properly the hands with soap	Behavioural change	Awareness campaigns and inspections	Daily	At the tubewell	1 woman/yard
Use of proper funnels	Behavioural change	Awareness campaigns and inspections	Daily	At the tubewell	1 woman/yard
Prohibition of the use of these containers	None uses these containers	Awareness campaigns and inspections	Monthly	At the tubewell and at the dwelling	1 woman/yard

Tubewell 9. The storage and consumption

Hazardous event	Hazard	Cause	Risk			Control measure
			Likelihood	Severity	Score	
Drinking water contamination	Microbial	Containers open	1	5	5	Use containers closed
		Cups used for drinking dirty	3	5	15	Wash properly the cups for drinking with soap
		Containers dirty	3	5	15	Wash properly the containers with soap
		Dirty environment nearby the containers	2	3	6	Clean properly the environment nearby the containers
		Containers stored outside the dwelling	1	5	5	Use dedicated containers for drinking water and store them inside the dwelling
		High drinking water storage time (>1d)	1	4	4	Change regularly drinking water (daily)
		Hands dirty	4	5	20	Wash properly the hands with soap before drinking
	Chemical	Chlorine overdose	1	5	5	Dose the correct quantity of chlorine

Continue...

...Continue

Control measure	Monitoring programme				
	What	**How**	**When**	**Where**	**Who**
Use containers closed	Behavioural change	Awareness campaigns and inspections	Daily	At the dwelling	1 woman/yard
Wash properly the cups for drinking with soap	Behavioural change	Awareness campaigns and inspections	Daily	At the dwelling	1 woman/yard
Wash properly the containers with soap	Behavioural change	Awareness campaigns and inspections	Daily	At the dwelling	1 woman/yard
Clean properly the environment nearby the containers	Behavioural change	Awareness campaigns and inspections	Daily	At the dwelling	1 woman/yard
Use dedicated containers for drinking water and store them inside the dwelling	Check the place where containers are stored	Awareness campaigns and inspections	Daily	At the dwelling	1 woman/yard
Change regularly drinking water (daily)	Behavioural change	Awareness campaigns and inspections	Daily	At the dwelling	1 woman/yard
Wash properly the hands with soap before drinking	Behavioural change	Awareness campaigns and inspections	Daily	At the dwelling	1 woman/yard
Dose the correct quantity of chlorine	Check the dosed quantity	Awareness campaigns and inspections	Daily	At the dwelling	1 woman/yard The Hygienists of Fingla

Responsible for the WSP: Mrs Zouba Alizèta

A.8.10 Tubewell 10. The source

Hazardous event	Hazard	Cause	Risk: Likelihood	Risk: Severity	Risk: Score	Control measure
Drinking water contamination	Microbial	Use of dirty shoes inside the tubewell structure	2	5	10	Remove shoes before entering the tubewell's apron
		Do the laundry close to the tubewell	5	5	25	Avoid doing the laundry close to the tubewell
		Improper hygiene and cleaning of the tubewell	2	3	6	Clean properly the concrete apron
		Presence of excreta and rubbish close to the tubewell	3	4	12	Avoid littering and the presence of excreta close to the tubewell
		Presence of children with an improper behaviour and hygiene	3	2	6	Awareness campaigns for the children
		Presence of animals around the tubewell	5	4	20	Build an adequate fence around the tubewell
						Awareness campaigns for the herdsmen
		Presence of stagnant water around the tubewell's walls	2	3	6	Fill the tubewell's border with stones
		Presence of latrines and cemeteries within 10m	1	3	3	Avoid realising latrines and cemeteries close to the tubewell
		Presence of water showers from the yards close to the tubewell	3	4	12	Construction of absorbing wells
		Tubewell's pipe dirty	2	4	8	Clean properly the pipe
		Reparation of the tubewell during breakdowns	2	4	8	Clean properly all the tubewell parts before putting them back
	Chemical	Use of pesticides close to the tubewell	4	4	16	Prohibition of the use of pesticides around the tubewell
		Lubrication of the tubewell chain	2	3	6	Remove properly the old grease and take care during the lubrication operation

Continue...

...Continue

Control measure	Monitoring programme				
	What	How	When	Where	Who
Remove shoes before entering the tubewell's apron	Behavioural change	Awareness campaigns and inspections	Daily	At the tubewell	Yoda Aliquetou, Bara Abibou
Avoid doing the laundry close to the tubewell	Behavioural change	Awareness campaigns and inspections	Daily	At the tubewell	Dabré Damata, Yoda Salamatou
Clean properly the concrete apron	Regular washing / cleanliness of the tubewell	Awareness campaigns and inspections	Weekly	At the tubewell	Bancé Azara
Avoid littering and the presence of excreta close to the tubewell	Behavioural change	Awareness campaigns and inspections	Weekly	At the tubewell	The President of the CGPE
Awareness campaigns for the children	Absence of children close to the tubewell	Awareness campaigns and inspections	Daily	At the tubewell	The President of the CGPE
Build an adequate fence around the tubewell	Fence in place	Inspections	August 2013	At the tubewell	The President of the CGPE
Awareness campaigns for the herdsmen	Behavioural change	Awareness campaigns and inspections	Annually	At the tubewell	The President of the CGPE
Fill the tubewell's border with stones	Presence of stones at the tubewell's border	Inspections	Annually	At the tubewell	The President of the CGPE
Avoid realising latrines and cemeteries close to the tubewell	Absence of latrines and cemeteries close to the tubewell	Awareness campaigns and inspections	During latrines and cemeteries realisation	At the tubewell	The President of the CGPE
Construction of absorbing wells	Presence of absorbing wells	Awareness campaigns and inspections	January 2013	At the yards close to the tubewell	Bara Habibou
Clean properly the pipe	Regular washing / cleanliness of the tubewell's pipe	Awareness campaigns and inspections	Weekly	At the tubewell	Bancé Azara
Clean properly all the tubewell parts before putting them back	Cleanliness of all the tubewell's parts	Inspections	During the reparation of breakdowns	At the tubewell	The Technician of the CGPE
Prohibition of the use of pesticides around the tubewell	Behavioural change	Awareness campaigns and inspections	Before the rainy season (when pesticides are used)	At the tubewell	The President of the CGPE
Remove properly the old grease and take care during the lubrication operation	Behavioural change	Awareness campaigns and inspections	When lubrication operations are carried out	At the tubewell	The Technician of the CGPE

Tubewell 10. The transport

Hazardous event	Hazard	Cause	Risk			Control measure
			Likelihood	Severity	Score	
Drinking water contamination	Microbial	Containers dirty	5	5	25	Wash properly the containers with soap
		Containers open	4	5	20	Use containers closed
		Hands dirty	5	5	25	Wash properly the hands with soap
		Utensils (funnel) dirty	5	5	25	Use of proper funnels
	Chemical	Jerry cans that contained chemicals	1	5	5	Prohibition of the use of these containers

Continue...

...Continue

Control measure	Monitoring programme				
	What	**How**	**When**	**Where**	**Who**
Wash properly the containers with soap	Verify the use of well cleaned containers	Awareness campaigns and inspections	Daily	At the tubewell	Guébre Habibou, Yoda Dihamatou
Use containers closed	Verify the use of closed containers	Awareness campaigns and inspections	Daily	At the tubewell	Guébre Habibou, Yoda Dihamatou
Wash properly the hands with soap	Behavioural change	Awareness campaigns and inspections	Daily	At the tubewell	Guébre Habibou, Yoda Dihamatou
Use of proper funnels	Behavioural change	Awareness campaigns and inspections	Daily	At the tubewell	Guébre Habibou, Yoda Dihamatou
Prohibition of the use of these containers	None uses these containers	Awareness campaigns and inspections	Monthly	At the tubewell	Bamboré Salimatou, Zandé Mariam

Tubewell 10. The storage and consumption

Hazardous event	Hazard	Cause	Risk: Likelihood	Risk: Severity	Risk: Score	Control measure
Drinking water contamination	Microbial	Cups used for drinking dirty	5	5	25	Wash properly the cups for drinking with soap
		Containers dirty	5	5	25	Wash properly the containers with soap
		Containers open	3	5	15	Use containers closed
		Hands dirty	5	5	25	Wash properly the hands with soap before drinking
		Containers stored outside the dwelling	5	5	25	Use dedicated containers for drinking water and store them inside the dwelling
		Dirty environment nearby the containers	5	3	15	Clean properly the environment nearby the containers
		High drinking water storage time (>1d)	3	4	12	Change regularly drinking water (daily)
	Chemical	Storage containers and cups for drinking used also for chemicals	1	4	4	Clean properly containers and cups before using them for drinking purposes
		Chlorine overdose	1	5	5	Dose the correct quantity of chlorine

Continue...

...Continue

Control measure	Monitoring programme				
	What	How	When	Where	Who
Wash properly the cups for drinking with soap	Behavioural change	Awareness campaigns and inspections	Monthly	At the dwelling	2 hygienists of Fingla, Gabré Salamatou
		Share the information	At every moment	Everywhere	Gabré Salamatou, 1 woman/yard
Wash properly the containers with soap	Behavioural change	Awareness campaigns and inspections	Monthly	At the dwelling	2 hygienists of Fingla, Gabré Salamatou
		Share the information	At every moment	Everywhere	Gabré Salamatou, 1 woman/yard
Use containers closed	Behavioural change	Awareness campaigns and inspections	Monthly	At the dwelling	2 hygienists of Fingla, Gabré Salamatou
		Share the information	At every moment	Everywhere	Gabré Salamatou, 1 woman/yard
Wash properly the hands with soap before drinking	Behavioural change	Awareness campaigns and inspections	Monthly	At the dwelling	2 hygienists of Fingla, Gabré Salamatou
		Share the information	At every moment	Everywhere	Gabré Salamatou, 1 woman/yard
Use dedicated containers for drinking water and store them inside the dwelling	Behavioural change	Awareness campaigns and inspections	Monthly	At the dwelling	2 hygienists of Fingla, Gabré Salamatou
		Share the information	At every moment	Everywhere	Gabré Salamatou, 1 woman/yard
Clean properly the environment nearby the containers	Behavioural change	Awareness campaigns and inspections	Monthly	At the dwelling	2 hygienists of Fingla, Gabré Salamatou
		Share the information	At every moment	Everywhere	Gabré Salamatou, 1 woman/yard
Change regularly drinking water (daily)	Behavioural change	Awareness campaigns and inspections	Monthly	At the dwelling	2 hygienists of Fingla, Gabré Salamatou
		Share the information	At every moment	Everywhere	Gabré Salamatou, 1 woman/yard
Clean properly containers and cups before using them for drinking purposes	Behavioural change	Awareness campaigns and inspections	Monthly	At the dwelling	Dabré Boukaré
		Share the information	At every moment	Everywhere	Dabré Boukaré, 1 woman/yard
Dose the correct quantity of chlorine	Check the dosed quantity	Awareness campaigns and inspections	Monthly	At the dwelling	2 Hygienists of Fingla, Gabré Salamatou

<u>Responsible for the WSP</u>: Mr Dabré Boukaré

A.8.11 Tubewell 11. The source

Hazardous event	Hazard	Cause	Risk			Control measure
			Likelihood	Severity	Score	
Drinking water contamination	Microbial	Improper hygiene and cleaning of the tubewell	4	4	16	Clean properly the concrete apron
		Use of dirty shoes inside the tubewell structure	4	4	16	Remove shoes before entering the tubewell's apron
		Do the laundry close to the tubewell	4	4	16	Avoid doing the laundry close to the tubewell
		Presence of excreta and rubbish close to the tubewell	3	4	12	Build an adequate fence around the tubewell
		Presence of latrines and cemeteries within 10m	1	5	5	Avoid realising latrines and cemeteries close to the tubewell
		Tubewell's pipe dirty	4	5	20	Clean properly the pipe
		Presence of animals around the tubewell	5	5	25	Awareness campaigns for the herdsmen
		Reparation of the tubewell during breakdowns	2	4	8	Clean properly all the tubewell parts before putting them back
		Presence of stagnant water around the tubewell's walls	4	4	16	Fill the tubewell's border with stones
	Chemical	Lubrication of the tubewell chain	3	5	15	Remove properly the old grease and take care during the lubrication operation
		Use of pesticides close to the tubewell	1	5	5	Prohibition of the use of pesticides around the tubewell

Continue...

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Control measure	Monitoring programme				
	What	**How**	**When**	**Where**	**Who**
Clean properly the concrete apron	Regular washing / cleanliness of the tubewell	Awareness campaigns and inspections	Weekly	At the tubewell	Bara Awa
Remove shoes before entering the tubewell's apron	Behavioural change	Awareness campaigns and inspections	Weekly	At the tubewell	Bara Awa
Avoid doing the laundry close to the tubewell	Behavioural change	Awareness campaigns and inspections	Daily	At the tubewell	Bara Awa
Build an adequate fence around the tubewell	Construction of the fence	Inspections	Annually	At the tubewell	Bancé Iliassa
Avoid realising latrines and cemeteries close to the tubewell	Absence of latrines and cemeteries close to the tubewell	Awareness campaigns and inspections	During latrines and cemeteries realisation	At the tubewell	Bancé Boukaré
Clean properly the pipe	Regular washing / cleanliness of the tubewell's pipe	Awareness campaigns and inspections	Weekly	At the tubewell	Bara Awa
Awareness campaigns for the herdsmen	Behavioural change	Awareness campaigns and inspections	Annually	At the tubewell	Bancé Hamidou
Clean properly all the tubewell parts before putting them back	Cleanliness of all the tubewell's parts	Inspections	During the reparation of breakdowns	At the tubewell	Bancé Inoussa
Fill the tubewell's border with stones	Presence of stones at the tubewell's border	Inspections	Annually	At the tubewell	Bancé Aminata
Remove properly the old grease and take care during the lubrication operation	Behavioural change	Awareness campaigns and inspections	During the lubrication operations	At the tubewell	Bancé Inoussa
Prohibition of the use of pesticides around the tubewell	Behavioural change	Awareness campaigns and inspections	Before the rainy season (when pesticides are used)	At the tubewell	Bancé Iliassa

Tubewell 11. The transport

Hazardous event	Hazard	Cause	Risk			Control measure
			Likelihood	Severity	Score	
Drinking water contamination	Microbial	Containers open	5	5	25	Use containers closed
		Hands dirty	5	5	25	Wash properly the hands with soap
		Containers dirty	5	5	25	Wash properly the containers with soap
		Utensils (funnel) dirty	5	5	25	Use of proper funnels
	Chemical	Jerry cans that contained chemicals	1	4	4	Prohibition of the use of these containers

Continue...

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Control measure	Monitoring programme				
	What	**How**	**When**	**Where**	**Who**
Use containers closed	Use of closed containers	Awareness campaigns and inspections	Daily	At the tubewell and at the dwelling	1 woman/yard
Wash properly the hands with soap	Behavioural change	Awareness campaigns and inspections	Daily	At the tubewell	1 woman/yard
Wash properly the containers with soap	Behavioural change	Awareness campaigns and inspections	Daily	At the tubewell	1 woman/yard
Use of proper funnels	Behavioural change	Awareness campaigns and inspections	Daily	At the tubewell	1 woman/yard
Prohibition of the use of these containers	None uses these containers	Awareness campaigns and inspections	Monthly	At the tubewell and at the dwelling	1 woman/yard The Hygienists of Diarra

Tubewell 11. The storage and consumption

Hazardous event	Hazard	Cause	Risk			Control measure
			Likelihood	Severity	Score	
Drinking water contamination	Microbial	Cups used for drinking dirty	5	5	25	Wash properly the cups for drinking with soap
		Containers dirty	4	5	20	Wash properly the containers with soap
		High drinking water storage time (>1d)	2	5	10	Change regularly drinking water (daily)
		Containers open	4	5	20	Use containers closed
		Hands dirty	5	5	25	Wash properly the hands with soap before drinking
		Containers stored outside the dwelling	5	5	25	Use dedicated containers for drinking water and store them inside the dwelling
		Dirty environment nearby the containers	2	3	6	Clean properly the environment nearby the containers
	Chemical	Chlorine overdose	1	5	5	Dose the correct quantity of chlorine
		Cups used for drinking rusty	1	5	5	Prohibition of the use of these cups

Continue...

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Control measure	Monitoring programme				
	What	**How**	**When**	**Where**	**Who**
Wash properly the cups for drinking with soap	Behavioural change	Awareness campaigns and inspections	Daily	At the dwelling	1 woman/yard
Wash properly the containers with soap	Behavioural change	Awareness campaigns and inspections	Daily	At the dwelling	1 woman/yard
Change regularly drinking water (daily)	Behavioural change	Awareness campaigns and inspections	Daily	At the dwelling	1 woman/yard
Use containers closed	Behavioural change	Awareness campaigns and inspections	Daily	At the dwelling	1 woman/yard
Wash properly the hands with soap before drinking	Behavioural change	Awareness campaigns and inspections	Daily	At the dwelling	1 woman/yard
Use dedicated containers for drinking water and store them inside the dwelling	Containers stored inside the dwelling	Awareness campaigns and inspections	Daily	At the dwelling	1 woman/yard
Clean properly the environment nearby the containers	Behavioural change	Awareness campaigns and inspections	Daily	At the dwelling	1 woman/yard
Dose the correct quantity of chlorine	Check the dosed quantity	Awareness campaigns and inspections	Daily	At the dwelling	1 woman/yard
Prohibition of the use of these cups	None uses these cups	Awareness campaigns and inspections	Daily	At the dwelling	1 woman/yard

Responsible for the WSP: Mrs Bancé Aminata

Annexe 9. Sustainability evaluation

A.9.1 Assessment in Senegal

Question	FonTov NGO	UniDak & DHA	WSP Team	RCP Representatives
Q1	0.83	0.83	0.89	0.89
Q2	0.50	0.66	0.81	1.00
Q3	0.83	0.92	0.97	1.00
Q4	0.83	0.75	0.89	0.55
Q5	0.66	0.83	0.86	0.55
Q6	0.66	0.83	0.72	0.55
Q7	n.a.	n.a.	n.a.	n.a.
Q8	0.50	0.58	0.44	0.44
Q9	0.33	0.17	0.30	0.00
Q10	0.33	0.17	0.25	0.00
Q11	0.33	0.17	0.50	0.11
Q12	0.17	0.17	0.30	0.00
Q13	1.00	0.92	0.97	0.89
Q14	1.00	0.92	0.94	0.78
Q15	0.33	0.75	0.55	0.55
Q16	0.50	0.67	0.39	0.67
Q17	0.33	0.50	0.58	0.55
Q18	0.17	0.42	0.58	0.67
Q19	0.83	0.83	0.92	0.66
Q20	0.83	0.83	0.94	0.66
Q21	1.00	0.92	0.86	0.89
Q22	1.00	0.92	0.83	0.89
Q23	n.a.	n.a.	n.a.	n.a.
Q24	0.17	0.33	0.58	1.00
Q25	n.a.	n.a.	n.a.	n.a.
Q26	n.a.	n.a.	n.a.	n.a.
Q27	1.00	0.92	0.75	0.77
Q28	0.17	0.58	0.75	0.33
Q29	n.a.	n.a.	n.a.	n.a.

n.a.: not applicable to the project

A.9.2 Assessment in Burkina Faso

Question	MMI NGO	Dakupa NGO	Local Hygienists
Q1	0.66	0.66	0.85
Q2	0.66	0.66	0.86
Q3	0.50	0.66	0.86
Q4	0.83	0.66	0.81
Q5	1.00	0.66	0.90
Q6	0.83	0.66	0.47
Q7	0.66	0.55	0.85
Q8	0.33	0.33	0.28
Q9	0.83	1.00	0.81
Q10	0.67	1.00	0.52
Q11	0.67	1.00	0.76
Q12	0.67	0.78	0.52
Q13	1.00	1.00	1.00
Q14	0.67	1.00	1.00
Q15	0.83	0.89	1.00
Q16	0.66	0.89	0.86
Q17	0.00	0.00	0.05
Q18	0.00	0.33	0.33
Q19	1.00	1.00	1.00
Q20	1.00	0.89	0.86
Q21	0.83	1.00	0.95
Q22	0.66	1.00	0.57
Q23	0.50	0.89	0.86
Q24	0.33	0.33	0.43
Q25	0.66	1.00	1.00
Q26	0.00	1.00	1.00
Q27	0.50	1.00	1.00
Q28	n.a.	n.a.	n.a.
Q29	1.00	1.00	1.00

n.a.: not applicable to the project

DICHIARAZIONE DI CONFORMITÀ DELLE TESI
PER IL CONSEGUIMENTO DEL TITOLO DI DOTTORE DI RICERCA
(DICHIARAZIONE SOSTITUTIVA DI ATTO NOTORIO E DI CERTIFICAZIONE)
(artt. 46-47 del D.P.R. 445 del 28.12.00 e relative modifiche)

Il sottoscritto RONDI LUCA Nato il 29/04/1985
a GATTINARA Provincia/Stato VERCELLI / ITALIA
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