POLITECNICO DI MILANO





Study and analysis of biological processes in WWTPs for management, control and automation

Dalila Pulcini

The research project

Problem analysis

State of the Art

First Year PhD

Control Strategies: Selection and Definition

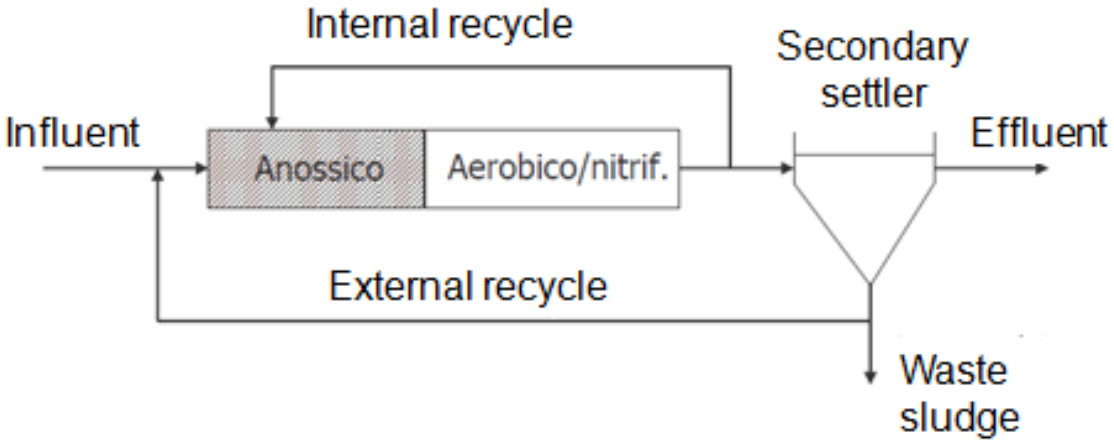
Experimental activity: Pilot plant

Second Year PhD

Real scale validation

Third Year PhD

Continuous Flow Plants



PREDENITRIFICATION/NITRIFICATION SCHEME

- ✓ Anoxic Tank, (***ANOX***): denitrification process
- ✓ Aerobic Tank, (***OX-NIT***): nitrification process
- ✓ Secondary Settler
- ✓ External recycle for sludge
- ✓ Internal recycle for aerated mixed liquor

State of the Art (1): Control Strategies

Variable	Lower limit	Upper limit
Influent Flow	Hydraulic capacity of the sewers and the equalisation tanks	Hydraulic capacity of the clarifier
Wastage Rate	SRT required (Nitrification)	SRT required (Solids flux to the settler)
Sludge Recirculation	Sludge blanket level Retention time in the settler	Hydraulic load Dilution of the sludge
Nitrates Recirculation	Nitrates demand	Denitrification capacity
Chemicals Addition	P requirements in the effluent	Economical cost
Carbon Addition	Denitrification capacity	Economical cost Excess of C load
Air flow	Respiration rate	Economical cost Excess of stirring

MODEL-BASED DESIGN OPERATION AND CONTROL OF WASTE WATER TREATMENT PLANTS

San Sebastian 2011, Prof Ayesa

State of the Art (1): Control Strategies

- Aeration
  - Objective
    - Supply dissolved oxygen for maintaining the activity in the aerobic processes
  - Operational constraints
    - Air Flow high enough to maintain DO and solids in suspension
      - Low DO reduces biological activity in aerobic processes
    - Avoid excess of aeration
      - Small increment in the biological activity
      - Increase of the operating costs (the oxygen goes to the atmosphere)
      - Risk of excess of stirring

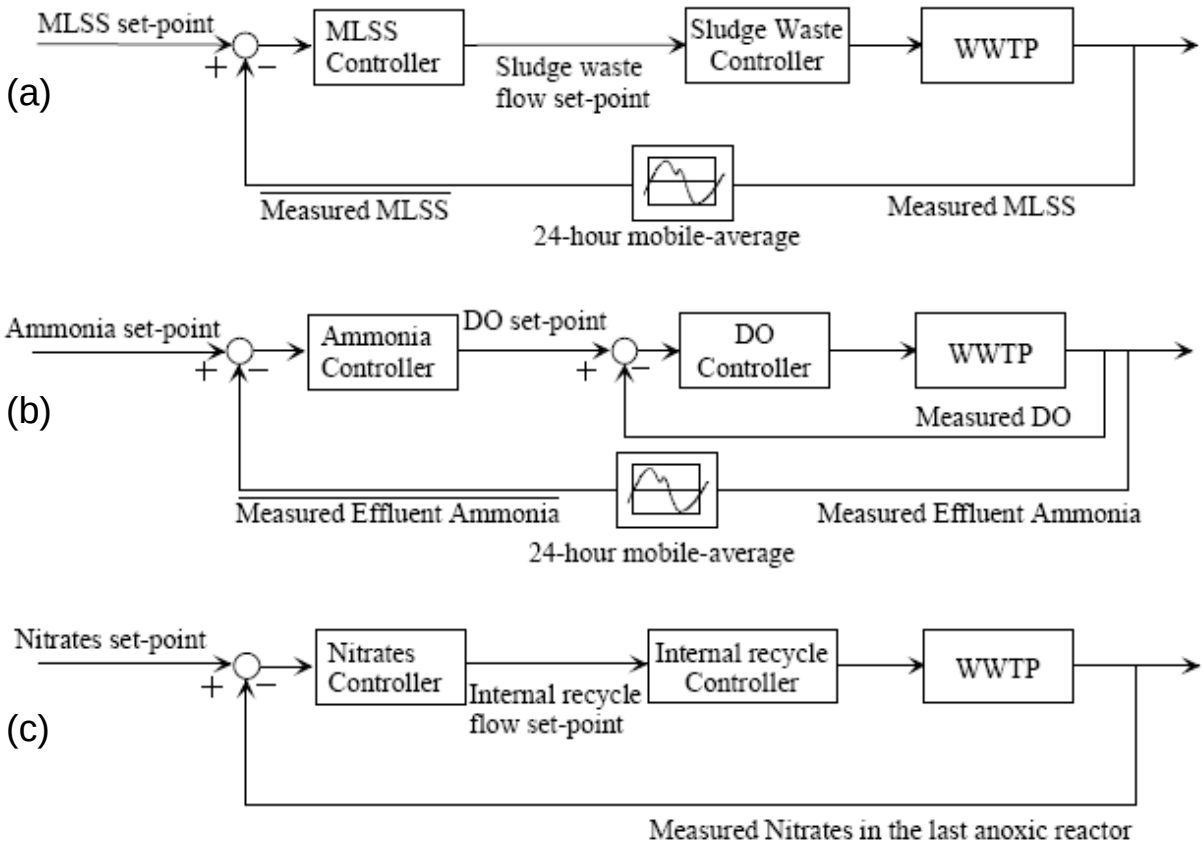
- Sludge recirculation
  - Objective
    - Regulation of the sludge mass in the settler
  - Effects
    - Low influence in the biological processes
    - Significant influence in effluent quality (solids)
  - Operational constraints
    - Sludge blanket height
    - Retention time of the settled sludge
    - Hydraulic perturbations in the clarification
    - Dilution of the sludge

MODEL-BASED DESIGN OPERATION AND CONTROL OF WASTE WATER TREATMENT PLANTS

San Sebastian 2011, Prof Ayesa

- Nitrates recirculation
  - Objective
    - To transport nitrates to the anoxic zones for denitrification
  - Operational constraints
    - Flow-rate sufficiently high to denitrify the influent bCOD
    - Prevent inhibition of the denitrification for excess of oxygen
    - Optimal recirculation depends at each moment on the operational conditions and influent load
  - Conventional operation
    - Flow-rate proportional to the influent

State of the Art (2): Case study Bilbao

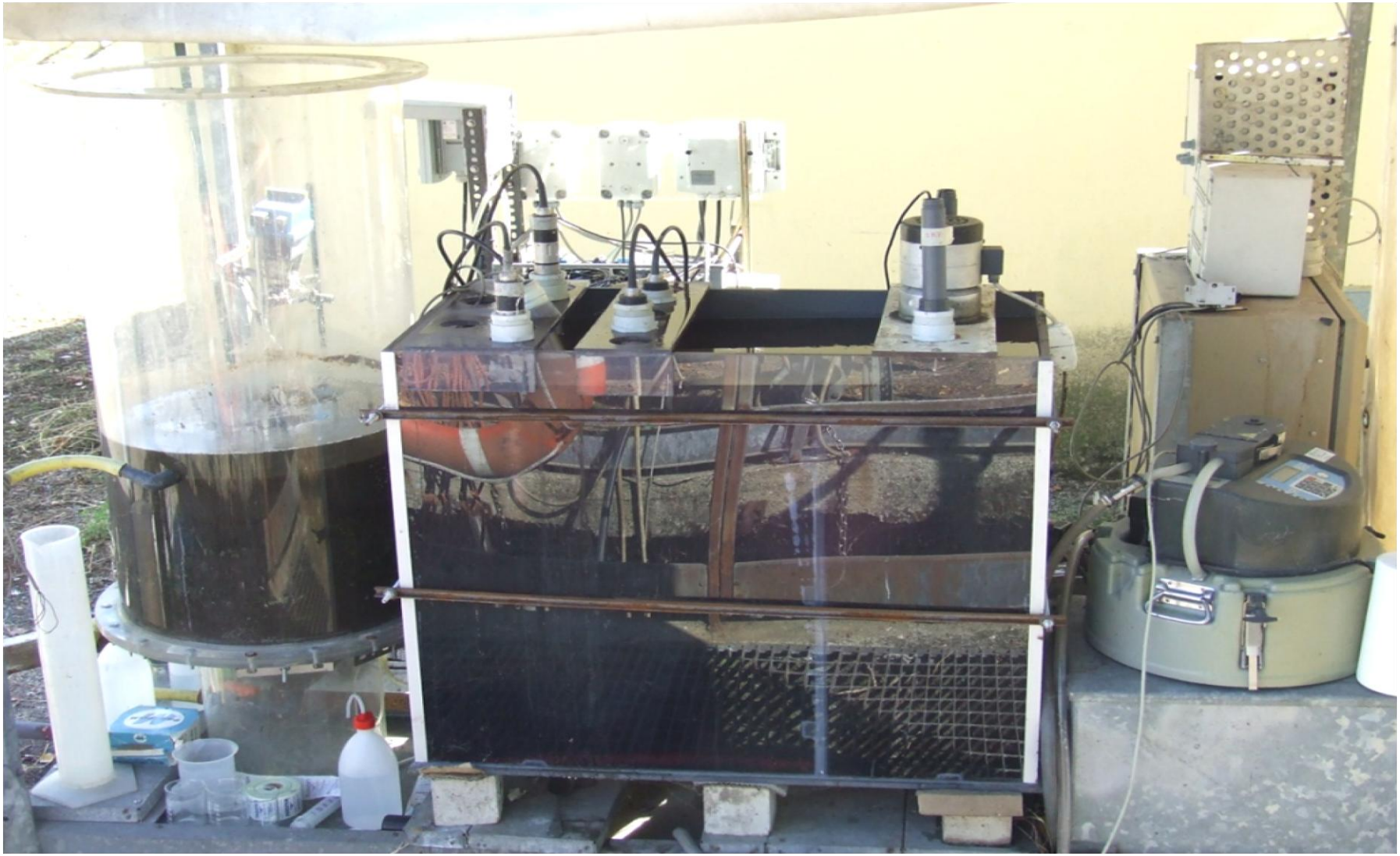


a) Maintaining a selected averaged value of the total mass of suspended solids in the biological reactors via the automatic manipulation of the wastage rate.

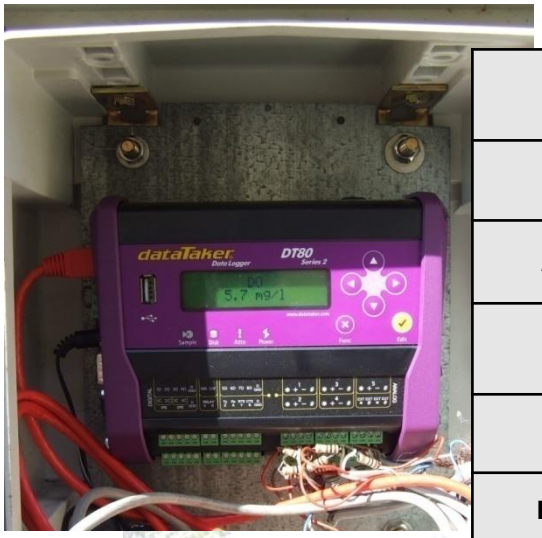
b) The measurement of effluent Ammonia concentration should be made at the exit from the biological reactors 24-hours mobile average filters the typical variation in the effluent concentration generated by the daily load profile the controller moves smoothly according to medium and long term disturbances

c) Control based on the **instantaneous** value of the Nitrates in the anoxic zone and does not need any kind of mobile averaged filter

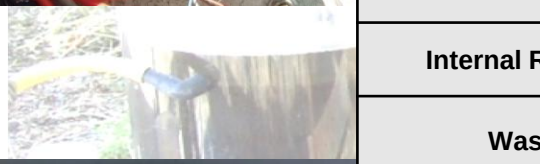
Pilot Plant

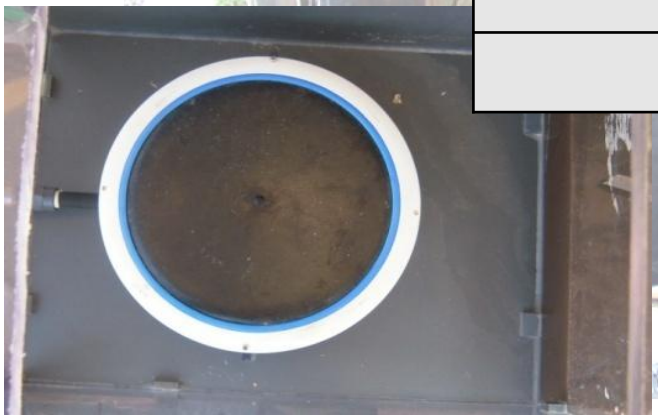


Pilot Plant



Main Features	Value	U.M
Anoxic Tank Volume	94,5	L
Aerobic Tank Volume	175,5	L
Settler	83	L
Influent Flow	460	L/d
External Recycle Flow	430	L/d
Internal Recycle Flow	760	L/d
Waste Flow	3	L/d
kla	140	1/d

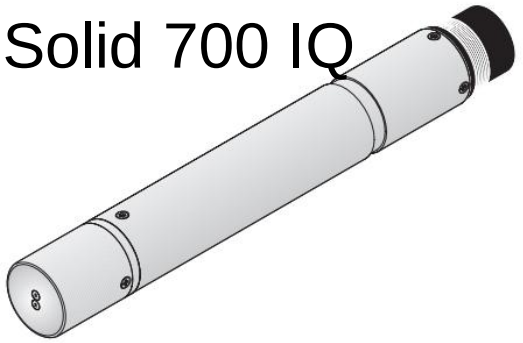




Probes installed

Trioximatic 700

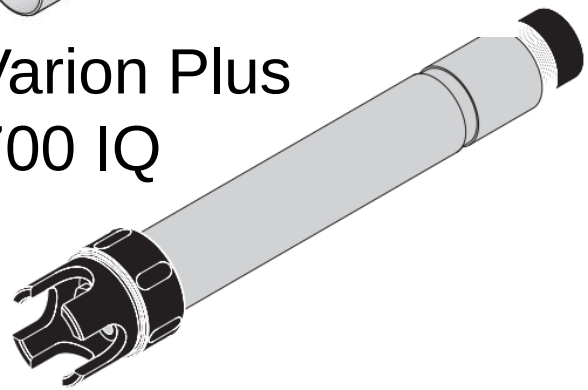
ViSolid 700 IQ



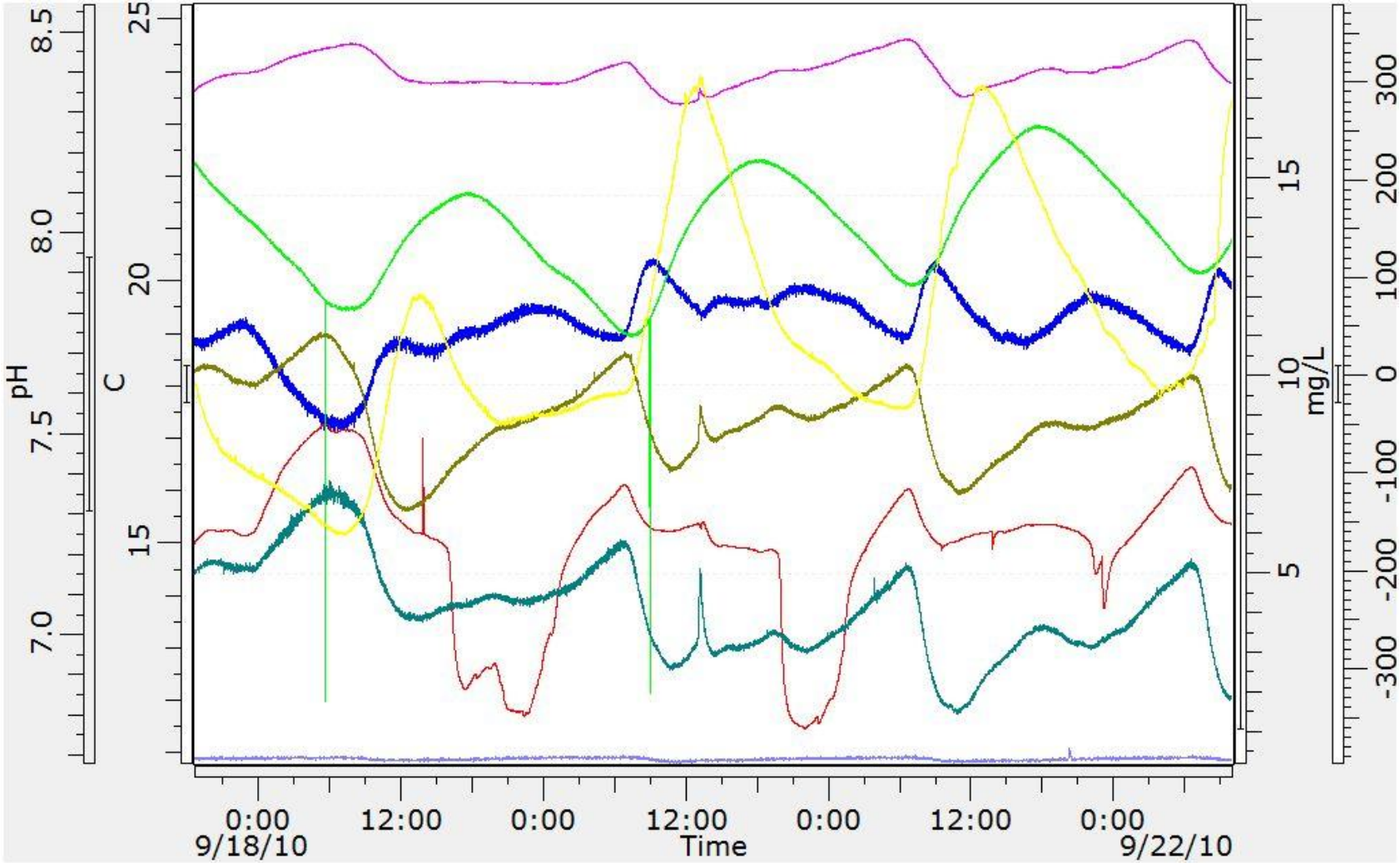
pH

ORP

Varion Plus
700 IQ

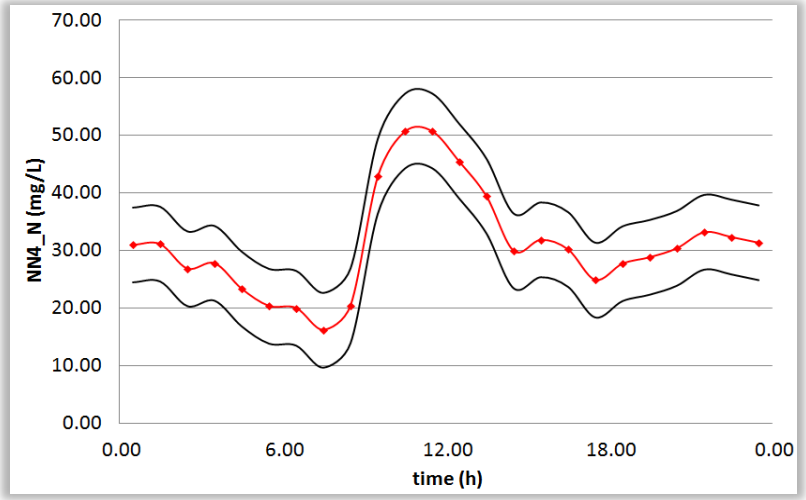


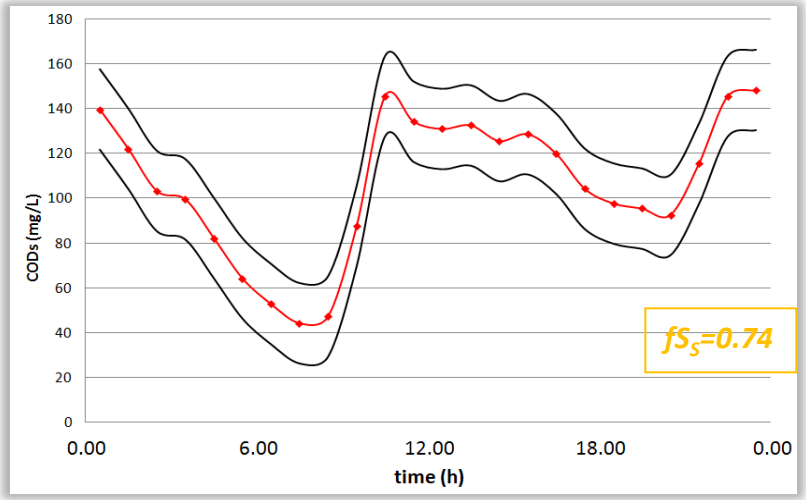
Probes installed

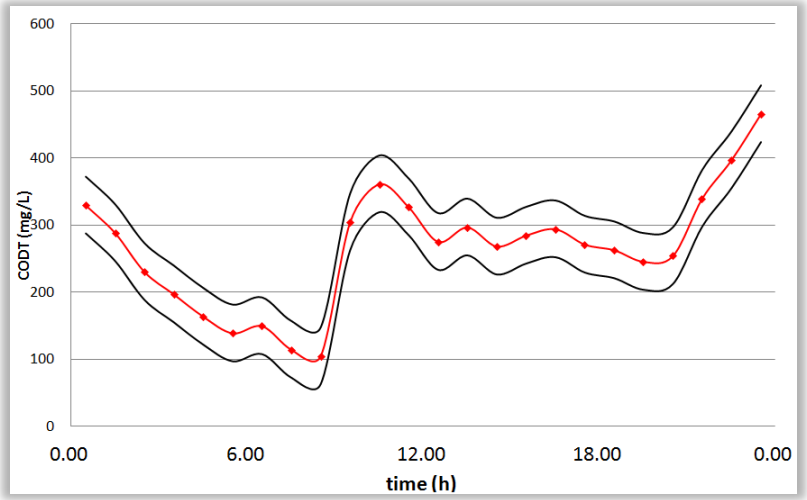


Influent Characterization

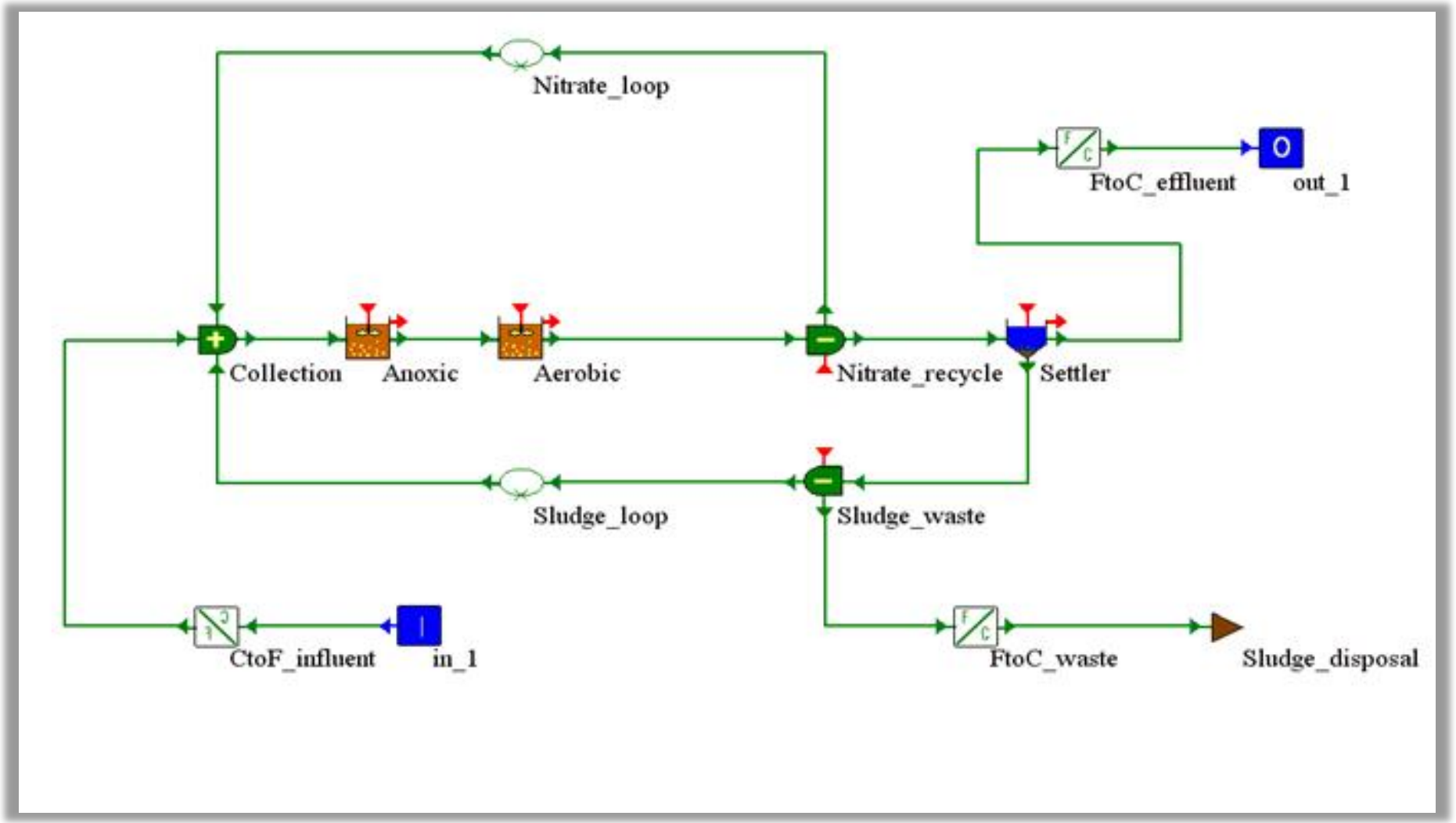
The real wastewater has been characterized using **seven** data-set, all composed by 24 values, collected in different days by an automatic sampler.



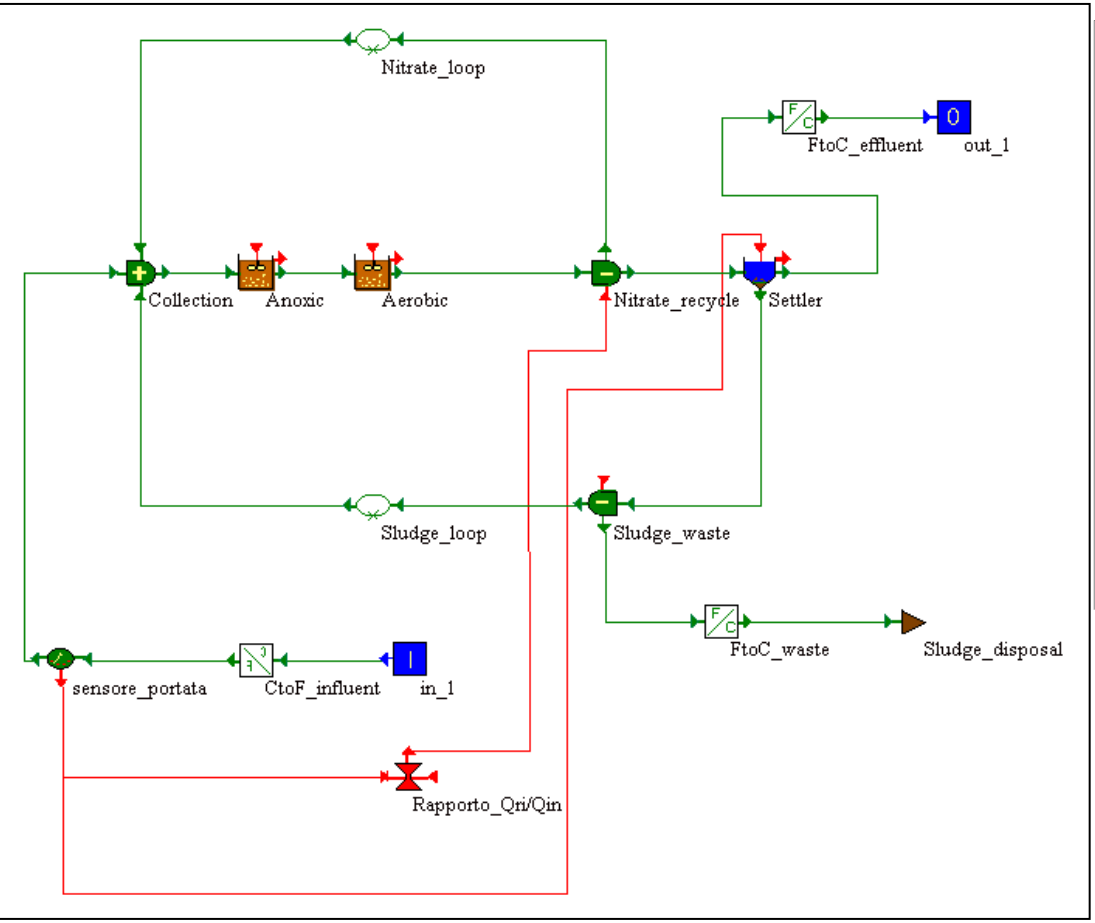


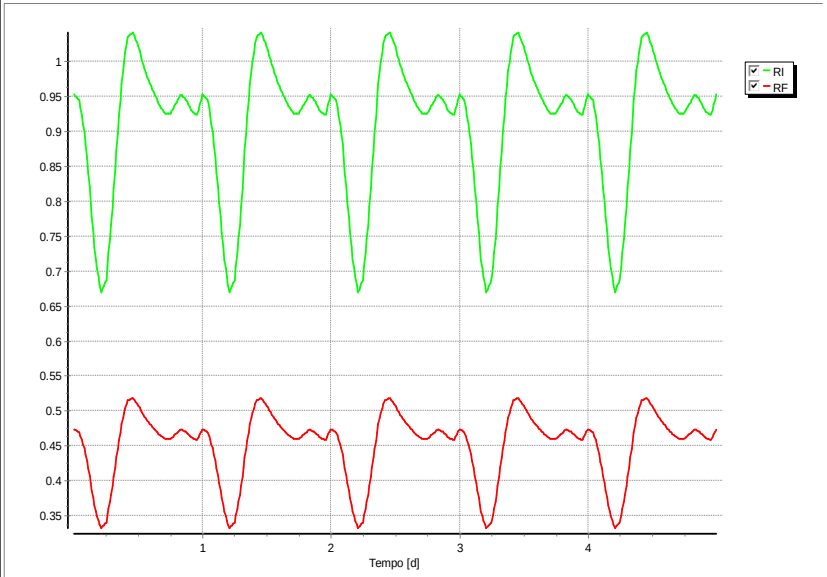


ASM1: WEST


Nitrate_loop
FtoC_effluent
out_1
Collection
Anoxic
Aerobic
Nitrate_recycle
Settler
Sludge_loop
Sludge_waste
CtoF_influent
in_1
FtoC_waste
Sludge_disposal

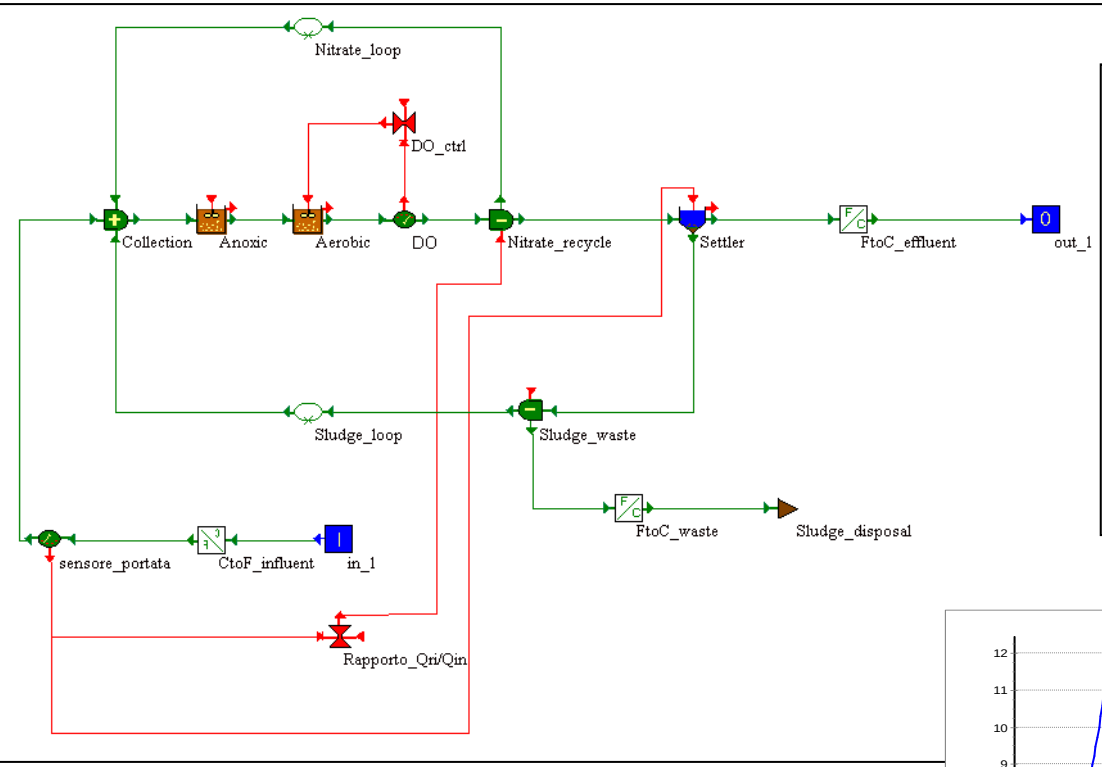
Control Strategies(1)

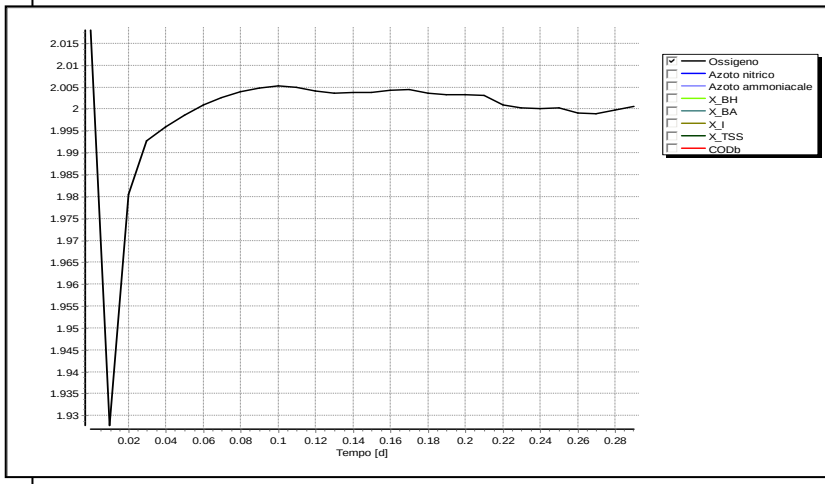


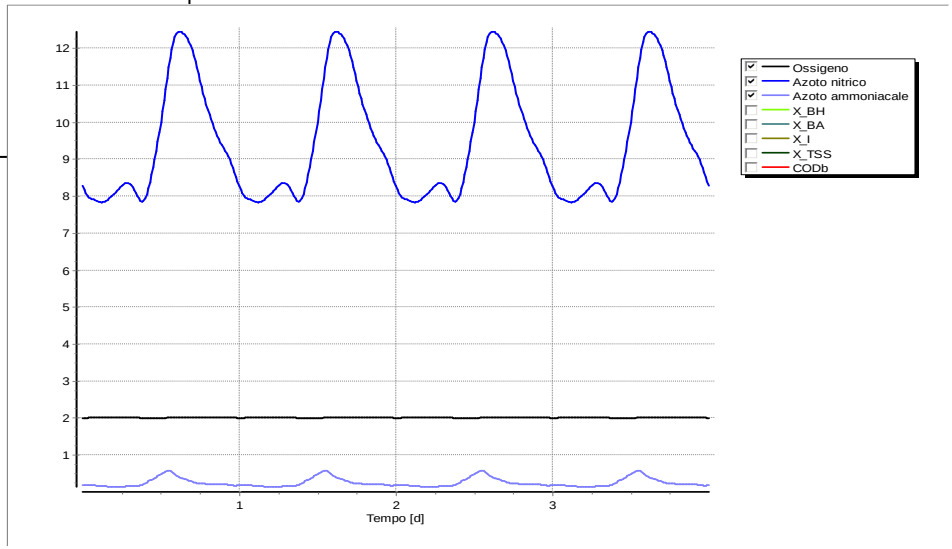


1. Constant Flow Rate for internal and external recycle according to the influent

Control Strategies(2)

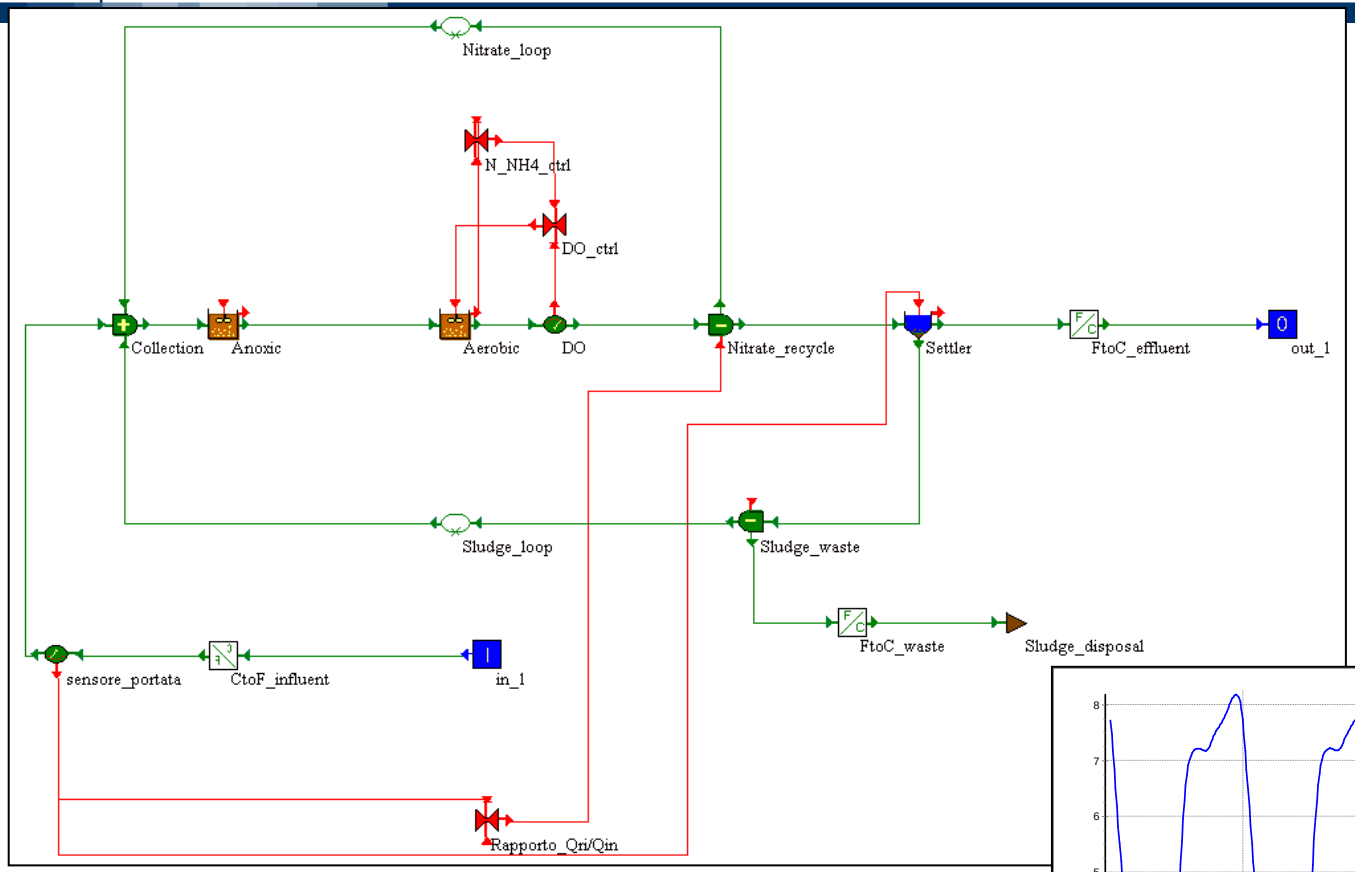


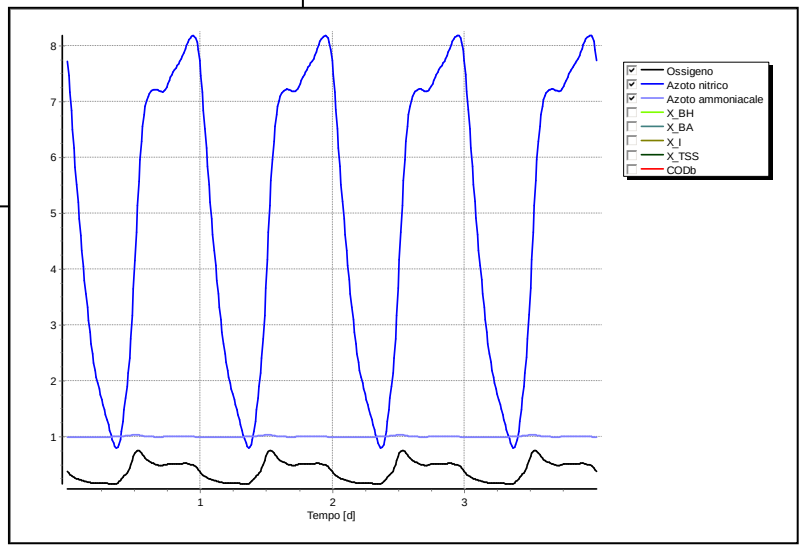




2.DO setpoint 2mg/l

Control Strategies(3)



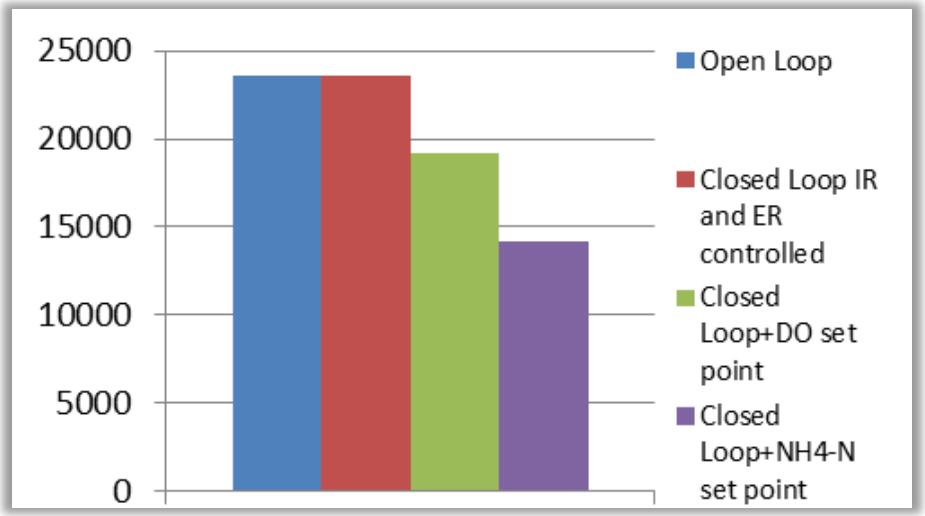


3. DO controlled by N-NH4 settpoint:1 mg/l

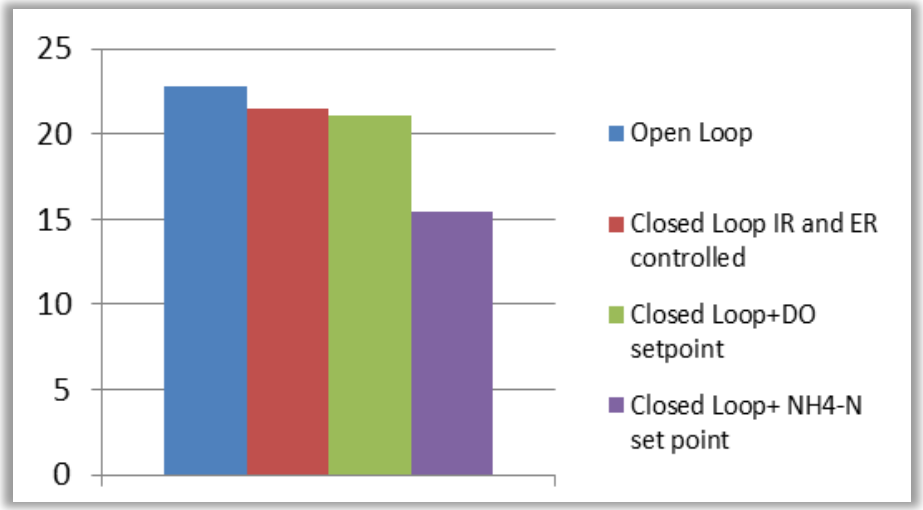
Results

The lower oxygen consumption, corresponding to the minimum value of KLa, was obtained controlling the DO by the ammonia concentration at the end of the aerobic zone.

The combination of DO controlled by ammonia concentration in aerobic zone and variable flow rate for internal and external recycle obtained best results in terms of Effluent Quality and cost saving.



KLa comparison for different control strategies



Effluent Quality for different control strategies

Tested strategies will be applied to the pilot plant to verify the simulated results

Thanks for your attention