SMALL WASTEWATER TREATMENT PLANTS IN ITALY: SITUATION AND CASE STUDIES OF UPGRADING

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Centralization or decentralization ?

- The choice depends on many factors that must be evaluated with a specific-case approach.
- In a **centralized plant** complex wastewater treatment technologies, sludge digestion and thermal drying are justified; monitoring and regulation systems can be conveniently installed.
- But centralization has also **disadvantages:** a big plant is served by a long branched sewer network and many pumping stations (costs of realization, exercise and maintenance); a centralized plant usually treats also industrial wastewater.
- With **decentralized small plants** the impact of residual pollutants is distributed in a wide territory, consequences of a failure in one plant are limited.
- With decentralized plants local reuse of treated water is favoured.
- The choice centralization / decentralization is still an open question.

The general Italian situation

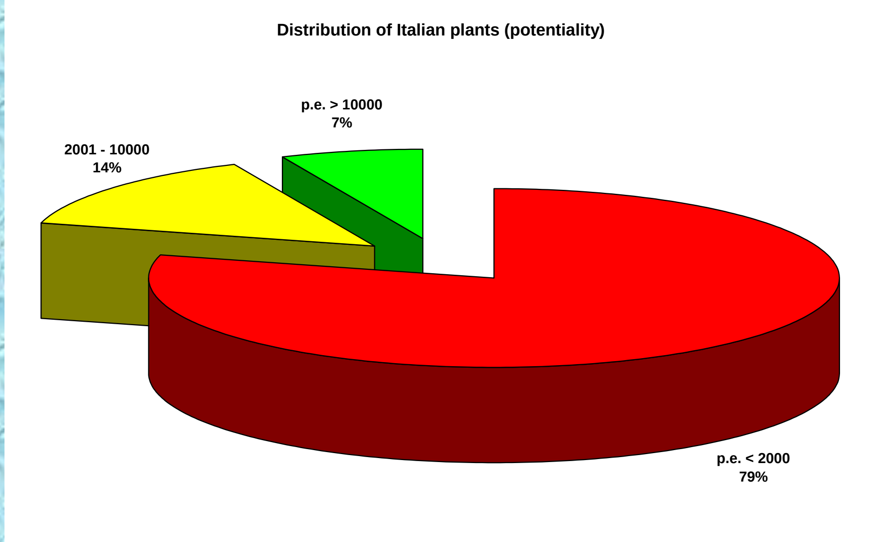
- The Italian national law D.Lgs. 152/2006 (that applies the European Directive nr. 271/91) requires emission limits for plants that serve more than 2000 p.e.; for smaller plants it requires **“an appropriated treatment”** and for isolated buildings it commits regions to individuate suitable treatments.

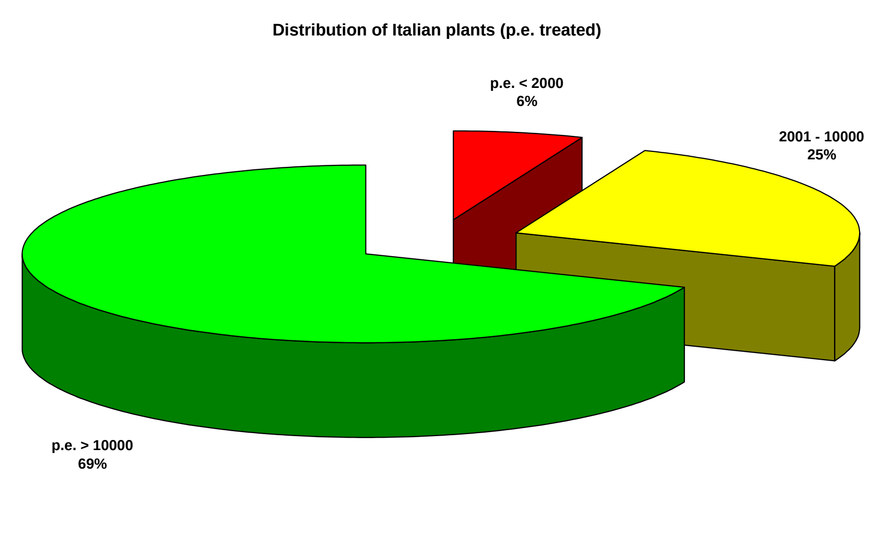
- Each Italian region has its own **local wastewater regulation**; these local regulations have been changed more times in the last 20 years
- Local emission limits depend on **potentiality** (p.e.) and **type of final receptor** (river, lake, soil); some regions divide their territory into areas with **different sensitivity** (limits are different for plants with same potentiality and type of final receptor).

- Some Italian regions have **technical norms** to project small wastewater treatment plants.

The general Italian situation

- In Italy there are 11509 WWTP; **78%** of them have a potentiality of **less than 2000 p.e.** and 14% have a potentiality between 2000–10000 p.e.
- All the smallest plants altogether treat only **6%** of pollutant load, plants between 2000–10000 p.e. altogether treat 25% of pollutant load.





The general Italian situation

- Plants that serve isolated buildings and plants for **less than 2000 p.e.** have only a **primary treatment** and often are Imhoff tanks.
- Plants with a **secondary treatment** are generally **activated sludge** plants with several different schemes (classical, extended aeration or predenitrification-oxidation, with static settler or with scraping bridge, sludge recirculation by pumping or gravity, turbine or diffused aeration); there are also **biofilm plants** as trickling filters (TF), rotating biological contactors (RBC) and **constructed wetland.**

Potentiality (p.e.)	Primary	Secondary	Tertiary	Total platns
p.e. < 2000	5659	3053	306	9018
2001 - 10000	112	1240	243	1595
10001 - 100000	61	508	193	762
p.e.> 100000	7	54	73	134
Total	5839	4855	815	11509

The general Italian situation

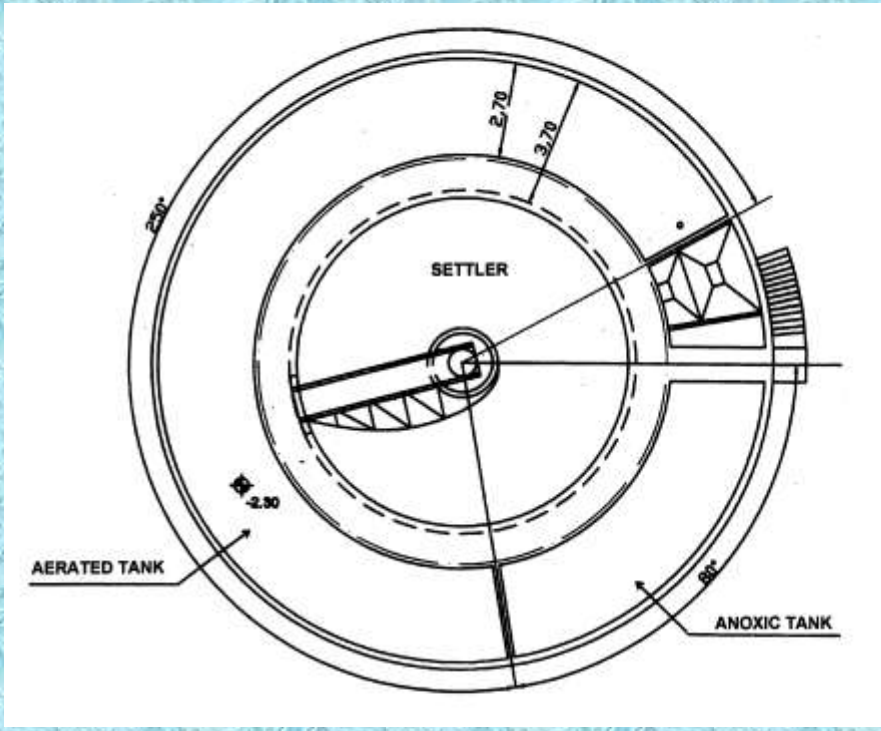
- A study conducted on 463 plants reports that **Imhoff tanks** have very variable pollutants removal efficiencies (for COD 30–70%, avg. 50%).
- **Activated sludge plants** work much better, but within this category there are **significant differences**. Average COD removal efficiency is 85% for classical-scheme, extended aeration and predenitrification-oxidation plants; gravity-recirculation plants remove only 54% of COD.
- TF remove 62% of COD, RBC remove 77% of COD, constructed wetlands have a COD removal efficiency similar to activated sludge.

- Plants of less than 2000 p.e. have **higher specific costs** than larger ones (28 €/p.e.·year vs. 20 €/p.e.·year).

- **Difficulties** encountered with small plants: wide variations of hydraulic and pollutants loads, infiltrations in sewers, cost of sludge transportation to bigger plants (often local treatment is limited to thickening).

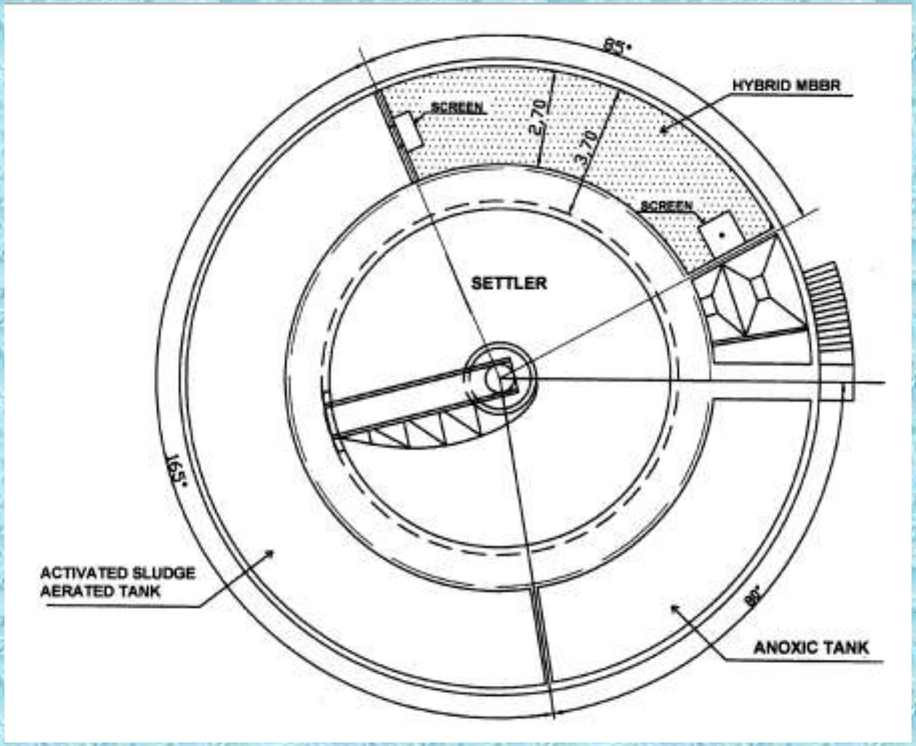
Case studies of upgrading (1)

- Plant nr. 1 was built for **3000 p.e.** and was made of a pumping station, a screen and a biological section with predenitrification tanks (150 m^3), oxidation tanks (470 m^3) and settlers (310 m^3); air was supplied by two 360 Nm^3/h blowers for line nr. 1 and a 580 Nm^3/h blower for line nr. 2.
- The plant was overloaded: effective hydraulic load was **3800 p.e.,** the organic load was **4500 p.e.,** the nitrogen load was **5800 p.e.**



Case studies of upgrading (1)

- The plant was upgraded by dividing each aerated tank into two parts: 2/3 was kept as activated sludge tank, 1/3 was converted into a hybrid MBBR reactor. AnoxKaldnes polyethylene carriers (spec. surf. 500 m^2/m^3) were put with filling degree 50%, a screen was installed, new air diffusers were installed. Also blowers were replaced: one 1100 m^3/h unit for activated sludge tanks, one 1400 m^3/h unit for the 2 hybrid MBBR.



After re-starting, with pollutants load of 370 kg_{COD}/d and 60 kg_{TKN}/d, removal efficiencies were 90% for COD, 99% for TKN and 87% for Tot-N.

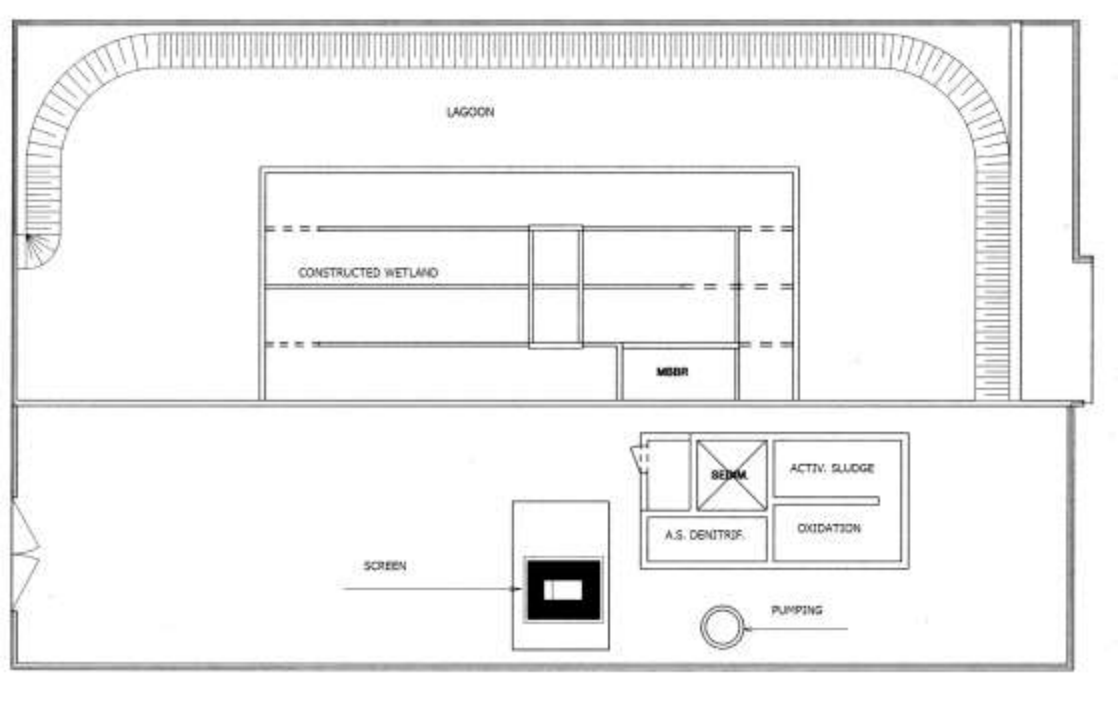
Case studies of upgrading (2)

- Plant nr. 2 was originally built for **400 p.e.** and was made of a pumping station, a screen, an activated sludge oxidation tank (vol. 55 m^3) with temporised aeration (14 hrs./day), a static settler (vol. 9 m^3), a small tank (vol. 8 m^3) out of use, a sludge thickener (vol. 20 m^3) out of use and a final constructed wetland.

- The plant was overloaded: effective hydraulic load was **413 p.e.,** organic load was **371 p.e.** and nitrogen load was **549 p.e.**

- The plant was upgraded: the thickener was converted into a predenitrification tank, the aeration time of the oxidation tank was increased to 18 hrs./day and the small tank (8 m^3) was transformed into a pure biofilm MBBR™. AnoxKaldnes polyethylene carriers (spec. surf. 500 m^2/m^3) were put with filling degree 50%, a screen was installed; air was supplied by a 50 Nm^3/h blower and medium bubbles diffusers.

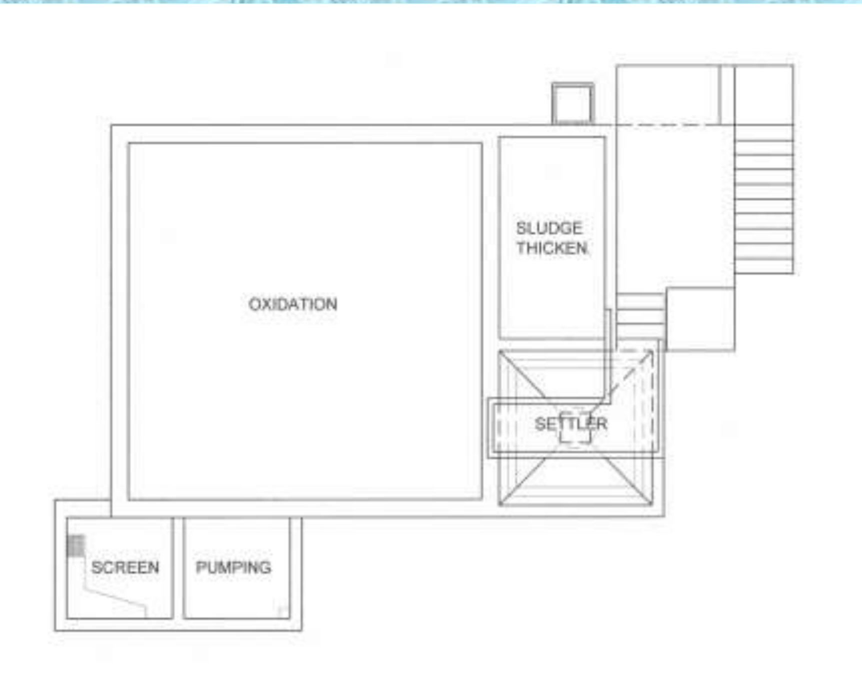
Case studies of upgrading (2)



After re-starting, with pollutants loads of 46 kg_{COD}/d and 6 kg_{TKN}/d, removal efficiencies were 82% for COD, 81% for TKN and 69% for Tot-N.

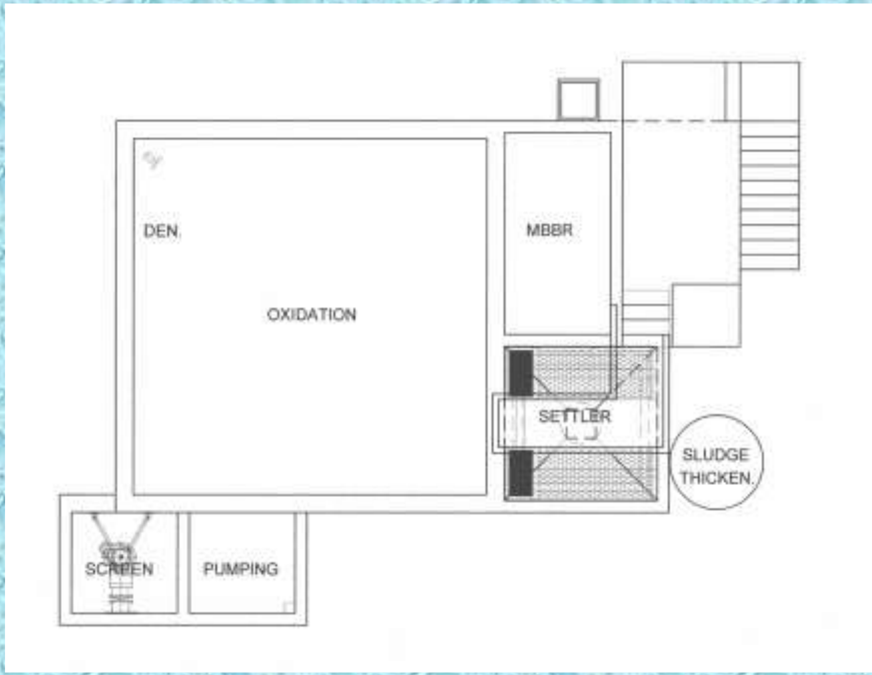
Case studies of upgrading (3)

- Plant nr. 3 was built for **500 p.e.** and was made of a pumping station, a coarse screen, an activated sludge oxidation tank (100 m^3), a static settler (11 m^3) and a sludge thickener (vol. 18 m^3).
- The plant was overloaded: effective hydraulic load was **1160 p.e.,** organic load was **765 p.e.** and nitrogen load was **820 p.e.**



Case studies of upgrading (3)

- The plant was upgraded: a fine screen was installed, an anoxic zone (20 m^3) was created in oxidation tank, inclined plates (60 from horiz, surf. 30 m^2) were installed in settler. The thickener was converted into a pure biofilm MBBR, a prefabricated sludge thickener was installed. In the new MBBR, AnoxKaldnes polyethylene carriers (spec. surf. 500 m^2/m^3) were put, filling degree 50%; a screen was installed. Air was supplied by 180 m^3/h blower, medium bub.diffusers.



After re-starting, with pollutants loads of 68 kg_{COD}/d and 10 kg_{TKN}/d, removal efficiencies were 87% for COD, 87% for TKN and 46% for Tot-N.

Case studies of upgrading (4)

- Plant nr. 4 was built for **3500 p.e.** and was made of a screen, a pumping station and an activated sludge biological section with an anaerobic selector (vol. 25 m^3), an oxidation tank (vol. 412 m^3) and two settlers (total vol. 115 m^3); excess sludge was treated in a thickener and a filter press.
- The plant was overloaded: effective hydraulic load was **5000 p.e.,** organic load was **5716 p.e.** and nitrogen load was **6333 p.e.**

- The plant was upgraded: a flow divider was built to send 80% of the load to a new equalization tank (20 m^3) and then to a new dissolved air flotation Deltafloat® tank (16 m^3); wastewater coming from the flotation tank and the remaining 20% of raw wastewater was sent to the existing biological section. Primary sludge from the flotation tank was treated together with secondary excess sludge.
- After re-starting, with pollutants loads of 693 kg_{COD}/d and 80 kg_{TKN}/d, the settler removed 60% of incoming COD and 16% of incoming TKN; the whole plant removed 95% of COD, 98% of TKN and 68% of Tot-N.

Case studies of upgrading (5)

- Plant nr. 5 was built for **2500 p.e.** and was made of a pumping station, a screen, an activated sludge tank (anoxic volume 100 m^3, aerated volume 92 m^3), a settler (volume 100 m^3), a sludge thickener and a belt filter press.
- The plant was not overloaded for pollutants loads, but during rainy weather the **hydraulic loads reached 3900 p.e.** and so the settler was overloaded.

- The plant was upgraded: a dissolved air flotation Deltafloat® tank (12 m^3) was installed to work in parallel to the existing settler during rainy days to separate treated water from sludge, which is recirculated to the biological tank.
- During rainy days the DAF tank has treated an average hydraulic load of 17 m^3/h (42 m^3/h including air saturated clarified water recirculation) and an average solid load of 60 kg_{SS}/h (including recirculation), it removed solids with an efficiency of 99.1%. The effluent has always respected emission limits without sludge loss to the constructed wetland. Excess sludge production has not changed significantly.

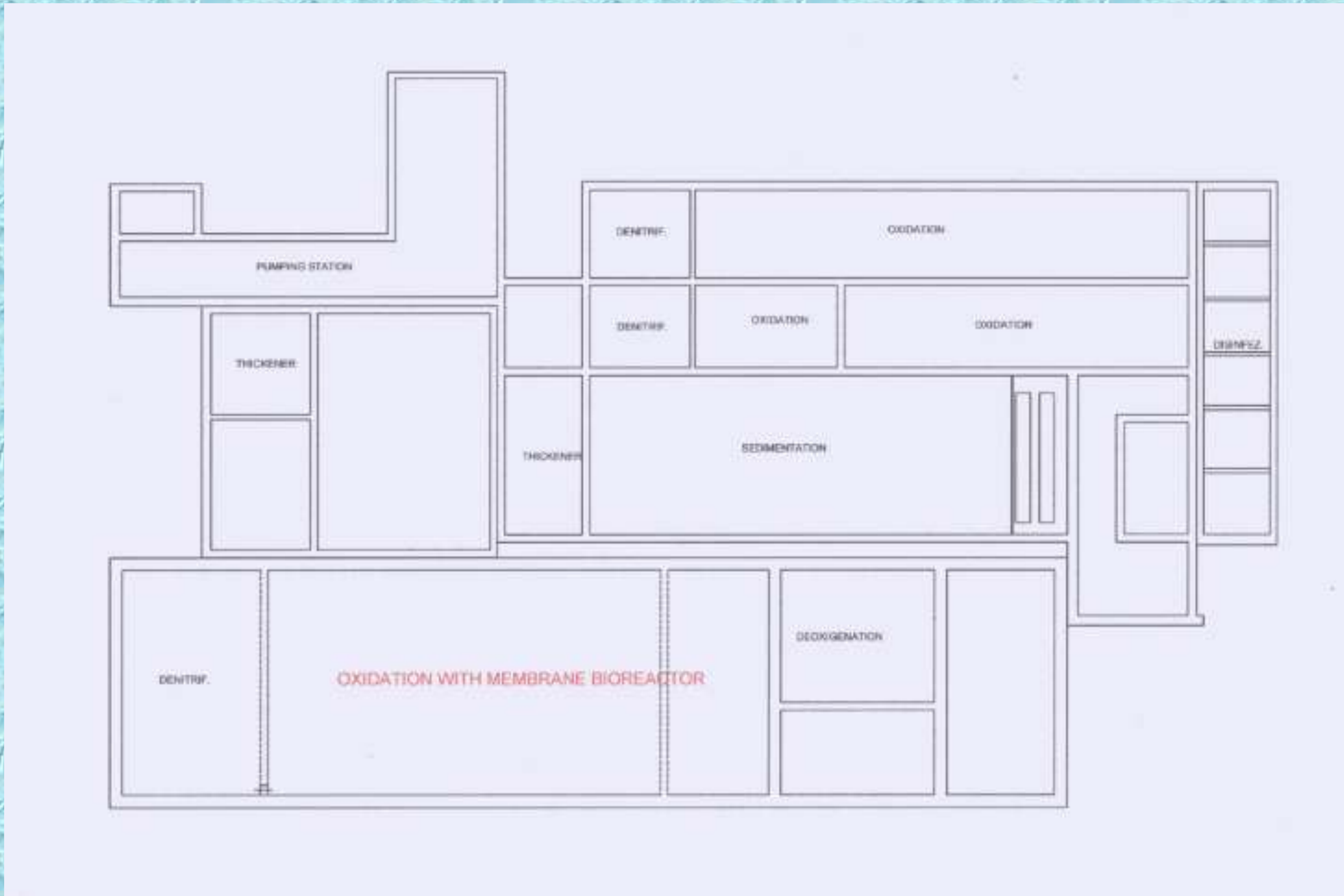
Case studies of upgrading (6)

- Plant nr. 6 was built in a touristic locality for 4000 p.e. during winter and 12500 p.e. during summer; it was made of a pumping station, a screen, an activated sludge biological section with two predenitrification tanks (vol. 104 m^3), three oxidation tanks (vol. 590 m^3) and two settlers (vol. 255 m^3), a disinfection tank (70 m^3); sludge is treated in a thickener (60 m^3).
- During summer the plant was overloaded: effective hydraulic load was 9400 p.e., organic load was 19900 p.e. and nitrogen load was 17450 p.e.; moreover an increase in hydraulic load was expected.

- The plant was upgraded by building a new biological line with membrane reactors: this new line is made of a predenitrification tank (225 m^3), an oxidation tank (800 m^3) with Kubota membranes (total surf. 2500 m^2) and a deoxygenation tank (150 m^3). In the old line activated sludge concentration is 4 kg_{TS}/m^3 and in the new line activated sludge concentration is 8 kg_{TS}/m^3.

- During last summer the plant treated 2400 m^3/d in the old line, 1000 m^3/d in the new line; with pollutants loads of 1312 kg_{COD}/d and 95 kg_{TKN}/d, removal efficiencies were 95% for COD, 99% for TKN and 60% for total nitrogen.

Case studies of upgrading (6)



Conclusions

- The choice between centralization and decentralization is still an open question and depends on many different factors and requires case-specific approach.

- In a centralized plant complex technologies are justified, monitoring and regulation systems can be conveniently installed; but a big plant is served by a long branched sewer network and many pumping stations. Decentralized small plants distribute the impact of residual pollutants in a wide territory, and consequences of a failure in one plant are limited.

- The case studies reported here demonstrate that overloaded small plants can be easily upgraded with advanced technologies with minimal additional space request and often by just recovery and conversion of existing tanks.

Thanks for attention !

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