

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

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Abstract

The choice between centralization and decentralization of wastewater treatment depends on many factors and requires a case-specific approach. Most of Italian plants are small, but they altogether treat only a little fraction of total pollutant load and must comply with different local regulations. This paper reports some examples of upgrading of small overloaded plants with advanced technologies; three plants were upgraded with moving bed biofilm reactors, two plants with dissolved air flotation and a plant with a new line of membrane bioreactors. In all these plants pollutants removal efficiencies improved with minimal additional space request or with just recovery or conversion of existing tanks.

Keywords: wastewater treatment; small plants; upgrading; centralization; decentralization

Introduction

The choice between centralization and decentralization of wastewater treatment depends on many factors that must be evaluated with a specific-case approach (Orth, 2007). In a centralized plant complex wastewater treatment technologies, sludge digestion and thermal drying are economically justified; moreover continuous monitoring and automatic 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 with high costs of realization, exercise and maintenance; moreover, a centralized plant usually treats also industrial wastewater (Masotti & Verlicchi, 2005). With many decentralized small plants the impact of residual pollutants is distributed in a wide territory, consequences of a failure in one plant are limited and local reuse of treated water is favoured (Wilderer & Schreff, 2000). So the choice between centralization and decentralization is still an open question. This paper is focused on the Italian situation of small plants and some case studies of upgrading with advanced technologies such as lamellar settlers, dissolved air flotation, moving bed biofilm reactors and membrane bioreactors.

General Italian Situation

According to a study published by the Italian Statistic Institute (ISTAT, 2006) among 11509 wastewater treatment plants, 78% of them have a potentiality of less than 2000 p.e. (most of which have only a primary treatment) and 14% of them have a potentiality between 2000–10000 p.e. (most of which have a secondary treatment). All the smallest plants altogether treat only 6% of pollutant load, while plants with a potentiality of 2000–10000 p.e. altogether treat 25% of pollutant load. Plants that serve isolated buildings have only a primary treatment and are generally Imhoff tanks; plants with a secondary treatment are generally activated sludge plants with 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 applications of biofilm processes as trickling filters (TF), rotating biological contactors (RBC) and constructed wetland. The Italian national law D.Lgs. 152/2006 (that applies the European Directive nr. 271/91) requires emission limits for plants that serve 2000 p.e. or more, while for smaller plants requires “an appropriated treatment” and for isolated buildings it commits regions to individuate suitable treatments.

Each Italian region has its own local wastewater regulation; local emission limits depend on potentiality (p.e.) and type of final receptor (river, lake, soil); moreover some regions divide their territory into areas with different sensitivity (so limits are different for plants with same potentiality and type of final receptor), and others have technical norms to project small wastewater treatment plants.

As reported in a study conducted on 463 plants (Avezzù et al, 2010), with Imhoff tanks removal efficiencies are very variable (for COD 30–70%, average 50%); activated sludge plants work much better, but within this large category there are significant differences. Average COD removal efficiency is 85% for classical–scheme, extended aeration and predenitrification–oxidation plants, but gravity–recirculation plants on average basis remove only 54% of COD. TF and RBC remove respectively 62% and 77% of COD. Plants of less than 2000 p.e. have higher specific costs than larger ones (28 €/p.e.·year vs. 20 €/p.e.·year); common difficulties encountered with small plants are wide variations of hydraulic and pollutants loads, infiltrations in sewers and cost of sludge transportation to bigger plants (often local treatment is limited to thickening).

Case Studies of Upgrading

Plant nr. 1 was originally built for 3000 p.e. and was made of a pumping station, a screen and a biological section with two parallel activated sludge lines. The biological section included predenitrification tanks (total volume 150 m³), oxidation tanks (total volume 470 m³) and settlers (total volume 310 m³); air was supplied by two 360 Nm³/h blowers for line nr. 1 and one 580 Nm³/h blower for line nr. 2. The plant was overloaded: the effective hydraulic load corresponded to 3800 p.e., the organic load to 4500 p.e. and the nitrogen load to 5800 p.e. So the plant was upgraded by dividing each aerated tank into two parts: 2/3 of the volume was kept as an activated sludge reactor, 1/3 was converted into a hybrid moving bed biofilm reactor (MBBR™). In this sector Anox–Kaldnes polyethylene carriers (specific surface 500 m²/m³) were put with filling degree 50%, a screen was installed to keep carriers in the tank and original

air diffusers were replaced with special medium bubbles diffusers. Blowers were also replaced: one 1100 Nm³/h unit for activated sludge tanks, one 1400 Nm³/h unit for hybrid MBBR™ tanks. After the re-starting phase, activated sludge concentration was 3.2 g_{TS}/m³, biofilm concentration reached 1.7 g_{TS}/m² (0.5 kg_{TS}/m³). 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 total nitrogen.

Plant nr. 2 was originally built for 400 p.e. and was made of a pumping station, a screen, an activated sludge oxidation tank (volume 55 m³) with temporised aeration (14 hrs./day), a static settler (volume 9 m³), a small tank (8 m³) out of use, a sludge thickener (20 m³) out of use and a final constructed wetland. The plant was overloaded: the effective hydraulic load corresponded to 413 p.e., the organic load to 371 p.e. and the nitrogen load to 549 p.e. So 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 m³) was transformed into a pure biofilm MBBR™. In this reactor Anox-Kaldnes polyethylene carriers (specific surface 500 m²/m³) were put with filling degree 50%, a screen was installed to keep carriers in the tank; air was supplied by a 50 Nm³/h blower and medium bubbles air diffusers. After the re-starting phase biofilm concentration in the tertiary MBBR™ reached 4.4 g_{TS}/m² (1.1 kg_{TS}/m³). 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 total nitrogen.

Plant nr. 3 was originally built for 500 p.e. and was made of a pumping station, a coarse screen, an activated sludge oxidation tank (volume 100 m³), a static settler (volume 11 m³) and a sludge thickener (18 m³). The plant was overloaded: the effective hydraulic load corresponded to 1160 p.e., the organic load to 765 p.e. and the nitrogen load to 820 p.e. So the plant was upgraded: the coarse screen was replaced with a fine screen, an anoxic zone (20 m³) was created in the oxidation tank, inclined plates (60° from horizontal, surface 30 m²) were installed in the settler, the old thickener was converted into a pure biofilm MBBR™ and a prefabricated sludge thickener was installed. In the tertiary MBBR™ tank Anox-Kaldnes polyethylene carriers (specific surface 500 m²/m³) were put with filling degree 50%, a screen was installed to keep carriers in; air was supplied by a 180 Nm³/h blower and medium bubbles air diffusers. After the re-starting phase biofilm concentration in the tertiary MBBR™ reached 1.0 g_{TS}/m² (0.26 kg_{TS}/m³). 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 total nitrogen.

Plant nr. 4 was originally built for 3500 p.e.; it was made of a screen, a pumping station and an activated sludge biological section with an anaerobic selector (25 m³), an oxidation tank (412 m³) and two settlers (total volume 115 m³); excess sludge was treated in a thickener and a filter press. The plant was overloaded: the effective hydraulic load corresponded to 5000 p.e., the organic load to 5716 p.e. and the nitrogen load to 6333 AE. So the plant was upgraded: a flow divider was built to send 80% of the load to a new equalization tank (20 m³) and then to a new dissolved air flotation Deltafloat® tank (16 m³); 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 the re-starting phase, 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 total nitrogen.

Plant nr. 5 was originally built for 2500 p.e. and was made of a pumping station, a screen, an activated sludge tank (anoxic volume 100 m³, aerated volume 92 m³), a settler (volume 100 m³), 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. So the plant was upgraded: a dissolved air flotation Deltafloat[®] tank (12 m³) 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. When this paper is being written (Oct. 2010) the plant is in the re-starting phase.

Plant nr. 6 was originally 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 (total volume 104 m³), three oxidation tanks (total volume 590 m³) and two settlers (total volume 255 m³), then a disinfection tank (70 m³); sludge is treated in a thickener (60 m³). During the summer the plant was overloaded: the effective hydraulic load corresponded to 9400 p.e., the organic load to 19900 p.e. and the nitrogen load to 17450 p.e.; moreover an increase in hydraulic load was expected. So the plant was upgraded by building a new biological line with membrane reactors: this new line is made of a predenitrification tank (225 m³), an oxidation tank (800 m³) in which there are also Kubota membranes (total surface 2500 m²) and a deoxygenation tank (150 m³). In the old line activated sludge concentration is 4 kg_{TS}/m³ and in the new line activated sludge concentration is 8 kg_{TS}/m³. During last summer the plant treated 2400 m³/d in the old line and 1000 m³/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.

Conclusions

The choice between centralization and decentralization requires a case-specific approach. 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.

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