An innovative system for reducing sewage sludge production

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Introduction

The management of sludge originating from wastewater treatment plants is currently one of the most critical issues of the whole treatment cycle of municipal sewage. In fact, although the sludge volume produced by sewage treatment plant represents only 2% of the volume of sewage flowing in the plant, its treatment and final disposal can bear up to 60% of the total operating costs of the treatment plant (Andreoli et al., 2007). The amount of sludge produced has increased dramatically worldwide over the last years. In Europe, an increase in sludge production of about 50% was observed during the last decade reaching an annual production of around 11 million tons dry solids (Kelessidis and Stasinakis, 2012). Therefore, in the near future, reducing excess sludge production will be one of the most important tasks for the wastewater treatment industry.

Strategies currently available for reducing sludge production during sewage treatment are divided in two great groups: those acting on the water line of sewage treatment plant and those acting instead on the sludge line. The first ones are particularly interesting since they handle the problem of the sludge at its origin thus reducing the quantity to send to the sludge line of the plant. The current available technologies for reducing sludge production in the water line are based on cell lysis-cryptic growth, uncoupling metabolism and maintenance metabolism (Foladori et al., 2010). However, the reduction of the sludge quantity obtainable by the systems/processes operating in water line available on the market does not usually exceed 50%.

In the present paper a new system, whose acronym is MULESL (MUch LEss SLudge), is proposed and tested at full scale for reducing up to 80% the quantity of sludge usually produced during sewage treatment. Thanks to the particular type of biomass (mixture of immobilized biofilm and granules) growing in MULESL, this system is featured by a long sludge age (longer than 120 days) thus maximizing maintenance metabolism. Moreover, due to the dynamic conditions arising from the sequential operation of MULESL, which allows the alternation of anaerobic, anoxic and aerobic conditions, an additional contribution to the the reduction of sludge production is expected from uncoupling metabolism. MULESL system can be obtained conveniently both by the realization of new plants and by converting the stage of activated sludge of an existing urban wastewater treatment plant.

Materials and methods

The effectiveness of MULESL system in removing the typical pollutants and reducing sludge production was evaluated at full scale by using 3,500 p.e. plant located in Putignano, Puglia, Italy. This plant was obtained by retrofitting an existing activated sludge basin. Figure 1 shows a sketch and picture of MULESL system.

The main feature of the plant lies in the complete separation of the biomass from the liquid phase. While biomass is confined to a dedicated compartment of the reactor (biomass compartment), packed with plastic material (wheel shaped elements), the wastewater is circulated between a liquid phase compartment where air is continuously supplied and the biomass compartment where the biological degradation processes occur. By this way, the treated sewage is always free of biomass and can be easily disposed of. Plant performances were evaluated in terms of removal efficiencies by measuring, in the influent and effluent of the plant, the typical gross parameters [such as chemical oxygen demand (COD), total suspended solids (TSS), volatile suspended solids (VSS), total Kjeldahl nitrogen (TKN), ammonia (NH_3) and total nitrogen (TN)] as well as sludge production

Results and discussion

Full scale plant performances recorded during about 1 year of operation are summarized in Table 1, in terms of average values and standard deviation. Looking at this table, it is possible to observe that the plant successfully removed COD and TSS with an average removal efficiency of 97% and 98%, respectively, which produced an effluent with a residual concentration of 33 mg/L and 8 mg/L, respectively.

These performances were obtained regardless of the large variation in influent value. Concerning nitrogen, the plant was able to remove about 95% of the TKN and ammonia influent content with residual final concentrations as low as 4 mg/L and 2 mg/L, respectively. Total nitrogen removal efficiencies of 95% were also obtained with average residual concentrations in the effluent (4 mg/L) just equal to those of TKN, thus indicating that absence of oxidized nitrogen. This was due to the presence of a stable and complete simultaneous nitrification-denitrification process.

Figure 1. MULESL sketch and photo

The balance of sludge produced and COD removed gave an average value of the specific sludge production of 0.13 $kgTSS/kgCOD_{removed}$. This value is much lower (up to 77% lower) than that reported in the literature for sewage wastewater treatment plants.

Table 1 MULESL treatment performance in terms of average values and standard deviation.

Parameter		Mean value (± st. dev.)
COD	influent (mg/L)	1596 (± 1338)
	effluent (mg/L)	33 (±11)
	removal efficiency (%)	97 (±2)
TSS	influent (mg/L)	659 (±768)
	effluent (mg/L)	8 (±4)
	removal efficiency (%)	98 (±1)
TKN	influent (mg/L)	90 (±39)
	effluent (mg/L)	4 (±2)
	removal efficiency (%)	95 (±3)
NH_3	influent (mgN/L)	47 (±10)
	effluent (mgN/L)	2 (±2)
	removal efficiency (%)	95 (±4)
TN	influent (mg/L)	90 (±39)
	effluent (mg/L)	4 (±2)
	removal efficiency (%)	95 (± 3)

References

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