An innovative plant for preventing sewage sludge generation

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Keywords: municipal wastewater, sewage sludge reduction, sludge age, granular sludge
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Introduction

The sludge originating from municipal wastewater treatment plants is currently one of the most critical issues of the whole treatment cycle due to the large quantities produced and associated disposal problems (economic burden, environmental threats, health issues etc.). Once treated, the sludge is typically disposed of by landfilling or incineration, although some of them have been banned or limited by recent EU and local laws because of possible negative effects on soil, water and health. This has led to a continuous increase of the sludge management costs during the last decades and consequently to more attention toward technologies/approaches aimed at reducing sludge production (Foladori et al., 2015; Collivignarelli et al., 2019).

Recently, an innovative plant design referred to as MULESL (MUch LEss SLudge; WO2019097463) was tested at a demonstrative scale for assessing the reduction at the source of sewage sludge production according to the Waste Framework Directive.

By means of the configuration of plant elements and adoption of particular operational conditions, MULESL allows to transform the existing activated sludge in a particular kind of sludge made up of biofilm and granules bounded in a plastic porous material. This configuration allows reaching very long SRTs, hence favoring 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

MULESL demonstrative plant with a treatment capacity of 2,000 person equivalents (PE) was built by retrofitting an existing activated sludge basin of Putignano's WWTP, located in sourthern Italy. Figure 1 shows a sketch and picture of MULESL system. The water line of Putignano's WWTP (28,000 PE) consists of preliminary treatment stage, primary sedimentation, biological treatment unit based on activated sludge process (under anoxic and aerobic conditions) and tertiary treatment. MULESL basin was fed with the sewage coming from the preliminary treatment stage of the conventional WWTP. Therefore, two water lines were operated in parallel at Putignano's WWTP, the first based on the traditional primary and secondary treatment whereas the second one on the innovative process.

MULESL performances were evaluated in terms of conventional and emerging pollutants removal, and sludge production reduction, and compared with those of the conventional activated sludge process treating the same municipal sewage. Chemical oxygen demand (COD), total suspended solids (TSS), volatile suspended solids (VSS), total Kjeldahl nitrogen (TKN), ammonia (NH_3) and total nitrogen (TN) were selected as conventional parameters. A list of 46 target emerging pollutants and their degradation products was also detected and regularly monitored in the influent and effluent of both traditional and innovative water lines.

Results and discussion

Figure 2 shows COD, TSS and TN mass balances of MULESL plant and traditional water line of Putignano WWTP over 3 years period. MULESL solid and COD mass balances gave a specific sludge production value of 0.04 kg of dry sludge per kg of COD removed, corresponding to 4.1 gTSS/PE·d. This value was 93% lower than that of the traditional water line of Putignano WWTP (i.e., primary and secondary sludge) recorded during the same period (i.e., 57 gTSS/PE·d). This result is even more remarkable bearing in mind that it was obtained with a smaller volume of the water line (27% smaller). Furthermore, MULESL sludge was already stabilized, being characterized by an organic matter content of 60%, allowing to save investment costs for digester facilities.

No negative impact on depuration performances was observed. In fact, MULESL unit successfully removed (in a single stage) COD, TSS, TKN, NH_3 and TN with an average removal efficiency of 95%, 94%, 92%, 92% and 84%, respectively, with effluent concentrations of 42, 15, 5, 2 and 11 mg/L, respectively.

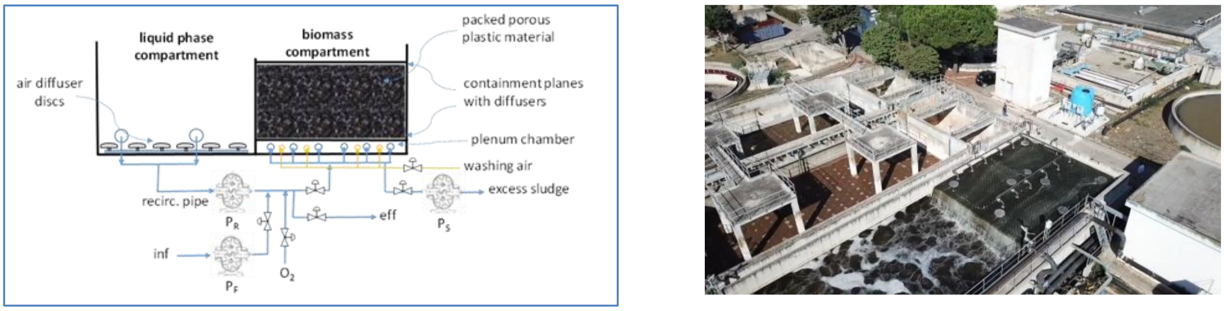

Figure 1. MULESL sketch and photo

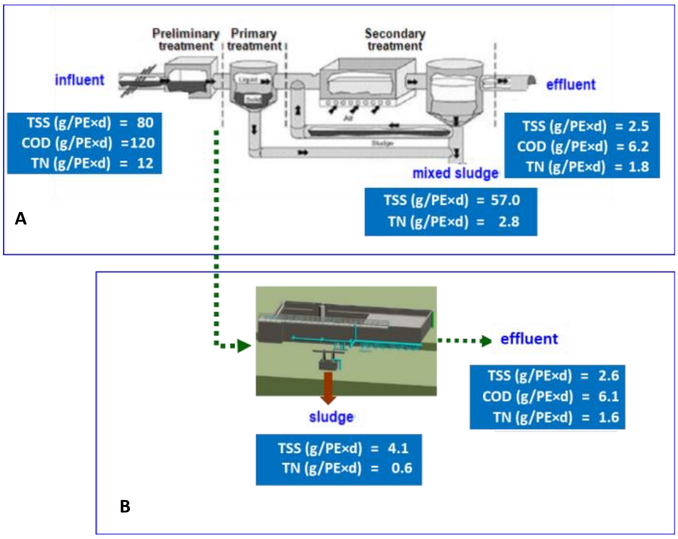

Figure 2. COD, TSS and TN mass balances of and traditional water line of Putignano WWTP (A) and MULESL plant (B).

As far as emerging pollutants is concerned, Table 1 reports the removal efficiency (in terms of average values and standard deviation) of selected emerging pollutants for MULESL plant and conventional primary and secondary treatments of Putignano's WWTP. The data reported in the table clearly show that MULESL system offered higher removal efficiencies. The results obtained for carbamazepine, flecainide and clopidrogel are of great relevance since the conventional treatments were not able to remove these compounds.

Table 1. Comparison of removal efficiency (%) between MULESL and traditional water line of Putignano WWTP for selected emerging pollutants.

Compound	MULESL plant	Primary and secondary treatment of Putignano's WWTP
Carbamazepine	55 ±16	no removal
Carbamazepine epoxide	84 ± 4	38 ± 7
Flecainide	59 ± 22	no removal
Clopidrogel	81 ± 13	no removal
Metoprolol	80 ± 19	68 ± 17
Levofloxacin	75 ± 13	41 ± 15
Sitagliptin	95± 3	62 ± 21

References

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