MIMIZATION OF SEWAGE SLUDGE PRODUCTION AS A SOLUTION FOR THE MANAGING PROBLEMS IN SMALL WWTP

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Abstract

Sewage sludge production is considered, nowadays, one of the most important problems in wastewater treatment, due to the high managing and treatment costs and the limitations in its final use. Those problems are even worst in small populations, where a lack of financial and qualified human resources is observed. In addition, the wide range of technologies (both intensive and extensive) which are suitable to be implemented in small wastewater treatment plants (WWTP), increase the variety of the sludge typology. According to the waste hierarchy, based on the 3Rs (reduce, reuse and recycle), numerous studies are currently addresed to the minimization of sewage sludge production. In this paper a review of the recent studies in the aim of sewage sludge minimisation is exposed focusing on those ones that could be applied in small WWTP.

Keywords: sewage sludge; minimization; management; small WWTP.

Introduction

Large amount of excess sludge is generated in the biological wastewater treatment process. The treatment of that waste presents high cost, around 25-65% of the total plant operating costs (*Zhao and Kugel*, 1997), and imposes great risks to the public health once the treatment system fails. The sludge composition and properties, which directly influence on its treatment and its potential final use, depend on the technology employed for the wastewater treatment. In small populations with less than 2000 p.e. both intensive and extensive systems can be applied for treating wastewater. However, extended aeration and primary treatment systems (septic and Imhoff tanks) are commonly applied in those populations (*Ortega et al.* 2008). The amount of sewage sludge produced on each system is estimated in 0.8-1.0 kg DM/kg BDO_5 removed for the extended aeration and 150-250 l/p.e.year in primary treatment units (*Crites et al.*, 2000).

Hence, the current legal constraints, the rising costs and public sensitivity of sewage sludge disposal have provided considerable impetus to explore and develop strategies and technologies for minimization of sludge production (*Wei et al.*, 2003). Therefore, an ideal way to solve sludge-associated problems is to reduce sludge production in the wastewater treatment facilities. Within the existing atsource minimization strategies, water line sludge minimization technologies are more appropriate for small communities WWTPs.

Those strategies are classified in two groups (Pérez-Elvira *et al.* 2006):

1.-Process whose aim is reducing yield growth in aeration tank (Y, g produced biomass /g consumed substrate):

1.1.-Lysis-cryptic growth.

1.1.1.-Chemical oxidation: by the application of ozone, chloride or photo-Fenton reaction. In the first case, a recycled sludge fraction is conducted to an ozonation unit before being decomposed in the aeration reactor. This method reaches high efficiency COD and total nitrogen removal. The installation shows a higher oxygen demand (OD) (1.2Kg addittional oxygen/ kg SS). The recommended dose to achieve an optimum cost-efficiency rate is 0.03-0.05 g O_3/g TSS is 0.03-0.05 g O_3/g TSS (Chu *et al.* 2009) Energy consumption for a 30% SP reduction amounts to 15% of plant maintenance.Chlorination is a lower cost alternative to ozonation (Chen *et al.* 2009). However, a poorer depurative efficiency and settleability is observed and there is a high risk of trihalomethanes' formation. Iron ions and hydrogen peroxide are the Photo Fenton reagents. Specifically, iron (II) sulfate is the most appropriate salt for the process (Tokumura *et al.* 2009). The same authors concluded that the process under sun light action achieves better results than those obtained with the much more expensive UV light.

1.1.2.-Ultrasound and cavitation: A determined recyled sludge fraction is treated with an ultrasound device (He *et al.* 2011). It is not convenient to subject twice the same sludge fraction to ultrasound treatment. Cavitation treatment reached a 80% SP reduction.

1.1.3.-Thermal and chemical-thermal treatments: A 60%SP reduction was achieved treating a recycled sludge current to 90°C (194 F) for 3 h. Lower temperature values lead to worse quality effluents (Pazoki *et al.* 2010). Chemical-thermal treatments obtained even better results, however they show drawbacks: bad odour generation and corrosion problems

1.1.4.-High purity oxygen process: It was established that this technology reaches a 60% decrease of biomass growth yield, and therefore, of SP. An injecting device has been designed (Young *et al.* 1998) that makes oxygen transfer more efficient. A drawback of this technology is the high cost of aeration.

1.1.5.-Enzymatic reactions: A recycled sludge fraction is inoculated into a thermophilic aerobic sludge digester, where solubilisation is carried out. Mesophilic bacteria thereafter perform sludge mineralization. An increase in solids suspension and COD was recorded in effluents from plants using this technique (Ødegaard *et al.* 2004)

1.1.6.-Other lysis-cryptic growth technologies: a reduction in the growth yield can be achieved by a strong alkaline-acid treatment (Dorica *et al.* 2000), mechanical desintegration. (Onyeche *et al.* 2002) or freezing-thawing (Chu *et al.* 1999).

1.2.-Sludge age and hydraulic retention time control: a high sludge age and an endogenous growth is desired to obtain a low biomass growth yield (Martinage *et al.* 2000), leading to an SP reduction around 40%. To set this performance, long aeration time and low organic loading is required.

And, despite that, these plants are 5-10% less efficient in BOD removal. Membrane bioreactors (Rosenberger *et al.* 2002) are the technology most-used to carry out an effective sludge age control, but with the incovenient of high management costs.

1.3.-Uncoupling metabolism: promotion of catabolisms' reactions limiting the anabolic pathways.

1.3.1.-Chemical uncoupler (CU): Compounds containing chloride show effluent removal problems and they often damage the general depurative efficiency of the plant. Several CUs (Aragón *et al.* 2009) were tested and only the TCS (3,3',4',5-tetracholorosalicylanilide) showed a conclusive SP reduction effectiveness. The plant requires an increase in OD after the addition of the CU. The presence of these additives also results in bioaclimatation and/or accumulation problems.

1.3.2.-Oxic-Settling-Anaerobic process (OSA): An anoxic sludge-holding tank is introduced in the recycled sludge line, where a long retention time is reached, so that the catabolic activity is enhanced. This technique reaches a 50% SP reduction without affecting facility purification effectiveness or sludge settleability (Chen *et al.* 2001); on the contrary, COD removal is also improved. Recently, a study established the possibility of the combination of both techniques, OSA and CU addition, specifically of TCS (Ye *et al.* 2010).

1.4.-Predation on bacteria: a low hydraulic retention time reactor is laid out before the aeration reactor. In this added reactor, bacterial growth is favoured. Its effluent is fed to the aeration tank where higher bacteriovoric microorganisms dominate and graze on the bacterial cells. Results of cited articles set an SP decrease of up to 80% and a good settleability. It has been proved that metazoa reactors use is appropriate for small WWTPs (Hendrickx *et al.* 2010). The greatest challenges of a worm reactor are the high OD to supply and the ammonia concentration and temperature control. Oligochaetes reactors lead also to high implementation and maintenance costs as well as to poor phosphorous removal effectiveness.

2.-Processes with low yield coefficient

2.1.-Sludge anaerobic treatment: an anaerobic stage is introduced before the aeration reactor in the conventional biological plant layout two-stage biological integrated system designed for small communities is ANaerobic ANoxic OXic (ANANOX). Another article pointed out (Jung *et al.* 2006) the effectiveness of an installation in which aerobic and anaerobic conditions follow alternately in a same reactor.

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