REMOVAL OF CARBON AND NITROGEN OF MUNICIPAL WASTEWATER WITH SUBMERGED FILTERS. EXPERIENCE FROM A FULL SCALE PLANT

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ABSTRACT

Characterization and evaluation of a submerged filter was carried out on a full scale plant performing degradation of organic matter and total nitrogen removal. The reactor consisted of the 3 cells: one unaerated cell (predenitrification) and two aerated cells. The full scale plant was fed continuously with pretreated municipal wastewater of Abegondo's municipality (Galicia, Spain). The reactor has operated beyond its design capacity (200 PE). In spite of it, the results showed that this process can reach BOD_5 removal performance of 90 % and TN removal performance of 75 %. It indicates that this technology can absorb overload variations while maintaining stable pollutant removal performance. To improve the denitrification process, it was used an intermittent aeration cycle in the unaerated cell.

Keywords: biofilms reactor, nitrification, denitrification, full-scale WWTP, submerged filter.

INTRODUCTION

European Standards are aimed to reduce total nitrogen discharge of wastewater treatment plants in so-called sensitive regions. Total nitrogen concentrations in their effluents down to 15 mg N/L for plants between 10,000 and 100,000 PE, will have to be achieved by nitrification and denitrification. Submerged aerated filters (SAFs) are biofilm systems in which a biofilm support medium is submerged in wastewater to create a large contact area for aerobic biological treatment. Air is introduced at the base of the reactor via a network of diffuser nozzles or discs. The SAF can also be used in an unaerated mode (submerged unaerated filters – SUFs) as an anoxic stage for denitrification. Normally the support medium has a large specific surface area (100 – 400 m^2/m^3) and is manufactured from expanded polystyrene, expanded shale or high-voidage plastic media. Reactors may be operated as either upflow or downflow systems. The SAFs/SUFs, compared to biological aerated filters (BAFs), do not require backwashing because accumulated solids in the reactor are controlled by biomass sloughing and air-scouring. Eliminating backwashing reduces construction and operational costs, and generally permits the design of simple reactors with few working parts. SAF reactors are particularly suitable for small plants where robust, simple, compact treatment is desirable. SAFs normally treat settled sewage and require secondary sedimentation. In recent years, several manufacturers have used SAFs in small package plants. Reports of these SAFs tend to be vague technical appraisals, providing little identification of factors affecting the treatment performance of the reactors or treatment capacity. Therefore, there is a need to thoroughly investigate and characterize full-scale SUF/SAF systems.

METHODS

The researched compact full scale plant consisted of 4 cells arranged in series: predenitrification cell (SUF), organic matter aerobic oxidation cell (SAF-1), nitrification cell (SAF-2) and lamellar final clarifier (Fig. 1). Nitrate was recycled by pumping from the SAF-2 cell to SUF cell. Bionet® modules with a specific surface area of 150 m^2/m^3 were used in each cell to develop biofilm (Fig. 2). The volumes of each filter cell were: 13 m^3 (SUF); 12 m^3 (SAF-1) and 12 m^3 (SAF-2). The support surface available for biofilm growth was: 1012.5 m^2 (SUF); 1080 m^2 (SAF 1) and 1080 m^2 (SAF 2). Each cell houses a number of coarse bubble diffusers. In the SUF cell worked with intermittent aeration.

The plant was installed at the municipal WWTP of Abegondo (Galicia, Spain). The influent composition was measured with composite samples. The concentration of the pollutants in treated effluent and the bulk liquid inside the 3 cells of reactor were measured with grab samples. Once steady state is reached in each experimental phase was analyzed two or three samples at intervals of 2 to 3 days. To estimate the sludge production were measured volume and concentration of waste sludge in excess.

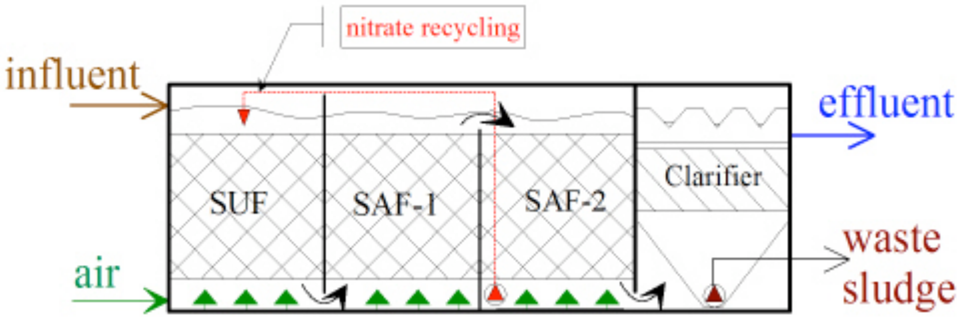

Figure 1.- SUF/SAF process scheme

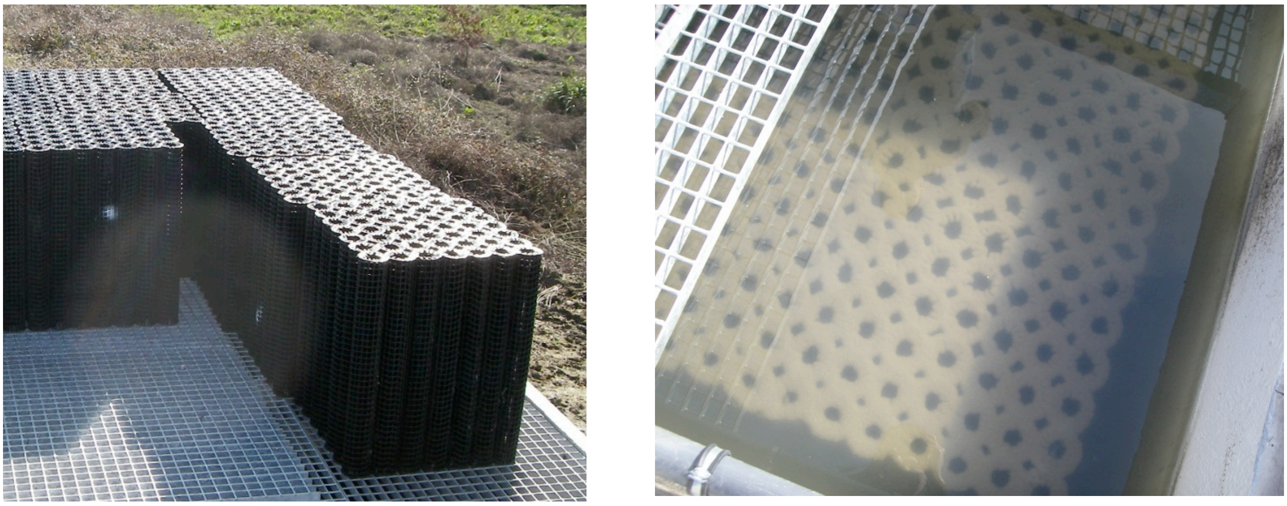

Figure 2.- Structured packed rigid media (Bionet). Left: Clear media. Right: Biofilm developed on media after elapsed time 3 days.

RESULTS AND DISCUSSION

The process has been extensively tested on a full scale plant (design capacity: 200 PE). The overall research project will last 1 year. The results presented correspond to the first period of 5 months. The reactor was fed with municipal wastewater pretreated with a medium concentration (in mg/L): 488 of BOD_5, 1333 of COD, 986 of SS, 74 of Total-Nitrogen (TN) and 17 of Total-Phosphorous (TP). The wastewater flows, *Q*m, were: 0.3 and 0.6 L/s. The nitrate recirculation flows, *R*, were: 2*Q*m y 4*Q*m.

After 3 days of operation, enough biofilm developed to allow complete oxidation of organic matter. Other researchers have also reported similar result (Gálvez *et al.*, 2003). For global volume of reactor, the organic load (L_R) ranged from 0.25 to 1.4 kg $DBO_5/m^3/d$ (the design value of L_R was 0.5 kg $DBO_5/m^3/d$). For the overall range of L_R, BOD_5 average removal was 90 % (Fig. 3). Thus, the maximum organic removal rate was 1.3 kg $BOD_5/m^3/d$. At an organic loading of 0.9 kg $COD/m^3/d$, the sludge yield was estimated at a value of 0.24 kg TS/kg COD (0.21 kg VS/kg COD). A similar result was observed by Fouad and Bhargava (2005).

On day 8, the TN removal reached the stability. For the overall range of nitrogen load, L_N, the average TN removal was 75 %, regardless of the nitrate recycling flows (Fig. 4). The TN removal took place by means nitrification – denitrification process. To optimize the denitrification process, an intermittent aeration cycle (on+off = 15+45 min) was used in the SUF cell. Results obtained by Ryhiner *et al.* (1993) showed the denitrification efficiency was improved by moderate aeration below 4 m/h. It's due to an increase in the rate of diffusion of carbon and nitrate into the biofilm. In our SUF, the aeration rate was approximately 6 m/h and the maximum dissolved oxygen concentration was 6 mg/L without inhibition of the denitrification process was taking place. The maximum TN removal rate was 0.18 kg $TN/m^3/d$.

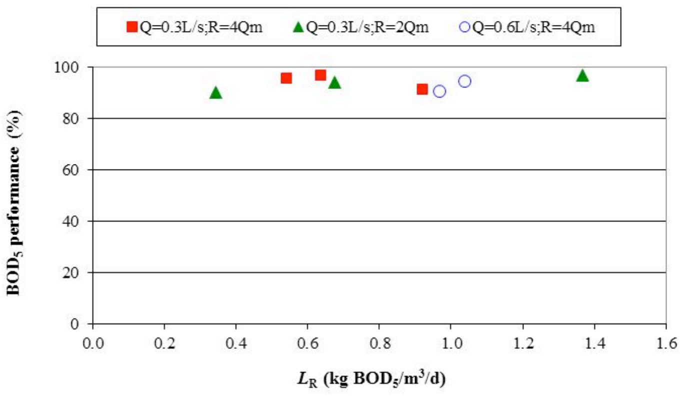

Figure 3.- Effect of organic loading on BOD_5 performance

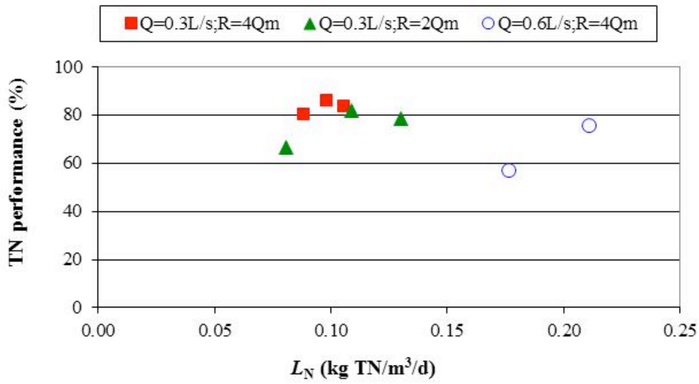

Figure 4.- Effect of TN loading on TN performance

CONCLUSIONS

SUF/SAF process is simple and efficient for the treatment of municipal wastewater. The full-scale reactor has been designed to treat 200 PE. However, due to the high pollutant loading of the influent, the reactor has effectively treated 250 PE for influent flow of 0.3 L/s, and 350 PE for flow of 0.6 L/s. This is a proof of the ability of this technology to absorb overload variations while maintaining stable pollutant removal performance. In the range tested of organic and TN loadings the process worked with high stable performance. The range of nitrate recycling flows from 2*Q*m to 4*Q*m is ideal for a good denitrification. The intermittent controlled aeration of the SUF is adapted to obtain a high efficiency of denitrification process. It is needed to optimize the cycle of this aeration.

ACKNOWLEDGEMENTS

The results presented were obtained as part of the Incite project 09MDS035E (Xunta de Galicia, Spain). The following company and research group are involved in the project: INNDES Ltd., Spain; Grupo de Enxeñería da Auga e do Medio Ambiente (GEAMA), Universidade da Coruña, Spain.

REFERENCES

Fouad, M. and Bhargava, R. (2005). Sludge production and settleability in biofilm – activated sludge process. J. Env. Engrg., 131(3):417 – 424.

Gálvez, J., Gómez, M., Hontoria, E., González, J. (2003). Influence of hydraulic loading and air flowrate on urban wastewater nitrogen removal with a submerged fixed-film reactor. Journal of Hazardous Materials, B101: 219-229.

Ryhiner, G., Sorensen, K., Birou, B., Gros, H. (1993). Biofilm reactors configuration for advanced nutrient removal. Proceedings IAWQ 2nd International Conference on Biofilm Reactors, Paris. pp. 161-169.