WASTEWATER REGENERATION FOR REUSE USING MEMBRANE BIOREACTORS (MBR). COMPARATIVE STUDY OF FLAT SHEET AND HOLLOW FIBRE MEMBRANES

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ABSTRACT

The objective of this work was to fill an existing gap in scientific and technological literature concerning the experimental comparison between two MBR configurations; flat sheet and hollow fibre submerged membrane modules for small-scale urban waste water treatment plants, so that tests have been performed in parallel. Results show that both MBR configurations can provide an excellent effluent quality supply, well enough for reuse according to regulations. However, the flat sheet membranes allow better integration and performance for small-water-treatment plants.
Keywords: membrane bioreactors (MBR), water reuse, flat sheet membranes, hollow fibre membranes.

INTRODUCTION

The implementation of state-of-the-art in the field of MBR technology calls for investigation into the suitability of the configuration to be used with the membranes for small waste water treatment plants. Especially, is difficult to find scientific articles covering a comparison of systems and technologies, and it proves difficult to extract clear and non-contradictory conclusions concerning the selection of one type of membrane between flat-sheet and hollow-fibre. (Henze at al., 2002; Judd, S., 2006; Yang et al., 2006; Leslejan et al., 2007).

The aim of this study is to compare two polymeric membrane configurations, flat-sheet and hollow-fibre, and select the most suitable membrane technology for application in compact units for small urban communities with wastewater flows of 10 m^3/day to 100 m^3/day.

The requirements that the treatment must satisfy are: 1.-The effluents shall meet the environmental and sanitary quality parameters imposed by the Royal Decree 1620/2007 for reuse. 2.-The configuration has to adapt to the compactness of the units. 3.-The system has to allow easy installation, operation and maintenance. The limits imposed by the Royal Decree 1620/2007 are outlined for the most applicable uses for the REMOSA compact purified water regeneration units.

METHODS

The work was performed using two MBR in parellel, one with flat-sheet (FS) polymeric membranes and another with hollow-fibre membranes (HF), also polymeric. The units were manufactured in FRP maintaining the maximum compactness and adapting to the design conditions. In July 2007 the units were installed inside a retention basin built in the REMOSA Pilot Plant to protect the environtment from the tests carried out. The physical, chemical and microbiological parameters in the intake (from the buffer tank) and the output water (drains) of the two units were analysed for 8 months. Complementary, the evolution of the activated sludge was observed using an optical microscope.

In both cases, the treatment was designed in three stages: a first anoxic stage denitrification was carried out with the help of an agitator to enhance the release of nitrogen and oxygen from the sludge. In a second aerobic stage, the bioreactor, the complete oxidation of the organic matter in the water was achieved by means of an aeration system. In a last stage, the effluent was filtered through the membranes to obtain permeate. A recirculation system allowed the concentrations of solids to be equalised between the bioreactor and the membrane compartment and to enhance denitrification with the supply of nitrates to the denitrification area. Both units were fed in parallel, continuously and simultaneously with wastewater drawn from the inlet pipe of the Súria WWTP. This water underwent a pre-treatment by passing through a screen of 3 mm mesh to trap the solids that could damage the membranes. Subsequently, the water was stored in a small buffer tank that fed the two units. After the treatment, the effluents were led to output drains and recovered for return to the inlet of the Súria WWTP.

RESULTS AND DISCUSSION

The characteristics of the inlet water are in line with those expected in urban waste water. Great variability was observed in the parameters analysed, an inherent feature in this type of water.

Figure 1 shows the evolution of BOD_5 with time at the inlet and output of both units. It reveals that for both systems the reduction observed is very high. With output values being very low with an average value in both units of 3 mgO_2/L. Considering an average concentration in the input wastewater of 265 mgO_2/l, the efficiency of the units is better than 98%.

Figure 3. Evolution of BOD_5 with time at the inlet and output of the two MBR.

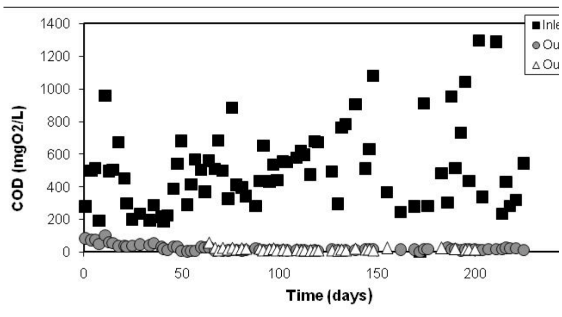

Figure 4. Evolution of COD with time at the inlet and output of the two MBR.

The evolution of the COD is shown in Figure 2. The profile is similar to BOD5, with an average output value of 21 mgO_2/L and 17 mgO_2/L for the unit with FS membranes and HF membranes respectively. Considering that the average concentration in the inlet wastewater is 515 mgO_2/L, the efficiency of the units is 96% and 97% respectively.

In Figure 3 the evolution is shown for the suspendend solids (SS). For comparison, are also shown the limits specified in Royal Decree 1620/2007, 10 ppm as reference, which corresponds to the ceiling for waters of residential use (water for gardens, lavatories, refrigeration, etc.) and the ceiling of 20 ppm for water of urban use (watering green areas, fountains, etc.). In all cases, the SS values at the output being well below these limits, with an average of 1 mg/l in both units. Considering that the average concentration in the input water is 350 mg/l, the efficiencies obtained are above 99%. Regarding the turbidity, Figure 4 shows the reference level details of Royal Decree 1620/2007 for water of residential use (2 NTU) and urban use (10 NTU). The treated waters reveal average values of 0.4 NTU for the unit with flat-sheet membranes and of 0.7 NTU for the unit with hollow-fibre membranes, both units complying with the established limits.

Regarding microbiological parameters, figure 5 shows the results obtained in the Escherichia Coli analysis. The results obtained at the output of both MBR fully comply with the limit set by the RD 1620/2007 for water of urban use (200 ufc/100ml) and in most cases fell below the detection limit of the technique, which is 5 ufc/100 ml. Logarithmic reductions of 8 were obtained considering the high presence of these microorganisms in the inlet water.

Another parameter that was monitored over time is the nitrogen concentration. The average nitrogen removal performance figures are 75% for the unit with flat-sheet membranes and 61% for the unit with hollow-fibre membranes.

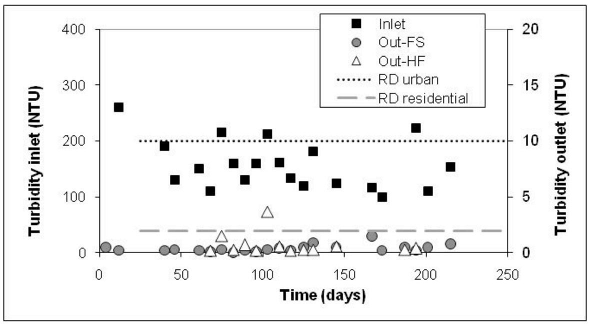

Figure 3. Evolution with time of the matter in suspension at the MBR outputs..

Figure 4. Evolution of the turbidity with time at the MBR output.

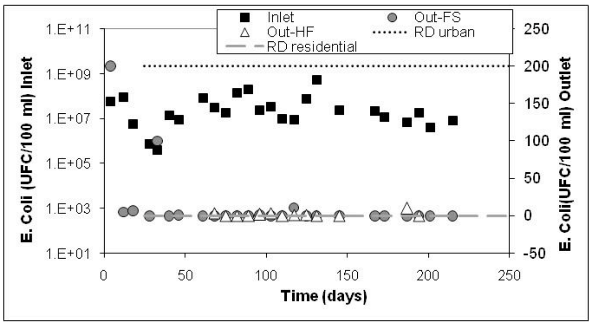

Figure 5. Evolution of E.Coli with time at the MBR output.

Another microbiological parameter analysed was the presence of nematode eggs. In both units values were obtained that comply with the levels imposed by the Royal Decree, in the case of water for both residential and urban uses. Finally attention is drawn to the tracking of some trace elements at the inlet and output of the units In general these elements show a decrease after passing through the MBR, the reduction in concentration of Mn and Zn being of particular relevance in the two membrane configurations studied, probably attributable to adsorption phenomena in the activated sludge.

CONCLUSIONS

Applying either of the two technologies, the quality of the effluents is excellent and complies with the most restrictive limits in the RD 1620/2007.

The flat-sheet membrane format permits better integration in compact water-regeneration units for small urban communities.

The final output obtained in permeate flow per membrane surface area is greater in the case of flat-sheet membranes. Moreover their installation, operation and maintenance are simpler.

REFERENCES

1. Henze et al. (2002) Wastewater Treatment. Springer. 3rd edition. Heidelberg (Germany)
2. Judd S. (2006). The MBR Book. Principles and Applications of Membrane Bioreactors in Water and Wastewater Treatment. Elsevier.
3. Lesjean B. and Huisjes E.H. (2007). Survey of European MBR market, trends and perspectives. IWA 4th International Membrane Technologies Conference, 15-17 May 2007, UK
4. Yang W., Cizek N. y Ilg J. (2006) State-of-the-art of membrane bioreactors: worldwide research and commercial applications in North America. Journal of Membrane Science, 270, 201-211.