A NEW PROCESS FOR THE WATER RECOVERY FOR OLIVE WASHING WASTE WATER BASED ON BIOFILTRATION AND MEMBRANE SEPARATION

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ABSTRACT

A treatment plant consisting of an $2m^3$ aerobic fixed-bed bioreactor and two subsequent batch membrane processes, that is ultrafiltration (UF) and nanofiltration (NF), was used to purify and recover 80% of water from an olive washing waste water stream.
This process eliminates most organic matter, polyphenols and reduces most of the saline content of the waste water. The NF permeate water is the product water, equal to 80% of the initial waste water volume, with a quality consistent with its agriculture use.
During this work, the biological treatment and the membrane process sections were both optimized.

KEYWORDS

wastewater, membrane, bioreactor, filtralite

INTRODUCTION

In the production of olive oil, a preliminary important step is the pre-washing of the collected olives before their milling. The washing process is performed in order to clean the olives by removing earth and all other undesired substances attached to the fruit peel. Up to 500 litres of potable water are required per ton of olives. Such a utility is hardly available in the Mediterranean regions. The wastewater produced by the washing process is a dark smelling liquid with a rather high phenol load. This polluted water must be treated before its disposal according to present-day European environmental rules, with very high costs for the olive oil mill.
This paper reports an experimental work carried out to develop a treatment process for the recovery of more than 80% of the potable water to be recycled to the olive washing process.

A treatment plant consisting of an $2m^3$ aerobic fixed-bed bioreactor and two subsequent batch membrane processes, that is ultrafiltration (UF) and nanofiltration (NF), was used to purify and recover 80% of water from an olive washing waste water stream. In table 1 a typical chemical analysis of this waste stream is reported.

Table 1 – Chemical Analysis of the olive wash waste water

pH	5,3
Conductivity [uS/cm]	966
BOD_5 [mg/l]	1215
COD [mg/l]	1840
Total Phenols [mg/l]	5,6

The basic flow sheet of the pilot plant is plotted in figure 1.

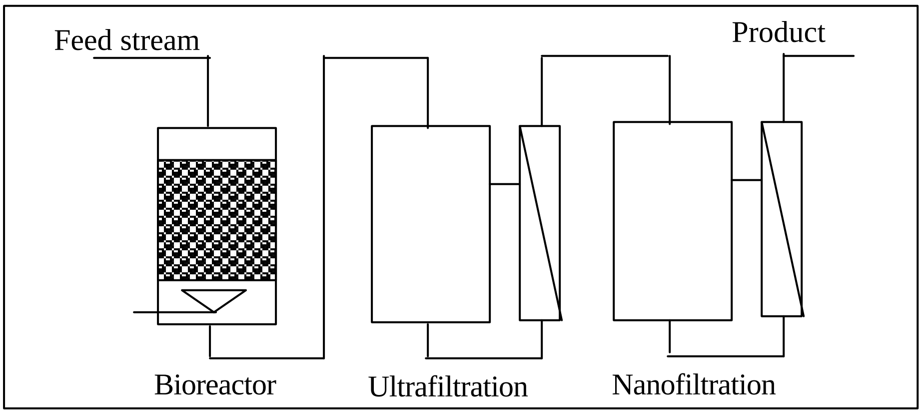

Figure 1 – A scheme of the adopted bioreactor battery

A series of two bioreactors were adopted, both filled with 4 to 8 mm rounded shaped expanded clay beads (Filtralite ®). An air stream of 15 Nm^3/h was fed to each reactor. The start procedure of the reactors was accomplished by operating for 5 days at a reduced waste water flow rate. After this period of time, the flow rate was set at 250 l/h (residence time 8 hours). The bioreactors operated in a continuous mode, whereas the membrane processes are carried out in batch mode. An UF membrane process purifies the waste water from bacteria and organic matter. The UF permeate is collected in a second reservoir, which feeds a NF membrane batch process. This separation eliminates most polyphenols and reduces most of the saline content of the waste water. The NF permeate water is the product water, equal to 80% of the initial waste water volume, with a quality consistent with its agriculture use.

WORK DESCRIPTION

The measured conductivity, COD and BOD_5 values and their relevant reductions are reported in table 2.

Table 2 – Chemical analysis of the exiting stream of the two experimental runs.

PROCESS STEP	**After biological treatment**		**After biological treatment + UF**		**After biological treatment + UF + NF**	
	value	**reduction**	**value**	**reduction**	**value**	**reduction**
Conductivity [uS/cm]	927	4,0 %	835	13,6 %	271	71,9 %
BOD_5 [mg/l]	668	45,0 %	298	75,5 %	47	96,1 %
COD [mg/l]	837	54,5 %	377	79,5 %	26	98,6 %
Total Phenols [mg/l]	4,4	21,0 %	1,4	75,0%	< 0,1	> 98,2 %

The start-up of the bio-reactor was performed in 5 days and the grow of a selected biofilm on the Filtralite ® was confirmed by electron microscopy after this period of time.
The additional membrane separation steps as post-treatment process produces the purified water with far less technical and economical effort. Moreover, much smaller biological treatment plants, which produces less mud and odours, can be designed.
Particular attention must be paid on the fouling of the membrane. For this process, the biotreatment represents a very good feed stock pre-treatment, which inhibits fouling and therefore maximizes productivity. Moreover, the longevity of the membrane modules can be easily maintained by using opportune optimization strategies and control systems (Stoller et al., 2005), reported here briefly. The method is based on the critical flux (Field et al., 1995), that is the permeate flux value above which fouling may be observed.
The criterion for the best operating strategy for an already installed plant is to obtain the fixed solvent recovery in the shortest time by providing, at the same time, a concentration of impurities in the final permeate lower than the required upper limit. The only degrees of freedom for the operation of the plant is in this case the flow rate of the permeate stream from each membrane process. In this respect a strategic choice is to operate a permeate flux smaller or larger than a critical flux value. In fact, on one hand the

overcoming of the critical flux conditions causes a progressive decreasing of the permeate flux, gets difficult to achieve the target concerning the solvent recovery and shortens the membrane's life. By the other hand, the attainment of a layer of impurities over the membrane, that is fouling, improves the separation rejection. In order to make the choice a long experimental campaign or the performances prediction by means of a simulation model is needed. In order to avoid to operate at fouling conditions the permeate flux should be maintained constant at a value equal the critical flux corresponding to the final conditions. It requires a preliminary experimental work to determine the effects of the pollutants on the permeate flux and, possibly, to predict the process performance by means a suitable simulation model, as was done in this work.

As a result, a small and compact waste water treatment system is obtained, which recovers 80% of the total treated volume for agriculture reuse. The resting 20% of concentrated waste water can be partially recycled back to the process or disposed opportunely like other biological mud.

CONCLUSIONS

The developed process is capable to produce great amounts of water with a quality consistent for agricultural use. It is possible to claim more than 80% of the wastewater.
The optimized process have a stable biological operation, capable to half the organic content of the main stream. This process is very useful as pretreatment of the waste stream for the membrane section, which can be operated at relative high fluxes without incurring in short term fouling.

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