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THE USE OF MEMBRANE BIOREACTOR FOR WASTEWATER TREATMENT

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ABSTRACT:

Water is a prime resource for any community, whether it is for household cleaning, sanitation, economic use or recreational purposes.

In this paper a biological wastewater treatment process was studied, a membrane bioreactor under aerobic conditions was constructed. Different simulations were tried and several factors and parameters were emphasized.

First, the membrane bioreactor was tested in the laboratory with artificial wastewater. Secondly the membrane bioreactor was tested at the municipal treatment plant using normal wastewater.

KEYWORDS:

wastewater treatment, membrane bioreactor, sludge production

1. INTRODUCTION

The membrane bioreactor concept is a combination of conventional biological wastewater treatment and membrane filtration. The concept is technically similar to that of a traditional wastewater treatment plant (WWTP), except for the separation of activated sludge and treated wastewater. In an MBR installation this separation is not done by sedimentation in a secondary clarification tank, but by membrane filtration. Technologically and biologically, the MBR system and the conventional system show great differences.

Membrane processes can be categorised in various, related categories, three of which are: their pore size, their molecular weight cut-off; or the pressure at which they operate. As the pore size gets smaller or the molecular weight cut-off decreases, the pressure applied to the membrane for separation of water from other material generally increases. The water treatment objectives will determine the basis by which a process is selected.

Micro-filtration (MF) and Ultra-filtration (UF) are processes that filter material on the basis of size and are generally applied in MBR concepts. In membrane separation, MF is typically used to separate or remove relatively large particles, such as emulsified oils, suspended solids and macromolecules with molecular weights greater than approximately 50,000. Pore sizes of MF membranes range from approximately 0.05 □m to 2 □m. UF and MF processes overlap to a large extent and the definition of each is vague. In general the UF membranes are able to achieve higher levels of separation, particularly regarding bacteria and viruses. UF can separate macromolecules to a molecular weight of greater than 5,000 and displays a pore size ranging from approximately 0.005□m to 0.1□m.

The method of extracting permeate from the bioreactor is referred to as the 'process' mode; this mode is interrupted with in-situ cleaning modes which vary depending on the membrane manufacturer and the extent of the fouling. During the process mode the membranes are often aerated with coarse bubbles to keep the solids from building up around the membrane.

Some membranes require a 'relaxation' mode to stabilise the surface solids' flux before being returned to the process mode. This relaxation mode is a simple stop of the permeate flow for a short period of time; the membranes, which are basically elastic in nature, then return to their original relaxed state. During relaxation the aeration of the membranes often remains on to assist the renewal of the biomass solids in the vicinity of the membrane surface, and also has the effect of scouring the surface of the membrane thus removing any solids build up. Other membranes utilise the so called 'back pulse' mode. After a process mode period of operation the permeate produced exits the system via Clean In Place (CIP) tank. This tank stores enough permeate to allow the membrane to be flushed for a short period in the opposite direction of process filtration. The latter has the effect of flushing the membrane surface of solids build up and fouling before being returned to process mode.

Some membranes are running at continuous process (permeation) mode, others require a regular back flush and / or relaxation mode.

All the membrane systems installed have the capacity to be cleaned with chemicals. The chemicals often used are: sodium hypochlorite (NaOCl), sodium hydroxide (NaOH), citric acid, oxalic acid, hydrochloric acid (HCl), and detergents or combinations of these. The use of the chemicals depends strongly on the fouling and the type of membrane.

2. EXPERIMENTAL

Membrane Bioreactor Description

For the construction of the membrane bioreactor a tank of 110 L capacity was used. This tank was field up with 90 – 100 L aerobic sludge from the municipal wastewater treatment plant. The membrane module and the aeration system were introduced inside the reactor. The wastewater was supplied by a flexible-tub pump (type PA– B1) and the effluent was evacuated by a same pump that was connected with the membrane. The whole system was controlled by a digital microelement (Logo! 12/24 RC) produced by Siemens.

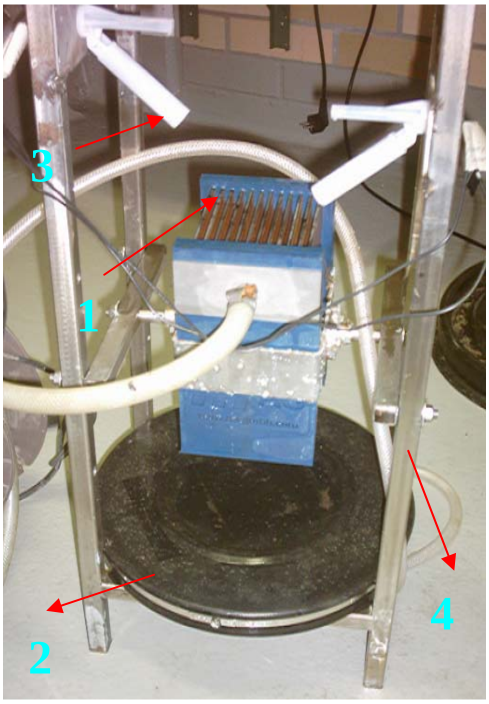

FIGURE 1. CONSTRUCTION OF THE MEMBRANE BIOREACTOR
1. Membrane with flat modules, 3. Level indicator
2. Aerator with fine bubbles, 4. Metallic supports

3. RESULTS AND DISCUSSIONS

3.1. Analyses using wastewater prepared in the laboratory

For the aerobic wastewater treatment, the wastewater was prepared in the laboratory using peptone, flash extract and normal water. The system worked continuously for four days. The wastewater was pumped in the bioreactor with a flow of 2.4 L/h, and the filtrated water was coming out with the same flow. In the last day the flows were increased at 7L/h. In the first two days wastewater with a TOC (total organic carbon) concentration of 448.2 ppm was used and then the amount of peptone and flash extract was doubled, so the concentration of TOC was of 1057 ppm. The TOC and TS concentration was measured everyday, and the SBL (sludge biological loading) value was calculated. The results are shown in the table 1.

The TOC concentration was measured with a Total Carbon Analyser (Shimadzu, TOC 5000). The carrier gas is a synthetic air with a flow rate of 150 ml/min. When the inside temperature reaches 6801C, the inorganic carbon removed from the solution by 25% phosphoric acid is determined. This device measure first the total carbon (TC) then, the inorganic carbon (IC), and finally shoes the values of the TOC as the difference between TC and IC.

The variation of the TOC in these four days is shown in the next diagram (fig 2). The diagram was built up proceeding from the table 1.

The variation of the TS (total solids) in these four days is shown in the next diagram (fig 3). The diagram was built up proceeding from the table 1.

TABLE 1. WATER RESULTS FROM THE AEROBIC WASTEWATER TREATMENT USING SYNTHETIC WASTEWATER

Days	h	TC (ppm)	IC (ppm)	TOC (ppm)	TS (g/L)	SBL (gTOC/gTS/d)
First day	0	63,10	0,657	62,44	3,2	0,098
	1	55,74	0,910	54,83		
	2	57,33	0,740	56,59		
	3	59,28	0,790	58,49		
Second day	0	51,67	1,297	50,37	3,6	0,087
	1	51,67	1,602	50,06		
	2	50,82	1,163	49,65		
	3	50,66	1,136	49,52		
	4	49,96	0,499	49,46		
Third day	0	47,82	0,813	47,00		
	1	47,33	0,995	46,33		
	2	47,64	2,000	45,64		
	3	47,48	1,620	45,86		
Fourth day	0	46,45	2,143	44,30	4	0,169
	1	56,87	12,63	44,24		

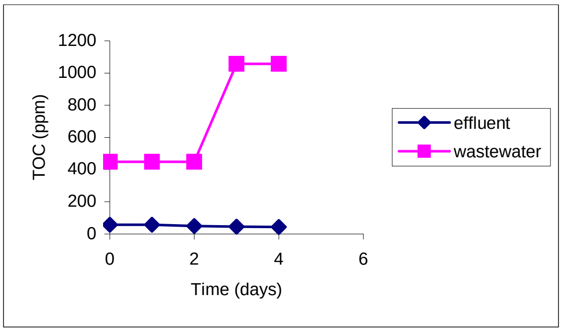

FIGURE 2. VARIATION OF TOC IN TIME

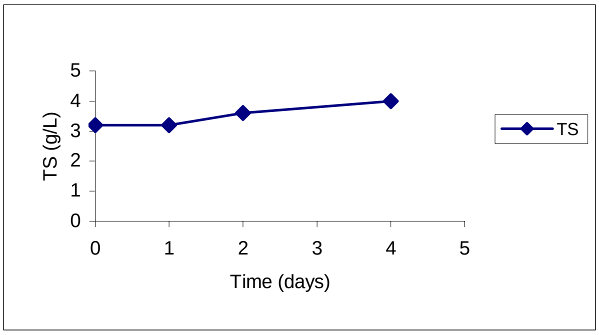

FIGURE 3. VARIATION OF TS IN TIME

CONCLUSIONS AND NOTICES:

It has been noticed that the total organic carbon was reduced substantially. The system was not affected by the increase of the wastewater concentration or by the increase of the flow. The total solids content in the bioreactor had increased during these four days so the sludge production is obvious. The system was working well.

3.2. ANALYSES AT THE WASTEWATER TREATMENT PLANT

The experimental apparatuses containing the bioreactor, the membrane, the pumps, the aeration system, were moved to the municipal wastewater treatment plant, and here another experiment was made, using municipal wastewater. The results are shown in the table 2.

The TOC diagram is presented next. The diagram was built up proceeding from the table 2. The TS variation is shown in the following diagram. The diagram was built up proceeding from the table 2.

Conclusions and notices:

The membrane bioreactor was working quit well at the municipal treatment plant. The concentration of total organic carbon was reduced. Because, the TOC concentration of the wastewater was very low compared to the wastewater prepared in laboratory, the system could work at a higher flow (10.08 – 11.88 L/h).

The total solid content suffered a sudden decrease during the first days, also because of the low TOC concentration of the wastewater, but later it started to increase as it is shown in the diagram. Unfortunately, some errors appeared in the system. The wastewater alimentation was from time to time blocked, and that is why the TS diagram presents these oscillations.

TABLE 2. WATER RESULTS FROM THE WASTEWATER TREATMENT PLANT

DATA	WATER	TC ppm	IC ppm	TOC ppm	COD mg/L	TS g/L	SBL gTOC/gTS/d
1.07	effluent	104.1	67.89	36.21	30.60	3.6	
	wastewater	203.2	98.61	104.5	251.8		
5.07	effluent	79.79	52.63	27.16	33.30	2.4	0.059-0.053
	wastewater	113.9	60.43	53.47	315.0		
6.07	effluent	75.54	49.85	25.69	31.10	2	0.092-0.083
	wastewater	163.6	94.83	68.77	257.7		
7.07	effluent	73.28	49.09	24.19	27.30	2	0.113-0.102
	wastewater	170.0	86.43	83.57	261.6		
8.07	effluent	73.50	49.94	23.56		2	0.099-0.089
	wastewater	167.5	93.30	74.20			
9.07	effluent	73.83	49.05	24.78		2.4	0.136-0.122
	wastewater	181.9	95.51	86.39			
12.07	effluent	66.77	49.99	22.78		2.4	0.052-0.047
	wastewater	95.99	55.64	40.35			
13.07	effluent	73.34	47.28	26.06	39.80	2	0.103-0.093
	wastewater	174.3	97.07	77.23	287.3		
14.07	effluent	73.25	46.88	26.37		2.4	0.104-0.094
	wastewater	176.1	96.83	79.27			
15.07	effluent	71.66	46.86	24.80		2.8	0.059-0.053
	wastewater	158.7	90.68	68.02			
16.07	effluent	68.45	46.29	22.16		3.2	0.073-0.065
	wastewater	179.9	105.7	74.20			
20.07	effluent	71.29	43.98	27.31	38.60	3.6	0.029-0.026
	wastewater	74.96	42.36	32.60	103.6		
21.07	effluent	53.23	27.67	25.56		3.2	0.066-0.059
	wastewater	157.0	90.02	66.98			
22.07	effluent	53.14	29.31	24.83		3,6	0.067-0.060
	wastewater	166,2	90.34	75.86			
26.07	effluent	65.11	35.30	29.81		4	0.062-0.055
	wastewater	165.7	87.98	77.72			

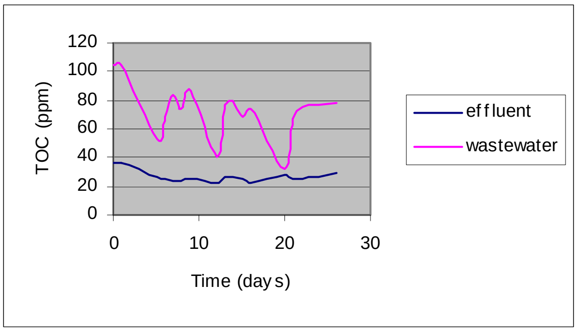

FIGURE 4. VARIATION OF TOC IN TIME

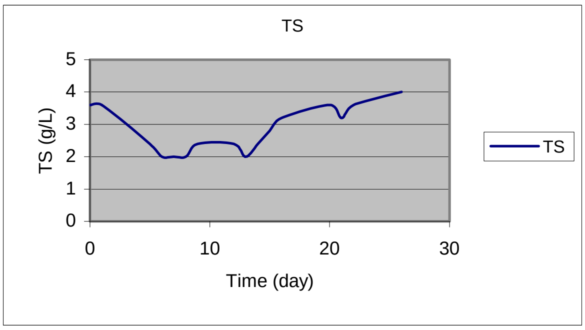

FIGURE 5. VARIATION OF TS IN TIME

4. CONCLUSIONS

In this paper a biological wastewater treatment process was studied, a membrane bioreactor under aerobic conditions was constructed. Different simulations were tried and several factors and parameters were emphasized.

First, the membrane bioreactor was tested in the laboratory with artificial wastewater. The system was working well, sludge production was starting and organic matter was reduced substantially. Secondly the membrane bioreactor was tested at the municipal treatment plant using normal wastewater. In the first days a sudden decrease of the total solid content was noticed, because the wastewater organic matter concentration was low and the bacteria from the sludge didn't have enough food for reproduction. But the sludge production started slowly and was influenced by the continuity of the system. So, an important factor which influences the system is the continuity of the system. Another factor is aeration; the bioreactor must be maintained under permanent aeration, in order to always have aerobic condition during the experiment.

The membrane separation bioreactor is preferred to other biological processes due to its ability to disinfect without the need of chemicals, high quality effluent and low space requirement for the experimental plant.

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