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Use of Three Types of Fish Scales as Biomass Support in Moving Bed Biofilm Reactor for Biological Treatment of Dairy Wastewater

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***Abstract*- This study focuses on the biological treatment of organic pollution load of effluents dairies. We propose a new method; it is the separate use of three fish species scales: Sardinapilchardus, Diplodussargus, Umbrinaroncador as solid support of free biomass colonization in moving bed biofilm reactor (MBBR) used to improve the properties and the quality of clearance. The results of monitoring depollution parameters (pH, COD, SM, total nitrogen) are promising. Finally the scales quantity necessary has been optimized for economic and ecological reasons.**

***Keywords*- fish scales, biological process, moving bed biofilm reactor, colonization, liquid effluents, dairy industry.**

I. INTRODUCTION

The dairy industry uses a lot of water during the manufacture of its products, which generates a huge amount of liquid waste [1]. Treatment can be achieved using different means. The biological purification process is very efficient and has been widely used thanks to the ecological and economic advantages it offers.

This method uses the principle of degradation of pollutants by the action of microorganisms. To increase the specific activity of the biomass, the formation of a biofilm scrubber has emerged as an attractive solution.

This Study suggests the use of a new method in biological processes. It is the recovery of fish scales as a solid support for biofilm formation in moving bed bioreactors in the presence of *Aspergillus Niger* strain.

II. MATERIALS AND METHODS

A. Biological model

The Aspergillus Niger has been used as a biological model in all manipulations due to its resistance to stress of some organic pollutants (phenol, detergent) and has a great degradation potential for many organic and inorganic pollutants [2].

The seeding of the effluent *by A. Niger* is done through the preparation of a liquid culture incubated 72 hours at 27 ° C. The cells were then recovered by centrifugation (4800 g, 20 min), washed 3 times with the artificial effluent contained in the bioreactor, diluted in a small volume of the effluent, and finally added back to the bioreactor.

B. Biofilm support

Fish scale, solid waste of the fishing industry, is used as support of colonization and biofilm formation byA. Niger. Three species of fish scales were tested separately: Sardinapilchardu (Pilchard, P.S), Diplodussargus (SarGros, SG.S), and Umbrinaroncador (Croaker, C.S).

The scales were collected and washed with hot demineralised water (80 ° C), dried overnight at 60 ° C and stocked at ambient temperature.

A preliminary study in which various amounts of materials ranging from 1g/l to 5g/l is tested. A better treatment is observed starting from 2 g/l for Pilchard scales and 4g / l for SarGros and Croaker scales.

C. Effluent

The tests were performed on a model effluent with physicochemical properties similar to dairy wastewater, prepared from UHT milk diluted 50 times.

D. Bioreactor

Degradation of the pollutant load is carried biologically. For this, a pilot was designed; it uses the principle of a moving bed biofilm reactor (MBBR) (Fig. 1). Homogenization is achieved by a hydraulic pump that circulates the effluent from the based bioreactor to the surface. The experiments were conducted at ambient temperature; it is regularly checked by a thermometer. Aeration is ensured by the filtered air continually injected by a pump.

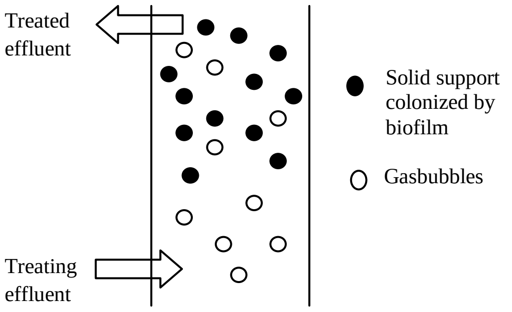

Fig. 1. Schematic representation of the bioreactor.

The witness test corresponds to the biodegradation test in the absence of a biomass support in the same conditions of aeration and agitation.

E. Analytical methods

Several physicochemical parameters were measured on average samples of six hours: the pH was measured using a pH meter (Type Fisher Scientific, Basic AB15). The temperature was determined in situ directly after collection using a conductivity meter (HANNA Instruments, EC215) through a specific probe. Total nitrogen was determined by the Kjeldahl method [3]. COD is determined according to French Standard NFT90-101 (2001) [4]. Suspended Matter (SM) is determined by filtering a volume of waste water of cellulose filter (0.45 microns) [5]. Phosphorus is determined by the colorimetric method according to the original German DIN 38405-D11-1 OPO43 (1993) [6].

III. RESULTS AND INTERPRETATIONS

Table 1 shows the evolution of various pollution parameters of the effluent with and without presence of scales

TABLE I. EVOLUTION OF THE POLLUTION PARAMETERS OF THE EFFLUENT WITH AND WITHOUT PRESENCE OF SCALES (PILCHARD SCALES, SARGROS SCALES AND CROAKERS SCALES).

	Time (Hours)	T(°C)	pH	COD (mg/l)	TNK (mg/l) (± % of degradation)	Phosphorus (mg/l) (± % of degradation)	Suspended Matter (g/l) (± % of degradation)
Witness (withoutscales)	**0**	17.4	7.58	4128	1401	68.75	0.88
	12	22.3	6.25	2654 (-35.7%)	630.45(-55%)	52.83(-23.1%)	0.54 (-38.6%)
	24	21.7	5.69	2476.8 (-40%)	490.35(-65%)	48.12 (-30%)	0.69 (-21.5%)
	36	21.6	5.64	1494 (-63.8%)	280.2 (-80%)	42.5 (-38.1%)	0.51 (-42%)
	48	21.2	6.76	1486.08 (-64%)	210 (-85%)	33.8 (-51%)	0.23 (-65%)
Pilchard scales (P.S)	**0**	17.9	7.21	4128	1471.07	67.6	0.82
	12	23.4	6.47	2592 (-37.2%)	770.55 (-47.6%)	24.11 (-64.3%)	0.35 (-57.3%)
	24	22.3	5.61	1728 (-58.1%)	560.4 (-62%)	33.5 (-50.4%)	0.9 (+9%)
	36	22	6.66	96 (-97.7%)	280.2 (-80.9%)	12.33 (-81.7%)	0.52 (-36.5%)
	48	21.5	7.21	48 (-99%)	70.05 (-95%)	8.67 (-87%)	0.44 (-46.3%)
SarGros scales (SG.S)	**0**	17.2	7.32	4128	1471.07	69.8	0.92
	12	23	5.77	1147.58 (-72.2%)	700.5 (-52.3%)	41.7 (-40.2%)	0.52 (-43.4%)
	24	23.5	6.76	804.9 (-80.5%)	360.45 (-75.5%)	45.3 (-35.1%)	0.53 (-42.4%)
	36	22.7	7.01	346.7 (-91.6%)	140.1 (-90.4%)	18.33 (-73.7%)	0.2 (-78.2%)
	48	21.2	7.05	146.7 (-97%)	70.05 (-96%)	11.95 (-83%)	0.14 (-84.8%)
Croakers scales (C.S)	**0**	22.5	7.25	4128	1471.07	68.75	0.91
	12	29.3	5.55	375.64 (-90.9%)	140.1 (-90.5%)	29.1 (-57.7%)	0.23 (-74.7%)
	24	27.7	7.06	0 (-100%)	70.05 (-95%)	13.3 (-80.6%)	0.21 (-76.9%)
	36	27.7	7.06	0 (-100%)	70.05 (-95%)	13.3 (-80.6%)	0.21 (-76.9%)
	48	27.7	7.06	0 (-100%)	70.05 (-96%)	13.3 (-82%)	0.21 (-76.9%)

A. Evolution of COD

Figure 2 show graphic presentation of COD evolution.

We note that the degradation of COD increases through time and varies according to the type of scales (Fig. 2).

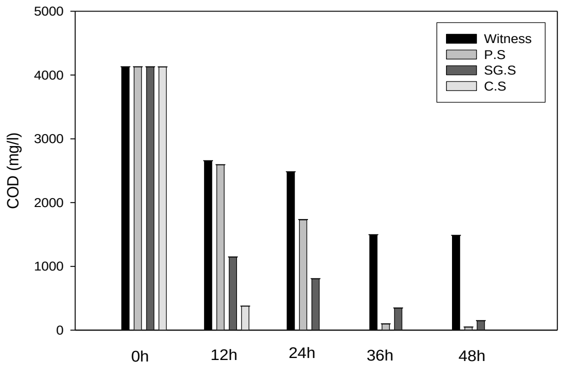

Fig. 2. Evolution of COD

COD decreases with through because of the use of organic compounds by *Aspergillus Niger*, this seems more important in the presence of scales, which may be explained by the colonization of these fungi on the basis of their carrier type.

B. Evolution of total nitrogen

According to Figure 3, we can see that generally nitrogen undergoes various transformations during biological treatment; the observed decrease in the above graph is due to the incorporation of nitrogen in the new cells of *Aspergillus Niger* produced.

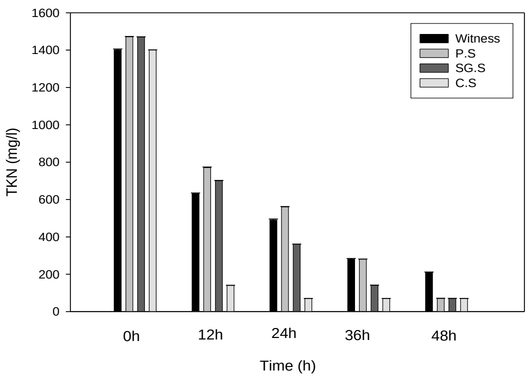

Fig. 3. Evolution of total nitrogen

These fungi provide the treatment for organic pollution load needed for the metabolism of many of their chemical elements, including nitrogen, which ranks first, since it is an important component of the fungal cell and accounts for approximately 5% of its dry matter [7].

The comparison between these values (Fig. 3) allows us to deduce that the decrease TKN is important after 24 hours in the presence of scales compared to the witness. This could be more remarkable by using the Croaker scales.

C. Evolution of phosphorus

Phosphorus compounds existing in natural waters and wastewater are in different forms, namely, soluble orthophosphate, soluble phosphate and organophosphorus derivatives [8].

The kinetics obtained followed by the orthophosphate during the various tests (Fig. 4) show that at first we observe a decrease of orthophosphate (dissolved orthophosphate in water are used for the growth of microorganisms, they are "bioavailable" [9]. Then in a second time an increase is noted (in the decomposition of organic matter, phosphorus fungi existing in water, sediment and transformed into inorganic phosphates dissolved by the mineralization process) [10].

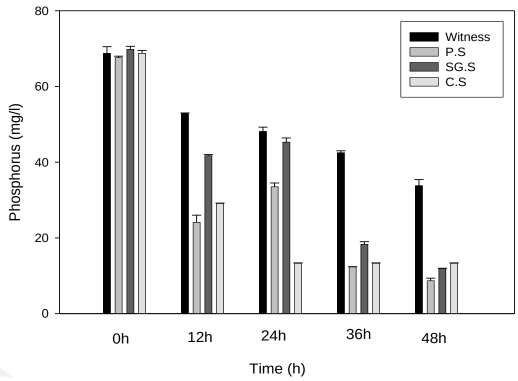

Fig. 4. Evolution of phosphorus

Effluent treatment in the presence of scales provides better reduction of phosphorus (Fig. 4). Its effect is more important in terms of reduction that time, in the tests carried out by the Croakers scales.

D. Evolution of suspended matter

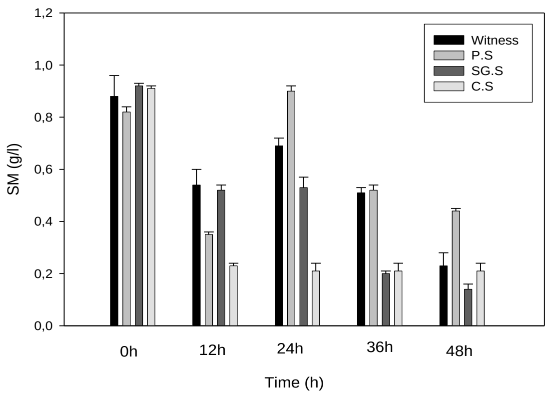

Fig. 5. Evolution of suspended matter SM

From the results of the evolution of the SM (Fig. 5.) a remarkable increase is registered for the witness and tests using P.S and SG.S (24 hours). While for tests using C.S, the rate of SM is reduced to reach 0.21 g / l after 24 hours of treatment.

Normally, the rate of SM should decrease over time of treatment. The increase reflects the adhesion of microorganisms on solid walls bioreactors due to specific properties of the biomass. When this material is detached, a sharp increase of SM can be observed [11].

IV. Discussion

A better homogenization is associated to optimize the mass transfer and help to improve the degradation rate. This is confirmed by the evolution of clearance in terms of performance reduction of COD, TKN and phosphorus recorded during this study.

The Kjeldahl nitrogen decreased by 95% and 96% respectively in treatment using the Pilchard scales and SarGros scales, always 48 hours after cleanup, and 96% after 24 hours of treatment using Croakers scales.

It is noticed that the presence of scales improves the quality of the treatment. Comparing the performance of three biomaterials (Pilchard scales, SarGros scales and Croakers scales), the presence of Pilchard scales and SarGros scales reduces COD up to 99% and 97% respectively after 48 hours of treatment, while the test conducted by the croaker scales causes a reduction of the COD rate to 100% in less time (only 24 hours) (Tab.1).

The results are better in terms of time compared to the performance of abatement of COD reduction found by Djelal et al. (2007) in fact 70% was obtained after 142 hours [12].

For Pilchard scales and SarGros scales, the phosphorus require more time to be degraded, which is explained by a reduction between 83 and 87% for the first and second test that last 48 hours. Concerning the processing carried out by Croakers scales to the same conditions of clearance; orthophosphate is reduced by 82% after 24 hours (Tab.1).

Finally, this study evaluates the role of fish scales as solid support for free biomass in the bioreactor moving bed in the presence of *A. Niger* to improve the properties and quality of clearance and this is confirmed by comparing the test results in the presence and absence of the biomaterials.

V. CONCLUSION

The structure and method of operation have been proven effective for biological aerobic treatment of effluents from dairies. The monitoring of classical parameters (TSS, COD, TKN and P) shows that the introduction of fish scales allows not only to improve the properties and quality of clearance, offering the potential for colonization of microorganisms and formation of biofilm on the surface cleaner but also respects the ecological and economic criteria in the recovery of solid waste.

Finally, the use of Croakers scales as support for free biomass shows the best results also in terms of the quality of clearance at the level of processing time required.

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