ALGAL BACTERIAL PROCESSES FOR THE TREATMENT OF AGROINDUSTRIAL WASTEWATER: A PRELIMINARY SCREENING

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1. INTRODUCTION

Large volumes of wastewaters from industries processing agricultural raw materials are continuously disposed to aquatic ecosystems worldwide (Bhatnagarab and Sillanpää, 2010). The disposal of such effluents in natural water bodies causes surface and groundwater contamination. Therefore, the development of cost-effective and environmentally friendly methods for the treatment of agroindustrial effluents is mandatory. Microalgal-bacterial processes constitute a less energy intensive and more environmentally friendly alternative to conventional treatment methods such as activated sludge or anaerobic processes due to its free O_2 production and its potential for nutrients recovery. Hence, in the presence of sunlight microalgae consume the CO_2 released during the bacterial mineralization of the organic matter and produce in turn the O_2 required by bacteria for the above referred mineralization and NH_4^+ oxidation (Muñoz and Guieysse, 2006) (Fig 1).

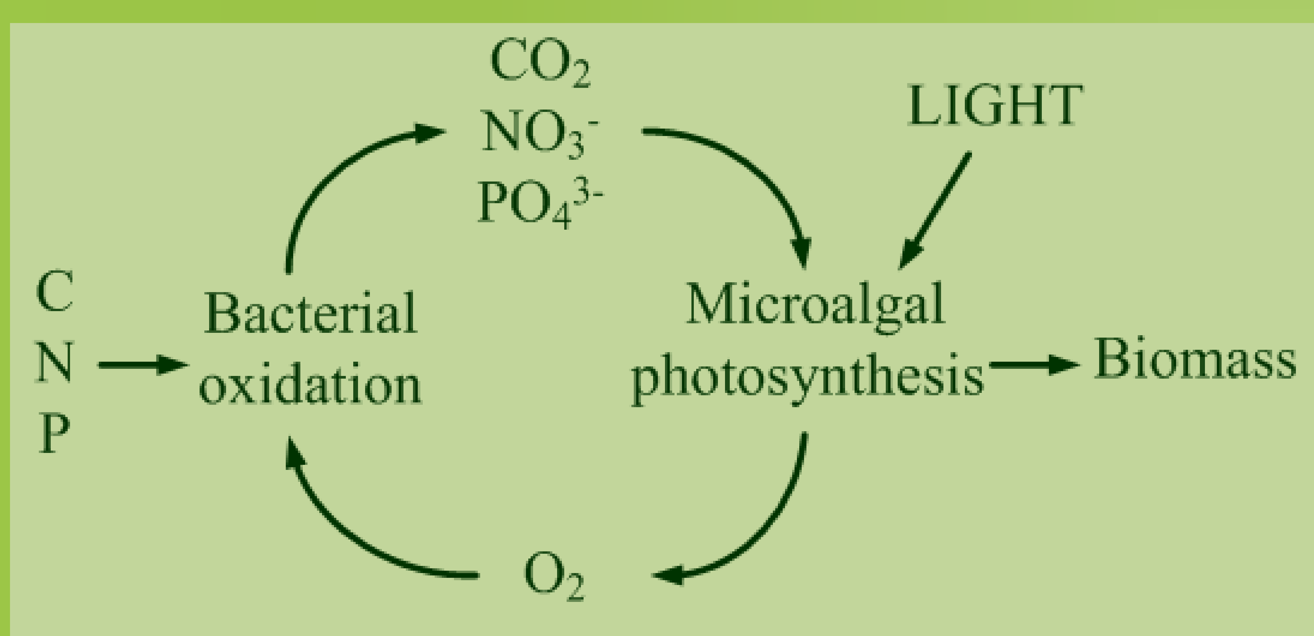

Figure 1. Principle of photosynthetic oxygenation in BOD and nutrientes removal processes

2. OBJECTIVES

This study systematically evaluated the potential and limitations of microalgal-bacterial technology for the removal of carbon, nitrogen and phosphorus from agroindustrial effluents.

3. MATERIALS AND METHODS

Four representative wastewaters from Castilla y León (Spain) were studied in the biodegradation tests: potato processing (PW, TOC= 327 mg/l; TN= 69 mg/l ; P-PO_4^{3-} = 6 mg/l), fish processing (FW, TOC= 381 mg/l; TN= 82 mg/l ; P-PO_4^{3-} = 6 mg/l), animal feed production (MW, TOC= 959 mg/l; TN= 197 mg/l ; P-PO_4^{3-} = 27 mg/l), and yeast production (YW, TOC= 1186 mg/l; TN= 703 mg/l ; P-PO_4^{3-} = 7 mg/l). Only the soluble fraction of the different agroindustrial wastewaters was considered in the present study (wastewater pretreatment by centrifugation at 10.000 rpm for 10 min). The biodegradation tests were carried out in glass bottles of 1,250 ml, filled with 1,000 ml of undiluted (1×), two times (2×), four times (4×) and ten times (10×) diluted (tap water) pretreated agroindustrial wastewater. The systems were inoculated with a symbiotic algal-bacterial consortium obtained by mixing activated sludge and microalgae, resulting in initial concentrations of 3.7±0.4 mg VSS/l and 0.7±0.3 mg VSS/l. These batch bottles were flushed with helium, closed with butyl septa and incubated at 30ºC under magnetic agitation (200 rpm) under 12/12 h/h light/dark periods at 76±4 μmol/m^2/s. All tests were carried out in duplicate and an additional 200 mg Cu/l supplemented-control test with 4 times diluted wastewater was also conducted to account for any potential C, N and P abiotic removal mechanism. The parameters monitored were the dissolved organic carbon (TOC), inorganic carbon (IC), total nitrogen (TN), NH_4^+, NO_2^-, NO_3^-, PO_4^{3-} and pH in the liquid phase according to Standard Methods, and CO_2 and O_2 in the headspace by GC-TCD.

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4. RESULTS AND DISCUSSION

PW showed a fast C and N removals regardless of the dilution applied likely due to its favorable C/N/P ratio (100/18/2) with removal efficiencies in wastewater of 45 and 70 %, respectively. A similar trend was recorded in FW, where its biodegradability occurred rapidly as a result of its favorable pH (7.58), and C/N/P ratio (100/19/1). C and P removals in MW were higher at the lowest wastewater dilutions. Despite its favorable C/N/P ratio (100/20/3), no biodegradation was recorded in 1× likely due to its high initial ammonium concentrations (189 mg NH_4^+/l). A total N removal of up to 80 % was recorded in the 4× tests. A similar biological inhibition to high ammonium concentrations was recorded in YW, where C and N removals increased in 10× compared to 4 ×, and no biodegradation occurred in 1× and 2× tests, whose initial ammonium concentrations were 565 and 271 mg NH_4^+/l, respectively. At the end of the tests the pH values recorded were lower than 10, which supported the fact that neither ammonium nor phosphorus removal took place by stripping or precipitation. The absence of NO_3^- and NO_2^- throughout the tests confirmed that nutrients removal occurred via assimilation into algal-bacterial biomass.

Figure 2. Test evolution in MW

Figure 3. Test evolution in YW

Table 1. Removal percentages of total carbon (C), nitrogen (N) and phosphorus (P) in every agroindustrial wastewater and batch dilution. N.B.O.= non biodegradation observed; N.T.= non tested.

Dilution	Element	Agroindustrial wastewaters removal percentage (%)			
		PW	FW	MW	YW
1x	C	23 ± 2	50 ± 1	N.B.O.	N.B.O.
	N	18 ± 0	64 ± 5	N.B.O.	N.B.O.
	P	-	12 ± 1	N.B.O.	N.B.O.
2x	C	45 ± 1	59 ± 6	47 ± 1	N.B.O.
	N	71 ± 0	78 ± 7	51 ± 1	N.B.O.
	P	-	-	83 ± 5	N.B.O.
4x	C	47 ± 7	57 ± 6	41 ± 4	7 ± 3
	N	71 ± 3	79 ± 0	80 ± 3	6 ± 1
	P	-	-	43 ± 9	-
10x	C	N.T.	N.T.	N.T.	44 ± 1
	N	N.T.	N.T.	N.T.	38 ± 3
	P	N.T.	N.T.	N.T.	-

5. CONCLUSIONS

In the absence of inhibitory compounds, the initial C/N/P ratio of the agroindustrial wastewater was correlated with its biodegradability under fully photosynthetic oxygenation (absence of external O_2 supply).

6. REFERENCES

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