

Biological Purification of Wastewater in Batch Culture: Process Technology Phragmifilter

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Abstract: The water pollution in the world poses a real public health problem. Indeed, the rarity of the source and degree of pollution are responsible for numerous health disasters. Thus, the wastewater reclamation becomes a primary parameter in environmental research. It is in this way that our research is undertaken, it relates to the purification of wastewater by *Phragmites australis* in arid and batch culture. The results obtained allow us to see the changing in environmental parameters (temperature, pH, dissolved oxygen) that influence the performance of purifying sewage systems and other parameters of the reduction in pollutants (MIS, OCR, Nitrogen, Phosphorus and bacterial contamination of fecal mass). Thus, using the model *Phragmites australis* in treatment ponds, thus allows the stratification of the water body and the homogenization temperature of the basin, the decrease in pH by one unit in the sewage two weeks of cultures, eliminating between 54 and 70% of ammonia nitrogen for initial expenses above 50 mg/L and finally, the reduction of 100% of *E. coli* and fecal streptococci.

Key words: *Phragmites australis* • Biological purification • MIS • OBR_s • OCR • Batch culture

INTRODUCTION

The research on the use of aquatic plants for water treatment has long focused on the comparison of purification performance of this new technique with oxidation ponds and mature, older. The reed (*Phragmites australis*) highlight of its merits was the main plant that has filled ponds and experimental stations built [1, 2, 3]. The use of aquatic plants to remove nutrients from polluted water and fighting against eutrophication of rivers and lakes has also been a driving force for research in the pioneering countries. Their ability to assimilate nitrogen or phosphorus is more to show today. These stations were very efficient in eliminating carbon pollution with yields up to 95% on the main parameters MIS, OBR_s, OCR, nitrogen and phosphorus. These results have encouraged the development of research into other channels, including the use of plants to absorb specific pollutants in water and recycling systems for biomass production in treatment ponds [4, 5, 6]. However, the influence of environmental parameters on the conduct of the processes that lead to the elimination of pollutants in these basins is still not well understood. Theories

governing principles of treatment in oxidation ponds or in systems with fixed biomass have often been transposed to reflect the elimination of pollutants in river macrophyte. The analysis of data reported in the literature shows however that these theories do not always explain the operation of this type of basin, where the reaction mechanisms put into play can be influenced by several factors among which we can identify the plant cover, temperature and the availability of dissolved oxygen. The objective of this work is to study the evolution of environmental parameters (pH, temperature, redox potential and dissolved oxygen) that influence the performance of purifying cleansing systems, enhance the removal of pollutants parameters (MIS, OCR, nitrogen, phosphorus and bacterial load) in the presence of plants, including reed ponds under arid climate.

MATERIALS AND METHODS

The tests are carried out batch wise in tanks of 100 liters are identical L = 150 cm, 50 cm and h = 40 cm. The experiment is performed with six bins in parallel, of which 5 are driven Reed (R) and the sixth without plant

Table 1: Initial composition of trays batch culture tests

Bin		R1	R2	R3	R4	R5	E
Dilution	Parameters	25% ED + 75% EC	50% ED + 50% EC	100% ED	25% ED + 75% EB	100% EB	100% ED
T (°C)		24	25	24	25	25	26
pH		6,9	7,2	7,6	7,4	7,1	7,5
Eh (mV)		-40	-200	-245	-260	-220	-300
O ₂ (mg/L)		0,50	0	0	0	0	0
Conductivity (μS/cm)		266	469	780	650	514	780
MIS (mg/l)		57	88	159	210	580	170
OCR (mg O ₂ /L)		130	216	431	530	1320	1640
OBR ₅ (mg O ₂ /L)		54	130	224	450	680	260
NH ₄ (mg/L)		9,10	23,8	50	41,23	23,80	51
NO ₃ (mg/L)		0,40	0,80	2,6	2,2	1	2,30
PO ₄ ³⁻		1,1	3	6,90	6	4,7	6,45
Total Germ(germ/mL)		248	15x10 ³	33x10 ⁴	IND	IND	IND
Mesophilic Flora (germ/mL)		150	2 X10 ³	51x10 ²	6x10 ⁴	IND	IND
Fecal Coliforms (germ/mL)		52	25 x10 ³	2 x10 ³	17x10 ⁴	10 ³	5 x 10 ³
<i>E. coli</i> (germ/mL)		41	18 x10 ²	16 x10 ³	19 x10 ²	45x10 ²	42x10 ⁴
fecal Streptococcus(germ/50 mL)		18	2 x10 ²	24 x10 ³	11x10 ²	11x10 ²	14x10 ²

* EB = raw water; ED = effluent decanted, EC = Water consumption; IND: ncountable

(E). The bins were filled with a mixture of raw water from unsettled, different initial concentrations of organic and mineral are shown at Table 1.

Measurements of pH, temperature, dissolved oxygen, redox potential and conductivity were performed at 10 cm, 20 cm and 30 cm deep, middle and end to 30 cm (longitudinal profile). The laboratory analysis have involved the following parameters: MIS, OCR, NH₄, PO₄, Total viable count, Flora Mesophyll, fecal coliforms, *E. coli*, fecal streptococci, analyzed according to methods [7, 8]. The adjustment period is approximately 6 days. At the beginning of the experiment, the effluent is emptied adaptation was quickly replaced by that required for the test. This is done in the morning to avoid water stress can be caused by high temperatures. The plants are not harvested during the duration of the experiment.

RESULTS

Evolution of Temperature, pH and Redox Potential:

The evolution of the average temperature was 10, 20 and 30 cm below the water level in the tanks covered with reeds (R) and a tray without plants, to free water surface (E), is presented in Figures (1) and Table 2. The values for the reed pans are an average over the five bins described above. Daily variation in outdoor temperature in January is the most important surface in the top 10 cm for both systems.

The presence of plants can reduce these fluctuations, however, only the superficial layers. In fact, average temperatures on the experimental period are 21.8±1.2, respectively, 19±0.5, 18.5±0.4 to 20, 40 and 60 cm depth bins reed and 24.7±1.5, 22.4±0.5 and 19.5±0.5 for tray without plants (Table 6. 4). The temperature difference between trays and bins without reeds varies between 2-4°C, over the first 20 centimeters. It is reduced to 1°C at 30 cm of depth. The evolution of pH is presented in Figures (2). As before, the averages for bins reeds are calculated for different depths 10, 20 and 30 cm. In the tray without plants, the pH becomes more alkaline over time. A 10cm deep, it increases by 2 units and reached 9.5 after 12 days of culture. This increase is explained by the photosynthetic activity of algae in this tank. In the tray covered with reed, the pH profile evolves towards values slightly acidic (7.3 to 6.3) with a decrease of one unit. The evolution of the redox potential is illustrated in Table (2). The presence of plants promotes the evolution of redox potential towards positive values and increases the oxidizing power of the medium. The initial value of the redox potential ranges from -262 to -216 between A.2 and A.5 mV and is -45 mV for R1. When the initial OCR is greater than 216 mg O₂/L (A.2 to A.5), the positive values of redox potential are reached from the 10th day of culture. With R1. (130 mg O₂/L), the redox potential reaches positive values in 4 days. In all cases, the maximum values reached are less than 250 mV.

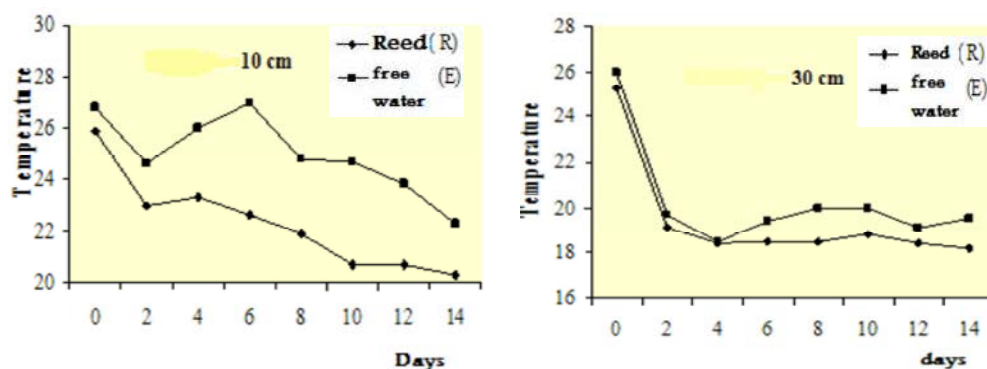


Fig. 1: Variation of Temperature in 10 and 30 cm of depth in basin with/without reed

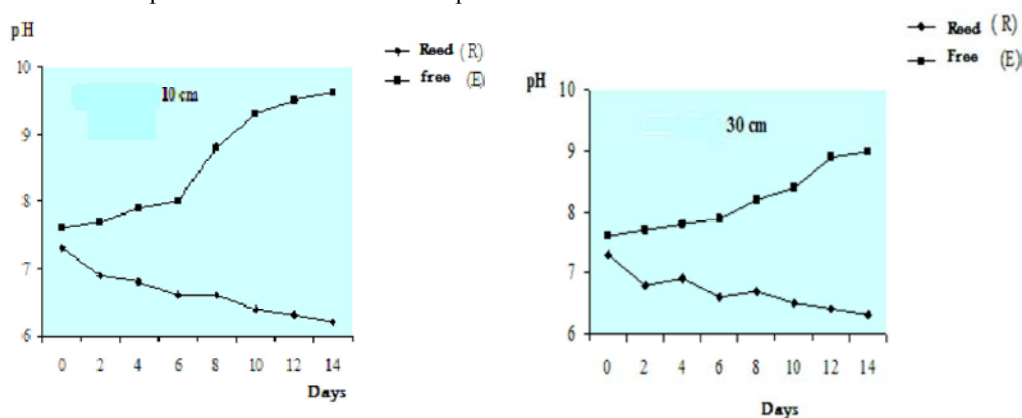


Fig. 2: Variation of pH in 10 and 30 cm of depth in basin with and without reed

Table 2: Evolution of redox potential in function of time in cultures of *Phragmites australis*

Days Experiences	R1	R2	R3	R4	R5
0	-45	-232	-262	-258	-200
2	-19	-162	-250	-250	-270
4	6	-18	-260	-261	-245
6	4	-80	-200	-180	-180
8	130	-5	-126	-130	-120
10	185	120	-158	-148	-190
12	194	168	50	50	-80
14	230	179	85	80	35

Table 3: Removal output of MIS, OCR and OBR₅ in Reeds Ferry in batch culture after two weeks of retention time

Output (%) trays	Mis	Ocrobr ₅
R.1	60	61
R.2	75	71
R.3	97	79
R.4	78	79
R.5	92	90

Elimination of Carbon Charge: The reduction of OCR and MIS is very fast in the first 5 days and then stabilizes when the concentrations of OCR reach 160 mg O₂/L

(Figure 3). The removal efficiencies in the bins range from 80-95% for OBR₅ of 61-90% for OCR, 60-92% for MIS (Table 3).

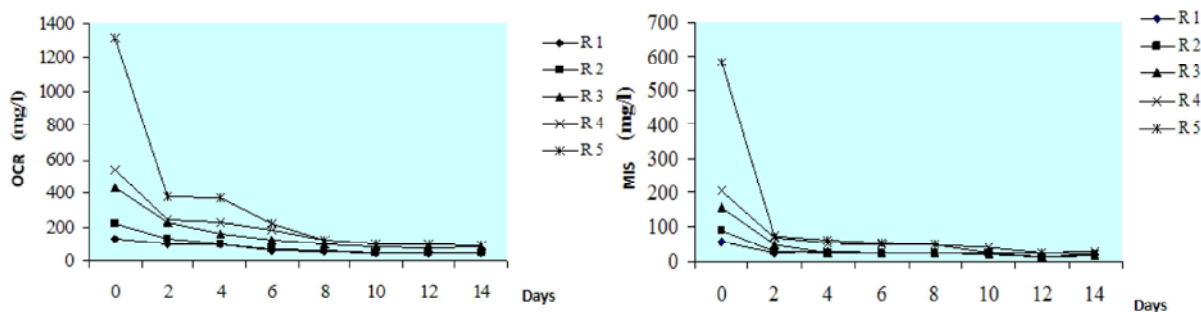


Fig. 3: Evolution of OCR and MIS versus time in days

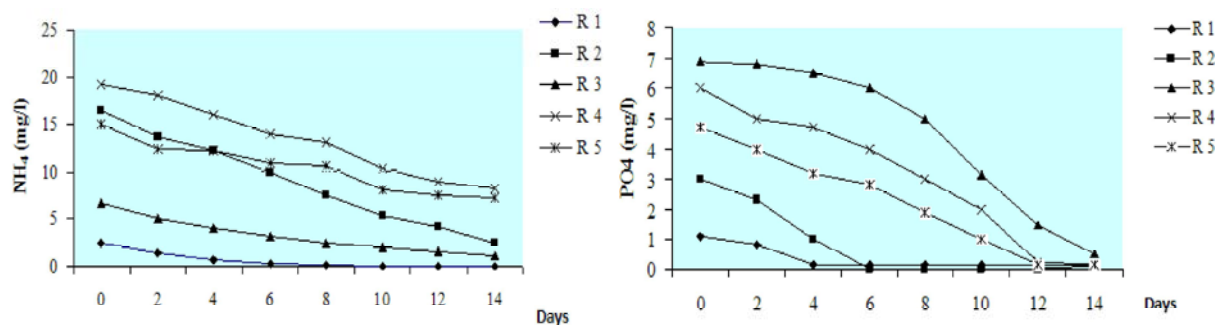


Fig. 4: Elimination of Phosphorus and ammoniac Nitrogen function of time

Table 4: Elimination of Bacterial load with fecal contamination

Germes Samples	Germes Total (germs/ml)	Mesophyllic Flora (germs/ml)	Fecal Coliforms (germs/ml)	<i>E. coli</i> (germs/ml)	Fecal Streptococcus (germs/50ml)
R1	248	150	52	41	18
R1*	11	9	Abs	Abs	Abs
Elimination	95%	94%	100%	100%	100%
R2	15x10 ³	2 X10 ³	25 x10 ³	18 x10 ²	2 x10 ²
R2*	18x10 ²	75	42 x10 ²	Abs	Abs
Elimination	88%	96%	83,20%	100%	100%
R3	33x10 ⁴	51x10 ³	2 x10 ³	16 x10 ³	24 x10 ³
R3*	8x10 ⁴	11x 10 ³	360	10 ³	Abs
Elimination	75,75%	78,43	82%	93,75%	100%
R4	IND	6x10 ⁴	17x10 ⁴	19 x10 ²	11x10 ³
R4*	10 ⁵	9x10 ³	82x10 ³	Abs	Abs
Elimination	-	85%	75,29%	100%	100%
R5	IND	IND	10 ³	45x10 ²	11x10 ²
R5*	22x10 ²	41x10 ²	25	Abs	Abs
Elimination	-	-	97,50%	100%	100%

Abs: absent

Elimination of Nitrogen and Phosphorus: Since ammonium is the dominant form of nitrogen in the early trials, we hypothesize that its elimination also reflects that of total nitrogen. In our experience (Figure 4), the elimination rates of ammonium ranged from 1.7 to 1.9 g of NH_4^+ / m³/day when the OCR concentrations are between 431 and 1640 mg O₂/L, who can say that the reduction of ammonium is constant when the organic load is high (= 431 mg O₂/L), but for low organic loads (130 mg O₂/L), the removal efficiency is more high (2.6 g NH_4^+ / m³/day).

The removal of phosphorus in ponds with macrophyte is mainly controlled by plant uptake and

complication reactions. In this part of the study, we did not analyze the presence and importance of concentrations of major ions (Ca_2^+ , Fe_2^+ , Fe_3^+ and Al_3) involved in these reactions. Emphasis will be placed on the yields achieved in the presence of plants. The concentrations of phosphorus (P-PO_4^{3-}) vary between 1 and 7 mg/L. Average speeds of extinction vary between 0.1 to 0.5 g/m³/day. The greatest elimination rates are obtained when the initial concentrations are high. However, the rate of elimination of phosphorus of the medium varies with the initial concentrations. The total phosphorus is removed in less than a week when the

initial concentrations are less than 4 mg/L. Between 4 and 7 mg/L, the removal efficiencies are between 93 and 100% in two weeks, whatever the load or nitrogen.

Elimination of Bacterial Load: The reduction of bacterial load is shown in Table (4). Levels of five experiments, the elimination of many germs fecal contamination is significant with a turnover rate ranging from 75.29% to 100% for fecal coliform and 100% for *E.coli* and fecal streptococci. However, the reduction of total bacteria was recorded only in experiments R1, R2 and R3 and that of the mesophilic flora was recorded in experiments R1, R2, R3 and R4. The elimination rate remains above 70%.

DISCUSSION

Changes in temperature during the two weeks of experience shows, in [9] that the temperature differences obtained between the bins and bins without reeds do not influence the selection of micro-organisms responsible for treatment, but it can play an important role during the warmer months and increase the volatilization of ammonia in tanks without plants, which can be toxic to wildlife and flora. However ponds reeds can limit heating and emission of ammonia (by limiting the growth of algae) [10, 11, 12]. The results concerning changes in pH (Figure 2) are agreements with those observed in Ghana in similar experiments which also show that the order of decrease in pH up to two units when the culture period is 4 weeks [13, 14]. The decrease in pH in tanks Reed does not seem to affect plant development because it is acidic ($4.5 < \text{pH} < 6.5$) that its growth is optimal [15, 16, 17]. Several factors may explain this decrease in pH. We can mention the accumulation of H^+ due to the activity of nitrifying bacteria, the accumulation of CO_2 due to plant metabolism or degradation of organic matter by heterotrophic bacteria [18, 19]. The production of H^+ by the plant to compensate for the removal of certain cations (mineral nutrition) [20,21]. And finally, the secretion of exudates (organic acids) in the roots of plants [20]. The elimination of the carbonaceous feedstock in the bins by *Phragmites australis* is indicated during the evolution of OCR and MIS. The slowdown of the observed reduction in OCR level bins experiment can be explained by the fact that fractions and dissolved biodegradable become important during the treatment. Indeed, this phase occurs when the majority of MIS is eliminated in the bins or in the first week of culture for all samples. Regarding the elimination of ammonia nitrogen, the results show that the organic load has no influence on the elimination of it beyond a

certain load, which can be considered equal to an OCR of 260 mg O_2/L in the experiment R.2. The reduction in bacterial load in fecal contamination is perfectly correlated with the presence of reeds. The fewer germs may be due, in on the one hand the limitation of nutrient requirements in the experimental setting and to the secretion of substances "Biocide by the roots of reeds. In our case, the factor temperature 25°C can be added by playing a role in inhibiting certain forms of bacteria.

CONCLUSION

The mechanisms we have studied purifying found that the use of reeds in lagoons allows the stratification of the water body and to homogenize the temperature of the basin. The pH decreases in this microcosm of a unit during the two weeks of treatment in culture. The presence of reed is changing the parameters of the medium. The redox potential of a medium reducing character ($< -200 \text{ mV}$) is evolving towards positive values ($\leq + 250 \text{ mV}$) and dissolved oxygen accumulates at the same time in the basin. The removal of ammonium is mainly due to nitrification/denitrification intensifies when the organic load is low. The efficiency of nitrogen removal is independent of the organic load for initial concentrations above 140 mg O_2/L . In two weeks of culture, the removal efficiency of ammonium varies between 54 and 70% for initial concentrations of $\text{NH}_4 > 50 \text{ mg/L}$. At the beginning of culture, when the environment is anoxic, it is possible that the *Anammox* bacteria oxidize ammonia to elemental nitrogen. Finally, in batch culture, the elimination of the bacterial load in fecal contamination is remarkable with a turnover rate of 100% for *E.coli* and *Fecal streptococci*.

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