Evaluation of the Treatment for Petroleum Production Wastewater Industry Using Artificial Wetland Planted with *Eichhornia crassipes*

A. Suarez, N. Agudelo, A. López, J. Briceño

Universidad Libre, Departamento de Ingeniería Ambiental, Facultad de Ingeniería
Carrera 70 53-40, andresf.suareze@unilibrebog.edu.co

ABSTRACT

Two artificial pilot scale wetlands of 384 l of volume with 60 cm of sand and gravel were evaluated for establish the behavior of *Eichhornia crassipes* in petroleum production wastewater treatment. One of the wetlands was planted, the other one was used as control. Physical and chemical parameters as pH, temperature, conductivity, dissolved oxygen phosphorus, nitrogen, nitrites, nitrates, COD, BOD, heavy metals, phenol chlorides and oil and fats were evaluated as function of time with residence time of 2 and 4 days at the entrance and exit of the wetland.

The planted wetland shows phenol removal of 82%, COD. BOD had removals about f 70%, oil and fats 82%, turbidity 86%, showing a high efficiency for this kind of systems. However there were no difference for the removal of heavy metals between the planted and no planted wetland as is characteristic of this kind of systems.

Keywords: Artificial wetlands, wastewater treatment, production wastewater

1 INTRODUCTION

The petroleum industry is an important economic activity for Colombia. Each day, the exploration and extraction of petroleum is increased, affecting the natural resources. In the oriental region of Colombia, the Rancho Hermoso field has a wastewater treatment plant due to the requirements of the local law, nevertheless, this water can't be used for other industrial or domestic process, for this reason a complementary treatment is necessary, in order to reuse the treated water inside the petroleum plant facilities.

Phenolic compounds and heavy metals are the major problems due to their high toxicity for the environment and the human health. For the removal of this compounds methods like adsorption, precipitation can be expensive and not environmental friendly. Artificial wetlands as complementary treatment can be used for the removal of heavy metals and organic compounds from the wastewater to levels that allow reuse them.

Eichhornia crassipes has been used for the wastewater treatment. In France, an early study related to the conditions of Salinity and pH for the growth of the plant. Suspended solids, total hydrocarbon and total organic carbon was evaluated. This study concluded that for the *Eichhornia crassipes* is necessary a salinity below 5 $mg.l^{-1}$ and pH less that 10 units. The removal of total organic carbon, total hydrocarbons and total suspended solids are 18%, 28% y 26% respectively [1].

Another study of water treatment in Bahía, Brazil, *Eichhornia crassipes* was studied in order to find the concentration of chromium adsorbed form solutions of 25 and 50 mg. l^{-1} of Cr. Accumulation of Cr in the root, cellular walls and xylem were find 30 days after the contact of the plants with the chromium solutions[2]**.**

In Israel, wastewater treatment with *Eichhornia crassipes* and *Pistiastratiotes* has reached removal that allow maintain low levels of BOD (5-7mgl^{-1}), COD (40-50mgl^{-1}), TSS SST (3-5mgl^{-1}) and turbidity between 1 and 2 NTU. [3]

In Guatemala, *Eichhornia crassipes* and *Thypaspp* were evaluated for heavy metal removal from effluent of an anaerobic treatment. Higher removals of chromium, copper, zinc, and lead were find for the *Eichhornia crassipes* than *Thypaspp*[4].

2 MATERIALS AND METHODS

Two Artificial wetlands were built with 384 l plastic box (figure 1). Gravel and sand were used in both wetlands; one of them was planted with *Eichhornia crassipes* collected form the Rancho Hermoso region, the other one was left as a blank in order to find the effect of the plants in the removal of organic and inorganic contaminants. The theoretical retention time was 4 days.

Inlet and oulet water was tested for pH, temperature, turbidity, conductivity, disolved oxygen, total phosporus, selenium, aluminum, mercury, phenol, chlorides, oil and fats acording with the Standard Methods for the Examination of Water and Wastewater [5]. The water samling was performed each 3 days the first 46 days, and then each week untill reach 90 days of sampling and measurement.

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Figure 1. Artificial wetland planted (right) and control (left)

Figure 2. *Eichhornia crassipes*

3 RESULTS AND DISCUSION

The initial characterization of the inlet water for the wetlands is showed in the table 1. There is no high variation in the inlet parameters for the study period. The values are the media of the inlet physical and chemical parameters measured in 90 days of study.

Parameter	Value
COD	314,78 $mg.l^{-1}$
BOD	139,94 $mg.l^{-1}$
pH	8,400
Turbidity	75,39 NTU
Phenol	1,54 $mg.l^{-1}$
Aluminum	3,8E-01 $mg.l^{-1}$
Selenium	2,5E-03 $mg.l^{-1}$
Barium	4,9 $mg.l^{-1}$
Arsenic	3,3E-03 $mg.l^{-1}$
Mercury	2,1E-04 $mg.l^{-1}$
Nitrogen	2,12 $mg.l^{-1}$
Chlorides	681,43 $mg.l^{-1}$
Total Suspended Solids	56,00 $mg.l^{-1}$
Oil and fats	36,31 $mg.l^{-1}$

Table 1. Physical and chemical properties of the inlet water

The stabilization period of the wetland was 90 days; the removal of the physical and chemical parameters is showed in the table 2.

Parameter	Outlet wetland Planted (%)	Outlet wetland Blank (%)
COD	79,0	70,3
BOD	73,3	64,9
Turbidity	91,7	90,0
Phenol	89,0	80,0
Aluminum	12,5	10,4
Selenium	15,4	12,6
Barium	56,2	51,3
Arsenic	16,7	16,7
Mercury	66,7	33,3
Nitrogen	33,3	36,4
Chlorides	26,1	24,1
TSS	92,5	89,7
Oil and fats	71,0	71,4

Table 2. Removal of physical and chemical parameters after 90 days.

The removal of COD and BOD is high in both wetlands, showing a little increase in the planted one. The COD and phenol removal is increased about 9% by the effect of the *Eichhornia crassipes*. However, most of the organic matter is removed by effect of the adsorption or the biofilm formed in the gravel as is expected for this kind of systems.

Mercury has a higher removal for the planted wetland than the blank, suggesting a bioaccumulation of this heavy metal in the *Eichhornia crassipes*. No toxicity at the plants is evidenced after the period of study as shows in the figure 3.

Figure 3.Planted wetland after 90 days of operation.

4 CONCLUSIONS

After 90 days of monitoring two artificial wetlands, equilibrium represented by a constant removal was achieved. The removal of organic matter Levels of 30 $mg.l^{-1}$ of BOD and 4.0 $mg.l^{-1}$ at the outlet of the planted wetland was reached, according with the literature those levels are indication of a god behavior for artificial wetlands. Chloride levels still has a high value at the end of the process, but the operation takes far away from the salinity conditions recommended in literature [6].

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