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Phytoremediation potential of an aquatic weed, *Eichornia crassipes, in* crude oil contaminated sites

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Abstract. The potential of plant-assisted bioremediation in crude oil polluted aquatic ecosystems was studied**.** The aim was to access the efficacy of *Eichornia. crassipes (*Water hyacinth) and their associated microorganisms in the treatment of crude oil contaminated waters and the duration of treatment required for the restoration of acceptable water quality. The experimental approach involved the exposure of the plants to varying concentrations of crude oil (500mg/l, 2500mg/l and 5000mg/l) under laboratory conditions for six weeks. From the results, percentage reductions of total hydrocarbon content were 98.46, 99.65 and 99.82% under 500mg/l, 2500mg/l and 5000mg/l of crude oil exposure concentrations respectively. In addition, the total heterotrophic bacteriaand fungi, and the hydrocarbon degrading bacteria and fungi in the exposure media increased from 0.07 to 1.48 Cfu/ml, while the growth of *E. crassipes* was enhanced from 1kg to 4kg. Water quality variables were also observed to improve significantly with percentage reductions of 99.82, 99.95, 99.99 and 85.05 for chemical oxygen demand, nitrate, phosphate and total organic carbon after six weeks of treatment with *E. crassipes.* It is concluded that the introduction of *E. crassipes*in oil contaminated waters resulted intheremoval of the crude oil and restoration of water quality through the interaction of *E.crassipes* and their associated microorganisms. Thus, *E.crassipes* can serve as an agent of bioremediation in crude oil contaminated waters.

Key words: Water hyacinth, bioremediation, microorganisms, Total Hydrocarbon.

Introduction

Nigeria continues to experience remarkable increases in operational activities in her oil and gas exploration and exploitation sector, refining and products marketing practices. These activities are cantered mainly in the Niger Delta Basin and have been associated with frequent oil spills resulting from oil pipeline vandalization, tanker accidents and accidental rupture of oil pipelines. As a result, crude oil and its refined petroleum products are frequently released into the terrestrial and aquatic environments. This is despite the introduction of more stringent environmental regulations. Consequently, the risk of oil spills affecting these ecosystems is still very high and is generally accepted as inevitable (Kinako, 1988; Venosa and Zhu, 2002). In order to minimize the adverse environmental effects of such discharges, it is imperative to clean up these pollutants by applying remedial measures (Ellis *et al*., 1990). The emergence of bioremediation approaches which are secondary treatment options hold great promise. Major techniques include; biostimulation, Bioaugumentation and phytoremediation; where the microorganisms associated with certain plants are harnessed to bring about degradation of the oil. This study attempts to determine the efficacy of *Eichornia.crassipes*and their associated microorganisms in the treatment of crude oil contaminated waters and the time required for the restoration of the quality of the water.

Materials and Methods

The crude oil was obtained from Shell Petroleum Development Company, Warri while both the water samples and the water hyacinth stock were collected from Jeddo River, Nigeria. In the laboratory, nine experimental tanks were filled with water and replicated into 3 micro plots. The aliquots of the pollutant (10mls 20mls and 50mls of crude oil were introduced into 20liters of water to constitute the treatment media as follows: (500mg/l, 2500mg/l and 5000mg/l). Approximately 1 kg of the weeds, E .crassipes stock were introduced into each of the tanks.The roots of the plants were washed thoroughly in running tap water for 48 hours to regain normal growth. Two experimental runs were conducted on the water samples and *E*. crassipes; prior to contamination with crude oil which served as controls. Data collection and collation to ascertain plant performance and the uptake of the crude oil was done weekly. The water samples were analyzed as described in the Standard Methods for Examination of Water and Wastewater (APHA, 2005)

Results and Discussion

From results shown in table1, the pH ranged from 6.10 to 6.15 under 500mg/l, 2500mg/l and 5000mg/l contamination regimes respectively following six weeks of introducing *E. crassipes*while temperature ranged from 27^{O}C to 30^{O}C. The observed pH and temperature values were within the optimum range (pH 6-8 and temp. 30^{o}C) for optimal biodegradation to occur (Mentzer and Ebere, 1996). Similarly, Dissolved oxygen (DO) increased from 5.11mg/l to 6.10mg/l in the test tanks after six weeks of treatment with *E. crassipes*. This could be attributable to the re-aeration of the water occasion by exposure to the atmosphere and the release of oxygen during photosynthesis by the plants.At the end of the treatment period, percentage reductions achieved for biochemical oxygen demand (BOD) were 99.52, 99.89 and 99.95 under 500mg/l, 2500mg/l and 5000mg/l of crude oil concentration regimes respectively while chemical oxygen demand (COD) percentage reductions were 98.46, 99.65 and 99.82 under 500mg/l, 2500mg/l and 5000mg/l of crude oil regimes respectively. The total organic carbon (TOC) values also revealed percentage reductions of 80.56, 83.80 and 85.05 under 500mg/l, 2500mg/l and 5000mg/l of crude oil exposure concentrations respectively. The percentage reductions in BOD, COD and TOC, achieved can be attributable to the contribution of *E. crassipes*and other factors such as; continuous aeration, sunlight and increased microbial activity which could have influenced the high rate of crude oil uptake by the plants. With respect to total hydrocarbon content, percentage reductions presented in Figure 1, were 91.91, 99.98 and 99.99 under 500mg/l, 2500mg/l and 5000mg/l of crude oil concentrations respectively.

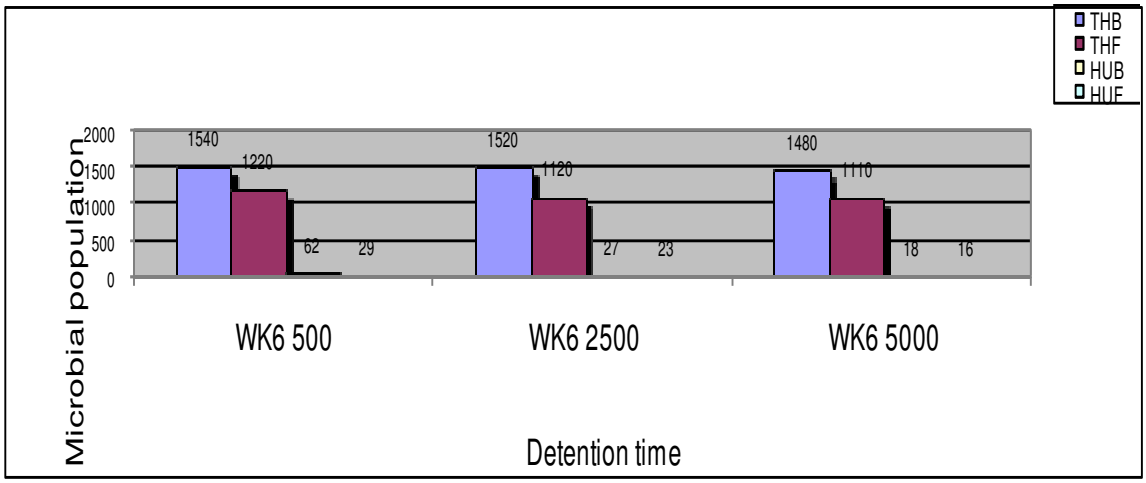

Figure1: Percentage Reduction in THC Following Introduction of Water hyacinth after 6 weeks

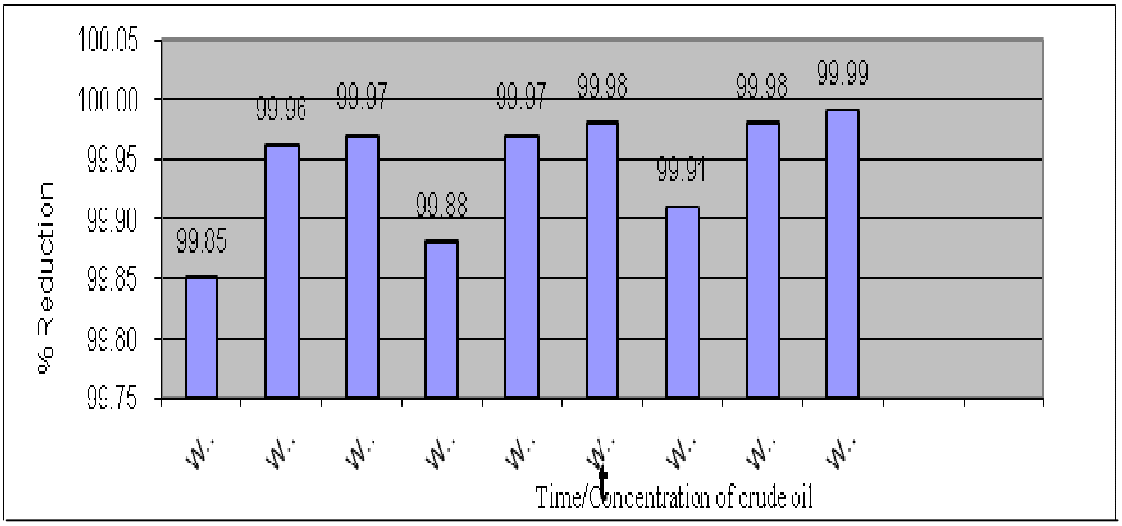

Figure 2: Changes in Microbial population in Plants after 6 weeks of Detention

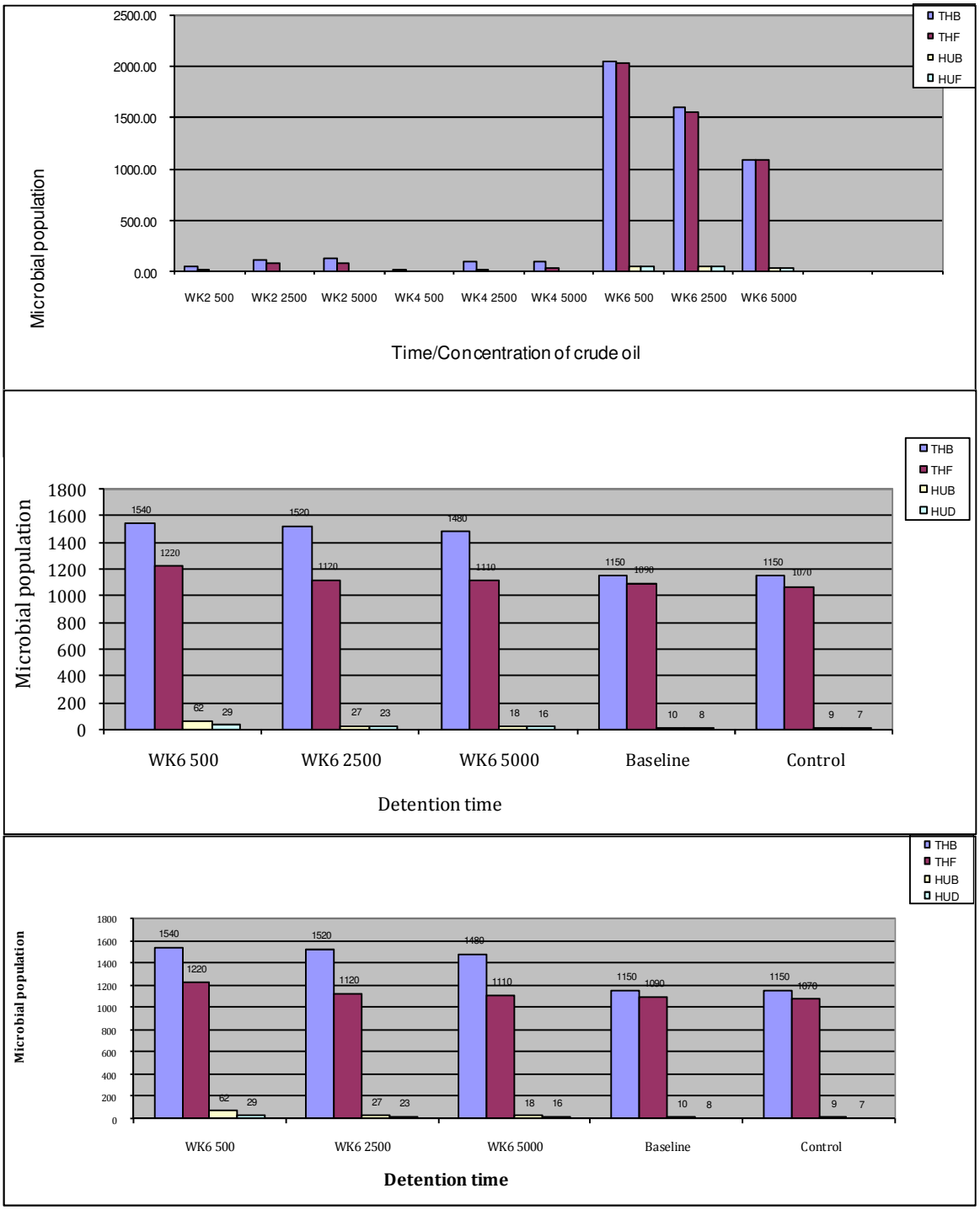

Figure 3: Changes in Microbial Population in the Water Sample after 6 weeks of Detention Time
Key: THB- Total heterotrophic bacteria; THF- Total heterotrophic fungi.
HUB- Hydrocarbon Utilizing Bacteria; HUF- Hydrocarbon Utilizing Fungi

Table 1: Mean values and percentage Reductions of water quality variables and total hydrocarbon content after six weeks of introduction of Water hyacinths

Parameters	Baseline Data Achieved for Water Sample	Mean Values and Percentage Reductions Achieved After 6 weeks of Contamination and Treatment		
Concentration		**500mg/l**	**2500mg/l**	**5000mg/l**
pH	6.10	6.12	6.14	6.15
Temperature,^{0}C	27.70	28.00	29.00	29.15
Biochemical Oxygen Demand, mg/l	5.86	99.52*	99.94*	99.95*
Dissolved Oxygen, mg/l	5.11	5.88	5.92	6.10
Chemical Oxygen Demand mg/l	7.42	98.46*	99.65*	99.82*
Nitrate, mg/l	3.95	99.52*	99.89*	99.95*
Phosphate, mg/l	0.416	99.96*	99.98*	99.99*
Total Hydrocarbon Content mg/l	0.001	99.91*	99.98*	99.99*
Total Organic Carbon, mg/l	276	80.56*	83.80*	85.05*

With respect to Total Hydrocarbons, (THC), the concentration before exposure of the plants to crude oil contaminated media was 0.04ppm while six week after exposure, 0.24, 0.54 and 0.64ppm were recorded under 500mg/l 2500mg/l and 5000mg/l exposure regimes respectively. However, the differences between the amount of THCs remaining in the medium and the amount taken up by the plants accounts for the amount either evaporated and/or utilized by bacteria in bringing about degradation. This reduction confirms that *E.crassipes* has water-purifying potentials and that the presence of microorganisms capable of degrading petroleum hydrocarbon and related compounds further enhances the process (Zobell, 1973). On the other hand, in figures 2 and 3, microbial counts in the roots of *E.crassipes/*waterincreasedafter six weeks of detention time. It is plausible that the exudates released from *E.crassipes* could have acted as a nutrient source for the microbes and enhanced microbial growth and activity. Thus, oil degradation was enhanced as a result of the utilization of the carbon as a source of energy. In addition, plant growth was stimulated (table 2) in the contaminated tanks. This could be attributable to the interaction between*E.crassipes* and the associated microorganisms which enhanced biomass production and the tolerance of *E.crassipes* to the toxic effect of crude oil.

Table 2: Growth parameters of *E. Ceassipes*

Concentration	**Plant height (cm)**		**Root length (cm)**		**Number of leaves**		**Wt. of *E.crassipes***	
	Before exposures	***Six weeks after***	***Before exposures***	***Six weeks after***	***Before exposures***	***Six weeks after***	***Before exposures***	***Six weeks after***
500ml/l	48	79	13	31	29	78	1kg	4kg
2500ml/l	49	74	11	33	33	77	1kg	4kg
5000ml/l	54	77	11	33	33	70	1kg	4kg

Conclusions

Our data have demonstrated that *E.crassipes*and their associated microorganisms possess great potential to remediate crude oil contaminated waters and hence can serve as agents of bioremediation.

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