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Phytoremediation potentials of water Hyacinth. *Eichhornia Crassipes* (mart.) Solms in crude oil polluted water

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ABSTRACT: The pollution of crude oil contaminated water has been a major problem in oil producing communities and the use of plant to clean such water bodies has been on investigation. In order to identify plants that can enhance the remediation of crude oil contaminated water, the effect of the growth of *Eichhornia crassipes* on the physico - chemistry and crude oil content of water contaminated with different concentrations of crude oil was investigated in this study. The containers were filled with water and the treatments used were 0ml, 10ml, 20ml, 30ml and 40ml of crude oil respectively. The control 0ml had no crude oil in it. This was replicated four times to give an observation of twenty. The phytoremediating plant *Eichhornia crassipes* was introduced into the containers two weeks after pollution. Morphological parameters were taken and the physico-chemical analysis of all the water bodies such as Dissolved Oxygen (DO), Conductivity, Temperature, Total Dissolved Solid (TDS), Turbidity, Salinity, Total Petroleum Hydrocarbon (TPH) and pH were determined. Results from this study shows that *Eichhornia crassipes* is a phytoremediating plant.©JASEM

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Phytoremediation process involves mitigating pollutant concentrations in contaminated soils, water or air with plants able to contain, degrade or eliminate metals, pesticides, solvents, explosives, crude oil and its derivatives (Raskin, 1996). Crude oil has a major impact in the environment into which it is released. Aquatic pollution resulting from crude oil contamination has been a multi-facet problem presently ravaging the aquatic ecosystem in oil producing communities all over the globe. In Nigeria the major cause of crude oil pollution is as a result of pipeline vandalization by saboteurs (individuals and group) seeking government attention to correct economic marginalization and ecological disaster occasioned by many years of unregulated crude oil exploration and exploitation by foreign companies. This has led to loss of species diversity, loss of habitat, destruction of breeding grounds of aquatic organism and sometimes death of organism including man (Ndimele, 2008). The social and economic lives of people living in such communities are also affected because their rivers and other water bodies can no longer sustain aquatic life and so their primary source of livelihood is affected. They can no longer drink or swim in their river as they used to and this affects their social life. Conventional oil spill counter measure of physical, chemical and biological methods have been used over time. Commonly used physical methods include booming and skimming, manual removal (wiping), mechanical removal, water flushing, sediment relocation and tilling. Chemical methods involve the use of dispersants and this has done more damage to the aquatic ecosystem than the crude oil itself (Lin and Mendelssohn, 1998). Hence, the needs for this study (Phytoremediation) a more environment friendly technique. Several aquatic plants have been shown to have the ability to filter contaminants on polluted water (Brooks and Robinson, 1998). Some aquatic plants accumulate metals and many species suffer phytoxicity while others grow easily in the presence of metals. There are seven species in the family Pontederiaceae and three genera. The genera are *Eichhornia* (kunth), *Hetherauteria* (Puiz and Par) and *Pontederia* (L). The genus *Eichhornia* is made up of three species namely; *E. crassipes* (common water hyacinth), *E. azurea* (rooted water hyacinth) and *E. paniculata* (Brazilian water hyacinth). Genus Hetherauteria also has three species which are *H. reniforms* (Kidney leaf mud plantain), *H. dubia* (grass leaf mud plantain) and *H. limosa* (Blue mud plantain) while the genus pontederia has only one species, *P. crassipes* (Richard, 1999).

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In Africa, *E. crassipes* was first reported in the Nile River in 1956 and has spread by 1966 to the Jebel Aulia Dam near Khartoun (Cook, 1976). *E. crassipes* was first reported in Lagos in 1984. it has expanded to other parts of the country including Yenagoa, Bayelsa State, Ahoada and Choba Rivers of Rivers State all in the Niger Delta Area of Nigeria. This floating invasive species of *Eichhornia* is probably the most prolific plant species in the World Rivers and canals. The leaves of the plant represent 60-70% of the water hyacinth plant biomass and the leaf turn over rate can range from 60-70% per month (Schmitz *et al,* 1993). Water hyacinth causes problems in many regions of the world by disturbing human activities such as fishing, irrigation and navigation. It also form micro habitat for some aquatic animals, birds and disease vectors. The decomposition of the plants if large biomass of the plants were killed at once, can use up all oxygen in the water. Despite all these problems created by water hyacinth some positive reports have been recorded. For example it has been reported to be useful in biogas generation because of its 64% methane content (Gopal, 1987). It is also used as fertilizer, for animal feeds, paper production and for water purification (Isichei *et al*., 2003). Hence the objective of this study is to determine the phytoremediation potential of Water Hyacinth. Hence, the aims of the study were to determine the bioaccumulation capacity of *E. crassipes* and to determine the extent of *E. crassipes* tolerance to toxicity.

MATERIALS AND METHODS

The Experiment was conducted in the screen house at the Botanic Garden of the Department of Plant Science and Biotechnology. The plant was collected from the Federal Medical Centre River Yenegoa, Bayelsa State and was properly identified in the University of Port Harcourt Department of Plant Science and Biotechnology Herbarium as *Eichhornia crassipes* (Mart) Solms (*pontederiaceae).* The experimental design used was a Completely Randomized Design (CRD) in which the treatment were assigned completely at random to the experimental units giving every group of units an equal opportunity of receiving the treatment. The experiment had 5 treatments that were replicated 4 times to give a total of 20 observations.

Treatments: Treatment 1 (A) = Control, 0ml of crude oil , Treatment 2 (B) = 10ml of Crude oil
Treatment 3 (C) = 20ml of Crude oil, Treatment 4 (D) = 30ml of Crude oil, Treatment 5 (E) = 40ml of Crude oil , The Crude oil used for this experiment was obtained from Shell Petroleum Development Company (SPDC) in Port Harcourt, Rivers State Nigeria. 17L of borehole water were poured into twenty different 20L containers.

Various concentrations of crude oil were administered into the container; The treatment used includes: 0ml, 10ml, 20ml, 30ml and 40ml respectively. The control 0ml had no crude oil on it. The treatments were replicated 4 times to give an observation of 20. The test plant *E. Crassipes* were introduced into each container two weeks after pollution.

Morphological parameters investigated include Plant height (m), Number of leaves and Leaf Area (cm^3). The parameters were determined at 2, 4, 8 and 12 weeks after pollution. Physico – chemical Analysis of water samples as pH, Dissolved oxygen (DO), Temperature, Conductivity, Total Dissolved Solid (TDS), Salinity and Turbidity using a Multiparameter Water Checker (HANNA H19828) were determined. This was done by rinsing the electrode of the multiparameter water checker with distilled water, after which it was dipped into the water sample, allowed to stabilize and the readings determined. Also, Total Petroleum Hydrocarbon Content and Heavy metal (Zn, Cd, Pb) were determined using Atomic spectrum Spectrometer (AAS). The data collected were statistically analyzed using SAS (2007 version 9.1) statistical package for all treatments tested. The mean were separated using least significance difference at 5% level of probability.

RESULTS AND DISCUSSION

Table 1: Result Showing The Concentration of Heavy Metals In The Plant.

Sample Label	Conc. (PPM)	Mean Absorbance
Zinc (Zn)	0.010	0.038
Cadmium (Cd)	0.014	0.0055
Lead (Pb)	0.131	0.0049

The result in Table 3.1 and the Bar chart graph in Fig 1 graph below shows the mean plant height, number of leaves and leaf area after two weeks of pollution.

Plant Height: After two weeks the control recorded the least plant height and this is significantly ($p \leq 0.05$) different from the pollution levels. Treatment of 40ml recorded a higher plant height and is significantly ($p \leq 0.05$) different within pollution levels and control (Table 1).

Number of Leaves: After two weeks the control recorded the least number of leaves and this is significantly ($p \leq 0.05$) different from the pollution levels. Treatment of 40ml recorded a higher number of leaves and is significantly ($p \leq 0.05$) different within pollution levels and control. Treatment of 10ml and 20ml were not significantly different from each other.

Leaf Area: After two weeks the control recorded the least leaf area and is significantly ($p \leq 0.05$) different from the pollution levels. Treatments with 30ml and 40ml recorded the highest leaf area with no significant difference from each other but significantly ($p \leq 0.05$) different from other pollution levels. Also treatment with 10ml and 20ml are not significantly different from each other.

Plant Height, Number Of Leaves And Leaf Area After 4 Weeks: The result in Table 3.2 show the mean plant height, number of leaves and leaf area after 4 weeks

Plant Height: After 4 weeks the control recorded the least plant height and was significantly ($p \leq 0.05$) different from the pollution levels. Treatments with 20ml, 30ml and 40ml recorded a higher plant height with no significant difference between them but were significantly different from treatment with 10ml.

Number of Leaves: After 4 weeks, the control recorded the least number of leaves. The treatment with 40ml recorded a higher number of leaves and was significantly ($p \leq 0.05$) different within pollution levels and control. Treatments with 10ml and 20ml were not significantly ($p \leq 0.05$) different from each other.

Leaf Area: After 4 weeks the control recorded the least leaf area. Treatment with 40ml recorded the highest leaf area and was significantly ($p \leq 0.05$) different within pollution levels and control.

Plant Height, Number Of Leaves And Leaf Area After 8 Weeks: The result in Table 3.3 show the mean plant height, number of leaves and leaf area after 8 weeks.

Plant Height: After 8 weeks the control recorded a high plant height which is not significantly ($p \leq 0.05$) different from the pollution levels although slight variations existed. There were no significant differences within the pollution levels.

Number of Leaves: After 8 weeks, the treatment with 10ml recorded a higher number of leaves and is significantly ($p \leq 0.05$) different within pollution levels and control. However, the control was not significantly ($p \leq 0.05$) different from the 10ml treatment.

Leaf Area: After 8 weeks the treatment with 10ml recorded a higher leaf area and is significantly ($p \leq 0.05$) different within pollution levels and control. Treatment with 40ml recorded the least leaf area.

Plant Height, Number of Leaves and Leaf Area After 12 Weeks

The result in Table 3.4 shows the mean plant height, number of leaves and leaf area after 12 weeks

Plant Height: After 12 weeks treatments with 10ml and 20ml recorded a higher plant height and were slightly significant from the treatment with 30ml but significantly ($p \leq 0.05$) different from pollution level with 40ml and control.

Number of Leaves: After 12 weeks the treatment with 40ml recorded a higher number of leaves and is significantly ($p \leq 0.05$) different within pollution levels and control. The control and treatment of 10ml are not significantly ($p \leq 0.05$) different.

Leaf Area: After 12 weeks the treatment with 10ml recorded a higher leaf area and was slightly significant from treatments with 20ml and 30ml but significantly ($p \leq 0.05$) different from treatment with 40ml and the control.

Table 2: Mean Plant Height (Ph), Number Of Leaf (Nl) And Leaf Area (La) After Two Weeks.

TREATMENT	MEAN PH(cm)	MEAN NL	MEAN LA (cm^3)
Control	37.0000^{d}	12.5000^{d}	61.1250^{c}
10ml	38.5000^{c}	14.5000^{c}	62.0750^{b}
20ml	39.1750^{b}	15.0000^{c}	62.1500^{b}
30ml	39.7750^{ab}	16.2500^{b}	63.5500^{a}
40ml	39.9800^{a}	17.5000^{a}	64.1750^{a}
LSD	0.6383	1.0894	0.9111

Above are the mean values of 4 replicates, the mean with the same letters are not significantly ($p \leq 0.05$) different.

Table 3: mean plant height (ph), number of leaves (nl) and leaf area (la) after four weeks.

Treatment	Mean PH (cm)	Mean NL	Mean LA (cm^3)
Control	38.1250[c]	13.5000[d]	62.2250[d]
10ml	39.4875[b]	15.2500[c]	62.7000[cd]
20ml	40.3000[a]	15.7500[c]	63.3250[c]
30ml	40.8250[a]	17.2500[b]	64.4250[b]
40ml	40.8250[a]	18.2500[a]	65.3250[a]
LSD	0.6279	0.8439	0.7278

Above are the mean values of 4 replicates, the mean with the same letters are not significantly ($p\leq 0.05$) different.

Table 4: mean plant height (ph), number of leaves (nl) and leaf area (la) after eight weeks.

treatment	Mean PH (cm)	Mean NL	Mean LA(cm^3)
Control	26.750[ab]	7.2500[c]	40.875[bc]
10ml	29.500[a]	7.7500[c]	50.750[a]
20m	27.500[a]	8.7500[bc]	45.750[ab]
30ml	29.250[a]	10.2500[b]	45.250[b]
40ml	24.000[a]	12.2500[a]	37.125[c]
LSD	2.8093	1.8011	5.3826

Above are the mean values of 4 replicates, the mean with the same letters are not significantly ($p\leq 0.05$) different.

Table 5: mean plant height, number of leaf and leaf area after twelve weeks.

Treatment	Mean PH (cm)	Mean NL	Mean LA (cm^3)
Control	29.875[b]	10.2500[c]	49.000[b]
10ml	34.375[a]	10.7500[c]	56.000[a]
20ml	32.700[a]	11.7500[bc]	52.000[ab]
30ml	32.325[ab]	13.2500[b]	51.250[ab]
40ml	27.000[c]	15.2500[a]	40.375[c]
LSD	2.7894	1.8011	4.9903

Above are the mean values of 4 replicates, the mean with the same letters are not significantly ($p\leq 0.05$) different.

Table 6: Result summary showing physico - chemical analysis of water

Treatment	Mean ph	Mean do	Mean temp.
Control	7.3825[b]	2.0100[a]	28.6975[b]
10ml	7.8400[a]	1.7325[ab]	28.6125[b]
20ml	7.1350[b]	1.3625[c]	28.8750[ab]
30ml	7.1775[b]	1.5025[bc]	28.7400[b]
40ml	7.8375[a]	1.4775[bc]	29.2625[a]
LSD	0.4087	1.8011	4.9903

Above are the mean values of 4 replicates, the mean with the same letters are not significantly ($p\leq 0.05$) different.

Table 7: Result of physico - chemical analysis of water continued.

Treatment	mean cond.	Mean tds
7		
LSD	43.329	21.843

Above are the mean values of 4 replicates, the mean with the same letters are not significantly ($p\leq 0.05$) different.

Table 8: Result Of Physico - Chemical Analysis Of Water Continued.

treatment	Mean Salinity	Mean Turbidity
Control	0.0275[a]	1.50[b]
10ml	0.0225[a]	2.79[b]
20ml	0.0300[a]	29.18[a]
30ml	0.0350[a]	40.68[a]
40ml	0.0325[a]	49.23[a]
LSD	0.0225	26.351

Above are the mean values of 4 replicates, the mean with the same letters are not significantly ($p\leq 0.05$) different.

Conclusion: The findings of this study indicate that the growth of *E. crassipes* in crude oil contaminated water affects the physico – chemistry of the water thereby enhancing degradation of crude oil. Crude oil pollution generally leads to an increase in pH, temperature, conductivity, salinity and turbidity although pH seems to be the most important parameter in this process. Phytoremediation however reduces the pH, conductivity, temperature, salinity and turbidity of the water due to absorption of pollutants by the plant. A significant increase in the morphological parameters (plant height, number of leaves and leaf area) was observed after 2 weeks and further increase were observed at 4 weeks. At 8 weeks and 12 weeks which the experiment lasted, the growth rate reduced greatly since it was a confined experiment which received limited sunlight. Chlorosis of the leaves was also observed and this may be an implication of the heavy metals absorbed by the plant. Cadmium in this case is toxic to the plant. Preferential accumulation of metals in the plant roots seems to be a generalized strategy to minimize damage caused by these elements in the plant. It can be concluded that the future of *E. crassipes* in Phytoremediation is still in research and developmental phase and there are many technical barriers which needs to be addressed. From this study, the use of *E. crassipes* has proved a promising technique for the removal / bioaccumulation of contaminants from crude oil polluted water. Its rooted nature has favored increased rhizosphere activity, thereby enhancing nutrient and metal uptake. Care must be taken not to overtake the potential at this early stage in case it suffers the fate of other new techniques.

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