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Phytoremediation Potentials of Guinea Grass (*Panicum Maximum*) and Velvet Bean (*Mucuna Pruriens*) on Crude Oil Impacted Soils

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ABSTRACT

Guinea grass (*Panicum maximum*) and Velvet bean (*Mucuna pruriens*) have been observed in impacted soils hence their trial in this study as hyper accumulators of heavy metals. Microbiological and Physico-chemical studies of impacted soil were conducted before planting in plastic pots filled with 17000g of soils treated with 0 ml (T1), 50 ml (T2), 100 ml (T3) and 200 ml (T4) of crude oil.These treatments were replicated four times to give an observation of thirty-two experimental pots for both experiments. After twenty days of pollution, thetest plants were introduced and allowed to grow for 6 weeks (42 days). Tissue analyses of heavy metals were carried out on the shoot to determine their presence. Microbiology analyses such as THBC, THFC, HUB and HUF and the physicochemical parameters of all soil treatments such as pH, soil texture, Conductivity, % Carbon content and base metals were determined. The results show that Lead (Pb) was not detected in Plants tissues; Nickel was not also detected in T2 and T3 for *Panicum maximum* and not detected in T1, T3 and T4 for *Mucuna pruriens.* Cadmium (Cd) ranged from -0.020 mg/kg to -0.051 mg/kg and from -0.054 mg/kg to -0.070 mg/kg for *Panicum maximum* and *Mucuna pruriens* tissues respectively. Also, Chromium (Cr) ranged from -0.124 mg/kg to -0.119 mg/kg and from -0.146 mg/kg to -0.153 mg/kg for *Panicum maximum* and *Mucuna pruriens* tissues respectively. It can be concluded from the study that Guinea grass (*Panicum maximum*) and Velvet bean (*Mucuna pruriens*) didn't significantly hyper accumulated the heavy metals (Lead, Cadmium, Chromium and Nickel) analysed.

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KEYWORDS: Phytoremediation, Crude oil,, Panicum maximum, Velvet Bean, Heavy metals

INTRODUCTION

The population of Nigeria is estimated to be 162 million people who make it the world's populous black nation (Inibehe *et al*, 2013). Nigeria becomes significantly important in the economic history of the world following its plentiful natural resources, extending from oil and gas, to rich water resources, huge arable land and rich forestry resources (Inibehe *et al*, 2013).

In 1956, the Royal Dutch Shell Company discovered crude petroleum oil in the present Bayelsa State which formely was Oloibiri village but commercial production started in 1958 (Nwilo and Badejo, 2010). However, in 1956 when oil was discovered in Nigeria, it has been suffering adverse environmental impacts due to activities of oil exploration and exploitation. Waste management including sewage treatment, the related process of deforestation and degradation of soil, climate change or global warming are the key environmental problems in Nigeria (Nwilo and Badejo, 2010).Crude oil contains heavy metals; its pollution causes soils to become unproductive for long after spillage and inhibits the plants growth performance (Isitekhale *et al.*, 2010). the toxic heavy metals increased in soil since industrial development and has caused environmental degradation especially in Niger Delta region. Complex mixture of toxics including bioaccumulation of heavy metals in crude oil contaminated soils could be hazardous to human health (Isitekhal *et al*, 2010).

On the other hand, preventing pollution of heavy metals is critical because cleaning polluted soils is difficult and very expensive. Even when physical or chemical removal of hydrocarbons has been accomplished, the residual metallic components of crude oil are difficult to remove. Many of these residues have been removed by the emerging technique of phytoremediation. \Hence, the research objectives are to assess the growth rate (Morphological parameters) of *Panicum maximum* and *Mucuna pruriens* plant species and their resistance to oil spills and to identify the plant species that extracts more heavy metals (hyper-accumulator of heavy metals).

METHODOLOGY

The growth studies were conducted using thirty two (32) experimental pots (I6 *Panicum maximu* experiment and 16 for the *Mucuna pruriens* ecperiment) each filled with 17000g of soil. The diameter of the pot was 30cm; the bottom diameter was 22cm.The pots were contaminated with various volumes of crude oil;0% (T1: 0 ml);T2: 50 ml (2.94% V/W); T3:100ml (5.88% V/W) and T4:200 ml (11.76 V/W). The pots were arranged in two groups: one for *Panicum maximum* and another one for *Mucuna pririens* with each group containing four treatments and four replicates. The experimental design employed was a Completely Randomized Design (CRD).The test plants were introduced twenty days after polluting the soil. Soil samples were obtained for analysis from the pots at beginning (before planting) and at the end of the study which lasted for six weeks (42 days); plants were harvested for chemical analyses to determine heavy metal accumulation by Atomic Absorption Spectrometer.

The soil samples were analysed for heavy metals (Lead, Chromium, Cadmium and Nickel), total petroleum hydrocarbon (TPH) content, soil organic matter content and physicochemical analysis. The phytoremediation potentials of these two experimental plants to heavy metals was determined as the percentage of the difference between the initial heavy metal content in soil and the heavy metal content harvested from plants shoots. Microbiological analysis carried out include Total Heterotrophic Bacteria Count (THBC), Total Heterotrophic Fungi Count (THFC), Hydrocarbon Utilizing Bacteria (HUB) and Hydrocarbon Utilizing Fungi (HUF)

RESULTS AND DISCUSSION

Soil Properties – Physical

The soil textures in all the samples were measured to find out the percentage clay, silt and sand in the soil. Table 1shows the pH, electrical conductivity [E.C (µS/m)], and carbon content, in addition to other physical properties.T he Soil samples consisted of three main particle sizes of clay, silt and sand. The carbon content (35.5%) was considerably higher in the 200 ml (T4) and lower (19.3%) in 100 ml (T3) soil and the electric conductivity (EC) (151.3µS/m) in sample 200 ml (T4) was the highest of all samples.

Table 1: Physical properties of soil samples in different treatments

Physical properties	Sample T1 (0 ml)	Sample T2 (50 ml)	Sample T3 (100 ml)	Sample T4 (200 ml)
% Sand	80	60	68	70
% Silt	7	17	13	9
% Clay	13	23	19	21
% Carbon	24.735	22.892	19.303	35.502
P^H (KCL)	5.5	5.9	6.2	7.1
E.C (µS/m)	105.445	97.589	82.289	151.345
Ca (cmol/kg)	3.125	2.124	4.013	4.633
Mg(cmol/kg)	0.765	0.807	0.997	1.124
K(cmol/kg)	0.286	0.301	0.372	0.420
Na(cmol/kg)	0.079	0.084	0.104	0.117

Chemical properties of plants (Heavy metals)

The results (Tables 2 and 3) show that both plants did not accumulate significant quantity of four heavy metals analysed from these plants grew for the period of six weeks. Lead and Nickel were not detected in both plants. Cadmium (Cd) ranged from -0.020 mg/kg to -0.051 mg/kg and from -0.054 mg/kg to -0.070 mg/kg for *Panicum maximum* issue and *Mucuna pruriens* tissue respectively. Chromium (Cr) ranged from -0.124 mg/kg to -0.119 mg/kg and from -0.146 mg/kg to -0.153 mg/kg for *Panicum maximum* tissue and *Mucuna pruriens* tissue respectively.

Table 2: Concentration in mg/kg of four heavy metals for *Panicum maximum*

	Lead (Pb)	Cadmium (Cd)	Chromium (Cr)	Nickel (Ni)
T1	ND	-0.020	-0.124	-0.023
T2	ND	-0.056	-0.115	ND
T3	ND	-0.071	-0.122	ND
T4	ND	-0.051	-0.119	

Table 3: Concentration in mg/kg of four heavy metals for *Mucuna pruriens*

	Lead (Pb)	Cadmium (Cd)	Chromium (Cr)	Nickel (Ni)
T1	ND	-0.054	-0.146	ND
T2	ND	-0.055	-0.107	-0.054
T3	ND	-0.070	-0.142	ND
T4	ND	-0.070	-0.153	ND

ND: Not Detected; Lead was not detected at the machine sensitivity of 0.001 while Nickel was not detected at machine sensitivity of 0.002.

Soil Properties – Chemical

The concentration of Lead in soil ranged between 49.37-57.22 mg/kg, the control soil sample has the concentration value of 46.24 mg/kg (Figure 1). The permissible limit values for Lead (Pb) according to the Netherlands standard (Table 4) are 85 mg/kg. All values are under the permissible limit.

The concentration of Nickel in soil ranged between 37.26-71.23mg/kg; the control soil sample has the concentration value of29.46 mg/kg (Figure 1). The target values of Nickel are35 mg/kg according to the Netherland Standard (Table 4**).** The highest soil concentration of Ni was found in sample T4 (71.23mg/kg). The lowest soil concentration of Ni was found in the sample T 3 (37.26 mg/kg*)***.** The analysis of Ni shows that all the samples have concentration of Ni higher than the permissible limit and there is a need of remediation. The observed high concentrations of Ni in soil also revealed a potential hazard of heavy metal exposure to living organisms inhabit the area or for crops that may grow on the soil.

The concentration of Cadmium in soil ranged between 35.267-41.224 mg/kg, the control soil has the concentration value of 25.237 mg/kg (Figure 1). The target values of Cadmium are0.8 mg/kg according to the Netherland Standard (Table 4)**.** The analysis of Cd shows that all the samples have concentration of Cd higher than the permissible limit and there is a need of remediation. The observed high concentrations of Cd in soil also revealed a potential hazard of heavy metal exposure to living organisms inhabit the area or for crops that may grow on the soil.

The concentration of Chromium in sample soil ranged between 23.367-30.655 mg/kg, the control soil sample has the concentration value of 19.237 mg/kg(Figure 1). All sample values are below the permissible limit (Table 4).

Chemical properties of plants (Heavy metals)

Both plants did not accumulate significant quantities of the four heavy metals analysed. Heavy metals may have been made less available for plant uptake because of soil pH (Table 1). The solubility of most heavy metals increases with decreasing pH; this is in line with research by David, (2005). Due to substantial population size of microorganisms tested in soil, there was minimal damage of heavy metals to plants which could be the reason why these metals made less available for plants uptake; as stated by Park *et al*. (2011). In relation to research study by Mitch (2002),heavy metals were less available to plants due to strong binding to soil particles and/or precipitation renders a significant soil metal fraction insoluble, and largely unavailable for plant uptake.

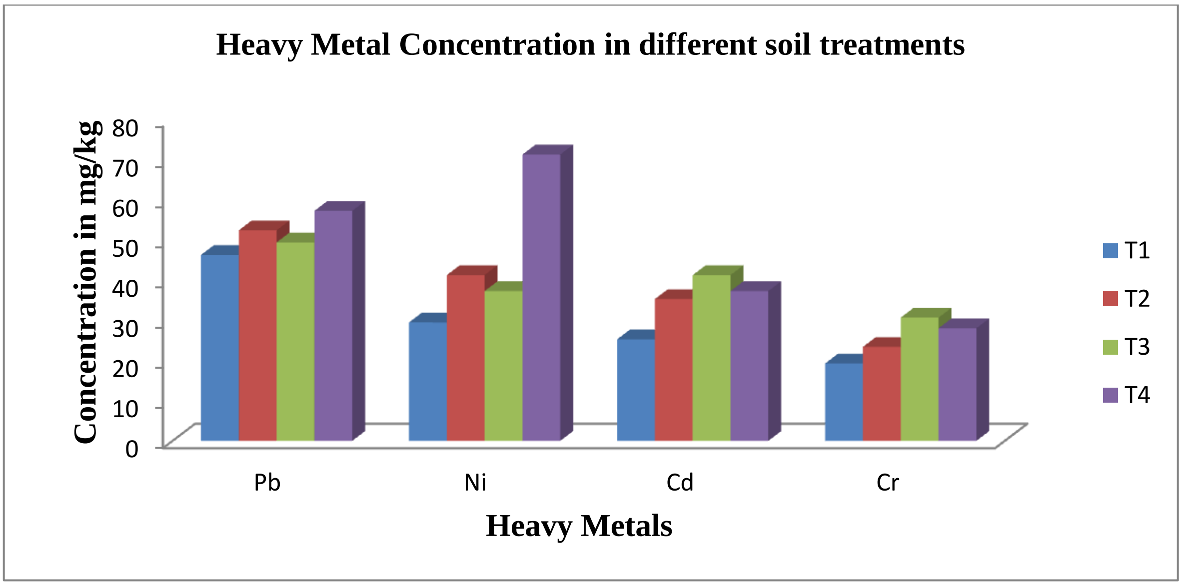

Figure 1: Heavy Metal concentration in different soil samples

Table 4: Netherlands and WHO metal standards in soil and plants

Serial N°	Metals	*Target Values of soil (mg/kg)	**Permissible Values of Plants (mg/kg)
1	Cadmium (Cd)	0.8	0.02
2	Nickel (Ni)	35	10
3	Lead (Pb)	85	2
4	Chromium (Cr)	100	1.30

Sources: Ministry of Housing, Netherland,1994, WHO, 1996

CONCLUSION

The findings of this study show that the introduction of crude oil in soil affects the physico-chemistry of soil by increasing heavy metals in soil. Crude oil leads to an increase in soil pH and electrical conductivity (E.C); this is related to work done by (Ochekwu and Madagwa, 2013). Introduction of crude oil also stimulates the microbiological activities of the soil. Generally, an increase in morphological parameters (plant height, number of leaves and leaf area) were observed and this was in line with Ochekwu and Madagwa, 2013.. Increase in number of dry leaves more especially at the last week of experiment (sixth week) was observed and this may be an indication of plants beginning to respond to heavy metals in soil. Both plants did not accumulate significant quantity of the four heavy metals analysed. Due to substantial population size of microorganisms tested in soil, there was minimal damage of heavy metals to the plants which could be the reason why these metals made less available for plants uptake; this is in line with "Microbial populations which are known to affect heavy metals mobility and availability to the plant (Park *et al*., 2011). For this research work, *Panicum maximum* and *Mucuna pruriens* may not be the hyper accumulator of heavy metals (Lead, Cadmium, Chromium and Nickel). It can be concluded that further researches are needed to test for these heavy metals and others in pots and field experiments.

REFERENCES

1. Ahmadpour P., Ahmadpour F., Mahmud T.M.M., Arifin A., Soleimani M. and Hosseini T. F.; 2012. Phytoremediation of heavy metals: A green technology, *African Journal of Biotechnology 11(76): 14036-14043*
2. Alkorta I., Hernandez-Allica J., Becerril J. M, Amezaga I., Albizu I., Garbisu C.; 2004.
3. 'Recent findings on the phytoremediation of soils contaminated with environmentally toxic heavy metals and metalloids such as zinc, cadmium, lead, and arsenic', *reviews in Environmental Science and Bio/Technology* 3: 71-90.
4. Ann M. M., 2001. Thesis: Phytoremediation of heavy metal Contaminated soil, Cochin University of Science and Technology, Cochin, Kerala,
5. Appenroth K.J.; 2010. The Definition of Heavy Metals in Plant Science, *Soil Heavy Metals*, Soil Biology, Vol 19: DOI 10.1007/978-3-642-02436-8_2.
6. Audrone J., and Saolius V.; 2005. Remediation technologies for soils contaminated with heavy metals, *Journal of Environmental engineering and landscape management*, xiii(2): 109a-113a.
7. Barałkiewicz D. and Siepak J; 1999. Chromium, Nickel and Cobalt in Environmental Samples and Existing Legal Norms, *Polish Journal of Environmental Studies*, 8(4): 201-208
8. Beiergrohslein E.; 1998. 'The use of surfactants in removal of zinc, lead and cadmium from contaminated soils', Pestic, Biochem. physiol, 13: 267-273
9. Bruce E. Pivetz; 2001. Phytoremediation of Contaminated Soil and Ground Water at Hazardous Waste Sites, United States Environmental Protection, EPA/540/S-01/500.
10. Chhotu D. J. and Fulekar M. H.; 2008. Phytoremediation of heavy metals, Recent techniques, *African Journal of Biotechnology 8 (6): 921-928*
11. David R.; 2005. Soil solution chemistry in a heavy metal contaminated forest model ecosystem. A dissertation submitted to the Swiss Federal Institute of Technology Zurich for the degree of Doctor of Sciences, Lausanne, Switzerland.
12. Ettler V, Vanek A, Mihaljevic M, Bezdicka P; 2005. 'Contrasting lead speciation in forest and tilled soils heavily polluted by lead metallurgy', *Chemosphere* 58(10): 1449-1459.
13. Gopamma D. and Srinivas N.; 2011. Effects of Soil Treatments amended with Organic Manure on Lubricant Oil Degradation, *Research Journal of Chemistry and Environment 15(4)*
14. Hemen S.; 2011. Metal Hyper accumulation in plants: A Review focusing on Phytoremediation Technology, *Journal of Environmental Science and Technology* 4(2): 118- 138
15. Hettiarachchi G.M., Nelson N.O., Agudelo Arbelaez S.C., Lemunyon J.L.; 2012. Phytoremediation: Protecting the Environment with Plants, Kansas State University, USA.
16. Inibehe G.U., Ineye D.E., and Nneoyi I.O.; 2013. Cointegration inferences on issues of poverty and population growth in Nigeria, *Journal of*

Development and Agricultural Economics, 5(7): 277-283.

17. Isitekhale H.H.E., Aboh S.I., Edion R.I. and Abhanzioya M.I.; 2013.Remediation of Crude Oil Contaminated Soil with Inorganic and Organic Fertilizer Using Sweet Potato as a Test Crop, *Journal of Environment and Earth Science 3 (7): 2224-3216*
18. Jan M. and Malcolm S.C.; 1994:Biogeochemistry of Small Catchments: A Tool for Environmental Research, Edited by B. Moldan and J.Cerny, Published by John Wiley & Sons Ltd.
19. Jonnalagadda S. B and Rao P. V; 1993. 'Toxicity, bioavailability and metal speciation', *Comparative biochemistry and physiology, Part C: Pharmacology, toxicology, and endocrinology* 106(3): 585-595.
20. Krishna R. Reddy; 2013.Electrokinetic remediation of soils at complex contaminated sites: Technology status, challenges, and opportunities, *Coupled Phenomena in Environmental Geotechnics – Manassero et al (Eds)Taylor & Francis Group, London, ISBN 978 1 138 00060 5*
21. Lambert M., Leven B.A., and Green R.M.; 1990. New Methods of Cleaning Up Heavy Metal in Soils and Water Great,*Plains/Rocky Mountain HSRC, Kansas State University, 101 Ward Hall Manhattan, KS* 66506 (800) 798-7796
22. Liesbet Van Cauwenberghe; 1997. Electrokinetics, *Ground-Water Remediation Technologies Analysis Center, O Series: TO-97-03*
23. Manara A.; 2012. Plant responses to heavy metal toxicity, *A. Furini (ed.), Plants and Heavy Metals, SpringerBriefs in Biometals, DOI: 10.1007/978-94-007-4441-7_2.*
24. Ministry of Housing, Netherlands, Physical planning and Environmental Conservation. Report HSE 94.021 (1994).
25. Mitch M. L.; 2002.Phytoextraction of Toxic Metals: A Review of Biological Mechanisms *Published in J. Environ. Qual. 31:109–120.*
26. Nwilo P.C. and Badejo O.T.; 2010. Impacts and Management of Oil Spill Pollution along the Nigerian Coastal Areas.
27. Ochekwu, E. B. and Madagwa, B.; 2013. Phytoremediation potentials of water Hyacinth. *Eichhornia Crassipes* (mart.) Solms in crude oil polluted water, *Journal of Applied Sciences and Environmental management*, 17(4): 503-507.
28. Olatunji O.S., Ximba B.J., Fatoki O.S., and Opeolu B.O.; 2014. Assessment of the phytoremediation potential of Panicum maximum (guinea grass) for selected heavy metal removal from contaminated soils, *African journalsof Biotechnology*13(19): 1979-1984.
29. Omosun, G.; Edeoga, H. O.; Markson, A. A. and Madunagu, B. E; 2010.Uptake of Lead, Nickel and Copper by three Mucuna species, *International Journal of Current Research*,4: 098-103
30. Osuji, L. C. and Onojake, C. M.; 2005. Field reconnaissance and estimation of petroleum hydrocarbon and heavy metal contents of soils affected by the Ebocha-8 oil spillage in Niger Delta, Nigeria. *Journal of Environmental Management*79: 133-139.
31. Parisa Z. and Somaye A.; 2014. The Phytoremediation Technique for Cleaning up Contaminated Soil by Amaranthus sp., *Journal of Environmental and Analytical Toxicology*, 4 (208): 2161-0525
32. Park J. H., Bolan N., Megharaj M.,Naidu R. and Chung J.W.; 2011. Bacterial-Assisted Immobilization of Lead in Soils: Implications for Remediation, *Pedologis*t 162-174
33. Prasa M.N.V.; 2011: A State-of-the-Art report on Bioremediation, its Applications to Contaminated sites in India, Dept. of Plant Sciences, University of Hyderabad, Hyderaba, India.
34. Priscila L.G., Majeti N.V., Patricia F.C., Peter J.L. and Ricardo A.A.; 2005. Phytoremediation: green technology for the clean-up of toxic metals in the environment, Braz. J. plant physiol. 17 (1): 53-64
35. Ralinda R. M.; 1996: Phytoremediation, Ground Water Remediation Technologies Analysis Center 615 William Pitt Way, Pittsburgh, PA 15238.
36. Rasaq A.O., Gregory O.A., Olumayowa J.O., Oladipo A. L., Owolabi M.S.; 2015. Concentration of Heavy Metals in Root, Stem and Leaves of *Acalypha indica* and *Panicum maximum jacq* from Three Major Dumpsites in Ibadan Metropolis, South West Nigeria.
37. Stegmann, Brunner, Calmano, Matz; 2001: 'Treatment of Contaminated Soil, Fundamentals, Analysis, Applications', Berlin: London: Springer.
38. Sonil N.and Jayanthi A.; 2013. Remediation of heavy metal contaminated soil, *African journal of Biotechnology*, 12(21), 3099-3109.
39. Thomas J.L. and David J.E.; 2006: *Transport and storage of metals ions in Biology, 7: 57-78*
40. U.S. Environmental Protection Agency; 2001: Solid Waste and Emergency Response Technology Innovation Office Washington, DC 20460 Brown fields Technology Primer: Selecting and Using Phytoremediation for Site Clean-up.
41. WHO; 1996: Permissible limits of heavy metals in soil and plants, (Genava: World Health Organization), Switzerland.

42. Yao Z., Jinhui L., Henghua X., Conghai Y.; 2012: The 7th International Conference on Waste Management and Technology, Review on remediation technologies of soil contaminated by heavy metals, *Procedia Environmental Sciences 16: 722 – 729.*
43. Yin Chan; 2008**:** Increasing soil organic carbon of agricultural land, *PRIMEFACT* 735