DETERMINATION OF THE BIOREMEDIATION POTENTIAL OF SAWDUST FROM GMELINA ARBOREA (ROXB) AGAINST CONTAMINATED SOIL IN NIGERIA.

[1]K. M. Ogunjobi, [2]M. U. Chikwendu, and [1]A. C. Adetogun
[1]Department of Forestry and Wildlife Management, Federal University of Agriculture, P.M.B. 2240, Abeokuta, Ogun State, Nigeria.
[2]Department of Forestry and Environmental Management, Michael Okpara University of Agriculture, P.M.B 7267, Umudike, Abia State, Nigeria.
*Corresponding author (Phone Number: +234-806-525-4590. Email: nwogwugwu.michael@gmail.com)

ABTRACTS
This study investigates the bioremediation potentials of sawdust from *Gmelina arborea* against contaminated soil in Nigeria. The study was carried out at Forestry and wildlife departmental wood laboratory federal university of agriculture Abeokuta (FUNAAB). Three-depth soil was taken at 0-15, 15-30 &30-45cm and was contaminated with polluted soil(diesel), sawdust sample was prepared for the used of absorption test, 100g of sawdust was added into 750g of contaminated soil in three different containers, the sample determines the physiochemical properties of the soil in 1,14&28days. Result reveals that effects of contact time are not significant in the physiochemical of the contaminated soil. Soil tested in contact on day 1 had the highest significant level $p \leq 0.05$ of chemical concentration at K(1987mg/kg) and lowest on day 14 at Na(127.2mg/kg). result on soil depth reveals highest in 0-15cm at K(1342.4mg/kg) and lowest at depth 30-45cm in Na(144.3mg/kg). result on interaction effect of contact time and depth on contaminated soil reveals that D1(15-30cm) was seen highest at value in K(2766.16mg/kg) and lowest in D14(30-45cm) at value in Na(116.83mg/kg). the findings of the study show that sawdust is good for the bioremediation of contaminated soil because of its absorbent properties which helps in amelioration of the soil.

Keywords: Bioremediation, Sawdust, Contaminated soil, Pollution, Crude oil etc

INTRODUCTION

The serious and often use of diesel causes the release of its derivatives in the environment due to the accidental spill of diesel and its activities, which is one of the main causes of soil pollution. (Das and Chandran, 2011). According to the International Tanker Owners Pollution Federation (ITOPF, 2016), the total amount of oil lost in the environment due to oil incidents in 2000 was 208,000 tons and 6,000 tons in 2016. According to the Agency, aromatic and halogenated solvents, liquid fuels, metals and polycyclic aromatic hydrocarbons (PAHs) were the main compounds observed in the contaminated areas (CETESB, 2012). These compounds are associated with the increased incidence of cancer in human and they are reported as potent mutagens, besides pulmonary, gastrointestinal, renal and dermatologic systems were affected after chronic exposure (ATSDR, 2012).

Considering the negative effects on the environment and human health caused by diesel oil in the soil, technologies have been developed for the removal of pollutants from the environment (Meneghetti, 2007). In the world, crude oil when refined to generate different fractions (diesel, petrol, kerosene, gasoline, lubricant.) has become the most essential commodity used in powering both big and small engines which are used on daily basis in our respective environment. In as much as the benefits and the importance of this crude oil is to humanity, the major negative effect which is oil spillage which causes environmental pollution can never be ignored; but can be controlled by taking into consideration some preventive measures majorly 'bioremediation' as the control factor.

Sawdust is a waste from wood and it can cause problem to human health likewise it is also useful to man as well. Sawdust can be used for particleboard, fuel, to support plants growth, for mulching, weed killer, and as absorbent in contaminated water.

The imbalance and inadequate power supply (electricity) in Nigeria, has made the need for alternative power supply of electricity to increased tremendously, which has led to the development of technology by devising an alternative means of generating power which is known as the generating set. This generating set make use of crude oil fractions (diesel, petrol) which at times drops in the process of filling, running and in maintenance of this generating set, which then leads to the process of oil spillage that causes soil pollution which affect plants and several useful microorganisms thereby reducing the soil fertility and the sustainable yield of plants growth in that environment.

Despite the benefits of this generating set, the negative effect it has on the soil and the environment is so severe that it has raise the concern for researchers to find the remedy to this problem, thereby introducing the use of sawdust as a bioremediation factor in controlling and preventing oil spillage from penetrating into the soil around the generating set centers.

The contamination or pollution of any environment with crude oil and other related products poses a threat to the life of aquatic and terrestrial organisms

including humans living in such polluted environments. This is due to the potential toxicity of crude oil products when present in high concentrations (Adebusoye *et al*, 2007). The potential dangers resulting from crude oil pollution have driven man into research for friendly approaches to reclaim polluted environments, particularly crude oil polluted soil (Chikere and Azubuike, 2013).

These dangers in combination with others can alter population dynamics and disrupt trophic interactions and structure of natural communities within an ecosystem (Bejarano and Michel, 2010). Petroleum products remain the principal source of energy; however, despite its importance and large amounts of usage on land, petroleum products have posed global environmental pollution (Amund, 2000; Plohl e*t al.*, 2002; Chikere and Chijioke-Osuji, 2006). In the Niger Delta region of Nigeria, terrestrial and aquatic systems are the main recipients of crude oil spillage, sometimes resulting in large-scale contamination of these environments.

Crude oil contamination in this area is gaining more prominence as a result of increased upstream and downstream activities of the petroleum industry hence increased deleterious effect on the ecology of this area (UN Report, 2001.). The problem of environmental pollution has assumed an unprecedented proportion in many parts of the world (Bank *et al*., 2003). Soil contamination by petroleum hydrocarbons is one of the world's most common environmental problems (US EPA, 2000). Petroleum products are considered to be recalcitrant to biodegradation and persist in ecosystems because of their hydrophobic nature and low volatility as such, they create a major threat to the environment (Karthikeyah and Bhandari, 2001, Abed *et al.*, 2002, Parrish et al, 2005, Lueprom-Chai *et al*., 2007). Contaminants present in soils can enter the food chain and seriously affect animal and human health (Khan, 2005).

We all know that nature is a very beautiful environment that gives the atmosphere its place to stay, it helps to nurture and clean the environment with different kinds of trees. But since the population grew and the needs for man arises to a point that the nature is affected by human activities in various ways, there came a need to protect forest and to established plantation to replace the trees that have been cut down or harvested.

Trees has different uses to human and its environment, when trees are converted into logs, they are used to make different kinds of constructions. During the process of converting trees into logs, there are fine particles of wood dust that are found which are called sawdust. The main aim of the study was to determine the bioremediation potential of sawdust *Gmelina arborea* (Roxb) against contaminated soil (Diesel) in Nigeria. The potential treatment for the bioremediation of the contaminated soil (diesel) seems to be the most effective solution to remove and reduce the overall effect of the oil spillage in the contaminated soil area. According to (Ogunjobi *et al*, 2018), excessive waste is generated during sawmilling activities and this reduces the volume of wood available for utilization and thereby put pressure on the forest estates for supply of materials to meet the needs of the increasing population. The sawdust constitutes environmental nuisance and health hazard.

Materials and Methods

Study Area

The experiment was carried out at Forestry and Wildlife departmental wood laboratory Unit and part of the samples was tested at Biotechnology laboratory at the Federal University of Agriculture, Abeokuta (FUNAAB) Ogun State, Nigeria. FUNAAB geospatially located between latitude 3.3619^{o}E and longitude 7.1475^{o}N respectively.

Fig.1 Map of the Study area

Sample Collection and Preparation of Contaminated soil (Diesel)

The collection of the contaminated soil containing diesel was obtained at the power generating station behind Computer Laboratory (FUNAAB). Three depth level of soil was taken (0-15cm, 15-30cm and 30-45cm). The oven dried contaminated soil (diesel) at 100^0C was allowed to cool for some minutes, then the contaminated soil containing diesel was pounded to the fine particle sizes and a screen size sieve of 0.2mm sieve was used to sieve the soil to have homogeneity of the three different depth. The samples were poured into three different experimental container and labelled (0-15cm, 15-30cm and 30-45cm).

Sample Collection and Preparation of Sawdust (*Gmelina arborea*)

The sawdust was collected at Eleweran Sawmill, Abeokuta Ogun State, Nigeria. The sawdust was oven dried at 78^0C in Biotech Laboratory. The oven dried sawdust was allowed to cool for some minutes, 0.1mm screen size sieve was used to sieve the sawdust to have a uniformity of particle sizes.

Sampling Techniques

The sawdust samples were oven dried and examined carefully through a sieve of screen size 0.1mm, to achieve uniformity in particle sizes which was used for the adsorption tests in the experiment. Three hundred grams (300g) of oven dried sawdust was weighed on a sensitive weighing scale and was divided into three (100g each), two thousand two hundred and twenty-five grams (2,250g) of oven dried contaminated soil (diesel) was weighed on a weighing scale and was divided into three (750g each). The three (3) treatment was used for the mixture of the contaminated soil and sawdust which include three replicates, this was aimed to see how the level of elements present in different depth of contaminated soil and sawdust would affect the experiment.

Inducement of sawdust into contaminated soil

A mass of 100grams of oven dried sawdust was added into 750g of contaminated soil in three different experimental buckets which was mixed thoroughly with a spatula. The samples for the physiochemical properties (Magnesium, Potassium and Sodium) were observed for day (1, 14 and 28).

Plate 1: Sampling container containing mixture of sawdust and contaminated soil

Plate 2: Oven dried contaminated soil

Plate 3. Digital measuring device

Plate 4. Collection of sawdust (*Gmelina arborea*)

Determination of the physicochemical parameters Magnesium (mg/kg), Potassium (mg/kg) and Sodium (mg/kg).

The mixture of samples (sawdust and soil) was digested and was further analyzed using Atomic Absorption Spectrophotometer (AAS) in Biotech Lab FUNAAB and the concentration of Magnesium, Potassium and Sodium was calculated. The procedure was repeated at the interval of 14 days during the study period.

RESULTS AND DISCUSSIONS

The effect of contact day on the contaminated soil

The result shows that the effect of contact time had no significant different (P>0.05) in the physico-chemicals of the contaminated soils. However, the soil tested on contact day 1 had the highest level of chemical concentration. Concentration of Mg (1344.9mg/kg), K (1987.3mg/kg) and Na (588mg/kg) was greater in the contaminated soil on contact day 1 while element concentration was reduced on contact day 14 at (236.0mg/kg) and relatively low on contact day 28 at (219.7mg/kg). Concentration of K and Na was highest in contact day 1 at (1987.3mg/kg and 588.0) and lowest at contact day 14 with value 482.1 and 127.2mg/kg respectively.

Table 1: The effect of contact day on the contaminated soil

Contact Day	Mg(mg/kg)	K(mg/kg)	Na(mg/kg)
1	1344.9[a]	1987.3[a]	588.0[a]
14	236.0[b]	482.1[c]	127.2[c]
28	219.7[b]	746.5[b]	255.8[b]

a,b,c,d = means with different superscript across the rows are significantly different (p< 0.05)

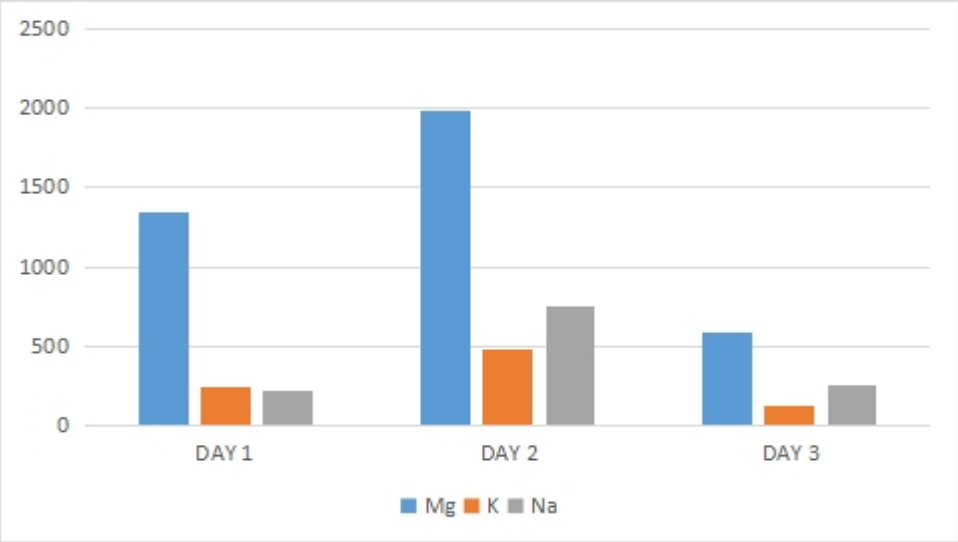

Fig. 2 Graph showing the effect of contact day on the contaminated soil

The effect of depth on the contaminated soil

There was no significant difference in the effect of depth on contaminated soil across various depths. K and Mg exhibited the highest concentration (1342.4mg/kg, 782.4mg/kg) in soil depth of 0-15 and 15 – 30cm while Na was higher in soil depth of 15-30cm at 441.1mg/kg and lowest at 30-45cm depth at 144.3mg/kg. (Table 2)

Table 2: The effect of depth on the contaminated soil

Depth	Mg(mg/kg)	K(mg/kg)	Na(mg/kg)
0 – 15	782.1[a]	1342.4[a]	385.5[b]
15 – 30	782.4[a]	1309.5[b]	441.1[a]
30 – 45	236.2[b]	564.0[c]	144.3[c]

a,b,c,d = means with different superscript across the rows are significantly different (p< 0.05)

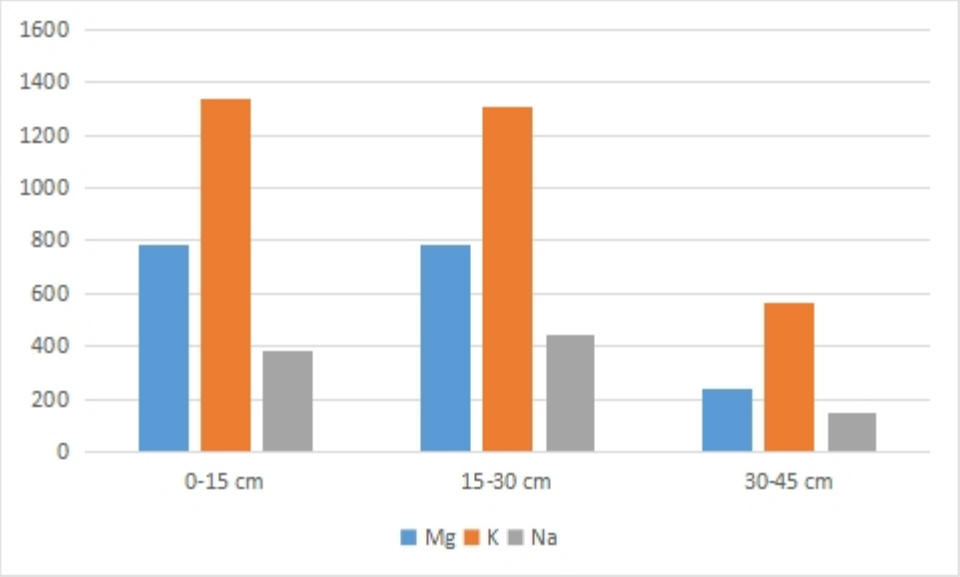

Fig. 3 Graph showing the effect of depth on the contaminated soil

The interactive effect of contact time and depth on the contaminated soil

Table 3 revealed significant difference in interaction of contact day and depth on contamination of the soil. The effect of contact day 1 and depth of 15 – 30cm produced the highest concentration of mg (1901mg/kg) while higher concentration of K (2770.83mg/kg) and Na (830.06mg/kg) was found in contaminated soil tested on contact day 1 in depth of 0 -15cm. result on contact day 14 was highest at K(517.94mg/kg), Mg(247.67) and the lowest was at Na(140.18mg/kg), result on contact day 28 in depth 30-45(764.98mg/kg,), Na(376.43) and lowest was in Mg (215.41mg/kg)

Table 3: Interactive effect of contact time and depth on the contaminated soil

Contact Day *Depth	Mg(mg/kg)	K(mg/kg)	Na(mg/kg)
D 1 Depth 0 – 15	188.25^{d}	2770.83^{a}	830.06^{a}
D 1 Depth 15 – 30	1901.86^{a}	2766.16^{a}	806.74^{a}
D 1 Depth 30 – 45	244.63^{b}	424.94^{d}	127.13^{d}
D 14 Depth 0 – 15	242.56^{b}	517.94^{c}	124.52^{d}
D 14Depth 15 – 30	217.71^{bc}	426.16^{d}	140.18^{c}
D 14Depth 30 – 45	247.67^{b}	502.20^{c}	116.83^{d}
D 28 Depth 0 – 15	215.41^{c}	738.32^{b}	201.87^{bc}
D 28 Depth 15 – 30	227.55^{bc}	736.26^{b}	376.43^{b}
D 28 Depth 30 – 45	216.16^{c}	764.98^{b}	189.07^{c}

a,b,c,d = means with different superscript across the rows are significantly different (p< 0.05)

DISCUSSION

The experiment was to test for the potential of remediating contaminated soil containing diesel with sawdust (*Gmelina arborea*) the experiment was divided into three in respect to three different depth (0-15cm, 15-30cm and 30-45cm) and the experiment was done for 28 days.

The results obtained during the experiment from day 1-28, this shows that the potential of using sawdust to bio remediate contaminated soil containing diesel. Bioremediation with bio product can have an impact in the industries that uses chemical product to remediate contaminated sites. The contaminated soil treatment with sawdust is based on the use of microorganisms that are able to transform organic pollutants into chemically simpler compounds such as carbon dioxide (Singh and Ward, 2004).

Sawdust was used in the experiment to prove that the bioremediation can be done by just using bio-product. Sawdust in this case was the absorbent of the crude oil in the setup of the experiment as it was also reported in Ogunjobi *et at*., (2021) on biosorption potentials of sawdust in removing zinc ions from aqueous solution. Sawdust had absorbed the crude oil of each setup by absorbing it, the sawdust degraded and created bacteria that had eaten the hydrocarbons and reduced the pollutant in the contaminated soil (Rodolfo, 2014).

In addition, they have toxic properties causing serious effects on human and environmental health (Jabbar *et al*.,2022). Bioremediation is a promising technique for the amelioration of soils contaminated with TPHs (Maleti´c *et al*.,2011).

The effect of contact day and depth on the contaminated soil shows the interaction between the depth and the contact day for the concentration of the elements. The contact day does not have significant $p > 0.05$, the treatment does not have significant effect which does not mean that the experiment was not effective but by statistics it did not really have significant. This result agrees with the findings of Ochor *et al*.,(2022) on assessment of the potential of oyster mushroom as myco-remediation of spent engine oil on polluted soil.

CONCLUSION AND RECOMMENDATIONS

From this study, we could conclude that sawdust is less expensive and effective absorbent for the removal of pollutant from the contaminated soil. Large amount of sawdust is generated in the sawmills, a portion of the sawdust can be used to remediate the contaminated soil. Based on the experiment, the results shows that the effect of contact days has no significant different in the physicochemical of the contaminated soil across the depth. However, the least concentration of the physicochemical was found in the soil depth of 30-45cm, Magnesium and Sodium exhibiting the highest concentration in the soil depth of 15-30cm while Potassium was higher in the soil depth of 0-15cm.

Bioremediation with bio product (sawdust), can have an impact in the industries that uses diesel to remediate contaminated sites. Sawdust has been proven to be the absorbent of diesel in the experimental setup which have reduced the pollutant regardless of the depth. The treatment has no significant different effect on both the contact day and depth statistically but the experiment is still very effective.

REFERENCES

Abed, M.M.R, Safi NMD, Koster J, deBeer D, El-Nahhal Y, Rullkotter J and Garcia-Pichel F (2002). Microbial diversity of a heavily polluted microbial mat and its community changes following degradation of petroleum compounds. Appl. *Environ. Microbiol*. 68(4): 1674- 1683.

Adebusoye, S.A, Ilori, M.O, Amund, O.O, Teniola, O.D and Olatope, S.O (2007). "Microbial degradation of petroleum hydrocarbons in a polluted tropical stream", *World Journal of Microbiology and Biotechnology*,23(8):1149-1159.

Agency for Toxic Substances and Disease Registry (ATSDR) (2012). Case Studies in Environmental Medicine: Toxicity of Polycyclic Aromatic Hydrocarbons (PAHs). Retrieved from: https://www.atsdr.cdc.gov/csem/pah/docs/pah.pdf.

Amund, I.J. (2000). The oil eating Microbe: A remedy to pollution menace. In: The Post Express, Property and Environment.

Azubuike, C.C., Chikere, C.B and Okpokwasili, G.C., (2016). Bioremediation techniques classification based on site of application: principles, advantages, limitations and prospects. *World J. Microbiol. Biotechnol.* 32 (11), 180.

Bank, M.K., Mallede, H. and Rathbone, H. (2003) Rehisoshere Microbial Characterization in Petroleum Contaminated Soil, Soil and Sediment Contamination, Vol. 12, No. 3. Pp. 371- 385.

Bejarano, A.C and Michel, J (2010). "Large-scale risk assessment of polycyclic aromatic hydrocarbons in shoreline sediments from Saudi Arabia: environmental legacy after twelve years of the Gulf war oil spill", *Environmental pollution*,158(5): 1561-1569.

Chikere, B.O. and Chijioke-Osuji, C. C. (2006). Microbial diversity and physico-chemical properties of a crude oil polluted soil. *Nigerian Journal of Microbiology*, 20(2):1039-1046.

Chikere, C.B and Azubuike, C.C (2013). "Catechol-2,3-dioxygenase screening in putative hydrocarbon utilizing bacteria", International Research Journal of Microbiology,4(1):1-6.

Das, N and Chandran, P (2011). Microbial degradation of petroleum hydrocarbon contaminants: An overview. *Biotechnology Research International*,1-13.

Environmental Sanitation Technology Company (CETESB) (2012). Explanatory text: Relation of contaminated and rehabilitated areas in the State of Sao Paulo, Direction of Control and Environmental Licensing of the State of Sao Paulo, Sao Paulo. (In Portuguese).

Jabbar, N.M., Alardhi, S.M., Mohammed, A.K., Salih, I.K. and Albayati, T.M. (2022) Challenges in the implementation of bioremediation processes in petroleum-contaminated soils: A review. *Environ. Nanotechnol. Monit. Manag*., 18, 100694.

Karthikeyah, R. and Bhandari, A. (2001). Anaerobic biotransformation of aromatic and polycyclic aromatic hydrocarbons in soil microcosms: a review. *J. Hazard. Subst. Res.* 3: 1-19.

Khan, A.G. (2005). Role of soil microbes in the rhizospheres of plants growing on trace metal contaminated soils in

phytoremediation. *Journal Trace Elem. Med. Biol*. 18: 355-364.

Lueprom-Chai, E.., Lertthamrongsak, W., Pinphanichakarn, P., Thaniyavarn, S., Pattaragulwanit, K. and Juntongjin, K.,(2007). Biodegradation of PAHs in petroleum-contaminated soil using tamarind leaves as microbial inoculums. *Songklanakarin J. Sci. Technol*. 29: 515-527.

Maleti´c, S.P., Dalmacija, B.D., Ron˘cevi´c, S.D., Agbaba, J.R. and Perovi´c, S.D.U. (2011). Impact of hydrocarbon type, concentration and weathering on its biodegradability in soil. *J. Environ. Sci. Heal.* Part A Toxic/Hazard. *Subst. Environ. Eng*. 46: 1042–1049.

Meneghetti, L R.R (2007). Bioremediation in the decontamination of basalt residual soil contaminated with diesel oil and biodiesel. (Theses) Federal University of Passo Fundo, Faculty of Engineering and Architecture, Passo Fundo, RS (2007) (In Portuguese).

Ochor, N.O., Chikwendu, M. U., Onyeizu, U. R. Ugwujor, P. K., Ogbonna O. A. and Ikpeazu, O.V. (2022). Assessment of the potential of oyester mushroom (*Pleurotus ostreatus*) as mycoremediation on spent engine oil polluted soil in Abia State, Nigeria. *Journal of Forestry, Environment and Sustainable Development*, 8(2): 63-71.

Ogunjobi, K.M., Adeoluwa, V.J, Gakenou O.F., Olufemi, O.O,Ayanleye, S.O and Lawal, K.J(2021). Biosorption potential of sawdust in removing zinc ions from aqueous solution. *International journal of science research and management (IJSRM)*, 9(10):191-198.

Ogunjobi, K.M., Shittu A.T., Gakenou O.F., Ashade O.C., Adetogun A.C. (2018). Preference of Wood Species for Furniture in Abeokuta, Ogun State, Nigeria. *J. For. Sci. Env*. 3 (1): 30-36.

Parrish, Z.D., Banks, M.K. and Schwab, A.P. (2005). Assessment of contaminant labiality during phytoremediation of polycyclic aromatic hydrocarbon impacted soil. Environ. Pollut. 137: 187- 197.

Plohl, K, Leskovsek, H and Bricelj, M (2002). Biological degradation of motor oil in water. Acta Chim. Slovenica. 49:279-289.

Rodolfo, L. C., (2014) : Bioremediation of contaminated soil containing crude oil. University of Applied Sciences. Bachelor's thesis December 2014. Degree Programme in Environmental Engineering.

Singh, A and Ward, O.P (2004). Biodegradation and bioremediation. Canada: library congress cataloguing, 3-13.

UN Report (2001). Protecting Ecosystem for People and Planet, United Nations Environmental Programme. Pp. 130-147.

USEPA (2000). Introduction to phytoremediation. Environmental Protection Agency, USA. Pp. 5.