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COMPARATIVE ANALYSIS OF COMPOSTING AND LANDFARMING AS BIOREMEDIATION TECHINQUES IN HYDROCARBON DEGRADATION

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Abstract: This study focuses on the comparative analysis of composting and land farming as bioremediation methods in hydrocarbon degradation. To achieve this, soil samples from a polluted site were collected at different distances of 10m-50m and were mixed together to have a composite sample. Then Physiochemical, total petroleum hydrocarbon (TPH) and microbial analysis were carried out after five weeks and it was observed that there were reduction in the concentration of heavy metals and total petroleum hydrocarbon (TPH) both for the land farming and the composting method. For land farming method, the degradation of TPH from week 1 to week 5 were 2149.15, 1916.45, 1657.38, 1075.13, and 397.03 respectively. While that of composting method the degradation of TPH from week 1 to week 5 were 2149.15, 2045.37, 1781.28, 1232.72, and 762.07 respectively. These show high level of efficacy in the use of these methods as remediation techniques. While for the heavy metals there were also a decrease in their concentrations, the decrease were within DPR standard. The microbial analysis showed an increase in the microbial population for the two methods in the first four weeks, though microbial population in the land farming method was high compared to the composting method.

Keywords: Bioremediation, Composting, Hydrocarbon, Nigeria.

INTRODUCTION

The increase in the exploration and production of crude oil has resulted in the generation and discharge of large quantities of hydrocarbon contaminated waste into the oil producing communities of Niger Delta region. The major oil operators in Nigeria generating tones of waste and lots of oil spill contamination of sites. The effect of hydrocarbon contaminated waste on the environment represents a considerable concern in some areas (Potin et al, 2003). Factors such as regulatory compliance, environmental risk, cost effectiveness, environmental impact and timeliness of disposal would affect the choice of an appropriate method for the treatment of a contaminated site. A number of hydrocarbon waste management options exist including, land fill storage, thermal destruction and bioremediation (Putin et al, 2003).

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Bioremediation was developed by researchers as one feasible way to accelerate or encourage the degradation of pollutant from contaminated sites. The basis of bioremediation is that organisms remove substances from the environment to carry out their metabolism activity and growth. Bioremediation is not only effective for the degradation of pollutants but can also be used to clean unwanted substances from air, soil, water and raw materials from industrial waste. Metals and their salt typically inhibit rather than support biological processes. However in recent years there has been increased attention on the implementation of biological approaches for bioremediation of some forms of inorganic contamination.

The vegetation is purely rain forest. In this zone rainfall is heavy. About 90% of the vegetation flourishes very well, the leaves are evergreen and luxuriant in appearance. The forest is dominated by tall tress such as Obeche and Mahogany which grows up to 45 meters in height. The forest is densely thick with varieties of plant species, community found in the area are palm trees, epiphytes, lianas, and other species of climbers. The climate and soil determines vegetation types as well as fauna that dwell around the area (Nwachukwu, 2010).

The quality of life on earth is linked inextricably to the overall quality of the environment. In early times, we had an unlimited abundance of land and resources; today however the resources in the world is not what it use to and this is due to our carelessness and negligence in using them.

The problem associated with contaminated land generally result from past industrial activities when awareness of the health and environmental effects connected with the production, use and disposal of hazardous substances were less organized than today. The problem is worldwide and the estimated number of contaminated site is significant (Nwachukwu, 2010). It is now widely recognized that contaminated land is a potential threat to human health, and this had led to international efforts to remedy many of these sites either as a response to the risk of adverse health or environmental effects caused by contamination or to enable the site to be redeveloped for use.

The conventional techniques used for remediation have been to dig up contaminated soil and remove it to a landfill, or to cap and contain the contaminated areas of the site (Vidali, 2001).

These methods have some draw backs. The first method simply moves the contamination elsewhere and may create significant risks in the excavation, handling, and transport of the hazardous materials. It is very difficult and increasingly expensive to find new land fill sites for the final disposal of the material. The cap and contain methods is only an interim solution since the contamination remains on site, requiring monitoring and maintenance of the isolation barriers long into the future, with all the associated costs and potential liability.

A better approach than these traditional methods is to completely destroy the pollutant if possible, or at least to transform them to innocuous substances. Some technologies that have been used are high temperature incineration and various types of chemical decomposition (e.g. Base-catalyzed dechlorination, UV, Oxidation). They can be very effective at reducing level of range of contaminants, but have several drawbacks, principally their technological complexity, the cost for small scale application and the lack of public acceptance, especially for incineration that may increase the exposure to contaminant for both the workers at the site and nearby residents (Noriss et. al, 1993).

PRINCIPLES OF BIOREMEDIATION

Going by definition, bioremediation is the use of living organisms, primarily microorganisms to degrade the environmental contaminants into less toxic forms. For bioremediation to be effective, microorganisms must attack the pollutants and convert them to harmless products. As bioremediation can be effective only when environmental conditions permits microbial growth and activity, its application often involves the manipulation of environmental parameters to allow for microbial growth and degradation to proceed at a faster rate.

Bioremediation techniques are typically more economical than traditional methods such as incineration, and some pollutant can be treated on site, thus reducing exposure risks for clean-up personnel, or potentially wider exposure as a result of transportation accidents. Since bioremediation is based on natural attenuation, the public considers it more acceptable than other technologies.

Most bioremediation systems can run under aerobic conditions, but running a system under anaerobic conditions may permit microbial organisms to degrade otherwise recalcitrant molecules.

MICROORGANISMS INVOLVED IN BIOREMEDIATION

Bioremediation is based on the idea that microorganism removes substance from the environment to carryout growth and metabolism. Microorganisms such as bacteria, profista and fungi are nature’s original recyclers. Microorganisms are found to be very good at degrading complex molecule and incorporating the breakdown products into their metabolism (Bouwer et. al 1993).

Their capability to transform natural and synthetic chemicals into source energy and raw materials for their own growth suggests that expensive chemical or physical remediation processes might be replaced with biological processes that are lower in cost and more environmentally friendly. Fungi for example are good especially of digesting complex organic compounds that are normally not degraded by other organisms. (Wilson et.al, 1993) Microbes utilize chemical contaminants in the soil as an energy source and through oxidation and reduction reactions metabolize the target contaminant into useable energy for microbes. By products released into the environment are typically in a less toxic form than the parent contaminants. For example, petroleum hydrocarbons can be degraded by microorganisms in the presence of oxygen through aerobic respiration. The hydrocarbon loses electron and is reduced. The result is formation of carbon dioxide and water (Nester et. al 2001).

EVALUATION OF LANDFARMING EFFECTIVENESS

The effectiveness of Bioremediation depends on many parameters. The parameters are grouped into three categories: soil characteristics, constituent characteristics, and climatic.

Table 1: Parameters used to evaluate the effectiveness of bioremediation.

Parameters Used to evaluate the effectiveness of bioremediation

Soil characteristics	Constituent Characteristics	Climatic Conditions
Microbial population density	Volatility	Ambient temperature
Soil pH	chemical structure	Rainfall
Moisture content	concentration and toxicity	Wind
Soil temperature		
Nutrient concentrations		
Texture		

Source: (Wilson et.al, 1993)

SOIL CHARACTERISTICS

Microbial population density

Soil normally contains large numbers of diverse microorganisms including bacterial, also fungi, protozoa, and actinomycetes. In well drained soils, which are most appropriate for land farming, these organisms are generally aerobic. Of these organisms, bacteria are the most numerous and biochemically active group, particularly at low oxygen source to sustain metabolic functions required for growth. Bacterial also require nitrogen and phosphorus for cell growth. Although sufficient types and quantities of microorganisms are usually present in the soil, recent applications of ex-situ soil treatment include blending the soil with cultured microorganisms or animal manure (typically from chickens or cows). In cooperating manure serves to both augments the microbial population and provide additional nutrients. (Wilson et.al, 1993)

The metabolic process used by bacteria to produce energy requires a terminal electron acceptor (TEA) to enzymatically oxide the carbon source to carbon dioxide. Microbes are classified by the carbon and TEA sources they use to carry out metabolic processes. Bacteria that use organic compounds (e.g., petroleum constituents and other naturally occurring organics) as their source of carbon are heterotrophic; those that use inorganic compounds (e.g., carbon dioxide) are autotrophic. Bacteria that use a compound other than oxygen (e.g., nitrate sulphate) are anaerobic; and those that can utilize both oxygen and other compounds as TEAs are facultative. For land farming and composting applications directed at petroleum products, only bacteria that are aerobic, facultative and heterotrophic are important in the degradation process (Vidali, 2001).

In order to evaluate the presence and population of naturally occurring bacteria that will contribute to degradation of petroleum constituents, conduct laboratory analyses of soil samples from the site. These analyses at minimum should include plate counts for total heterotrophic bacteria. Plate counts results are normally reported in terms of colony forming units (CFUs) per gram of soil. Microbial population densities in typical soil range from 10^4 to 10^7 CFUs/gram of soil for land farming and composting to be effective, the minimum heterotrophic plate count should be 10^3 CFUs/gram or greater. Plate counts lower than 10^3 could indicate the presence of toxic concentrations of organic or inorganic (e.g., metals) compounds. In this situation, land farming and composting may still be effective if the soil is conditioned or amended to reduce the toxic concentrations and increase the microbial population density. More elaborate laboratory tests are sometimes conducted to identify the bacterial species present. This may be desirable if there is uncertainty about whether or not microbes capable of degrading specific petroleum hydrocarbons occur naturally in the soil. If insufficient numbers or types of microorganisms are present, the population density may be increased by introducing cultured microbes that are available from vendors (Vidali, 2001).

SOIL pH

To support bacterial growth, the soil pH value should be within the 6 to 8 range. With a value of about 7 (neutral) being optimal. Soil with pH values outside this range prior to bioremediation process will require pH adjustment prior to and during bioremediation operations. Soil pH within the bioremediation process can be raised through the addition of lime and lowered by adding elemental sulfur. If the soil pH is less than 6 or greater than 8, make sure that pH adjustments, in the form of soil amendments, are included in the design and operational plans for the remediation process (Nester et. al, 1993).

MOISTURE CONTENT

Soil microorganisms require moisture for proper growth. Excessive soil moisture, however, restricts the movement of air through the subsurface thereby reducing the availability of oxygen which is also necessary for aerobic bacterial metabolic processes. In general, the soil moisture is between 40 and 85 percent of the water-holding capacity (field capacity) of the soil or about 12 percent to 30 percent by weight. Periodically, moisture must be added in landfarming or composting operations because soils become dry as a result of evaporation, which is increased during aeration operations (i.e. tilling and/ plowing). Excessive accumulation of moisture can occur at remediation areas with high precipitation of poor drainage. These conditions should be considered in the design (Balbe et.al, 1998).

Soil temperature

Bacterial growth rate is a function of temperature. Soil microbial activity has been shown to decrease significantly at temperatures below 10 ^{o}C to 45 ^{o}C; the rate of microbial activity typically doubles for every 10 ^{o}C rise in temperatures. When ambient temperatures return to the growth range, bacterial activity will be gradually restored. The period of the year when the ambient temperature is within the range for microbial activity is commonly called the land farming season (Balbe et.al, 1998).

NUTRIENT CONCENTRATIONS

Microorganisms require inorganic nutrients such as nitrogen and phosphorus to support cell growth and sustain biodegradation processes. Nutrients may be available in sufficient quantities in the site soils but, more frequently, nutrients need to be added to the landform soils to maintain bacterial populations. However, excessive amounts of certain nutrients (i.e. phosphate and sulfate) can repress microbial metabolism. The typical carbon: nitrogen: phosphorus ratio necessary for biodegradation falls in the range of 100:10:1 to 100:1:0.5, depending upon the specific constituents and microorganisms involved in the biodegradation process (EPA, 1994).

The naturally occurring available nitrogen and phosphorus content of the soils should be determined by chemical analyses of samples collected from the site. These types of analyses are routinely conducted in agronomic laboratories that test soil fertility for farmers. These concentrations can be compared to the nitrogen and phosphorus requirements calculated from the stoichiometric ratios of the biodegradation process. A conservative approximation of the amount of nitrogen and phosphorus required for optimum degradation of petroleum products can be calculated by assuming that the total mass of hydrocarbon in the soil represents the mass of carbon available for biodegradation (EPA, 1994).

SOIL TEXTURE

Texture affects the permeability, moisture content, and bulk density of the soil. To ensure that oxygen addition (by tilling or plowing), nutrient distribution and moisture content of the soils can be maintained within effective ranges, one must consider the texture of the soils. For example, soils which tend to clump together (such as clays) are difficult to aerate and result in low oxygen concentrations. It is also difficult to uniformly distribute nutrients throughout these soils. They also retain water for extended periods following a precipitation event. (Vidali, 2001).

One should identify whether clayey soils are proposed for land farming at the site. Soil amendments (e.g. gypsum) and bulking materials (e.g. sawdust, or straw) should be blended into the soil as the landform is being constructed to ensure that the land farming medium has a loose or divided texture. Clumpy soil may require shredding or other means of pretreatment during landform or composting construction to incorporate these amendments. (Vidali, 2001)

CONSTITUENT CHARACTERISTICS

Volatility

The chemical structures of the contaminants present in the soils Proposed for treatment by Bioremediation is important because volatile constituents tend to evaporate from the landform or composting, particularly during tiling or plowing operations, rather than being biodegraded by bacteria. Constituent vapors emitted from landfarm or composting process will dissipate into the atmosphere unless the landform or composting is enclosed within a surface structure such as a green house or plastic tunnel or covered with a plastic sheet (Vidali, 2001)

Petroleum products generally contain more than one hundred different constituents that possess a wide range of volatility. In general, gasoline, kerosene, and diesel fuels contain constituents with sufficient volatility to evaporate from a landform or composting process. Depending upon state-specific regulations for air emissions of volatile organic compounds (VOCs), control of VOC emissions may be required. Control involves capturing vapors before they are emitted to the atmosphere and then passing them through an appropriate treatment process before being vented to the atmosphere. (Wilson et.al, 1993)

The chemical structures of the contaminants present in the soils proposed for treatment by land farming or composting are important in determining the rate at which biodegradation will occur. Although nearly all constituents in petroleum products typically found at polluted sites are biodegradable, the more complex the molecular structure of the constituent, the more difficult, and less rapid, is biological treatment. Most low molecular - weight (nine carbon atoms or less) aliphatic and monoaromatic constituent are more easily biodegraded than higher molecular weight aliphatic or polyaromatic organic constituents. (Wilson et.al, 1993)

Concentration and toxicity

The presence of very high concentrations of petroleum organics or heavy metals in site soils can be toxic or inhibit the growth and reproduction of bacterial responsible for biodegradation in land farming or composting . In addition, very low concentrations of organic material will also result in diminished levels of bacteria activity (Onyie, 2010).

In general, soil concentrations of total petroleum hydrocarbons (TPH) in the range 10,000 to 50,000ppm, or heavy metals exceeding 2,500ppm, are considered inhibitory and/or toxic to most microorganisms. If TPH concentrations are greater than 10,000ppm, or the concentration of heavy metals is greater than 2,500ppm, then the contaminated soil should be thoroughly mixed with clean soil to dilute the contaminants so that the average concentrations are below toxic levels (Onyie, 2010).

Climatic conditions

Typical landforms are uncovered and, therefore, exposed to climatic factors including rainfall, snow, and wind, as well as ambient temperatures (Onyie, 2010).

Ambient temperature

The ambient temperature is important because it influences soil temperature. As described previously, the temperature of the soils in the land farming or composting impacts on bacterial activity and, consequently, biodegradation .The optimal temperature range for land farming or composting is 10^{o}C’ to 45^{o}C.(Bouwer and Zenhnder, 1993)

RAINFALL

Rainwater that falls directly onto the landform area will increase the moisture content of the soil and cause erosion. As previously described, effective land farming requires a proper range of moisture content. During and following a significant precipitation event, the moisture content of the soils may be temporarily in excess of that required for effective bacterial activity. On the other hand during periods of drought, moisture content may below the effective range and additional moisture may need to be added (Bouwer and Zenhnder, 1993)

If the site is located in an area subject to annual rainfall of greater than 30 inches during the land farming season, a rain shield (such as a tarp, plastic tunnel, or green house structure) should be considered in the design of the Ian farm. In addition, rainfall run on and run off from the landform should be controlled using berms at the perimeter of the landform. A leachate collection system at the bottom of Ian farm and a leachate treatment system may also be necessary to prevent groundwater contamination from the landform (Bouwer and Zenhnder, 1993)

WIND

Erosion of landform soils can occur during windy periods and particularly during tilling or plowing operations. Wind erosion can be limited by plowing soils into windrows and applying moisture periodically (Altas and Bartha, 1992)

COMPOSTING AS AN APPROACH TO BIOREMEDIATION

The use of compositing in bioremediation has received little attention (Potter et. al, 1999). Despite its application in the treatment of soils contaminated with organic compounds for many years. Much of the works on treatment of contaminated soil by composting has been done on soils with lower concentration of the contaminating substances than used in the present study, in spite of the fact that compost has been reported to have potential for remediation of heavily contaminated sites (Garcia-Gomez et. al, 2003; Manios, 2006).

Generally composting involves mixing the contaminated material with an organic bulking agent and formed into piles or windows while mechanically manipulating the soil to improve soil conditions, there by accelerating the biodegradation rate of the contaminant. The bulking agent is usually a material of low density that lowers the contaminated soil bulk density, increases porosity and oxygen diffusion and can help to form water stable aggregate. These increases aeration and microbial activity (Wie et. al, 2000). Another new and interesting technique to integrated waste management is composting. Co-composting is a low cost waste management technique which may be an alternative that offers solution to the restrictions in land farming. Hence the need to evaluate use of co-composting as a remediation option for the treatment of petroleum hydrocarbon contaminated soil. Co-composting has been defined as a method of composting two or more raw materials together. Co-composting is suggested to be advantageous because the material used in most cases complement each other and also give the waste a better nutrient balance (Wie et al., 2000).

LAND FARMING AS AN APPROACH TO BIOREMEDIATION

Land farming involves spreading contaminated soil over a collection system and stimulating microbial activity by allowing good aeration and by monitory nutrient availability (US EPA, 2006 Land farming). The petroleum products from the soil during land farming are largely removed through volatilization biodegradation or adsorption (Hejazi et. al, 2003). The volatile organic compounds from the land farm area can present air pollution problems if the treatment area is not properly covered to minimize the emissions (Hejazi et al 2003). Apart from the VOC emission, other constraints faced by land farming as a treatment option includes; requirement for large land area for treatment, availability of the pollutant degrading bacteria effectiveness of the technology at high constituent concentration, improved concentration reduction on cases requiring more than 95% of pollution reduction and the flexibility of the technology in integrating the removal of petroleum hydrocarbon with other contaminant that may occur with the petroleum products. Although problems associated with the depth of pollution can be solved by existing treatment, the polluted soil often requires a large treatment area which can increase the risk of human exposure to the contaminants. However such exposure is only temporary, as contaminants will be degraded if environmental conditions are optimal (Ausma et al., 2002).

STUDIES IN COMPOSTING AND LAND FARMING

Over the years, studies have been carried out using the land farming and composting approach to bioremediation. And there have been a number of successes in the use of these. One of such places is the Shengil oil fields in China, where the land farming technology was used in remediating large quantities of dehydrated soil sludge which were generated in the disposal process of oil containing sewage (Thomas and Ward, 1993). In using this approach four different treatment were made to study the impact of certain process parameters on the bioremediation efficiency, 52,75^{o}C of the oil contaminants were degraded in 160 days when treated in a green house while oil contaminants decreased by only 15.46% in the untreated sludge.

Another place where bioremediation has been used is the Pepisco Frito lay Simba Isando in South Africa. The remediation was carried out in site so as to avoid the expensive removal of contaminated soil form off site clearing. The composting approach was used in order to aerate the soil, providing the most suitable condition for the growth of bacteria colonies. The aim of the study was the bioremediations the soil to a value below a total hydrocarbon value of 2000mg/kg. This was based on the fact that the site was industrial and would not readily be used for agricultural or human occupation in the foreseeable future (Day, 1992).

P.C Mmom and T. Daakar (2010) assessed the effectiveness of land farming in remediation of hydrocarbon polluted soil in the Niger Delta Nigeria. They carried out this study with the aim of reducing hydrocarbon content of the polluted soil and possibly water with their varying degrees of success. The results of the soil analysis using this approach show 14.54 to 82.24% and 16.01 to 50.54% reduction in the TPH and poly aromatic hydrocarbon concentration after land farming.

No doubt from these examples, it can rightly be said that the land farming and composting approaches to remediation have been used in different ways. Therefore this work examines what has been done before. It only limits itself to comparing the two approaches.

MATERIALS AND METHODS

MATERIALS

The materials used in this study includes contaminated soil, wood shavings, fresh grass clippings, beaker, thermometer, soil auger, measuring tape, spades in the manuals turning of the piles. The soil samples for the composting and land farming approaches were collected from varied distances from the polluted site.

METHODS

A sampling area of 50 by 50 m^2 was delineated around the epicenter of spillage. Similarly an area of 50 m^2 by 50m^2 was selected for the control. The samples were collected at distance from the center of the spillage at 10m, 20m, 30m, 40m, and 50m respectively.

LANDFARMING

The polluted site was excavated using stainless shovels beyond the polluted depth of 20cm as established during site assessment which was performed manually with the aid of soil auger. The excavated materials were heaped together. The rhizosphere of unpolluted or control soil were also excavated manually using shovels and rakes and transferred to the polluted sites which have been spiked and tilled. The excavated polluted soil and those of the unpolluted soil were thoroughly mixed to homogeneity with shovels and rakes. The resultant soils mixture was windrowed to a height and width of 3 m and 5 m, respectively and a length of 10m. The windrows which were constructed against the slope were turned two times per week for five weeks. (Nwachukwu, 2010)

All soil samples were subjected to complete analysis for pH, organic carbon, and available phosphorous for fertility characterizations, heavy metal analysis and total petroleum hydrocarbon concentration level (TPH). (Nwachukwu, 2010)

COMPOSTING

Fresh grass clippings were cut just before the experiment with a domestic lawnmower. Wood shavings were bought from a wood processing plant at Omoku-Nigeria about 8km away from the treatment site. Soil samples were collected from the site into concreted composting cell. During the collection of the contaminated soil, surface litter was removed and the soil collected to a depth of 20cm. the collected soil was sieved to remove large roots, macro-fauna and stones. The total petroleum hydrocarbon of the soil microbial count and nutrient concentration were determined (Mmon and Dekor, 2010)

The sieved contaminated soil was bulked with the grass clippings and wood shaving in approximate ratio of 3:1:1 by volume. The mixture was turned mechanically to attain a good homogenization of the mixture (Mmon and Dekor, 2010)

The bulked contaminated soil was heaped into a pile of 1m high 3m wide and 10m long. This was done for ease of turning, which was carried out manually. The pile was made on the floor, and was then covered with polyethylene material. . (Mmon and Dekor, 2010)

Compost samples for chemical and microbiological analyses were collected every time the piles were turned and homogenized. The pile turned two times per week for five weeks. (Nwachukwu, 2010)

All soil samples were subjected to complete analysis for pH, organic carbon, and available phosphorous for fertility characterizations, heavy metal analysis and total petroleum hydrocarbon concentration levels (TPH). There was only one control for the two bioremediation process. (Nwachukwu, 2010)

RESULTS AND DISCUSSION OF RESULTS

The results of Physiochemical, total petroleum hydrocarbon (TPH) concentration and microbial obtained for the analysis of contaminated soil samples before and after remediation are shown in tables 2 to 5 and in figures 1 to 4 respectively.

Table 2: Result of Concentration of heavy metals in the soil sample before and after land farming (mg/L)

Parameters Remediation	Before Remediation	After	DPR (1991)
Parameters	Before	After	DPR (1991)

Remediation	Remediation		
Pb^{2+}	0.0131	0.001	0.005
Zn^{2+}	0.009	0.003	1.5
Cu^{2+}	0.015	0.009	1.00
Cr_{6+}	0.001	BDL	0.03
Ca_{2+}	0.003	BDL	0.02
Ni^{2+}	0.0009	BDL	-
Hg^{3+}	BDL	BDL	-
Ag^{6+}	BDL	BDL	0.0003
Ba^{2+}	BDL	BDL	<0.001

BDL: Below defection level

Table 3: Result of Concentration of heavy metal in the soil sample before and after composting (mg/L)

Parameters Remediation	Before Remediation	After	DPR (1991)
Pb^{2+}	0.0131	0.0015	0.005
Zn^{2+}	0.009	0.005	1.50
Cu^{2+}	0.015	0.002	1.00
Cr_{6+}	0.001	0.005	0.03
Ca_{2+}	0.003	BDL	0.02
Ni^{2+}	0.0009	BDL	-
Hg^{3+}	BDL	BDL	-
Ag^{6+}	BDL	BDL	0.0003
Ba^{2+}	BDL	BDL	<0.001

BDL: Below defection level

Table 4: Result of Concentration of TPH in the soil sample during remediation using landfarming and composting (mg/Kg)

Weeks Land farming	TPH level in in composting	TPH level	DPR (1991)
1	2149.15	2149.15	500
2	1916.45	2045.37	500
3	1657.38	1781.28	500
4	1075.13	1232.72	500
5	397.03	762.07	500

Table 5: Result of microbial population in the contaminated soil during remediation using Composting and land farming (cfu)

Weeks	THB($X10^5$)	THUB ($X10^5$)
	In Land farming	in composting
1	124.02	124.02
2	593.10	582.00
3	816.00	713.05
4	1297.01	961.24
5	754.22	346.07

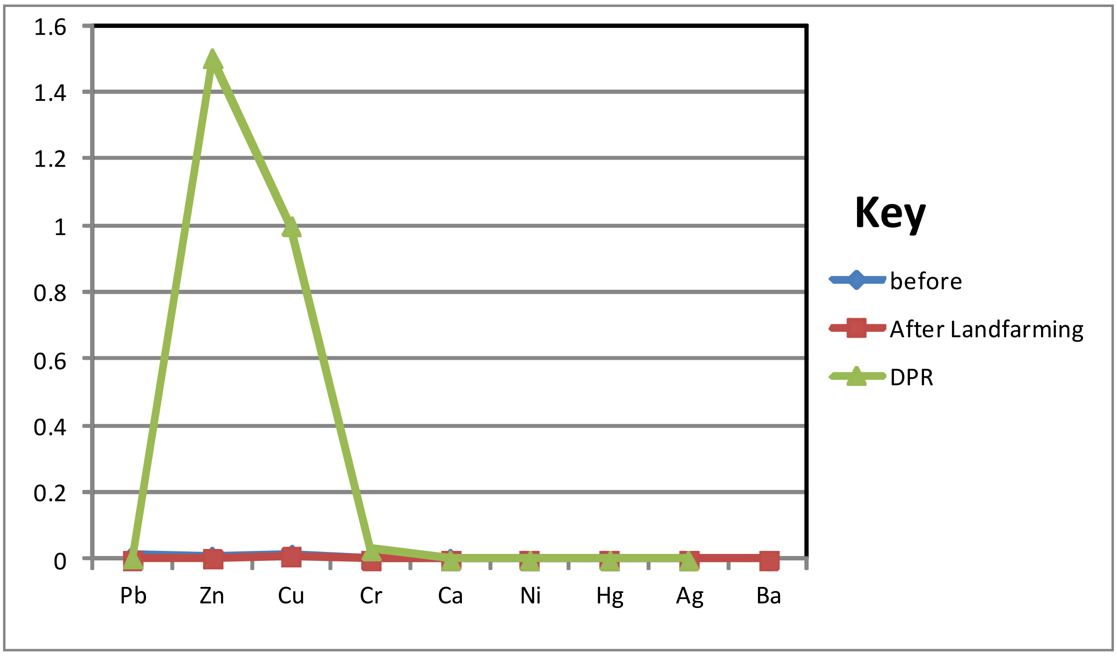

Fig.1: Graphical Representation of Concentration of Heavy Metals before and after remediation using land farming method.

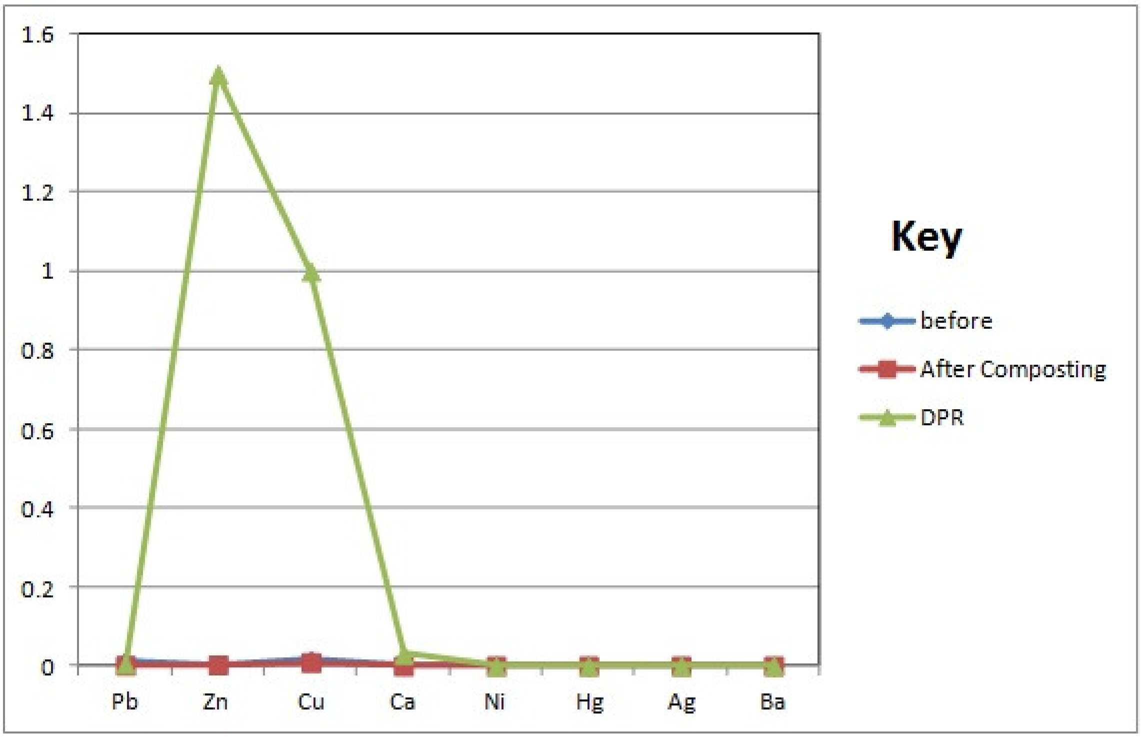

Fig.2: Graphical Representation of Concentration of Heavy Metals before and after remediation using composting method

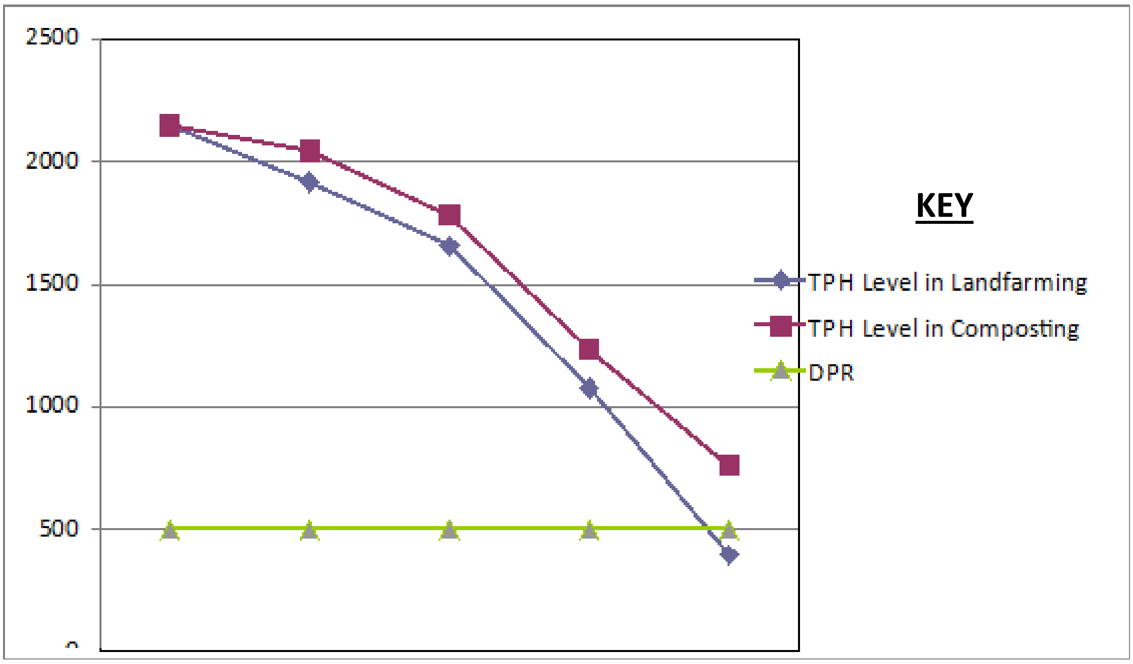

Fig.3: Graphical Representation of concentration of heavy metals in before and after remediation using composting method

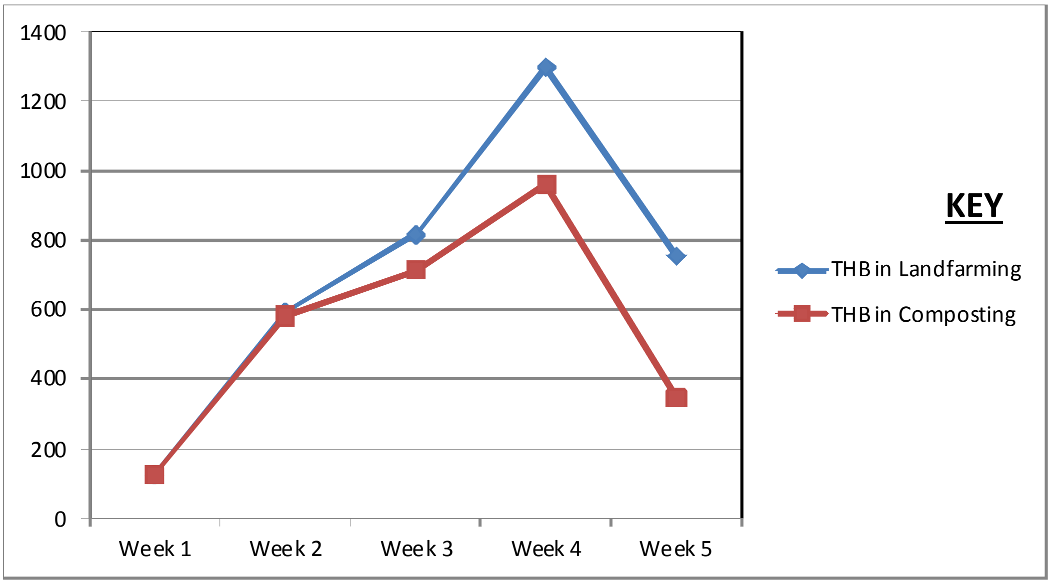

Fig. 4: Graphical Representation of Microbial Population in the Contaminated Soil during remediation using composting and Land-farming

DISCUSSION OF RESULTS

In this study, the pH value of the soil sample was 6.52. To support bacteria growth, the soil pH should be within the 6 to 8 range with a value of about 7 (neutral). Soil pH can be raised through the addition of lime (calcium and magnesium compound or lowered by applying sulphur or aluminum sulphate. The degree of acidity or alkalinity is considered a master variable that affects nearly all soil properties-chemical, physical and biological. Some organisms are unaffected by a rather broad range of pH values, others may exhibit considerable intolerance to even minor variations in the pH. It determines the fate many soil pollutants affecting their breakdown and possible movement through the soil and into the groundwater (Akpofure et. al, 2000). It is a major controller of plant nutrient availability and of microbial reaction in soils. The amount of acid or alkali in the soil determines the availability of many nutrients for plant growth and maintenance. If the pH of soil is too high or too low the nutrient are either locked on to the soil particles or are washed out of the soil. The pH of the soil greatly affects the solubility of the minerals. Strongly acidic soils (pH 4 to 5) usually have high concentration of soluble aluminium and thereby affect plant growth. Nitrogen fixation and decomposition activities are also hindered in strongly acidic soil.

Similarly, in this study, soil samples were examined to determine if there were reductions in the hydrocarbon contents in the soil after land farming and composting. Concentrations of total petroleum hydrocarbon (TPH) were found to have reduced as shown in tables 4 and 5. It was also observed that the reduction in TPH value using land farming was more compared to the value obtained using composting. However, the values were greater than 50mg/kg of DPR limit but below 500mg/kg allowable limit for industrial area in the land farming technique.

Many soils naturally have varying trace amount of heavy metals even in undisturbed environment. This amount can be changed because many industrial processes produce heavy metals which if not properly and carefully controlled end up in the environment in soils and water. Any increase in these heavy metals indicates that there is contamination. When the concentration of these heavy metals such as cadmium reaches certain levels they can become toxic to plants.

Lead when taken into the body enters the blood stream from where it is redistributed to soft tissues and the skeleton. Lead may cause blood enzymes change, anemia, hyperactivity and other subtle neurobehavioral effects. They assume particular importance when considering bioaccumulation because there is no indication currently that most of them are used by animals in their metabolic processes. Contamination in soil may have detrimental effect in any microbes. It can result to heavy metal toxicity (EPA 1997).

Heavy metal analysis in soil appears to be more useful in detecting sources of pollution since the soils are likely to be sinks for pollutant. The heavy metals analyzed in the study are notable constitutes of crude oil. It was observed in this study that Cd, Ni Hg, Ag and Ba had most of their values below detection limit after using the two bioremediation technique. It confirmed the fact that microbes play a crucial role in the reduction of heavy metal concentrations in soil. The result of heavy metal analysis before and after land farming and composting are shown in table 4 and 5.

Comparing the two results obtained from the methods use, it can be concluded that there is significance difference in the TPH level, showing that the methods used were effective. It can also be seen that the level of degradation of TPH in landfarming was higher compared to the one obtained in composting.

CONCLUSION AND RECOMMENDATIONS

CONCLUSION

Remarkable decrease in the levels of total petroleum hydrocarbons and heavy metals in the remediated soil samples were observed when compared with those of the polluted soil samples. This shows that the methods can be effectively used to naturally remediate an oil polluted site.

RECOMMENDATIONS

There are various methods and approaches that can be used for remediating a hydrocarbon spill, but I recommend land farming and composting methods, because they require simple materials and cost effective.

Employment can be created for the youths during the remediation of a spill site, rather than using methods of remediation requiring mechanical equipments; it is recommended that land farming approach which requires filing be used so as to satisfy the need of employment.

More stringent measures should be employed by the federal government and bodies responsible for exploration and production of oil so as to reduce the rate of hydrocarbon spill.

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