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Research Paper

Effectiveness Assessment of Land farming Remediation strategy in Omkpobu, Rivers State, Nigeria

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ABSTRACT
Landfarming is a remediation techniques or strategy with the ultimate aim of reducing hydrocarbon-impacted soil to an acceptable restored and one means of doing this is landfarming. Landfarming techniques have shown that remediation can be done faster at a cheaper rate compared to tolerant limit. It is a technique that have been in use for quite sometimes to ensure environmental sustainability. With all the numerous spills all across Niger Delta, Nigeria ranging from various sources it become imperative for the remediation of the impacted areas. Remediation is a means or a process by which an impacted area contaminated by crude oil is other strategies.To effectively assess the effectiveness of landfarming at Omukpobu the delineated area with impact exceeding the acceptable limit of 5,000 kg/mg of Total Petroleum Hydrocarbon was thoroughly delineated to ensure no impact is left unexhumed in the excavation process. This process was carefully done using Geo Positioning System (GPS), Physical markers, cordoning tapes etc. To achieve this heavy equipment such as excavator was used to exhume the impacted soil up to 4.5 meter deep were no impact is visible and very low olfactory smell. The impact at all level of the excavation process was professionally monitored and ensured to be line with best practise. At 0.5m deep little olfactory was noticed up to 2 meters deep. As the exhuming processes continued the impact tends to be increasing by means of olfactory check.such as from 2.3 meters to about 3.2 meters deep is mild while from 3.3 metre deep to 4.0 meters deep has a high or strong olfactory smell. Exhumed impacted soil was made to undergo steps associated with landfarming techniques. The exhumed were spread over a prepared treatment bed area for aeration or oxygenation. The treatment bed was strategically designed to be in line with environmental best practise as use of HDPE liner.The HDPE helps to limit impact and as well avoid possible or transfer of impact from one area to the other. The spread soil was frequently tilled before there were used to construct windrows to aid the aeration process. The total petroleum hydrocarbons of land farmed soil were drastically reduced before they were returned. These is in line with the view of International Centre for Soil and Contaminated Sites (2006) that ''Effective remediation through landfarming will increase microbial activities that will eventually address contamination on soil. This research looked at the effectiveness of the techniques in addressing or remediated a contaminated soil using Omukpobu as a case study. Landfarming strategy proves to be very effective in the management or treatment of hydrocarbon-impacted soil. This was proven as the analysed result shows very good improvement from an initial of 9,250 mg/kg Total Petroleum Hydrocarbon impact to a low value of 2, 306 kg/mg of Total Petroleum Hydrocarbon which was below the EGASPIN intervention level in Nigeria.
Keywords: *Remediation; hydrocarbons; oil spillage; groundwater; Niger Delta.*

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I. INTRODUCTION

Ex situ waste management at the top soil zone or in biotreatment cells is referred to as landfarming. Transport polluted soils, sediments, or sludge to the land farming site, where they are incorporated into the polluted soil's soil surface region. To aerate the mixture, it is turned over (tilled) at regular intervals. Due to its low cost and lack of equipment requirements, land farming is usually regarded as one of the most basic bioremediation approaches (Ekundayo, 2001). The term "ex situ bioremediation" is most commonly used, while "in situ bioremediation" is also used infrequently (Elektorowicz, 1994). The fact that the two medications are available in different places triggered this discussion (Leung M, 2004). Pollution levels have a big impact on whether land farming is done ex situ or in situ. In land farming, contaminated soils are routinely dug and/or tilled, but the type of bioremediation appears to be determined by the treatment site. Ex situ bioremediation occurs when toxic soil exhibits the characteristics of other ex situ bioremediation processes; otherwise, in situ bioremediation occurs when hazardous soil is removed and treated on-site. If the contamination is less than 1 m below ground surface, bioremediation can be done without digging; however, pollutant concentrations greater than 1.7 m below ground surface necessitate excavation to the earth's surface for bioremediation to be effective, according to Nikolopoulou et al (2013). Volatilization, oil compound leaks, and persistent hydrocarbon remnants, on the other hand, pose environmental and societal issues for rehabilitation professionals. Two potential landfarm-based bioremediation strategies are bioaugmentation and biostimulation. Due to the obvious drawbacks of bioaugmentation (Abdusalam,2009), such as the short lifespan of boosted strains, biostimulation using naturally occurring pollutant-degrading bacteria should be preferred in contaminated environments. This would necessitate a large treatment area, pollutant-degrading bacteria, the technology's efficacy at high constituent concentrations (greater than 50,000 parts per million), increased intensity reductions in cases of contamination reductions greater than 95 percent, and the technology's adaptability by combining petroleum hydrocarbon expulsion with some other pollutants associated with petroleum products. Microbial hydrocarbon removal from polluted earth environments has become a well-established technology, with a variety of systems in use around the world. As a result of pollution caused by unregulated dumping and the formation and enforcement of environmental legislation, land farming became popular in North America and Europe (to reduce the danger of air and groundwater pollution).

This 'low-tech' biological treatment method involves the controlled application and dispersion of an organic biodegradable waste on the ground's surface, as well as the waste's assimilation into the soil's surface zone (Abdulsalam, 2009). In the United States, at least a third of all refineries planned full-scale or pilot-scale land farms in 1983. The American Petroleum Institute (API) was founded in 1983. In compared to other more traditional procedures, the treatment has gained appeal due to its simplicity and cost effectiveness (American Petroleum Institute 1983; Harmsen 1991). They are both physical and chemical processes, thus they are essentially two aspects of land farming. When a considerable amount of filthy soil is collected, landfarming requires a lot of space to heal it, which raises the risk of contamination if ex situ intervention is used. Potential difficulties linked with the volatilization of lighter hydrocarbons from compost can be fully avoided by repeating landfarms. As a result, potentially harmful compounds and dust are kept out of the equation. Nonetheless, only in the presence of greenhouse gases, most especially in warm locations, does volatilization become substantial. The efficacy of oxygenation equipment may limit land farming's ability to remediate dirty soil. To allow tilling equipment access to contaminated'subsurface' soil, landfarms must be carefully designed (Philip JC, 2005). The depth of polluted soil varies depending on the capability of the tilling equipment. However, when the treatment area expands, the amount of water required to maintain an adequate level of moisture for bioactivity can become significant, particularly in arid terrain, resulting in higher treatment costs. While physiochemical constraints in land farming may limit efficiency, knowledge gained over the last two decades on how to overcome them (Verstraete & Top 1999; Holden & Firestone 1997) has made environmentally friendly petroleum product processing more accessible.

II. METHODOLOGY

Landfarming at the research area involves the following methodology: Spreading of excavated impacted area, continuous tilling and homogenization of soil lumps for proper aeration or oxygenation and windrowing of impacted soil to a defined period depending the favourable weather condition. ‘’Landfarming is an ex-situ waste management method that occurs in the upper soil zone or in bio treatment cells or bed’’ (Maila MP, Colete TE: 2004). The source area was delineated after an initial assessment that involves drilling to the depth of 4 meter. An impact above Environmental Guidelines And Standards for the Petroleum Industry in Nigeria (EGASPIN) intervention level of 5, 000 Total Petroleum Hydrocarbon (TPH) for soil. The impacted area above regulatory intervention limit of 5, OOO mg/kg was excavated to the depth of 4.5 meters. The excavated soil of about 450 cubic meters was evenly spread within an area of 200 square meter treatment bed. A composite soil samples made up of 15 subsamples (5 subsamples=1 composite sample) were collected from 3 base of the excavation to ensure no contamination or base is clear of hydrocarbon impact. Similarly, samples were collected from the 4 walls of the excavation. i.e. Wall A, Wall B, Wall C and Wall D for impact verification samples.Four (4) samples made up of 20 subsamples were collected from the four walls of the excavated area (fig.2). Shin Pan Test method of determining degree of contamination (soil) impact was conducted at site to give preliminary idea of what the degree of contamination looks like. Clean water free from any form of coloration was collected from a domestic borehole. The water was poured into the shin pan. Random soil samples were collected from the impacted soil, excavation base and walls to check for any form of shin by dissolving the soil particles in the water in the pan. This method is followed up with laboratory analysis of the collected samples. Method of determining degree of contamination (soil) impact was conducted at site to give preliminary idea of what the degree of contamination looks like. This method is followed up with laboratory analysis of the collected samples. The treatment bed was lined with High Density Polyethylene (HDPE) liner to prevent leaching. The impacted soil were spread within the treatment bed with about 0.2m thickness for aeration. The spread-impacted soil was tilled continuously before use in the construction of first series of windrows. About 84 windrows was erected with size of about 1.2 meters wide and 10 meters long. The standing windrows were left for about 8 weeks. The windows were broken down and spread evenly again at a very slim thickness. Samples from the impacted soil, which have gone through the process of land farming, was collected similarly to establish the present status the contaminant after the treatment process. The spread soil was tilled and homogenized, after which the soil was used to construct second series of windrows after being left for 48 hours for aeration. Soil samples were collected to check treatment progress of the soil. Laboratory shows analysed sample is below 5,000 kg/mg of Total Petroleum Hydrocarbon. The treated soil was then returned back to its origin state.

Description of the Study Area

The study area was within an existing oil facility Right Of Way (ROW) with clay silt as its soil lithology formation. It is an area that houses series of oil and gas facilities such well head, Manifold, flow stations and pipeline of various sizes traversing the area mostly within the multinational acquired area known as the Right of Way (ROW). The study area particularly is located in a community known Omkpobu in Ikwere LGA of Rivers state in Nigeria
(Fig. 1).

III. RESULTS AND DISCUSSION

Upon the completion of remediation of impacted soil in the research, there were massive reduction in the Total Petroleum Hydrocarbon (TPH) in the soil. This was due to the ability of the process to have increased the microbial growth through the process aeration.

The Table 3 shows the result of the laboratory analysis of impacted soil from the research area after undergoing remediation processes. At 0.5 meter the Total Petroleum Hydrocarbon is at 49.8 mg/kg. This shows TPH level that is which accept range as it regards the regulatory intervention value of 5,000 mg/kg. At the depth of 1 meter with coordinate N 4.9561111 E 6.80625 the Total Petroleum Hydrocarbon stands at 40.18 mg/kg based on the laboratory analysis. The result shows the TPH level 1m is within acceptable regulatory intervention value of 5,000 mg/kg.

Similarly, the intervention value of 1.5 meters depth based on laboratory analysis stands at 62.84 mg/kg. This result also shows that the Total Petroleum Hydrocarbon is within the regulatory intervention of 5,000 mg/kg.

The Table 2 shows the result of the laboratory analysis of impacted soil from the research area after undergoing remediation processes. At 2 meters depth the Total Petroleum Hydrocarbon is 33.14 mg/kg. This shows that Total Petroleum Hydrocarbon as it relates to this depth is way far below the regulatory intervention level of 5,000 mg/kg. At the depth of 2.5 meters similarly the Total Petroleum Hydrocarbon is way far below regulatory intervention after the remediation process. Based on the laboratory analysis the Total Petroleum Hydrocarbon stands at 30.52 mg/kg.

Also, the case of the depth of 3 meters after remediation not different from the depth analysed above as it relates to being way far from the regulatory intervention level. The Total Petroleum Hydrocarbon of this depth is at 56.69 m/kg based on the laboratory analysis after the impacted soil was remediated.

The Table 3 shows the result of the laboratory analysis of impacted soil from the research area after undergoing remediation processes. The impacted soil from 4 meters depth used to be the dept with highest Total Petroleum Hydrocarbon value. Its value previously before remediation processes was at 9, 250 mg/kg which way above the in the intervention level of 5,000 mg/kg regulatory intervention. This value drastically reduced after undergoing remediation. Sample analysed from this depth was taken from its treatment location area point one (1) and two (2). The Total Petroleum Hydrocarbon of the treatment area point one based on laboratory analysis is 2,187 mg/kg and that of treatment area two at 2,307 mg/kg. The results show reduction of the Total Petroleum Hydrocarbon below the regulatory intervention level of 5,000 mg/kg and what it used to be prior to remediation.

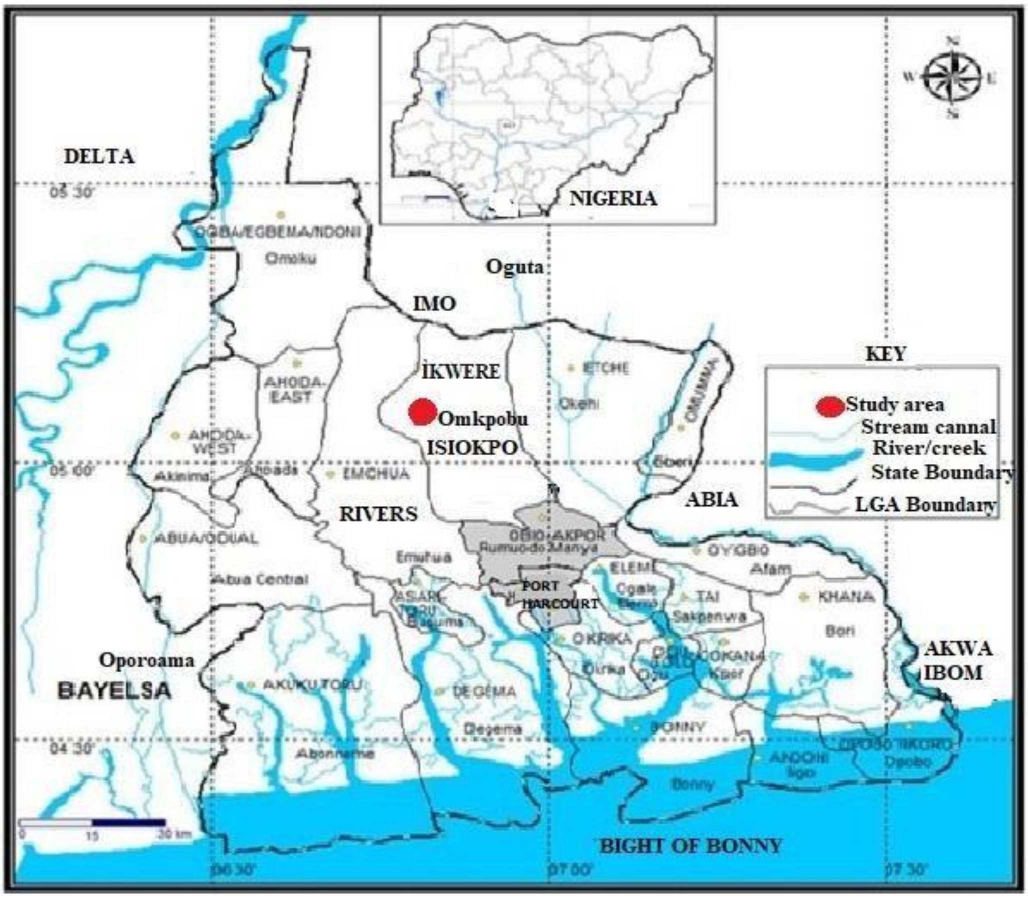

Fig. 1. Map of study area showing Omkpobu

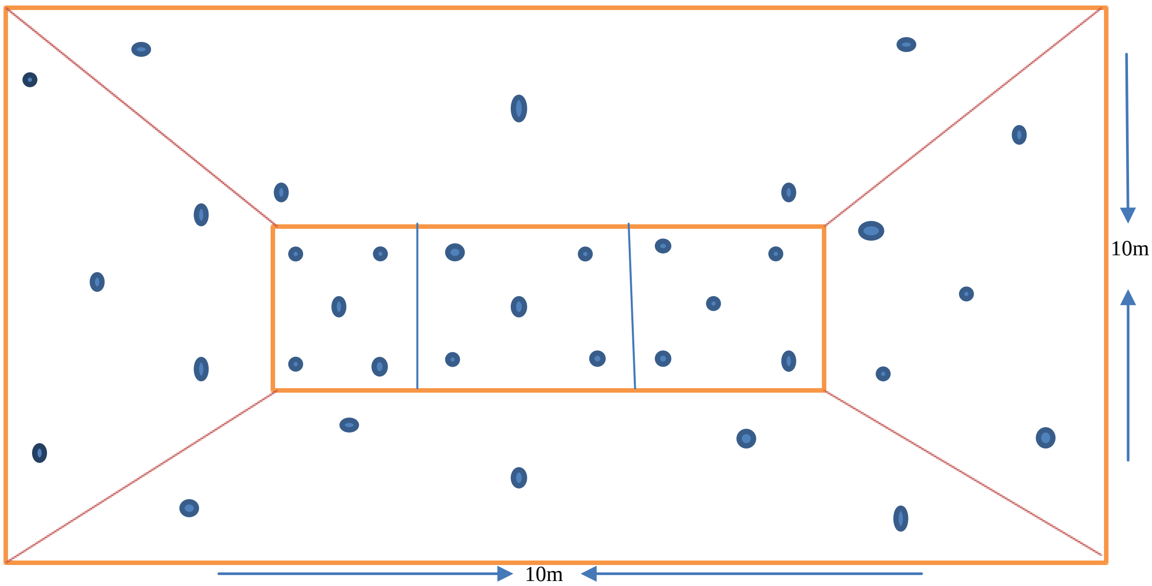

Fig. 2. Excavation wall and base composite sampling spread

Table 1. Results of total petroleum hydrocarbon of remediated impacted soil from 0.5 meter to 1.5 meters

Field ID	Test Method	HA14	HA14	HA14	DPR Target value	DPR interventio
Depth (m)		0.5 m	1.0 m	1.5 m		
Unique laboratory number	USEPA 8015	2019/4328	2019/4329	2019/4330		

TPH (mg/kg)	49.80	40.18	62.84	50 mg/kg	5000 mg/kg
Anayte	TPH	TPH	TPH		
Surrogate (mg/kg)	0-Terphenyl	0-Terphenyl	0-Terphenyl		
Expected concentration	5.00	5.00	5.00		
Obtained concentration	4.93	4.63	4.08		
% Rec	99.00	93.00	82.00		
Control limit	70-130	70-130	70-130		

Table 2. Results of Total Petroleum Hydrocarbon of remediated impacted soil from 2 meters to 3 meters

Field ID	**Test Method**	**HA14**	**HA14**	**HA14**	**DPR Target value**	**DPR intervention value**
Depth (m)		**2 m**	**2.5 m**	**3 m**		
Unique laboratory number	USEPA 8015	2021/4331	2019/4332	2019/4333		
TPH (mg/kg)		33.14	30.52	56.69	50 mg/kg	5000 mg/kg
Anayte		TPH	TPH	TPH		
Surrogate (mg/kg)		0-Terphenyl	0-Terphenyl	0-Terphenyl		
Expected concentration		5.00	5.00	5.00		
Obtained concentration		4.73	4.01	4.54		
% Rec		95.00	80.00	91.00		
Control Limit		70-130	70-130	70-130		

Table 3. Results of Total Petroleum Hydrocarbon of remediated impacted soil from 4m (Treatment area point 1 and 2)

Field ID	**Test Method**	**Ha 14 Treatment bed 1**		**HA14 treatment bed 2 DPR intervention value**	**DPR Target value**
Depth (m)	**USEPA 8015**	**0.3 m**	**0.3 m**		
Unique laboratory number		2021/4334	2019/4335		
TPH (mg/kg)		2187	2307	50 mg/kg	5000 mg/kg
Anayte		TPH	TPH		
Surrogate (mg/kg)		0-Terphenyl	0-Terphenyl		
Expected concentration		5.00	5.00		
Obtained concentration		4.91	98.00		
% Rec		98.00	84.00		
Control limit		70-130	70-130		

IV. CONCLUSION

The effectiveness of landfarming as a remediation strategy cannot be over emphasized. This was proven with the research and laboratory analysis of samples collected over the research duration. Data analyzed in the result discussion section shows a massive improvement in the reduction Total Petroleum Hydrocarbon from the soil. Furthermore, Landfarming proves to be cost effective and time saving in terms of addressing hydrocarbon-polluted environment. Exsitu method save or reduce time line. Every contaminated area has its hotspots is defined by the degree of contamination.

The hotspots area is important to be addressed using exsitu method as such land farming as it is in the case of this research was used. Land farming in the cause of this research is cost effective as it involves the process of excavating hotspots, spread into thin layer and windrowing for adequate aeration. The research however, found out that exsitu.

The exsitu method, land farming as used in this research specifically displayed a significant way or means upon which Total Petroleum Hydrocarbon (TPH) can be reduced on soil. The principle is simple the contaminated soil was land farmed within a large area at a very slim thickness to quicken the healing process. The land farmed soil were frequently tilled, and homogenized for effective and adequate aeration. Subsequently, the land farmed soil was windrowed still with the objective to quicken the aeration process. The continuous tilling, windrowing of the soil led to a significant reduction in Total petroleum hydrocarbon on the soil over time. From an initial assessment value of 9,250kg/mg, they was massive reduction to 2,307 mg/kg for the duration of 12 weeks.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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