STM JOURNALS

International Journal of
Pollution: Prevention & Control

Volume 1, Issue 2, 2023DOI (Journal):10.37591/IJPPC (July-December)

https://journals.stmjournals.com/ijppc

Research IJPPC

The Influence of Fresh Raffia Palm Trunk on the Bioremediation of Oil-based Drill Cuttings

Bright Nweke[1,*], Achinike Okogbule Wonodi[2], Ikenna. M. Chikwue[3]

Abstract

This study determines the effect of fresh raffia palm for biodegradation of oil-based drill cuttings bioremediation. The experiment was conducted at the rivers institute of Agricultural research and training (RIART) located at the Rivers State University, Port Harcourt. Samples of oil-based drill cuttings were bulked in eleven reactors with four replications (T1, T2, T3-T11). The physiochemical properties of the initial drill cuttings were analyzed. Also, the physiochemical properties of the oil-based drill cuttings of fresh raffia palm such as. Total Petroleum Hydrocarbon, Benzene Toluene Ethylene Xylene, Total Polycyclic Aromatic Hydrocarbon were analyzed in the laboratory before and after treatments. Total Petroleum Hydrocarbon, Benzene Toluene Ethylene Xylene and Polycyclic Aromatic Hydrocarbon reduction were drastic in all treatment options at the end of 16weeks of remediation. Total Petroleum Hydrocarbon, Polycyclic Aromatic Hydrocarbon and Benzene Toluene Ethylene Xylene rate of percentage reduction assortments from 84 to 91% in all the treatment options for the period of 16weeks. Results also displayed a high coefficient of determination of (R^2) between the range of 0.9809 to 0.9953 in all the treatment option. The results as obtained using the Analysis of Variance (ANOVA) showed a significant difference at 95% and highly significant at 99% confidence level. Similarly, the coefficient of variation of every low percentage were revealed for the treatment option respectively. This confirmed that the experimental Root Mean Square Error (RMSE) was very low, Residual Prediction Deviation (RPD) are considered excellent, thereby it is acceptable and reliable.

Keywords: Biodegradation, Bioremediation, Fresh Raffia Palm and Oil-Based Drill Cutting, Polycyclic Aromatic

INTRODUCTION

Several oil and gas exploration and development projects are underway in Nigeria. Oil and gas operation involves the practice of dumping wasted drilling mud and cuttings into swamps which censored across and offers a potential health concern to local animals [1]. Oil exploitation and exploration, on the other hand, has increased the quality of life while simultaneously posing a variety of environmental problems and health risks. Toxic substances connected with the activities are released into the environment, where they penetrate biological systems, disrupt biochemical processes, and cause normal organism functions to be disrupted [2].

Drilling mud cum fluid is a lubricant that is used in oil and gas drilling operations to cool and lubricate the drill bit throughout the drilling process. They are solid-in-liquid emulsions and dissolved materials with chemical additives that are used to

***Author for Correspondence**
Bright Nweke
E-mail: guru4real1@yahoo.com

[1,2]Ph.D Scholar Department of Agricultural and Environmental Engineering, Rivers State University of Science and Technology, Nkpolu, PMB 5080, Port Harcourt, Nigeria
[3]Professor, Department of Agricultural and Biosystems Engineering, Federal University of Technology, Owerri, Nigeria

Received Date: July 28, 2023
Accepted Date: August 10, 2023
Published Date: January 09, 2024

Citation: Bright Nweke, Achinike Okogbule Wonodi, Ikenna. M. Chikwue. The Influence of Fresh Raffia Palm Trunk on the Bioremediation of Oil-based Drill Cuttings. International Journal of Pollution: Prevention and Control. 2023; 1(2): 41–48p

remove cuttings during exploration. The impact of drilling mud discharges on the Nigerian Niger Delta ecosystem is a current environmental concern, particularly considering the components used in the formulation of these drilling muds and the disappearance of the Niger Delta's rich biodiversity, which is a key resource for sustainable development [3]. According to studies, drilling mud additives might contain harmful compounds such as chromate, biocides, organic polymers, hydrocarbons, heavy metals, and trace elements, which have a potential to bio-accumulate and interfere with normal biological functions of creatures like humans [4]. Drilling fluids contain a variety of different components that can have an environmental impact. Many disposal requirements are based on the concentrations of these compounds combined with the total petroleum hydrocarbon concentration.

Several alternatives for treating oil-based drill cuttings before disposal are needed in a related development, including oil-based drill cuttings extraction or washing, re-injection, stabilization/solidification, bioremediation, thermal desorption, and landfarming, also known as land spreading, is a bioremediation technique in which oily drill cuttings are scattered on land, where evaporation and the natural flora and fauna of the soil work together to diminish and degrade the waste's oil content [5]. The oils with more complex polycyclic aromatic hydrocarbons can be difficult to decompose biologically, and they may linger in the environment, particularly in soil.

This is because the magnetism of the drilling mud and additives used during drilling heavily influence the chemical composition of the resulting oil-based drill cutting. The combination of particulates and pieces of rock released during geologic establishments in the drill hole made during crude-oil drilling operations is another definition of drill cutting. [6, 16] also claimed that these substances are hazardous to the environment because they are carcinogenic or mutagenic. Government regulatory agencies in crude-oil producing countries banned the use of oil-based drill-cuttings (OBDC) due to concerns about their negative environmental effects. While the drill cuttings may be beneficial to the soil, with the clays and lime adding structure and reducing acidity, mud systems containing calcium chloride and other soluble non-biodegradable salts can also contribute to the environment's electrical conductivity, with the possibility of groundwater contamination [7]. Oil-based drill cuttings are muddily consistency materials with high contents of salts and hydrocarbons, which come from drilling fluid additives and the reservoir geological formation, according to [8]. Furthermore, according to [16], proper management of drilling cuttings is of the utmost concern for oil companies and environmental protection authorities, because the toxicity and high rate of generation of this waste make it difficult to achieve effective treatment solutions at reasonable costs. The influence of fresh raffia palm trunk on the bioremediation of oil-based drill cuttings strategies relies on organic wastes or bio-stimulants from raffia palm, particularly fresh and compost tea application to bio-contaminate the contaminants with the goal of promoting bioactivity as a result of creating microorganisms that will be responsible. The application of organic wastes from fresh raffia palm provides a diverse range of microorganisms and easily available nutrients that improve the structure and water retention capacity of the material being treated. Furthermore, as stated in [6, 9], this low-cost technique enables the processing of huge volumes of wastes, will be an added advantage of simultaneous treatment of many waste streams.

For example, governing elements determining the effectiveness of African palm substrate (nutrients content, PH, oxygen, and water availability) are dependent on the amount and type of organic wastes applied. High carbon concentrations in heavy oil-based drill cuttings bioremediation with African palm materials can result in a C/N ratio imbalance as a result of nitrogen deficit, affecting microbial activity. That is to say, the amount of nitrogen provided by organic wastes is quite important. However, as mentioned in [9, 10], if substantial amounts of organic wastes are sprayed, this carbon source may be preferentially decomposed over the target chemicals, delaying hydrocarbon biodegradation in the bioremediation of oil-based drill cuttings techniques, compost tea given by organic wastes serves as a benefit for the substrate. The contaminant's adsorption/desorption processes, on the other hand, are influenced not only by the contaminant's volatility, water solubility, and affinity for organic matter, but also by the matrix's porosity and composition.

These factors, which are highly dependent on the influence of fresh raffia palm trunk on the bioremediation of oil-based drill cuttings are therefore the type and number of organic wastes applied, which will regulate contaminants bioavailability and biodegradability of which [11–13] reported in their study that Oil-based drilling cuttings are biologically impoverished and cohesive oil-rich silt. The influence of freshness raffia palm trunk in the bioremediation of oil-based drill cuttings has not been thoroughly documented in scholarly literature. The overall goal of this study is to figure out how much TPH, PAH, and BTEX have been reduced in contaminated material. However, this study considered fresh raffia palm trunk as potential nutrients for bioremediation [14–17].

MATERIALS AND METHODS

Study Area Description

The experiment was conducted at the Rivers Institute of Agricultural Research and Training (RIART), Rivers State University, Port Harcourt, Nigeria. The oil-based drill cuttings was obtained from the Boskel Nigeria Limited, in Rivers State, Niger Delta region of Nigeria. The experiment was carried out from 21st of August 2020 to 21st of December 2020. The climatic condition is that of a humid tropical climate with an average rainfall of about 2100 mm of which 70% of rain falls between April and September. The randomized complete block design (RCBD) was used in this study. The experimental bio-reactor contain 20 liters. Four liters were marked each provided for different treatment options. The vegetative cover is the tropical rain forest with longitude and latitude of (5°19'N, 6°28'E).

Source of Bio-stimulant Used

The fresh raffia palm as amended material used contain in treatment 2 (rector 2). Fresh Raffia palm was collected from Fresh Raffia palm trunk located at Okoroagu in Etche Local Government Area. There were Eleven treatment options (consisting of ten treatment involving fresh *raffia* palm and compost tea from raffia palm all were used as treatment materials while the control was left uncontaminated with four replications. Compost tea which serves as tea for irrigation that enhanced tilling for aeration. All these bio-stimulants or derivatives were tested and filled in 20 Liters of bucket at very low thermal conductivities containing fixed masses of the oil-based drill cuttings according to their fixed ratios. The content was mixed thoroughly to get a composite mixture thereafter they were safeguard and kept at room temperature except for control. Samples were taken every 4weeks and analyzed for reduction in total petroleum hydrocarbon (TPH) in the ratio of 2:1

Statistical Analysis

The single factor experimental analysis of variance (ANOVA) was used to perform on the various replications of the experimental cells in order to determine the percentage reduction of TPH, PAH and BTEX. This was done based on the F-test. Differences were considered significant if $C_{omputed} > F_{tabulate}$ at 5% and 1% significance levels. The experiment was carried out using the Randomized Complete Block Design (RCBD).

Percentage Reduction

$$\text{Initial concentration} - \text{Final concentration} \,/\, \text{Initial concentration} \times 100/1$$

RESULTS AND DISCUSSIONS

The physicochemical properties of fresh raffia palm trunk on the bioremediation of oil-based drill cutting detailed in Table 1.

Table 1. Result of Fresh Raffia palm trunk on oil-based drill cuttings bioremediation.

Period	TPH	PAH	BTEX
(weeks)	*(Mg/kg)*	*(Mg/kg)*	*(Mg/kg)*
0	15967.9	128.07	1
4	8645.64	73.71	0.63
8	6265.99	42.93	0.35
12	4315.94	34.98	0.26
16	2672.82	20.61	0.16

RESULT DISCUSSION

Total Petroleum Hydrocarbon (TPH)

The fresh raffia palm trunk effect on the TPH concentration in oil-based drill cuttings bioremediation as shown in Table 1. Also, Figure 1, display the TPH concentration against time (weeks) on oil-based based drill cuttings bioremediation. The result shows that the concentrations of TPH reduced with increase in the number of weeks. Between the 0 to 16 weeks of the degradation, there are 0, 45.86, 60.76, 72.97 and 83.26 percentage reduction on TPH concentration with average of 7573.66mg/kg of TPH respectively. Table 2 shows the reductions in percentage in respect to TPH as a result of addition of fresh and microorganisms' augmentation as shown in Figure 1. The reductions in percentage were as a result of addition of fresh raffia palm trunk into the oil-based drill cuttings bioremediation which possesses very high gratified of Phosphorus as shown in Table 2. This agrees with the findings of [16] that the addition of oil palm ash in diesel leads to the abundant of phosphorus that aids to the degradation of TPH in this study as well as the work of [17] which typified the ability of microorganisms in oil-based drill cuttings contaminated environment (soil) that enhances degradation. Figure 1 illustrates the relationship between the concentration of TPH and remediation period (0, 4, 8, 12 and 16 weeks as stated below).

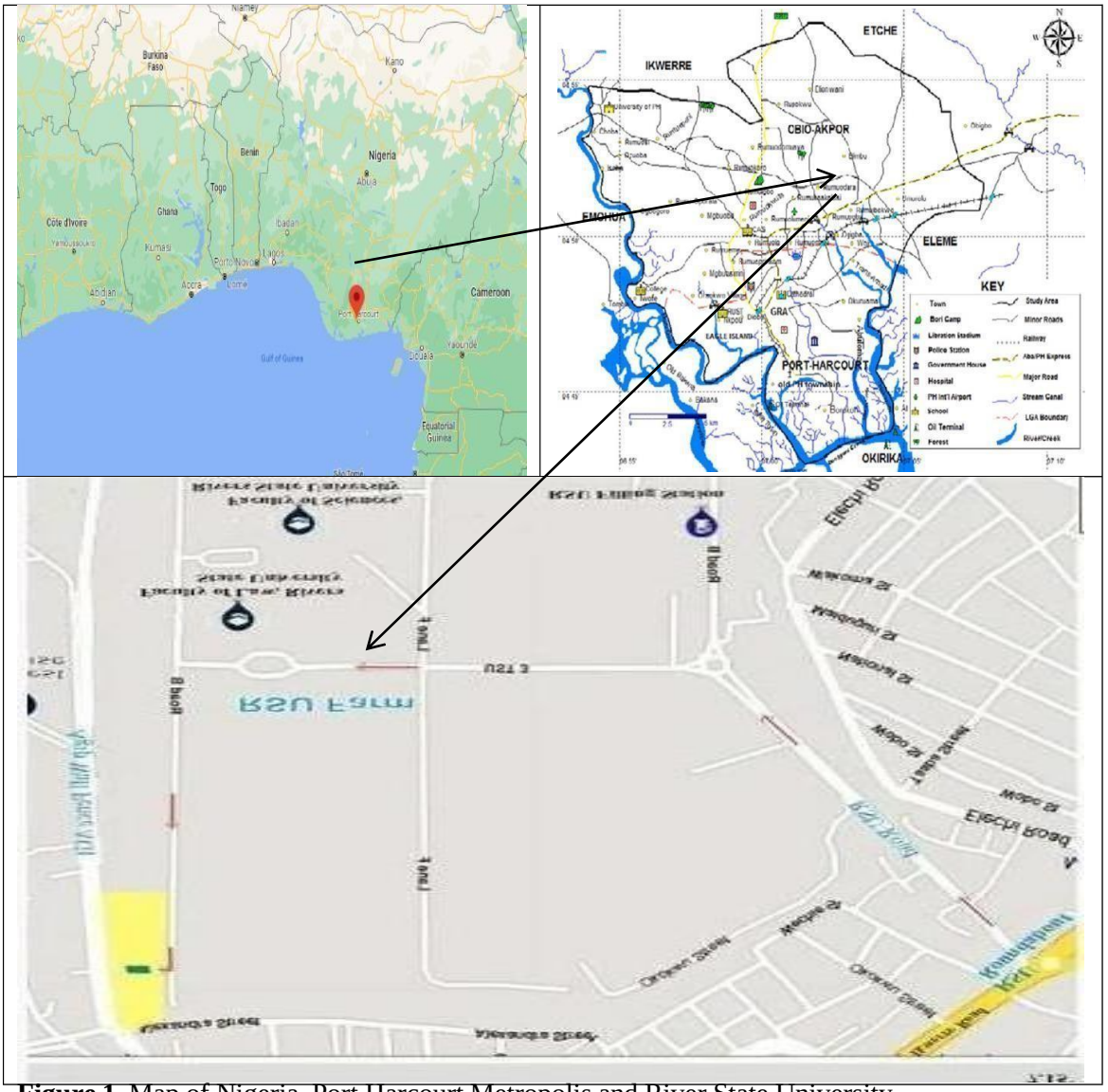

Figure 1. Map of Nigeria, Port Harcourt Metropolis and River State University.
Source: Goggle Map, 2021

Table 2. Showing % reduction in TPH, PAH and BTEX on fresh raffia palm.

Parameters (mg/kg)	Period (Weeks)				
	0	***4***	***8***	***12***	***16***
TPH	0	44.86	58.96	71.78	82.76
PAH	0	40.94	65.81	68.85	82.76
BTEX	0	56	62	72	84

The coefficient of determination, R^2 is 0.9809 at the 16 weeks of remediation used. The ANOVA result for the effect of fresh on the TPH concentration is made known and it is apparent that there were significances differences in the treatment means 5% level at 1% significance levels. This suggests that with 99% confidence, the difference in treatments means was due to the fresh applied.

Polycyclic Aromatic Hydrocarbon

Table 1 and Figure 2 displays the polycyclic aromatic hydrocarbon (TPAH) chemical concentration bioreactor containing treatment T_2. Before the treatment commenced at the initial stage of remediation, there was an increase in the level of TPAH. Then the results display in Table 2 specifies that the concentrations of TPAH in the oil-based drill cuttings bioremediation decreased as the fresh of raffia palm trunk was introduced, addition of compost tea which serves as source of irrigation swing into action and pulverized the oil-based drill cuttings as quick as possible. This is because, Figure 2 illustrates the affiliation between the concentration of TPAH and the bioremediation period (0, 4, 8, 12 and 16 weeks in that order). This rapport is displayed by exponential regression equation as:

$$Y = 118.91e^{-0.11x} \quad (1)$$

Similarly, the coefficient of determination, $R^2 = 0.9854$ at the 16 weeks of bioremediation of which this study used. The result of the ANOVA for the effect of fresh on the concentrations of TPAH is shown and it is apparent that there were significant differences in the treatment means 5% level at 1% significance levels. This suggests that with 99% confidence, the difference in treatments means was due to the fresh applied.

Figure 2. Pictures showing the fresh palm wine extracted from fresh raffia palm trunk.

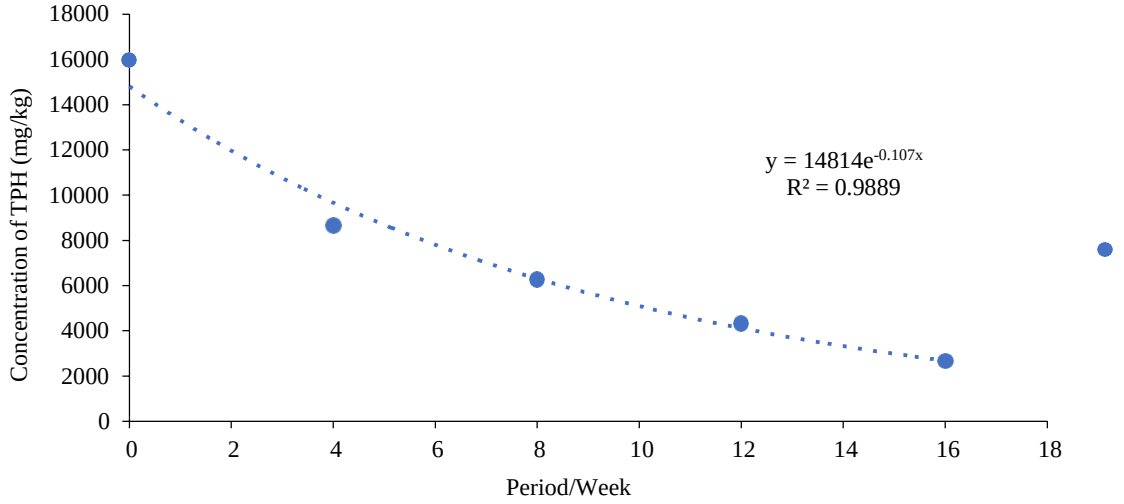

Figure 3. Display the effect of fresh raffia palm on TPH bioremediation.

The TPAH percentage reductions of 0, 40.94, 65.81, 68.85and 82.76% for weeks 0, 4, 8, 12 and 16 as indicated in Table 2. The decrease in the result of the TPAH in the oil-based drill cuttings after 16 weeks of bioremediation could be as a result of the prevalence of high phosphorus content of fresh raffia palm trunk and prompt to an increase in the degradation rate of TPAH in the oil-based drill cuttings [13].

PAH Bioremediation

Benzene Toluene ethylbenzene Xylene

Benzene Toluene ethylbenzene and xylene also known as BTEX refer to volatile organic compound which occur naturally in sea water, crude oil, petroleum deposit and forest fire resulting from volcanic eruption of gas emission as it readily evaporates when warm or hot in climatic region leading to very higher concentrations especially in the vapour phase. The effect of fresh raffia palm trunk on Benzene Toluene Ethylbenzene and Xylene is displayed in Table 1 and Figure 3. In a nutshell, the rapport between the concentration of BTEX and the bioremediation period is shown in Figure 3 (0, 4, 8, 12 and 16) weeks. The exponential regression equation typified the relationship, and it is stated as: Figure 4.

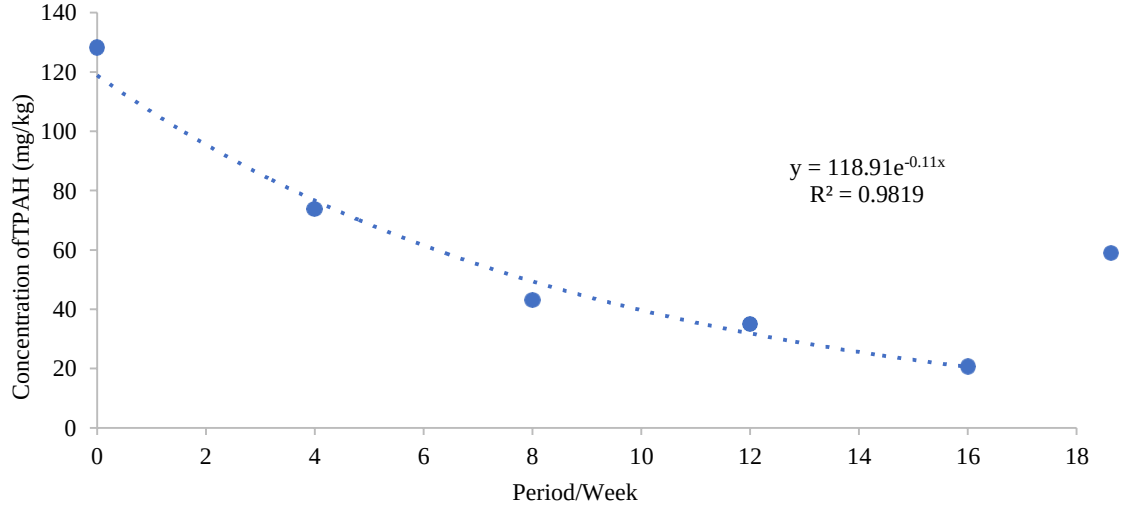

Figure 4. Display the effect of fresh raffia palm on.

$$Y = 0.9721e^{-0.114x} \quad (2)$$

With coefficient of determination, R^2 = 0.9953 at the 16 weeks of remediation used in this study. The result of the ANOVA for the fresh effect on the concentration of BTEX is shown and it is apparent that there were significant differences in the treatment means 5% level at 1% significance levels. This suggests that with 99% confidence, the difference in treatments means was due to the fresh applied. The concentration of BTEX reduction ranges from 1.00, 0.63, 0.35, 0.26, and 0.16 for weeks 0, 4, 8, 12 and 16 in that order throughout the period of bioremediation. The percentage reduction for BTEX were 0, 56, 62, 72 and 84% for 0, 4, 8, 12 and 16 weeks (Table 2). An enquiry into Figure 3 displayed that the concentrations of BTEX reduced with increase in the number of weeks and high content of fresh respectively.Figure 5

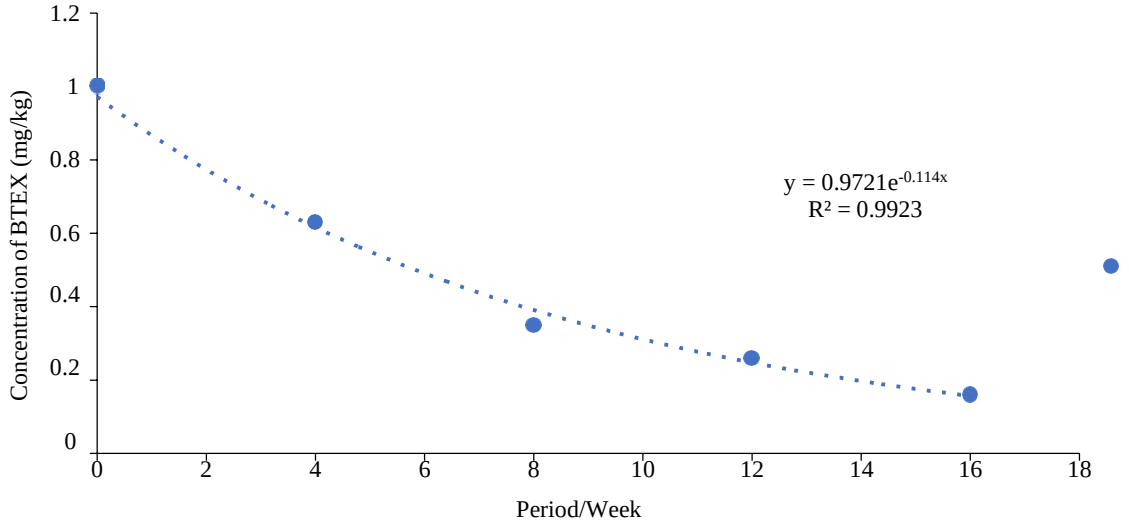

Figure 5. Display the effect of fresh raffia palm on BTEX Bioremediation.

CONCLUSION

The effectiveness of fresh raffia palm for the bioremediation of oil-based drill cuttings was examined experimentally. The result of the test Analysis agrees with the conclusions that, Fresh raffia palm influenced the biodegradation of the parameters chosen (TPH, PAH, BTEX) in the oil-based drill cuttings bioremediation. This is because of its high nutrient composition (NPK). This fresh raffia palm degraded TPH, PAH, and BTEX up to 83, 83, and 84 %, and a coefficient of determination (r^2) ranges from 0.9809 to 0.9953, respectively. Hence, it is recommended that fresh raffia palm could be used for crude oil polluted oil-based drill cuttings remediation.

REFERENCES

1. Amajuoyi.C. A. & Wemedo. S.A.(2015). Effect of Oil Palm Bunch Ash (Elaeis Guineensis) on the Bioremediation of Diesel Polluted Soil. *American Journal of Microbiology and Biotechnology*. *2, 6–14*
2. Ali-Akbar B., Farhad. S. Nadali. A., Reza. B., Hossein. M. & Pooya P. (2019). Co-composting of Oil-Based Drilling Cuttings by Bagasse. Bioprocess and Biosystems Engineering. *102 (2): 599–606*
3. Anna, S., Danuta, W., & Urzula, G. (*2016*). Natura Carrier in Bioremediation: A Review. *Electronic Journal of Biotechnology*, *23*, 28 – 36
4. Ayotamuno, M. J., Kogbara, R. B., & Agumwamba, J. C. (2006). Bioremediation of a petroleum Hydrocarbon polluted Agricultural Soil at various levels of soil tillage. *Nigerian* Journal of Technology. 25,44–51.

5. Bright, F. E., Ruhuoma, W. K., Chinedu, A., Buari, T. A., Ademola, S. A, & Ayegbokiki; S. T. (2017). Characteristic Strength of Groundnut Shell Ash (GSA) and Ordinary Portland Cement (OPC) Blended Concrete in Nigeria. *Journal of Engineering. 3(7), 01–07.*
6. Chen, Z., & Bowman, M., (2015), Monitored Natural Attenuation (MNA) as a Cost-Effective Sustainable Remediation Technology for Petroleum Hydrocarbon Contaminated Sites: Demonstration of Scientific Evidence, 19th World Congress of Soil Science, *Soil Solution for a Changing World, 38–39.*
7. Christopher, U. A., Jude, C. I & Anthony I. O. (2017). Studies on the Removal of Petroleum Hydrocarbons (Phcs) from a Crude Oil Impacted Soil Amended with Cow Dung, Poultry Manure and NPK Fertilizer. *Chemistry Research Journal, 2017, 2(4):22–30. ISSN: 2455–8990.*
8. David; M. B; Matthiys, B.; Richard, G; James, D; & Peter, J. B. (2017). Heavy Hydrocarbon Fate and Transport in the Environment. *Journal of Engineering Geology and Hydrology.; 50, 333 – 346*
9. El-Liethy M. A. · M. M. El-Noubi · A. L. K. Abia · M. G. El-Malky · A. I. Hashem · G. E. El-Taweel. (2021). Eco-friendly bioremediation approach for crude oil-polluted soils using a novel and biostimulated *Enterobacter hormaechei* ODB H32 strain. International Journal of Environmental Science and Technology.
10. Emeka. C, Bright. N & Achinike. O. W., (2021). Maize Growth Response on Soil Enhanced with SMS Under Different Irrigation Interval. International Journal of Academic Engineering Research (IJAER) ISSN: 2643–9085. 5 (9): 16–23.
11. Emmanuel. E. I & Nosa.O. O. (2019). Environmental Evaluation and Biodegradability of Drilling Waste: A Case Study of Drill Cuttings from Ologbo Oilfield Wells at Edo State, Nigeria.
12. Kadafa. A. A (2012). Environmental Impacts of Oil Exploration and Exploitation in the Niger Delta of Nigeria. Global Journal of Science Frontier Research Environment & Earth Sciences Volume 12 Issue 3 Version 1.0
13. Latifa, H., Safia, H., Khaled, B., Nouri, H. L., Leila, B. & Mohammed, K. (2018). *Environments, 5*,124 – *133*
14. Njoku, K.L, Yussuf, A., Akinola, M.O., Adesuyi, A.A., Jolaoso, A.O & Adedokun, A.H. (2016). Mycoremediation of Petroleum Hydrocarbon Polluted Soil Pleurotus Plumonarius. *Ethiopian Journal of Environmental Studies & Management 9(Suppl. 1): 865 – 875,.ISSN:1998–0507.*
15. Onakughotor, E. D., & Agule, P. O. (2014). Impact of the Age of Particulates on the Bioremediation of Crude Oil Polluted Soil. *Journal of Applied Chemistry. 7*(11), 24 –33
16. Okparanma.R. N, Ayotamuno M. J. & Araka.P.P (2010).Polycyclic Aromatic Hydrocarbons in Nigeria Oil Based Drill-Cuttings; Evidence of Petrogenic and Pyrogenic Effects. *World Applied Sciences Journal 11(4), 394–400.*
17. Yelebe. Z.R., Samuel. R. J & Yelebe. B.Z (2015). Kinetic model development for bioremediation of petroleum contaminated soil using palm bunch and wood ash.
(a) International Journal of Engineering Science Invention ISSN (Online): 2319 – 6734, ISSN, Volume 4 Issue 5, PP.40–47.

