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Potential of Chicken Dropping and Empty Oil Palm Fruit Bunch as Amendment for Bioremediation of Diesel-Contaminated Soil at Effurun, Delta State, Nigeria

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ABSTRACT: Diesel pollution in soil poses significant environmental and health risks. Therefore, the objective of this paper was to investigate the potential of chicken dropping (CD) and empty oil palm fruit bunch (EPFB) as an amendment for bioremediation of diesel-contaminated soil at Effurun, Delta State, Nigeria using standard methods. Results obtained for physicochemical parameters show that: pH (9.6) for chicken dropping,(10.24) for empty oil palm fruit bunch and (9.3) for uncontaminated soil); electrical conductivity (CD-6910mS/m, EPFB-3710mS/m and for uncontaminated soil (US)-98mS/m; Phosphorous (CD-35.033mg/Kg, EPFB-Nil, US-23.037) sulphate (CD-50,699mg/Kg, EPFB-Nil, US-9.469) nitrate(CD-2.973 and EPFB-0.477-0.117mg/Kg5, and US-0.477mg/Kg) PALs and TPH (CD-.CD-2.973mg/Kg and 12.644mg/Kg, EPFB-Nil, US- <0.001mg/Kg and <0.001m/Kg), THB and HUB (CD-3.9 x 105 CFU/g and 7.5 x 105 CFU/g, EPFB- 2.25 x 105 CFU/g and Nil, US- 2.65 x 105 CFU/g and 3.0 x 105 CFU/g). Remediation data reveals a significant difference between the amendments (treatments), it was observed that the chicken droppers better remediates diesel-contaminated soils. However, environmental agencies and oil industries should consider using chicken dropping and empty oil palm fruit bunch which are agricultural waste products for the bioremediation of diesel or hydrocarbon-polluted soils.

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Diesel contamination can lead to soil degradation, groundwater pollution, and ecosystem disruption, Bioremediation offers a sustainable solution, leveraging microorganisms to break down pollutants. Petroleum products are the main sources of energy for daily life and industries (Yahemba *et al.,* 2022) . The increasing global demand and consumption of this product have led to an increase in accidental spills of petroleum hydrocarbons, causing serious environmental degradation. The environment is polluted by these products, which leak or leak during exploration, production, processing, transportation, and road accidents along highways and storage. Human health, marine organisms and Land and agricultural lands are affected by pollution, which poses a global threat to the ecosystem (Okoye *et al.,* 2024). Among petroleum products, oil is a complex combination of alkanes and odorous compounds that can often be cited as soil pollutants. Diesel oil is produced by the fractional distillation of crude oil

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between 200°C and 350°C at atmospheric pressure, producing a mixture of carbon chains that typically contain between 8 and 21 carbon atoms per molecule (Yahemba *et al.,* 2022) . Diesel fuel is generally more toxic than long-chain hydrocarbons because it contains low molecular weight compounds and a high percentage of saturated hydrocarbons. Oil pollution is increasing in Nigeria and other developing countries. The increased use of diesel oil in automobile engines, industrial trucks, and generators has increased consumption, which invariably results in oil contamination of land and water bodies when these generators are serviced and the oil is released into the environment. This often results in distortions of the physical, biological, and chemical properties of the soil (Onaiwu and Ilaboya 2021)

Soil is the main element of the natural ecosystem, a medium of nutrients and unconsolidated materials and environmental sustainability. It forms the layer of plant life. Soil has developed as a result of pedogenic processes through the erosion of rocks. It is made up of inorganic and organic components with defined chemical, physical, mineralogical, and biological properties (bacteria, fungi, archaea, protozoa, etc.) . It ranges from the depth to the surface of the soil and provides an environment for the growth of Thakre plants (Arshi and Khan 2018). Various technologies are used to remediate contaminated environments, such as mechanical, chemical and biological processes. However, mechanical and chemical processes are not cost-effective for the process because secondary pollution can lead to the incomplete decomposition of pollutants, which is dangerous for the ecosystem. Biological methods (bioremediation, biodegradation), on the other hand, are a cost-effective, environmentally friendly and simple approach that uses microorganisms such as bacteria, plants, fungi and microalgae to reduce, detoxify and/or mineralize pollutants into harmless compounds (water, carbon dioxide and oxygen), which are then converted into energy and biomass during the process (Bekele *et al.,* 2022).

Environmental pollution attracts regulatory attention to pollution control in the oil and gas industry regulated by the main legislation of the Petroleum Act of 1967. Regulatory agencies such as the Federal Ministry of Environment (FMENV) and the Department of Petroleum Resources (DPR) here in Nigeria require operators to treat and control the discharge of these effluents to ensure that the environment is friendly to humans and other living beings on earth (Onwuka *et al*., 2019) . Yahemba *et al*. (2022) studied samples amended with chicken droppings with higher bacterial growth than the control sample; the oil-utilizing bacteria identified in this study belonged to the genera Bacillus, Acinetobacter, Pseudomonas, Micrococcus and Staphylococcus. Makut and Majekodunmi. (2019), research on the bioremediation potential of chicken waste in crude oil-contaminated soils from automobile workshops, the results revealed that there was a rapid and gradual reduction of total petroleum hydrocarbons during remediation in all the impacted soils with 30% poultry excrement compared to that of untreated soil. Amajuoyi and Wemedo (2015) found that there was a significant difference between control and diesel oil-contaminated soils treated with different weights of OPBA (oil palm bunch ash) for heterotrophic bacteria and fungi and using oil. According to Gbosidom and Teme (2015), material increases organic carbon and soil organic matter over time. Total soil nitrogen was generally deficient in the soil. However, an improvement was seen at the end of the experiment. Soil available phosphorus increased with the levels of amendment and then depleted in the soil over time.

At the end of the experiment, there was a soil improvement in available phosphorus. The bioremediation of diesel oil-polluted soil using Chicken droppings (CD) which is rich in nutrients and microorganisms and Empty oil palm fruit bunch (EPFB, a lignocellulosic waste has been shown to offer a potential alternative measure compared to other conventional biodegradation methods, as it does not involve the use of inorganic chemicals that can have negative effects on plants and detoxifies the pollutants. Instead of transferring them elsewhere. It will be effective in bioremediation of the contaminated area and less costly and environmentally friendly (Onwuka *et al*., 2019). Therefore, the objective of this paper is to investigate the potential of chicken dropping and empty oil palm fruit bunch as an amendment for bioremediation of diesel-contaminated soil at Effurun, Delta State, Nigeria

MATERIALS AND METHODS

Study Area: The study area is located in the Federal University of Petroleum Resources, Effurun (FUPRE), and Delta State, Nigeria. The research site is situated beside the Environmental Management and Toxicology Department School of Science block. The region is characterized by a tropical monsoon climate. The area experiences high temperature and humidity levels throughout the year, with average temperatures ranging from 25 ° C to 32 ° C and an annual rainfall of about 2,500mm. The soil is predominantly sandy loam, with a pH of 5.5 to 6.5 ranges and consists of organic matter and nutrients.

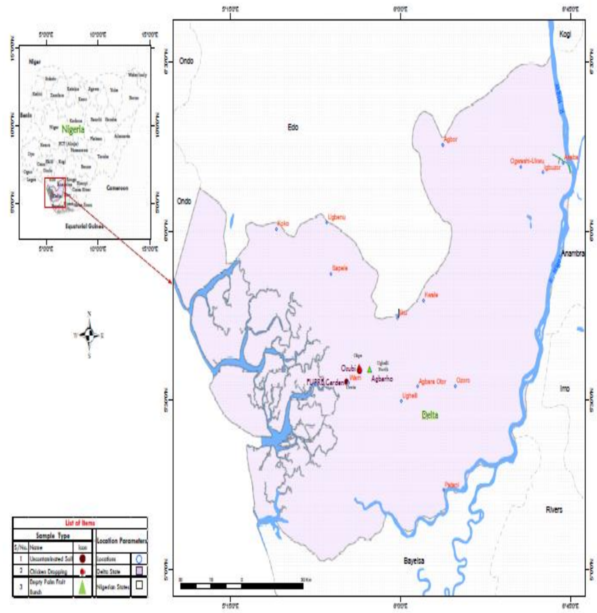

Fig 1: Coordinates Of The Samples

Sample Collection: *Uncontaminated soil sample*: Uncontaminated soil samples were collected from four points with a soil auger from the topsoil (0-15cm) and composited. The composited soil was air-dried at room temperature, sieved with a 2mm sieve, and stored in Ziploc bags at ambient temperature till ready for use.

Refined petroleum products (diesel): Two liters of diesel were purchased locally from the Hullmas filling station located in Osubi, Okpe LGA, Delta State. The diesel was dispensed from the pump and packaged in sterile gallons (Akinyemi et al., 2019).

Chicken droppings were collected from a poultry farm adjacent to the Palace of Praise church, situated along the old Osubi-Eku Road in Osubi. Additionally, Empty Oil Palm Fruit Bunch (EPFB) was collected from the oil mill near Eytan Guest House in Agbarho, both in Delta State, Nigeria. These materials were air-dried for two weeks, after which they were crushed and sieved to remove any impurities. The EPFB was ground and then sieved as well (Onwuka *et al.*, 2019; Amajuoyi and Wemedo, 2015**).**

Experimental Design: The research on bioremediation utilized biostimulation techniques. This was performed in pairs of sterile glass containers or bottles, each holding a 200g sample of untainted soil. The samples were treated with three varying concentrations of diesel (2,500mg/kg, 5,000mg/kg, and 10,000mg/kg) and supplemented with chicken manure (20g) and Empty Palm Oil Fruit Bunch (20g), as referenced by Agarry *et al.* (2018). A control setup, consisting of uncontaminated soil and diesel without any supplements, was also analyzed during this research. The setup for Total Petroleum hydrocarbon (TPH) extraction was observed at four-week intervals for 12 weeks. Both the control setup and each treatment or amendment underwent a series of physicochemical assessments and microbiological counts. These were conducted on the first day and then every four weeks during the bioremediation process, according to Tudararo-Aherobo and Mesogboriwon (2020), Agarry and Latinwo (2015), and Agarry (2018). The moisture levels of all setups were kept at 35% by adding sterile distilled water and were mixed with a hand trowel every three days for aeration. Additionally, they were watered weekly with 2-10 ml of sterile distilled water throughout the study. The 3 different

*Diesel Concentration (1=2,500mg/kg, 2=5,000mg/kg, and 3=10,000mg/kg)
A= Control- US + D (Uncontaminated soil +Diesel) - *Diesel polluted soil
B= *Diesel polluted soil+ Chicken dropping (CD) (20g)
C= *Diesel polluted soil + Empty palm fruit bunch (EPFB) (20g)

Data Analysis: All statistical analyses were conducted with Statistical Package for Social Scientists (SPSS) and Microsoft Excel computer software. Data are presented as mean ± SD. One-way Analysis of variance (ANOVA) was used to determine the effect of chicken dropping and Empty palm fruit bunch (EPFB) on bioremediation of diesel polluted soil. The Significant level for all analyses was set at confident limits of $p < 0.05$.

Percentage total petroleum hydrocarbon (TPH) loss was calculated using the Equation 1;

$$\%\ \text{TPH loss} = \frac{(\text{TPH Initial} - \text{TPH Final})}{\text{TPH Initial}} * 100 \quad (1)$$

RESULTS AND DISCUSSION

Physicochemical Parameters and Microbiological Characteristics of Test Samples: The physicochemical and microbiological value of chicken droppings, processed empty oil palm fruit bunches (EPFB), and uncontaminated soils (US) are presented in Table 1. All test samples exhibited an alkaline pH: 9.6 for chicken droppings (CD), 10.24 for EPFB, and 9.31 for uncontaminated soil, with

EPFB showing the highest pH value, as noted by Amajuoyi and Wemedo (2015). Electrical conductivity (EC) influences nutrient availability, pollutant mobility, microbial activity, soil structure, and the overall process of bioremediation. The chicken droppings had the highest EC value at 6,710 mS/m, followed by EPFB at 3,740 mS/m, while the uncontaminated soil had an EC of 98 mS/m. These results highlight the effectiveness of chicken droppings as an amendment compared to EPFB (Ataikiru *et al.,* 2017). In terms of nutrient content, including nitrates (NO3), phosphates (PO4), and sulfates (SO4²□), chicken droppings were found to be more abundant than either EPFB or uncontaminated soil, as indicated in Table 1. Furthermore, this study revealed the presence of polycyclic aromatic hydrocarbons (PAHs) and total petroleum hydrocarbons (TPH) in chicken droppings, with concentrations of 2,973 mg/kg and 12,644 mg/kg, respectively. In contrast, these compounds were absent in EPFB and negligible in uncontaminated soil (<0.001 mg/kg). The microbiological count of total heterotrophic bacteria (THB) and hydrocarbon-utilizing bacteria (HUB) was highest in chicken droppings, with values of 3.9 x 105CFU/g and 7.5 x 105 CFU/g, respectively. EPFB had only THB at 2.25 x 105 CFU/g. These microbiological values significantly influenced the degradation of diesel-polluted soil. Chicken droppings demonstrated higher biodegradation potential due to their greater content of hydrocarbon-utilizing bacteria and nutrients compared to EPFB (Akinyemi *et al.,* 2019). The addition of poultry droppings may have introduced extra hydrocarbon-degrading microbes and nutrients to the existing microbial community in the contaminated soil, surpassing every other treatment agent. This study illustrates effective diesel degradation, resulting in significant reductions in contaminant concentrations. These findings provide valuable insights into the ecological roles of chicken droppings and their potential impact on surrounding ecosystems, emphasizing the importance of understanding their chemical and biological dynamics in environmental studies and management practices.

Table1: Comparison of the mean values of the bioremediation chicken droppings (CD) and empty oil palm fruit bunch and uncontaminated soil

S/N	Parameters	Chicken Droppings	Processed Empty Palm Oil Fruit Bunch	Uncontaminated Soil
1	pH.	9.6	10.24	9.31
2	Temperature ^{0}C	26.2	26.5	26.7
3	Electrical Conductivity (mS/m)	6710	3740	98
4	Salinity as Chloride (Cl-) (mg/Kg)	308.42	447.82	15.81
5	Alkalinity (mg/Kg)	138	21	110
6	$N0_3$-N (mg/Kg)	2.691	0.477-0.117	0.477
7	Available Phosphorous (mg/Kg)	35.033	Nil	23.037
8	$SO_4{}^{2-}$(mg/Kg)	50.699	Nil	9.469
9	Chromium (Cr) (mg/Kg)	4.596	<0.001	1.106
10	Copper (Cu) (mg/Kg)	33.19	1.651	2.638
11	Nickel (Ni) (mg/Kg)	20.333	5.926	8.929
12	Lead (Pb) (mg/Kg)	29.535	5.895	13.862
13	Zinc (Zn) (mg/Kg)	6.386	6.386	19.999
14	PAH (mg/Kg)	2.973	Nil	<0.001
15	TPH (mg/Kg)	12.644	Nil	<0.001
16	THB (N x 10^5 CFU/g)	3.9	2.25	2.65
17	THF (N X 10^4 CFU/g)	1.53	2	0.4
18	HUB (N X 10^3 CFU/g)	7.5	Nil	3
19	HUF (N X 102 CFU/g)	5	Nil	6

Legend: $SO4^2$–Sulphate; N- Numeric value of substance/sample, TPH- Total petroleum hydrocarbon; PAH–Polyaromatic hydrocarbon HUF–Hydrocarbon Utilizing fungiNO3– Nitrate THF – Total Heterotrophic Fungi HUB– Hydrocarbon Utilizing Bacteria; THB– Total Heterotrophic Bacteria

Biodegradation of the various concentrations of TPH during bioremediation studies: Total petroleum hydrocarbon (TPH) refers to a broad range of chemical compounds found in diesel oil, encompassing several hundred different substances. Table 2 presents data obtained from a gas chromatographic flame ionization detector (GCFID). This study demonstrates a gradual decrease in the mean concentration of TPH over the 84 days, as illustrated in Table 2 and Figure 1. This decline is attributed to the degradation of hydrocarbons facilitated by the presence of amendments and indigenous microbial activity.

Additionally, TPH levels decreased across various concentrations of diesel-contaminated soil, ranging from 2,500 mg/Kg to 10,000 mg/Kg. High concentrations of hydrocarbons can inhibit biodegradation due to limitations in nutrients or oxygen or through the toxic effects of volatile hydrocarbons. If hydrocarbon contamination is significant, it can adversely affect biodegradation rates. These findings align with the research conducted by Tudararo-Aherobo and Mesogboriwon (2020).

Table 2: Biodegradation of the various concentrations of TPH during bioremediation studies

AMENDMENTS	DAY1Mean+ SD	DAY 28	DAY 56 Mean + SD	DAY 84 Mean + SD
DCS (control-A1)	195.47± 0.346	187.71± 1.344	174.26± 1.902	166.08± 0.332
DCS (Control-A2)	214.52± 2.73	211.37± 1.032	200.04± 0.474	188.62± 0.382
DCS (Control-A3)	240.51± 0.855	229.25± 2.319	217.28± 0.403	204.01± 0.346
DCS (Ai) +Chicken Dropping	36.89± 0.134	16.11± 0.247	11.2± 0.099	8.42± 0.346
DCS (A2) + Chicken Dropping	49.86± 0.219	32.48± 0.410	23.96± 0.318	16.63± 0.290
DCS (A3) + Chickeen Dropping	66.35± 0.339	50.13± 0.410	43.46± 0.191	29.94± 0.530
DCS (Ai) + Empty Oil Palm Fruit Bunch	149.75± 1.202	131.03± 0.877	114.92± 1.577	93.51± 0.438
DCS (A2) + Empty Oil Palm Fruit Bunch	172.74± 1.442	151.27± 0.495	139.91± 0.460	115.17± 0.339
DCS(A3) + Empty Oil Palm Fruit Bunch	194.91± 0.354	173.43± 0.856	162.38± 0.375	140.03± 0.523

*Legend: The 3 different *Diesel concentration (1=2,500mg/kg, 2=5,000mg/kg, 3=10,000mg/kg): A1=2,500mg/Kg, A2=5,000mg/Kg and A3=10,000mg/Kg), Diesel Contaminated Soil: DSC*

Table 3: Percentage reduction of total petroleum hydrocarbon (TPH) of the various amendments during bioremediation

TREATMENTS	CONCENTRATION	% TPH REDUCTION
Diesel contaminated soil (DCS)	2,500mg/Kg (A1)	15.04%
Diesel contaminated soil (DCS)	5,000mg/Kg (A2)	12.07%
Diesel contaminated soil (DCS)	10,000mg/Kg(A3)	15.18%
DCS + Chicken droppings (CD)	2,500mg/Kg(A1)	76.06%
DCS + Chicken droppings (CD)	5,000mg/Kg (A2)	66.65%
DCS + Chicken droppings (CD)	10,000mg/Kg(A3)	54.88%
DCS + Empty oil palm fruit bunch (EPFB)	2,500mg/Kg(A1)	37.56%
DCS + Empty oil palm fruit bunch (EPFB)	5,000mg/Kg (A2)	33.33%
DCS + Empty oil palm fruit bunch (EPFB)	10,000mg/Kg(A3)	28.16%

*Legend: The 3 different *Diesel concentration (1=2,500mg/kg, 2=5,000mg/kg, 3=10,000mg/kg): A1=2,500mg/Kg, A2=5,000mg/Kg and A3=10,000mg/Kg), Diesel Contaminated Soil: DCS*

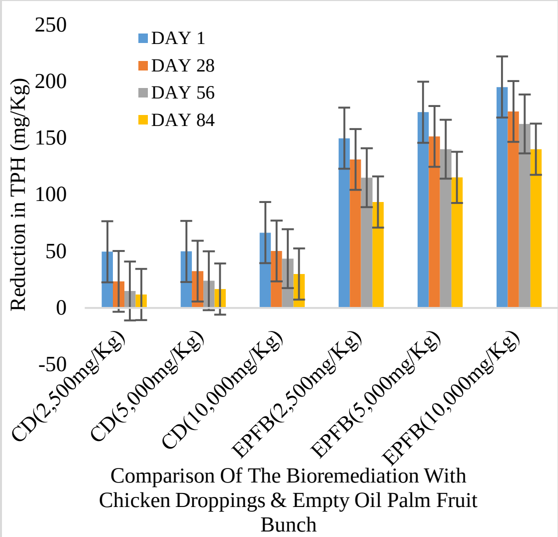

Fig 1: Comparison of bioremediation chicken droppings (CD) and empty oil palm fruit Bunch

Table 3 illustrates the percentage reduction in TPH for different amendments applied to the contaminated soil. The control group exhibited the lowest percentage reduction, ranging from 12.07% to 15.18%. In contrast, the addition of empty oil palm fruit bunches resulted in a percentage reduction between 28.16% and 37.56%. Chicken droppings led to the highest percentage reduction, which ranged from 54.88% to 74.06%. This effectiveness is attributed to the availability of abundant nutrients and the presence of hydrogen-degrading bacteria or microbes, supporting the findings of Akinyemi *et al.* (2019).

Conclusion: This comprehensive study demonstrates the effectiveness of bioremediation using organic nutrients to restore diesel-contaminated soil. The findings underscore the potential of this eco-friendly approach to mitigate soil pollution and promote sustainable environmental management.

Declaration of Conflict of Interest: The authors declare no conflict of interest.

Data Availability: Data are available upon request from the first author.

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