



AN ASSESSMENT OF PHYSICOCHEMICAL PROPERTIES OF MECHANIC WORKSHOP POLLUTED SOIL IN ANYIGBA SUPPLEMENTED WITH FISH POND SLUDGE

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ABSTRACT

An assessment of the physicochemical properties of mechanic workshop polluted soil in Anyigba, Kogi State, Nigeria incorporated with different concentrations of fish pond sludge (10%, 20% and 40%) was studied for six months. pH, moisture content, organic carbon, organic matter content, nitrate and phosphate were analyzed using standard procedures. The results revealed a range of 6.55 ± 0.53 - 7.30 ± 0.15 for pH, 14.17 ± 1.34 to 19.30 ± 2.00 % for moisture content, 0.69 ± 0.52 to 3.21 ± 0.15 % for organic carbon, 0.21 ± 0.12 to 0.92 ± 0.06 mg/kg for nitrate and 7.73 ± 0.58 to 15.25 ± 1.80 mg/kg for phosphate. There were no significant differences in the pH of the soil undergoing bioremediation at 0.05 probability limits. However, significant differences were observed in the moisture content, organic carbon, organic matter content, nitrate and phosphate of the mechanic workshop polluted soil incorporated with fish pond sludge at 95% confidence interval. The findings from this study revealed that mechanic workshop soil treated with 40% sludge (M+40%) showed the highest rate of utilization of organic carbon, organic matter content, nitrate and phosphate compared to 10% (M+10%) , 20% (M+20%) treatments. Hence, this study recommends the use of higher concentration of biodegradable organic waste in improving the physicochemical properties of hydrocarbon polluted soil.

1. Introduction

Mechanic workshop soils are often enriched with hydrocarbon derivatives such as used engine oil of different brands and greases which over time confers the characteristic black coloration associated with mechanic workshop environment (Fredrick *et al.*, 2024). These hydrocarbon products are often poorly disposed of in the environment thereby making the receiving soil to be rich in straight chain hydrocarbons, trace metal and also aromatic compounds (Stephen *et al.*, 2025).

Mechanic workshop soil are often polluted as a result of the continuous deposition of the hydrocarbons derivative wastes which were usually not treated or recycled before discarding in to the mechanic workshop environ. These hydrocarbon derivatives usually alter the physical and chemical properties of the soil. Soil parameters such as pH, moisture content, organic carbon, electrical conductivity of the soil is influenced by the presence of myriad hazardous substances such as toxic organic compounds, petroleum waste products and solvents (Fredrick *et al.*, 2024). When soil physicochemical properties are negatively impacted over a long period of time, the soil loses its aesthetic value, its fertility and overall quality. Such soil altered with hydrocarbon is unhealthy for plants growth and may contaminate ground water during surface run-offs as well as seepage into underground water sources

Organic materials such as animal manure, residues of plants and compost have been utilized in bio-stimulation and bioaugmentation of soil contaminated with hydrocarbon derivatives (Akeem *et al.*, 2024). However, recent research has explored the potentials of fish pond sludge in bioremediation of hydrocarbon impacted soil due to its high nutrient content and beneficial microbial population (Stephen *et al.*, 2025). Fish pond sludge normally accumulates in the ponds, its rich in organic matter, nitrogen-fixing bacteria, phosphate-solubilizing bacteria, and other microorganisms that can stimulate plant growth and improve soil quality (Lanzén *et al.*, 2020). While several studies have investigated the use of organic manures such as cow droppings, poultry litter, pigeon dropping for soil bioremediation (Stephen

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and Temola, 2014), there remains a knowledge gap regarding the utilization of fish pond sludge in bio-remediation of mechanic workshop polluted soil.

Hence, the need to look for a cheap and eco-friendly biodegradable waste such as fish pond sludge in mitigating the presence of hydrocarbon contaminants in the environment. This study aims to address this gap by evaluating the efficacy of fish pond sludge in improving the physicochemical properties of mechanic workshop polluted soil. Fish pond sludge serves dual purposes –as a bio-stimulating product (rich in organic matter and nutrients) as well as bio-augmentation (bacteria and fungi are present in the sludge). This might become an economically viable tool that developing countries such as Nigeria can adopt in reclaiming low level mechanic workshop polluted soil.

2. Material and methods

2.1 Fish Pond sludge: fish pond sludge was collected as described by Stephen *et al.* (2025). The residue was spread on concrete platform to air dry for a period of two weeks to ensure proper drying.

2.2 Experimental Design

This study involved pot experiment. The pots were perforated at the base and sides of the bowl and filled with mechanic workshop soil incorporated with 10%, 20% and 40% of dried fish pond sludge. Five pots were used for the mechanic workshop soil as well as the pristine soil. Two of the plastic pots contain 6Kg of pristine soil (positive control) and mechanic workshop soil (negative control) while the remaining pots containing mechanic workshop soil were incorporated with 10% (M+10%), 20% (M+20%) and 40% (M+40%) of dried fish pond sludge.

2.3 Sample analysis

Sampling was carried out monthly for a period of six months to assess the physicochemical properties of the mechanic workshop polluted soil undergoing bioremediation. pH and Phosphorus were determined using the method described by Onyeonwu (2000). Organic carbon, organic matter content, nitrate and moisture were determined as outlined by Ibitoye (2006). Briefly, Soil pH was determined at room temperature using glass electrode pH meter (Hannia, Italy). Ten grammes (10 g) of soil sample was suspended in 25 milliliters of distilled water and mixed thoroughly. The pH meter was standardized using phosphate buffer solution at pH 7.0 after which the pH of the samples were determined in duplicates by inserting the glass electrode in the soil suspension. The reading on the meter was recorded as the pH of the sample (Onyeonwu, 2000).

For the Organic matter content was determination, crucibles were dried at 160°C for 20 minutes, cooled in a desiccator and weighed (W₁). Five grammes (5g) of soil samples was weighed and added to the crucible (W₂). The samples in crucibles were heated at 500°C for seven hours. The crucible with ashes of samples was transferred into desiccator, cooled and reweighed (W₃). The percentage organic matter content in each sample was calculated thus:

$$\% \text{ organic matter} = \frac{W_2 - W_3}{W_2 - W_1} \times 100$$

Where W₁ = weight of the crucible without sample

W₂ = weight of the crucible with sample before drying

W₃ = weight of the crucible with ash

Nitrate was determined using the micro Kjeldahl method as described by Association of official Analytical Chemist, AOAC (2005) and Ibitoye (2006). Two grams of air- dried soil sample was put in a clean dry Kjeldahl flask containing 20 ml concentrated tetraoxosulphate (vi) (H₂SO₄) acid with one catalyst tablet. The flask was heated gently to avoid splashing until the liquid became clear with pale straw colour. The heating was continued further to ensure complete digestion and then allowed to cool. Fifty (50) ml of de-ionized water was added to the digest and mixed well. The volume was made up to 100 ml with distilled water in a standard flask and distilled with 10 ml of 40 % sodium hydroxide (NaOH) solution added to the digest. Distilled ammonia was liberated into 100ml conical flask containing 5 ml of 2% boric acid. The distillate was titrated with 0.01M HCl. Blank distillations was carried out and titrated. The percentage nitrogen was calculated from the formula:

$$\% \text{ Nitrogen} = \frac{V_1 - V_0}{10 \times \text{weight of sample}}$$

Where V₁ = Titre value of sample

V₀ = Titre value of the blank

The phosphorous content of the soil sample was determined as outlined by Onyeonwu (2000). Two grammes of finely ground soil was weighed into 25 ml capacity conical flask after which 30 ml of HClO₄ was added and digested in a fume cupboard at 130 °C until the solution appeared clear. The flasks were removed and cooled to room temperature;

50 ml of distilled water was added to the digest and filtered into 100 ml capacity flask. The absorbance of the coloured solution was determined at 882 nm wavelength after 30 minutes using a spectrophotometer (Genesys 20, USA). The moisture content of the soil was determined using the dry weight method as described by Ibitoye (2006). Empty crucible was dried in an oven at 105 °C for a few minutes, locked in a desiccator and weighed (W_1). A 5 g of sample was placed in a crucible (W_2). The crucible with the sample was dried in an oven at 105°C until a constant weight was achieved. The crucible was then transferred to a desiccator to cool and weighed with minimum exposure to the atmosphere (W_3). The loss in weight of the sample after drying was the moisture content. It was calculated using the formula:

$$\% \text{ moisture} = \frac{W_2 - W_3}{W_2 - W_1} \times 100$$

Where W_1 = weight of the crucible without sample

W_2 = weight of the crucible with sample before drying

W_3 = weight of the crucible with sample after drying

2.4 Statistical Analysis

The data obtained were analyzed using the Statistical Package for Social Sciences (SPSS) version 25. Descriptive statistics was performed to determine the percentages and mean of variables while a one-way Analysis of Variance (one way ANOVA) was carried out to determine the association between variables.

3. Results and Discussion

The physicochemical properties of mechanic workshop polluted soils from Anyigba undergoing bioremediation using fish pond sludge is shown in Table 1. The pH of mechanic workshop polluted soil ranged from 6.55 ± 0.53 - 7.30 ± 0.15 . The least pH was observed in the pristine soil while the highest pH was observed in mechanic workshop polluted soil fortified with 40% fish pond sludge (M+40%). The pH of the soils were weakly acidic at the end of the study. There were no significant differences in the pH of the soil at 0.05 probability limits regardless of the treatments (Table 1). The pH observed in M+40 % may be due to buffering effect of the fish pond sludge which is favourable for bioremediation process (Hafizi *et al.*, 2017).

The moisture contents of the same soil ranged from 14.17 ± 1.34 to 19.30 ± 2.00 %. The highest moisture content of the soils was observed in the mechanic workshop polluted soil amended with 40% fish pond sludge, M+40%, followed by the mechanic workshop polluted soil amended with 20% fish pond sludge, M+20%, while the least moisture content was observed in the unamended polluted soil, P+C. Significant differences were observed in the moisture contents across the soil treatments at 95% confidence limit. This result contradicts an earlier report of the use of organic amendment by Stephen and Temola (2014), to enhance bioremediation of hydrocarbon polluted soil. However, the highest moisture content in M+40% compared to other treatments may be due to the amount of fish pond sludge added to the soil. Osuji *et al.* (2016), reported an increased water-holding capacity in soil rich in organic manure.

Table 1: Physicochemical properties of mechanic workshop polluted soil from Anyigba undergoing bioremediation (M+SE)

Parameters	Pristine(U+C)	Polluted (P+C)	M + 10%	M + 20%	M + 40%
pH	6.55 ± 0.53^a	6.70 ± 0.22^a	7.05 ± 0.27^a	7.20 ± 0.20^a	7.30 ± 0.15^a
Moisture (%)	14.74 ± 1.00^b	14.17 ± 1.34^b	$15.13 \pm 1.21^{a,b}$	$16.82 \pm 1.19^{a,b}$	19.30 ± 2.00^a
Organic carbon	0.69 ± 0.52^c	3.21 ± 0.15^a	$2.64 \pm 0.20^{a,b}$	$2.80 \pm 0.18^{a,b}$	2.15 ± 0.30^b
O.M.C (%)	0.37 ± 0.05^c	5.12 ± 0.05^a	$4.54 \pm 0.34^{a,b}$	4.78 ± 0.32^a	3.70 ± 0.46^b
Nitrate (Mg/kg)	0.21 ± 0.12^b	0.92 ± 0.06^a	0.77 ± 0.06^a	0.82 ± 0.05^a	0.64 ± 0.08^a
Phosphate (Mg/kg)	7.73 ± 0.58^b	15.25 ± 1.80^a	10.60 ± 0.73^b	9.67 ± 3.00^b	10.18 ± 2.00^b

^{a,b,c}: means of six replicates denoted by different superscripts along the same row are significantly ($p < 0.05$) different, M+10%: Mechanic workshop polluted soil amended with 10% fish pond sludge. M+20%: Mechanic workshop polluted soil amended with 20% fish pond sludge. M+40%: Mechanic workshop polluted soil amended with 40% fish pond sludge, O/M.C: Organic matter content

The organic carbon of the soil from Anyigba ranged from 0.69 ± 0.52 to 3.21 ± 0.15 percent. The highest organic carbon was observed in P+C (un-amended mechanic workshop polluted soil). followed by M+20% and M+10% while the least organic carbon was recorded in U+C (Pristine soil). There were significant differences in the organic carbon contents of the soils undergoing bioremediation at 0.05 probability limits. The low organic carbon observed in M+10%, M+20% and M+40% compared to P+C may be related to the ease in utilization of the incorporated sludge in the soil undergoing bioremediation. The result also revealed that among the organic treatment, M+40% had lower

organic carbon signifying higher metabolic activity during the bioremediation process (Huang *et al.*, 2014).

The highest nitrate concentration was observed in P+C followed by M+ 20% while the least concentration was recorded in the pristine soil (U+C). The nitrate concentration ranged from 0.21 ± 0.12 to 0.92 ± 0.06 mg/kg. Significant differences were observed in the nitrate levels of the soil undergoing bioremediation at 95% confidence interval. They result also show that the higher the amount of biodegradable sludge treatment, the higher the nitrate utilization in the soil by soil organisms (Ma *et al.*, 2019).

The phosphate levels of all treatments were higher than the nitrate levels. It ranged from 7.73 ± 0.58 to 15.25 ± 1.80 mg/kg. The highest phosphate value was observed in the unamended polluted soil (P+C) followed by M+10% while the least value was observed in the pristine soil (U+C). Significant differences were observed in the phosphate levels of the soil undergoing bioremediation at 95% confidence interval (Table 1). The pattern of concentration of nitrate and phosphate were similar in the soil undergoing bioremediation. However, the pattern of results obtained from the sludge addition was slightly different in nitrate and phosphate concentrations. In nitrate, the pattern of concentration was P+C >M+20% >M+10% > M+40%>U+C while the pattern in phosphate showed P+C >M+10% >M+20% > M+40%>U+C concentration. In both parameters, the highest utilization of nitrate and phosphate was observed in M+40%. This is in agreement with an earlier report by Fadina *et al.* (2019) that reported higher utilization in nutrients from organic manure during reclaiming hydrocarbon polluted soil.

4. Conclusion

The findings from this study after six months showed that mechanic workshop soil treated with 40% sludge (M+40%) had the highest rate of utilization of organic carbon, organic matter content, nitrate and phosphate by soil organisms compared to 10% (M+10%) , 20% (M+20%) treatments. Hence, this study recommends the use of higher concentration of biodegradable organic wastes such as fish pond sludge in improving the physicochemical properties of hydrocarbon polluted soil.

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