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Bioremediation of Spent Oil Contaminated Soil in Apo Mechanic Village in the Federal Capital Territory Abuja using different Organic Matter

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ABSTRACT

Spent oil polluted soil is widespread all over Nigeria. The pollution occurs in the urban as well as in the rural areas. This study is aimed at the Bioremediation of spent hydrocarbon-contaminated soil in Apo mechanic village in the federal capital territory Abuja. Standard microbiological method was used in isolation and identification of bacteria from the amended contaminated soil. The total heterotrophic spent hydrocarbon bacteria count in the amended spent hydrocarbon contaminated soil was high. After week 3, the control was 2.88± 0.12x10^{6}cfu/g, from chicken dropping recorded 5.81 ± 0.03 x10^{6}cfu/g, from cow dung it was 6.91 ± 0.10 x10^{6}cfu/g and low in week 1 the control recorded 1.94± 0.21 x10^{6}cfu/g, from chicken dropping amended soil 4.13 ±0.90 x10^{6}cfu/g, from cow dung it was 5.61 ± 0.25 x10^{6}cfu/g. The hydrocarbon-utilizing bacteria isolated were Bacillus sp, Citrobactersp, Micrococcussp, Pseudomonas sp, Flavobacteriumsp and Alicagenes sp. Duration effect on hydrocarbon utilization after amending the contaminated soil was recorded highest in week 3 the control recorded 3.08± 0.02 mg/g, from chicken dropping it recorded 5.98 ± 0.22 mg/g reduction and from cow dung it recorded 6.01 ± 0.11 mg/g and lowest after week 1 from the control recorded 1.57± 0.21 mg/g, from the chicken dropping it was observed that the reduction was 3.13 ± 0.15 mg/g, from cow dung it was observed that the reduction was 3.81 ± 0.05 mg/g. Physicochemical properties of the control and amended contaminated soil showed the highest in week 3 the pH was 8.6 in chicken dropping and 8.7 cow dung and lowest in week 1 the pH from the control was 6.0, from the chicken dropping it was 7.5, from cow dung it was 7.2. The Total organic carbon was 1.72 in Control. In week 1 the total organic carbon was 2.08 mg/g in chicken dropping and 2.12 mg/g in cow dung and in week 3 it was 3.24mg/g in chicken dropping and 3.45 mg/g in cow dung, it was observed that using chicken dropping and cow dung will help the indigenous bacteria and fungi species in utilization of spent hydrocarbon on contaminated soil.

Keywords: *Spent oil. Polluted soil, Utilization, Amended, chicken dropping and cow dung.*

1. INTRODUCTION

Spent oil polluted soil is widespread all over Nigeria. The pollution occur in the urban as well as in the rural areas. Automobile and other mechanical workshops are located all over the country.The spent oil contaminates the soil and creates unsatisfactory conditions for plant growth. Spent oil pollution causes delayed seed germination of crop plants and low leaves yield [1, 2]. Natural attenuation may effectively reduce the dissolved concentration or toxic forms of inorganic contaminations in the soil, both metals and non metals may be attenuated by sorption reactions. Natural attenuation lets the soil to use its abundant biological and physico-chemical processes to remediate any pollution [2]. The effect of spent oil on soil properties and the growth of plant is dependent on the concentration. Beyond 3% concentration it becomes very detrimental to the functional ability of the soil and plant growth [3]. Soil pollution with spent oil destroys soil structure and increases bulk density, nutrient availability and uptake by plants [4]. This is in addition to poor wettability, reduced aeration and increased propensity to heavy metal accumulation. Spent oil significantly affect both the physical and chemical properties of the soil [5]. Spent oil pollution of soil leads to build-up of magnesium, lead, zinc, iron, copper. Through translocation in plant tissues, these metals finally get into human when these plants are consumed as food [6,7]. The process is an ecologically sound technique that uses natural biological micro organisms, plants or their enzymes to return a contaminated environment to its natural condition [8]. Bioremediation technique can be classified into *in situ* or *ex situ*. The former involves treatment of the contaminated material at the site while ex situ involves taking the contaminated material elsewhere to be treated. The procedures are mostly low-cost simple technology using microorganisms [9]. Bioremediation of spent oil involves the utilization of micro organisms that transform the contaminant hydrocarbon compounds to harmless forms by metabolic processes of these organisms. Recalcitrant contaminants are better treated under anaerobic conditions [10].

Another practical use of bioremediation is in the treatment of municipal wastewater that is microbiologically decontaminated under controlled environmental conditions. This study aimed at bioremediation of spent oil contaminated soil in Apo mechanic village in the Federal Capital Territory Abuja using different organic matter like poultry litter and cow dung as amendments

2. Materials and Methods

2.1 Study location

This research was carried out in Apo mechanic workshops area in Abuja, Nigeria with zip code of 900104. Abuja is located within coordinates Latitude: 9° 03' 28.26" N and Longitude: 7° 29' 42.29" E. Abuja covers an area of 1,769 km^2, it is 360 meters elevated above sea level. The population of Abuja is about 3,464,000 people. The city has heavy vehicular use and much automobile mechanical activities go on in the Apo mechanic workshop area.

2.2 Soil Sampling and Preparation of Amendments

Soil samples were collected from four different locations within the spent oil discharge zones of mechanic workshops using a clean, sterile hand trowel. Sampling was done at a depth of 0–15 ± 0.2 cm to obtain surface soil. The collected samples were thoroughly mixed (composited), placed in clean black polythene bags, and transported to the laboratory using clean head pans to avoid cross-contamination. Poultry litter was sourced from a poultry farm located in Lugbe, Abuja. The litter was air-dried, manually sorted to remove foreign materials, and ground into a semi-powdered form for use as an organic amendment in the bioremediation process. Similarly, fresh cow dung was obtained from an abattoir in Lugbe. It was also air-dried and processed in the same manner as the poultry litter, soil samples were air-dried, homogenized, and passed through a 2.0 mm sieve. The processed soil was then weighed for subsequent analysis and experimental setup. Baseline physicochemical and microbiological properties of the soil were determined, including soil pH, total petroleum hydrocarbon (TPH) content, total organic matter (TOM), and microbial isolation and identification.

2.3 Treatment of Soil Sample

The four samples were mixed together in a clean head pan to get a composite mixture.

1000g of polluted soil sample was placed in each of the four containers labeled A, B, C, &D. Two sets of these were prepared each set treated with either chicken droppings or cow dung as amendment. Soil samples in containers A served as control while containers B, C, & D were amended with 100g, 200g, 500g of poultry droppings or cow dung respectively. The different treatment options were watered with 50 ml sterile water weekly after treatment to moisten the soil andwere mixed individually twice a week for aeration.

2.3. Isolation of Hydrocarbon-Degrading Bacteria

Soil samples from each treatment group were collected in triplicate at 7-day intervals to enumerate total aerobic heterotrophic bacteria (AHB). For microbial enumeration, 1g of each soil sample was suspended in 9 mL of sterile distilled water and thoroughly mixed. Serial dilutions were performed by transferring 1 mL of the suspension to the next test tube containing 9 mL of sterile water, continuing this process up to the 10th dilution.

From the 6th dilution tube, 0.1 mL aliquots were aseptically plated on nutrient agar supplemented with 50 µg/mL nystatin to inhibit fungal growth. All plates were prepared in triplicate and incubated at 30 °C for 24 hours. After incubation, visible colonies were counted to estimate the total viable AHB population.

To isolate hydrocarbon-utilizing bacteria (HUB), soil samples were plated on mineral salt medium (MSM) prepared following the formulation of Zajic and Supplisson (1972), with the following composition (per 1000 mL distilled water, pH 7.4):

- K_2HPO_4 – 1.8 g
- NH_4Cl – 4.0 g
- $MgSO_4 \cdot 7H_2O$ – 0.2 g
- KH_2PO_4 – 1.2 g
- $FeSO_4 \cdot 7H_2O$ – 0.01 g
- NaCl – 0.1 g
- Agar – 20 g
- Used engine oil – 1% (v/v) as the sole carbon source

Plates were incubated at 30°C for 5 days, after which bacterial colonies were counted. Representative colonies were randomly selected and purified by repeated sub-culturing on nutrient agar to obtain pure isolates for further identification.

2.3.1. Colony Counting Procedures

The standard plate count technique was employed to quantify the microbial population in the soil samples throughout the experimental period. This method provides a direct and quantitative estimation of viable bacteria capable of growing on the selected culture media.

After incubation, the number of bacterial colonies on each plate was counted using a manual or digital colony counter, and the results were expressed as colony forming units per gram of soil (cfu/g).

The colony count was calculated using the following formula:

No. of colonies x dilution factor

Qty. of gram of soil used.

Where:

- *Number of colonies* is the average count per plate.
- *Dilution factor* corresponds to the serial dilution level used.
- *Weight of soil sample* is typically 1 gram.

All values were recorded in triplicates and reported as mean cfu/g to reflect the microbial load in each treatment.

2.3.2. Microscopic and Biochemical Characterization of Isolates

Each bacterial isolate was initially characterized based on its colony morphology, including observations of colony size, shape, margin, consistency, elevation, and pigmentation on nutrient agar plates. Further microscopic examination was conducted to determine the Gram reaction and cell morphology using the Gram staining technique.

A series of biochemical tests were performed to further characterize the isolates. These included:

- Catalase test
- Oxidase test
- Indole production test
- Sugar fermentation/oxidation tests (e.g., glucose, lactose, sucrose)

These tests provided essential phenotypic information for preliminary identification.

The bacterial isolates were subsequently characterized and identified based on a combination of their microscopic features,

biochemical profiles, and molecular techniques, where applicable. These procedures allowed for reliable identification of hydrocarbon-degrading bacteria associated with the bioremediation process.

5. Physico-Chemical Properties of the Graded Amended Soil Samples

5.1. Total Petroleum Hydrocarbon (TPH) Determination

The residual hydrocarbon content of the soil samples was determined using the toluene cold extraction method as described by Adesodun and Mbagwu [11]. Briefly, 10 g of air-dried, homogenized soil was weighed into a 50 mL Erlenmeyer flask, followed by the addition of 20 mL of toluene (AnalaR grade). The mixture was agitated for 30 minutes on an orbital shaker (Model: NBiotek-101M).

After extraction, the liquid phase was separated, and the absorbance was measured at 420 nm using a Zorvo Visible Digital Spectrophotometer Analyser (Model 721 LDC). The Total Petroleum Hydrocarbon (TPH) concentration in each sample was quantified by comparing the absorbance values against a standard calibration curve prepared using fresh-used lubricating oil diluted with toluene.

C = Coe−kt, Where:

- CCC = Hydrocarbon content in the soil at time ttt ($g \cdot kg^{-1}$)
- C0C_0C0 = Initial hydrocarbon content in the soil ($g \cdot kg^{-1}$)
- kkk = Biodegradation rate constant (day^{-1})
- ttt = Time (days)

This approach allowed for both the estimation of residual hydrocarbon content and assessment of the biodegradation efficiency of the soil amendments.

5.2. Determination of Total Organic Carbon (TOC)

The ASTM (2003) method was employed for the determination of total organic carbon in the soil samples. Precisely 1 g of air-dried, sieved soil was weighed into a 250 mL Erlenmeyer flask. Subsequently, 10 mL of 1N potassium dichromate ($K_2Cr_2O_7$) solution and 20 mL of concentrated sulfuric acid (H_2SO_4) were added. The flask contents were gently swirled to ensure thorough mixing.

The mixture was then allowed to stand on an asbestos sheet for approximately 30 minutes to complete the oxidation reaction. After the reaction period, 100 mL of distilled water was added to dilute the mixture. Following this, three drops of a suitable indicator (e.g., diphenylamine or ferroin) were added.

The contents were titrated with 0.5N ferrous sulfate ($FeSO_4$) solution until a sharp color change from blue to reddish-brown (maroon) was observed, indicating the endpoint. The amount of ferrous sulfate used was recorded, and the organic carbon content was calculated accordingly.

5.3. Soil pH Determination

The pH of the amended and control soil samples was monitored periodically during the bioremediation process. A 10% (w/v) soil suspension was prepared by adding 10 g of air-dried soil to 100 mL of distilled water. The mixture was thoroughly stirred and allowed to stand for 1 hour, after which it was filtered using Whatman No. 1 filter paper.

The pH of the filtrate was measured using a standardized digital pH meter. The glass electrode was calibrated prior to use with buffer solutions of pH 4.0, 7.0, and 9.0. The electrode was then immersed in the soil solution, and the pH value was recorded.

5.4. Determination of Nitrogen (Kjeldahl Method)

Nitrogen content in the soil samples was determined using the Kjeldahl digestion and distillation method. The required apparatus included a Kjeldahl digestion and distillation unit, conical flasks, burettes, and pipettes.

Reagents:

- Concentrated sulfuric acid (H_2SO_4, 93–98%)
- Copper sulfate ($CuSO_4 \cdot H_2O$)
- Potassium sulfate (K_2SO_4) or anhydrous sodium sulfate (AR-grade)
- 35% sodium hydroxide (NaOH) solution
- 0.1 M hydrochloric acid (HCl), standardized against 0.1 M sodium carbonate
- Methyl red indicator
- Salicylic acid or Devarda's alloy (for nitrate reduction if nitrate is present)

Approximately 1 g of soil sample was weighed into a Kjeldahl digestion flask. To this, 0.7 g of copper sulfate and 1.5 g of potassium sulfate were added as catalysts, followed by 30 mL of concentrated sulfuric acid.

The mixture was gently heated until frothing subsided and then boiled vigorously until the digest turned clear, indicating complete digestion of organic matter. The digestion was continued for an additional 30 minutes to ensure thorough breakdown.

After cooling, 50 mL of distilled water was added to dilute the digest, and the mixture was transferred into a distillation flask. A receiving conical flask containing 20–25 mL of 0.1 M HCl and 2–3 drops of methyl red indicator was positioned to collect the distillate. Water was run through the condenser to maintain condensation.

Subsequently, 30 mL of 35% NaOH was carefully added to the distillation flask without mixing. The contents were then heated, and ammonia was distilled over for 30–40 minutes into the acid-containing receiving flask.

After distillation, the outlet tube was rinsed with a small quantity of distilled water to ensure complete transfer. The excess acid in the receiving flask was then back-titrated with 0.1 M NaOH. A reagent blank was run using the same quantity of standard acid to correct for any background nitrogen content in the reagents.

The total nitrogen content was calculated based on the amount of HCl neutralized by the distilled ammonia.

3.5.5 Determination of Phosphorus

Phosphorus content in the soil samples was determined using the Vanado-Molybdate Colorimetric Method, which involves the formation of a yellow-colored vanado-molybdo-phosphoric acid complex, ammonium molybdate reacts with orthophosphate ions under acidic conditions to produce a yellow-colored complex. The intensity of the color, which is directly proportional to the phosphorus concentration in the sample, was measured using a visible spectrophotometer at a wavelength of 490 nm.

Quantification was carried out by comparing the absorbance readings of the samples to a calibration curve prepared using standard phosphate solutions.

3.5.6 Determination of Soil Organic Matter

Soil organic matter (SOM) content was determined by loss-on-ignition (LOI) method using a muffle furnace.

Clean, dry porcelain crucibles were first weighed and their initial weights recorded.

Oven-dried soil samples (previously dried to remove moisture) were then placed in the crucibles, and the combined weights of the crucibles and soil samples were measured and documented. The crucibles containing the soil samples were then placed in a muffle furnace, and the temperature was gradually increased to 440 °C. The samples were allowed to combust overnight to ensure complete oxidation of organic matter.

After combustion, the crucibles were carefully removed using heat-resistant tongs and allowed to cool to room temperature. The final weights of the crucibles and residual ash were then recorded.

3 Results

3.1 Total heterotrophic spent hydrocarbon utilizing bacteria count

Table 1 Shows the total heterotrophic spent hydrocarbon utilizing bacteria count in the amended spent hydrocarbon contaminated soil. From week 1 the control recorded 1.94± 0.21 x10^6cfu/g, from chicken dropping amended soil 4.13 ±0.90 x10^6cfu/g, from cow dung it was 5.61 ± 0.25 x10^6cfu/g. After week 2 control recorded 2.85± 0.01 x10^6cfu/g, from chicken dropping it was 6.21 ± 0.13 x10^6cfu/g, from cow dung7.15 ± 0.05 x10^6cfu/g. After week 3 the control was 2.88± 0.12x10^6cfu/g, from chicken dropping recorded 5.81 ± 0.03 x10^6cfu/g, from cow dung it was 6.91 ± 0.10 x10^6cfu/g.

3.2 Bacterial identification

Cultural, morphology and biochemical characteristic of bacteriaisolated is as given in Table 2. colonies appear milksh, circular, coarse, flat, convex, entire and opaque, gram negative, catalase positive, oxidase negative, indole negative, nitrate positive, glucose positive were *Bacillus* sp. smooth elevated colonies and cocci on nutrient agar, gram negative, catalase negative, oxidase negative, indole positive , nitrate positive, fructose negative were*Citrobacter* sp. smooth elevated colonies and bright yellow colonies on nutrient agar, gram positive, catalase negative, oxidase negative, indole positive , nitrate positive, fructose negative were *Micrococcus* sp. smooth none elevated colonies green pigment on nutrient agar, gram positive, catalase negative, oxidase negative, indole positive , nitrate positivewere*Pseudomonas* sp.

Table 1: Total heterotrophic bacteria population count in the amended spent hydrocarbon contaminated soil

weeks	Control	**10^6 CFU/gTHB**	
		Chicken dropping	Cow dung
Week 1	1.94± 0.21x10^6	4.13 ±0.90 x10^6	5.61 ± 0.25 x10^6
Week 2	2.85± 0.01 x10^6	6.21 ± 0.13 x10^6	7.15 ± 0.05 x10^6
Week 3	2.88± 0.12x10^6	5.81 ± 0.03 x10^6	6.91 ± 0.10 x10^6

Table 2: Cultural, morphology and biochemical characteristic of bacterial isolated

Cultural Morphology	Gram Reaction		Biochemical characteristic			Sugar fermentation				Inference
			Cat	Ox	In	Nit	Fru	Mal	Glu	
milkish, circular, coarse, flat, convex, entire and opaque	-		+	-	-	+	+	-	+	*Bacillus* sp
smooth elevated colonies and cocci on NA	-		-	-	+	-	-	+	+	*Citrobacter*sp
smooth elevated colonies and bright yellow colonies on NA	+		-	-	-	+	-	+	+	*Micrococcus*sp
smooth none elevated colonies green pigment on NA	-		-	-	-	+	-	-	+	*Pseudomonas* sp
smooth none elevated colonies grayish white unpigment on NA	-		+	+	-	-	-	-	+	*Alicagenes*sp
yellowish brown or orange-pigmented colonies on NA	+		-	+	-	+	+	-	+	*Flavobacterium*sp

KEY: NA- nutrient agar, Cat-catalase, Nit- nitrate, Ox-oxidase, In-indole, Glu- glucose, mal – maltose, Fru – fructose

3.3 Bacteria occurrence

The Bacteria utilizing hydrocarbon isolated after amendment is as given in Table 3. The bacteria occurrence was *Pseudomonas*sp(50.0 %) from chicken dropping and (75.0 %) from cow dung. *Micrococcus*sp was (25.0 %)from chicken dropping and (50.0%) from cow dung.*Flavobacterium*sp was (75.0 %)from cow dung. *Bacillus*sp(50.0 %) from chicken dropping and cow dungamended soil. *Citrobacter*sp was (50.0 %) from chicken dropping amended soil.*Alicagenes*sp was (75.0 %) respectively.

Table 3: Bacteria utilizing hydrocarbon isolated after amendment

		No. (%) isolated	
Bacteria	No. sample	Chicken dropping	Cow dung
*Pseudomonas*sp	4	2(50.0)	3(75.0)
*Micrococcus*sp	4	1(25.0)	2 (50.0)
*Flavobacterium*sp	4	0(0.0)	3(75.0)
Bacillus sp.	4	2(50.0)	2 (50.0)
*Citrobacter*sp	4	2 (50.0)	0 (0.0)
*Alicagenes*sp	4	0 (0.0)	3 (75.0)

3.4. The physicochemical properties of the control and amended contaminated soil

Physicochemical properties of the control and amended contaminated soil are as given in Tables 4. In week 1 the pH from the control was 6.00, from the chicken dropping it was 7.5, from cow dung it was 7.2. In week 2 the pH was 8.4 in chicken dropping, 8.6 in cow dung. In week 3 the pH was 8.6 in chicken dropping and 8.7 cow dung. The Total organic carbon was 1.72 in control in week 1,2.08 mg/g in chicken dropping and 2.12 mg/g in cow dung, in week 2 it was 2.81 mg/g in chicken dropping and 3.11 mg/g in cow dung amended soil, in week 3 it was 3.24mg/g in chicken dropping and 3.45 mg/g in cow dung. The organic matter in control was 23.50 %, in week 1 it was 31.56% in chicken dropping and 38.66 % in cow dung, in week 2 it was 17.50 % in chicken dropping and 28.50 % in cow dung, in week 3 it was 14.40 % in chicken dropping and 15.00% in cow dung.

The Nitrogen recorded 6.59 mg/kg in control soil, in week 1 it was 5.39 mg/kg in chicken dropping and 5. 28 mg/kgin cow dung, in week 2 it was 4.10 mg/kg in chicken dropping and 4.08 mg/kgin cow dung, in week 3 it was 3.75 mg/kg in chicken dropping and 3.64mg/kgin cow dung. The Phosphate was 50mg/kg in control contaminated soil, in week1 the Phosphate recorded was 42 mg/kg in chicken dropping and cow dung, in week 2 it was 34 mg/kg in chicken dropping and 36 mg/kg cow dung, in week 3 it was 26 mg/kg in chicken dropping and 24 mg/kg cow dung respectively.

Table 4: Physicochemical properties of the amended contaminated soil

		Week 1		Week2		Week3	
Parameter	Control	chicken dropping	cow dung	chicken dropping	cow dung	chicken dropping	cow dung
pH	6.00	7.5	7.2	8.4	8.6	8.6	8.7
Total organic carbon	1.72	2.08	2.12	2.81	3.11	3.24	3.45
Organic matter	23.50	31.56	38.66	17.50	28.50	14.40	15.00
Nitrogen (mg/kg)	6.59	5.39	5. 28	4.10	4.08	3.75	3.64
Phosphate (mg/kg)	50	42	42	34	36	26	24

4: Discussion of Findings

As observed in this study that the highest bacteria count recorded in contaminated soil without amendment was 2.88± 0.12 x10^6cfu/g compared with ones amended with chicken droppings that recorded 6.21 ± 0.13 x10^6cfu/g and 7.15 ± 0.05 x10^6 cfu/g in cow dung amendment, this shows that the indigenous bacteria begins metabolizing the spent hydrocarbon after amendment. This result is in agreement with the results [12,13]. The heterotrophic bacteria utilizing spent hydrocarbon isolated in this study were *Bacillus* sp, *Citrobacter*sp, *Micrococcus* sp, *Pseudomonas* sp, *Flavobacterium*spand *Alicagenes*sp these bacteria species have beenreported to play an important role in degradation of spent hydrocarbon contaminated soil and is similar to previous studies [14]. The reduction of spent hydrocarbon as observed in this study suggest that soil contaminated with spent hydrocarbon can be reclaimed or degraded by the use of agro waste such as chicken dropping and cow dung by continually applying these agro waste on the soil, it was recorded that the highest reduction of spent hydrocarbon was after week 3 chicken dropping it recorded 5.98 ± 0.22 mg/kg reduction and from cow dung it recorded 6.01 ± 0.11 mg/kg. The high reduction may be due to increase in bacteria count as recorded in this study. The finding is in agreement with the work [15] who reported high reduction of hydrocarbon after amending contaminated soil with agro waste.

The soil pH is the negative logarithm of the active hydrogen ion (H+) concentration in the soil solution. As the measure of soil acidity or neutrality it has a considerable influence on the availability of nutrients and affects microbial population in soils. In this study the pH values of the soil samples before amendment showed all the samples to be slightly acidic which could be because spent hydrocarbons contain many free cations causing them to have properties of weak acid and the fluctuations may also be due to the metabolites produced by the micro-organisms during the remediation period. The final pH values are within the optimal soil pH range 7.2-8.7 necessary to support bacterial and fungal growth and this is same as reported [16,17,18]. Nitrogen value before the experiment was 4.5mg/kg. On completion of the experiment, nitrogen levels dropped to 6.59 mg/kg this is in agreement with the report [19]. In the treated soil samples, nitrogen values ranged between 3.75 mg/kg to 5.39 mg/kg for chicken droppings and 3.64 mg/kg to 5. 28 mg/kg for cow dung. Nitrogen value decreased with time in the treatment categories because nitrogen availability and utilization is essential for the growth and metabolism of micro-organisms as reported in previous works [20,21].Though, [22] reported increase in Nitrogen values. Nitrogen is a component of amino acids that synthesize proteins and enzymes in micro-organisms which directly affects the rate of degradation of hydrocarbon. Lower concentration of nitrogen, phosphorous and other mineral nutrients have been reported as limiting factors for the growth of micro-organisms in hydrocarbon polluted environments. Total organic carbon values during this study in contaminated soil was 1.72% while in the chicken dropping amendment it ranges from 2.08 to 3.24 in the cow dung samples it ranges from 2.12 to 3.45. Carbon content increased with time in all the treatment categories. In this study, carbon increased gradually in all the treatment groups and is higher than the control; this is in agreement with the result [23] that hydrocarbon-polluted soils have high carbon content.

5. Conclusion

The findings of this study demonstrate that spent oil-contaminated environments, such as those found in mechanic workshops, can be effectively and efficiently bioremediated using indigenous hydrocarbon-utilizing bacteria. The extent of biodegradation was found to be significantly influenced by soil nutrient availability, particularly nitrogen and phosphorus levels.

The relatively low reduction in total petroleum hydrocarbon (TPH) levels in unamended soils highlights the importance of nutrient supplementation. The results indicate that the addition of organic waste materials, such as chicken droppings and cow dung, which are rich in essential nutrients, can substantially enhance the bioremediation process. This approach not only accelerates hydrocarbon degradation but also offers a sustainable waste management solution.

Overall, the study confirms that indigenous microorganisms possess the metabolic capability to degrade spent lubricating oils, thereby playing a vital role in the natural attenuation and remediation of petroleum hydrocarbon pollutants. These findings support the use of bioaugmentation and nutrient amendment strategies for the effective restoration of oil-contaminated soils.

6. Conflict of Interest Statement

The authors declare no conflicts of interest

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