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EFFECTS OF VERMICAST TEA ON THE REMEDIATION OF SPENT ENGINE OIL CONTAMINATED SOIL

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ABSTRACT

The need to maintain the rising numbers of both serviceable and degenerating automobiles in Nigeria has led to the springing up of vehicle workshops in approved and unapproved locations, where mechanics discharge spent engine oil indiscriminately into the soil and water environments. It is therefore desirable to explore potentially affordable and sustainable remediation methods. This study examined the efficacy of vermicast tea for the remediation of spent engine oil contaminated soil. Spent engine oil contaminated soil was collected from an automobile workshop, and mixed with different concentrations (20%, 50%, and 100%) of vermicast tea. The total petroleum hydrocarbon (TPH), moisture content, organic matter content, pH, and cation exchange capacity (CEC) in the contaminated soils were determined on day one, day 21, and day 42, using standard procedures. It was found that the TPH concentrations reduced in both vermicast tea treated and untreated soils, but percentage reductions were higher in contaminated soils treated with vermicast tea (63.65% – 74.74%) than in soil without vermicast tea (59.85%). The moisture content, organic matter content, pH, and cation exchange capacity of the spent engine oil contaminated soil were impacted due to the presence of vermicast tea. Moreover, remediation was observed to be significantly higher ($p<0.05$) at day 42 of exposure to vermicast tea, than at day 21. These results imply that vermicast tea can hasten natural remediation of soil contaminated with spent engine oil. It is recommended that future studies on the use of vermicast tea to remediate spent engine oil-contaminated soil for a longer period.

Keywords: Contaminated soil, Spent engine oil, Total petroleum hydrocarbon, Vemicast tea

INTRODUCTION

Spent engine oil a black to brown liquid that is drained from automobile and generator engines after servicing. Spent engine oil contains high amounts (80%–90%) of long-chain saturated hydrocarbons, a liquid combination of low to high molecular weight (C15–C18) aliphatic and aromatic hydrocarbon (Okonokhua et al,.2007). Spent engine oil drained from machines in mechanic workshops are often disposed of indiscriminately in the soil, leading to contamination and pollution in such environments. Spent engine oil can contaminate soil, making it unfertile for farming or plant growth for several years (Nwinyi and Olawore, 2017; Adesipo *et al.*, 2020). Reports have shown that soils polluted with spent engine oil have poor qualities such as decreased pH, decreased total nitrogen, and low available phosphorus. In addition to its negative impacts on soil geotechnical properties, spent engine pollution adversely affects plants' height, root number, and root length of crop plants. Spent engine pollution can increase the amount of heavy metals at the topsoil beyond allowable or safe limits (Njoku *et al.*, 2012; Okoro *et al.*, 2013; Zitte *et al*., 2016; Iren and Ediene, 2017; Ogbeh *et al*., 2019). Haphazard disposing of spent engine oil in automobile mechanic shops poses threat to humans and ecosystems. Periodic monitoring and remediation of spent engine oil contamination is therefore necessary.

The physical and chemical techniques used in remediation of polluted soil costly, labour-intensive, distract the soil microflora and fauna, and alter the physical and chemical properties of soil (Javed and Hashmi, 2021). Consequently, biological remediation is now receiving attention a reliable option for treatment of contaminated soils (Javed and Hashmi, 2021). Among bioremediation technologies, phytoremediation and microbial remediation have received major focus of researchers (Javed and Hashmi, 2021).

Vermiremediation presents an ideal clean-up method, but its use is restricted to only mildly contaminated soil settings. Due to the fact that vermiremediation only makes use of earthworms' inherent soil-conditioning skills, ethical issues should not be a major concern. (Dada *et al.*, 2021). A technique that can potentially mitigate these challenges is indirect vermiremediation. Indirect vermiremediation involves the application of products rather than live earthworms in waste treatment. One of these earthworm products is vermicast tea. Vermicast tea is a strong liquid fertilizer that is nutrient- and microorganism-rich and helpful. It's simple to produce, great for boosting plant growth and soil health Arancon et al. (2004). Vermicast tea can be used to provide plants the nutrients and microbes they require to thrive, leading to healthier and more fruitful plants. Vermicast tea is obtained by soaking earthworm castings in water and passing the mixture through a fine linen or sieve.

Verimcast tea can also be seen as the liquid that drains off vermicomposting beds. Vermicast tea is rich in diverse aerobic microorganisms, degrading enzymes, and other beneficial compounds like nutrients and hormones (Cooper *et al.*, 2012). Rejón et al. (2013) and Chiang (2013) studied the potential of vermicast tea as a bioremediation agent of pesticides and oil and reported that the tea is an effective biodegradation compound.

Studies have confirmed that earthworms and their castings can be successfully deployed to regain the quality of polluted soil (Schaefer and Juliane, 2007; Gupta and Garg, 2009; Ekperusi and Aigbodion, 2015; Chachina *et al*., 2016; Njoku *et al*., 2017). Likewise, earthworms and their composts have been confirmed to have the ability to remediate oil polluted soil (Ekperusi and Aigbodion, 2015; Javed and Hashmi, 2021). However, not many studies have been done on bioremediation potential of vermicast tea. This study therefore aimed to evaluate the remediation potential of vermicast tea on spent engine oil contaminated soil. The use of vermicast tea as a potential remediation agent for soil contaminated with spent engine oil is significant because it can lead to improved soil health and increased agricultural productivity.

MATERIALS AND METHODS

The Study Area

This study was conducted in the Cell Biology and Genetics (Environmental Biology) laboratory of the University of Lagos, Akoka, Yaba, Lagos state, Nigeria. The University is situated in the North-East of Lagos, in the Lagos Mainland Local Government Area of Lagos State Nigeria. It lies along the Latitude 6° 30'N and longitude 3 ° 24'E (Nodza *et al*., 2014). The map of the study area is shown in Figure 1.

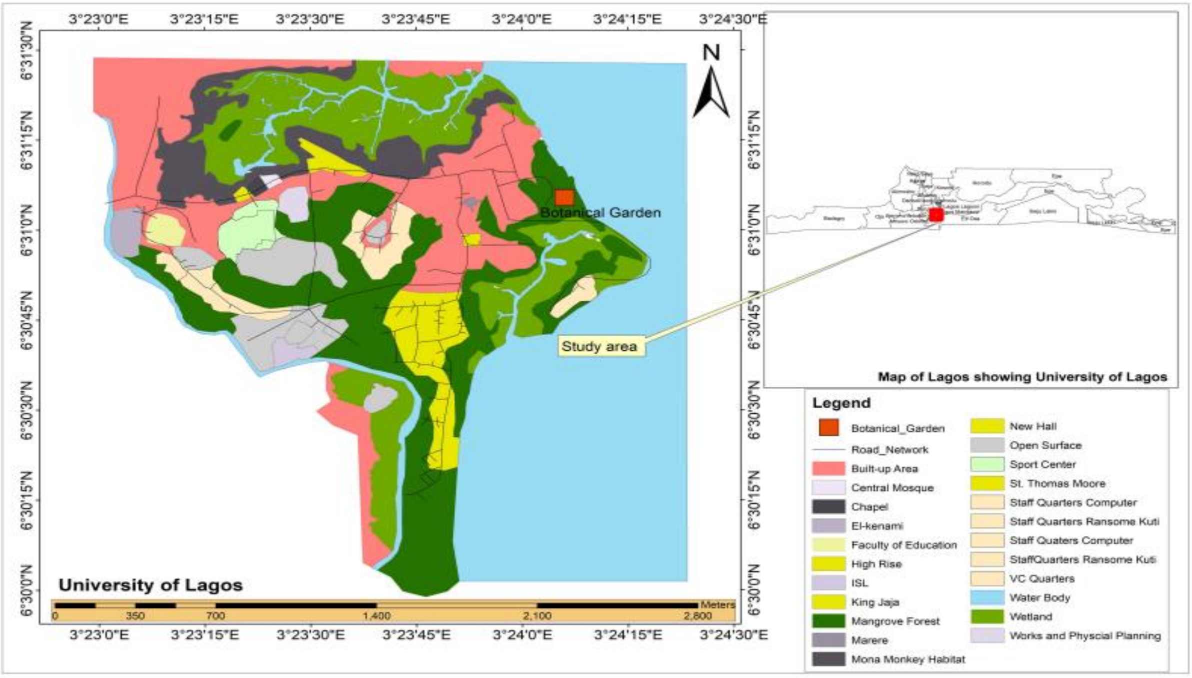

Figure 1: Map of university of Lagos showing the study site**.**

Sample collection, preparations, and study designs

The contaminated soil used for this study was collected from a motor repair shop in Ebute Meta East, Lagos State, Nigeria. The size of sieve that the soil was passed through was 5-mm. Turret (finger-like) earthworm castings were collected from unfarmed, vegetated fields on the main campus of the University of Lagos, Nigeria. The vermicasts (5 kg) were put into distilled water (5 liters) and allowed to disaggregate. The mixture was homogenized by mixing every six hours. Vermicast tea was obtained by filtering the mixture after 48 hours. Three dilutions of vermicast tea (20%, 50%, and 100%) were prepared using appropriate volumes of distilled water.

Twelve plastic containers were each filled with 700g of sieved, spent engine oil-contaminated soil. The containers were divided into four treatment groups A, B, C, and D. The contaminated soil in treatment groups A, B, and C was mixed with 20%, 50%, and 100% vermicast tea, respectively. Group D was not treated with vermicast tea and served as the control. The soil was thereafter left for 42 days. Samples of soil (100g) were taken from each container, and analysed for total petroleum hydrocarbon (TPH) and physicochemical parameters at day one (initial), day 21, and day 42.

Determination of the total Petroleum Hydrocarbon (TPH) contents of the soil samples

The TPH contents of the soil were determined after extracting the petroleum hydrocarbons in the soil using the procedures outlined in US EPA Method 3550c (US EPA, 2007). Ten grams (10g) of air-dried soil samples were weighed into a centrifuge tube, and 10 ml of an acetone-hexane (1:1) mixture was added to it. The mixture was sonicated and properly mixed by shaking manually for one minute. The mixture was thereafter put through to ultrasonic treatment for 15 minutes for total petroleum Hydrocarbon (TPH) extraction.

The TPH content of the soil was calibrated using gas chromatography and flame ionization detection (GC/FID). The oven temperature was programmed from 40°C (held for 3 min.) to 330 °C at 15 °C/min. and subsequently held for 10 min. 1µL of sample extracts were separately injected in splitless mode. The GC Injector and Detector temperatures were 250 and 320°C, respectively, Helium was used as the carrier gas, at constant flow. Percentage TPH loss was taken as percentage remediation. The percentage remediation of TPH and the contribution of vermicast tea to the TPH loss on different days was calculated using Orji-Oraemesi and Njoku (2022) formula:

$$\text{Quantity of TPH} = GC\ reading(\frac{mg}{L}) \times \frac{Volume\ of\ solvent}{Weight\ of\ sample} \times 100$$

$$\text{Percentage TPH loss} = \frac{initial\ amount\ of\ TPH\ at\ a\ given\ time}{initial\ amount\ TPH} \times 100$$

Contribution of the vermicast tea to TPH loss =Amount of TPH loss in soil with vermicast tea – Amount of TPH loss in soil without vermicast tea

$$\text{Rate of TPH loss} = \frac{percentage\ TPH\ loss\ for\ each\ treatment}{Number\ of\ \ days}$$

Determination of physicochemical parameters

The pH, CEC and moisture content of the soil samples were determined using the procedures outlined by Latimer and AOAC International (2016).The organic matter content was determined using the method described by Bernaldo *et al* (2019). The percentage moisture was calculated as:

$$\%\ \text{Moisture content} = \frac{initial\ weight(g) - final\ weight}{initial\ weight(g)\ of\ sample} \times 100$$

Statistical Analysis

The data obtained from laboratory analyses of the soil samples were subjected to inferential descriptive statistics.

RESULTS AND DISCUSSION

Concentration of total petroleum hydrocarbon, Percentage Remediation and Rate of Remediation Due to Vermicast Tea

Table 1 shows the total petroleum hydrocarbon content and percentage remediation of soil treated with various amounts of vermicast tea while Figure 1 shows the chromatograms of the petroleum hydrocarbons. The initial TPH values were high and decreased on day 21 and day 42 in both soil treated with vermicast tea and soil without vermicast tea. The percentage remediation of vermicast tea was higher on the second 21 days than on the first 21 days. The lowest percentage TPH loss occurred in soil treated with 50% vermicast tea (29.231%) while the highest TPH loss occurred in soil treated with 100% vermicast tea. Soil treated with vermicast tea led to a higher rate of TPH loss on day 21 than on day 42. There was a significant difference between the percentage of remediation at day 21 and at day 42 ($p< 0.05$) between soil treated with vermicast and soil without vermicast tea.

The degradation of the amounts of total petroleum hydrocarbons in the soils with vermicast tea as compared with the soils without vermicast tea as we observed in this study shows the potential of vermicast tea to degrade the amounts of total petroleum hydrocarbons in the soil. The reduction of petroleum hydrocarbons from the soils could be attributed to the degradation of petroleum products by vermicast tea. This is similar to what Ameh et al. (2013) reported that the use of *Eudrilus eugenia* for vermin-assisted bioremediation of petroleum hydrocarbon-contaminated mechanic workshop soils resulted in a higher reduction in the total petroleum hydrocarbon treated soil as compared to the samples without worms. Also, Dores-Silva et al. (2019) reported that using vermicast tea on spent oil-contaminated soil significantly reduced its overall hydrocarbon content and increased the diversity of its microbial life. The TPH loss was accelerated by the presence of vermicast tea, this shows that vermicast tea has the potential to remediate spent engine oil-contaminated soil. The higher percentage of remediation within 42 days agrees with the report by Milic *et al.*, (2009) where the highest reduction occurred from day 49 to day 96.

The rate of TPH loss was faster in the soil treated with vermicast tea than in the soil without vermicast tea. In soil with vermicast tea, the fastest rate of TPH loss occurred in the soil with 20% vermicast tea (2.203% loss/day) and the soil without vermicast tea had the slowest rate of TPH loss (1.902% loss/day). The higher rate of TPH loss in soil with vermicast tea as compared to the one without vermicast tea can be attributed to the presence of enzymes in the vermicast tea and this agrees with the study by (Kanaly et al, 2000). The higher remediation rate of the TPH loss in the first 21 days than in the second 21 in some treatments is similar to what Orji-Oraemesi and Njoku (2022) reported in their study that the remediation rate of crude oil-contaminated soil was higher in the first 45 days than in the last 45 days of the experiment. However, the higher remediation rate of TPH loss in soil without treatment in the first 21 days could be attributed to the existence of hydrocarbon-exacting bacteria and fungi already present in the soil.

Table 1: Concentration of total petroleum hydrocarbon, Percentage Remediation and Rate of Remediation Due to Vermicast Tea

Concentration of Vermicast Tea	Days	Initial TPH level (%)	Concentration of the TPH levels (%)	Percentage Remediation of TPH (%)	Rate of Remediation (% loss/day)
0%	21	120.349	72.281	39.941	1.902
	42	120.349	48.318	59.852	1.425
20%	21	120.349	64.664	46.270	2.203
	42	120.349	34.055	71.703	1.707
50%	21	120.349	85.171	29.231	1.392
	42	120.349	43.741	63.655	1.516
100%	21	120.349	67.638	43.799	2.085
	42	120.349	30.443	74.705	1.779

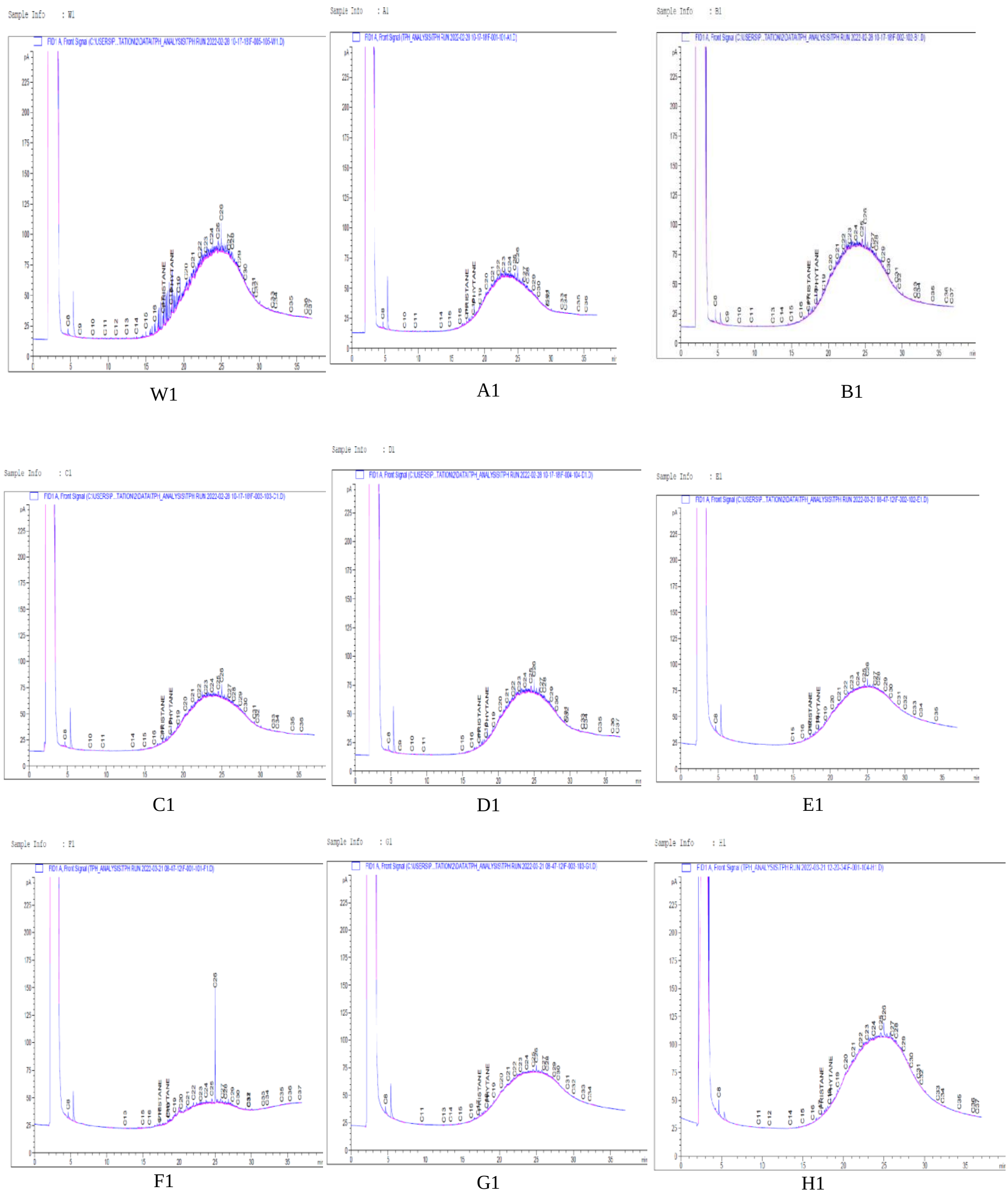

Figure 2: Gas chromatogram of hydrocarbon compounds graphical representation of spent engine oil contaminated soil with different concentrations of vermicast tea on day one (w1 = initial), on week 3(A 1=20%,B1=50%, C1 =100%, D1 =control) and on week 6 (E1 =20%,F1=50% ,G1 = 100%, H1 = control)

Contributions of vermicast tea to remediation of spent engine oil contaminated soil

Table 2 shows the contribution of vermicast tea to the percentage remediation of spent engine oil contaminated soil, The percentage remediation contributed by the vermicast tea to the spent engine oil contaminated soil on day 21 was 6.329% in 20% treatment,-10.710% in 50% treatment and 3.858% in 100% treatment. On day 42, the percentage of remediation contributed by the vermicast tea was 11.851% in 20%, and 14.852% in 100% treatment. The contribution of vermicast tea to the percentage loss of TPH was least in the soil treated with 50% vermicast tea (-10.710%) on day 21 and 3.805% on day 42 while the highest contribution of vermicast tea to the percentage remediation on day 42 was (14.852%) in 100% treatment. Generally, the vermicast tea contributed a higher loss of TPH on day 42 than on day 21 in all the treatments.

Table 2: Contributions of vermicast tea to remediation of spent oil contaminated soil

Days	Loss in soil without vermicast tea (%)	Loss in soil with vermicast tea for 20% (%)	Contribution of vermicast tea to the TPH loss for 20% (%)	Loss in soil with vermicast tea for 50 %(%)	Contribution of vermicast tea to the TPH loss for 50% (%)	Loss in soil with vermicast tea for 100% (%)	Contribution of vermicast tea to the TPH loss for 100% (%)
21	39.941	46.270	6.329	29.231	-10.710	43.799	3.858
42	59.852	71.703	11.851	63.655	3.803	74.705	14.852

Vermicast tea contains a variety of nutrients, microbes, and enzymes (El Sheikha *et al*, 2022). These enzymes present in the vermicast tea (alkane hydroxylase, alcohol dehydrogenate, lipase, esterase, alkaline phosphates, and protease) have some potential to support the development of good bacteria in the soil, these bacteria can breakdown petroleum hydrocarbons (Hou and Erica,2021). During this process, the bacteria use the hydrocarbons as a source of fuel and break them down into carbon dioxide and water. The soil can be safely reused when this procedure successfully removes petroleum hydrocarbons from it. However, TPH loss in the soil and how well vermicast tea treats petroleum hydrocarbon contamination are connected to a number of factors, like the concentration of petroleum hydrocarbons Kalia and Kaur., (2015). The kind of soil and the environmental conditions can all have an impact on how well vermicast tea treats petroleum hydrocarbon contamination hydrocarbons (Kalia and Kaur, 2015).

Impact of vermicast tea on the pH, Moisture, Cation exchange capacity (CEC), and Organic matter of spent engine oil contaminated soil oil

The physio-chemical properties of the soil with different amounts of vermicast tea and without vermicast tea are shown in Table 3. The pH values of the soil with vermicast tea and that of soil without vermicast tea showed an increase throughout day 21 compared to day 42 which showed a steady decrease throughout the treatment. The pH values of soil with vermicast tea on day 42 showed a decrease in all treatments compared to the initial pH. The pH values of soil treated with 50% vermicast tea on day 21 had the highest pH value (7.697±0.067) while soil treated with 0% vermicast tea on day 42 showed the lowest pH values (7.163±0.025). The soil's pH is a crucial physical characteristic since it greatly affects the concentration and uptake of solutes as well as the microorganisms that exist in the soil (Tale and Ingole, 2015). Soil pH is significant in controlling numerous physicochemical reactions in the soil (Njoku *et al*,2016). Slightly acidic circumstances promote the growth of native bacteria that aid in the breakdown of spent engine oil (Tale and Ingole, 2015; Uwidia and Uwidia, 2021). The untreated soil's initial pH was weakly alkaline to moderately alkaline, which is consistent with a report by Masakorala *et al*. (2014) that found that the pH of soil that had been contaminated with petroleum hydrocarbons ranged from weakly to moderately alkaline. In the soil without vermicast tea, there was an increase in pH and then a reduction, which contradicts the findings of (Polyak *et al*.,2018) reported that oil-contaminated soils' pH immediately decreased without the use of any sort of remediating agent. The negative correlation between pH and TPH loss we observed in this study may be due to an increase in pH that accelerates decreases in the solvability of hydrocarbon contaminants in the experiment (Nwaichi *et al*,2015).

The initial moisture content of the contaminated soil was 1.420%. The percentage moisture content of soil without vermicast tea on day 21 was 6.180±1.406% while on day 42 the moisture content dropped to 1.007±0.171%. For soil treated with vermicast tea, the percentage moisture content was lowest on day 42 for 50% treatment (0.653±0.157%). There was an observable, significant difference in the percentage moisture content for different weeks of treatment. ($p < 0.05$), there was higher moisture content on day 21 than on day 42 in all treatments. Moisture has an impact on how quickly microbes produce enzymes in general (Maphuhla *et al*., 2021). This is because enzyme production occurs during microbial metabolism, and this hastens the breakdown of petroleum hydrocarbons, which depend on moisture. The high moisture content we observed in this study may be attributed to the TPH loss we observed in this study. Soil moisture availability has an impact on the generation of enzymes, enzyme synthesis will be high if the soil has enough moisture (Maphuhla *et al*., 2021) Adequate moisture promotes the growth and activity of the bacteria that can degrade TPH. The high moisture content at day 21 may be attributed to the presence of vermicast tea which also served as a source of moisture to the contaminated soil. The low moisture content we observed at day 42 treatment, may be due to lack of continuous wetting of soil with vermicast tea which could lead to low permeability, low porosity, and high resistance to water penetration as a result of water droplets adhering to the hydrophobic layer of the spent engine oil contaminated soil (Njoku, *et al.*, 2008).The negative correlation between moisture, TPH loss and rate of TPH loss propose that high moisture content leads to high degradation of TPH loss and accelerate high rate of TPH loss, this indicate that remediation and rate of remediation is accelerated by high moisture content.

The initial organic matter content of contaminated soil was 33.020%. For soil without vermicast tea on day 21, organic matter was 35.513±11.530% while on day 42, the organic matter content dropped to 17.077± 2.752%. For soil treated with vermicast tea, the highest organic matter content was recorded on day 21 for 20% treatment (37.073±7.357%) followed by soil treated with 100% vermicast tea (37.013±5.886%) while the lowest organic matter was recorded on day 42 for 20% (15.537±1.95%). Generally, the higher organic matter content across all treatments was recorded in week 3 in all treatments than on day 42. Organic matter preserves soil fertility and guards against desertification, erosion, and soil deterioration (Yunaiati, 2018; Maphuhla *et al*, 2021). Organic matter is the major source of plant nutrients like phosphorus and nitrogen (Njoku *et al*. 2008). Organic matter increases the water content and infiltration rate of nutrients (Tale and Ingole, 2015) but in this study, we observed a positive correlation between the percentage of organic content and moisture content in the soil with vermicast tea. However, Nwaichi *et al*. (2015) reported that total organic matter content increased in unamended soil with merely the introduction of Organic matter, which sustains soil fertility. The decline in the percentage of organic matter observed at day 42 of this study could be attributed to a lack of continuous wetting of the contaminated soil with vermicast tea, this is close to the result of (Kathiresan *et al*.,

2014) that vermicast tea can be used to increase the amount of organic matter in the soil, which will improve the soil's fertility and have a good effect on plant growth.

The initial cation exchange capacity (CEC) of spent engine oil-contaminated soil was 2.720meq. In soil without vermicast tea on day 21, the cation exchange capacity increased to 3.843±0.182meq and then dropped in week 6 to 1.027±0.045meq. For soil treated with vermicast tea, higher CEC was observed in all the day 21 treatments, for 20% CEC was 3.92±0.414meq, for 50% CEC was 3.747±0.435meq and for 100% CEC 3.69±0.209meq while the lowest CEC was observed in day 42 treatments, for 20% CEC was 1.153±0.142meq, for 50% it was 1.127±0.050meq and for 100% it was 1.07±0.113meq. The highest CEC(3.92±0.414meq) was observed on day 21 in soil treated with 20% vermicast tea while the lowest CEC(1.027±0.045meq) was observed on day 42 in soil treated without vermicast tea. Generally, a higher increase in CEC was observed in all the day 21 treatments, and there was a decrease in CEC in all the day 42 treatments. The increase in the cation exchange capacity (CEC) of the soil treated with vermicast tea is similar to the study of Akinbile *et al*. (2016), who reported that utilizing vermicast tea to remediate crude oil-polluted soil enhanced CEC by up to 24%. This may be linked to the presence of advantageous microorganisms and enzymes in the vermicast tea. This is also similar to Ekechukwu *et al*. (2017), who reported that Vermicast tea boosted CEC by up to 60% during vermiremediation in soil contaminated with crude oil. The organic matter and helpful microbes and enzymes in the vermicast tea, along with the earthworms' physical modification of the soil structure, may be responsible for the rise in CEC. The negative correlation between TPH loss and CEC indicates that an increase in CEC will lead to a high reduction in TPH loss.

Table 3: Impact of Vermicast Tea on the pH, Moisture, CEC and Organic Matter of Contaminated Soil

Concentration	Day	pH	Moisture (%)	CEC (meq/100)	Organic Matter (%)
	0 (Initial)	7.310	1.420	2.720	33.020
20%	21	7.653±0.045	4.943±1.146	3.920±0.414	37.073±7.357
	42	7.210±0.079	1.360±0.925	1.153±0.142	15.537±1.956
50%	21	7.697±0.067	5.840±1.117	3.747±0.435	31.81± 6.192
	42	7.203±0.015	0.653±0.157	1.127±0.050	19.007±4.227
100%	21	7.577±0.029	3.913±0.118	3.690±0.209	37.013±5.886
	42	7.227±0.038	0.717±0.161	1.070±0.113	26.683±6.000
0%	21	7.593±0.214	6.18±1.406	3.843±0.182	35.513±11.530
	42	7.163±0.025	1.007±0.171	1.027±0.045	17.077± 2.752

Correlation between the Percentage Remediation, Rate of Remediation of TPH loss, and the Physiochemical Parameters

Table 4 shows the correlation between the physio-chemical parameters, percentage remediation, and the rate of remediation. pH, moisture, CEC, and organic matter have positive correlations with each other. The percentage remediation has a positive correlation with the rate of remediation (r=0.242) but a negative correlation with the pH, moisture, organic matter, and CEC of the soil. The rate of remediation of TPH loss has a negative correlation with moisture (r = -0.059) and a positive correlation with other physiochemical parameters of soil and percentage remediation of TPH.

Table 4: Correlation Between the Percentage Remediation, Rate of Remediation of TPH loss, and the Physiochemical Parameters

	pH	Moisture	CEC	Organic Matter	% Remediation	Rate of % remediation
pH	1.000					
Moisture	0.958	1.000				
***CEC**	0.986	0.960	1.000			
Organic Matter	0.901	0.827	0.917	1.000		
% Remediation	-0.907	-0.918	-0.901	-0.731	1.000	
Rate of % remediation	0.063	-0.059	0.039	0.414	0.242	1.000

Enzymes present in the vermicast tea

The enzymes present in the vermicast tea are shown in Table 5. The vermicast tea had 164.94±0.84μ Alkane hydroxylase (AHY), 129.47±2.26μ of Alcohol dehydrogenase (ADH), 14.94±0.33μ was recorded for Lipase, and Esterase had 1.81±0.01μ while Alkaline Phosphates recorded 84.39±0.57μ. Protease had 199.48±4.61μ.

Table 5: The Enzymes Present in the Vermicast Tea

Enzymes	Enzymes Activities(μ)
Alkane hydroxylase (AHY)	164.94±0.84
Alcohol dehydrogenase (ADH)	129.47±2.26
Lipase	14.94±0.33
Esterase	1.81±0.01
Alkaline Phosphates	84.39±0.57
Protease	199.48±4.61

CONCLUSION

We investigated the effect of vermicast tea on the remediation of spent engine oil-contaminated soil. From the study, we observed that the removal of spent engine oil from the soil was higher in 6 weeks than in the first 3 weeks (midway) across all the treatments. Generally, soils treated with 100% vermicast tea had the highest level of TPH loss compared to soils without vermicast tea. The impact of vermicast tea on the pH, moisture, organic matter, and cation exchange capacity of the spent engine oil-contaminated soil treated with vermicast tea was higher than in the soil without vermicast tea. It is recommended that future studies on the use of vermicast tea remediate spent engine oil-contaminated soil for a longer period.

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