Middle East Research Journal of Engineering and Technology
ISSN: 2789-7737 (Print) ISSN: 2958-2059 (Online)
Frequency: Bi-Monthly
DOI: 10.36348/merjet.2023.v03i02.001

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Assessment of Organic Level Contamination of Soils Surrounding Vehicle Repair Workshops in Wiiyaakara Town, Khana, River State, Nigeria

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Abstract: The aim of this study was to assess the level of contamination using soil organic matter measurement around vehicle repair workshops in Wiiyaakara, Khana, Rivers State, Nigeria. Sampling, preparation, and analysis of surface soils were carried out adhering to standard methods. Stations 1, 2 and 3 had pH of 5.034±0.1, 90±1.09 and 4.890±0.54 respectively. The TOC varied (%) from 2.967–3.916 with a mean value of 3.493±0.39, % TOM had range of 5.115–6.751 with a mean value 6.079±0.69 across the three studied stations. Similarly, % N ranged from 0.149 to 0.196, with a mean value of 0.177±0.02 while % Phosphorus was of mean, 7.098±1.13 but ranged from 5.545 to 8.194. Given that wastes are released into the environment without consideration for potential environmental effects, the wastes produced and disposed of into the environment by auto mechanic repair shops are of major concern. The result showed relatively higher variations in all the study parameters. This is an indication of contamination and should be well monitored to avoid potential pollution. Government should regulate the siting of mechanic workshops especially far from living homes and water bodies.

Keywords: Contamination, Soil, Assessment, Auto mechanic workshop, Wiiyaakara Town, phosphorus.

Research Paper

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How to cite this paper:
Timothy M. N *et al* (2023). Assessment of Organic Level Contamination of Soils Surrounding Vehicle Repair Workshops in Wiiyaakara Town, Khana, River State, Nigeria. *Middle East Res J. Eng. Technol*, *3*(2): 21-26.

Article History:
| Submit: 14.03.2023 |
| Accepted: 17.04.2023 |
| Published: 19.04.2023 |

1.0 INTRODUCTION

The soil is one of nature's unique treasures and is essential to all living things. It provides a home for a variety of animals, grows vegetables, feeds the flora with nutrients, holds minerals, and works as a water storage area. It serves as a conduit for the detritus food chain in addition to providing water and nutrients for plants. The soil is a multiphasic, incredibly active system that serves a variety of purposes: it is the primary source of biomass and synthetic-free materials; it promotes the expansion of biodiversity (habitat, species, etc.); it provides the primary source of carbon; and it also plays a significant role in human activities and the existence of the bionetwork (Horsfall & Spiff, 2013). Its natural quality has progressively deteriorated as a result of exploitation brought on by man's drive for ultimate needs, happiness, and comfort, leading to contamination and pollution from many sources. These interventions in natural processes have led to a number of environmental problems (Timothy *et al*., 2021). When assessing their potential exposure to humans, the fate of pollutants in soil is significant. The intricacy of the pathways specified by the emission sources, interactions with the soil surfaces, and changes in the chemical and biological conditions of the environment where the soil is located throughout time are all important factors.

According to Marcus *et al.*, (2017), environmental contamination, whether it be terrestrial or aquatic, poses substantial health risks to both plants and the animals that live there. Amongst the numerous pollutants that change the natural chemistry of the environment is the presence of metals above their natural levels.

According to Khan and Kathi (2014), vehicle repair shops discharge waste materials into the environment, including engine oil, transmission oil *etc*. Their inappropriate disposal causes hazardous fumes to be released during abrasion and adds to the metal contamination of the surroundings of vehicle repair businesses. Harrison and Chirgawi (1989) claim that while some waste may be burned in the open and the ashes left at the site, garbage is mostly thrown randomly with little regard to environmental effects.

The activities of the increasing number of car mechanic shops in Wiiyaakara town, which also has a daily market, schools, and considerable vehicular traffic as a result of its strategic location, need to be evaluated in order to protect the safety of the surrounding area. Since most locals depend significantly on agriculture as their sole source of income, this will increase awareness of the

health danger it poses and allow for adequate planning before installing a garage around cultivable property.

The purpose of the study is to assess the contamination level of the surrounding soils from car repair shops in Wiiyaakara town, Khana local government area, Rivers State.

2.0 MATERIALS AND METHODS

2.1 Study Area

The study focused on assessing the contamination level of the surrounding soils from two popular auto mechanic repair workshops in Wiiyaakara town. Wiiyaakara town is a popular town located about 15 km away from Bori, the traditional headquarters of the Ogoni people and the capital of the Khana local government area. It is located at the geographical coordinates of 4047'7.224" North and 706'57.87" East. As they are blessed with both arable land and fresh water, the indigenous people are peasant farmers, involved in the production of all kinds of farm products, fishing, and local dragging of sand and granite Due to its strategic position at the centre of the Khana local government area, it experiences heavy vehicular movement from motorists, connecting the northern, eastern, and southern parts of Khana as well as other local government areas such as Opobo and Andoni local government areas. In addition, it accumulated a premier secondary school, two primary schools, a primary health center, and a popular hotel. The presence of government institutions in the community attracts a huge number of people, resulting in heavy vehicle traffic and the presence of various types of automobiles, leading to an increase in the number of existing auto mechanic shops.

2.2 Sample Collection

Soil samples were collected twice a month for three months (October–December, 2019) from three (3) popular auto mechanic workshops using a hand auger. At each location, the surface soil samples were randomly collected from the same depth of 0–20 cm to form composite samples. These samples were representative of the top soil around each workshop. Additionally, control soil samples were taken at random (from a depth of 0–20 cm) from a pristine plot of land that was centrally located, at least 20 km from each impacted site, and where no industrial, commercial, or auto mechanic activities are currently being carried out (or have ever been). Thus, a total of twenty-four (24) soil samples were obtained and analysed in three months for six determinations. In each month, three (3) top composite soil samples from the study areas were collected twice, stored in sample bags and labelled as Station 1, Station 2 and Station 3, representing surface soil samples surrounding three selected auto mechanic workshops from Wiiyaakara Town; control soil samples were collected twice monthly, also within the space of three months, stored in polythene bags and labelled as Control sample (CS), and transported to a research laboratory (Jaros Inspection Services Limited, Km 2, Iwofe/College of Education Road, Rumuepirikom, Port Harcourt) for laboratory analysis.

2.3 Sample Preparation and Digestion

Using the conning and quartering approach, each composite sample was then bulked down to produce a representative sample. To prevent microbial degradation, all samples were air-dried to a consistent weight (Kakulu, 1993). The dried samples were homogenized by grinding them with a clean porcelain pestle and mortar, sieving them through a 2 mm plastic screen, and then storing them in plastic cans with labels. While soil samples for the physicochemical characteristics were analysed using normal analytical techniques.

3.0 RESULTS AND DISCUSSION

3.1 Soil Physicochemical Properties

The interactions and dynamics of metals within the soil matrix are known to be influenced by physicochemical factors such pH, total organic carbon (TOC), total organic matter (TOM), total nitrogen (TN), phosphorus (P), electrical conductivity (EC), and particle size distribution. Tables 1-3 gives the raw result of the monthly concentrations of the study soils. Table 4 summarises the findings of the physicochemical properties of the soils examined.

Table 1: Monthly determinations of the physicochemical parameters of station 1

Determinations	Parameters						Particles Size Density		
	pH	TOC	TOM	TN	P	EC	%Clay	%Sand	%silt
October 1st	5.03	2.967	6.751	0.149	5.548	94.33	33.41	55.37	11.22
2nd	5.00	3.357	5.115	0.191	5.545	74.94	25.3	54.26	20.44
November 1st	5.19	4.041	6.179	0.189	6.194	92.42	32.25	54.29	13.46
2nd	4.89	3.696	6.691	0.194	5.005	91.47	31.25	55.35	13.4
December 1st	5.10	3.916	6.745	0.173	5.433	92.45	33.24	55.38	11.38
2nd	4.92	3.593	6.739	0.196	5.545	93.61	32.05	57.45	10.50
Min. value	4.89	2.967	5.115	0.149	5.005	74.94	25.30	54.26	10.50
Max. value	5.19	4.041	6.751	0.196	6.194	94.33	33.41	57.45	20.44
Mean	**5.022**	**3.595**	**6.370**	**0.182**	**5.545**	**89.87**	**31.25**	**55.35**	**13.40**

Table 2: Monthly determinations of the physicochemical parameters of station 2

Determinations	Parameters						Particles Size Density		
	pH	TOC	TOM	TN	P	EC	%Clay	%Sand	%silt
October 1st	4.63	3.265	5.415	0.158	7.689	69.43	31.57	60.39	14.65
2nd	5.32	3.169	5.314	0.143	7.499	73.66	41.43	54.65	12.63
November 1st	4.99	3.064	5.218	0.149	6.988	80.01	31.35	51.48	13.52
2nd	4.79	2.87	5.012	0.156	8.219	75.72	21.20	55.29	11.28
December 1st	4.98	2.761	4.918	0.141	7.463	69.7	21.11	55.24	13.22
2nd	4.63	2.673	4.813	0.147	7.478	81.12	40.84	55.05	15.10
Min. value	4.63	2.673	4.813	0.141	6.988	69.43	21.11	51.48	11.28
Max. value	5.32	3.265	5.415	0.158	8.219	81.12	41.43	60.39	15.10
Mean	**4.890**	**2.967**	**5.115**	**0.149**	**7.556**	**74.94**	**31.25**	**55.35**	**13.40**

Table 3: Monthly determinations of the physicochemical parameters of station 3

Determinations	Parameters						Particles Size Density		
	pH	TOC	TOM	TN	P	EC	%Clay	%Sand	%silt
October 1st	4.49	4.211	7.05	0.201	8.189	92.43	22.59	70.71	12.27
2nd	5.38	4.121	6.952	0.189	8.159	90.76	25.51	66.69	15.36
November 1st	5.54	4.013	6.853	0.171	8.288	89.99	27.39	55.55	14.33
2nd	4.99	3.819	6.649	0.223	8.219	92.48	26.22	60.38	15.18
December 1st	5.91	3.714	6.55	0.194	8.133	90.7	23.08	54.22	14.49
2nd	4.83	3.618	6.452	0.198	8.176	92.46	27.01	55.15	13.87
Min. value	4.49	3.618	6.452	0.171	8.133	89.99	22.59	54.22	12.27
Max. value	5.91	4.211	7.05	0.223	8.288	92.48	27.39	70.71	15.36
Mean	**5.190**	**3.916**	**6.751**	**0.196**	**8.194**	**91.47**	**25.30**	**60.45**	**14.25**

Table 4: Summary of the mean concentrations of physicochemical properties of study soils

parameters	Stations			Range	Mean ± S.D	Mean of control
	1	2	3			
pH	5.022±0.16	4.890±0.54	5.190±1.09	4.890 – 5.190	5.034±0.12	4.480±1.00
TOC(%)	3.595±0.39	2.967±0.10	3.916±0.45	2.967 – 3.916	3.493±0.39	1.986±0.01
TOM(%)	6.370±0.65	5.115±1.00	6.751±2.11	5.115 – 6.751	6.079±0.69	3.434±0.43
TN(%)	0.182±0.02	0.149±0.00	0.196±0.00	0.149 – 0.196	0.177±0.02	0.099±0.00
P(mg/kg)	5.545±1.99	7.556±1.67	8.194±0.98	5.545 – 8.194	7.098±1.13	5.896±0.17
EC(µs/cm)	89.87±9.34	74.94±6.56	91.47±5.34	74.94 – 91.47	85.43±7.44	63.41±6.10
% Clay	31.25±4.62	31.25±5.02	25.30±5.10	25.30 – 31.25	28.28±2.43	16.35±1.54
% Sand	55.35±3.58	55.25±3.97	60.45±3.83	55.35 – 60.45	57.90±2.08	71.07±5.02
% Silt	13.40±1.55	13.40±1.39	14.25±1.27	13.40 – 14.25	13.82±0.35	12.58±1.22

3.1.2 pH

Table 1 presents the results of soil pH from the three auto mechanic workshops. The studied pH of the soil pH ranged from 4.890 to 5.190 with a mean value of 5.034±0.12. Station 3 has the highest pH 5.190±1.09 while Station 2 has the lowest value of 4.890±0.54. The values of pH obtained in this study are in the same range as those published by Pam *et al*., (2013), Osakwe (2014), Nebo *et al*., (2018), and Adebayo *et al.,* (2017), but lower than those reported by Sadick *et al.* (2015), Adewoyin *et al*., (2013), Odueze *et al.,* (2017), Olayinka *et al*., (2017), Ogunbunmi (2014), and Oguntimehim (2008) and higher than those reported by Oviasogie and Ofomaja (2007) in similar studies.

It was clear from comparing the results with the control that there was no discernible difference between the pH of the soil surrounding the auto mechanic workshops and the control, which is classified as extremely strongly acidic. Compared to the control, auto mechanic workshop 1 and workshop 3 had higher pH values (less acidic). This shows that the acidity of the soils was caused by operations in the auto repair workshops that caused acid from discharged motor batteries to leak into the soils. The pH of soil has a significant impact on the chemistry of the metals there (Gambrell, 1994). It affects how easily heavy metals move about in the soil. A reduction in soil pH leads to an increase in the solubility of metallic metals. It favours accessibility, adaptability, and redistribution, increasing their usefulness to plants (Timothy *et al*., 2021). The soils in and surrounding these places typically have an acidic pH, which is suspected to strongly favour the availability and mobility of heavy metals (Osakwe, 2014).

3.1.2 % Total Organic Carbon (TOC)

Table 4 shows the values of TOC analysed in the soils surrounding the three selected auto mechanic workshops. From the results, the TOC for Station 1 was

5.022±0.16; Station 2, 4.890±0.54; and Station 3, 5.190±1.09. Across the stations, the TOC varied (%) from 2.967–3.916 with a mean value of 3.493±0.39. Table 4 shows that Station 2 has the lowest TOC value of 2.967±0.10 while Station 3 has the highest TOC value of 3.916±0.45. These values are higher than those published by Akpoveta *et al.,* (2010) and lower than those by Osakwe (2014), but fall within the range of the results presented by Olayinka *et al.,* (2017) and Iyama and Edori (2021) in their study.

However, TOC values across the three auto mechanic workshops are relatively higher than that of the control and this by implication it shows that the activities of these workshops which is discharge of adopted oil, among others may have contributed to the significant increase in the level of the TOC in the study areas. This suggest the presence of degradable and compostable substances and thus, increase in microbial activities in the soils. The TOC values across the three auto mechanic workshops are, however, relatively higher than those of the control. As a result, it can be inferred that the activities of these workshops, which may have included the discharge of adopted oil among other things, may have contributed to the significant rise in the level of the TOC in the study areas. This means the soils may include more compostable and biodegradable materials, which would promote microbial activity.

3.1.3 % Total Organic Matter (TOM)

Table 1 presents the results of TOM analysis on the studied soils. The results revealed that Station 1 has a TOM value (%) of 6.370±0.65; Station 2, 5.115±1.00; and Station 3, 6.751±2.11. From the results obtained, Station 3 has the highest value of TOM with a mean of 6.751±2.11 and Station 2 has the lowest value with a mean of 5.115±1.00. Compared with the results, which ranged from 5.115–6.751 with a mean value 6.079±0.69 across the three studied stations, these values are in agreement with the results published by Pam *et al*., (2013), Sadick *et al*., (2015), Odueze *et al*., (2017), and Olayinka *et al*., (2017) in similar research.

The findings demonstrate that all of the values obtained are much higher than those from the control site when compared to those of the control. This implies that the everyday activities conducted in the workshops may have contributed to the elevated level of TOM in the soil near the study workshops. According to Akan *et al.,* (2013), carbon-based material is crucial for metal binding. According to Brummer and Herms (1982), carbon-based matter forms insoluble or soluble carbon-based metal complexes that immobilise heavy metals under strongly acidic conditions and mobilise them under weakly acidic to alkaline conditions.

3.1.4 % Total Nitrogen

Table 1 presents the percentage total nitrogen of the three selected auto mechanic workshops. The values are in Station 1, 0.182±0.02; station 2, 0.149±0.00; Station 3, 0.196±0.00. Station 3 has the highest TN value, while Station 2 has the least. The range value for the three locations ranged from 0.149 to 0.196, with a mean value of 0.177±0.02. This result is in consonance with those obtained in peculiar ecosystems (Ideriah *et al*., 2006; Ekeke & Okonwu, 2013; Kpee & Edori, 2021). This result is at variance with the high negative values recorded at Etche in Rivers State after charcoal production meaning rise in mean values in soil property (Chima *et al*., 2013). When comparing the findings from the soils surrounding the three auto mechanic shops with those from the control site, it is discovered that the values for the shops are all higher than those of the control site, and the significant increase in %TN of the soils around these shops could be attributed to the work done in these shops. These numbers are considerably less than those Osakwe (2014) published in comparable investigations.

3.1.5 % Phosphorus

The results obtained in Table 1 present the results of phosphorus in surrounding soils from the study locations. The results show that Station 1 has a mean value 5.545±1.99; Station 2, 7.556±1.67; and Station 3; 8.194±0.98. Ideriah *et al.,* (2006) had a range of 9.22 (wet season)-15.11 (dry season) and those of Kpee and Edori (2021) around Mgbuodia in Rumuolumeni as 3.6-6.4 corroborating similar range of result for this study. From the results, it shows that Station 3 has the highest phosphorus content of 8.194±0.98 while Station 1 has the lowest value of 5.545±1.99. With a mean value of 7.098±1.13, the computed value for the three car repair shops ranged from 5.545 to 8.194. When the data from the three auto mechanic workshops are compared to those from the control site, it is seen that the values for auto mechanic workshops 2, and 3 are all lower than the control; auto mechanic workshop 1 has a nitrogen value that is similar to the control.

3.1.6 Electrical Conductivity

Table 1 presents the results of the electrical conductivity of soil from the three auto mechanic workshops. From the results obtained, Station 1 has a mean value 89.87±9.34 µs/cm, Station 2 has a mean 74.94±6.56 µs/cm, and Station 3 has a value 91.47±5.34 µs/cm. It is observed from the result that Station 2 has the lowest EC value of 74.94±6.56 µs/cm while Station 3 has the highest EC level of 91.47±5.34 µs/cm. The result shows the mean values across the three stations with range varied from 74.94-91.47 µs/cm with a mean value of 85.43±7.44 µs/cm. These values were within the lower range recorded by Puyate and Rim-Rukeh (2008) in earlier studies for 18.9-156.4. When compare the results of the soils around the three auto mechanic workshops and that of the control site, It is observed from the figure that the electrical conductivity values across the three auto mechanic workshops are all higher than that of the control site, and by implication, the high electrical conductivity values in these soils is attributes to the presence of the workshops in the area under study.

The outcome displays the average values obtained from the three stations, with a mean value of 85.43±7.44 µs/cm and a range of 74.94 to 91.47 µs/cm. When comparing the results of the soils around the three auto repair shops with those of the control site, it can be seen from the figure that the electrical conductivity values in each of the three auto repair shops are all higher than those of the control site, and consequently, the presence of the workshops in the study area is responsible for the high electrical conductivity values in these soils.

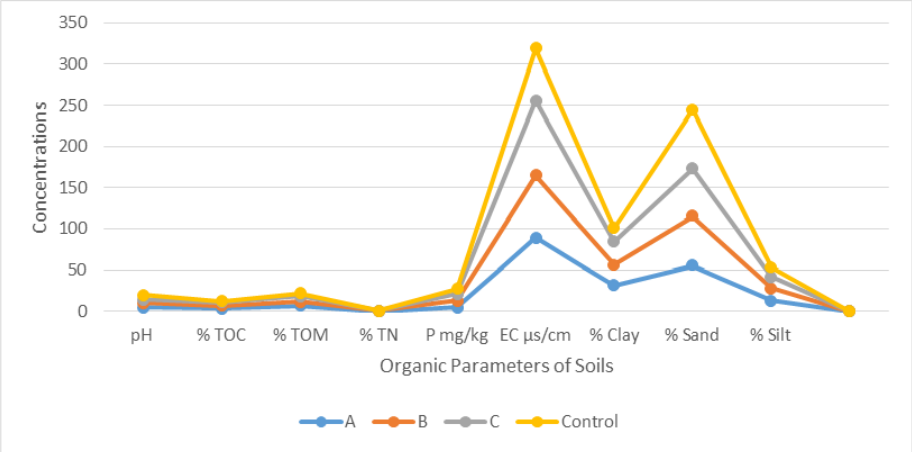

Figure 1: Trend of organic Parameters in Auto-mechanic Workshops

4.0 CONCLUSION

The study assessed the contamination level by evaluating the physicochemical properties of surface soil surrounding three auto mechanic workshops in Wiiyaakara Town, Khana, River State. The results of the analysis revealed that the mean concentrations of the studied physicochemical properties were all higher than that of the control sites except for % sand. High concentrations of heavy metal observed in the study were connected with the high carbon-based matter content as it favours heavy metal binding in the soil and immobilizes heavy metals at strongly acidic conditions thus, contributed to the high level of these metals, hence the contamination of the soil. The soils in and surrounding these places typically have an acidic pH, which is suspected to strongly favour the availability and mobility of heavy metals. This is an indication that the significant increase in concentrations of the physicochemical parameters is a direct consequence of the activities of the auto mechanic workshops.

REFERENCES

- Adebayo, A. J., Jayoye, J. T., Adejoro, F., Ilemobayo, I. O., & Labunmi, L. (2017). Heavy metal pollution of auto mechanic workshop soils within Okitipupa, Ondo State, Nigeria. *Academia Journal of Environmental Science*, 5(12), 215-223.
- Adewoyin, O. A., Hassan, A. T., & Aladesida, A. A. (2013). The impacts of auto-mechanic workshops on soil and groundwater in Ibadan metropolis. *African Journal of Environmental Science and Technology*, *7*(9), 891-898.
- Akan, J. C., Audu, S. I., Mohammed, Z., & Ogugbuaja, V. O. (2013). Assessment of heavy metals, pH, organic matter and organic carbon in roadside soils in Makurdi metropolis, Benue State, Nigeria. *Journal of Environmental Protection*, *4*(6), 18–28.
- Akpoveta, O. V., Osakwe, S. A., Okoh, B. E., & Otuya, B. O. (2010). Physicochemical characteristics and level of some heavy metals in soil around metal scrap dumps in some parts of Delta State, Nigeria. *Journal of Applied Science & Environmental Management*, *14*(4), 54-60.
- Brummer, G., & Herms, U. (1982). Effects of accumulation of air pollutants in forest ecosystems. D. Reidel.
- Chima, U. D., Adedeji, G. A., & Uloho, K. O. (2013). Preliminary assessment of the impact of charcoal production on physico-chemical properties of soil in rivers state, Nigeria. *Ethiopian Journal of Environmental Studies and Management*, 6(3), 286-294.
- Ekeke, C., & Okonwu, K. (2013). Comparative Study on Fertility Status of Soils of University of Port Harcourt, Nigeria. *Research Journal of Botany*, 8: 24-30. URL: https://scialert.net/abstract/?doi=rjb.2013.24.30
- Gambrell, R. P. (1994). Trace and toxic metals in wet lands-a review. *Journal of Environmental Quality*, *23*, 883-891.
- Harrison, R. M., & Chirgawi, M. B. (1989). Sources of metals in the soil. *Science of Total Environment Journal*, *83*, 13-34.
- Horsfall Jr., M., & Spiff, A. I. (2013). *Principle of environmental pollution, toxicology & waste management*. Onyoma research publications.
- Ideriah, T. J. K., Omuaru, V. O. T., & Adiukwu, P. U. (2006). Soil quality around a solid waste

dumpsite in Port Harcourt. *Afric J Ecol*, 44(3), 388-394.

- Iyama, W. A., & Edori, O. S. (2021). Comparative Study of Organic Parameters of Soils from Three Selected Universities in Port Harcourt Metropolis, Nigeria. *European Journal of Applied Sciences*, *9*(1), 21-34. https://doi.org/10.14738/aivp.91.9114.
- Khan, A. B., & Kathi, S. (2014). Evaluation of heavy metal and total petroleum hydrocarbon contamination of roadside surface soil. *International Journal of Environmental Science and Technology*, *11*(8), 2259-2270.
- Kpee. F., & Edori, O. S. (2021). Determination of Some Heavy Metals and Physicochemical Parameters of Soil, Vegetable and Some Fruits Grown in Mgbuodohia, Rumuolumeni, Port Harcourt. *Journal of Scientific and Engineering Research, 8(2), 186-193.*
- Marcus, A. C., Nwineewii, J. D., & Edori, O. S. (2017). Heavy metals assessment of leachate contaminated soil from selected dumpsites in Port Harcourt, Rivers State, Nigeria. *International Journal of Chemical Studies*, *5*(6), 1507-1511.
- Nebo, C. U., Udom, G.J., & Echirim, C. N. (2018). Contamination impact assessment of automobile mechanic workshop on soil and groundwater resource in Port Harcourt, Nigeria. *International Journal of Science Inventions Today*, *7*(3), 451-463.
- Odueze, J. C., Nwakonobi, T. U., & Itodo, I. N. (2017). Influence of physico-chemical characteristics of soils on heavy metal contamination in Makurdi, Benue state. *Journal of Environmental Science, Toxicology & Food Technology*, *11*(5), 84-92.
- Ogunbunmi, T. O. (2014). *Quality of Soil and Groundwater in automobile workshops in Akinyele Local Government Area, Oyo State, Nigeria*. http://80.240.30.238/handle/123456789/706
- Oguntimehim, I., & Ipinmoroti, K. O. (2008). Profile of heavy metals from automobile workshops in Akure, *Nigeria. Journal of Environmental Science Technology*, *1*(7), 19-21.
- Olayinka, O. O., Akande, O. O., Bamgbose, K., & Adetunji, M. T. (2017). Physicochemical Characteristics and Heavy Metal Levels in Soil Samples obtained from Selected Anthropogenic Sites in Abeokuta, *Nigeria. Journal of Applied Sciences & Environmental Management*, *21*(5), 883-891.
- Osakwe, S. A. (2014). Heavy metal contamination and physicochemical characteristics of soils from automobile workshops in Abraka, Delta State, Nigeria. *International Journal of Natural Sciences Research, 2*(4), 48-58.
- Oviasogie, P. O., & Ofomaja, E. (2007). Available Mn, Zn, Fe, Pb and physicochemical changes associated with soil receiving cassava mill effluent. *Journal of chemical society of Nigeria*, *31*(1), 69-73.
- Pam, A. A., Sha'Ato, R., & Offem, J. O. (2013). Evaluation of heavy metal in soil around auto mechanic workshop clusters in Gboko and Makurdi, central Nigeria. *Journal of Environmental Chemistry and Ecotoxicology*, *5*(11), 298-306.
- Puyate, Y. T., & Rim-Rukeh, A. (2008). Some physico-chemical and biological characteristics of soil and water samples of part of the Niger Delta area, Nigeria. *J Appl Sci Environ Manage*, 12(2), 135-141.
- Sadick, A., Amofo-Out, R., Acquah, S. J., Nketia, K. A, Asamoah, E., & Adjei, E. O. (2015). Assessment of heavy metal contamination in soil around auto mechanic workshop clusters in central agricultural station, Kumasi-Ghana. *Applied Research Journal*, *1*(2), 12-19.
- Timothy, M. N., Iyama, W. A., & Chidi, O. N. (2021). Evaluation of physicochemical characteristics of soils at auto mechanic workshops in Bori and environs, Rivers State, Nigeria. *Journal of Health, Applied Sciences and Management*, *5*(2), 178-186.
- Timothy, M. N., Marcus, A. C., & Iyama, W. A. (2022). Assessment of Trace Metal Content in Soils of Automobile Workshops around Bori Urban Area, Rivers State, Nigeria. *European Journal of Applied Sciences*, *10*(3), 209–221. https://doi.org/10.14738/aivp.103.12175