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Full Length Research Article

QUALITY ASSESSMENT OF THE PHYSICOCHEMICAL PROPERTIES OF SOILS FROM AUTOMOBILE WORKSHOPS AND TRANSFORMER INSTALLATIONS SITE IN LAFIA, NASARAWA STATE

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ABSTRACT
Analysis of soils for physical and chemical properties from selected auto-mechanic workshops and transformer installations in Lafia town, Nasarawa State was carried out according to standard methods. The levels of heavy metals concentration in the soil were assessed using Inductively Coupled Plasma Atomic Emission Spectroscopy (ICP-AES Thermo Fisher ICAP 6300). The results obtained for the physicochemical properties and concentrations of heavy metals in the auto-mechanic workshops and the transformer installations varied according to the sampling locations and the type of metals. It was observed that in the auto-mechanic workshops, the levels of these metals were: Co (0.50-0.72 mg/kg), Fe (1.36-1.96 mg/kg), Pb (0.53-0.69 mg/kg), Cu (1.49-1.79 mg/kg), Cd (0.94-1.12 mg/kg), Ni (0.05-0.10 mg/kg), and Zn (10.14-11.14 mg/kg) while that of the transformer site ranged: Co (0.88-0.96 mg/kg), Fe (1.35-1.77 mg/kg), Pb (0.06-0.08 mg/kg), Cu (0.75-0.92 mg/kg), Cd (0.05-0.11 mg/kg), Ni (0.12-0.15 mg/kg), and Zn (6.00-7.14 mg/kg). The values obtained for the physiochemical parameters of the soil samples varied with the nature of activities taken place where samples were collected. The pH of the soil from the auto-mechanic workshop ranged from: (5.87-6.20), conductivity (77.59-126 s/m), organic carbon (0.63-0.93), organic matter (1.08-1.60), sand (66.14-89.05), clay (4.91-14.95), silt (6.04-22.03), sulphate (2.16-3.14), and phosphate (2.16-4.08). Values obtained for the soil from the transformer installations site showed that the pH ranged (5.55-6.54), electric conductivity (86.22-121.92 s/m), organic carbon (0.46-0.97), organic matter (1.21-1.48), sand (74.14-89.47), silt (6.28-13-33), clay (4.25-12.53), sulphate (3.21-4.16), and phosphate (3.22-4.12), respectively. Although most of the physicochemical parameters of the samples analyzed are in conformity with the standard soil guideline range, the results obtained for heavy metals revealed that soils from some of the sampling locations are impacted negatively as observed in the significant concentrations of some heavy metals which are above the threshold limit for normal agricultural soil.

Keywords: soil, metals, analysis, auto-mechanic, transformer, pollution.

INTRODUCTION

The environment we live provide us with comfort and the energy needed for so many chemical and biochemical processes thereby creating a balance between these processes. However, when the natural balance is threatened there would be consequences. It has been observed in recent times that the environment is under constant threat from anthropogenic substances comprising of noxious and toxic chemical compounds. These unwanted pollutants are continuously being released into our soil, water, and air. Some of them originate mostly from domestic effluents, workshops, industrial and agricultural activities and many of them having ecological implications with negative effects on the health and well-being of the populace (Adesuyi *et al.*, 2016; Adesuyi *et al.,* 2018a; Njoku *et al.,* 2018; Anuoluwapo *et al*., 2019; Haodong *et al.,* 2022). Auto-mechanic workshops are establishments offering miscellaneous repair services ranging from simple and fast oil change to complex engine rebuilding. They also provide body repair and painting services. The operational processes in auto-mechanic workshops often involve the use of highly toxic and hazardous materials (Mohiuddin *et al.,* 2011; Kawo *et al.,* 2018). Automotive service and repair shops are among the main contributors of hazardous wastes due to the kind of activities and waste the generate. Wastes from automobile workshop activities can be categorized into either maintenance or materials handling wastes (Alabi *et al.,* 2013). Auto repair/automobile shops create many different types of waste during their daily operations such as overhauling of vehicle engines, metal fabrications and automobile panel beating. Some of the wastes associated with the mechanic workshops include spent oils, greases, lubricants and paints (Amusan *et al*., 2003; Maha, 2022). It is common knowledge that most of the automobile and mechanical workshops carryout these repair activities with disregard to environmental best practices. During the process reasonable amount of spent engine oil and metal scraps/fillings are deposited on the soil. The soils which now act as a sink is contaminated with the pollutant which eventually prevent soil microbial activities, immobilization of soil nutrients, lowering of soil pH and soil fertility status (Amos *et al.,* 2011). It has been observed that dangerous waste commonly created in auto-mechanic shops is from the solvents used to clean parts. These solvents have been reported to be extremely dangerous to humans and the environment. These wastes that are generated daily gradually accumulate and become a burden. Poor handling and management of the used fluids and solvents coupled with the improper disposal of large amounts of waste from different sources into water drains, streams, rivers, farm lands, open vacant plots is a common practice in Nigeria (Okonokhua *et al.,* 2007; Udousoro *et al.,* 2010). The indiscriminate dumping of used motor oil and other waste constitute environmental hazard with global implications. The waste may contain components such as: Pb, Cd, As, Cr and other potentially toxic metals.

Besides solvents, paint and other greases, the frictional wear of equipment, hydraulic fluids also contained some of these heavy metals (Pb, Cd, Zn, Fe, Cu) in substantial amount capable of threatening the life of the populace. Usually an automobile waste will consist of auto body scraps (Al and Zn), pieces of mild steel (Fe), electrical components and wires (Cu and Pb). In addition to these toxic metals many of the petroleum and associated products contained metals and other organic chemicals that can also be highly toxic (Ipeaiyeda *et al*., 2007; Adelekan and Adewole, 2011).

Some of the metals are considered serious pollutants because of their toxicity, persistency and non-degradable nature. The presence of the metals in soil within and around automobile mechanic workshops poses a threat to water bodies (surface and groundwater) within and away from their vicinity because the metals are mobile and can end up in the water bodies (Shinggu *et al.,* 2007; Nwachukwu *et al.,* 2011; Sarah, and Thaura, 2021). Heavy metals could make their way to humans through the food chain, where they perturb biological processes (Adesuyi *et al.,* 2015; Akoto *et al.,* 2008).

The adverse effect of heavy metals and their consequences include; reduced intelligence, attention deficit and behavioral abnormality and contribution to cardiovascular diseases in adults and children (Adelekan and Abegunde, 2011; Ahmed *et al.,* 2021). For children, ingestion of contaminated soil is the most significant pathway into the body system (Iwegbue *et al.,* 2006; Luter *et al.,* 2011).
Due to the growing concerns over the indiscriminate activities of mechanics and uncontrolled monitoring of discharge of transformer oils into the environment where this equipment are sited. With challenges of unprocessed waste from towns, cities such as lubricating oil, spent engine oil and other chemical compounds into the environment, there is the need to assess the level of threat posed by this menace. This study is therefore aimed at evaluating the pollution status of soil from transformer installations and mechanic workshops in Lafia town for monitoring and remediation strategy.

MATERIALS AND METHODS

Materials

All the chemicals used were analytical grade purchased from VWR International Ltd, UK. The solutions used were freshly prepared from analytical reagent grade chemicals and deionized water. The chemicals were used throughout the experiment without further purification. Samples were filtered using Whatman 540 filter paper before analysis. Prior to analysis all glass wares, plastic containers, crucibles, mortar and pestle were washed thoroughly with liquid soap, rinsed with distilled water and then soaked in 10 % HNO_3 solution for 24 h. The glass wares were re-washed with distilled water and dried in an oven at 80 ^oC for 5 h to minimize interferences by samples.

Sampling Location

The sampling sites are automobile mechanic workshop and Abuja Electricity Distribution Company (AEDC) transformer installation sites located in Lafia town, Nasarawa State, North central Nigeria (Fig.1). All the automobile sites and the transformer installation have been in operation for over fifteen years. Some of the wastes generated from these sites include solvents, spent engine oil, spent lubricants, paints, grease and transformer oil.

Soil Sampling Collection

The study area was divided into three distinct zones with at least two samples collected from each site (mechanic workshop, transformer installation and control samples from locations with no human activities taken place). 2kg of top soil samples were collected by scooping using auger hand trowel at a depth of 0-15 cm based on soil depths principle described by Awofolu (2005) in order to make a composite sample. A total of nine samples were randomly collected at the site and transferred into a clean sterile plastic container ready for treatment. The samples were then packed in clean polyethylene plastic bags for further treatment.

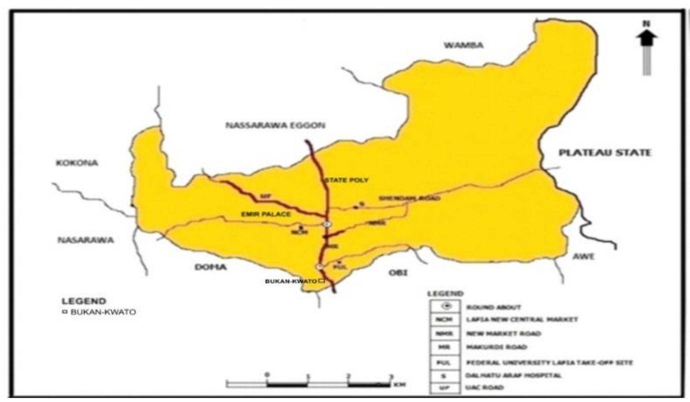

Fig.1: Map of Lafia the Sampling Location

Sample Preparation

The soil samples collected from the study area were first dried at room temperature (22 – 26 ˚C) to remove moisture, crushed and ground in porcelain mortar and pestle and were passed through a 2 mm sieve and stored in well labeled polythene bags ready for analysis. All soil extractions and digestions were carried out by dissolving the fractions in Aqua Regia in the ratio of 2:1 (75 % conc. HCl, 25 % conc. HNO_3).

Physicochemical and Heavy Metal Analysis of Soil

The pH of the soil samples was determined using a digital pH meter in 1.0:2.5 soil-water suspension, particle size distribution was determined using the hydrometer method, Cation Exchange Capacity (CEC) was determined by saturating the samples with sodium acetate, Electrical conductivity (EC) was determined in 1.0:2.5 soil-water saturation and organic matter using Walkley-Black method as described by Durak *et al*. (2010) while the sulphate and phosphate concentrations of the soils were determined according to the method by Lucatusu (2000). Heavy metal analysis of the samples was carried out using Inductively Coupled Plasma Atomic Emission Spectroscopy (ICP-AES Thermo Fisher ICAP 6300).

RESULTS AND DISCUSSION

Physicochemical characteristics of soil

The result of the analysis of the physicochemical characteristics of the soil samples (Tables 1 and 2) shows a trend suggesting the influence of automobile workshop activities on the physicochemical properties of soil in the mechanic workshop and transformer installations. The result showed that the soil pH ranged from

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5.87±0.2-6.20±0.5 and 5.55±0.3 – 6.02±0.3 in the mechanic workshop and transformer installation while the controlled sample ranged from 6.08±0.4-6.54±0.5, respectively. The value shows moderately acidic content which are within the Nigerian soil standards as reported by Abenchi *et al.* (2010).

The insignificant value (6.20±0.5) from Tudun kauri location is an indication of less human activities which does not threaten the quality of soil within that location. However, with the growing infrastructural and human population it will lead to the degradation of the soil. Although all values obtained are within the established standard for Nigeria soils. The low pH could be as a result of the contamination from the mechanic workshop. The organic carbon content varied in the samples investigated. The values ranged from 0.63±0.0 to 0.87±0.0 and 0.46±0.00-0.92±0.1 while the control sample was 0.93±0.1-0.97±0.1 (Tables 1 and 2). The organic matter of the soil ranged from 1.08±0.1-1.52±0.1, 1.21±0.00 and 1.25±0.00-1.60±0.2 in the mechanic workshop, transformer installation and the control soil. The organic matter content suggests active participation of microorganisms in the soil. The values obtained for the organic matter are within the established standard of 1-6% as indicated by Fred and Harold (2010). The electrical conductivity of the soil is a very important parameter as is used to measure soluble salt content in the soil and also as an overall indicator of the level of macro and micronutrients in the soil. Conductivity of the soil investigated ranged from 84.34±4.0-126.47±7.0 µS cm^{-1} and 90.02±7.3-121.92±0.1 µS cm^{-1} in the investigated soil and a ranged value of 76.97±0.2 -77.59±3.6 µS cm^{-1} in the uncontaminated (control) soil (Tables 1 and 2). This value indicates that the mechanic location waste contamination affects soil structure and modified its physicochemical properties which could be the reason for the significant values when compared with the control soil sampling location.

The particle size distribution puts the soils in the sandy or loamy and textural classification. The sandy nature of the soil suggests low sorption capacity for metal ions. Thus, oil and hydrocarbon oil related pollutant are known to result in reduced soil moisture availability or holding capacity, or increased moisture deficit in soils (Njoku et al., 2008). The trend in terms of significant value shows sand>silt>clay. This is consistent with the nature of the soil type in the studied location (Sha' ato *et al*., 2000). The sulphate mean concentrations ranged from 2.16±0.0 - 3.14 mg/L in the mechanic workshop and 3.21±0.1-4.16±0.3 mg/L in the transformer site while the control site ranged from 3.06±0.1 – 3.88±0.2 mg/L. The phosphate determined was found to range from 2.16±0.00 – 4.08±0.1 mg/L and 3.22±0.2-4.12 ±0.4 mg/L in the mechanic and transformer installation sites while the control site was 3.06±0.1-3.88±0.4 mg/L, respectively (Tables 1 and 2). The higher sulphate and phosphorus content in the control site could be attributed to organic waste and other decomposing materials. Petrochemical agents and other hydrocarbon oils from activities in the mechanic workshop and transformer installation could have affected the soil leading to the observed lower values of sulphate and phosphate in soil in those location sites. Such pollutants are known to also lead to reduction in organic nutrients of soil in addition to the interruption of microbial functions in affected soil (Anuoluwapo *et al.,* 2019).

Table 1: Physicochemical Parameters of Soil from Mechanic Workshop

Parameters		**Sampling location**			
	Tudun kauri	**Low-cost**	**Sabon pegi**	**Govt.College**	**Control**
Ph	6.20±0.5	6.03±0.3	5.87±0.2	5.96±0.2	6.08±0.4
Electrical conductivity	102.00±6.9	84.34±4.0	93.29±4.5	126.47±7.0	77.59±3.6
Organic carbon	0.63±0.0	0.81±0.0	0.87±0.0	0.71±0.1	0.93±0.1
Organic matter	1.08±0.1	1.39±0.2	1.50±0.1	1.22±0.1	1.60±0.2
Sand	80.42±5.2	89.05±5.2	72.94±4.8	66.14±4.0	88.12±5.0
Silt	9.18±4.3	6.04±2.2	12.11±5.0	22.03±5.0	6.14±2.2
Clay	10.40±4.4	4.91±1.9	14.95±6.1	11.83±4.6	5.74±2.0
Sulphate	3.14±0.1	2.54±0.0	2.16±0.0	3.09±0.1	5.06±0.1
Phospahate	4.08±0.1	2.54±0.1	2.16±0.0	3.09±0.1	6.02±0.1

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Table 2: Physicochemical Parameters of Soil from Transformer Installation

Parameters	Sampling location				
	Tudun gwandara	Lowcost Housing	Prison yard	Mararaba	Control
pH	6.11±0.4	6.18±0.5	5.55±0.3	6.02±0.3	6.54±0.5
Electrical conductivity	96.48±8.4	111.18±9.1	121.92±10.1	90.02±7.3	76.97±0.2
Organic carbon	1.23±0.0	1.48±0.1	1.35±0.1	1.21±0.0	1.25±0.0
Organic matter	0.92±0.1	0.84±0.0	0.73±0.1	0.46±0.0	0.97±0.1
Sand	80.02±5.4	74.14±4.0	89.47±4.9	76.56±4.0	79.42±4.1
silt	8.91±1.6	13.33±1.5	6.28±1.4	13.17±1.3	11.51±1.4
Clay	11.07±2.1	12.53±1.5	4.25±3.0	10.27±2.1	9.19±2.0
Sulphate	4.16±0.3	3.21±0.1	3.77±0.2	4.12±0.4	3.88±0.2
Phospahate	3.22±0.2	3.94±0.5	3.77±0.3	4.12±0.4	3.88±0.4

Heavy Metals Concentration in Mechanic Workshop and Transformer Installation Soil Samples

The automobile workshop and transformer soil contained significantly higher concentrations of all heavy metals analysed (Co, Fe, Pb, Cu, Cd, Ni and Zn) in comparison to the uncontaminated or control soil (Tables 3 and 4). As shown in the Tables, Zn was the predominant metal in all the soil samples. The highest concentration of 11.14 mg/kg and the least value of 10.14±0.3 was determined in soil samples from the mechanic workshop while the transformer installation the values obtained ranged from 6.00±0.7 – 7.14±0.8 mg/kg. In each case these values are lower than those obtained in the control soil (6.88±0.8-8.23±0.1). Next to Zn in terms of concentration is Fe, Cd, Cu, Pb and Co mg/kg. Studies had revealed that heavy metals such as V, Pb, Al, Ni, Cr, Fe and Cu are very high in spent engine oil compared to unused engine oil (Alabi *et al.,* 2013; Anuoluwapo *et al.,* 2019). Thus, the pattern of metal concentrations in the soil is automobile mechanic workshop > transformer installation > control soil. This is to be expected as shown in a similar study by Anuoluwapo (2019) where a mechanic workshop was found to contained high concentrations of metals due to discharge of grease and other lubricants. It was also found that the metals were detected in higher concentration than the transformer installation site and the control site. However, as shown (Table 3) the values obtained for most of the samples are within the standard limits of soils by Kabata-Pendias (1995). This result underscore the importance of the study to critical stakeholders in the health sector in view of the fact that heavy metals in soil are toxic and some of the soluble metals may find their way into soil, rivers, lakes and streams and may end up in the food chain. The resulting effect of this pollution may lead to geoaccumulation, bioaccumulation and bio-magnifications in the ecosystems.

Table 3: Heavy Metals Concentration in Mechanic Workshop

Metals	Sampling location					
	Tudun gwandara	Low cost Housing	Prison yard	Mararaba	Control	Limits in soil $mgkg^{-1}$
Co	0.65±0.1	0.72±0.1	0.66±0.1	0.50±0.1	0.43±0.0	25
Fe	1.96±0.1	1.40±0.1	1.36±0.1	1.73±0.1	0.94±0.0	NS
Pb	0.63±0.1	0.61±0.1	0.69±0.1	0.53±0.0	0.47±0.0	100
Cu	1.62±0.1	1.49±0.0	1.72±0.1	1.79±0.1	1.01±0.0	100
Cd	1.10±0.0	1.12±0.1	0.94±0.0	0.99±0.0	0.96±0.0	5
Ni	0.05±0.0	0.09±0.0	0.10±0.0	0.05±0.0	0.05±0.0	100
Zn	10.18±0.3	11.14±0.1	10.14±0.3	10.18±0.3	8.23±0.1	300

NS: Not specify

Table 4: Heavy Metal Concentration in Transformer Installation

Metals	Sampling location				
	Tudun gwandara	Lowcost Housing	Prison yard	Mararaba	Control
Co	0.94±0.1	0.88±0.1	0.91±0.1	0.96±0.1	0.72±0.1
Fe	1.48±0.1	1.35±0.1	1.77±0.1	1.36±0.1	0.99±0.1
Pb	0.08±0.0	0.07±0.0	0.07±0.0	0.06±0.0	0.03±0.0
Cu	0.84±0.1	0.92±0.1	0.81±0.1	0.75±0.0	0.61±0.0
Cd	0.09±0.0	0.11±0.0	0.05±0.0	0.05±0.0	0.02±0.0
Ni	0.12±0.0	0.12±0.0	0.14±0.0	0.15±0.0	0.10±0.0
Zn	7.10±0.8	6.18±0.8	6.00±0.7	7.14±0.8	6.88±0.8

CONCLUSION

The study on the quality assessment of the physical and chemical properties of soil from automobile workshop and transformer installation revealed variable concentration of metals in the samples investigated. The values obtained indicated that the soil from the automobile mechanic workshop contained significant concentrations of Co, Fe, Pb, Cu, Cd, Ni and Zn heavy metals than the transformer installation and the control soil. The significant concentration of these metals has negative tendency towards the environment. Similarly the physical parameter shows a similar trend. The controlled samples ranked better in terms of the quality of the parameters investigated when compared to the auto-mechanic workshop and transformer installation site. The observed pattern relates to the kind of activities being carried out at the different locations. More so that locations of the mechanic workshops are within residential areas across the town the tendency of increased pollution is apparent. With observed negligence in handling of waste, there exist the tendencies of seepage of spent oils with debilitating effect on humans. The observed pattern of the physicochemical parameters suggests that gradual changes are taken place in the soil especially the mechanic workshop due to increasing activities of automobile repairs. Thus, the change of soil properties observed is a strong indication of growing pollution level that requires remediation strategy.

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