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Assessment of selected heavy metals in soil samples from mechanical workshop in Azare Town, Katagum Locthe al Government, Bauchi State, Nigeria

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Abstract

This study evaluated the level of different selected heavy metals namely; Cadmium (Cd), Copper (Cu), Lead (Pb), Manganese (Mn) and Zinc (Zn) pollutants in soil sample, from Azare mechanical workshop (*Babban Gareji*), Katagum Local Government, Bauchi State, Nigeria. The soil were collected using stainless steel soil auger, from the surface to about 15cm soil depths, 4 core different samples randomly taken were homogenized in a clean plastic bucket and composited to represent a sample. The representative soil samples (4) were taken to the laboratory, dried, crushed and sieved to remove larger particles. Ten cube of centimeters ($10cm^3$) of 1:3 ratio of HNO_3 and HCl was added to 2.0g portion of the soil sample on a hot plate until a clear solution was obtained, the content of the beaker was then allowed to cool. Twenty cube centimeters ($20cm^3$) of distilled water was added and then filtered using filter paper (0.45µm) in $100cm^3$ volumetric flask. The solution was analyzed for the levels of Cadmium, Lead, Manganese, Copper and Zinc using Atomic Absorption Spectroscopy (AAS) technique. The results obtained showed the following levels for Cd 0.0265 mg/kg, Pb 3.0746 mg/kg, Mn 1.2466mg/kg, Cu, 2.4113 mg/kg and Zn 0.4557 mg/kg respectively for the soil samples from mechanical workshop, while that of control samples was Cd 0.0533 mg/kg, Pb 0.1398 mg/kg, Mn, 0.4890 mg/kg, Cu 0.2541 mg/kg and Zn 0.0376 mg/kg respectively. The results of heavy metals obtained from the analysis of soil from the mechanic workshops indicated that their concentrations are relatively higher than that of the control sites but lower than the WHO standard except for manganese which is higher than the WHO standard.

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1.0 Introduction

In Nigeria, selected heavy metals pollution is widespread especially from mechanic workshop. These mechanic workshops are found in open plots of land in the vicinity of urban towns and cities. It has been widely accepted that soil plays a key role in earth ecosystem. The very survival of mankind is tied on its productivity as a medium for plants to grow. Selected Heavy metals emanating from anthropogenic Automobiles introduce a number of toxic metals into the environment. Also the wear of auto tires, degradation of parts, grease, peeling paint and metal in auto-catalysts is sources of heavy metals pollution. This has led to elevated levels of selected heavy metals in mechanic workshop soils. This implies that water bodies (surface and ground water) within and away from the mechanic workshops may equally be polluted with these metals due to continuous interactions

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between soil and water and the high dispersion rate (Anegbe *et al*., 2018).

Heavy metals are generally referring to those metals which poses a specific density of more than 5g/cm^{3}and adversely affects the environment and living organism (Jarup, 2003).A heavy metal is not toxic unless when its concentration in the plants and animal exceeds a certain level that is required, some elements called trace elements or micro nutrients, have essential function in plants and animal cell this has been shown for Co, Cu, Fe, Mn, Cd and Ni, only when the internal concentration exceeds a certain threshold level they demonstrate toxic effects and then they are commonly termed heavy metals (Klaus, 2010). Heavy metals are significant environmental pollutants and their toxicity is the problem of increasing significance for ecological, evolutionary, nutritional and the environmental reasons (Jaishankar *et al*., 2014). Heavy metals represent a heterogeneous group of elements widely varied in their biological functions. Several heavy metals (cadmium, chromium, lead, mercury) are harmful to plants even in small quantities, while some other heavy metals such as copper (Cu), zinc (Zn), manganese (Mn) and iron (Fe) are essential for plant growth and development (Paul *et al.*, 2012). Pollution occurs when there is the potential for harm. Harm of man is not confined to physical injury but encompasses offence caused to any of his senses or harm to his property, therefore smells and noise which may not cause injury can constitute pollution. Harm to living organisms can include harm to their health or interference with the ecological systems of which they form apart (Ramamohana, 2017).

Air pollution is the introduction into the atmosphere of chemicals, particulates, or biological materials that cause discomfort, disease, or death to humans, damage other living organisms such as food crops, or damage the natural environment or built environment. Ghorani-Azim *et al*. (2016) reported that air pollution is a major concern of new civilized world, which has a serious toxicological impact on human health and the environment. It has a number of different emission sources, but motor vehicles and industrial processes contribute the major part of air pollution. According to the World Health Organization (WHO), six major air pollutants include particle pollution, ground-level ozone, carbon monoxide, sulfur oxide, nitrogen oxide and lead. Long and short term exposure to air suspended toxicants has a different toxicological impact on human including respiratory and cardiovascular diseases, eye irritation, skin diseases, and lon term chronic diseases such as cancer. Pollution, in its all types (air, water, land), means the entrance of some substances beyond the threshold concentration level into the natural environment which do not naturally belong there and not present there, resulting in its destruction and causing harmful effects on both humans/all living organisms and the environment. So, in land pollution as well, solid or liquid waste materials get deposited on land and further degrade and deteriorate the quality and the productive capacity of land surface, It is sometimes used as a substitute of or together with soil pollution where the upper layer of the soil is destroyed. However, in fact, soil pollution is just one of the causes of the land pollution (Savasan, 2022).

Water is one of the renewable resources essential for sustaining all forms of life, food production, economic development, and for general wellbeing. It is impossible to substitute for most of its uses, expensive to transport, and it is truly a unique gift to mankind from nature. Water is also one of the most manageable natural resources as it is capable of diversion, transport, storage, and recycling. All these properties impart to water its great utility for human beings. The surface water and groundwater resources of the country play a major role in agriculture, hydropower generation, livestock production, industrial activities, forestry, fisheries, navigation, recreational activities (Wang *et al*., 2012).

It has been justified that world health organization (WHO), Estimated that about a quarter of the diseases facing mankind today occur due to prolonged exposure to environmental pollution (Kimani, 2007). Heavy metal pollution of the environment, even at low levels, and their resulting long-term cumulative health effects are among the leading health concerns all over the world. Heavy metals are known as non-biodegradable, and persist for long durations in aquatic as well as terrestrial environments. They might be transported from soil to ground waters or may be taken up by plants, including agricultural crops (Oluyemi *et al.*, 2008). Plants grown around such areas are likely to absorb these metals either from the soil through the roots or from atmospheric contaminants through the leaves (Fifield and Haina, 1997). The soil contamination to consumers. For instance, plants accumulate heavy metals from contaminated soil without physical changes or visible indication, which could cause a potential risk for human and animal (Osma, (2014). Based on its persistent and cumulative nature, as well as the probability of potential toxicity effects of heavy metals as a result of consumption of leaves or fruits grown near the mechanical workshop. It is on this basis that this study was designed to determine the concentrations of selected heavy metals pollution in mechanic workshop (*Babban Gareji*) in Azare metropolis Katagum Local Government, Bauchi State. This research work was designed to assess level of some selected heavy metal pollution in mechanic workshop (*Babban Gareji*) in Azare metropolis, Katagum Local Government, Bauchi State. The essential selected heavy metals to determined are:

Manganese (Mn), Copper (Cu), Cadmium (Cd), Zinc (Zn), Lead (Pb). These elements were chosen because some are essential to human, plant and animal while others can pose danger to health even at low concentration. The aim of this research is to assess the levels of selected heavy metals pollution in mechanic workshop (*Babban Gareji*) in Azare metropolis, Bauchi State, Nigeria.

2.0 Materials and Methods

2.1 Description of the Study Area

The study was conducted in the mechanic workshop (*Babban Gareji*) in Azare, Katagum Local Government Area in North-East, Bauchi State, Nigeria. Azare, Bauchi –State, Nigeria was chosen for the present study. Azare is situated between 12° 17’ 0" North, 10° 21' 0" East. It has an area of 1,436 km² (554 sq. mi) and a population of 295,970 at the 2006 census.

Figure 1. Map of Azare, Bauchi State showing the study area
Key = Red circle area is the sampling mechanic workshop *Babban Gareji*

2.2 Soil Sampling

A total of four (4) soil samples were collected from four (4) selected points within (*Babban Gareji*) mechanic workshop of Azare town using standard soil auger, at the depths of 0-15 cm, representing 1 sample per location, respectively. Soil samples were collected at random from the four different locations (50 meters interval) at *Babban Gareji* mechanic workshop which were then mixed up to obtain a composite soil sample. The soil samples were placed in polythene bags and transported to the laboratory. The control sample was collected from State low-cost Azare. Shehu Shagari Street, where there are neither car repairs nor commercial activities, with no drainage influence.

2.3 Sample Treatment and Analysis

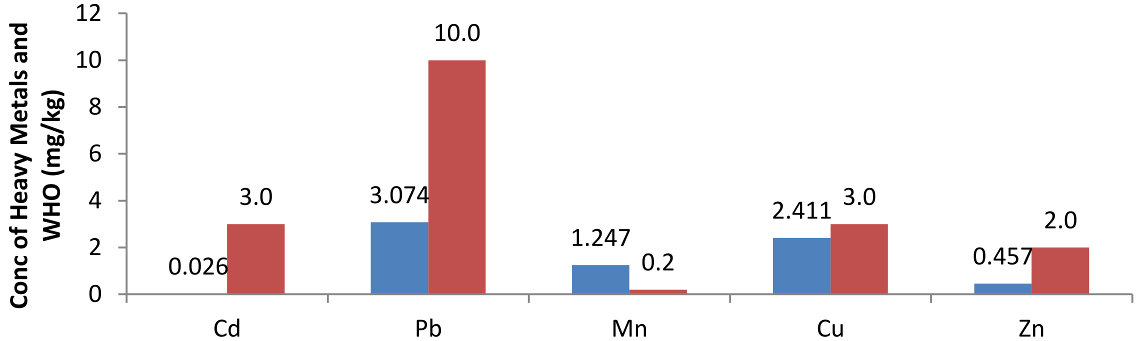
Soil samples were air-dried at room temperature for 7 days to avoid microbial degradation. The samples were homogenized and gently crushed repeatedly using a mortar and pestle, and passed through a 0.125mm sieve prior to analysis. Two (2g) of a well homogenized sample obtained from sample preparation procedure above was weighed into a standard Erlenmeyer flask and 12mL of freshly prepared aqua regia (HNO_3: HCl, 1:3) was added. The beaker was covered and the contents heated for 30minutes on the medium heat of a hot plate. The mixture was allowed to cool and then filtered through a Micro cellulose filter (0.45µm) into a 100mL standard volumetric flask. The filtrate was diluted to 100mL with de-ionized distilled water. Blank solutions were also prepared using aqua regia and de-ionized water. The digested samples solutions were analyzed using Atomic Absorption Spectroscopy (AAS) Agilent Technologies Series Model No. 240FS Standard solutions of the various heavy metals were analyzed. All soil samples were analyzed in triplicate to minimize error.

3.0 Results and Discussions

3.1 Results

The present study reports the selected heavy metal content (Cd, Cu, Pb, Mn and Zn) determined in soil samples collected from Azare mechanic workshop (*Babban Gareji*), Azare town Bauchi State, Nigeria.

The observed concentrations of (Cd, Cu, Pb, Mn and Zn) were compared with the recommended limit as established by the WHO. The mean concentrations and range of selected heavy metals found in the soil samples collected from the Azare mechanic workshop *Babban Gareji* are presented in Figures 2 and 3 below.

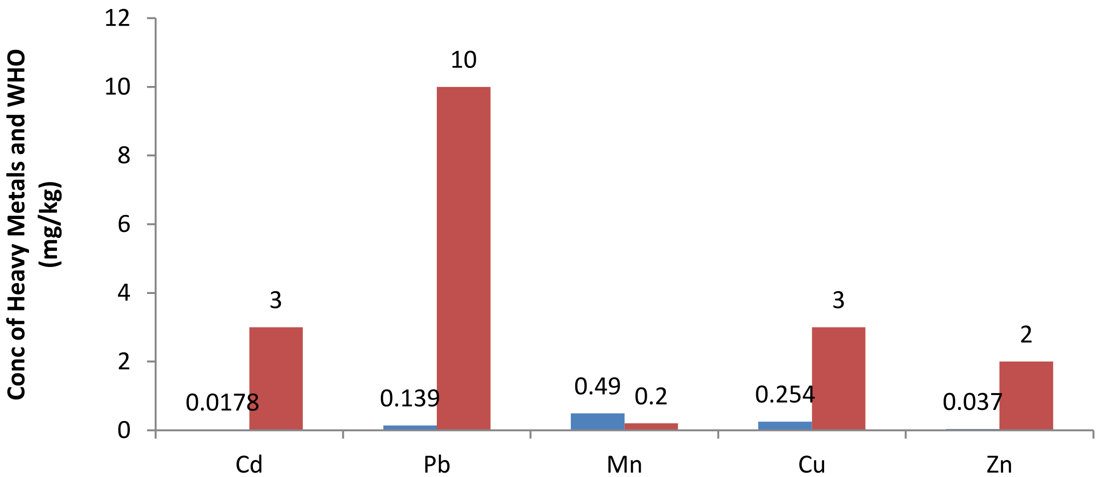


Heavy Metals

Figure 2. The mean concentration of selected heavy metals in the soil samples collected from mechanic workshop analyzed in (mg/kg) and WHO maximum permissible limits.

Legend

- Mechanic Workshop
- WHO Limits



Heavy Metals

Figure 3. The mean concentration of selected heavy metals in the soil samples collected as a control analyzed in (mg/kg) and WHO maximum permissible limits

Legends

- Control Samples
- WHO Limits

3.2 Discussions

Mean concentration obtained in this study is 0.0265 mg/kg and ranged from 0.0229mg/kg – 0.0300 mg/kg for Cadmium (Cd). The concentrations obtained in this work is relatively low compare to WHO permissible limit of 3 mg/kg, and that of control values 0.0533 mg/kg. This finding of elevated Cd concentration is consistent with that of (Rabe *et al*., 2018). Cd was detected in all the sample sites and control. Cadmium can enter the human body through smoking cigarettes, contaminated water due to landfills, certain foods such as shellfish, and mostly through handling the metal itself. Cadmium is a very toxic metal and needs to be handled with great caution. Lethal doses of cadmium affect various organs in animals which includes the liver, kidney, lungs, testes, skeletal, nervous and immune system and can also results in osteomalacia and osteoporosis. Cadmium is a category 1 carcinogen (Hyun *et al.*, 2015).

Menace of soil contamination by lead is epidemic. Over the years, it piles up and stored up in various significant parts of the body such as bones, aorta, kidney, liver and spleen. Lead can gain access into the human body via different pathways; these include ingestion (food (65%) and water (20%)) and inhalation (air (15%)).The high concentration of lead shows that the environment is polluted due to high activities such as fuel combustion and vehicle emission (Nwachukwu *et al*., 2010). Lead has toxic properties and it is found in large amount in many electronic devices (Nwachukwu *et al*., 2010). It is a major constituent of lead-acid battery used extensively in car batteries and tires which can end up in soil through the activities carried out in the work shop and through erosion. The concentrations of Lead in the soil of the automobile mechanic workshops ranged from 2.0362mg/kg to 4.1130 mg/kg with a mean value of 3.0746 mg/kg. The computed mean value of the concentration of the metal from the soil of the mechanic workshops was found to be lower than the WHO permissible value of 10 mg/kg, but higher than 0.1398 mg/kg of the soils from the control site. It is in agreement with the results obtained by (Nwachukwu *et al*., 2010).

Concentrations ranged from 1.1553 mg/kg to 1.4123 mg/Kg with the mean concentration of 1.2466 mg/kg and that of control 0.4890 mg/kg for Manganese (Mn). Mn levels obtained in this study are relatively higher than the WHO permissible limit values as 0.2 mg/kg. Although the concentration found for Mn is above the control level, there is, at present, no soil quality criteria established for Mn. Nevertheless, Mn in the soils examined need to be further monitored to prevent an explosive increase. Potential sources of Mn could be from used batteries, discarded metal rails, machinery parts and wastes from welding works and spray paintings of vehicles. Mn in trace amounts is an essential element for plants and animals, its optimum concentrations are very essential for respiratory enzymes and connective tissues development. High concentration of Mn results in Kidney failure, liver and pancreas malfunctioning as similarly reported by Jessica *et al.* (2020).

Particles are released into the atmosphere by windblown dust, volcanic eruption, anthropogenic sources, primary copper smelters and ore processing facilities. Copper accumulated in the liver and brain, contamination of drinking water with a high level of copper may lead to chronic anaemia. Also, copper toxicity is a fundamental cause of Wilson's diseases. The concentration of copper in the soil samples from the automobile mechanic workshops ranged from 1.4273 mg/kg to 4.2180 mg/kg with a mean value of 2.4113 mg/kg. Although the computed mean value of the concentration of copper obtained from the automobile mechanic workshops was higher than that of the control (0.2541 mg/kg), it is well below the WHO permissible limit of 3 mg/kg which is in consistent with (Inioluwa, 2021).

Despite the importance of trace elements like Zn and the significant role it plays in the metabolism and physiological wellbeing of various organisms, a higher level of its concentration can be very hazardous to the very existence of such organisms (Ogunkolu and Ogbole, 2019). It is vital in the process of protein synthesis and its concentration in the surface water is known to be fairly low as a result of its restrained mobility from its natural source i.e. the point where the rock weathering took place. The concentration of Zinc in the soil samples from the automobile mechanic workshops ranged from 0.2875mg/kg to 0.7357 mg/kg with a mean value of 0.4557 mg/kg. The mean value of the concentration of zinc from the automobile mechanic workshops was found to be higher than the mean value of 0.0376 mg/kg from the control site and lower than the permissible limit of 2 mg/kg set by WHO.

4.0 Conclusion

The results of heavy metals obtained from the analysis of soil from the mechanic workshops indicated that their concentrations are relatively higher than that of the control sites but lower than the WHO standard except for manganese which is higher than the WHO standard, both control and mechanic workshop. The higher concentration could be as a result of the minimum content of these metals due to the activities that were taking place around the mechanic workshop. The poor infrastructural development common in all the mechanic villages such as the lack of concrete floor workshops and tarred roads, lack of toilet and emission testing facilities, lack of engineering drainage system and storm water management facilities calls for immediate action of redevelopment and soil remediation in the mechanic villages. Mechanic villages properly planned and mechanics are to operate under a defined code practice, continuous education and training should be provided to the mechanics, emphasizing on the environmental implications of their poor occupational waste management. Code of practice and specific regulation guiding the establishment and the operation of mechanic villages must be in place and accordingly enforced. Therefore, it is recommended that the government and health agency should set standards or surveillance on activities done at the mechanic workshops to adopt a good waste management system to reduce the level of heavy metals accumulation and concentration in the soil. The people living around the mechanic workshop should understand the harmful effect pose by heavy metals in the environment and even food items. Public enlightenment campaigns should be intensified on the proper ways of depositing waste in the mechanic workshops.

Declarations

Ethics approval and consent to participate

Not Applicable

Consent for publication

All authors have read and consented to the submission of the manuscript.

Availability of data and material

Not Applicable.

Competing interests

All authors declare no competing interests.

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