EVALUATION OF HEAVY METALS IN AUTO-MECHANICAL DUMPSITES

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ABSTRACT: This research was carried out to analyse some selected heavy metals in auto-mechanic dumpsites at Abakaliki mechanical sites. Four dumpsites were selected based on geographical spread. An Atomic Absorption Spectrophotometer (205 Bulk Scientific Model) was used to analyse the digested soil samples for the selected heavy metal content. The results were compared with the control and the WHO permissible limits of heavy metals that should be found in the environment. Mean concentrations of Cd were in the range of 5.43 ± 0.22 - 8.27 ± 0.25 mg/Kg, Cr 6.46 ± 0.27 - 9.41 ± 0.18 mg/Kg, Cu 10.34 ± 0.30 – 16.41 ± 0.26 mg/Kg, Pb 20.49 ± 0.30 – 45.72 ± 0.00 mg/Kg, Mn 4.21 ± 0.17 – 6.77 ± 0.10 mg/Kg, Fe 24.50 ± 0.24 – 30.25 ± 0.32 mg/Kg, As 1.65 ± 0.11 – 7.24 ± 0.12 mg/Kg, Zn 19.45 ± 0.13 – 24.61 ± 0.10 mg/Kg. The results from all the locations were higher than the controls and World Health Organization (WHO) guidelines indicating a clear case of high levels of pollution. The heavy metal pollution may be due to waste from welding activities, forging and foundry activities, battery repairs, fuel and oil handling, painting and coatings done in these sites. With this level of heavy metal pollution, the environment will be threatened as these heavy metals can be eroded and washed into the water environment, making the water unfit for human consumption. Drastic Public enlightenment campaigns on waste disposal and its effects with comprehensive legislation are recommended. This research will expose the danger and effects of heavy metals in dumpsites to the occupant of such environment. It will also form a baseline of the environmental effects of indiscriminate dumping of refuse.

Keywords: Heavy Metals, Dumpsites, Pollution, Environment, Human Health

INTRODUCTION

Heavy metals are natural elements characterized by their relatively high atomic mass and their high density. Although typically occurring in relatively low concentration, they can be found all through the crust of our planet. Commonly, a density of at least 5 g cm^{-3} is used to define a heavy metal and to differentiate it from other, "light" metals. Other, broader definitions for "heavy metals" require an atomic mass higher than 23 or an atomic number exceeding 20; these definitions are highly error-prone and confusing. Both alternative definitions cause the inclusion even of nonmetals, resorting to the atomic mass criterion. The maximum number of elements classified as "heavy metals" rockets high to 99 out of the total 118 building blocks of our universe. Looking at the periodic table of elements, we learn that heavy metals *Sensu stricto* (according to the density criterion) occupy a large space, namely, columns 3–16, of periods 4 to 6, encompassing the transition metals, post-transition metals, and lanthanides (Duffus, 2002)

Some heavy metals like copper, selenium, or zinc are essential trace elements, with functions indispensable for various biological processes also driving the entire human metabolism (Mertz, 2002). Cobalt, a heavy metal, serves as the central atom within the vitamin B_{12} complex and plays a crucial role in the reductive branch of the propionic acid fermentation pathway (Stowers et al, 2014). The absence of this vital metal compound would result in the unavailability of the distinctive flavour profile characteristic of emmentaler cheese, highlighting its significance in culinary applications. Many heavy metals are of outstanding technological significance, e.g., iron, zinc, tin, lead, copper, tungsten, etc. Recently, different heavy metals have acted as the central atom of artificially designed "bioinorganic" catalysts for special chemical transformations (Terfassa et al., 2014). Moreover, among them, we find precious noble elements like gold, silver, iridium, rhodium, or platinum (Rao & Reddi, 2000). On the other hand, many of them, e.g., mercury, cadmium, arsenic, chromium, thallium, lead, and others, classically represent the "dark side of chemistry"; they exert toxic effects even at low concentrations (Duruibe et al., 2007). In this context, some heavy metals have gained dubious popularity by being the materials major crimes can be made of.

Heavy metals are natural components of the Earth's crust are in rather low concentrations between the low parts per million, ppb ranges (noble metals) and up to 5% (iron); here, heavy metals are mainly found chemically bound in carbonates, sulphates, oxide, or silicate rocks or also occur in their metallic, elemental form. Weathering and erosion resulted in their leaching and mitigation into soil, rivers, and groundwater. They cannot be degraded or destroyed. To a small extent, they enter our bodies via food, drinking water and air. As trace elements, some heavy metals (e.g. copper, selenium, zinc) (Duffus, 2002) are essential to maintain the metabolism of the human body. However, at higher concentrations, they can lead to poisoning.

One major source that increases heavy metal concentration in the ecosystems in Nigeria is the auto mechanic activities (Adewole & Uchegbu, 2010). These auto mechanic workshops are found in open plots of land in towns or cities (Nwachukwu et al., 2010, 2011). Within these workshops are people that specialize in engine handling, repair of the gearbox, and electrical aspect of auto repairs; others engage in repairs of brakes and steering, automatic or standard transmission engines, spray painting, recharging of auto batteries, welding and soldering. Each of these activities generates various types of waste (gasoline, diesel, spent engine oil and paint), which are disposed of by simply dumping in the surrounding areas. These introduce heavy metals in no small measure to the environment. Heavy metals in these wastes include cadmium (Cd), nickel (Ni), copper (Cu), lead (Pb), arsenic (As), chromium (Cr), tin (Sn), zinc (Zn), and so on which ends up in the environment (Yahaya et al., 2009).

Heavy metals are dangerous because they tend to bioaccumulate**.** Bioaccumulation means an increase in the concentration of a chemical in a biological organism over time compared to the chemical's concentration in the environment. Compounds accumulate in living things any time they are taken up and stored faster than they are broken down (metabolized) or excreted. Heavy metals are serious pollutants because of their toxicity, persistence and non-degradability in the environment (Yahaya et al., 2009).

The increasing pollution of heavy metals in the environment has become a global phenomenon (Malik et al., 2010; Linnik & Zubenko, 2000). Heavy metals can bio-accumulate and bio-magnify via food, which are assimilated, resulting in adverse health effects. Some common health effects associated with heavy metal poisoning include kidney damage, blindness and breathing-related problems (Agah et al., 2009). The high rate of chronic diseases, severe health problems and chemical attacks in our environment, which stem from the ingestion and absorption of toxic metals, has in recent times become more alarming and calls for concern. Hence, this study seeks to elucidate the effects of heavy metal contamination in our environment, especially the auto dumpsites where heavy human activities occur daily without monitoring and surveillance of any kind.

The study aims to determine the concentration of heavy metals in the soil from four auto-mechanic dumpsites at Abakaliki Mechanic Village, Ebonyi State.

MATERIALS AND METHODS

Study Area Description

Abakaliki is in Ebonyi State, South Eastern Nigeria. The area lies between latitudes 06 0 05' N and 06 0 25' N and longitudes 008 0 00 ' E and 008 0 18 ' E, (Fig 1). The area is a gently undulating terrain and lies within Ebonyi River Basin and the Cross River plains; in some isolated sub-areas, however, the topography is rugged.

Abakaliki, is a town and the capital of Ebonyi state, South Eastern Nigeria. It lies at the intersection of roads from Enugu, Afikpo, and Ogoja. An agricultural trade centre (yam, cassava, rice, palm oil and kernels) for the Igbo people, the town is located in an area known for its lead, zinc, and limestone deposits. Lead has been mined since precolonial times, and limestone is quarried for a cement plant at Nkalagu, 27 miles (44 km) west-northwest. A university is located in the town, and the Local Government Area has a population of 198,100 according to the 2006 national population census.

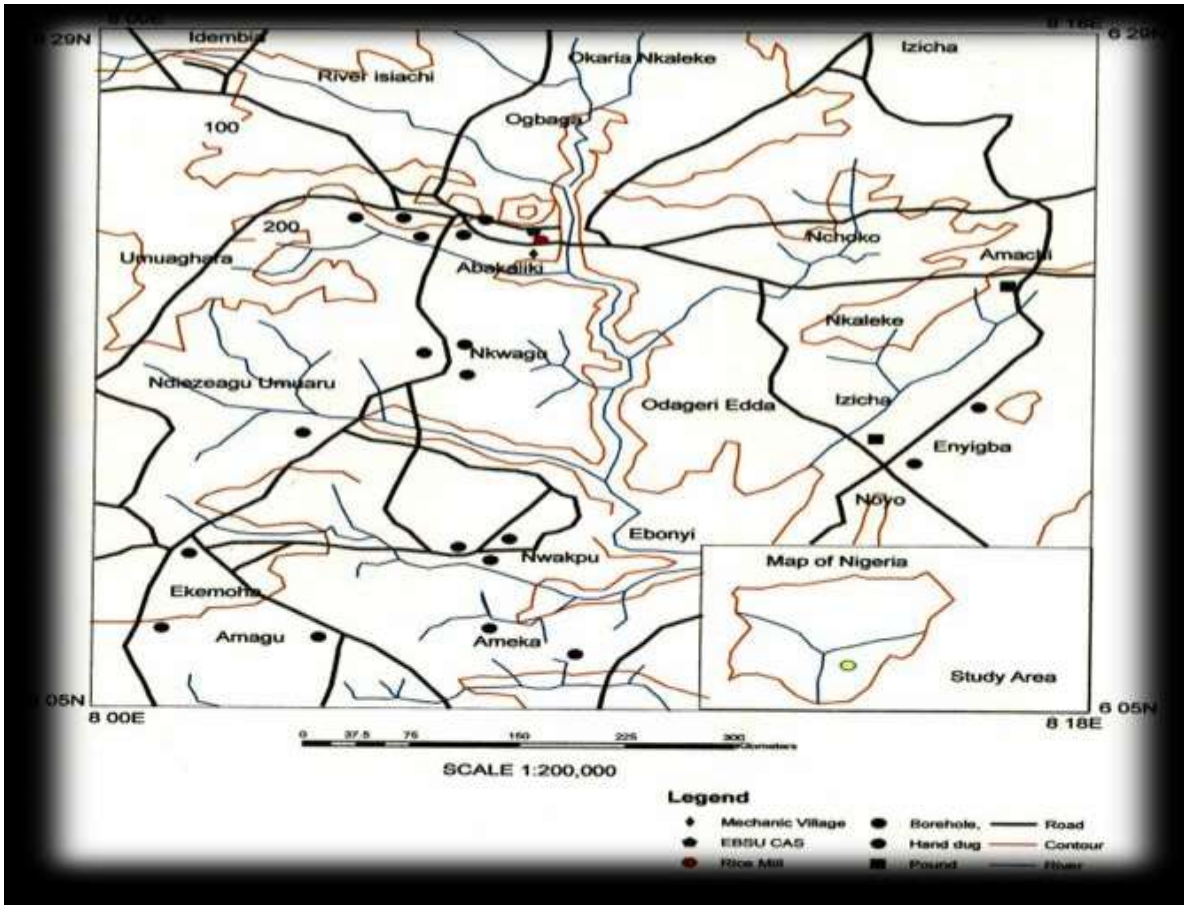

Figure 1: Map of Abakaliki (Ebonyi State Government Publication, 2022)

Sample Preparation, Digestion and Analysis

The samples were collected at three different sites in Mechanical Workshop Sites, Abakaliki, Ebonyi State, with uniform depths of between 5.5cm and 10 cm in triplicates. The method of preparation used was adopted from Okereke *et al.* (2019). The soil samples were air-dried in the laboratory for four days and transferred to an oven for complete drying. After drying, the samples were sieved using a 0.5 mm particle size mesh in order to obtain fine particles. The sieved soil sample was properly ground by using a ceramic and pestle mortar to enhance oxidation of the soil samples. After grinding, 2 g of the finely ground soil was accurately weighed and then transferred to a beaker and 30 ml of the acid mixture (4 parts H2SO4, 2 parts HCl and 1 part HNO_3) was added for digestion. The mixture was heated gradually at first and then more strongly until white fumes were no longer evolved. The viscous mass was mixed with hot dilute HCl acid and filtered in line with the method of Oladeji *et al.* (2016). The insoluble fraction, which consists of unchanged minerals and the silica liberated from the silicates, was washed with diluted HCl acid and hot water. The filtrate was made up to 100 ml in volumetric flasks before being transferred to well-labelled 120 mL bottles. The same procedure was repeated for the remaining soil samples. Blanks were prepared at concentrations between 0.00 and 10.00 mg/L and calibration curves were plotted to check for background contamination by the reagents used. The concentrations of elements of interest (Cd, Cr, Cu, Pb, Mn, Fe As and Zn) were determined using an atomic absorption spectrometer AAS 205 Bulk Scientific Model according to the method described by APHA (1998).

A hollow cathode lamp was installed for the desired element in the instrument, and the wavelength dial was adjusted to the setting appropriate for the element. The instrument slit width was set according to the manufacturer's suggested value for the element being measured. Thereafter, the instrument was turned on, and the lamp current was adjusted as suggested by the manufacturer. The instrument was allowed to warm up for 20 minutes, and the current was readjusted as necessary. The wavelength dial was adjusted until optimum energy gain was obtained. The lamp was aligned in accordance with the directions in the operating manual. The burner head was installed, and its position was adjusted. After turning the air on, the recommended flow rate was adjusted to give maximum sensitivity for the metal being measured. Acetylene gas was turned on, and the flow rate was adjusted, ignited and allowed a few minutes for the flame to stabilized. A blank of deionised water that has been given the same treatment and acid concentration as the standards and samples were aspirated. The instrument was zeroed. The standard solution was aspirated, and the aspiration rate was adjusted to obtain maximum sensitivity. The burner was adjusted horizontally and vertically to obtain maximum response.

At least three concentrations of each standard metal solution were selected. The response should have one concentration greater and one less than expected. A blank was aspirated, and thereafter, the instrument zeroed. Each standard metal solution was, in turn, aspirated into the flame and recorded. The absorbance was recorded. A calibration curve was prepared by plotting the absorbance of the standards against their concentrations.

The nebulizer was rinsed by aspirating distilled water that contained 1.5 cm^3 of HNO_3 per litre. The blank solution was then atomized, and the instrument was calibrated to zero. Following this, the sample was atomized, and its absorbance was measured. After changing the lamps, the procedure was repeated for each element. The concentrations of the metals were estimated using the calibration curve.

RESULTS AND DISCUSSION

Table 1 presents the mean concentrations of the heavy metals, in mg/Kg, found in the auto mechanical dumpsites at Abakaliki mechanical dumpsites, including the Control. Columns 1, 2, 3 and 4 show the triplicate analysis of the four sites A, B, C and D, their mean concentrations, and their standard deviations.

Table 1: Mean Concentrations (mg/Kg) of the Heavy Metals in the Four Dumpsites and Control

Parameters	Site A	Site B	Site C	Site D	Control	WHO Std
Cd	6.22±0.15	8.27±0.25	7.25±0.11	5.43±0.22	0.02±0	0.02
Cr	8.44±0.12	6.46±0.27	7.45±0.12	9.41±0.18	1.17±0.18	0.05
Cu	15.30 ±0.19	16.41 ±0.26	15.86 ±0.28	10.34±0.35	2.74±0.06	2.0
Pb	23.83 ±0.52	20.49 ±0.30	22.16 ±0.18	45.72±0.60	0.02±0	0.01
Mn	4.21±0.17	6.77±0.10	5.49±0.16	5.51±0.19	1.77±0.12	0.50
Fe	30.25 ±0.32	28.34 ±0.10	29.30 ±0.15	24.50±0.24	1.57±0.05	3.0
As	2.68±0.06	7.24±0.12	4.96±0.17	1.65±0.11	0.42±0.02	0.09
Zn	19.45 ±0.13	19.65 ±0.16	19.55 ±0.22	24.64±0.14	2.35±0.04	2.0

The results, as presented in Table 1, showed the mean Cadmium (Cd) concentrations in the dumpsites as 6.22±0.15, 8.27±0.25, 7.25±0.11 and 5.43±0.22 mg/Kg for sites A, B, C and D, respectively. Figure 2 shows that Site D recorded the lowest values while Site B recorded the highest concentration. The values recorded in the four sites when compared with the Control (0.02±0) were very much higher. These values recorded were higher than what was reported by Orji et al. (2018) on the same site, which averaged 0.07mg/Kg. Occupational exposure to Cd may occur in the alloy, battery, glass works, and electroplating activities at the sites, and this can also be taken into the lungs through industrial dust. Studies have shown that a high accumulation of cadmium in the body leads to painful degenerative bone disease, kidney failure, and lung diseases (Orji et al., 2018).

The results in Table 1 showed the mean concentrations of Chromium (Cr) in the dumpsites as 8.44±0.12, 6.46±0.27, 7.45±0.12 and 9.41±0.18 mg/Kg for Sites A, B, C and D, respectively, and these did not agree with the values that were recorded for Control 1.17±0.18mg/Kg. Figure 2 showed that Site B recorded the lowest value while Site D had the highest value, and all these when compared with the Control, were higher. The results observed were higher than the ones reported by Ogah et al. (2020) on the same site, which ranged between 1.97 and 4.65mg/Kg. Fang et al. (2019) submitted that metallurgical, refractory and chemical industries introduce chromium into the soil, and this subsequently creates health problems for the workers of the sites. This ranges from dermal, renal, and neurological diseases to the development of several cancers, including the lungs, larynx, bladder, kidneys, testicles, bone, and thyroid (Fang et al., 2014).

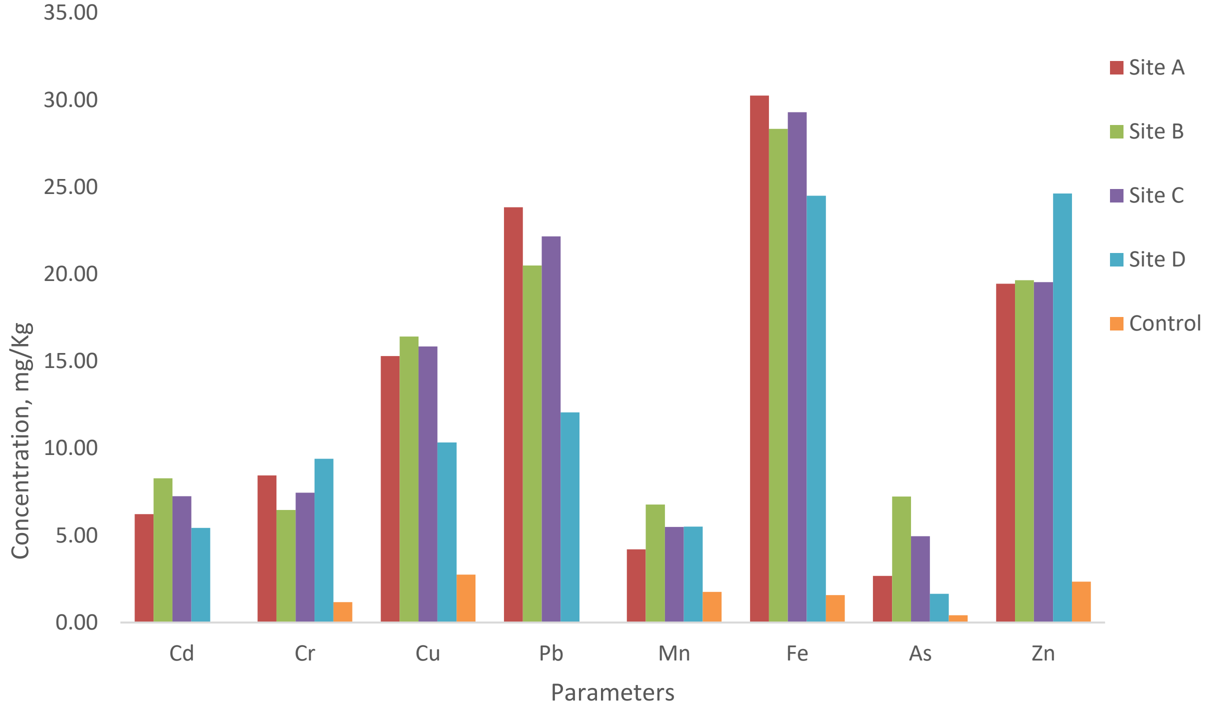

Figure 2: Bar Chart Showing the Mean Concentrations of the Heavy Metals the Dumpsites and the Control

The results observed from the analysis show that the mean concentration of Copper (Cu) in Site A is 15.30±0.19, B 16.41±0.26, C 15.86±0.26 and D 10.34±0.35, while the control was 2.74±0.06 mg/Kg. The results showed that the mean concentrations of Cu were higher than the control, as shown in Figure 2. Site B recorded the highest value, while Site D recorded the lowest value. The value observed was very low when compared with the value submitted by Ogah et al. (2020), which was 89.35 mg/Kg on the same site. Research has shown that Cu could help in the regulation of water, seed production, and disease resistance in plants and animals to maintain the central nervous system, production of blood haemoglobin and prevention of anaemia (Bernard & Ayandeji, 2020). However, excess Cu may result in liver and kidney damage, stomach and intestinal irritation and brain tumours (Wuana & Okieimen, 2011).

The results in Table 1 showed that the mean concentration of Lead (Pb) in Site A recorded 23.83±0.52, B 20.49±0.30, C 22.16±0.18, D 45.72±0.60 and Control 0.02±0 mg/Kg. The results showed that the mean concentration of Pb in all the sites was higher than the control. Figure 2 shows that Site B recorded the lowest value of 20.49±0.30 and Site D shows the highest value of 45.72±0.60 mg/Kg. Ogah et al (2020) submitted Pb mean concentration in the range of 162.88-257.77, and these were higher than the results of our findings. The results of our findings were far higher than that submitted by Orji et al. (2018), which were in the range of 0.90 to 2.40 mg/Kg. Lead, no matter the concentration, is very harmful to man and has even led to loss of lives. Lead can affect almost every organ and system in your body leading to neurological disorder, encephalopathy, arthrosclerosis, brain damage, dementia, cancer anaemia etc. Ogah et al. (2020). The elevated level of Pb in the dumpsites may be due to the dumped auto-mechanic waste of welding activities, lead (Pb) used in lead (Pb) battery cells, painting and coating done in these areas.

The results in Table 1 show that the mean concentrations of Manganese (Mn) in the four sites in the dumpsites were A 4.21±0.17, B 6.77±0.10, C 5.49±0.16, D 5.51±0.19 and the Control was 1.77±0.12 mg/Kg. Figure 2 shows that Site A recorded the lowest concentration of 4.21±0.17 while Site B recorded the highest value of 6.77±0.10, and these were higher than the Control 1.77±0.12 mg/kg, revealing the presence of Manganese in the auto-mechanic sites. However, the concentration of Mn in the four sites was higher than the WHO permissible limits of 0.50mg/kg. The results of our findings were not in agreement with the submission of 41.2±0.80 to 50.1±0.50 (Adekunle et al, 2021). The levels of Mn in the soil make the soil to be contaminated at the four sites. Manganese are found in abundance in the earth's crust and is detrimental when it is in high concentrations above the WHO permissible limit. Manganese helps the body form connective tissue, bones, blood clotting factors, and sex hormones. It also plays a role in fat and carbohydrate metabolism, calcium absorption, and blood sugar regulation (MountSinar, 2023).

The results in Table 1 show that the Iron (Fe) mean concentrations in the four auto-mechanic sites were Site A 30.25±0.32, B 28.34±0.10, C 29.30±0.15, D 24.50±0.20 and Control 1.57±0.05 mg/Kg. Figure 2 shows that Site D recorded the lowest concentration of Fe while Site A was the highest. The results, when compared with the Control, were higher than the Control and far below the WHO permissible limit of 3.0. The results recorded were not in agreement with the findings of Beetseh and Ocheje (2013), which were in the range of 40.98 to 50.80 mg/kg and were higher than our findings. The increase in iron (Fe) content in the workshops may be due to dumping of iron(Fe) scrap, unused body parts of vehicles, tin cans, solvents, hydraulic fluid, spent lubricants, etc at these workshops (Ayeni, 2010; Abidemi, 2011). Too much iron can lead to life-threatening conditions, such as liver disease, heart problems and diabetes (Mayoclinic, 2023).

Table 1 shows that the mean concentrations of Arsenic (As) in the soil samples in the Sites A was 2.68±0.06, B 7.24±0.12, C 4.96±0.17, D I.65±0.11 and Control 0.42±0.02. The results in Figure 2 show that Site D was the lowest in concentration, while Site B was the highest. All the concentrations of As observed at the sites recorded higher concentrations of As than the Control and the WHO permissible limits, which was 0.09 mg/kg. The levels of arsenic concentration value obtained were higher than those reported by (Iwegbue, 2013) and Idugbose et al. (2014). However, the concentration of the As falls above the permissible limit of the As as stipulated by WHO. At this level in the soil, Arsenic has numerous concentrations in the soil in all sites respectively, meaning the soil in all sites is contaminated. The implication of this is that prolonged accumulation of arsenic in humans can cause central nervous system damage and may be detrimental to human health Idugbose *et al*.,(2014).

Results in Table 1 show the mean concentrations of Zinc (Zn) in the auto mechanic sites as Site A 19.45±0.13, B 19.65±0.16, C 19.55±0.22, D 24.64±0.14 and Control 2.35±0.04. Figure 2 shows that Site A had the least value while Site 24.64 recorded the highest concentration. All the results recorded were higher than the Control and WHO permissible limit of 2.0 mg/Kg. The values obtained were higher than the one submitted by Beetseh & Ocheje (2013) that ranged from 0.166 to 67.38 mg/Kg and 3.80 to 4.32mg/kg Ogunkolu *et al* (2019). Onder *et al* (2003) reported that high concentration of Zinc in heavy traffic zones indicate that fragmentation of car tyres are the likely source of the metal. Other possible sources of zinc in relation to automobile traffic, in addition to wearing off of brake linings, are losses of oil and cooling liquid of vehicles and wearing of road-paved surfaces (Osakwe, 2009). The high concentration of zinc recorded in the study area is probably a result of the access road leading to many towns and many vehicles move to and fro from the towns. High concentrations of Zn can cause flu-like nausea symptoms like fever, coughing, headache and fatigue (Ajmera, 2023). High level of Zn can hinder your body's ability to absorb copper, potentially leading to a deficiency in this key mineral over time Ajmera, 2023.

Conclusion

The heavy metals were analysed using an atomic absorption spectrophotometer to give a good reflection of the results. The auto mechanic dumpsites were heavily polluted with Cd, Cr, Cu, Mn, Pb, Fe, As and Zn based on the concentration of heavy metals obtained and when compared with the World Health Organization. This is as a result of man-made contributions, which might partly result from the use of metal-containing additives as lubricants. There was an indication of an uneven distribution of the metals in soils from various sites, though there was no significant difference in metal distributions between them.

Recommendations

1. That government should provide appropriate places that will serve as automobile villages where auto repairs will be carried out and at safe distances from human habitation;
2. Continuous monitoring and further studies on the levels of these heavy metals should be carried out on a regular basis to ascertain long term effects of this pollution;
3. Kept at safe distances from human habitation. Measures should be put in place to legislate against the deposition of metal pollutants in the environment;
4. Education and legislation on management of wastes in place such, such as auto-mechanic sites, should be intensified to forestall the effects of heavy metal-related wastes on the soil environment.

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