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Assessment of Heavy Metal Concentration in Soil and Water Samples from Automobile Mechanic Workshops in Owo, Ondo State, Nigeria

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ABSTRACT

The level of heavy metal concentration in the soil at various automobile mechanic workshops and the water from the hand dug wells in the vicinity of the workshops were assessed in this study using standard scientific methods. The results showed a significantly ($p<0.05$) higher level of Zn than other metals assessed. The highest concentration of the metals were found in the soil at Ikare junction with higher value of the metals obtained in the topsoil where 1.27, 100.65, 75.57 and 207.88 mg/g were recorded for Cd, Pb, Cu and Zn respectively. Cd was not detected in the soil at Eyinogbe workshop site. Moreover, the metals showed a linear reduction across the soil strata as the concentration of these metals were higher at the surce while low at the 20-30 cm depth. Furthermore, in the water samples from hand dug wells in the vicinity of the workshops, Cd was detected in only 2 (22.22%), Pb in 6 (66.67%), Cu in 7 (77.77%) and Zn in 9 (100%). The level of these metals found in the water exceed the upper limit permissible by World Health Organization, therefore, there is a need for an awareness campaign by the regulatory agencies to discourage indiscriminate discharge of automobile mechanic workshop wastes into the environment.

***Keywords:** Heavy metals, Soil, Water, Automobile mechanic workshop, Cd, Pb, Cu, Zn.*

1. INTRODUCTION

Heavy metals are chemical elements mostly within density greater than 4g/dm^3 found in all kinds of soils, rocks, and water in terrestrial and fresh water ecosystem. The very low general level of their content in soils and plants as well as the definite biological role of most of them makes them microelements [1]. They occur in typical background concentrations in these ecosystems. However, anthropogenic releases can result in higher concentration of these metals relative to their normal background values, when these occur; heavy metals are considered serious pollutants because of toxicity, persistence and non degradable condition in the environment, thereby constituting threat to human beings and other forms of biological life [2].

Automotive service and repairs shops are the largest small quantity generators of hazardous waste. Auto-repair shops create many different types of waste during their daily operations. These include use of oil and fluids, dirty shop rags, used parts, asbestos from brake pads and waste from solvents used for cleaning parts. All of which are expensive to dispose off and sometimes hazardous [3-5]. The most dangerous waste commonly created in auto – repair shops is from the solvents used to clean parts. Many of the chemicals that make up the cleaning solvent are extremely dangerous to human and the environment [6]. If not handled properly, these chemicals can find their way into the air we breathe, the water we drink, our soil, lakes, and streams. Many part cleaner and solvent are dangerous to workers health, used oil may contain components such as lead, cadmium, barium and other potentially toxic metals [7].

Heavy metal pollution refers to cases where the quantities of these elements in soil are higher than the maximum allowable concentrations, and this is potentially harmful to biological life at such locations [8]. Large quantities of pollutants have continuously been introduced into ecosystems as a consequence of urbanization and industrial processes, as observed by Begum *et al.*, [9], metals are persistent pollutants that can be biomagnified in the food chains, becoming increasingly dangerous to human beings and wildlife. Globally, the problem of environmental pollution due to heavy metals has begun to cause concern in most large cities since this may lead to geo-accumulation, bioaccumulation, and biomagnifications in the ecosystems [10].

Chronic problems associated with long-term heavy metal exposures are mental lapse (lead); toxicological effects on kidney, liver and gastrointestinal tract (Cadmium); skin poisoning and harmful effects on kidneys and the central nervous system (arsenic). There is a link between long term exposure to copper and decline of intelligence in young adolescents [11]. Cadmium exposures result in kidney damage, bone deformities, and cardiovascular problems. The threat that heavy metals pose to human and animal health is aggravated by their low environmental mobility, even under high precipitations, and their long term persistence in the environment [12].

All these have deleterious effects on agriculture, and ultimately human beings. Short-term and long-term effects of pollution differ depending on metal and soil characteristics [13]. In the after-effect of heavy metal pollutions, the role of pollutant bounding or leaching increases, which determine their bioavailability and toxicity. Heavy metal pollution of the soil also has negative side effects on plants showed a phytotoxic effect of soil collected from abandoned mechanic village and reported that the soil depressed and inhibited plant growth. Therefore, this study was aimed at determining the presence of heavy metals in the soil of automobile mechanic workshops in Owo city and the ground water in their immediate environment [14].

2. MATERIALS AND METHODS

2.1 Soil Sampling

Soil samples was collected from automobile mechanic workshops at the three major mechanic villages in Owo city, Ondo state Nigeria namely; Eyinogbe, Ikare Junction and Owaluwa. The samples were obtained in triplicates at each site at the depth of 0 to 10cm, 10 to 20 cm and 20 to 30cm, using a depth calibrated soil auger. Each sample was immediately placed in a fresh plastic bag and tightly sealed then transported to the laboratory for analysis.

2.2 Water Sampling

Water samples were collected from three hand dug wells at different distances (10m, 15m and 20m) away from the workshops, following standard water sampling procedure. Each sample was directly collected into a factory-fresh 1.5L plastic bottle which has been previously washed with 1:1HNO_3 with cap securely tightened. Few drop of HNO_3 was added to the samples to prevent loss of metals, bacteria and fungal growth. Temperature and pH of the water samples were taken at the time of collection. After collection, the bottles were placed inside ice coolers for transportation to the laboratory where they were then transferred to the refrigerator for analysis.

3. SOIL AND WATER ANALYSIS

3.1 Soil treatment

The soil samples was spread on a cleaned plastic sheet placed on a flat surface and air-dried in an open air in the laboratory under room condition for 24 hours. The soil was grinded to remove lumps and then sieved on a 2mm sieve.5g of the sample was taken from the sieved soil sample and put into a beaker. 10ml of nitric per chloric acid, ratio 2:1 was added to the sample. The sample was digested at 105^{o}C. HCl and distilled water, ratio 1:1 was added to the digested sample and the mixture was transferred to the digester again for 30min. The digestate was removed from the digester and allowed to cooled at room temperature. The cooled digestate was washed into a standard volumetric flask and was made up to mark with distilled water.

3.2 Water treatment

Water samples was digested by measuring 100ml into a beaker and 5ml concentrated HNO_3 was added. The sample was boiled slowly on a hot plate and then evaporated to about 20ml. 5ml concentrated HNO_3 was further added and covered with a watch glass and heated. Concentrated HNO_3 was continually added and heated until the solution appears light coloured and cleared. It indicated that the digestion is completed. 2ml concentrated HNO_3 was added and slightly heated to dissolve the remaining residue. The beaker and watch glass were rinsed with distilled water and it was then transferred into a 50ml volumetric flask, allowed to cooled and was made up to mark with distilled water.

3.3 Determination of Heavy metals

Determination of heavy metals (Pb, Cu, Cd and Zn) in water samples was done in duplicate in an Atomic Absorption Spectrophotometer (AAS Model 210/211 VGP) after calibrating the equipment with different standard concentration of each element prior to the introduction of the sample solution. The absorbance reading was obtained at the wavelength of each element.

4. RESULTS AND DISCUSSION

4.1 Results

The results of the heavy metal concentrations in the three soil samples analyzed in this study is shown in Tables 1-3. The results showed variations between the sites and across the depth of the sampling in soil samples. The concentration of the heavy metals in the soil taken from the Ikare junction workshop were higher than those found in samples taken at Eyinogbe and Owaluwa respectively. This might be connected to the age and bulk of work done at the various centres. Mechanic village at Ikare junction is by far the busiest of the three major mechanic workshops in Owo and it was the first to be established probably due to its location at road intersect leading to Ikare, Benin and Akure from Owo.

Table 1: Heavy metals concentration (mg/g) of soil at three different depths at the automobile mechanic workshop at Eyinogbe.

Depth	Cd	Pb	Cu	Zn
0 to 10cm	Nd	13.3±0.57	16.55±0.08	84.69±0.53
10 to 20cm	Nd	48.10±0.28	16.51±0.08	18.92±0.18
20 to 30cm	Nd	16.75±0.64	18.18±0.12	4.16±0.02

Table 2: Heavy metals concentration (mg/g) of soil at three different depths at the automobile mechanic workshop at Ikare junction

Depth	Cd	Pb	Cu	Zn
0 to 10cm	1.27±0.01	100.65±0.919	75.57±0.77	207.88±2.21
10 to 20cm	0.86±0.02	53.8±0.42	57.36±1.470	189.91±1.26
20 to 30cm	0.74±0.02	55.80±1.41	63.10±1.39	139.93±1.15

From the results, the soil samples had a very high concentration of Zinc (Zn) at all the depths under study. Cadmium (Cd) had the least concentration. The concentrations of Copper (Cu) and Lead (Pb) varied at the different depths and also at the different auto mechanic sites. Also, the concentration of Cd, Pb and Zn decreased with depth i.e the highest concentrations were recorded on the soil surface (0 to 10cm) while the least concentration was recorded in the 30cm depth except at Eyinogbe where Pb concentration was least in the topsoil. This shows a linear correlation of reduction of heavy metals with depth through the soil layers. This observation agrees with the findings of BCMELP [15] that heavy metals are prone to accumulation in the surface horizons of soil due to their low water solubility and this result in low mobility.

Table 3: Heavy metals concentration (mg/g) of soil at three different depths at the automobile mechanic workshop at Owaluwa

Depth	Cd	Pb	Cu	Zn
0 to 10cm	0.16±0.01	123.10±0.57	95.29±0.76	286.10±0.21
10 to 20cm	Nd	59.65±0.64	59.65±0.64	289.57±0.07
20 to 30cm	Nd	26.00±0.28	23.75±0.01	93.11±0.21

Lead occurs naturally in the all soils, in concentrations ranging from 1 to 200mg.kg^{-1}, with a mean of 15mg/kg [16]. Some high concentrations of lead have been reported in literature and most were in one way or the other connected to manufacturing sites of vehicle batteries. The high concentration of Pb in the topsoil might be due to continual lead deposition in the soil since vehicle batteries are repaired or otherwise handled in these locations. Pb has been considered a hazard when it is equal to or exceeds 400mg/kg in bare soil [17,18]. Although, the level of Pb found in the soil samples analyzed were below this limit, the fast rate at which it is building up at sites that are less than 50 years old suggests that it may pose a serious environmental hazard in the next few years.

Table 4: Concentration of heavy metals (mg/l) in water samples from hand dug wells at the vicinity of automobile mechanic workshops in Owo.

Sample	Cd	Pb	Cu	Zn
E_{10}	Nd	Nd	0.04±0.00	0.34±0.00
E_{20}	Nd	0.46±0.01	0.05±0.00	0.47±0.00
E_{30}	0.09±0.01	0.30±0.01	Nd	0.90±0.00
I_{10}	0.01±0.00	Nd	0.04±0.00	0.28±0.03
I_{20}	Nd	0.28±0.01	0.30±0.01	16.55±0.18
I_{30}	Nd	0.19±0.01	0.03±0.00	0.32±0.01
O_{10}	Nd	1.41±0.03	0.43±0.05	152.44±0.28
O_{20}	Nd	Nd	Nd	0.92±0.00
O_{30}	Nd	0.14±0.00	0.01±0.00	0.58±0.00

Key: E= Eyinogbe, I = Ikare junction, O = Owaluwa, Nd = not detected, 10 = hand dug wells at 10m, 20 = hand dug wells at 20m, 30 = hand dug wells at 30m from the automobile mechanics workshops.

Cadmium was found in the soil samples analyzed at all depth at the mechanic workshop located at Ikare junction. The low concentration of Cd at all the sites may be due to the fact that the aggregate Cd levels in the sludge discarded into the soil may be low. Also, Cd tends to be more mobile in the soil system than many other heavy metals [19]. Therefore it might have been leached into deep soil stratum. Absorption/desorption of Cadmium is about 10-fold more rapid than for Lead [20]. Chronic cadmium exposures results in kidney damage, bone deformities and cardiovascular problems [21,22]. Therefore, the population exposed to the Ikare junction mechanic workshop site may be at risk of developing health complications.

The high concentration of copper in the soil analyzed may be traceable to the use of copper conductor and wires, tubes, solders and myriads of other maintenance items made from copper. According to D'Ascoli et al. [23] when copper ends up in soils, it strongly attaches to organic matter and mineral. As a result, it does not travel very far after release. Perhaps, this explains why the highest values of Cu recorded on most of the locations were in 0 to 10cm depth. As a result of this limited mobility, applied copper tends to accumulate in soil [24].On Cu rich soils, only a limited number of plants have a chance of survival. In surface water, copper can travel great distances, either suspended on dust particles or as free ions [25].

The concentrations of Zinc found in this study agree with those reported earlier in literature. Lenntech (2009) reported that Zinc content in the soil can be as low as 2.5mg/g or as high as 450mg/g, although the average is about 50mg/kg. Zinc is known to accumulate in plants with intake of too large quantities of Zn from plant grown on Zinc-rich soil, there are lower chances of developing cancer of the lung, nose, larynx and prostrate as well as respiratory failures, birth defects and heart disorders [26].

The World Health Organization, W.H.O (1996) set the maximum permissible limits of heavy metals in drinking water as follows: Cadmium (0.003mg/l), Lead (0.01mg/l), Copper (2.0mg/l) and Zinc (0.52mg/l). All water samples analyzed in this study are within the recommended limit of Cu whereas where detected, the level of the other heavy metals analyzed were beyond the permissible limit an this suggests that they may pose serious danger to consumers as far as these specific heavy metals are concerned [27]. These high values obtained for the metals may be connected to the proximity of the wells to the mechanic workshop and during rain, water may wash part of the waste to area near the wells and the elements may leach into the water through the soil. Also, containers from the mechanic workshop sites used as drawer for getting water from the wells may introduce the metals into the well.

5. CONCLUSIONS

High concentrations of Zn, Cu and Pb were found in soil samples at the automobile mechanic workshops when compared to some literatures and previous studies. No significant difference was observed in the concentrations of Cd in the soil samples. However, it was found that Zinc had the highest concentration in the soil samples while Cd had the least and the order observed for this study is Zn > Cu > Pb > Cd. Furthermore, the concentration of Cd, Pb and Zn detected in the water from wells around the mechanic workshops were above the WHO maximum permissible limits for heavy metals in water. Moreover, further investigation is needed to specifically identify the cause(s) of exceptionally high concentrations of Zn in the soil and water samples observed at some of the sites.

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