Anaylsis of Selected Heavy Metal Concentrations in the Soil of Kobo Mechanic Workshop in Lapai, Niger State

Hamid Yinka Adio[1], Abdulgafar Ahmed[1], Muhammad Sulieman T.[2]
[1]*Department of Chemistry, Ibrahim Badamasi Babangida University, Lapai, Niger State, Nigeria*
[2]*Department of Chemistry, Federal University of Technology, Minna, Niger State, Nigeria*

Abstract: - **The heavy metal (Iron, Lead, Zinc and Cadmium) concentrations from the soil of mechanic workshops were determined using Atomic Absorption Spectrophotometry (AAS). The metals were extracted by adding 10 cm^3 of 50 % hydrochloric acid (HCl) to 2 gram portion of the soil samples and digested on electric hot plate. The extract was diluted to 50 cm^3 with deionize water and the Atomic Absorption Spectrophotometry determination was carried out. The samples analyzed showed the mean concentrations of 0.902 mg/kg, 0.491mg/kg, 0.143 mg/kg and 0.00176 mg/kg of Fe, Pb, Zn and Cd respectively. The permissible limits recommended by WHO/FAO for Lead, Cadmium and Zinc are 0.3 mg/kg, 0.2 mg/kg and 0-250 mg/kg respectively. All the heavy metal concentration except Zinc and Cadmium were higher than WHO standard limits. In addition, the study concluded that the soil in Kobo mechanic workshops in Lapai is polluted with high concentration of Iron and Lead thus not safe for plant, animal and other living organisms.**

Keywords: **Atomic Absorption Spectrophotometry, AAS, Heavy metals in soil, Mechanic workshop**

I. BACKGROUND OF THE STUDY

1.1 Mechanic Workshop

In Nigeria and most developing nations, increased automobile repairs workshops activities are due to ever-increasing demand for personal vehicles, most of which are used “Tokunbo” vehicles. Automobiles used (waste) oil contains oxidation products, sediments, water and metallic particles resulting from machinery wears, used batteries, organic and inorganic chemicals used in oil additives and metals . Percolation of leachates from these materials poses threats to environment. Unfortunately, information on the impact of automobile mechanics’ activities on the ecosystem is still very rare.

Automobile waste poured on the ground increase the level of heavy metals which drains into both surface water and ground water because of the connection between lands, air, water and soil.

In mechanic workshops, there are accidental or deliberate releases or discharge of petrol, diesel, solvents, grease, and lubricants on the land and the atmosphere. The use of automobiles has also led to trace element and heavy metals-contaminated soil, which have grave consequences for soil dwelling organisms (Gupta & Gupta, 1998).

Heavy metals cannot be degraded during bioremediation but can only be transformed from one organic complex or oxidation state to another. Due to a change in their oxidation state, heavy metals can be transformed to become either less toxic, easily volatilized, more water soluble (and thus can be removed through leaching), less water soluble (which allows them to precipitate and become easily removed from the environment) or less bio-available. Bioremediation of heavy metals can be achieved via the use of microorganisms, plants, or the combination of both organisms.

1.2 Activity at the Mechanic Workshop

Motor servicing centres popularly known as mechanic workshops are sources of automobile waste in many urban areas. In these land use, fossil fuel products of different types are used leading to excess accumulation of heavy metals which are major constituents of the products in soils in and around these locations. These accumulations deteriorate vegetation that are nearby, accumulate in the plants tissues, deteriorate surface runoff and percolate the water table causing non-point pollution.

The impacts of pollution from automobiles have reached a disturbing level. Environment contaminants are widely distributed in the soil thereby having effect on the tropic chain, plant, animals and man and these pollutants can remain in the soil for a long time, (Campbell, 2005).

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1.3 Soil

Soil is a natural body consisting of mineral constituent of variable thickness, which differs from the parent material in their morphological, physical, chemical and mineralogical characteristic (Birwland, 1999). Soil composes of particles of broken rocks that have been altered by chemical and environment process that militates weathering and erosion. Soil is also a mixture of mineral or organic constituents that are in solid, gaseous and aqueous state, (Chesworth, 2008).

Soil is formed from weathering of rocks and mineral, the surface rock break down into smaller pieces through a process of weathering of rock surface and organic matter. Soil formation pathogenesis is in the combine effect of physical, chemical, biological and anthropogenic processes on soil parent materials.

1.3.1 Soil pollution and contamination

Maduka, (2004) defined pollution as the introduction, by man, into the environment, substances or energy, liable to cause hazard to human health, harm to living resources and ecological systems, damage to structures or amenity or interference with legitimate uses of the environment.

Certain contaminants/pollutants such as heavy metals are part of the earth naturally. Their natural background levels in soils are altered to various levels of pollution usually as a result of anthropogenic activities.

Soil is an essential component of terrestrial ecosystems because the growth of plants and biogeochemical cycling of nutrients depend upon it. Pollution along with other types of degradation, such as mechanic wastes, erosion and the continuing spread of urbanisation, poses a threat to the sustainability of soil resources. Soil pollution can also be a hazard to human health when potentially toxic substances move through the food chain or reach ground water which serves as drinking water.

In comparison with air and water, the soil is more variable and complex in composition and it functions as a sink for pollutants, a filter which retards the passage of chemicals to the groundwater and a bioreactor in which many organic pollutants can be decomposed.

There are various changes which occur in the environment, due to natural or artificial causes. Major factors contributing to environmental problems include; increase in human population, industrial development and urbanization, unsustainable use of resources and local changes, (Botkin & Keller, 1997).

It is generally accepted that most of the soil in technologically advanced regions of the world is polluted or contaminated, at least, to some extent.

Realistic estimate of areas affected by soil pollution is difficult owing to unreliable official figures and paucity of data for many parts of the world. Industrially contaminated land tends to contain higher concentrations and a greater possible range of pollutants than other sources of pollution. There are between 50,000 and 100,000 contaminated sites in the United Kingdom (UK) which occupy up to 100 000 ha. In the United States of America (USA), 25,000 contaminated sites have been identified, 6000 sites are being cleaned-up in the Netherlands, there are known to be at least 3,115 sites in Denmark and 40,000 suspect areas have been identified on 5,000 – 6,000 sites in the former western part of Germany.

1.3.2 Effect of Heavy Metal Polluted Soil on Plant Growth

The heavy metals that are available for plant uptake are those that are present as soluble components in the soil solution or those that are easily solubilised by root exudates (Blaylock & Huang, 2000). Although plants require certain heavy metals for their growth and upkeep, excessive amounts of these metals can become toxic to plants. As metals cannot be broken down, when concentrations within the plant exceed optimal levels, they adversely affect the plant both directly and indirectly. An example of indirect toxic effect is the replacement of essential nutrients at “cation” exchange sites of plants (Taiz & Zeiger, 2002). Further, the negative influence heavy metals have on the growth and activities of soil micro organisms may also indirectly affect the growth of plants. For instance, a reduction in the number of beneficial soil microorganisms due to high metal concentration may lead to decrease in organic matter decomposition leading to a decline in soil nutrients. Enzyme activities useful for plant metabolism may also be hampered due to heavy metal interference with activities of soil microorganisms. These toxic effects (both direct and indirect) lead to a declining plant growth which sometimes results in the death of plant (Schaller & Diez, 2002).

Environmental pollution by heavy metals, even if it is at low concentrations and the long- term cumulative health effects that go with it, is of major health concerns all over the world. For instance bioaccumulation of lead (Pb) in the human body interferes with proper functioning of the mitochondria thereby impairing respiration as well as causing constipation, swelling of the brain, paralysis and could eventually lead to death (Oluyemi et al, 2008).

In biological systems, heavy metals have been reported to affect cellular organelles and components such as cell membrane, mitochondrial, lysosome, endoplasmic reticulum, nuclei, and some enzymes involved in metabolism, detoxification, and damage repair (Wangs, 2001). Several studies from our laboratory have demonstrated that reactive oxygen species (ROS) production and oxidative stress play a key role in the toxicity and carcinogenicity of metals such as arsenic (Yedjou, 2006), cadmium, chromium , lead, and mercury. Because of their high degree of toxicity, these five elements rank among the priority metals that are of great public health significance. They are all systemic toxicants that are known to induce multiple organ damage, even at lower levels of exposure. According to the United States Environmental Protection Agency (U.S. EPA), and the International Agency for Research on Cancer (IARC), these metals are also classified as either “known” or “probable” human carcinogens based on epidemiological and experimental studies showing an association between exposure and cancer incidence in humans and animals.

It is worth mentioning that, in most real life situations (such as disposal of sewage sludge and metal mining wastes) where soil may be polluted with more than one heavy metal, both antagonistic and synergistic relationships between heavy metals may affect plant metal toxicity. The authors reported that there was no synergistic interaction between these heavy metals probably because the concentrations used in the experiment were too high for interactive relationship to be observed between the metals

1.4 Relationship of Heavy Metals to Living Organisms

Heavy metals no doubt are important constituents for plant and humans but only in small amount. Some micronutrient elements may also be toxic to both animals and plants at high concentrations; for example copper, chromium, fluorine, molybdenum, nickel, selenium or zinc. Other trace element such as arsenic, cadmium, mercury and lead are toxic even at small concentrations.(Divrikli, et al, 2006).

Some heavy metals e.g Cu, Se and Zn are essential to maintain the metabolism of human body. The increasing trend in concentration of heavy metals in environment as creates considerable attention amongst ecologist, globally during the last decade.

The concentration of metal in bio available form is not necessarily proportional to the total concentration of the metal. The concentration of various elements in the air, water and land may be increased by their natural level due to the agricultural, domestic and industrial effluent (Opaluwa et al., 2012).

Foremost amongst the modes of ecosystem contamination in urban areas is the prevalence of automobile workshops and services stations. Automobile wastes include solvents, paints, hydraulic fluids, lubricants and stripped oil sludge; result of activities such as battery charging, welding and soldering, automobile body works engine servicing and combustion processes. All these find their way somehow into the ecosystem especially the aquatic habitat.

II. MATERIALS AND METHOD

2.1 Apparatus and Reagents

Apparatus

- Beaker 250 cm^3
- Volumertic flask 50 cm^3
- Measuring cylinder 50 cm^3
- Mortal and pistle
- Sieve 0.5 mm
- What's man filter paper 150 mm
- Sample dish
- Hot plate
- Analytical weighing balance
- Sample bottle
- Atomic absorption spectrophotometer: UNICAM 919

Reagents	Supplied by	Percentage purity
Hydrochloric acid (HCl)	LOBA Chemie	36%
Nitric acid ($HN0_3$)	LOBA Chemie	70%
Zinc metal (Zn)	NOVARA	94%
Iron metal (Fe)	NOVARA	98.5%
Lead metal (Pb)	NOVARA	96.5%

2.2 Sample Location and Sampling

All soil samples were collected at various locations within the kobo mechanic workshops area in Lapai. A control sample was collected at 100 meter away the mechanic site in the area.

Sample location on the settlement map of Lapai town is shown in the plate below.

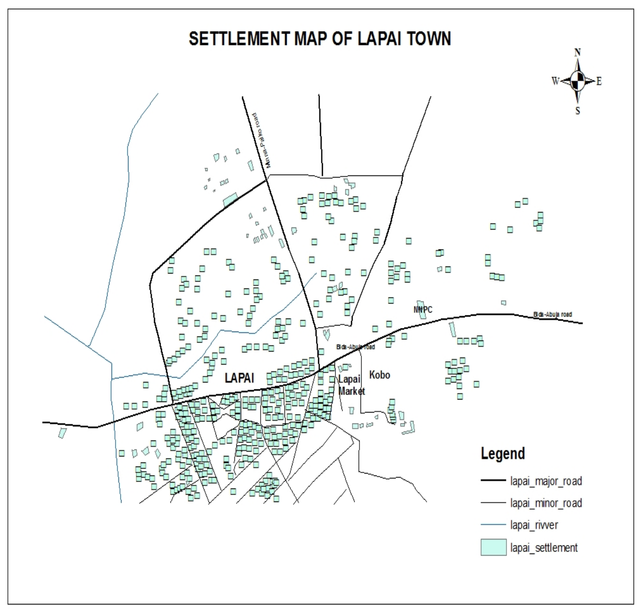

Figure 1: Map of Lapai town showing the Kobo mechanic workshop site.

Soil samples were collected at 30 meter away from each other at three different locations. They were labelled as A, D, E, G respectively, all the samples were collected at a depth of 0-15cm.

Site	Kobo Mechanic workshop along	Label
Site 1	Suleja road	A
Site 2	Lapai motor park (central)	D
Site 3	Ibrahim road	E
Site 4	Suleja road (control)	G

Soil samples collected at site 1 to 3 are within the Kobo mechanic workshop while soil sample collected at site 4 is 100 meter away from site and is consider as the control sample.

2.3 Soil Samples Pretreatment

The soil samples were dried in the oven set at a temperature of 105 °C for 24hrs. The dried samples were then grinded and sieved using 0.5 mm mesh sieve to remove stones, plants roots, and to obtain soils of uniform particle sizes. The samples, were packed in a polythene bags and kept in a dry place.

2.4 Preparation of 50% Hydrochloric acid

50% HCl solution was prepared by pouring 50 cm^3 of distilled water into 100cm^3 of volumetric flask, followed by adding 50ml of concentrated hydrochloric acid (14M) into the flask.

2.4.1 Preparation of 500 mg/L of Zinc Standard Solution.

The solution was prepared by dissolving 0.50 g of pure zinc metal into 10 cm^3 concentrated hydrochloric acid in 1000 cm^3 volumetric flask and made up to the mark with distilled water (AAS Data Book, 1979).

2.4.2 Preparation of 1000 mg/L of Iron Standard Solution

The solution was prepared by dissolving 1.0 g of iron granules in to 20 cm^3 of 5M Hydrochloric acid in 1000 cm^3 volumetric flask and made up to the mark with distilled water.

2.4.3 Preparation of Lead Standard Solution.

The solution was prepared by dissolving 1.0 g of lead metal into 50 cm^3 of 2M nitric acid in 1000 cm^3 volumetric flask and made up to mark with distilled water (AAS Data Book, 1979).

2.5 Digestion Process of Soil Samples

2.0 g of well mixed sample was put into 100 cm^3 glass beakers and digested with 10 cm^3 of 50% hydrochloric acid. The light green solution obtained was heated on a hot plate, until a dark green solution appeared given off a colourless gas with chocking smell. This gas and the odour were assumed to be the evolvement of Hydrogen chloride gas. Heating continued until the solution had evaporated to near dryness. This digestion process was done in a fume cupboard, so as not to allow the gas to get into the surrounding because of it choking smell. The sample was withdrawal from hot plate and 10 cm^3 of deionised water was added and filtered using Whatman's filter paper150 mm size into 50 cm^3 of volumetric flask, during the filtration a pale yellow colour was observed and the solution was made up to mark to give the final volume depending on the suspected level of metals. Replicate digestion was done to determine and correct error that might occur during the process of digestion.

2.6 Heavy Metal Analysis

Analysis of Iron, Lead, Zinc and Cadmium was done using atomic absorption spectrophotometer, UNICAM 919 at Sheda Science and Technology Complex, Gwagwalada, Abuja.

2.0 g of sample in the powdered form was accurately weighed and digested in 10 cm^3 of hydrochloric acid 14M. After digestion, the solution was heated gently and then filtered. The entire filtrate was diluted up to 50 cm^3 with distilled water. The filtrate solution was used for analysis of Iron, Lead, Zinc and Cadmium, by AAS using respective hollow cathode lamps. The concentrations of various elements were determined by using A.R. grade reagents.

III. RESULTS AND DISCUSSION

3.1 Results

The result of the absorbance and the concentrations of each metal in the samples were determined and mean value of each element was calculated.

Table 1: Total result of standard absorbance and concentration of soil samples

S/N	Heavy Metal			Absorbance and Concentration (mg/kg)					
	Soil Samples	Fe		Pb		Zn		Cd	
		Abs	**Conc**	**Abs**	**Conc**	**Abs**	**Conc**	**Abs**	**Conc**
1	Sample A	1.282	0.898	0.232	0.566	0.868	0.110	-0.004	0.0005
2	Sample D	1.288	0.903	0.214	0.504	1.133	0.150	-0.002	0.0007
3	Sample E	1.289	0.904	0.188	0.403	1.272	0.170	-0.021	0.0041
4	Sample G	1.252	0.873	0.052	0.107	0.236	0.022	-0.003	0.0007

KEY:

Soil sample A: Soil samples along Suleja road kobo mechanic workshop

Soil sample D: Soil sample at Lapai motor pack kobo mechanic workshop

Soil sample E: Soil sample Ibrahim road kobo area kobo mechanic workshop

Soil sample G: Soil sample Suleja road kobo mechanic workshop.

Table 2: The table below shows the mean value of absorbance and concentration of all samples collected at mechanic workshops.

Heavy metal	Absorbance	Concentration (mg/kg)	Permissible limit (mg/kg)
Fe	1.286	0.902	___
Pb	0.211	0.491	0.3
Zn	1.091	0.143	<50
Cd	-0.009	0.00176	0.2

3.2 Discussion

Iron in sample E has the highest concentration value of 0.904 mg/kg followed by sample D and A having concentration value of 0.903 mg/kg and 0.898 mg/kg respectively while sample G has the lowest concentration value of 0.873 mg/kg. Lead concentration value in sample A has the highest value of 0.566 mg/Kg among the samples values and sample G has the lowest value. Zinc present in soil sample of E has the highest among the values 0.170 mg/kg while sample G has the lowest value of 0.022 mg/kg. Soil sample E has the highest value of cadmium which is 0.00408 mg/kg and the lowest of all is sample A which has the value of 0.00047 mg/kg.

The mean concentration of Soil sample A, D and E were calculated which are 0.902 mg/kg, 0.491 mg/kg, 0.143 mg/kg and 0.00176 mg/kg for Fe, Pb, Zn and Cd respectively and sample G, which is the control sample was used to compare their level of concentration, the result show that all the absorbance and concentration of heavy metals present in sample A to E is higher than sample G (control).

The standard level of heavy metal were use to compare the level of concentration in all the sample, the result shows that soil samples A, D, E and G has high level of iron more than the tolerable limit. Sample A, D and E has high concentration of lead more than the permissible limit. The zinc and cadmium present in all the samples are tolerable.

There is very high concentration of Lead 0.491 mg/kg in all the samples which exceed the world health organization limit 0.3 mg/kg. There is evidence that the workshop located within these areas are not only a major service centre for light and medium vehicles, but also a centre for heavy automobile and electricity, generator repairs and services. It also serves as a retail outlet for engine oil and deposited with acid batteries and other automobile iron parts. This would definitely pose health hazard to the inhabitants of the area. This will also affect the crops cultivated within the area to be rich in lead and pose a serious damage to the living organism within the area. Though sample G has a tolerable limit of lead it is considered safe.

In addition the result shows that there was decrease in concentration of Zn and Cd in soil. Similarly the level of Zn and Cd contamination which is 0.143mg/kg and 0.00176 mg/kg in this study is small compare to 0.902 mg/kg and 0.491 mg/kg of Iron and Lead respectively.

Sample E has high concentrations of the selected heavy metals this shows that soil sample E is very rich in heavy metals and this can lead to a very serious health effect to the people living around the area.

IV. CONCLUSION

The concentrations of heavy metal in soil of Kobo mechanic workshops determined are; 0.902 mg/kg, 0.491 mg/kg, 0.143 mg/kg and 0.00176 mg/kg for Fe, Pb, Zn and Cd respectively. With the exception of Zinc and Cadmium, all other metals were found to be of higher concentrations above the permissible level. It is therefore concluded that the kobo mechanic workshops in Lapai is polluted with heavy metals and thus not safe for plants, animals and other living organism.

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