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Heavy metal concentration in soil of some mechanic workshops of Zaria-Nigeria

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This research paper investigated the elemental composition of soil samples from four selected mechanic workshops in Zaria. A total of eight samples were analyzed at Centre for Energy Research and Training (CERT) Ahmadu Bello University Zaria using standardless X-Ray Fluorescence spectroscopy (XRF). From the result, it was found that Silicon (Si) has the highest mean concentration ranging from 0.0013-0.0024 ppm and Ba, Ni, Cr, Mn, Cu, V, Mo and Zn having very low concentration witha mean of (0.000035 0.000053) ppm, (0.000009 0.000012) ppm, (0.0000054 0.000012) ppm, (0.0000049 0.000012) ppm, (0.0000052 0.000017) ppm, (0.0000052 0.000029) ppm, (0.0000068 0.00007) ppm and (0.00001 0.000055) ppm respectively. Lead was found in only one sampling point (Samaru Dogon Icce) with an abundance of 0.00018 ppm which is less than the maximum permissible limits (MPL) recommended by W.H.O. Hence, the result shows that there were no much toxic elements in some of the mechanic workshops in Zaria. It is advisable that substances containing heavy metals should not be disposed in farm lands or any dumpsites close to residential areas.

Key words: Heavy metals, soil, contamination, mechanic workshop.

INTRODUCTION

Man's activity in the environment has led to the pollution of soil mainly by chemical contaminants. Presently in developing countries like Nigeria where estimates have been made that; there is large number of illiteracy in the country, lack of knowledge on how to eradicate the problem of soil pollution. The presence of heavy metals in soil can affect the quality of food, groundwater, micro-organisms activity, plant growth etc. (Antoaneta et al., 2009). When contaminated soils are later abandoned and then used for agricultural purposes such as farming, animal breeding, herding etc. plants take in these metals in the process. For the fact that they are not bio-degradable (cannot be broken down into smaller parts by bacteria), can have adverse effect on plants. Also these heavy metals have toxic effect on living organisms in the soil when permissible concentration levels are exceeded.

In Zaria (Kaduna state), because of the large number of roadsides mechanical workshops where motor oil, body parts, grease, battery electrodes and electrolytes which contained heavy metals are commonly found and used and because most of the activities in the mechanical workshops are carried out on the ground (soil), the soil is mostly contaminated. Generally, the most common of these heavy metals found in the soil include Lead (Pb), Copper (Cu), Zinc (Zn), Cadmium (Cd) etc. Lead and copper are the commonly heavy metals found in the soil. Lead at certain exposure level, is a poisonous substance to animals as well as human beings.

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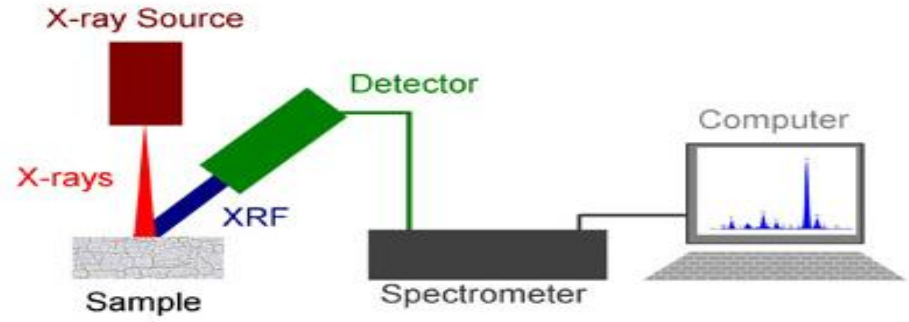

Figure 1. Schematic arrangement of Energy Dispersive XRF spectrometer Source: http://www.horiba.com/scientific/products/x-ray-fluorescence-analysis/tutorial/xrf-spectroscopy.

According to USDA (2000), acute (immediate) poisoning from heavy metals is rare through ingestion or dermal contact, but it is possible. 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 (Adelekan and Abegunde, 2011). According to an estimate made by the National Institutes of Occupational Safety and Health (NIOSH), more than 3 million workers are potentially exposed to lead in the work place (Binns and Ricks, 2004). In most part of the United States, heavy metal toxicity is an uncommon condition; however, it is a clinically significant condition when it does occur. If unrecognised or inappropriately treated, toxicity can result in significant illness and reduced quality of life (Ferner, 2001). Therefore, it is important for research to be conducted to evaluate and limit exposure of dangerous levels of these heavy metals in the environment.

EXPERIMENTAL

Sample collection

A total of eight samples were collected from four locations (Samaru, Kofar-Doka, Sabon Gari and Tudun Wada). At each sampling point, samples were collected randomly using polythene bags and hand gloves and then transported to the laboratory for analysis.

Sample preparation

The samples were homogenised and crushed with an agate mortar grain size less than 125 nm. Three drops of toluene acid (binder) was then added to 0.5 g of the powdered sample and crushing continued until the mixture was returned to fine powder again. The 0.5 g weighed of the crushed sample was placed under a hydraulic press machine and a 10-tone pressure was applied which compressed and converted to fine powder and then into pellet form. The pellets were carefully labelled, covered with Mila and stored in partitioned sample storage plastic containers for analysis.

Sample analysis

The analysis was done using Mini pal which is a compact energy dispersive X-ray spectrometer designed for the elemental analysis of a wide range of samples (Figure 1). The system is controlled by a PC running the dedicated Mini pal analytical software. The Mini pal 4 version in use is PW 4030 X-ray spectrometer, which is an energy dispersive microprocessor controlled analytical instrument designed for the detection and measurement of elements in a sample (solids, powders and liquids), from sodium to uranium. The source (X-ray tube in this case) irradiates the sample and the detector measures the irradiation coming from the samples. The detector that is able to measure the different energies of the characteristic radiation coming from the sample directly.

RESULTS AND DISCUSSION

Two categories of soil samples were collected and analysed for heavy metals from each sampling point. A total of eight samples were obtained, four of which are at the surface and the remaining four are at about 0.5 m beneath the surface of the ground, the results of the analysis are presented in Figures 2 to 5.

The results obtained from Samaru Dogon Icce (Figure 2) workshop shows the presence of lead, this is because Samaru Dogon Icce workshop is one of the busiest workshop in Zaria and its environs, and it is located along several higher institutions and the busiest Zaria - Sokoto express way. This leads to more number of vehicles in the area which constitutes the accumulation of lead. Lead (Pb) is only present in point 1 in Samaru Dogon Icce workshop, because point 1 was collected from the surface of the soil where lead accumulated more while point 2 was collected 0.5 m beneath the soil surface which has lesser content of lead compared to that of point 1.

Lead was only found in Samaru Dogon Icce workshop because all the samples which were analysed was collected during the rainy season which lead to the washing away of top soil accompanied by washing away of some of these metals. Also, the presence of Pb in

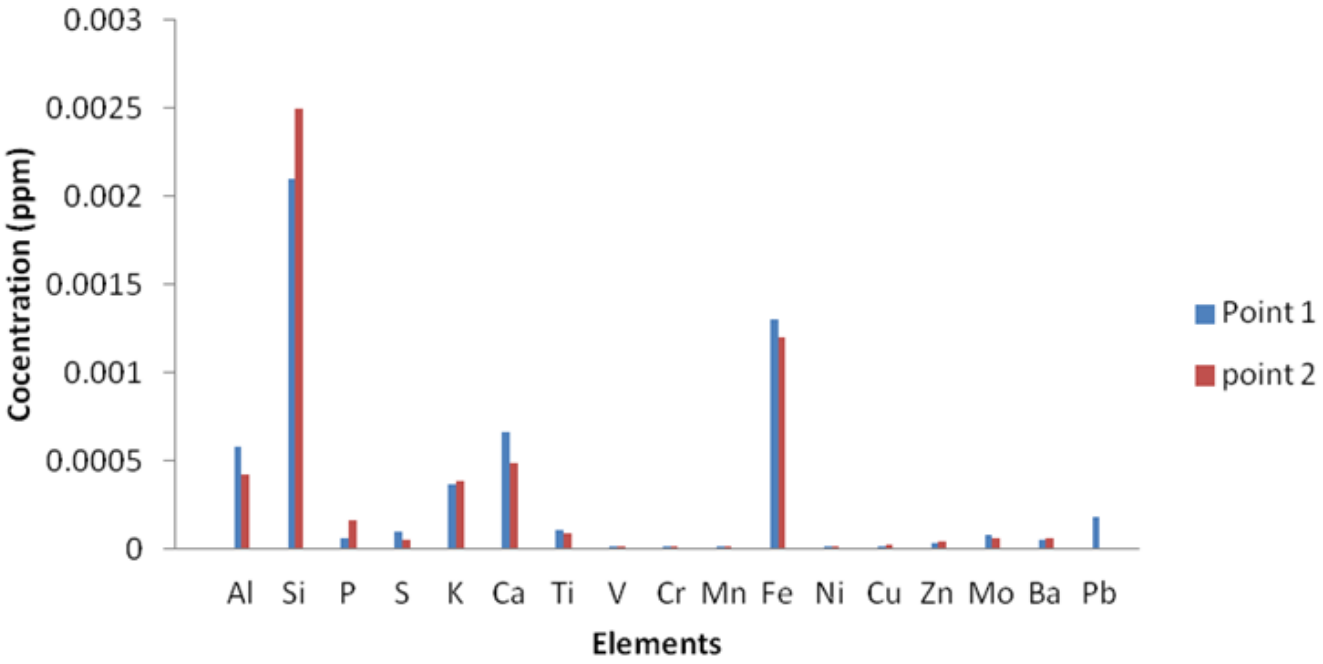

Figure 2. Variation of concentration of Elements from Samaru Dogon Icce mechanic workshop.

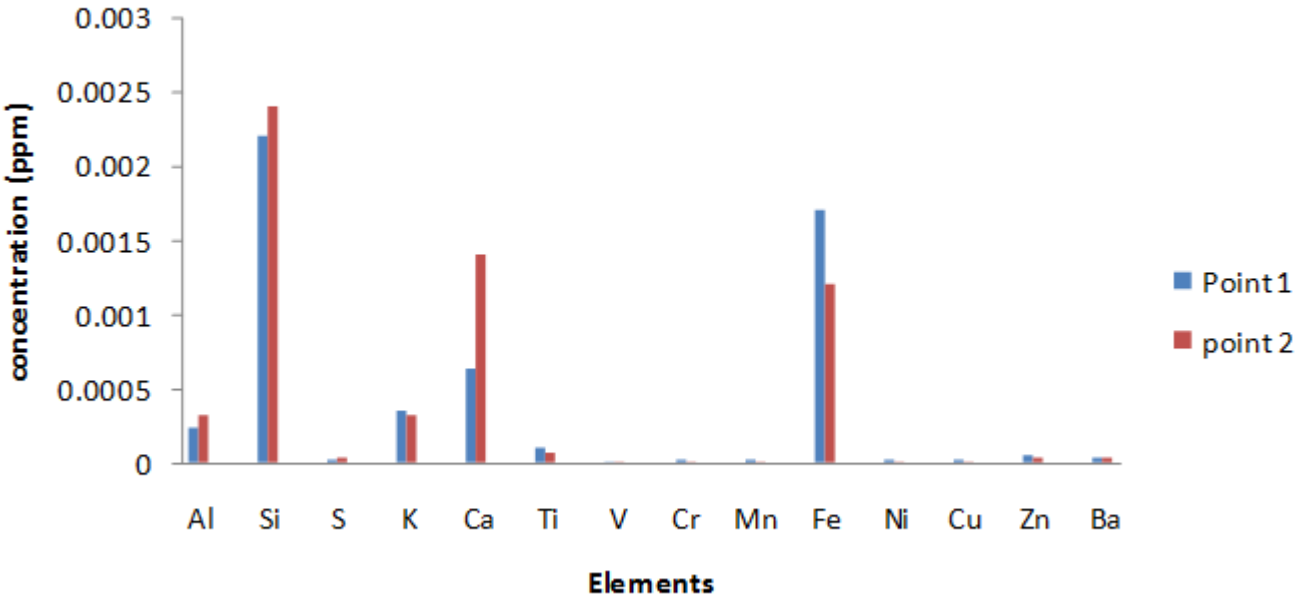

Figure 3. Variation of concentration of elements from Sabon Gari mechanic workshop.

auto-repair workshop in Samaru Dogon Icce soils may be due to fall-out of lead from batteries or lead accumulators, which are commonly used and abandoned in the workshops. The presence of iron (Fe) in large concentration from Sabon Gari (Figure 3) and Kofar Doka (Figure 4) mechanic workshops deserves evaluation because of the fact that different types of trees are present in the site, the dropping and decomposition of their leaves accumulate in the soil.

In all samples from the four mechanic workshops, it can be observed that silicon has the highest concentration with a mean ranging between 0.0013 to 0.0024 ppm. This is due to the fact that silicon is the key component of sand. Some of the soil obtained from these mechanic

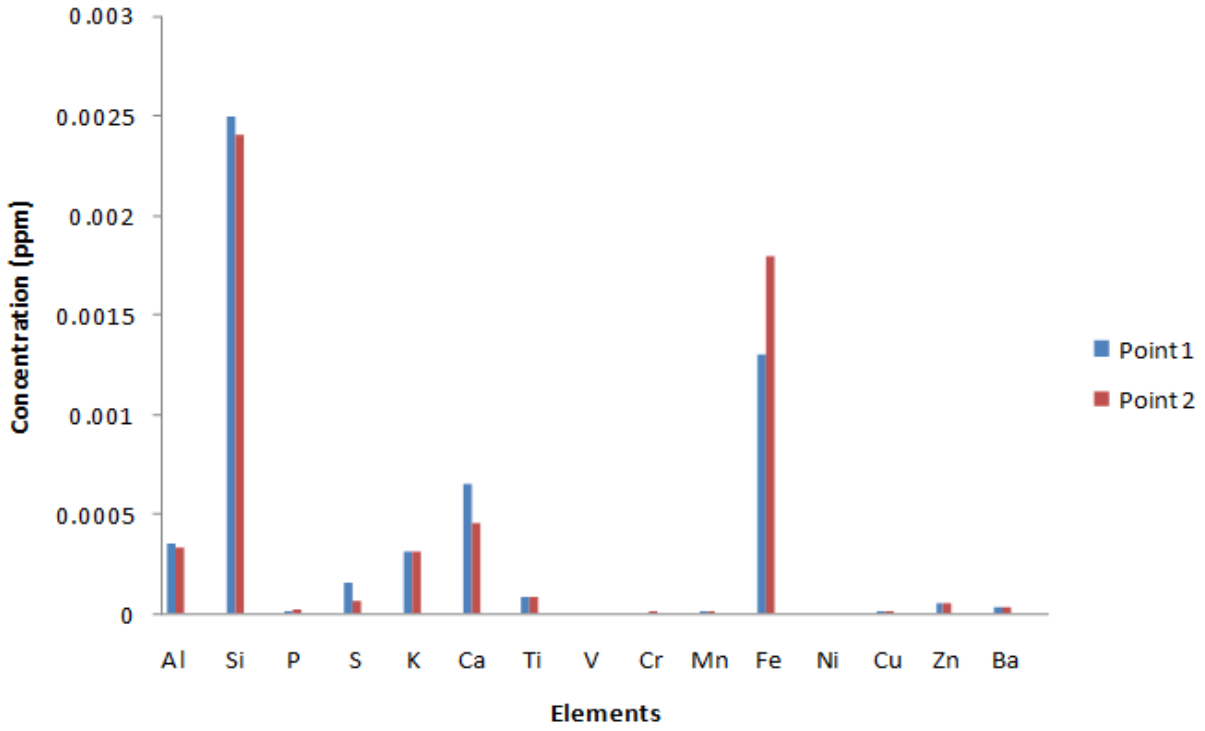

Figure 4. Variation of concentration of Elements from Kofar Doka mechanic workshop.

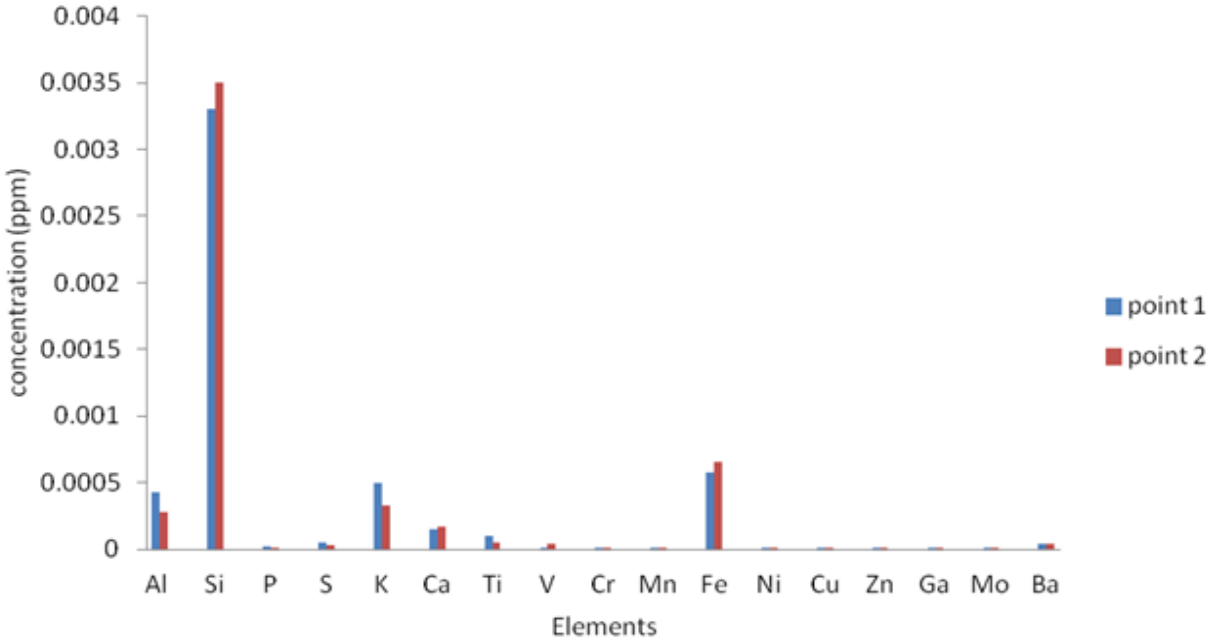

Figure 5. Variation of concentration of elements from Samaru Dogon Icce mechanic workshop.

workshops with excess silicon can be used as manure by local farmers to enhance and standardize rice production for the public consumption and industrial purposes. Also any crop that is cultivated using such soil as manure is expected to have high concentration of silicon and when taken by animals it helps in building strong bones and formation of connective tissues, it also assists in healthy growth of hair, skin and finger nails (Buhari, 2011).

By mere observation on the frequency distribution charts, one can see that there is no much difference in the concentrations of both points 1 and 2. Only for the concentration of Point 1 and Point 2 from Kofar Doka and Sabon Gari mechanic workshop; the concentration of Fe of Point 2 is large compared to that of Pont 1. This is because Point 2 was taken from the area very close to trees and iron (Fe) is much more present in the leaves that frequently drop and decomposed. From Figures 2 to 5, concentration of potassium for both points 1 and 2 are low and in very close ranges compared to the remaining elements. This is because in soils, plants absorb potassium in greater amount than any other nutrient. The total K content of soils frequently exceeds 20,000 ppm (parts per million). Nearly all of this is in the structural component of soil minerals and is not available for plant growth. Because of large differences in soil parent materials and the effect of weathering of these materials in the United States, the amount of K supplied by soils varies (George et el; 2002). For children, ingestion contaminated soil is most significant in pathway for land (Chaney et al., 1989; EPA, 1997). Also, the maximum permissible limits (MPL) for lead is 15 ppm (15 part per million) while the abundance recorded in this work is only 0.00018 ppm. This is the indication that the mechanic workshop does not cause much toxicity to the plants and animals in the area even though lead is poisonous no matter the amount of concentration, its toxicity can result in significant illness and reduced quality of life (Ferner, 2001).

It can also be observed from Figures 1 to 4 that Ba, Ni, Cr, Mn, Cu, V, Mo and Zn have very low concentration with a mean of (0.000035-0.000053)ppm, (0.000009-0.000012)ppm, (0.0000054 0.000012)ppm, (0.0000049 0.000012)ppm, (0.0000052 0.000017)ppm, (0.0000052 0.000029)ppm, (0.0000068 0.00007)ppm and (0.00001-0.000055)ppm respectively. This is because soil samples were collected from a depth of 0 to 15 cm and also were collected during the rainy season which may have caused the washing away of top soil leading to washing away of most of these metals from the soil surface and also because heavy metals in auto-repair workshop soils are not significantly derived from the natural geology or the processes of weathering and deposition (Ayodele and Modupe, 2007). From Figures 1 to 5, the order of abundance is Si>Fe>Al>Ca>K>Pb>Ti>P>S>Zn>Ba>Mn>Cu>V>Cr, with an exemption of Pb that is only present in trace amount in the samples collected from Samaru Dogon Icce mechanic workshop. Pb is considered the primary contaminant of most auto-mobile workshops no matter the amount of concentration.

Conclusion

The heavy metal concentrations in soil samples from some selected mechanic workshops of Zaria and environs were collected and analysed using XRF at Centre for Energy and Training (CERT), Ahmadu Bello University, Zaria. The result obtained from this work shows that the pollution levels within the study area as a result of fall-out of lead from batteries or lead accumulator has not risen to a dangerous level at the moment. But there is also the danger of build-up of small doses either through inhalation or absorption through skin or bio-accumulation. Data obtained from this research work shows that Si has the highest concentration in all the samples analysed with a mean concentration of 0.0013 to 0.0024 ppm. Silicon is also the only element that does not damage plant when accumulated in excess. Therefore some of the soil obtained from these mechanic workshops with excess silicon can be used as manure by local farmers to enhance and standardize rice production for the public consumption and industrial purposes. Also V, Mn, S and Cr have the lowest concentration level in all of the samples collected and analysed from the mechanic workshops. Hence, all these soil samples collected for analysis when used up by humans are less prone to Human Carcinogen (Ayodele et al., 2007) and less exposed to diseases such as brain damage, skin and throat irritation.

Lead derived mostly from exhausts of vehicles is in Nigeria still used as minor additives to gasoline and various auto-lubricants. It is estimated that about 2800 metric tons of vehicular gaseous lead emission is deposited to urban areas in Nigeria annually (Ayodele and Modupe, 2007). Concern for lead concentration in automobile workshop soils may therefore arise principally due to the fact that mechanic workshop could be identified as playground or near residential areas where children play about freely.

However, Pb concentration was only obtained from a sample collected from Samaru Dogon Icce mechanic workshop with a concentration of 0.00018 ppm which is less than the maximum permissible limits (MPL) of Pb recommended by WHO which is 15 ppm (15 part per million). Since lead is a very poisonous element, it is advisable not to use the soil from Samaru Dogon Icce mechanic workshop for crop cultivation since its toxicity can result in significant illness and reduced quality of life (Ferner, 2001).

RECOMMENDATION

Based on the observations and experience from this work, the following were recommended:

(i) This research work should be carried out from time to time so as to monitor the amount of heavy metals released into the soil to avoid accumulation.
(ii) Also, the research should also be carried out in the dry season or preferably in both dry and rainy season so as to get more accurate results.

(iii) There is need to investigate any water body close to the mechanic workshops so as to assess and monitor the concentration level of heavy metals likely present in the water due to the activities in the mechanic workshops.

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