Utilization of AAS and GIS Tools in Assessment of Distribution of Pb, Cd, Cr and Mn Concentrations Within Top-Soil of An Automobile Workshop Within University College Hospital, Ibadan, Nigeria

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Abstract: **- Increased frequency of acquisition and use of automobiles have required the establishment of repair workshop in different parts of most cityin developing countries. Apart from the vehicular emission, which is a major route of environmental pollution; the different waste materials generated in most of these auto-fixer workshops has contributed widely to environmental contamination and pollution with heavy metals. This study was designed and carried out to ascertain distribution and degree of pollution of selected heavy metals: Pb, Cd, Cr and Mn within an automobile workshop located at University college Hospital, Ibadan. The concentrations of Pb, Cd, Cr and Mn in top soil samples from this workshop were determined using Atomic Absorption Spectrophotometry (AAS). The mean concentrations of each of these heavy metals within the topsoil samples were 235.13mgPbkg^{-1}, 5.28mgCdkg^{-1}, 45.96mgCrkg^{-1} and 411.23mgMnkg^{-1} respectively and the abundance of the metals within the workshop'stop soil follows the order: Mn>>Pb>>Cr>Cd.Overall, the mean concentrations of Pb and Cd measured within the workshop'stop soil samples exceeded Standard Regulatory limits. ArcGIS software was employed in producing the geochemical maps. The Quantification of Contamination (QoC) analysis showed that Pb, Cd, Cr and Mn have anthropogenic source of contamination and the contamination factor values for Cd, Pb and Mnindicated values greater than 6. This study shows that the concentration and distribution of Pb, Cd, Cr and Mn within the study area soils correlates directly to activities originating from the automobile repair workshops. Consequently, these top soils overloaded with noxious metals will pose a health risk to the inhabiting populace of the area surrounding the workshop.**

Keywords: **Automobile workshop, Contamination, Top Soil, Heavy metals, AAS, ArcGIS**

I. INTRODUCTION

The advent of industrialization has led to a widespread of environmental contamination and pollution. With the advancement in Science and Technology, humans create countless tons of toxic waste annually. These generated wastes are being dumped indiscriminately on the soil, which has been known as sinks for most contaminants. Soil is an essential renewable resource on which man depends for production of his food or diet. Different soil types vary in their sustainability both in agriculture and also other purposes such as construction and other land use [2].Humus, mineral constituents, living organisms, soil air and soil water are some of the materials that make up soils. Though soil is very important in human life because mankind's survival is tied to the preservation of soil productivity [1],it could also serve as natural reservoirs for minerals, trace elements and heavy metals; hence, this makes it possible for it to receive large quantity of pollutants and contaminants [3].

The various activities of man in recent years have elevated the amount of distribution of heavy metals into the environment especially landor soil. Heavy metals are viewed as an international problem due to the effects they have on ecosystems in most countries [4]. Anthropogenic sources of soil contaminations, which include vehicle emissions, combustion of fossil fuel, mining, construction activities and effluent from agricultural industry, are often associated with rapid and uncontrolled urbanization and industrialization[5]. Thus, apart from natural geochemical processes, several arrays of anthropogenic sources usually release toxic heavy metals into our environment[6]and thereby lead to occurrence of anomaly in the balance of these metals within the natural environment. Consequently, there has been an increased surge in the occurrence of heavy metals within normal soils [7]. According to Hanif [8], the level of pollution is on the increase due to urbanization, industrialization, human activities and natural sources.

Heavy metal poses a lot of threats to living organisms especially man in the area of health. Human tends to be exposed to these metals through ingestion, inhalation and direct contact with the metals. According to Adewole and Uchegbu[9], one of the major sources of increase heavy metal concentration of the ecosystem in Nigeria is automobile mechanic activities. Discarded batteries are common stuffs in an automobile workshop along with spent solvents like used engine oil, lead laden gasoline and some other hydrocarbon

by-products, which usually are commonly found at such workshops. The problem is that, if just one of these batteries should leak out Hg, Pb, Ni, or Cd; it can place several lives at risk. The high level of heavy metal contamination of soil has become a global issue that must be given adequate attention and must be tackled head long. There must be a paradigm shift in the way we add up to the increment of these heavy metals into our soil resources. For instance, Thomas et al[10] shows high level of Zn and Ni in soil after the application of phosphate fertilizer while Hong et al[11] noted a case of lead poisoning in Zamfara State in the North Western part of Nigeria as reported by Nigerian Daily Trust in 2013, where over 2000 children and pregnant women were affected.

In essence, it means that our activities as human has distorted the balance of biochemical and geochemical cycles of different heavy metals, thereby causing them to bio-accumulates and geo-accumulates [7]. Literatures revealed that heavy metals get accumulated in soils and could have negative influence on man and his environment [12]. Hence, this study became necessary and was done to assess the occurrence and distribution of some selected heavy metals in top soil samples taken from an automobile workshop within University College Hospital, Ibadan, Nigeria.

II. METHODOLOGY

Study Area: The study area is an automobile service workshop located within the University College Hospital Ibadan**.**It is situated in the south-western part of Nigeria and located within Ibadan, the capital city of Oyo State. It is also popularly referred to as 'mechanic workshop' and has a coordinates of Lat. 7°24'13" N and Long. 3°54'20" E, while the control site was located at a Child's Care Center at Ibadan with latitude 7°24'7.3" N and longitude 3°54'33.4". The study area is one of the Nigerian tertiary institutions in the city of Ibadan while the control site was a school playground/field. Figure 1 shows themap of the study area indicating the workshop and the control point.

Sampling Procedures and Analysis: Topsoil samples were randomly taken at a depth of 0–15 cm from the study area. All the samples were mixed thoroughly to give a composite sample representative of the sampling points.They were then transferred into well labeled polythene bags, and double–bagged to avoid contamination. The total number of samples analyzed in this study was 17 (16 from automobile workshop and 1 from outside the workshops). Soil sampling was carried out between the months of April and July 2019.

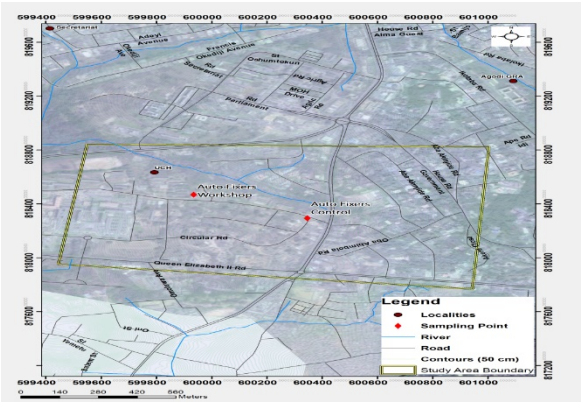

Fig. 1: Satellite image showing the selected study site

0.5g of the 0.5mm sieved soil was weighed into a beaker and 5ml of an acid mixture of Aqua regia mixture in ratio 2:1 was added. The beaker content was put on a hot plate at 70^0C under a fume cupboard and allowed to undergo digestion. A color change was observed from brownish color to colorless. The digest was allowed to cool and made up to 25ml with distilled water.

The total concentration of the selected heavy metals namely lead, chromium, manganese and cadmium in filtrates were determined using the Buck Atomic Absorption Spectrophotometer (Model 210/211 VGP).The Buck Scientific AAS instrument setting and operational conditions were followed in accordance with the manufacturers' specifications.

III. RESULTS AND DISCUSSION

Heavy Metal Concentrations in Topsoil Samples

The mean concentrations of heavy metals (Pb, Cr, Cd and Mn) in the soils of the automobile workshops studied are clearly presented in **Table 1**. The concentrations of Chromium at Auto-Fixers ranged from 22.10mgkg^{-1} to 71.20mgkg^{-1} with an average value of 45.96mgkg^{-1}, while Cadmium levels at the Auto-Fixers were in the range of 0.50mgkg^{-1} to 7.40mgkg^{-1}. Lead concentrations vary from 38.85mgkg^{-1} to 495.50mgkg^{-1} at the Auto-Fixers workshop with a mean value of 235.13mgkg^{-1}. The level of Manganese in the soils at the workshop ranged from 28.20mgkg^{-1} to 870.00mgkg^{-1}, witha mean value of 411.23mgkg^{-1}. Heavy metal contents in the soil samples from the automobile repair workshops show that the average values exceeded the DPR benchmark for Pb and Cd measured. Studies by Yusuf et al [13] have shown that the pollution of Illela Garage in Sokoto State, Nigeria with Fe, Pb and Cr to have exceeded the permissible limit prescribed by World Health Organization (WHO) and Federal Environmental Protection Agency. The spatial distribution maps of the heavy metals analyzed are presented in **Figures 2-5**.

Table 1: Mean concentrations of heavy metals ($mgkg^{-1}$) in soils of the automobile workshops. AF: Auto Fixers Workshop; CAF: Auto Fixers Control; DPR: Department of Petroleum Resources

Sampling points	Pb ($mgkg^{-1}$)	Cd ($mgkg^{-1}$)	Cr ($mgkg^{-1}$)	Mn ($mgkg^{-1}$)
AF	235.15±180.14	5.28±2.03	45.96±13.18	411.23±191.68
CAF	30.30	0.60	23.05	9.40
DPR	85.00	0.80	100.00	437.00

Table 2: Allowable limits of heavy metal concentrations in soil (mg kg^{-1})

Heavy metal	Austria	Germany	France	Luxembourg	Netherlands	Sweden	United Kingdom
Cd	1-2	1	2	1-3	0.5	0.4	3
Cr	100	60	150	100-200	30	60	400
Cu	60-100	40	100	50-140	40	40	135
Ni	50-70	50	50	30-75	15	30	75
Pb	100	70	100	50-300	40	40	300

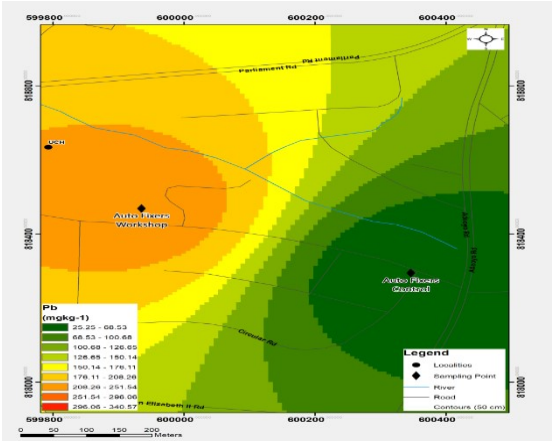

Figure 2: Distribution of Pb concentrations at Auto-Fixers Workshop

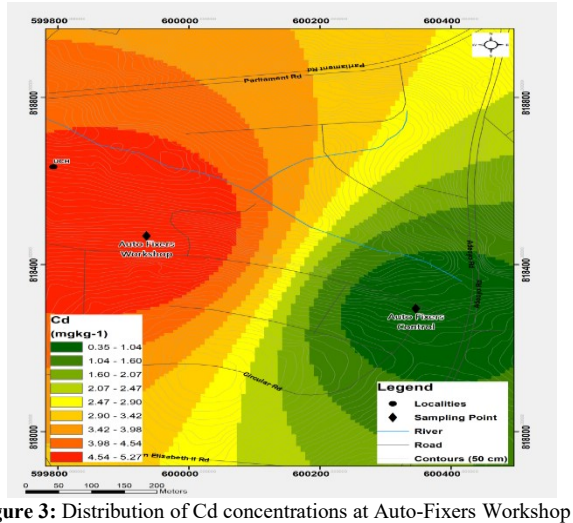

Figure 3: Distribution of Cd concentrations at Auto-Fixers Workshop

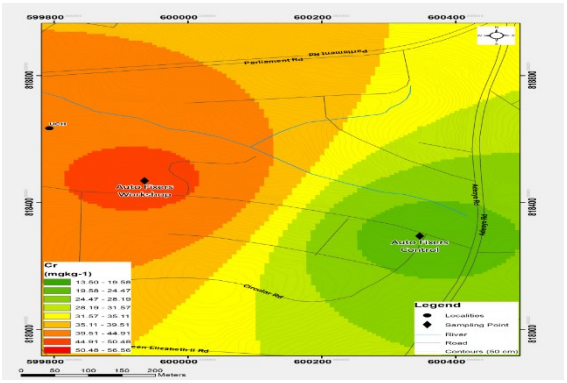

Figure 4: Distribution of Cr concentrations at Auto-Fixers Workshop

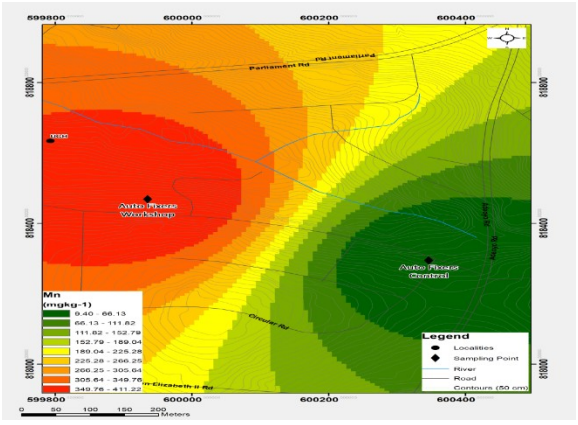

Figure 5: Distribution of Mn concentrations at Auto Fixers Workshop

Applying the contamination factor (CF) to analyze the data showed that the soils from the sites is contaminated with Pb, Cd and Mn; whereas the values for Cr at the sites indicated moderate to considerable contamination (**Table 3**). Contamination factor values for cadmium (Cd), lead (Pb) and manganese (Mn) indicated values greater 6. The results of this study at present showed that the contamination factor values for chromium (Cr) at the workshop is lower than 6, which is an indication of moderate contamination.

As observed in Table 2, the CF for Pb in the workshop was 7.76, while the contamination factor values for Cd reads 8.80 and Chromium CF values in the Auto-Fixers workshops' topsoil samples was 1.99. The contamination factor's values of Mn for Auto-Fixers workshops read 43.45.

Table 3: Contamination Factor and Degree of Contamination values for the Study Site

Parameters	Auto-Fixers	Remarks
Pb	7.76	Very high CF
Cd	8.80	Very high CF
Cr	1.99	Moderate CF
Mn	43.45	Very high CF
Degree of pollution	62.00	Very high C_d ($C_d \geq 32$)

Geo-accumulation index was assessed based on the seven descriptive classes for increasing I-geo values proposed by Müller[14].

The pollution levels of these heavy metals in the environment expressed in terms of the geo-accumulation indices indicate that the Auto-Fixers workshop is moderately polluted in Pb and Cd, while, Cr and Mn showed a level of no contamination. The results (**Table 4**) showed that

Cadmium in Auto-Fixers workshops indicated the Igeo class of 2, while Chromium and manganese within the soil samples from the study sites were of Igeo class 0, which depicts that, the soil's quality from the automobile-repair workshops were not polluted by the metals. The state of heavy metal pollution in the study site is presented in **Figure 6**.

Table 4: Calculated Igeo Index and grade of pollution intensity of metals for the study sites

Metals	A-F Igeo values	Igeo Class	Pollution Intensity
Pb	1.66	2	Moderately polluted
Cd	2.31	3	Moderately-strongly polluted
Cr	-1.12	0	Unpolluted
Mn	-1.41	0	Unpolluted

A-F means Auto-Fixers

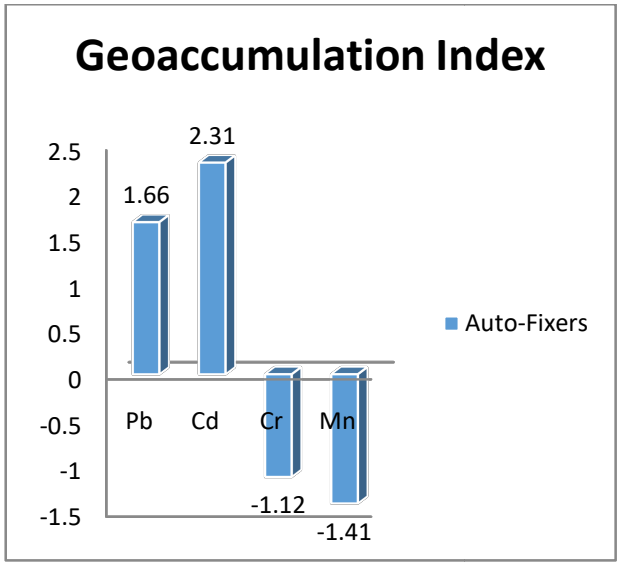

Figure 6: State of heavy metal pollution in the study area based on Igeo calculations

The analysis of QoC (**Table 5**and **Figure 7**), used to describe the geogenic and anthropogenic sources of metal contamination in the soil samples, also showed that the concentration of Pb, Cd, Cr and Mn for all the sites were mainly derived from anthropogenic sources in all the workshops. The values for Quantification of Contamination index for Pb (87.11%), Cd (88.64%), Cr (49.85%) and Mn (97.71%) showed magnitude for anthropogenic impacts.

Table 5: Quantification of Anthropogenic Concentration of Metal (%)

Study Site	Pb	Cd	Cr	Mn
Auto-Fixers Workshop	87.11	88.64	49.85	97.71

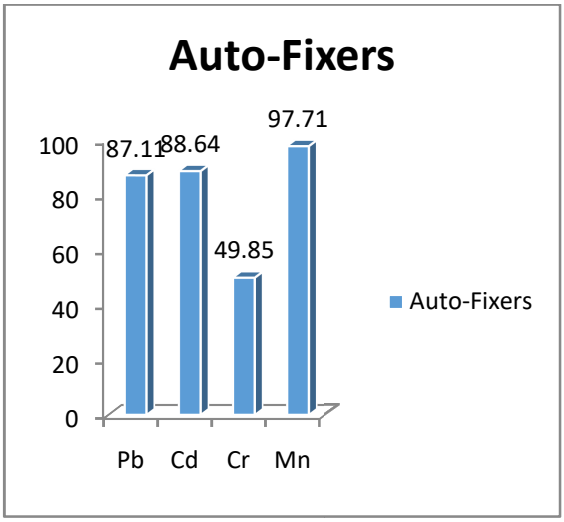

Figure 7:Variation of QoC index from the studied sites

IV. CONCLUSION

The evaluation of the heavy metal concentrations in the study site revealed that soil investigated is contaminated with most of these metals. Comparing the control site with the soils from the workshop showed the degree of contamination of these soils by Pb, Cd and Mn, with Mn and Pb presenting the highest concentrations as shown by the following order of abundance for the metals at the study site Mn>>Pb>> Cr>Cd.On average, the soil from Auto-Fixers Workshops had about 87.11%, 88.64%, 49.85% and 97.71% more Pb, Cd, Cr and Mn, respectively, compared to the control samples. Findings emanated from the study indicated that the topsoil from the workshop are highly polluted by Pb, Cd and Mn. Elevated values of Pb, Cd, Cr and Mn were found in soils at the automobileworkshop when compared to established guidelines of several countries (**Table 2**). The concentrations of lead (Pb) from the study sites were significantly higher than the limits set by NESREA which is 164 mg kg^{-1}. The result obtained from the contamination factor showed that the soils from the study site are enriched by Pb, Cd and Mn. The elevated levels of these heavy metals in the study area portend immediate hazards to health.

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