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Gradations in Concentration of Heavy and Mineral Elements with Distance and Depth of Soil in the Vicinity of Auto Mechanic Workshops in Sabon Gari, Kaduna State, Nigeria

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Abstract**—**The concentration levels of six heavy metals (Cd, Cr, Fe, Ni, Pb and Zn) and two mineral elements (Ca and Mg) were determined in soil samples collected from the vicinity of two auto mechanic workshops in Sabon-Gari, Kaduna state, Nigeria, using Atomic Absorption Spectrometry (AAS), in order to compare the gradation of their concentrations with distance and depth of soil from the workshop sites. At site 1, concentrations of Lead, Chromium, Iron and Zinc were generally found to be above the World Health Organization limits, while those of Nickel and Cadmium fell within the limits. Iron had the highest concentration with a range of 176.274 ppm to 489.127 ppm at depths of 5 cm to 15 cm and a distance range of 5 m to 15 m, while the concentration of cadmium was least with a range of 0.001 ppm to 0.008 ppm at similar depth and distance ranges. In addition, there was more of calcium (11.521 ppm to 121.709 ppm), in all the samples, than magnesium (11.293 ppm to 21.635 ppm). Similar results were obtained for site II. The concentrations of all the metals analyzed showed a downward gradient with increase in depth and distance from both workshop sites except for iron and zinc at site 2. The immediate and remote implications of these findings on the biota are discussed.

Keywords**—**AAS, Heavy Metals, Mechanic Workshops, Soils.

I. Introduction

THE contribution of anthropogenic activities to the pollution load in our immediate environment cannot be overemphasized. Several seemingly insignificant activities can become non discountable when the effects of such activities can accumulate over time. The heavy metals discarded indiscriminately from various sources in various mechanic workshops can become such remarkable sources of environmental degradation, especially taking into account the fact that many such workshops are located near residential or farming areas [1]. Heavy metals receive particular concern considering their strong toxicity even at low concentrations. They portend more danger because of their non-biodegradable nature, long biological half-lives and their potential to accumulate in different body parts [2]. Accumulation of heavy metals in agricultural soils may result in soil contamination and affect food quality and safety [3]-[5].

Soil is the compartment which receives heavy metals coming from different sources such as atmospheric deposition, waste disposal and incineration, urban effluent discharge, traffic emissions, fertilizer application, and long term application of waste water in agricultural land. It also controls their movement to other compartments of the earth [6]. The total content of elements in soil depends on the physical and chemical properties of both the soil and the elements in question. The chemical profiles of the soil gradually decrease as a result of leaching, thus leading to the mobility of such elements through food to man, the ultimate top of the chain [7].

As a result of the activities that go on in and around auto mechanic workshops, heavy metal pollution is expected, and the resulting consequences are inevitable [8].

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II. Materials and Methods

The auto mechanic workshops were located at latitude 11.0996 ^{0}N and longitude 7.72287 ^{0}E, and latitude 11.1016 ^{0}N and longitude 7.72244 ^{0}E, both in Sabon gari local government area of Kaduna State.

Six soil samples were collected at distances of 5 m, 10 m and 15 m from each of the mechanic workshops. At each distance, two samples were collected, one at 5 cm and the other at 15cm depths. All the soil samples were kept and transported in air tight polythene. They were then dried at room temperature for a period of ten days to attain a stable weight. The air dried samples were crushed and sieved using a 2 mm mesh. All twelve soil samples were digested using aqua-regia [9]. The digested samples were then analyzed for Zinc Cadmium, Chromium, Iron, Lead, Nickel, Magnesium and Calcium using a Varian AA 240 FS Atomic Absorption Spectrometer.

III. Results and Discussions

Table I shows the Concentration of Elements in Soil Samples from Site 1, Taken at Corresponding Depths of 5 and 15 cm, and Distances of 5, 10 and 15 m from the Site. The concentrations of the trace metals Pb, Cr, Fe and Zinc exceeded the World Health Organization (WHO) limits which are 0.05ppm, 0.25ppm, 0.5ppm and 0.5ppm respectively. From the results, it can also be seen that the trend in concentration of the trace metals is in the order: Iron > Zinc > Lead > Chromium > Nickel > Cadmium. This trend is not unexpected as the environment is often littered with scrap metal, old rusty abandoned tools, equipments and in some cases abandoned vehicles.

TABLE I
CONCENTRATION OF ELEMENTS IN SOIL SAMPLES FROM SITE 1, TAKEN AT CORRESPONDING DEPTHS AND DISTANCES FROM THE SITE

	Concentration (ppm), for Distance and Corresponding Depth					
Element	5m ,5cm	5m,15cm	10m, 5cm	10m,15cm	15m, 5cm	15m, 15cm
Ca	121.709	19.507	48.775	20.105	45.428	11.521
Fe	418.461	322.556	489.127	176.274	310.149	383.088
Mg	21.635	18.954	19.360	11.293	12.925	18.562
Zn	2.436	2.348	3.446	1.298	1.945	3.017
Cr	0.674	0.489	0.705	0.460	0.631	0.719
Ni	0.446	0.142	0.390	0.067	0.081	0.108
Pb	1.606	0.701	0.757	1.228	0.446	0.675
Cd	0.008	-0.001	0.002	-0.001	-0.002	-0.002

Figs. 1-4 give the plots of changes in concentrations of the studied elements (in ppm), at corresponding depths of 5 cm and 15 cm and distances of 5 m, 10 m and 15 m in Site 1.

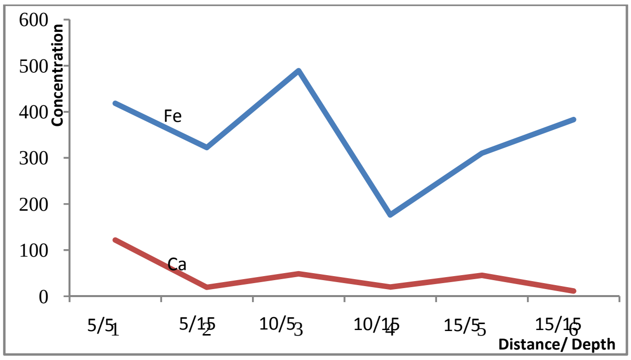

Fig. 1 Plot of Change in Concentration of Ca and Fe (ppm) at Depth of 5 to 15 cm and Distance of 5 to 15 m in Site 1

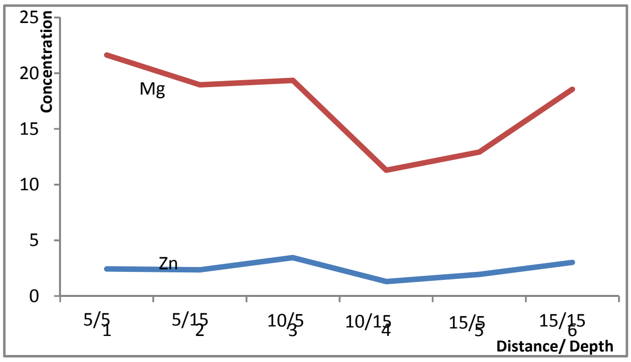

Fig. 2 Plot of Change in Concentration of Mg and Zn (ppm) at Depth of 5 to 15 cm and Distance of 5 to 15 m in Site 1

A similar trend was also observed for soil samples taken from the second auto mechanic workshop as shown in the results in Table II, which gives the Concentration of Elements in Soil Samples from Site 2, Taken at Corresponding Depths of 5 and 15 cm, and Distances of 5, 10 and 15 m from the Site. The heavy metals concentration trend for site 2 was in the order: Iron > Zinc > Chromium > Lead > Nickel > Cadmium.

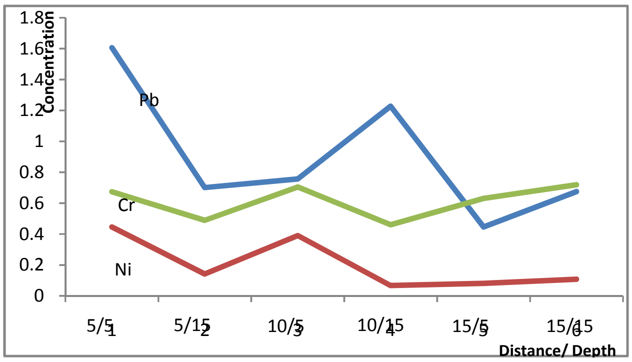

Fig. 3 Plot of Change in Concentration of Cr, Ni and Pb (ppm) at Depth of 5 to 15 cm and Distance of 5 to 15 m in Site 1

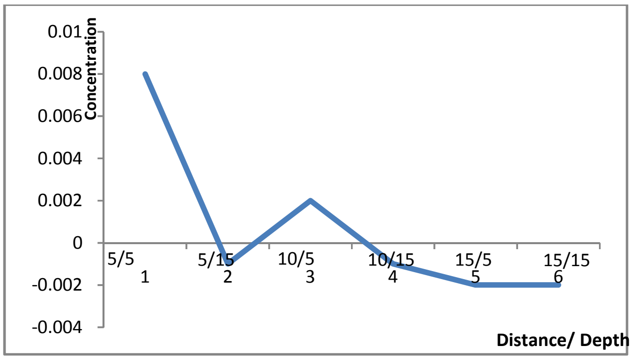

Fig. 4 Plot of Change in Concentration of Cd (ppm) at Depth of 5 to 15 cm and Distance of 5 to 15 m in Site 1

Calcium and Magnesium were present in reasonable quantities in soils from both sites. The concentration of Calcium was however more than three times above the WHO limit, while that Mg fell within the limit. At site 2, the concentration of Calcium at farther distances were above the WHO limits for Ca in soil (18.89 ppm), while all the

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concentrations recorded for Mg fell below the WHO limits for Mg (25.17ppm).

TABLE II
CONCENTRATION OF ELEMENTS IN SOIL SAMPLES FROM SITE 2, TAKEN AT CORRESPONDING DEPTHS AND DISTANCES FROM THE SITE

	Concentration (ppm), for Distance and Corresponding Depth					
Element	5m, 5cm [1]	5m, 15cm [2]	10m, 5cm [3]	10m, 15cm [4]	15m, 5cm [5]	15m, 15cm [6]
Ca	16.321	12.664	19.023	70.291	28.163	12.129
Fe	308.807	479.807	286.170	312.978	488.743	617.026
Mg	14.291	21.016	15.112	18.504	11.806	13.350
Zn	1.678	2.074	1.108	3.008	2.208	2.476
Cr	1.488	0.830	0.468	0.633	3.690	1.060
Ni	0.096	0.167	0.060	0.129	0.301	0.138
Pb	0.610	0.418	0.220	0.550	0.571	0.716
Cd	0.000	-0.002	-0.001	0.003	0.000	-0.002

Figs. 5-8 give the plots of changes in concentrations of the studied elements, in ppm, at corresponding depths of 5 cm and 15 cm and distances of 5 m, 10 m and 15 m in Site 2. Cadmium, Chromium, Nickel, Lead, Calcium and Magnesium all show a downward trend in concentration with increase in distance from the sites at both the 5 cm and the 15 cm depths, as can be seen from Figs. 1-4, 6, 8. This indicates a drop in their concentrations as we move away from the workshop sites. Iron and Zinc at site 2 (Figs. 5, 7) are however a departure from this observation, possibly because of the contribution of other sources to their presence in the environment studied.

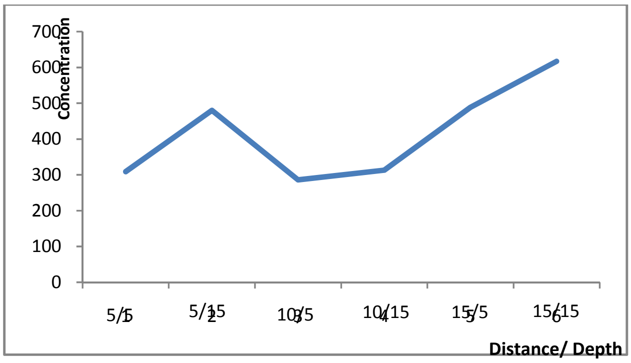

Fig. 5 Plot of Change in Concentration of Fe (ppm) at Depth of 5 to 15 cm and Distance of 5 to 15 m in Site 2

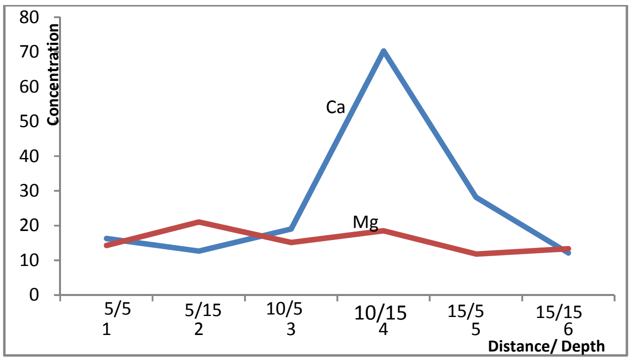

Fig. 6 Plot of Change in Concentration of Ca and Mg (ppm) at Depth of 5 to 15 cm and Distance of 5 to 15 m in Site 2

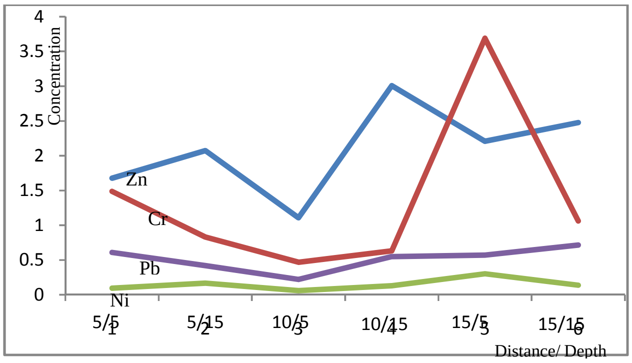

Fig. 7 Plot of Change in Concentration of Cr, Ni, Pb and Zn (ppm) at Depth of 5 to 15 cm and Distance of 5 to 15 m in Site 2

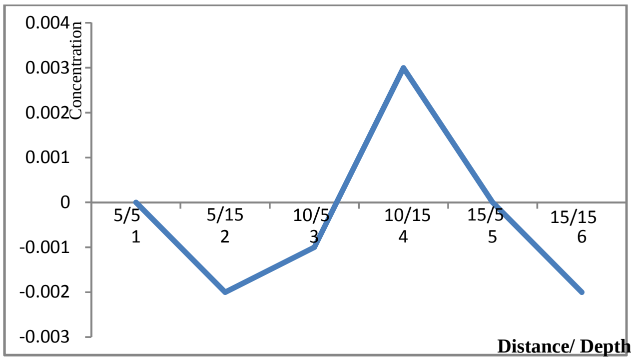

Fig. 8 Plot of Change in Concentration of Cd (ppm) at Depth of 5 to 15 cm and Distance of 5 to 15 m in Site 2

IV. CONCLUSION

The trace elements Pb, Ni, Fe, Cd, Cr and Zn with mineral elements Ca and Mg were found to be distributed in the soil and water within the vicinity of the two mechanic workshops in Zaria. The trend of change in concentration of elements in the soil with distance for the first mechanic workshop was a decrease in concentration with an increase in distance from the workshop for all metals. The trend in the change of concentration of all metals except Magnesium in the soil around site 2 was an increase in concentration with a corresponding increase in distance from the mechanic workshop. This trend is as a result of the presence of other mechanic workshops in the same vicinity although these mechanic workshops were not considered during sampling. Furthermore, this trend poses great threat to the lives of residents in this vicinity since it is predicted that there will be an alarming heavy metal load in soils that are of greater contact with the people. For instance, the concentration of Pb is 0.643ppm at 15m which is 12.86 times greater than the permissible limit which is 0.05ppm and this is very dangerous. Pb in the body no matter how small is attributed to damage of the nervous system, brain disorders, and blood disorders in mammals. Lead is a neurotoxin that accumulates both in soft tissues and the bones. Also the concentration of Iron in site 2 is about 1105.77 times greater than the WHO limit. Excess Iron has adverse effects such as, diabetes, heart disease etc. This is an alarming situation.

It is recommended that auto mechanic workshops be situated far from residential areas and places where farming activities take place in order to reduce the chance of the metals getting into the food chain.

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