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Assessment of Heavy Metals from Selected Soil of Auto Mechanic Workshops within Potiskum Town, Yobe State, Nigeria

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Abstract

The concentrations of As, Cd, Cr, Pb and Zn in selected auto mechanic workshops along the major highways of Potiskum town, Yobe State were determined with Buck Scientific 210 VGB Atomic Absorption Spectrophotometer (AAS) AVG. Pearson's correlation coefficient was used to determine the relationship between the metals. The mean concentrations in mg/kg of the metals found in soil samples were in the sequence of Pb (56.186 ± 0.031) > Zn (34.418 ± 0.029) > Cd (21.822 ± 0.029) > Cr (18.947 ± 0.031) > As (2.764 ± 0.027). The concentrations of Cd in soil samples were above the permissible limits set by WHO while As, Cr, Pb and Zn were below the permissible limits set by WHO. The concentrations of heavy metals found in the auto mechanic workshops may be greatly influenced by anthropogenic activities such as dump site areas, metallic wastes, disposal battery wastes, car tyres, and presence of iron benders, organic and inorganic particles used in oil additives, burning of fossil fuels, presence of metal works and indiscriminate dumping of refuse to the soil of auto mechanic workshops might also contribute significantly to the heavy metals pollution. It is concluded that heavy metals concentrations were found and detected. The concentrations of Cd have exceeded the permissible limit while As, Cr, Pb and Zn were below the permissible limit set by WHO. Therefore, preventive measures must be put in place to monitoring and avoid the future contamination of these heavy metals.

Keywords: Heavy Metals, Pollution, Soil, Anthropogenic Activities.

Introduction

Environmental pollution has increased due to the increasing man's activities such as burning of fossil fuels and automobile exhaust increase in the industrialization and economic activities. The large increase of automobile repairs and workshop activities has partly increased due to the increase in demand of personal used vehicles. Automobiles use oil that contains oxidation product, sediments, water and metallic particles resulting from used batteries, organic and inorganic particles used in oil additives, metallic

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particles resulting from machinery wears and metals [1]. Spent oil soil pollution leads to the build-up of essential and non-essential elements in the soil and eventual translocation in plant tissues [2]. Burning of fossil fuels and petroleum activities have been identified also as a primary source of environmental pollution. In general, heavy metals are systemic toxins with specific neurotoxic, nephrotoxic, fetotoxic and teratogenic effects. Heavy metals have a diminishing effect on biochemical processes posing a threat to human health, animal life and plant growth [3,4].

The pollution of soils by heavy metals from automobile sources is a serious environmental issue. These metals are released during different operations of the road transport such as combustion, components wear, fluid leakage and corrosion of metals. Lead, cadmium, copper, and zinc are the major metal pollutants of the roadside environments and are released from fuel burning, wear out of tires, leakage of oils, and corrosion of batteries and metallic parts such as radiators etc [5]. Majority of the heavy metals are toxic to the living organisms and even those considered as essential can be toxic if present in excess. The heavy metals can impair important biochemical processes posing a threat to human health, plant growth and animal life [3,4,6].

Waste is usually generated in an environment of auto mechanic workshop as a result of some activities like used batteries, packaging materials, metal scraps, spent lubricants and worn-out parts, which contains heavy metals [7a,7b]. Whereby such activities are not monitored properly, they may give rise to higher level of metals and hydrocarbon. Soil is classified as universal receptor; it contains large amount of heavy metals and hydrocarbons with different range in concentration depend on sources. Heavy metals can contaminate soil from different way and can show different behavior in soil [8].

The ability of soil to modify a surface introducing pollutants like heavy metals depend on the soil properties (pH, cation exchange capacity, moisture content and soil texture). Surface of soil that has metals can be carried away by run-off water and can be transported to the groundwater. Heavy metals can be rated as the most harmful group because of their ability to bioaccumulate within tissues and organs in the bodies of organisms [9]. Low concentration of heavy metals can be release in the body, but large quantities can be accumulated in the kidneys, liver, bones and brain [10]. The presence of heavy metals in an environment can easily affect the quality of food, micro-organism activity, plant growth, groundwater etc [11]. Contaminants may tend to affect the abandoned soil and later use for agricultural purposes, but since they are not degradable, they tend to have adverse effect on plants. So also, toxic effect of heavy metals can affect living organisms in the soil when they exceeded their concentration levels.

Therefore, this study is aimed at assessing heavy metals from selected soil of auto

mechanic workshops within Potiskum Town, Yobe State, Nigeria.

Materials and Methods

Map of Study Area

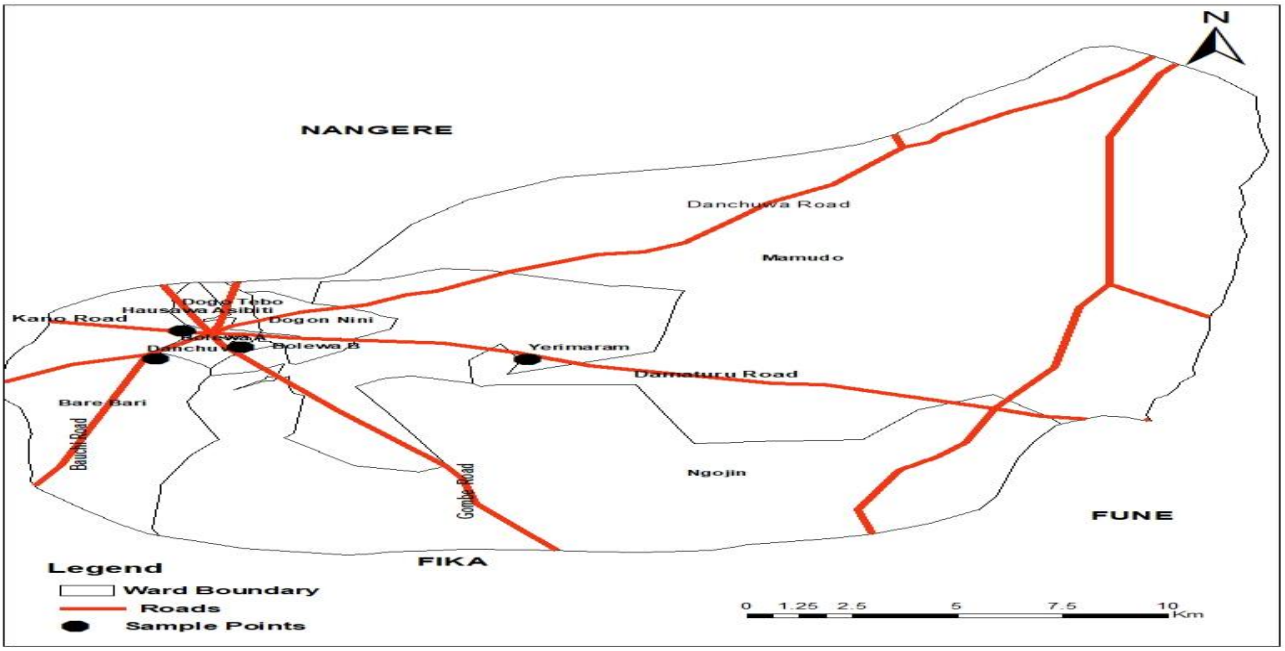


Figure 1: Map of Potiskum showing the samples sites

Materials

All the chemicals and reagents used were of analytical grade, distilled water was used throughout the research work. All glass wares, plastic containers, crucibles, mortar and pestle were washed throughout. Glasses were washed with liquid soap, rinsed with distilled water and then soaked in 10% HNO_3 solution for 24 hours. They were then washed with distilled water and dried in drying oven at 80^oC for hours. All digestions were conducted in acid – washed (5% HNO_3) apparatus.

Method of Sample Collection

A total of thirty two (32) composite soil samples were collected from four (4) selected auto mechanic workshops within Potiskum town, Yobe State using standard soil auger between May and July, 2025 at the depths of 0 – 5 [cm], 5 – 10 [cm], 10 – 15 [cm], and 15 – 20 [cm] were representing four samples per locations. Soil samples were collected at random from the four different locations at each auto mechanic workshop with soil depth separately. The soil samples were placed in polythene bags and transported to the laboratory for further analysis. The location and elevation of each selected site

was recorded with a global positioning system (GPS application). The control samples were collected far from the point of impact where there are neither car repairs nor commercial activities with drainage influence.

Determination of Metal Contents of Each Sample

Concentration of the metal ions present in the sample was determined by reading their absorbance using Atomic Absorption Spectrophotometer AAS (Buck Scientific Model 210GP) and comparing it on the respective standard calibration curve. Three replicate determinations were carried out on each sample. The metals were determined by absorption/concentration mode and the instrument readout was recorded for each solution. The same analytical procedure was employed for the determination of elements in digested blank solutions and for the spiked samples. Replicate analysis, mean and standard deviation were employed, there was no much significant variation between the individual measurements

Soil Sample Treatment and Analysis

Soil samples were air-dried at room temperature for 1 week to avoid microbial degradation. The samples were homogenized and gently crushed repeatedly using a mortar and pestle, and passed through a 0.125mm sieve prior to analysis. 1g of a well homogenized sample obtained from sample preparation procedure above was weighed into a standard Erlenmeyer flask and 12mL of freshly prepared aqua regia (HNO_3:HCl, 1:3) was added. The beaker was covered and the contents heated for 2 hrs on the medium heat of a hot plate. The mixture was allowed to cool and then filtered through a Whatman No. 42 filter paper into a 50mL standard volumetric flask. The filtrate was diluted to 50mL with de-ionized distilled water. Blank solutions were also prepared using aqua regia and de-ionized water. The digested sample solution were analysed using the atomic absorption spectrometer {Buck Scientific 210 VGP Atomic absorption spectrophotometer, (AAS)}. Standard solutions of the various heavy metals were analysed. All soil samples were analysed in triplicate to minimize error.

Data Analysis

Data were statistically analyzed using Microsoft Office Excel. Summary results are presented as mean ± standard deviation (Mean ± SD). The value of correlation coefficient was calculated using IBM SPSS Statistics version 22 to determine the relationship between the heavy metals.

Results and Discussion

Table 1: Mean Concentration (mg/kg) of As, Cd, Cr, Pb and Zn from Bauchi Road (BR) Workshop (Mean ± SD).

S/No	Sample Id	Arsenic (mg/kg)	Cadmium (mg/kg)	Chromium (mg/kg)	Lead (mg/kg)	Zinc (mg/kg)
1.	BR.MS.5	ND	4.252±0.029	18.947±0.031	32.657±0.029	18.321±0.029
2.	BR.MS.10	ND	3.785±0.030	2.550±0.029	25.329±0.030	ND
3.	BR.MS.15	ND	1.542±0.028	0.950±0.028	17.914±0.028	9.138±0.028
4.	BR.MS.20	ND	ND	5.450±0.028	15.943±0.030	ND
5.	BR.DS.5	ND	16.939±0.031	0.975±0.028	39.514±0.030	ND
6.	BR.DS.10	ND	18.084±0.028	8.275±0.027	36.514±0.031	ND
7.	BR.DS.15	ND	21.822±0.029	5.375±0.029	47.314±0.030	30.031±0.028
8.	BR.DS.20	ND	6.332±0.029	5.600±0.028	56.186±0.031	ND
WHO Limit (mg/kg)		40	0.8	100	85	300

Keys: BR – Bauchi Road, BR.MS – Bauchi Road Main site, ND – Not Detected

Table 2: Mean Concentration (mg/kg) of As, Cd, Cr, Pb and Zn from Damaturu Road (DR) workshop (Mean ± SD).

S/No	Sample Id	Arsenic (mg/kg)	Cadmium (mg/kg)	Chromium (mg/kg)	Lead (mg/kg)	Zinc (mg/kg)
1.	DR.MS.5	ND	7.734±0.028	4.100±0.027	19.929±0.029	14.235±0.029
2.	DR.MS.10	ND	11.285±0.028	6.225±0.029	38.614±0.030	13.041±0.030
3.	DR.MS.15	ND	ND	0.500±0.028	44.657±0.028	13.821±0.032
4.	DR.MS.20	ND	2.453±0.030	4.850±0.029	11.186±0.030	ND
5.	DR.DS.5	ND	3.715±0.028	8.450±0.030	6.214±0.030	32.418±0.029
6.	DR.DS.10	ND	ND	1.075±0.028	8.614±0.310	ND
7.	DR.DS.15	0.847±0.027	14.182±0.035	5.575±0.028	33.471±0.030	ND
8.	DR.DS.20	ND	4.673±0.030	7.725±0.027	30.171±0.031	ND
WHO Limits (mg/kg)		40	0.8	100	85	300

Key: DR – Damaturu Road, DR.MS – Damaturu Road Main site, DR.DS – Damaturu Dump site, ND – Not Detected

Table 3: Mean concentration (mg/kg) of As, Cd, Cr, Pb and Zn from Kano Road (KR) workshop (Mean ± SD).

S/No	Sample I.d (cm)	Arsenic (mg/kg)	Cadmium (mg/kg)	Chromium (mg/kg)	Lead (mg/kg)	Zinc (mg/kg)
1.	KR.MS.5	ND	ND	0.375±0.027	7.843±0.029	5.648±0.029
2.	KR.MS.10	2.764±0.027	8.738±0.028	0.875±0.028	ND	ND
3.	KR.MS.15	ND	6.776±0.031	4.550±0.029	0.386±0.030	28.607±0.030
4.	KR.MS.20	0.042±0.028	6.005±0.028	ND	4.371±0.029	41.602±0.029
5.	KR.DS.5	1.389±0.028	6.963±0.027	0.550±0.027	30.557±0.028	9.505±0.028
6.	KR.DS.10	ND	1.519±0.028	10.750±0.028	ND	6.245±0.031
7.	KR.DS.15	ND	6.729±0.029	14.650±0.028	1.029±0.027	11.020±0.032
8.	KR.DS.20	ND	6.308±0.030	5.650±0.0287	23.957±0.028	14.464±0.028
WHO Limits (mg/kg)		40	0.8	100	85	300

Key: KR – Kano Road, KR.MS – Kano Road Main site, KR.DS – Kano Road Dumpsite, ND – Not Detected

Table 4: Mean concentration (mg/kg) of As, Cd, Cr, Pb and Zn from Gombe Road (GR) workshop (Mean ± SD)

S/No	Sample Id (cm)	Arsenic (mg/kg)	Cadmium (mg/kg)	Chromium (mg/kg)	Lead (mg/kg)	Zinc (mg/kg)
1.	GR.MS.5	ND	17.383±0.032	1.925±0.027	ND	ND
2.	GR.MS.10	0.458±0.028	ND	8.025±0.028	ND	ND
3.	GR.MS.15	ND	7.173±0.028	2.600±0.029	18.471±0.027	ND
4.	GR.MS.20	ND	15.374±0.028	2.725±0.028	ND	ND
5.	GR.DS.5	ND	ND	3.900±0.028	12.171±0.027	12.857±0.031
6.	GR.DS.10	ND	7.897±0.029	6.750±0.028	ND	5.969±0.033
7.	GR.DS.15	ND	3.622±0.031	ND	6.900±0.027	32.281±0.027
8.	GR.DS.20	ND	6.986±0.029	1.125±0.028	ND	19.515±0.031
WHO Limits (mg/kg)		40	0.8	100	85	300

Key: GR – Gombe Road, GR.MS – Gombe Road Main site, GR.DS – Gombe Road Dumpsite, ND – Not Detected

Discussion

Lead (Pb): Among the four sites, the concentration of Pb in BR road is recorded to have the highest level with mean concentration of 56.186±0.031 mg/kg in the dumpsite area within the depth of 20 cm while the lowest value 0.386±0.030 mg/kg found in KR road within the depth of 15cm from the workshop main site area. The permissible limits set by WHO for Pb is 85 mg/kg. Therefore, the mean concentration found in this study does not exceed the limits set by WHO. However, the Pb levels observed in this study are significantly lower than those report.

This value was higher than the critical soil Pb limits for Canada (25mg/ kg), and Eastern Europe (32 mg/kg); and lower than Czech Republic (70 mg/kg).

The high concentration of Lead (Pb) found in this study compared to the other studies is an indicative that Pb is among the soil pollutants found in the environment of mechanic workshop. The comparatively high level of Pb may be due to the activities carried out in the workshop, fall out of Pb from batteries and other lead accumulators which are usually used and abandoned in the workshop. Proximity of highway roads to the workshop area would also contribute to the Pb level accumulated in the soil. Improper disposal of waste lubricant and auto exhaust emission are likely source of high Pb contamination. Another research has shown that concentration of Pb in the soil is likely to have derived from vehicle exhaust fumes containing some lead rich aerosols [13]. In another study, use of tetraethyl lead as an anti-knocking agent in gasoline gives rise to its release during emissions from automobiles and fossil fuel combustion.

Report shows that the major source of Pb pollution is exhaust gases of petrol engines, which account for nearly 80% of the total lead in the air. The comparatively high Pb level in the workshop is due to fallout of lead from batteries or lead accumulators which are usually abandoned in the workshop areas close to the major road. This would have contributed to the Pb level accumulated in the soils. This is because lead is easily derived mostly from exhausts of vehicles, improper disposal of waste lubricants and auto – exhaust emission are likely sources of high Pb contamination.

Cadmium (Cd): The summary of Cadmium found in all the sites of the study, Cd shows high concentration at site A (BR) with mean concentration of 21.8 mg/kg at depth of 15cm in their dumpsite area and lower concentration of 1.52 mg/kg at dumpsite within 10cm depth. The concentration on Cd in this study has exceeded the limit set by WHO for heavy metals in soil. This finding is consistent with that of Luther which investigated heavy metals in soil of auto mechanic workshop and refuse dumpsite, maximum Cd level observed is above the reported in Imo, South–East Nigeria [14]. Cadmium can enter the human body through smoking cigarettes, contaminated water due to landfills, certain foods such as shellfish, and mostly through handling the metal itself. Cadmium is a very toxic metal and needs to be handled with great caution. Lethal doses of cadmium may affect various organs in animals which include the liver, kidney, lungs and immune system.

Chromium (Cr): The result reveals that BR road workshop has the highest concentration of Cr with mean value of 18.947±0.031 mg/kg at the depth of 5cm and the lowest in 0.950±0.028 mg/kg in 15cm depth around the main site. The value obtain in Cr is lower than the permissible limits set by WHO standard. The mean concentration of Cr obtained in this study is higher than 15.40 to 86.40 µg/g obtained by [15]

in a similar study, but higher than 1.095±0.00 to 39.975±0.129 µg/g reported by [16]. The higher concentration may be due to sewage and paints working space in the workshop, this may also be attributed to the age of the workshop and also due to the discharge of waste products from the metallic workshop directly into the environment. Cr is toxic by inhalation and dermal route and causes lung cancer, nasal irritation, nasal ulcer, and hypersensitivity reactions. According to [17], chromium level in road side soil is associated with the chromic plating of some vehicle parts used for preservation of corrosion.

Zinc (Zn): Mean concentrations in all samples (mg/kg) range from 41.602±0.029 in KR road at 20cm depth from main site in the workshop to 30.031±0.028 in BR road at depth of 15cm from dumpsite area. The highest Zn levels were obtained at Site C (KR) within 20cm depth. By the result shown, Zn fell below the permissible limits set by WHO on soil samples. The range of values obtained in this study is lower than those reported by [13,14,18]; but higher than the levels reported by [14]. The higher level in the KR may be attributed to the age of the site which is about twenty years of operation and also the results of its location along the roadside, roadside soil could easily be due to wear and tear of vehicles with galvanized steel surface [13]. Zn when released during mechanical abrasion of vehicles and from combustion of engine oil and vehicles tyres [18]. Other possible sources of Zn in relation to automobile traffic are losses of oil and cooling liquid of vehicles and wearing road paved surface. The amount of Zn recorded at Kano road (KR) was the highest probably because of the access road leading to many towns and many vehicles movements to and fro from the express way.

Arsenic (As): Tend to have the lowest concentrations among all the metals studied and the highest level of concentration found is at Site C Kano Road (KR) with mean level of 2.76 mg/kg in the main site at 10cm depth. The level of As mean concentration found in site B, C and D. Arsenic is below the permissible limit set by WHO and therefore, does not pose any threat to health in the environment but proper maintenance and carefulness need to be administered.

Conclusion

It was concluded that, heavy metals concentration are found in some selected auto mechanic workshops from Potiskum town, Yobe State where as the concentrations of these heavy metals found are as follows: Pb (56.186 ± 0.031) > Zn (34.418 ± 0.029) > Cd (21.822 ± 0.029) > Cr (18.947 ± 0.031) > As (2.764 ± 0.027). Pb is the most abundant metals found in the soil. Cd (18.9mg/kg) was found to be above permissible limits set by WHO (0.8mg/kg). It is toxic metal and needs to be handled with great caution. If breathe in and can damage lungs and may even cause death. Accumulation of Cd in kidneys can lead to kidney failure, while foodstuffs that are rich in cadmium can greatly increase the cadmium concentration in human bodies' i.e

liver, mushrooms, shellfish, mussels, cocoa powder and dried seaweed. The concentrations of Cd in soil samples were above the permissible limits set by WHO while As, Cr, Pb and Zn were below the permissible limits set by WHO. The concentrations of heavy metals found in the auto mechanic workshops may be greatly influenced by anthropogenic activities such as dump site areas, metallic wastes, disposal battery wastes, car tyres, and presence of iron benders, organic and inorganic particles used in oil additives, burning of fossil fuels, presence of metal works and indiscriminate dumping of refuse to the soil of auto mechanic workshops might also contribute significantly to the heavy metals pollution.

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