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## INVESTIGATION OF THE ENVIRONMENTAL IMPACT OF HEAVY METALS EMISSIONS FROM AUTO-MECHANIC WORKSHOPS IN POTISKUM-NIGERIA

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### ABSTRACT

This research paper investigated the elemental concentrations on environmental implications of heavy metals' emission in soil from automotive workshops in Potiskum metropolis, Yobe State, Nigeria. Soil samples were collected from 10 workshops with 1 control site, were analysed at central laboratory, Umaru Musa Yar'adua University, Katsina State, Nigeria, using Energy Dispersive X-Ray Fluorescence (ED-XRF). Statistical analysis revealed excessive mean elemental concentrations, with Aluminium (Al) and Iron (Fe) level being extremely high in all the sample locations. The findings highlight the need for effective majors to mitigate heavy metal pollution in soil within automotive workshops. This study provides baseline data on heavy metals contamination levels in Potiskum automotive workshops environment.

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**Key Words:** Heavy Metals, Pollution, Auto mechanic workshop Potiskum, Soil

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### 1.0 INTRODUCTION

Heavy metals are any metallic chemical element that have high atomic weight and high density (greater than  $5\text{g/cm}^3$ ); most of them are toxic or carcinogenic even at low concentrations, such as mercury (Hg), cadmium (Cd), arsenic (As) and chromium (Cr) [1] - [3]. The main sources of heavy metals in the environment are natural such as weathering of rocks, sea-salt sprays, forest fires, volcanic eruptions or soil minerals and anthropogenic due to human activities such as auto-mechanic workshops, metallic parts, paints, batteries, used oil [4]. Mostly, heavy metals are non-biodegradable in natural environment and are characterized in two groups. The first group is toxic metals (i.e. Pb, Cd and As etc.) which are undesirable; don't have biological benefits for human health and toxic at any concentrations. The second group is essential metals (i.e. Cu, Zn, Mn, Fe, Ni and Cr etc.) which are desirable and have biological benefits for human health at low concentrations, but it become toxic at high concentrations [5].

Research shows that, the major sources of soils' pollutions are heavy metals. Heavy metals' pollution especially Cu, Ni, Cd, Zn, Cr and Pb may cause environmental health risk to plants, animals, human beings and among others. Kamran *et al.*[6] proved that "mobility of these heavy metals by activity of several atmospheric events e.g., runoff water and blowing winds enhanced their accumulation in the topsoil, polluting air and water that leads to chronic disorders in living bodies inhabiting these localities." [7] pointed out that "soils in urban areas are frequently disturbed and subjected to mixing, filling and contamination with heavy metals, herbicides, pesticides residuals, oils and chemicals from motor engines and also heavy machines." While these workshops provide essential services, they also generate significant environmental pollutants, including heavy metals. Heavy metals such as; lead, cadmium, chromium, cobalt are toxic and can contaminate soil, water and air, posing serious

health to humans and the environment. Pollution arising from the disposal of used engine oil is one of the environmental problems in Nigeria, and is more widespread than crude oil pollution which calls for urgent attention [8]. Mechanic workshops are potential sources of heavy metal pollution due to the use of petroleum products, batteries, and other materials that contain heavy metal. The improper disposal of waste materials, including used oil, batteries and scrap metals can lead to the release of heavy metals into the environment. Perhaps, according to and [9], emphasis that “the improper disposal of these used motor oil, body parts, grease, battery electrodes had contaminated the soil which results in an increase in pollution incidents in the environment.” Another study by [10], reported the lead (Pb) and iron in drinking water of Potiskum metropolis above the recommended value set by WHO their result showed that these heavy metals have risk associated with the water and soils of the study area.

Despite limited studies on the spatial distribution of heavy metals pollutants, their ecological risks and potential public health implications in Potiskum. While auto mechanic workshops are known to contribute to soil, water, and air pollution through improper disposal of used oil, paints, lubricant, and vehicle spare parts, based a review of existing literatures, data on the impact of heavy metal emissions in the environment due to auto-mechanic workshop in Potiskum is not available therefore, this study link this gap by providing the empirical data on the heavy metal emissions in Potiskum.

This study aims to investigate the environmental impact of heavy metal emission such as Zn, Fe, Cd, Co, Pb, Cr, Mn and Al from automotive workshops in Potiskum, Nigeria. Specifically, the study assessed the levels of heavy metals in soil sample collected from workshops surrounding areas. The findings of this study will contribute to our understanding of the environmental impacts of mechanic workshops and inform strategies for mitigating heavy metal pollution in Nigeria.

**2.0 MATERIALS AND METHOD**  
**Sample Map’s Location**

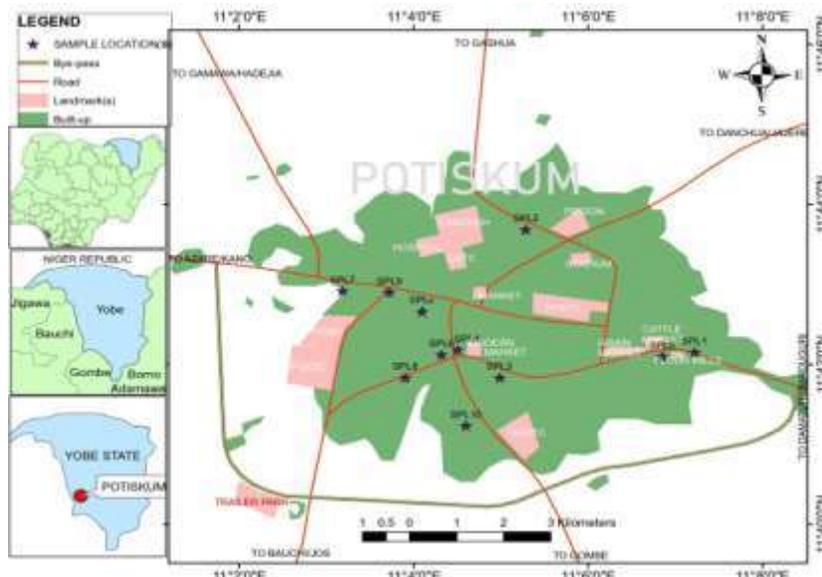


Figure 1: Map of Nigeria showing Yobe State and Potiskum Local Government Area

## Sampling Points and Location of Soil Sample

Table 1 below shows the sample code, workshops names, sampling points and with their sample location's addresses of the study area:

Sample Code	Workshop's Name	Sample Coordinates by GPS		Sample Location's Address
		Latitude (N)	Longitude (E)	
SPL1	Alh. Sani Danjuma & Habu Ibrahim Mechanic Workshop.	Lat. 011°42'90"	Long. 011°70'13"	Opp. B.A Bello Filling Station, Along Maiduguri Road, Potiskum
SPL2	Oga Ibrahim Buramau Mechanic Workshop.	Lat.011°43'41"	Long. 011°05'77"	Sabon Tashan Nangere, Ugwanda, Along Gashu'a Road, Potiskum
SPL3	Alh. Lawan Amashi Mechanic workshop.	Lat.011°43'50"	Long. 011°40'59"	Rafin Bodori, Along Maiduguri Road, Potiskum
SPL4	Yabure Mechanic Workshop.	Lat.011°42'50"	Long. 011°40'25"	Honda Palace, Opp. Nepa Graveyard, Potiskum
SPL5	Alh. Sa'edu Mechanic Workshop.	Lat.011°42'60"	Long. 011°60'51"	Adjacent Flour Mill, Along Maiduguri Road, Potiskum
SPL6	Idi Master Mechanic Workshop.	Lat.011°42'10"	Long. 011°40'21"	Opp. Tamir Guest House, Along Bauchi Road, Potiskum
SPL7	Abban Malam Mechanic Workshop.	Lat.011°42'55"	Long. 011°30'1"	Opp. Rest House, Along Kanc Road, Potiskum
SPL8	Fanteka Garage Palace.	Lat.011°41'50"	Long. 011°30'54"	Adjacent Tashan Kunne, Along Bauchi Road, Potiskum
SPL9	Garejin Bello (Alh. Yawale) Mechanic Workshop.	Lat.011°42'48"	Long. 011°30'29"	Opp. First Bank Plc, Potiskum.
SPL10	New Maliya Mechanic Workshop.	Lat.011°41'14"	Long. 011°04'8"	Opp. Arjali Filling Station, Potiskum
SPL11	Central Primary School, Potiskum.	Lat.011°42'39"	Long. 011°40'50"	Mohammed Idriss Way, Potiskum

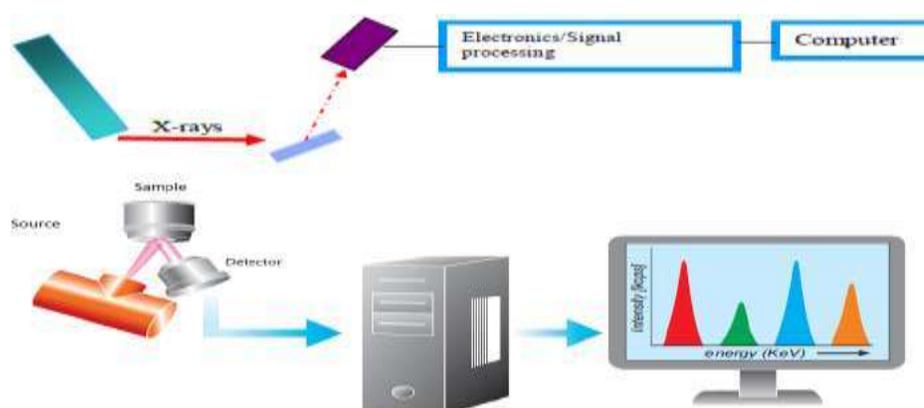
**Key: SPL means Sample Location, SPL1 – SPL10 means uncontrolled sample locations and SPL11 means controlled sample location**

### Sample collection

In this paper, the research work focused on Ten (10) different representatives of soil samples locations from the auto-mechanic workshops in Potiskum local government area of Yobe State, with one (1) control sample location for comparison. Global Positioning System (GPS) device was used to mark the sampling location and elevation above sea level. Soil samples were collected at a depth of 0 to 20 cm using soil auger at each of the samples location using random sampling. Using hand-glove the samples were carefully put into clean and labelled plastic containers (200 ml) for analyses in the laboratory.

### Sample preparation

The figure 2 below shows the picture of the experimental setup of the soil samples prepared for laboratory analysis in which are eleven (11) in number using Energy Dispersive X-Ray Fluorescence (ED-XRF) analysis. The heavy metals in soil samples were determined using Energy Dispersive X-Ray fluorescence (ED-XRF) analytical techniques at the Central's laboratory, Umaru Musa Yar'adua University, Katsina State, Nigeria.



**Figure 2: Experimental setup for X-ray fluorescence machine adopted from Clapera et al. [11]**

Firstly, the soil samples were dried naturally at room temperature in a clean room and then oven dried at 105°C to constant weight for 6 hours [12]; the oven dried soil were grinded manually using a porcelain mortar and sieve into powder through a 2 mm plastic mesh which attend homogenization in a turbulent mixer and the representative soil sample were obtained. Grinding is an effective way of eliminating large and inconsistent grain sizes to produce homogeneous samples from unfastened powders. The samples were carefully put into clean and labeled plastic containers (200 ml) for analyses in the University's laboratory. As the prepared sample reached the laboratory, (5 – 15)g of each sample were weighed into 32 mm sample cups with a polypropylene X-ray film of 4µm thickness and were hydraulically press placed on the machine (mini pal 4 version) for analysis[12], [13].

### Sample analysis

The measurements were conducted using Mini pal 4 version machine (Figure 1), model ARL QUANT'X ED-XRF Analyser Serial Number: 9952120, a product of Thermo fisher Scientific Company Switzerland with a mass of only 28 kg, equipped with a 30 kV rhodium anode tube, 5 filters, a helium purge facility, a high-resolution Silicon Drift Detector, a spinner and a 12-position removable sample changer enabling unattended batch analysis. According to [14], the rotating or spinning of the sample reduces heterogeneity and accuracy of the analysis.

### 3.0 RESULTS AND DISCUSSION

The ED-XRF analysis results obtained for the soil samples of the study area shows presence of Zn, Fe, Pb, Cr, Mn and Al, for most of the samples at 0 to 20 cm soil depths with their concentrations in ppm as shown in Table 1. The values varies as follows: Zn (86.18 – 643.44), Fe (14198.92 – 106198.03), Pb (26.34 – 230.04), Cr (0.00 – 86.25), Mn (508.52 – 9257.04), and Al (36793.61 – 83470.82). From the result, only Cd and Co that were not detected in all the locations of the study area, Cr was also detected in almost all the sample locations of the study areas except in Central Primary School, which happens to be below detection limit. All the concentration values in the study area were found to be within the permissible limit set by all international organizations such as WHO, 1996 and International Benchmark Concentration prepared for U.S Department of Energy as cited in [15], and as cited in [16]. The high concentration of Cd in some of the samples might be due to the natural and anthropogenic means in the study area such as: natural weathering of the earth's crust, soil erosion, oil disposals, dismantles of metals' scrap and among others.

**Table 2:** Elemental Concentrations (EC) of heavy metals in soil samples in ppm

Sample Codes	Zn	Fe	Cd	Co	Pb	Cr	Mn	Al
SPL1	585.69	106198.03	BDL	BDL	230.04	86.25	1743.82	39872.98
SPL2	221.44	28820.06	BDL	BDL	54.91	11.22	597.53	48820.06
SPL3	643.44	33263.58	BDL	BDL	128.01	27.29	1637.01	47476.14
SPL4	179.35	20681.68	BDL	BDL	36.92	14.09	508.52	49645.45
SPL5	288.35	68829.00	BDL	BDL	76.71	38.85	2378.50	83470.82
SPL6	88.67	14198.92	BDL	BDL	47.21	4.72	883.91	51227.46
SPL7	433.33	37236.96	BDL	BDL	50.09	16.42	9257.04	36793.61
SPL8	124.98	20449.68	BDL	BDL	71.61	3.56	680.35	67973.48
SPL9	145.30	20574.07	BDL	BDL	58.16	7.05	664.87	51984.08
SPL10	138.79	27761.93	BDL	BDL	56.12	1.91	639.32	44206.31
SPL11	86.18	20864.07	BDL	BDL	26.34	BDL	560.38	52280.37

BDL (BELOW DETECTION LIMIT)

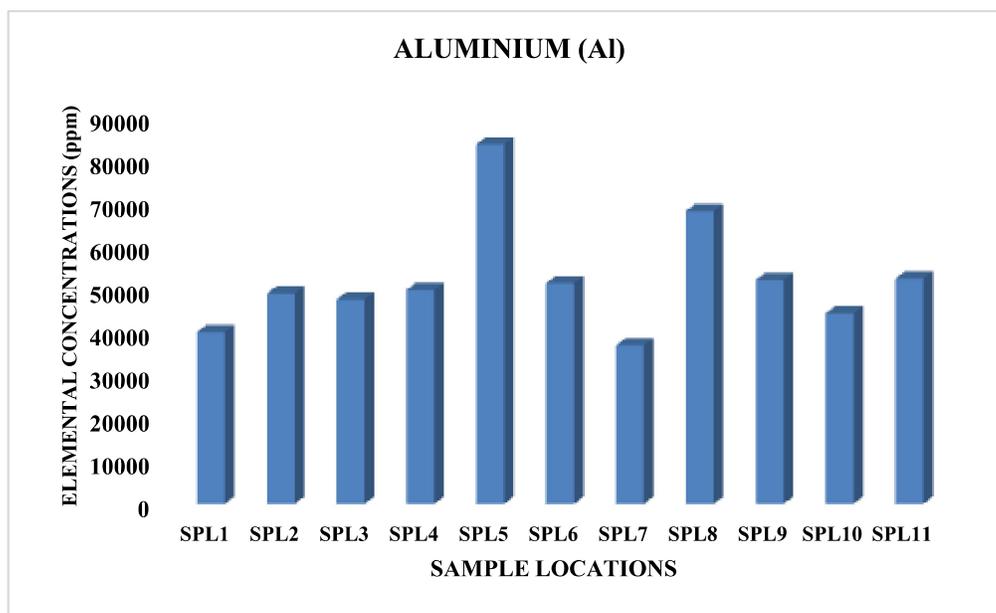
Based on the results obtained, the mean  $\pm$  standard deviation of the elemental concentration is in the order of Al ( $52159.16 \pm 49064.25$ ) > Fe ( $36261.63 \pm 26202.00$ ) > Mn ( $1777.39 \pm 1149.98$ ) > Zn ( $266.87 \pm 189.73$ ) > Pb ( $76.01 \pm 54.95$ ) > Cr ( $19.22 \pm 23.96$ ). PPMC correlation coefficients of elemental concentration values of heavy metals in the study area were evaluated, in which strong positive correlations were obtained between Zn – Cr and Fe – Cr, at significant levels of 0.05 and 0.01 respectively. Moderate positive correlation was found between Fe – Mn, Fe – Al and Cr - Mn. Weak negative correlation was found between Zn – Pb, Zn – Al, Fe - Pb and Mn – Al amongst others. The mean concentrations of Zn, Fe, Al, Pb and Mn of the study area were above the permissible limits and only Cr that is below the permissible limit set by the international organizations (WHO, USEPA, EU & FAO/WHO). The higher concentration of heavy metals in auto-mechanic workshops' soils in this study area might be due to natural and anthropogenic means such as: natural weathering of the earth's crust, soil erosion, oil disposals, dismantles of metals' scrap and among others. Higher concentrations of Zn, Fe, Pb, Mn and Al can cause neurological damage, developmental delays and increased disease risk. Heavy metals (Fe, Al, Zn, Mn, Pb and Cr) can contaminate soil, water and air, causing ecological damage and human health problems. Exposure can lead to neurological damage, cancer, reproductive issues and other health effects.

The mean elemental concentration is in the order of Al > Fe > Mn > Zn > Pb > Cr with lowest and high mean values of 19.19 ppm and 52204.55 ppm for Al and Cr, respectively. Based on the research result obtained the mean and standard deviation of elemental concentration is in the order of Al ( $52159.16 \pm 49064.25$ ) > Fe ( $36261.63 \pm 26202.00$ ) > Mn ( $1777.39 \pm 1149.98$ ) > Zn ( $266.87 \pm 189.73$ ) > Pb ( $76.01 \pm 54.95$ ) > Cr ( $19.22 \pm 23.96$ ).

**Table 3:** Statistical summary showing Mean, Range and Std. Deviation of concentrations of Heavy Metals in soil samples from the study area (in ppm).

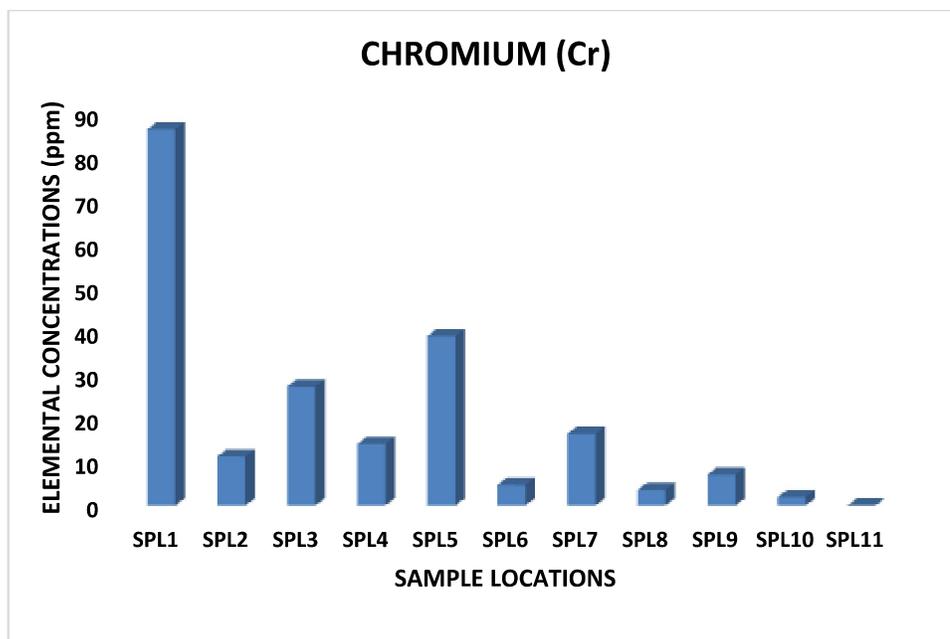
Elements	Min & Max	Mean	Mean ± SD
Zn	86.18 - 643.44	266.87	266.87 ± 189.73
Fe	14198.92 – 106198.03	36261.63	36261.63 ± 26202.00
Cd	BLD	BLD	BLD
Co	BLD	BLD	BLD
Pb	26.34 – 230.04	76.01	76.01 ± 54.95
Cr	0.00 – 86.25	19.22	19.22 ± 23.96
Mn	508.52 – 9257.04	1777.39	1777.39 ± 1149.98
Al	36793.61 – 83470.82	52159.16	52159.16 ± 49064.25

Figure 3: shows the bar chart that illustrates comparison of ED-XRF analysis results of Al obtained in this study. Al was observed in all of the samples with the highest concentrations in Alh. Sa'edu's Mechanic Workshop and lowest concentration was observed in Abban Malam's Mechani workshop.



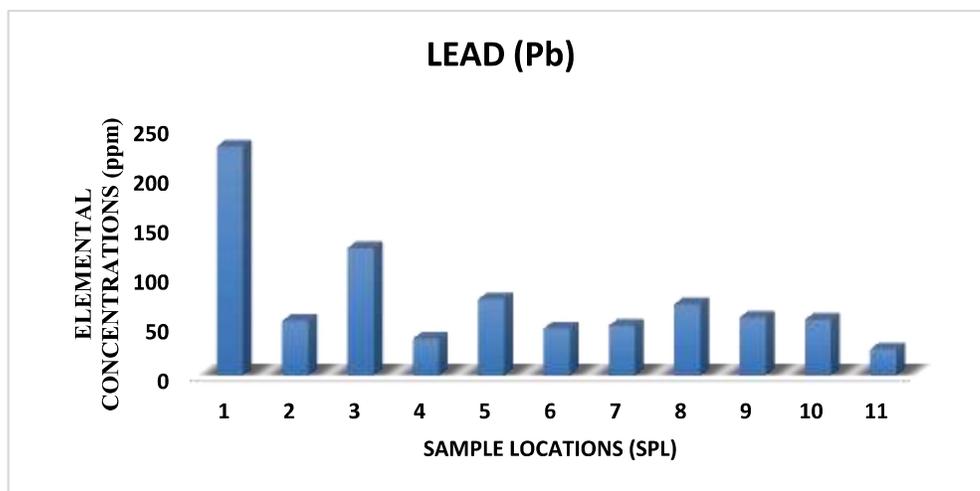
**Figure 3 Mean Elemental Concentrations of Aluminum in Auto Mechanic Workshops in Potiskum.**

Figure 4: shows the bar chart that illustrates comparison of ED-XRF analysis results for Cr obtained in this study. Cr concentration was highest in Alh. Sani Danjuma & Habu Ibrahim's Mechanic Workshop and was not detected in Central Primary School (Controlled site), meaning; was below the permissible limit as set by the international organizations (WHO, USEPA, EU & FAO/WHO). Moreover, Cr is one of the toxic and carcinogenic heavy metals because of their high toxicity to human tissues even at low concentration [17].



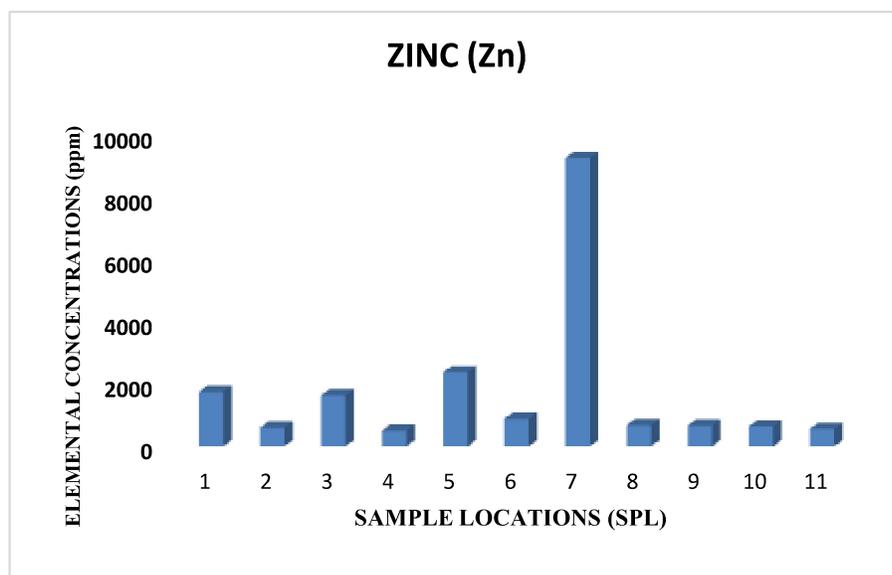
**Figure 4 Mean Elemental Concentrations of Chromium in Auto Mechanic Workshops in Potiskum.**

Figure 5: illustrates comparison of ED-XRF results for Pb obtained in this study. Pb was observed in all the samples locations with the highest concentrations in Alh. Sani Danjuma & Habu Ibrahim’s Mechanic Workshop and lowest concentrations in Central Primary School (Controlled site).



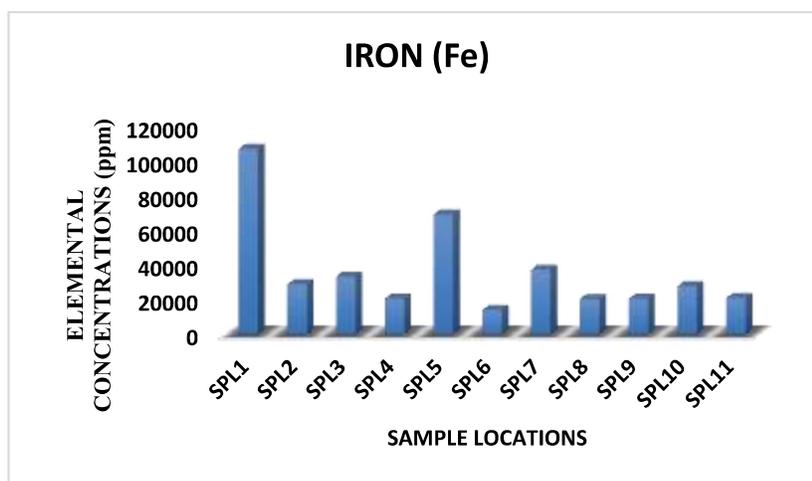
**Figure 5 Mean Elemental Concentrations of Lead in Auto Mechanic Workshops in Potiskum**

Figure 6: illustrates comparison of ED-XRF results for Zn obtained in this study. Zn was recorded in all samples locations with the highest concentrations in Abban Malam’s Mechanic Workshop and lowest concentration in Yabure’s Mechanic Workshop. Zn is also one of the toxic essential heavy metals and is highly detrimental to plants when its concentration in soil exceeds tolerable limits [18].



**Figure 6 Mean Elemental Concentrations of Zinc in Auto Mechanic Workshops in Potiskum.**

Figure 7: illustrates comparison of ED-XRF results for Fe obtained in this study. Fe is presence in all the samples locations with the highest concentrations recorded in Alh. Sani Danjuma & Habu Ibrahim’s Mechanic Workshop and the lowest concentrations were recorded in Idi-Master’s Mechanic Workshop. Fe is the second most abundant element in Earth’s crust which is widely used as constructional materials, pigments paints, among others. Fe is commonly found in all types of soils and rocks.



**Figure 7 Mean Elemental Concentrations of Iron in Auto Mechanic Workshops in Potiskum.**

Figure 8: illustrates comparison of ED-XRF results for Mn obtained in this study. Mn was present in almost all the samples locations with the highest concentrations in Abban Malam’s Mechanic Workshop and lowest concentration in Oga Ibrahim Buramau’s Mechanic

Workshop. Mn is one of the heavy metals found in the soil and is necessary in many organisms' diets but can become carcinogenic and toxic in high doses [18].

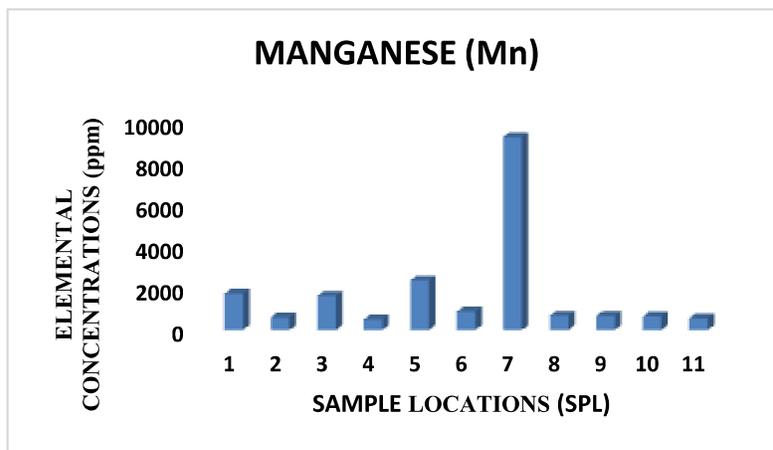


Figure 8 Mean Elemental Concentrations of Manganese in Auto Mechanic Workshops in Potiskum.

Table 4: shows the PPMC correlation coefficients of elemental concentration values of heavy metals in the study area. Strong positive correlations were obtained between Zn – Cr and Fe – Cr, at significant levels of 0.05 and 0.01 respectively. Moderate positive correlation was found between Fe – Mn, Fe – Al and Cr - Mn. Weak negative correlation was found between Zn – Pb, Zn – Al, Fe - Pb and Mn – Al amongst others.

Table 4: The PPMC correlation coefficients of Elemental Concentrations (EC) of Heavy Metals in the study area

Elements		Zn	Fe	Cd	Co	Pb	Cr	Mn	Al
Zn	Fe	1.000							
Cd	Co		1.000						
Pb	Cr	-0.638*	BLD						
Mn		BLD	BLD	BLD					
Al		BLD	-0.052						
		-0.193		BLD	BLD				
			0.961**						
		-0.734*		BLD	BLD	1.000			
			0.178						
		0.410	0.017	BLD	BLD	-0.075	1.000		
		-0.323							
				BLD	BLD	-0.215	0.127	1.000	
				BLD	BLD	-0.241	-0.081	-0.278	
									1.000

\*\*Correlation is significant at the 0.01 level. \*Correlation is significant at the 0.05 level.

Table 5: shows the comparison of mean elemental concentrations of heavy metals of the study area with permissible limit set by international organizations for soil in (ppm). The comparison displays that the mean concentration Cd and Fe in the study area were to be above the permissible limit as set by the international organizations (WHO, USEPA, EU & FAO/WHO). The mean concentrations of Zn, Fe, Pb, Mn and Al in the study area were above the permissible limits and only Cr was found to be below the permissible limits, Cd and Co were detected as set by all the international organizations mention above.

**Table 5: Comparison of Mean Elemental Concentrations (EC) of Heavy Metals with permissible limit set by standard organizations for soil in (ppm)**

Elements Ppm	Current Study	WHO	USEPA	EU	FAO/WHO
Zn	266.87	200.00	200.00	300.00	99.40
Fe	36261.63	7000.00	-	-	425.50
Cd	BLD	0.80	3.00	3.00	0.20
Co	BLD	100.00	400.00	180.	-
Pb	76.01	85.00	85.00	300.	0.30
Cr	21.14	100.00	-	140.	73.30
Mn	1777.39	35.00	-	-	67.90
Al	52159.16	40.00	-	-	-

Source: [14],[15]

Table 6 shows the mean elemental concentration of the study area compared with the research conducted in the three different areas, all in Nigeria. The concentration of heavy metals in the regions are of order; for Zn: PKM > ABJ > IBD, for Fe: PKM > ABJ > IBD, for Cd: IBD > ABJ > FKA, for Co: ABJ > IBD > GMB, for Cd: IBD > ABJ > GMB, for Pb: ABJ > IBD > PKM > GMB, for, Cr: for Mn: PKM > ABJ > GMB > IBD and for Al: PKM > ABJ > IBD. The comparison shows that Fe, Mn and Al concentration in the study areas were higher than previous studies, this might be due to the natural and anthropogenic means in the study area such as: natural weathering of the earth’s crust, soil erosion, metals’ dismantling and oils spread.

**Table 6: Comparison of Mean Elemental Concentrations (EC) of Heavy Metals with other studies conducted elsewhere for soil in (ppm).**

Elements	Present Studies	GOMBE	ABUJA	IBADAN
Zn	266.87	BLD	231.00	201.00
Fe		BLD		
Cd	36261.63	1.00	621.00	519.00
Co	BLD	7.50	8.50	12.30
Pb		55.00		
Cr	BLD	50.05	20.50	18.10
Mn		400.00		
Al	76.01	-	621.00	519.00
	21.14		185.00	221.00
	1777.39		421.00	351.00
	52159.16		12054.00	10421.00

Sources; [19], [20], [21] &, [22].

**CONCLUSION**

This study utilized Energy-Dispersive X-Ray Fluorescence (ED-XRF) to determine heavy metal concentration in soil samples from some selected mechanic workshops in Potiskum. Zn, Pb, Mn, Al and Fe were found to be above the permissible limit, this might be due to natural and anthropogenic causes. However, the result indicated that most of the essential elements like Fe, Zn and Al are adequate in the study’s locations, while the most toxic metals like Cd, Cr and Co were not above the permissible limit in the study locations. Furthermore, heavy metal contamination can have devastating long-term environmental impacts, including soil degradation, water pollution and loss of biodiversity. In a nutshell, the

study's findings emphasize the urgent need for policy makers and environmental agencies to develop and implement effective remediation strategies to mitigate the devastating impacts of heavy metal contamination. Finally, the study suggested the assessments of heavy metal translocation from auto-mechanic workshops soil to nearby agricultural soil of Potiskum.

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