IJST EXPLORE International Journal of Science and Technology
CENTRE OF PROFESSIONAL RESEARCH PUBLICATIONS
ISSN 2049-7318

International Journal of Science and Technology Volume 4 No. 5, May, 2015

Heavy Metal Contamination Levels in Topsoil at Selected Auto Workshops in Accra

R. A. Sam, F. G. Ofosu, S. M. Atiemo, I. J. K. Aboh, O. Gyampo, H. Ahiamadjie, J. P. Adeti,J. K. Arthur
National Nuclear Research Institute, Ghana Atomic Energy Commission, P.O. Box LG 80, Legon-Accra, Ghana

ABSTRACT

This work has the objective to ascertain the heavy metal contamination levels in topsoil at auto workshops and also determine the anthropogenic and crustal contributions. Surface soil dust samples of particle sizes below 100 µm from two roadside auto-workshops were analyzed using Energy Dispersive X-Ray Fluorescence Analysis to investigate the heavy metal contents. 18 elements were identified in each soil sample collected from the two roadside auto-workshops. Pollution indices {enrichment factor (EF), contamination factor (CF), degree of contamination (DC), pollution load index (PLI),} were used to assess the contamination status of the heavy metals in the soil samples. Generally the elements Zn, Pb, Cu, Ni, Pb were found to be mostly of anthropogenic origins. The extent of contamination observed at the two sites for most of the metal elements ranged from moderate to considerable contamination. Lead (Pb) was revealed to be the greatest contaminant and was found to be mostly very high at the electrical shops. The anthropogenic contributions to the soil dust contaminants are largely in the small particle size fractions.

Keywords: *Heavy Metal, Topsoil, Auto-Workshops, Pollution Indices, Anthropogenic, Contamination*

1. INTRODUCTION

The release of heavy metals into air, water and soil is one of the most significant environmental problems caused by anthropogenic activities such as urban road construction, quarrying, agriculture, waste incineration, sewage disposal, automobile workshops, bush burning etc. The presence of heavy metals has been considered as useful indicators for contamination in surface soil, sediment and dusty environment [1].

Heavy metals are non-degradable and their accumulations not only contaminate the surface environment but also contribute to air pollution, as they may become airborne and eventually enter the drainage system to affect aquatic ecosystems [2]. In general, the presence of heavy metals in high concentrations in the environment results in health hazards such as adverse effects of the nervous system, blood forming, renal and reproductive systems. Others include reduced intelligence, attention deficit and behavioral abnormality, as well as its contribution to cardiovascular disease in adults [3]. Heavy metal can cause serious health effects with varied symptoms depending on the nature and quantity of the metal ingested [4].

Auto repair shops offer miscellaneous repair services ranging from simple and fast oil change to complex engine rebuilding. They provide auto body repair, electrical, welding and spraying services as needed. The operational processes at auto workshops often involve the use of toxic and hazardous materials such as solvents, paints, primers, etc. The car refinishing process results in the improved look of vehicles but generates hazardous wastes that require appropriate disposal [5]. Petrol, diesel, solvents, grease, and lubricants can either be accidentally or deliberately released into the environment. Many of these petroleum products are organic chemicals that can be highly toxic and hazardous to soil, fauna and man. The use of automobiles and their repair has generally led to heavy metal-contamination in soil, which has grave consequences on soil dwelling organisms [6].

As a result of frictional wear, the hydraulic fluid in an automobile collects heavy metal debris such as Pb, Cd, Zn, Fe, Cu, etc. Usually, automobile waste will consist of auto body scraps (mainly of Al), pieces of mild steel, electrical components and wires (mostly Cu) [7]. Most auto repair shops in Ghana are located by the road side in the open and operated on bare soil. They normally have electrical, mechanical, welding, and spraying sections. Because they are operated on bare soil, the heavy metals from the vehicle fuel, lubricants, batteries, etc. are easily released into the environment and carried to distance locations by rain water. They can also be carried into the ambient air by resuspended dust particulates. This can have adverse effect on soil, water and air quality in the general environment even distant from the vicinity of the auto repair shops. The objective of this work is therefore to ascertain the heavy metal (contamination) levels in topsoil at auto workshops and the possible anthropogenic and crustal contributions.

2. MATERIALS AND METHODS

2.1 Sampling

Two auto workshops located in the Ga East District of Accra were chosen for this study. These were selected from areas of very low vehicular density. Care was also taken not to select areas characterised by intense human activity to avoid other sources of pollution. Most of the auto repair shops have the electrical, mechanical, welding, and spraying sections (shops) within the same location, operated in the open and on bare soil.

Three top soil samples were taken from the locations of the electrical, mechanical, welding, and spraying unit of the two auto workshops. The top soil samples were gathered and collected into self-sealed polythene bags, using soft touch brush and plastic dust pan. Acetone, cotton and a tissue paper were used to clean the container and the brush at each stage to avoid contamination. The samples were put in ziploc polyethene bags and stored at room temperatures until analysis. Sampling was done once every week from September to November. The two auto workshops were labelled as sites A and B with their respective electrical, mechanical, welding and spraying sections indicated as ES, MS, WS and SS.

2.2 Sample preparation

The soil samples were dried overnight in a Fisher Isotemp Vacuum Oven Model 281; at 35°C to ensure that the samples were dried at ambient temperature. The samples were then sieved using meshes (metric test sieve BS 410 WS Tyler) with geometric diameters of 100 µm and 45 µm on a mechanical shaker (Retsch AS 200) for 15 minutes at amplitude of 10 mm/g to separate them into two particle size fractions. Soil particle size fractions below 100 µm were used for the work. These were used because the greater part of anthropogenic contaminants are present in small size fractions. The soil particles between 100 µm and 45 µm (labeled as 100 µm) and those below 45 µm (labeled as 45 µm) were the two size fractions used for the work. As a measure of avoiding cross contamination, the sieves were cleaned with acetone after working on each sample. Each of these particle size fractions was then pulverized for 15 minutes into fine powder using the Fritsch Pulverisette 2 to ensure homogeneity and also to avoid particle size effect in the elemental analysis. About 10 grams of each of the pulverized samples was pelletized under 10 ton pressures using a hydraulic press (hydraulic unit model No. 3912) without a binder into discs of 2.5 cm in diameter.

2.3 Sample Analysis

Energy Dispersive X-ray Fluorescence (EDXRF) technique was used for the elemental analysis of the soil dust samples. The samples were irradiated using an X-ray tube with Mo anode target in a secondary target arrangement. The X-ray tube was operated at a voltage of 45 kV and a current of 10 mA. Each sample pellet was irradiated for 600 seconds. Elements from K to Pb were detected using Mo secondary target while Ti secondary target was used for Si. A silicon drift detector (SSD) with a resolution of 135 eV FWHM at (Mn-Kα) energy of 5.9 keV was used for the detection of the X-ray photons. Fundamental parameters approach in the Quantitative X-Ray Analysis Software (QXAS) package was used for the quantitative analyses of the elements. The IAEA Soil 7 Standard Reference Material (SRM) was used for validation to ensure the accuracy of the results [8, 9].

2.4 Data Analysis

2.4.1 Pollution indices

To interpret and assess the contamination status for heavy metals in the soil samples, four soil pollution indices were used {enrichment factor (EF), pollution load index (PLI), contamination factor (CF) and degree of contamination (DG)} [10].

2.4.1.1 Enrichment Factor

Enrichment Factor (EF) of an element in the samples is based on the standardization of a measured element against a reference element. A reference element is often the one characterized by low occurrence variability. It is used to differentiate heavy metals originating from human activities and those of natural sources. This is determined by the relation:

$$EF_X = [X_S / E_{S(ref)}] / [X_C / E_{C(ref)}] \quad (1)$$

where EF_X is the enrichment factor for the element X, X_S is the concentration of element of interest in sample, $E_{S(ref)}$ is the concentration of the reference element used for normalization in the sample, X_C is the concentration of the element in the crust and $E_{C(ref)}$ is the concentration of the reference element used for normalization in the crust [11, 12]. Five contamination categories are recognized on the basis of the enrichment factor: (EF < 2; states deficiency to minimal enrichment), ($2 \leq EF \leq 5$; moderate enrichment), ($5 < EF \leq 20$; significant enrichment), ($20 < EF \leq 40$; very high enrichment) and (EF > 40; extremely high enrichment) [11, 13].

2.4.1.2 Contamination Factor

To assess the extent of contamination of heavy metals in soil dust, contamination factor and degree of contamination has been used [11, 14].

The C_f^i is the single element index which is determined by the relation:

$$C_f^i = \frac{C_{0-1}^i}{C_n^i} \quad (2)$$

Where C_f^i is the contamination factor of the element of interest, C_{0-1}^i is the concentration of the element in the sample, C_n^i is the background concentration which in this study uses the continental crustal average [11, 12].

C_f^i is defined according to four categories: (CF < 1 refers to low contamination factor), ($1 \leq CF \leq 3$ indicates moderate contamination), ($3 < CF \leq 6$ indicates considerable contamination) and (CF > 6 indicates very high contaminated) [15, 16].

The sum of the contamination factors of all the elements in the sample gives the degree of contamination as indicated in the equation below:

$$C_{deg} = \sum c_f^i \quad (3)$$

Four categories has been defined for the degree of contamination as follows; (<8 shows low degree of contamination), (8-16 shows moderate degree of contamination), (16-32 shows considerable degree of contamination) and (>32 shows very high degree of contamination).

2.4.1.3 The Pollution Load Index (PLI)

The pollution load index was calculated using:

$$PLI = (CF_1 \times CF_2 \times CF_3 \times \ldots \times CF_N)^{1/N} \quad (4)$$

Where N is the number of metals studied and CF is the contamination factor calculated as described in (2). The PLI gives an estimate of the metal contamination status and the necessary action that should be taken. A PLI < 1denotes perfection; PLI = 1 gives an indication that only baseline levels of pollutants are present and PLI > 1 indicates deterioration of site quality [17, 18].

4. RESULTS AND DUSCUSSION

The results of the elemental concentrations obtained at the two auto workshops are shown in tables 1 and 2. The elements Si, K, Ca, Ti and Fe which are elements mostly of crustal origin are seen to be present in high concentrations. Cr, Ni, Cu, Zn and Pb which are mostly of anthropogenic origin are present in trace quantities. The elemental concentration ratios of the 45 µm size fraction to that of 100 µm for most of the elements gave values greater than one. This shows that the anthropogenic pollutants are mostly in the small size fractions. Si had ratios mostly less than one, showing its crustal origin. The highest ratio of 22.84 occurred at the electrical section at site A for Cu. A ratio of 7.49 was observed at the same electrical section for Pb. Pb at auto electricals section are mainly from the acid Pb batteries while Cu is mostly from the connecting electrical wires.

Table 1 Elemental concentrations at auto workshop A for the two size fractions

Site A												
	Electrical section (AES)			Mechanical section (AMS)			Spraying section (ASS)			Welding section (AWS)		
Elements	100 µm	45 µm	Ratio*	100 µm	45 µm	Ratio*	100 µm	45 µm	Ratio*	100 µm	45 µm	Ratio*
	Conc (ppm)	Conc (ppm)		Conc (ppm)	Conc (ppm))		Conc (ppm))	Conc (ppm)		Conc (ppm)	Conc (ppm)	
Si	401220	321600	0.80	256810	325220	1.27	321110	312400	0.97	321110	266050	0.83
K	16750	21100	1.26	22390	22860	1.02	22310	20540	0.92	21620	21100	0.98
Ca	13090	22550	1.72	20520	20160	0.98	22540	25860	1.15	20870	22550	1.08
Ti	1373.56	7282.93	5.30	2713.71	5762.05	2.12	3930.85	5707.01	1.45	3445.68	5369.18	1.56
V	-	-	-	311.52	451.66	1.45	-	-	-	202.84	217.57	1.07
Cr	96.70	113.27	1.17	151.31	390.17	2.58	335.30	272.57	0.81	473.92	520.51	1.10
Mn	157.80	1294.49	8.20	565.92	1055.60	1.87	993.54	1482.61	1.49	811.91	1294.49	1.59
Fe	18380	23620	1.29	10100	16450	1.63	13260	19350	1.46	13390	19840	1.48
Ni	28.57	62.64	2.19	62.69	82.62	1.32	48.43	55.94	1.15	187.76	220.47	1.17
Cu	9.58	218.88	22.84	83.12	157.51	1.90	33.27	67.05	2.02	31.92	67.04	2.10
Zn	67.69	395.22	5.84	347.73	599.45	1.72	120.44	228.35	1.90	192.77	379.79	1.97
Br	0.98	12.73	12.94	1.39	1.51	1.09	5.83	10.98	1.88	3.11	7.11	2.28
Rb	10.10	49.62	4.91	23.30	31.43	1.35	32.90	43.80	1.33	29.18	38.73	1.33
Sr	147.15	529.69	3.60	526.47	541.91	1.03	523.96	537.53	1.03	510.92	529.69	1.04
Y	1.84	14.66	7.99	5.08	13.99	2.75	6.26	11.09	1.77	5.56	10.66	1.92
Zr	78.42	1074.43	13.70	426.53	3089.36	7.24	239.48	978.43	4.09	173.08	846.50	4.89
Pb	9.17	68.66	7.49	33.15	55.38	1.67	28.08	46.70	1.66	105.09	74.72	0.71

* Ratio of 45 µm to 100 µm soil particle size fractions.

Table 2 Elemental concentrations at auto workshop B for the two size fractions

Site B												
	Electrical section (BES)			Mechanical section (BMS)			Spraying section (BSS)			Welding section (BWS)		
Elements	100 µm	45 µm	Ratio*	100 µm	45 µm	Ratio*	100 µm	45 µm	Ratio*	100 µm	45 µm	Ratio*
	Conc (ppm)	Conc (ppm)		Conc (ppm)	Conc (ppm))		Conc (ppm))	Conc (ppm)		Conc (ppm)	Conc (ppm)	
Si	194970	175360	0.90	228380	188760	0.83	183280	202110	1.10	160670	153510	0.96
K	9392	6982	0.74	9879	9723	0.98	9496	9513	1.00	5584	7365	1.32
Ca	5911	8050	1.36	7413	12350	1.67	20210	36710	1.82	4356	6443	1.48
Ti	10800	10740	0.99	13400	14040	1.05	14290	17050	1.19	15190	15110	0.99
V	458.11	561.01	1.22	542.62	691.55	1.27	636.82	631.96	0.99	599.30	757.51	1.26
Cr	-	-	-	235.30	520.51	2.21	667.97	192.44	0.29	125.20	-	0.00
Mn	853.33	969.35	1.14	1,718	2,372	1.38	2,128	2,410	1.13	1,543	1,586	1.03
Fe	72,680	83,160	1.14	63,970	90,680	1.42	72,080	86,660	1.20	105,600	126,180	1.19
Ni	119.19	111.98	0.94	127.21	216.03	1.70	278.20	167.34	0.60	135.67	110.94	0.82
Cu	139.51	307.06	2.20	81.45	214.89	2.64	108.30	185.76	1.72	116.19	215.74	1.86
Zn	155.13	259.92	1.68	268.55	522.63	1.95	479.58	756.54	1.58	316.70	573.56	1.81
Br	6.12	22.67	3.71	8.13	15.56	1.91	12.60	17.44	1.38	6.63	13.14	1.98
Rb	34.08	34.50	1.01	29.77	36.30	1.22	33.17	39.60	1.19	25.75	28.33	1.10
Sr	103.72	97.61	0.94	91.94	104.33	1.13	127.45	201.17	1.58	79.71	81.55	1.02
Y	13.76	20.94	1.52	11.69	26.26	2.25	17.11	27.87	1.63	14.00	20.46	1.46
Zr	447.85	1,131	2.52	798.25	3,076	3.85	710.04	2,502	3.52	561.78	1,863	3.32
Pb	1,211	2,025	1.67	107.37	142.03	1.32	204.76	287.73	1.41	184.25	314.16	1.71

* Ratio of 45 µm to 100 µm soil particle size fractions.

Table 3 give the average concentrations of the metal elements Cr, Ni, Cu, Zn and Pb compared with the New Dutch list. The new Dutch list is a guideline regarding tolerable contamination of soil. It is based on a publication of intervention values and target values of soil quality standards that have been issued by The Netherland Ministry of Housing, Spatial Planning and Environment [2].

It can be seen from table 3, that most of the metals are above the optimum levels with some reaching up to or above the action levels in both 100 µm and 45 µm size fraction at the two auto workshops. Cr is above action levels at AWS in both 100 µm and 45 µm size fractions which is quite expected as AWS is a welding section. Cr is also seen to be above the action levels at BSS in the 100 µm and BMS in the 45 µm. Ni is above the action level at BSS and AWS in the 100 µm and 45 µm size fractions respectively. Cu concentrations are seen to be above the action levels at the electrical section in the 45 µm size fraction. Zn concentrations went above the action levels at BSS (which is a spraying section). Pb levels at the electrical sections were above the action levels. Generally, the 45 µm size fraction recorded more concentration levels above the action level than the 100 µm. This shows that the metal contaminants from anthropogenic sources are largely in the smaller size fractions.

Table 3: Comparing this work to the New Dutch lists of metal contamination (ppn) in soil.

			Cr	Ni	Cu	Zn	Pb
Dutch list	Optimum Level		100	35	36	140	85
	Action Level		380	210	190	720	530
This Work	100 µm	AES	96.7	28.6	9.6	67.7	9.2
		AMS	151.3	62.7	83.1	347.7	33.2
		ASS	335.3	48.4	33.3	120.4	28.1
		AWS	473.9	187.8	31.9	192.8	105.7
		BES	-	119.2	139.5	155.1	1210.8
		BMS	235.3	127.2	81.5	268.6	107.4
		BSS	668.0	278.2	108.3	479.6	204.8
		BWS	125.2	135.7	116.2	316.7	184.2
	45 µm	AES	113.3	62.6	218.9	395.2	68.7
		AMS	390.2	82.6	157.5	599.4	55.4
		ASS	272.6	55.9	67.1	228.3	46.7
		AWS	520.5	220.5	67.0	379.8	74.7
		BES	-	112.0	307.1	259.9	2024.8
		BMS	520.5	216.0	214.9	522.6	142.0
		BSS	192.4	167.3	185.8	756.5	287.7
		BWS	-	110.9	215.7	573.6	314.2

Table 4: Pollution index categories and definitions

Pollution index categories	Definition
Contamination Factor (CF)	
CF < 1	Low contamination
1 ≥ CF ≤ 3	Moderate contamination
3 > CF ≤ 6	Considerate contamination
CF > 6	Very high contamination
Degree of Contamination (DC)	
< 8	Low degree of contamination
8-16	Moderate degree of contamination
16-32	Considerable degree of contamination
>32	Very high degree of contamination
Pollution Load Index (PLI)	Definition
0	Perfection
1	Only baseline levels of pollutants present
>1	Progressive deterioration of site

Table 5: Contamination Factors (CF) of the elements with the corresponding Degree of Contamination (DC) and Pollution Load Index (PLI) for site A

Contamination Factors								
Element	AES		AMS		ASS		AWS	
	100 (µm)	45 (µm)	100 (µm)	45 (µm)	100 (µm)	45 (µm)	100 (µm)	45 (µm)
Si	1.43	1.14	0.91	1.16	1.14	1.11	1.14	0.95
K	0.8	1.01	1.07	1.09	1.07	0.98	1.03	1.01
Ca	0.32	0.54	0.49	0.49	0.54	0.62	0.5	0.54
Ti	0.24	1.28	0.48	1.01	0.69	1.00	0.6	0.94
V	-	-	2.31	3.35	-	-	1.5	1.61
Cr	0.97	1.13	1.51	3.9	3.35	2.73	4.74	5.21
Mn	0.17	1.36	0.6	1.11	1.05	1.56	0.85	1.36
Fe	0.33	0.42	0.18	0.29	0.24	0.34	0.24	0.35
Ni	0.38	0.84	0.84	1.1	0.65	0.75	2.5	2.94
Cu	0.17	3.98	1.51	2.86	0.6	1.22	0.58	1.22
Zn	0.97	5.65	4.97	8.86	1.72	3.26	2.75	5.43
Br	0.39	5.09	0.55	0.6	2.33	4.39	1.25	2.85
Rb	0.11	0.55	0.26	0.35	0.37	0.49	0.32	0.43
Sr	0.39	1.41	1.4	1.45	1.4	1.43	1.36	1.41
Y	0.06	0.44	0.15	0.42	0.19	0.34	0.17	0.32
Zr	0.48	6.51	2.59	18.72	1.45	5.93	1.05	5.13
Pb	0.73	5.49	2.65	4.43	2.25	3.74	8.41	5.98
DC	7.94	36.84	22.47	51.19	19.04	29.89	28.99	37.68
PLI	0.37	1.49	0.88	1.48	0.9	1.3	1.03	1.46

Tables 5 and 6 show the contamination factors (CF) at sites A and B for the two segregated size fractions (100 µm and 45 µm). Taylor and McLennan (1985) continental crustal averages were used for the computation [19]. The 45 µm size fraction had relatively higher contamination factor index than the 100 µm at both sites for the greater part of the results. This could be attributed to the fact that the greater part of the anthropogenic contributions are in the 45 µm size fraction. Elements of crustal origin (Si, K, Ca, Ti, Fe, Rb Sr) recorded low contamination levels in both size fractions which is expected. The elements Ni, Cu, Zn which are mostly of anthropogenic origin had levels from low to considerable

contamination for the greater part. Lead (Pb) recorded the highest contamination levels. Lead levels at site B were all of very high contamination.

Both size fractions at site B indicated very high degrees of contamination but site A had contamination levels ranging from low to very high. The 45 µm size fraction at both sites showed levels of very high degree of contamination.

Pollution severity and its variation along the sites were determined with the use of pollution load index (PLI). This index is a quick tool to compare the pollution status at different places [20, 21]. The PLI is aimed at providing a measure of the degree of overall contamination [22]. Results of this study have shown that the PLI values at both sites are greater than 1 indicating that there is progressive deterioration of these sites. The progressive deterioration of the sites is mainly due to the unprofessional approach to auto repair works and the inappropriate disposal of the wastes.

Table 6: Contamination Factors (CF) of the elements with the corresponding Degree of Contamination (DC) and Pollution Load Index (PLI) for site B

Contamination Factors								
Elements	BES		BMS		BSS		BWS	
	100 (µm)	45(µm)	100 (µm)	45 (µm)	100 (µm)	45 (µm)	100 (µm)	45 (µm)
Si	0.69	0.62	-	0.38	0.65	0.72	-	0.45
K	0.45	0.33	0.47	0.47	0.45	0.46	0.27	0.35
Ca	0.14	0.19	0.18	0.3	0.49	0.88	0.1	0.16
Ti	1.89	1.88	2.35	2.46	2.51	2.99	2.66	2.65
V	3.39	4.16	4.02	5.12	4.72	4.68	4.44	5.61
Cr	-	-	2.35	5.21	6.68	1.92	1.25	-
Mn	0.9	1.02	1.81	2.5	2.24	2.54	1.62	1.67
Fe	1.29	1.48	1.14	1.61	1.28	1.54	1.88	2.24
Ni	1.59	1.49	1.7	2.88	3.71	2.23	1.81	3.26
Cu	2.54	5.58	1.48	3.91	1.97	3.38	2.11	1.99
Zn	2.22	3.71	3.84	7.47	6.85	10.81	4.52	4.87
Br	2.45	9.07	3.25	6.22	5.04	6.98	5.26	6.06
Rb	0.38	0.38	0.33	0.4	0.37	0.44	0.31	0.22
Sr	0.28	0.26	0.25	0.28	0.34	0.54	0.21	0.22
Y	0.42	0.63	0.35	0.8	0.52	0.84	0.42	0.62
Zr	2.71	6.85	4.84	18.64	4.3	15.16	3.4	11.29
Pb	96.86	161.98	8.59	11.36	16.38	23.02	14.74	25.13
DC	118.2	199.63	36.95	70.01	58.5	77.59	45	66.79
PLI	1.32	1.76	1.37	2.01	1.86	2.28	1.37	1.62

Enrichment factors (EF) for given elements relative to silicon concentrations were calculated. Silicon was appropriate to be considered as the reference element because it is from crustal origin as there is no known anthropogenic activity either within the vicinity of the sampling sites or in the long-distance, releasing the element into environment. The results of the enrichment factors of the elements for the 100 µm and 45 µm size fractions are respectively shone in tables 7 and 8. The enrichment factor values of the elements in the 45 µm size fraction are generally higher than that of the 100 µm which agrees with the observation made in the results of the contamination factors. Elements of anthropogenic pollution origins, like Zn, Pb, Cu, Ni, etc, are highly enriched with respect to crustal composition (Si, Ca, Fe, etc.). Similarly as observed in the case of the contamination factors, Pb had extremely high enrichment at the electrical workshops at site B. Pb had relatively the highest enrichment of all the elements mostly in the 45 µm size fractions. Site B is seen to be generally of significant enrichment. Generally, EF values less than 10 are not considered significant, because such small enrichments may arise from differences in the composition of local soil material and crustal average used as the reference in EF calculations.

Table 7: Enrichment factors of the elements for 100 µm size fraction

	Si	K	Ca	Ti	V	Cr	Mn	Fe	Ni	Cu	Zn	Br	Rb	Sr	Y	Zr	Pb
Site A(100 µm)																	
Electrical	1.00	0.56	0.22	0.17	-	0.68	0.12	0.23	0.27	0.12	0.68	0.28	0.08	2.75	0.04	0.33	0.51
Mechanical	1.00	1.17	0.54	0.52	2.53	1.66	0.65	0.20	0.92	1.66	5.45	0.61	0.28	15.39	0.17	2.83	2.91
Spraying	1.00	0.94	0.48	0.60	-	2.94	0.92	0.21	0.57	0.53	1.51	2.04	0.32	12.25	0.17	1.27	1.97
Welding	1.00	0.91	0.44	0.53	1.32	4.15	0.75	0.21	2.19	0.51	2.41	1.09	0.28	11.94	0.15	0.92	7.37
Site B (100 µm)																	
Electrical	1.00	0.65	0.21	2.74	4.90	-	1.30	1.86	2.29	3.66	3.20	3.53	0.55	3.99	0.60	3.92	139.88

Mechanical	1.00	0.58	0.22	2.90	4.95	2.90	2.23	1.40	2.09	1.83	4.73	4.01	0.41	3.02	0.44	5.96	10.59
Spraying	1.00	0.70	0.75	3.85	7.25	10.26	3.44	1.97	5.70	3.02	10.52	7.74	0.57	5.22	0.80	6.61	25.16
Welding	1.00	0.47	0.18	4.67	7.78	2.19	2.85	3.29	3.17	3.70	7.93	4.65	0.50	3.72	0.74	5.97	25.83

Table 8: Enrichment factors of the elements for 45 µm size fraction

	Si	K	Ca	Ti	V	Cr	Mn	Fe	Ni	Cu	Zn	Br	Rb	Sr	Y	Zr	Pb
Site A (45 µm)																	
Electrical	1.00	0.88	0.48	1.12	0.00	0.99	1.19	0.37	0.73	3.48	4.94	4.46	0.48	12.36	0.39	5.70	4.81
Mechanical	1.00	0.95	0.42	0.87	2.90	3.38	0.96	0.25	0.95	2.48	7.41	0.52	0.30	12.51	0.37	16.21	3.83
Spraying	1.00	0.89	0.56	0.90		2.46	1.41	0.31	0.67	1.10	2.94	3.96	0.44	12.92	0.30	5.34	3.37
Welding	1.00	1.07	0.57	1.00	1.71	5.51	1.44	0.37	3.11	1.29	5.74	3.01	0.46	14.95	0.34	5.43	6.32
Site B (45 µm)																	
Electrical	1.00	0.54	0.31	3.02	6.67		1.64	2.37	2.40	8.96	5.96	14.56	0.62	4.18	1.02	11.00	260.05
Mechanical	100	0.69	0.44	3.67	7.64	7.76	3.72	2.40	4.30	5.83	11.13	9.28	0.60	4.15	1.19	27.80	16.94
Spraying	1.00	0.63	1.23	4.17	6.52	2.68	3.53	2.14	3.11	4.70	15.05	9.72	0.61	7.47	1.18	21.12	32.06
Welding	1.00	0.65	0.28	4.86	10.29		3.06	4.11	2.71	7.19	15.03	9.64	0.58	3.99	1.14	20.70	46.09

5. CONCLUSIONS

This work has focused on the heavy metal contamination levels in top soil at auto workshops with the possible anthropogenic and crustal contributions. The elemental concentrations for the seventeen elements identified from EDXRF analysis show that generally, the anthropogenic contributions to the soil dust contaminants are largely in the fine than the course sizes.

The extent of contamination observed at the two sites for most of the metal elements ranged from moderate to considerable contamination. Pb was revealed to be the greatest contaminant and was found to be mostly very high at the electrical sections.

The progressive deterioration of the sites are due mainly to the unprofessional approach to auto repairs and maintenance by the roadside auto mechanics and the indiscriminate and inappropriate disposal of wastes. The activities of the roadside auto mechanics should therefore be of concern as they can contribute significantly to pollution in soil, water and air in the environment leading to negative effect on the environment and ill-health effect.

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