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HEAVY METAL CONTAMINATION OF TOP SOIL AT AUTO-REPAIR WORKSHOPS IN CAPE COAST, GHANA

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ABSTRACT: *Trace metal contamination at 4 selected auto workshops at cape coast Ghana has been ascertained in this study. A total of 18 soil samples from auto-repair workshops and 44 soil samples from control sites were sampled and analyzed using energy dispersive x-ray fluorescence technique (EDXRF). Heavy metals like Fe ,Cu, Zn ,Cr, Pb and Mn were analyzed .Mn concentrations were between 364.6713 μ g/g and 1934.063 μ g/g. Cu concentrations were between 42.33 μ g/g and 299.36 μ g/g, Zn concentrations fell between 67.08 μ g/g and 544.26 μ g/g, Cr concentration were between 93.54 μ g/g and 1266.23, Ni concentrations were between75.89 μ g/g and 217.52, Pb concentrations were also between 73.89 μ g/g and 713.65 μ g/g, Fe concentrations were between 21485 μ g/g and 47317.50 μ g/g, which is below its natural occurrence. The enrichment factor (EF) was also used to identify possible levels of contamination from anthropogenic sources. Mechanical shop, Spraying shop, Wielding shop and Electrical shop were contaminated with Fe, Ni, Cu and Mn.*

KEYWORDS: Energy Dispersive X-ray Florescence, Enrichment Factor, Heavy metals, Contamination, Concentration.

INTRODUCTION

Heavy metal contamination of urban topsoil has been of major concern regarding their toxicity, persistence and non-degradability in the environment. Adverse effects of elevated concentrations of heavy metals to soil functions, soil microbial community composition and

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microbial growth have long been recognized under both field and laboratory conditions Heavy metal contamination of topsoil is usually from anthropogenic sources (Wikipedia). A large body of literature is available concerning automobile exhaust emissions. Other metals such as zinc, cadmium, copper, chromium, nickel, barium, aluminum and manganese are also associated with automobile-related pollution. These are often used as minor additives to gasoline and various auto-lubricants; they are released during combustion and spillage into the environment. In 2004, Ghana banned lead and introduced methylcyclopentadienyl manganese tricarbonyl (MMT) as an additive to gasoline (Debora M. 2004). MMT is an organic derivative of manganese, which is added to gasoline as an antiknock agent and to improve octane rating. Some of these heavy metals are components of automobile parts such as tires and engines, from which they are released during abrasion and wears (Lu et al, 2009 and Madany; Ferguson and Kim 1991). There has been little attention given to vicinities of automobile workshops, which are also liable to pollution arising from gasoline combustion exhausts, lubricating oil spills, and other chemical inputs to automobile operations. Auto repair workshops are facilities where automobiles are usually operated in semi-stationary or stationary modes. This tends to aggravate the direct deposition of exhaust emissions, and scrap batteries. Auto-repair workshops in Cape Coast are of interest in this study because of the land upon which these workshops are situated for residential purposes owing to an increase in population. The presence of Cape Coast University is enough reason for the increasing population. Most residents exclude some portion at the backyard for vegetation. Possibility may arise to dig a well in residential houses close to these auto-repair workshops land. Soil, being a complex porous material, retains and transports hazardous pollutants to ground water. This makes residents directly vulnerable to soil contaminants. Each of these workshops usually hosts a variety of artisans such as auto-electricians, battery servicemen, vulcanizers, and panel beaters. Scrap batteries and solder, waste engine oil, brake fluid and other fluid generated by their activities in the workshop are not properly disposed off. They are usually thrown away on the soil. Since the activity of artisans in auto-repair workshops is one of the major routes for entry of heavy metals into the environment to cause contamination of soil and drinking wells, land and crops, monitoring the available pools of metals in contaminated soils becomes important. There has not been enough information in the scientific literature on soil quality, especially heavy metal distribution in auto-repair workshop soils. This investigation was carried out in order to verify the distribution of

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heavy metals and the extent of contamination in the vicinities of auto-repair workshops in Cape Coast.

The main purpose of the study is to establish the concentrations of Zn, Ni, Cr, Mn and Pb for topsoil's in some auto-repair workshops, Use enrichment factors to determine the anthropogenic addition of heavy metals to natural soil, Conduct environmental contamination evaluation of the auto- mechanic shop at Cape Coast, Ghana and assess the level and extent of contamination by comparison with international soil standards and to identify any need for regular monitoring and/or remediation.

Experimental

Soil samples were also taken from selected sites in Abura, Kotokoraba, University of cape coast and Sidwo all in cape coast metropolitan assembly in Ghana.

Sample Preparation

The preparation included sieving, pulverizing and pelletizing.

Sieving

The samples were sieved into deferent size fractions to obtain sizes of 500>200, 200>100, 100>45 and 45> using a 500µm, 200 µm, 100 µm and 45 µm mesh size sieves and Retsch As 200 (shaker) machine. The shaker was set to amplitude of 10mm/g. for the sieving of each sample in a period of 15 s. Grain size above 500um were considered as debris and therefore rejected.

Pulverising

The soil samples were pulverized using the Fritsch Pulverisette 2 (pulveriser) for 10mins to obtain fine particles from the samples. All samples were relabeled with abbreviations.

10 grams of the pulverised sample were made into thick sample pellets of diameter 2.5 cm using the hydraulic press (hydraulic unit model no. 3912) with an applied load of 10 metric tons. The elemental concentrations were determined using energy dispersive X-ray

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fluorescence (EDXRF) analysis. EDXRF provides a rapid and non-destructive method for the analysis of trace and major elements in the samples (Yeung et al, 2003). The compact 3K5 X-ray Generator EDXRF Spectrometer which was used for the elemental analysis has a Mo anode and operated at 800w [40kV and 20mA]. The irradiation was done using a Mo secondary target arrangement coupled to cooled silicon drift detector (SDD) with a 12 μm beryllium window thickness. The SDD detector has a resolution of 145 eV for 5.9 KeV x-ray energy. Samples pellets were placed at an angle of 45^0 to the primary beam and irradiated and for 600 seconds. The data acquisition and analysis was done using Quantitative X-Ray Analysis Software (QXAS) package respectively.

RESULTS AND DISCUSSIONS

Concentration

Table 1: shows the concentration of elements (ppm) in the various size fractions of the analyzed soil sample from auto-workshop Tungsten (W) was significantly low. The highest value recorded was found in mechanical shop .The concentration of W was very high in the mechanical shop and was higher than the background. The spraying shop recorded the highest concentration of Cr (1266.228 μ g/g) which was far higher than that of the control. Cr is a known carcinogen hence such level should be a source of concern for human health particularly children and the vulnerable aged living close to these areas. The concentration of Mn was in the range of 364.6713 μ g/g to 1939.063 μ g/g (Table 1). These values are lower than the crustal average of manganese which is 9000 μ g/g. This indicates that there is no contamination of Mn in the soil. Some of the soil samples showed significantly higher values of the heavy metal contents than the control. This may be due to the presence and accumulation of the vehicular emission in the sampled soils. Agricultural activities that result in the removal of the metals from the reachable layers may have also contributed to the low heavy metal content in the control samples. Significantly high value of Cr was measured from all the study area which was above the recommended value The values obtained from this study were above the permissible level for soils, as recommended by

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(USEPA 1986) and this raises a lot of environmental concern and calls for urgent attention The soil sample were highly contaminated with Zn and Cu .The highest concentrations were (544.2558 μ g/g) and (299.363 μ g/g) respectively. The Zn and Cu were known to come from tire and brake lining respectively. The elements Br, Zr, Ni Ti and Mn were obtained in significant concentrations. From the table above, it was observed that the smaller the size fraction of the soil sample the more concentrated the elements.

Enrichment Factor

Results from table 2: were obtained with reference to the equation

EF (M) = $[(X_i/A_i)]/[(X_c/A_c)]$,

Where Factor M = enrichment factor for the element, X_i is the concentration of the element in the sample ,A_i is the concentration of reference sample, X_c is the concentration of the element in the crust and A_c is the concentration of Reference element in the crust. Five contamination categories are recognized on the basis of the enrichment factor (Yonming et al, 2006; Kartal et al, 2006): EF < 2 implies depletion to minimal enrichment, EF = 2-5 implies moderate enrichment, EF = 5-20 there is no significant enrichment, EF = 20-40 very high enrichment, EF > 40 extremely high enrichment

Iron was used as the reference element with an average concentration of 47317.5ug/g (from results) and an appearing standard value of 56300ug/g. The values of the enrichment factors for K, Ti, Sr, and Rb, in the selected auto, repairs shop were all below 2 and this implies that there is no contamination of these elements in the samples. They could be classified as being of crustal origin. It is observed that Pb has its maximum value of 712.6517ug/g at the electrical workshop. EF of the Pb ranged is between 52.93 and to80.5 which shows very high enrichment. Pb is extremely enriched in the entire sampled workshop Cu is enriched with an enrichment value of 2.9 at the electrical shop, which is moderately enriched. Mn was highly enriched at spraying shop due to the presence of chemicals in the oil paint. Cr is moderately enriched at spraying shop (31.59). From table 2 it was observed that the smaller the particulate size fractions, the more the trace metals are enriched.

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CONCLUSION

Heavy metal contents and their possible sources in soil samples collected from selected workshop in Cape Coast have been studied in this work. Ti, V, Cr, Mn, Ni, Cu, Zn, Br, Zr, and Pb were among other elements identified in the sampled soil using energy dispersive x-ray fluorescence analysis. The mean concentration of V, Cr, Zn, and Pb was higher than the alert values in some cases. The enrichment factor calculated for the elements showed that Cr, V, Cu, and Br, were moderately enriched.

The disposal of waste lubricant oil and auto exhaust emission are suspected to be a significant source of metal contamination of topsoil in these workshops. Metals concentrations were generally found to increase substantially with decreasing size fractions. The finding suggests the need for closer examination, in order to quantify the proportion of the bioavailable phases of the metals. Potential ingestion of dust by children would result in high risk of adverse health effects, since some heavy metals example Cu, Zn, Cr, and Pb have already shown chronic risks.

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Site	Particle Size	K	Ca	Ti	V	Cr	Mn	Fe	Ni	Cu	Zn	Br	W	Pb
BG	**500>200um**	15201.64	19570.00	5694.50	288.42	423.85	1452.71	34892.50	150.20	60.63	253.26	**9.47**	9.36	**108.12**
	200>100um	**16596.65**	23156.67	5405.00	322.40	**548.76**	1468.55	32430.00	**217.52**	58.60	158.44	**9.88**	**12.31**	**88.67**
	100um>	15500.32	**26203.75**	**7378.05**	**437.85**	412.42	**1939.06**	**47317.50**	158.30	**100.59**	**401.41**	**14.28**		**196.08**
ES	**500>200um**	10218.03	6789.74	3569.35	455.71	185.88	364.67	25341.09	75.43	42.33	67.08	**2.41**	6.02	**312.83**
	200>100um	18860.86	10295.45	**6300.63**	458.11	182.09	529.23	**39232.25**	103.95	77.25	109.16	**3.51**	**8.21**	**614.52**
	100um>	**18942.43**	**16556.94**	6127.98	**535.50**	**520.51**	**844.04**	37941.64	**119.01**	**112.79**	**243.36**	**7.11**		**712.65**
MS	**500>200um**	12950.65	10670.39	3993.53	279.38	702.83	860.46	**29094.47**	**202.78**	70.16	152.11	**3.92**	13.35	**54.88**
	200>100um	14992.79	20371.41	3331.29	231.42	**717.37**	705.09	28463.33	91.54	112.29	232.12	**9.21**	**15.48**	**87.30**
	100um>	43373.17	**25138.75**	**7956.18**	**550.36**	93.54	**1742.25**	53515.00	97.62	**141.47**	**544.26**	**6.86**		**159.64**
SS	**500>200um**	**16007.88**	11820.00	5407.84	396.98	232.12	979.41	34835.60	115.10	57.27	200.85	**12.02**		**82.51**
	200>100um	15902.99	21375.00	**9110.43**	**636.82**	667.97	**1560.71**	**42670.00**	**163.31**	70.79	300.01	**9.22**		**116.42**
	100um>	12306.78	**129577.50**	3405.90		**1266.23**	1438.31	21485.00	117.92	**299.36**	**319.84**	**18.23**		**100.77**
WS	**500>200um**	13245.28	10965.64	5878.50	350.19	272.26	810.59	41782.29	124.91	52.14	205.94	**3.75**	7.73	**75.89**
	200>100um	**15956.02**	18614.04	6495.45	329.68	290.95	955.41	45995.00	129.97	62.21	304.17	**4.68**	11.15	**94.74**
	100um>	14289.15	**20809.90**	**6979.78**	**408.44**	**334.63**	**1126.87**	**46890.00**	**138.71**	**73.00**	**357.93**	**7.12**	**12.91**	**102.28**

Table1: Concentration of elements (ppm) in the various size fractions of analyzed samples

NB**:** **BG** – background (Control area), **ES** –Electrical workshop, **MS** - Mechanical workshop**, SS**- Spraying workshop WS-Wielding workshop

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TABLE 2: RESULTS OF THE ENRICHMENT FACTORS FOR VARIOUS ELEMENTS

site	Particle size	K	Ca	Ti	V	Cr	Mn	Fe	Ni	Cu	Zn	Br	Rb	W	Pb
BG	**500>200um**	1.12	0.72	1.53	3.28	6.51	2.35	1.00	3.08	1.69	5.56	5.82	0.44	9.58	13.29
BG	**200>100um**	1.31	0.92	1.57	3.95	9.07	2.55	1.00	4.79	1.76	3.74	6.53	0.51	13.57	11.72
BG	**100um>**	0.84	0.72	1.47	3.67	4.67	2.31	1.00	2.39	2.07	6.50	6.47	0.49	0.00	17.77
ES	**500>200um**	1.03	0.35	1.32	7.14	3.93	0.81	1.00	2.13	1.63	2.03	2.04	0.35	8.49	52.93
ES	**200>100um**	1.23	0.34	1.51	4.64	2.49	0.76	1.00	1.89	1.92	2.13	1.92	0.45	7.48	67.17
ES	**100um>**	1.28	0.56	1.52	5.60	7.35	1.26	1.00	2.24	2.90	4.91	4.02	0.56	0.00	80.54
MS	**500>200um**	1.14	0.47	1.29	3.81	12.95	1.67	1.00	4.98	2.35	4.00	2.89	0.37	16.39	8.09
MS	**200>100um**	1.35	0.92	1.10	3.23	13.51	1.40	1.00	2.30	3.84	6.24	6.94	0.93	19.44	13.15
MS	**100um>**	2.08	0.61	1.40	4.08	0.94	1.84	1.00	1.30	2.58	7.79	2.75	0.44		12.79
SS	**500>200um**	1.18	0.44	1.46	4.52	3.57	1.59	1.00	2.36	1.60	4.41	7.40	0.36		10.16
SS	**200>100um**	0.96	0.65	2.01	5.93	8.39	2.06	1.00	2.74	1.62	5.38	4.63	0.46		11.70
SS	**100um>**	1.47	7.79	1.49		31.59	3.78	1.00	3.92	13.58	11.40	18.19	2.32		20.11
WS	**500>200um**	0.81	0.34	1.32	3.33	3.49	1.09	1.00	2.14	1.22	3.77	1.92	0.26	6.61	7.79
WS	**200>100um**	0.89	0.52	1.33	2.85	3.39	1.17	1.00	2.02	1.32	5.06	2.18	0.35	8.66	8.83
WS	**100um>**	0.78	0.57	1.40	3.46	3.83	1.36	1.00	2.11	1.52	5.85	3.26	0.41	9.84	9.35

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