

Geoaccumulation Index And Enrichment Factors of Some Heavy Metals from Soils at the Welding Workshops , at Old Panteka Market, Kaduna – Nigeria.

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ABSTRACT

The concentration of five soil heavy metals (Cr, Cu, Cd, Pb, and Ni) was measured in eleven sampling sites along Old Panteka market Kaduna from two different depths. These samples were determined using atomic absorption spectrometer. The assessment of heavy metal pollution was derived using the Enrichment Factors (EF) and geoaccumulation index (Igeo). This study revealed that the soil is predominantly polluted by Pb>Cu>Cd>Ni>Cr and Cu>Pb>Cd>Ni>Cr at 0 – 5 cm and 5 – 10 cm depths respectively. As recorded the highest EF value of 29.63 and 20.54 for Pb and Cu at 0-5 cm and 5-10 cm depths respectively followed by Cu (17.13), Cd (10.07), Ni (0.99) and Cr (0.53) at 0 – 5 cm and Pb (19.68), Cd (12.47), Ni (1.19) and Cr (0.55) at 5 – 10 cm depths respectively, and the mean Igeo provided the same trend of pollution levels as in the case of the EF, which indicates that the highest level goes to Pb (1.61) and Cu (1.58) at 0 – 5 cm; Cu (1.71) and Pb (1.50) at 5 – 10 cm depths respectively, which exhibits unpolluted to moderately polluted. Meanwhile, Ni recorded (0.15) and (0.22) at 0 – 5 cm and 5 – 10 cm depths respectively, while Cr recorded (-0.07) and (0.08) also at 0 – 5 cm and 5 – 10 cm depths respectively, which illustrates that both of these metals vary from unpolluted to moderately polluted. The concentrations of Cr, Cu, and Ni levels are below 0 at the control sites, which demonstrates background concentrations.

Keyword: C Enrichment factor, geoaccumulation index, Heavy metals (Cr, Cu, Cd, Pb, and Ni), Panteka, pollution, Workshops

1.0 INTRODUCTION

Pollution of the environment may occur through industrial and commercial activities of man. This happens when substances resulting from human activities enter the environment. The environment is said to be polluted when the concentration of these substances attain levels which may cause discomfort and/or harm to man, fauna, and flora of his environment. The pollution of the environment has been found to result

from man's determination to match desire with production through the establishment of various industries with potentials to pollute the environment. Industry, big or small, is a source of pollution of water, soil, and air (Udosen *et al.*, 1990). The sizes of workshops vary but the typical medium sized workshop occupies about 5 ha of land area (Ilemobayo *et al.*, 2008). Activities conducted in these shops are typical of metal fabrication workshops and invariably involve working with solders, metal filings

and other materials which contain heavy metals unto bare soil. Lead (Pb), for example, is known to come from the use of leaded gasoline whereas Cu and Cd from tyre abrasion, lubricants, industrial and incinerator emissions (Thorpe and Harrison, 2008; Wilcke and Zech, 1998). The source of Ni and Cr in welding workshop is believed to be due to corrosion of vehicular parts Lu *et al.* (2009), Akhter and Madany (1993) and Fergusson (1991) and chrome plating of some motor vehicle parts (Al-Shayep and Seaward, 2001). The phenomenon contributes significantly to the pollution of the urban environment. This makes the study of welding workshops soil important for determining the origin, distribution and level of heavy metal in urban workshop surface environments. However, the quantitative data on heavy metal concentrations, their contamination levels, and their pollution sources have not been systematically gathered and intercompared. Therefore, this study focuses on heavy metal contamination in urban welding workshop soils. The sources, concentrations, pollution levels, sample collection and analytical tools of heavy metals are elucidated in this study.

2.0 Materials and Methods

2.1 Study area: The study area, situated in the northern part of Kaduna state between $10^{\circ}23'$ - $10^{\circ}43'$ N and between $7^{\circ}17'$ - $7^{\circ}37'$ E (Fig. 1). The climate of the study area; wet season is characterized by torrential rainfall from May to October, while the dry season is November to April (Samali *et al.*, 2011). The natural vegetation cover is tropical grassland of the Northern guinea savannah type with short scattered trees interspersed with tall grasses. Urbanization has taken over the original vegetation of Kaduna. The soil is mainly sandy clay, which reduces infiltration and accelerates overland flow

and erosion, particularly where the soil surface has little or no vegetation cover.

2.2 Soil sampling: Twenty-two soil samples were collected during the month of May 2016 from different depth with an interval of 0-5 cm and 5-10 cm. The 1 kg of each soil samples was collected using a stainless steel spade and a plastic scoop; all samples collected were stored in sealed polythene bags and transported to the laboratory for pre-treatment and analyses.

2.3 Chemical analysis: The soil samples were dried, mechanically in the laboratory, the soil samples after air drying at room temperature, were sieved with nylon mesh (2 mm). The <2 mm fraction was ground in an agate and pestle and passed through a 63-micron sieve. Soil samples were analyzed for heavy metals. Furthermore, soil samples were digested by taken 2g each, weighed into a beaker using an analytical balance - Mettler AE160, 50 cm³ of concentrated Nitric acid (HNO₃) and 1cm³ Perchloric acid (HClO₄) were added. The mixture was digested by boiling gently on a hot plate. After digestion, the sample was evaporated to dryness and the residue mixed with 0.1M HNO₃ and filtered into a 100 mL flask using Whatman No.1 filter paper (Ogunfowakan *et al.*, 2009). The blank determination was also carried out. Metals in the final solutions were determined using variant model AA650FS, Atomic Absorption Spectrometer (AAS). Standard stock solutions for all the elements were prepared in the laboratory following the procedures as described in APHA (1989). The glassware used was Pyrex, which was washed several times with soap, distilled water and diluted nitric acid to remove any impurities.

2.4 Contamination assessment methods: The assessment of soil enrichment can be carried out in many ways. The most

common ones are the index of geoaccumulation and enrichment factors (Lu *et al.*, 2009). In this work, the index of geoaccumulation (Igeo) and Enrichment Factor (EF) have been applied to assess heavy metals (Cr, Cu, Cd, Pb, and Ni) distribution and contamination in the welding workshop samples along Old Panteka market.

A quantitative measure of the extent of metal pollution in the studied soil was calculated using the geoaccumulation index proposed by Muller (1969). This index (Igeo) of heavy metal is calculated by computing the base 2 logarithms of the measured total concentration of the metal over its background concentration using the following mathematical relation (Ntekim *et al.*, 1993):

$$\mathbf{Igeo} = \log_2 (C_n/1.5B_n) \quad \mathbf{1.0}$$

where, C_n is the measured total concentration of the element n in the soil fraction, B_n is the average (crustal) concentration of element n in shale (background) and 1.5 is the factor compensating the background data (correction factor) due to lithogenic effects. Loska *et al.* (2003) gave the following interpretation for the geoaccumulation index:

$I_{geo} < 0$ = practically unpolluted,

$0 < I_{geo} < 1$ = unpolluted to moderately polluted,

$1 < I_{geo} < 2$ = moderately

$2 < I_{geo} < 3$ = moderately to strongly polluted,

$3 < I_{geo} < 4$ = strongly polluted,

$4 < I_{geo} < 5$ = strongly to extremely polluted and

$I_{geo} > 5$ = extremely polluted.

2.5 Enrichment factor: Enrichment Factor (EF) has been employed for the assessment of contamination in various environmental media by several researchers. Its version

adapted to assess the contamination of various environmental media is as follows:

$$\mathbf{EF} = \frac{(C_x/C_{ref})_{\text{sample}}}{(B_x/B_{ref})_{\text{background}}} \quad \mathbf{2.0}$$

C_x = Content of the examined element in the examined environment

C_{ref} = Content of the examined element in the reference environment

B_x = Content of the reference element in the examined environment

B_{ref} = Content of the reference element in the reference environment

An element is regarded as a reference element if it is of low occurrence variability and is present in the element in trace amounts. It is also possible to apply an element of geochemical nature whose substantial amounts occur in the environment but has no characteristic effects i.e. synergism or antagonism towards an examined element. The contamination categories are recognized on the basis of the enrichment factor:

$EF < 2$ states deficiency to minimal enrichment,

$EF = 2-5$ moderate enrichment,

$EF = 5-20$ severe enrichment,

$EF = 20-40$ very high enrichment and

$EF > 40$ extremely high enrichment (Manno *et al.*, 2006)

The enrichment factor, due to its universal formula is relatively simple and easy tool for assessing enrichment degree and comparing the contamination of the different environment.

3.0 Results and Discussion

3.1 Heavy metal concentrations: Table 1 summarizes the minimum, maximum, mean and standard deviation of a number of metals (Cr, Cu, Cd, Pb, and Ni) in twenty-two soil samples collected at Old panteka market welding workshops soil of Kaduna

State. A close look at Table 1 shows that the variability in the range of all the metal distributions as compared with their means respectively is an indication of pollution of the sample with that metal ion. The decreasing trend of averages of metal levels was as follows: Pb>Cu>Cd>Ni>Cr and Cu>Pb>Cd>Ni>Cr at 0-5 cm and 5-10 cm depths respectively.

3.2 Distribution and enrichment of metals:

The Enrichment Factor (EF) of Cu, Cd, Pb and Ni concentration in the soil as shown in Table 2 are 17.13, 10.07, 29.63, 0.99 and 20.54, 12.47, 19.68, 1.19 at 0 – 5 cm and 5 – 10 cm depths respectively and the calculated results of Igeo for these heavy metals at both depths have Igeo ranging from grade $0 < I_{geo} < 2$ indicating that the environment range from unpolluted to moderately polluted by these elements Table 3. Meanwhile, enrichment factor (EF) of Cr at both depths recorded 0.53 and 0.55 at 0 – 5 cm and 5 – 10 cm respectively, which indicates that the soil is uncontaminated (deficiency to minimal enrichment) by Cr metal. Since the soil samples have been taken from welding workshops with the considerable high volume of metal works, heavy traffic rates, and motor vehicles burning leaded gasoline and spent engine oil from welding generator sets could be considered as the main sources of the lead in the soils of the study area. The behavior of Cu shows that the enrichment factors (EF) are 17.13 and 20.54 at both depths, whereas, the values of the geochemical index range from -0.63 to 1.58 at 0 – 5 cm and -0.63 to 1.71 at 5 – 10 cm respectively, indicating uncontaminated to slightly contaminated soil. Relatively higher values of Cu concentrations in the analyzed soil samples reflect anthropogenic effects which might be as a result of burning fossil fuel, wear and tear of tyres and other metal filing emanating from welding activities taken

place in the workshops (Kabata pendias and Pendias, 1984).

4.0 Conclusion

This study revealed that the soil at old Panteka market welding workshops is predominantly polluted by Pb>Cu>Cd>Ni>Cr and Cu>Pb>Cd>Ni>Cr at 0-5 cm and 5-10 cm depths respectively. As recorded the highest EF value of 29.63 and 20.54 for Pb and Cu at 0-5 cm and 5-10 cm depths respectively followed by Cu (17.13), Cd (10.07), Ni (0.99), and Cr (0.53) at 0 – 5 cm and Pb (19.68), Cd (12.47), Ni (1.19) and Cr (0.55) at 5 – 10 cm depths respectively, and the mean Igeo provided the same trend of pollution levels as in the case of the EF, which indicates that the highest level goes to Pb (1.61) and Cu (1.58) at 0 – 5 cm; Cu (1.71) and Pb (1.50) at 5 – 10 cm depths respectively, which exhibits unpolluted to moderately polluted. Meanwhile, Ni recorded (0.15) and (0.22) at 0 – 5 cm and 5 – 10 cm depths respectively, while Cr recorded (-0.07) and (0.08) also at 0 – 5 cm and 5 – 10 cm depths respectively, which illustrates that both of these metals vary from unpolluted to moderately polluted. The concentrations of Cr, Cu, and Ni levels are below 0 at the control sites, which demonstrates background concentrations.

The distribution of metal concentration in the study area has come about as a result of anthropogenic influences, in particular, welding activities.

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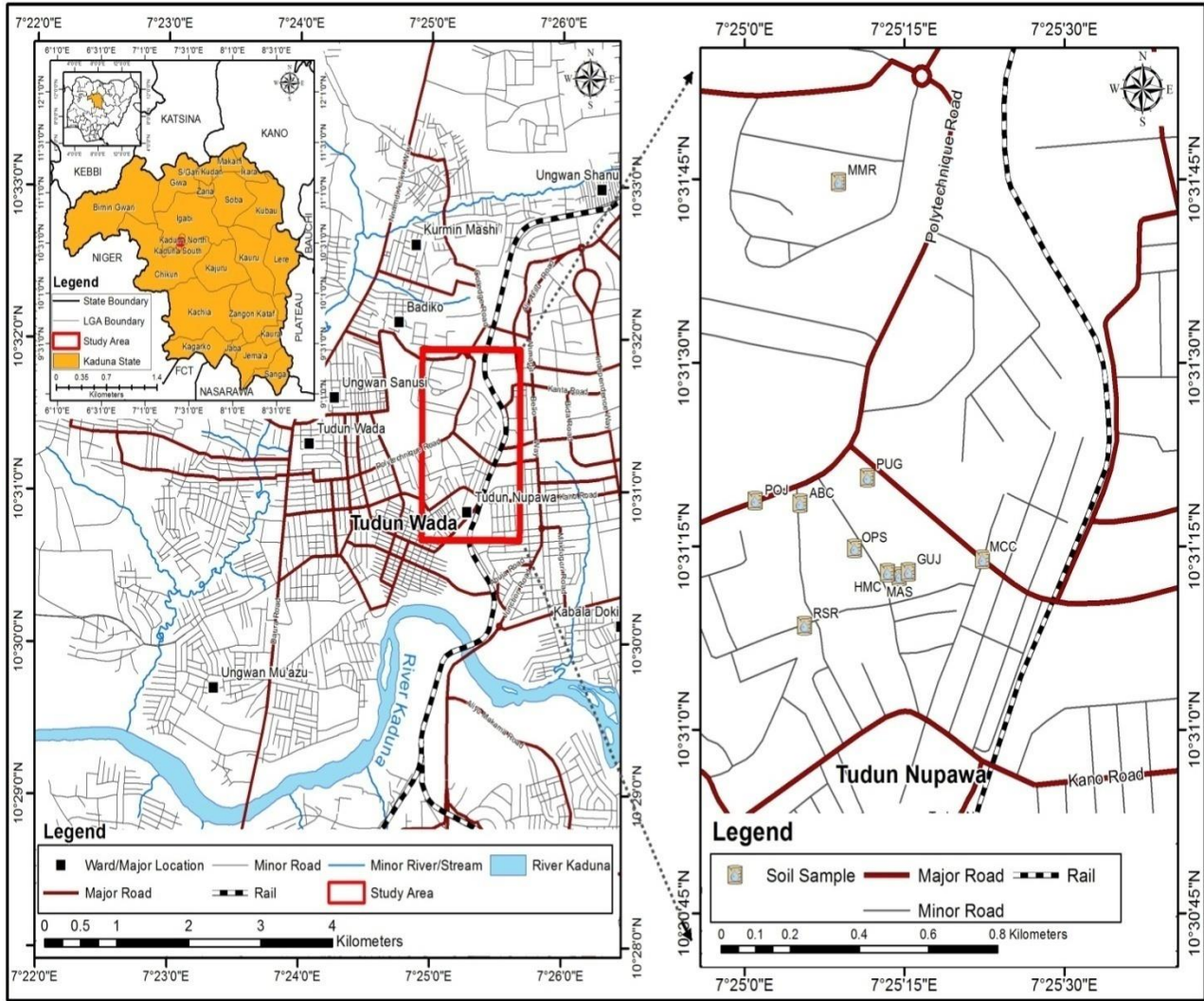


Figure 1: Map of Kaduna Metropolis showing Soil Sampling Points
Source:Fieldwork

Table 1: Basic statistical parameters for the distribution of heavy metals in the investigated soil samples

Sites	Soil (0 - 5 cm)					Soil (5 - 10 cm)				
	Cr	Cu	Cd	Pb	Ni	Cr	Cu	Cd	Pb	Ni
GUJ	101.55	2550.53	5.35	1133.73	145.05	90.68	2692.73	7.30	958.40	170.78
MMC	15.45	111.20	1.68	203.45	25.10	8.58	183.60	1.28	140.80	40.00
OPS	21.03	151.50	1.43	243.28	36.23	8.80	190.53	1.35	219.75	50.35
MMR	28.65	464.35	1.35	116.30	46.23	27.63	1546.78	1.28	126.88	57.90
ABC	34.90	320.80	1.33	176.23	47.08	27.73	160.15	2.75	116.43	43.50
PSR	75.10	794.68	3.25	1158.88	102.70	161.73	514.15	2.20	337.00	120.43
HMC	82.33	2379.20	3.70	957.30	111.63	71.10	3446.43	4.50	853.68	156.53
PUG	113.95	349.33	6.30	902.08	100.50	82.80	350.48	11.23	674.48	108.93
POJ	11.48	906.85	1.65	187.95	45.83	26.00	167.43	2.10	216.68	55.33
MCC	0.00	15.68	1.45	219.30	9.35	0.10	16.00	1.55	95.85	14.18
MAS	43.93	434.60	5.78	1220.45	77.33	34.98	897.23	5.55	589.75	74.95
Sum	528.37	8478.72	33.27	6518.95	747.03	540.13	10165.51	41.09	4329.70	892.88
Mean	48.03	770.79	3.02	592.63	67.91	49.10	924.14	3.74	393.61	81.17
S Dev	137.87	2283.84	8.58	1698.84	192.27	143.15	2773.03	10.76	1129.69	229.86
Min	0.00	15.68	1.33	116.30	9.35	0.10	16.00	1.28	95.85	14.18
Max	113.95	2550.53	6.30	1220.45	145.05	161.73	3446.43	11.23	958.40	170.78

Source: Experimentation

Key: GUJ: Gulubi Junction; MMC: Mallam madori close; OPS: Opposite Police Station; MMR: Mallam madori Road before bridge; ABC: Adjacent Baptist Church; PSR: Police Station road; HMC :Hamzy Metal Construction; PUG: Pick-up garage; POJ: Poly Junction; MAS:Masallaci Street

Table 2: Average, background, enrichment factor and grade of pollution intensity of heavy metals in soil samples

Metals	Average value	shale Soil conc.(mg/kg)	Soil mean		Enrichment factor		Degree of contamination
			0 – 5 cm	5 – 10 cm	0 – 5 cm	5 – 10 cm	
Cr	90.0	48.0	49.10	0.53	0.55	uncontaminated	
Cu	45.0	770.79	924.14	17.13	20.54	Extremely contaminated	
Cd	0.3	3.02	3.74	10.07	12.47	Extremely contaminated	
Pb	20.0	592.63	393.61	29.63	19.68	Extremely contaminated	
Ni	68.0	67.91	81.17	0.99	1.19	Slightly contaminated	

Source: Experimentation

Table 3: Geo-accumulation index of studied welding workshops soil at 0 - 5 cm and 5 - 10 cm depth

Source	Site	Cr	Cu	Cd	Pb	Ni	
Soil (0 – 5 cm)	GUJ	-0.12	1.58	1.08	1.58	0.15	
	MMC	-0.94	0.22	0.57	0.83	-0.61	
	OPS	-0.81	0.35	0.50	0.91	-0.45	
	MMR	-0.67	0.84	0.48	0.59	-0.34	
	ABC	-0.59	0.68	0.47	0.77	-0.34	
	PSR	-0.25	1.07	0.86	1.59	0.00	
	HMC	-0.21	1.55	0.91	1.50	0.04	
	PUG	-0.07	0.71	1.15	1.48	-0.01	
	POJ	-1.07	1.13	0.56	0.80	-0.35	
	MAS	-0.49	0.81	1.11	1.61	-0.12	
	CONTROL	-	-0.63	0.51	0.86	-1.04	
	Soil (5 - 10 cm)	GUJ	-0.17	1.60	1.21	1.50	0.22
		MMC	-1.20	0.43	0.45	0.67	-0.41
OPS		-1.19	0.45	0.48	0.86	-0.31	
MMR		-0.69	1.36	0.45	0.63	-0.25	
ABC		-0.69	0.38	0.79	0.59	-0.37	
PSR		0.08	0.88	0.69	1.05	0.07	
HMC		-0.28	1.71	1.00	1.45	0.19	
PUG		-0.21	0.72	1.40	1.35	0.03	
POJ		-0.72	0.39	0.67	0.86	-0.27	
MAS		-0.59	1.12	1.09	1.29	-0.13	
CONTROL		-3.13	-0.63	0.54	0.50	-0.86	

Source: Experimentation