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EVALUATION OF HEAVY METALS LEVEL OF SOIL IN OLD PANTEKA MARKET AREA OF KADUNA, NIGERIA

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ABSTRACT

The aim of this research is to determine the level and distribution of Cu, Cd, Cr, Pb and Ni from soils samples within the vicinities of Old Panteka market of Kaduna state, Nigeria. The design of this study is to compare the soil heavy metal concentrations with regulatory standard values permitted by the Nigerian environmental guideline as well as international standards and also subject the data to descriptive analysis to determine the correlation between the heavy metals and some physicochemical parameter. Forty-four soil samples at 0 to 5cm and 5 to 10 cm depths from ten (10) sample locations and one control sample was collected on the same day at Old Panteka market of Kaduna, Nigeria. The total concentrations of Cu, Cr, Cd, Pb and Ni were determined using Atomic Absorption spectrophotometer. Cation exchange capacity (CEC), pH, electrical conductivity (EC) and particle size distribution of the soil samples were also determined. The mean concentrations of heavy metal of the metal/welding soils at 0-5 cm were; Cr: 0.00 - 113.95 mg/kg, Cu: 15.68 – 2550.53 mg/kg, Cd: 1.33 - 6.30 mg/kg, Pb: 116.30 - 1220.45 mg/kg, Ni: 9.35 - 145.05 mg/kg, while at 5-10 cm, the ranges were; Cr: 0.10 - 161.73 mg/kg, Cu: 16.00 - 3446.43 mg/kg, Cd: 1.28 - 11.23 mg/kg, Pb: 95.85 - 958.40 mg/kg, Ni: 14.18 - 170.78 mg/kg. The concentrations of the studied metals in the soils from the experimental sites were higher than the corresponding values from the control site at both depths with a general increase in metal concentration with soil depth in most of the sites. Results of the heavy metals in the soils of the experimental sites indicated that the metals were mostly above the European commission (1986) recommended limits for these metals in soil with few exceptions.

Keywords: Soil; heavy metals; Correlation; Atomic Absorption spectrophotometer; Cation exchange capacity (CEC); pH; electrical conductivity (EC); Particle size

INTRODUCTION

Heavy metals are common environmental pollutants and are released into soils from natural or anthropogenic sources. The main natural sources of metals in soils are weathering of parent materials and soil erosion(Yoon et.al 2007). The anthropogenic sources are associated mainly with industrial activities such as metal finishing, paint pigment and battery manufacturing, leather tanning, mining activities, foundries and smelters, diffuse sources e.g., piping, constituents of products, combustion by-products, traffic emissions and other human activities like urban composts and municipal waste water sludge depositions and use of pesticides and phosphate fertilizers (Omar and Alkhashman, 2004; Boularbah *et al*., 2006). Soils are the major sinks for heavy metals released into the environment by aforementioned anthropogenic activities and unlike organic contaminants which are oxidized to carbon (IV) oxide by microbial action, most metals do not undergo microbial or chemical degradation but undergo oxidation to cations in the presence of moisture and oxygen (Kirpichtchkova *et al.,* 2006) and the total concentration of heavy metals in soil persist for a long time after their introduction (Andriano, 1986). In Nigeria and many developing countries, many industrial workshops such as welding workshop, mechanical and electrical workshops are located by the roadsides in residential areas where their customers could easily have access to them. The wastes produced in these workshops are potential environmental pollutants that need to be given a serious attention. Welding is a process in which two or more pieces of metal are joined together by the application of heat, pressure or a combination of both (Disc, 1981).

With the development of new techniques arising in the first half of the 20th century, welding replaced bolting and riveting in the construction of many types of structures, including bridges and building. It is also a basic process in the motor and aircraft industries and in the manufacture of food machinery. Along with soldering and brazing, it is essential in the production of virtually every manufactured product involving metals (Disc, 1981; Odukoya *et al*., 2000). The welding processes most commonly employed today are gas and electric welding. The impact of these processes on the environment must be given attention. Contamination of the environment by metals can cause interference with plant metabolism and consequently the food chain.

This is because the conversion of nitrate is inhibited so that the supply of the nitrogen available to the plant is reduced (Cook, 1976). It is worthy of note that the major industrial activities in old Panteka market area are welding of metals alongside soldering. However due to a tremendous increase in population and vehicular traffic, as well as the creation of a variety of ancillary activities such as vehicle repairs, vulcanizer, auto electricians, and battery chargers etc. These activities result in heavy metals contamination of soils. Although few studies conducted on these workshops have been reported for some small and medium-size cities in the country namely: Iwo (Ipeaiyeda *et al*., 2008), Port Harcourt (Iwegbue, 2009), Akure (Ilemobayo *et al*., 2008), and locations in the Imo river basin (Nwachukwu *et al*., 2010), there is a need to conduct studies in bigger cities so that more definitive conclusions can be made for the country as a whole.

Using Kaduna (old Panteka) as a case study, this research would be carried out to look at these welders workshops closely and make conclusions regarding the heavy metals contamination of the soil environment where they are located. There is, therefore, need for a continuous monitoring of the level of heavy metal in the area in order to keep a check on the environment and to provide data for future research works.

MATERIALS AND METHODS

In the present study, soil samples were collected from ten (10) selected locations in old Panteka, Kaduna. Global Positioning System device model eTrex HC series was used to measure the coordinates of each sampling point around the old Panteka market where most artisanal welding activities occur namely; *Mallam madori* close (MMC), Pick-up garage (PUG), *Gulubi* Junction (GUJ), Poly Junction (POJ), *Mallam madori* Road before bridge (MMR), *Hamzy* Metal Construction (HMC), *Masallaci* Street (MAS), Opposite Police Station (OPS), Police Station road Junction (PSR), Adjacent Baptist Church (ABC) and *Malumfashi* Close located at *Malumfashi* road as a control site about 1Km away from old Panteka market, which is largely a residential area and the soil samples were collected at depths of 0 – 5 cm and 5 – 10 cm. The soil surface was cleared with a plastic hand trowel to a depth of approximately 20 cm before the samples were collected using a plastic spoon at 0 – 5 cm and 5 – 10 cm depth. After every collection, the plastic hand trowel and spoon were washed with soap and rinsed with distilled water to avoid sample contamination(Awofolu,2005) . Five soil samples from each sampling location and depths were randomly collected and pooled together to form a composite from each of the sampling locations. The control samples were collected to validate the heavy metal concentration in soil and labeled control sample from *Malumfashi* close that is majorly residential with low traffic volume and industrial activities. A total of forty-four (44) soil samples were collected on the same day. The collected soil samples were stored in a polyethylene bag, labeled properly and taken to the laboratory where the pH was measured immediately and recorded using digital analyzer model Grison MicropH 2000.

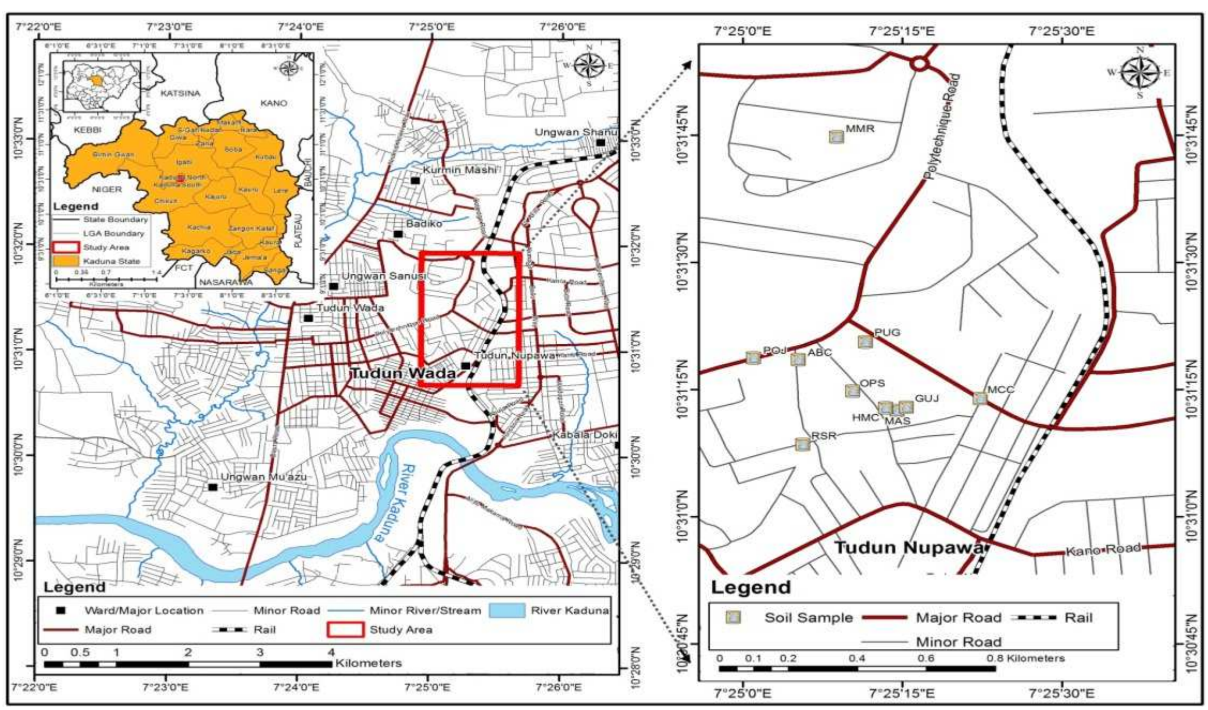

Figure 1: Map of Kaduna Metropolis showing Soil Sampling Points
Source: Fieldwork

Sample pre-treatment

The collected study samples and the control were air-dried at room temperature, disaggregated in a ceramic pestle and mortar, and sieved through a 2 mm sieve to remove stones and pebbles.

The <2 mm fractions of the soil were stored in cellophane bags and used for all soil analyses. Particle size distribution w determined by Bouyoucos hydrometer method (Bouyoucos, 1951) and pH was determined by Electric pH Meter (Grison MicropH 2000) with a direct readout. Electrical conductivity was measured by a high powered microcomputer conductivity meter HANNA HI 9828. Cation exchange capacity was determined by the Black, 1965 procedure. The total heavy metal content was determined using atomic absorption spectrophotometer (Varian model AA650FS) at Multi-user Science Research Laboratory, Ahmadu Bello University, and MSc. Laboratory respectively, while the physicochemical parameters were carried out in the department of soil science Laboratory at Institute of Agricultural research Samaru, Zaria Nigeria.

Quality Control

As part of quality control measure to ensure the reliability of results, samples were handled carefully to avoid contamination. Recovery test was carried out on the AAS machine by spiking analyses, Validation of the technique was conducted on the soil samples. This was done by spiking the pre-digested samples with a multi-element standard solution (5 mg/L of Cd, Cu, Ni, Pb, and Cr) as reported by Awofolu (2005).

RESULTS AND DISCUSSION

Physicochemical Properties

The result of the analyses of the physicochemical parameters of the welding workshops and the control site soil are presented in Tables 1 and 2. The particle size distribution of the workshop soil samples ranged from 7.41% - 25.97% for clay, 11.12% - 18.48% for silt and 59.21% - 77.77% for sand at 0 - 5 cm depth, while at 5 – 10 cm depth, the workshop soils ranged from 8.40% - 30.97% (clay), 12.12% - 18.89% (silt) and 54.21% - 75.12% (sand). The values recorded at the control sites were 18.40% (clay), 15.90% (silt) and 65.70% (sand) at 0 - 5 cm and 5 - 10 cm depths respectively. The soil textural class is basically sandy-loamy. The pH values obtained from soils in the study area ranged from 7.42 - 10.32 at 0 – 5 cm and 7.49 - 10.45 at 5 – 10 cm depths which was alkaline in nature at both depths while at the control site, it was 8.53 (0 – 5 cm) and 8.47 (5 – 10 cm) indicating also alkaline nature. pH plays a significant role in solute concentration and in sorption and desorption of contaminants in soil (Gillman, 1981; Elliot *et al*., 1986). It is an important and useful index of the availability of nutrients, the potency of toxic substances present in the soil and the physical properties of the soil (Iwegbue *et al*., 2009). The alkaline pH values of the soils might be as a result of the sorption of metals in the soil (Lee and Saunders, 2003). The pH values obtained in this study are similar to that reported for dumpsites by other researchers (Uba *et al*., 2008; Elaigwu *et al*., 2007; Gupta and Sinha, 2006). The ranges of values obtained in this study are within the range of 6.80 - 8.20 and 6.50 - 8.30 reported by Aruleba and Ajayi (2012) and Inobeme *et al*., 2014 respectively. It is, however, higher than 3.60 - 6.73 as reported by Osakwe (2014). The presence and mobility of heavy metals in the soil are affected by the pH of the soil. The implication of soil pH variations with depths can be attributed to the oxidation states of certain heavy metals. The conductivity of a heavy metal which is proportional to the mobility and metal concentration is highly dependent on the redox state.

The As^{3+} forms are significantly more mobile and toxic in the environment than the As^{5+} species (Rajaković *et al.,* 2013). The EC values were found to vary significantly across the sites; Tables: 1 and 2. EC serves as a measure of soluble nutrients (Smith and Doran, 1996) for both cations and anions and is useful in monitoring the mineralization of organic matter in the soil (De Neve *et al*., 2000). The results of EC were quite high with values ranging from 0.32 – 11.20 µs/cm across depths. These may be due to the indiscriminate disposal of metal scraps by artisans at the old Panteka industrial area onto the soil and eventually into the well water. These values were higher than the values reported by Osakwe and Ofuya (2008) and Oviasogie and Omoruyi (2007). The high E.C of soils is an indication of the high or significant presence of ions. The observed E.C values in the workshops soil could be attributed to the reactions between some depositions containing metals from vehicular scraps and some metals, resulting in the availability of some soluble and ionizable inorganic salts in the soils. The EC values were higher than those obtained in scrap dump sites in Warri by Iwegbue *et al*., (2009) (0.13 - 0.28 μscm^{-1}). These results were lower when compared to 140±28.30 to 530± 28.20 as reported by Inobeme *et al.,* (2014), in soils around paint industries in Kaduna. The discrepancy in the electrical conductivity values could be as a result of the differences in the soluble salts content of the soil. CEC of heavy metals depends on the density of ionic strength of the surfaces of soil colloids and on the relative charges of metal species in the soil solution. The surface negative charges may be pH dependent (soil organic matter) (Evans, 1987). Cations are less bioavailable because they have less competition from H^+ for available binding sites. According to Awode *et al*., (2008), CEC of soil is more greatly influenced by organic matter than by the concentration of clays, hence CEC tends to be higher in most study sites than in the control sites. On variation with soil depth, the CEC values of some of the study areas decreased down the soil profile. This reduction in CEC of the studied soil down the profile is a reflection of nutrient-depleting wastes or displacement by toxic metals which are indirectly introduced through the indiscriminate disposal of waste and metal scraps.

Total Heavy Metal Concentration (Mean Cr concentrations)

The mean level of Cr in the workshop soils ranged from 0.00 mg/kg - 113.95 mg/kg at 0 – 5 cm depths. However higher values of 0.10 - 161.73 mg/kg were recorded at 5 – 10 cm depth, this could be due to leaching effect of chromium containing metals or solders from welding activities taken place at the workshops. Chromium concentrations in the workshop soils were generally above standard limits (0.03 mg/kg) set by FEPA (1991). Sources of Cr in the soils could be due to automobiles scraps, coloured polyethylene bags, discarded plastic materials and empty paint containers (Jung *et al*., 2006).

(Mean Cu concentrations)
Copper had relatively high values ranging from 15.68 - 2550.53 mg/kg at 0 – 5 cm and 16.00 - 3446.43 mg/kg at 5 – 10 cm depths. The exceptionally high values in Gulubi Junction (GUJ) and

Table 1: **Physicochemical parameters of welding workshop soils and control site at 0 – 5 cm depth**

SITE CODES	Clay (%)	Silt (%)	Sand (%)	Texture Class	pH	EC (µs/cm)	CEC (Cmol/kg)
GUJ	7.41	16.89	75.97	S-L	7.48±0.08	2.85±0.01	33.50±0.01
MMC	7.41	14.82	77.77	S-L	8.15±0.00	2.42±0.03	37.81±0.01
OPS	25.97	18.47	59.21	S-L	7.42±0.03	0.32±0.03	33.63±0.03
MMR	18.47	11.12	70.41	S-L	8.33±0.03	2.40±0.00	32.86±0.01
ABC	18.47	18.48	74.11	S-L	10.32±0.03	5.62±0.03	50.32±0.03
PSR	9.41	14.82	75.77	S-L	9.42±0.03	9.70±0.00	62.35±0.01
HMC	9.92	14.82	75.26	S-L	9.50±0.00	5.10±0.00	46.10±0.00
PUG	10.41	12.97	76.62	S-L	9.80±0.00	1.40±0.00	50.37±0.00
POJ	9.26	15.97	74.77	S-L	8.72±0.03	11.05±0.00	51.95±0.01
MAS	7.56	16.18	76.26	S-L	9.05±0.00	0.70±0.00	41.21±0.00
CONTROL	18.40	15.90	65.70	S-L	8.53±0.06	4.10±0.00	39.41±0.00

S-L: Sandy-Loamy.
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

Hamzy Metal Construction (HMC) welding workshop could be attributed to welders and smelters activities containing copper wires, electrodes, copper pipes and alloys from corroding metals and soldering process which have littered the vicinity for a long period of time, with the metals released from the corrosion gradually leaching into the soil (Nwanchukwu *et al*., 2011). The levels of Cu recorded in this study were higher than those recorded in soils of auto mechanic sites in Makurdi by Aloysius *et al*., (2013). Copper concentrations in most studied sites were above standard limits (140 mg/kg) set by European commission (1986). The mean copper values in the control sites were lower than those in the study areas.

Table 2: Physicochemical parameters of welding workshop soils and control site at 5 –1cm depth

SITE CODES	Clay (%)	Silt (%)	Sand (%)	Texture Class	Ph	EC (µs/cm)	CEC (Cmol/kg)
GUJ	10.92	18.89	70.46	S-L	7.52±0.06	2.72±0.23	33.48±0.10
MMC	8.41	15.82	72.46	S-L	8.33±0.08	2.52±0.08	37.82±0.03
OPS	30.97	14.82	54.21	S-L	7.49±0.06	0.42±0.08	33.65±0.05
MMR	18.68	12.12	69.20	S-L	8.43±0.06	2.45±0.05	32.85±0.05
ABC	8.40	16.48	75.12	S-L	10.45±0.01	5.74±0.03	50.30±0.05
PSR	9.43	17.82	72.75	S-L	9.42±0.03	9.80±0.05	62.38±0.08
HMC	9.92	15.62	74.46	S-L	9.72±0.03	5.25±0.05	45.15±0.05
PUG	12.40	12.98	72.62	S-L	9.77±0.14	1.47±0.03	50.42±0.02
POJ	9.30	16.10	74.60	S-L	8.67±0.03	11.20±0.13	51.97±0.03
MAS	11.54	18.20	70.26	S-L	9.32±0.38	0.75±0.05	41.57±0.59
CONTROL	18.40	15.90	65.70	S-L	8.47±0.08	4.25±0.05	39.44±0.03

S-L: Sandy-Loamy
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

(Mean Cd concentrations)
Workshop soil heavy metal contents were significantly lower in the control site compared to the study areas. Cd concentrations in the workshop soils were above the standard limits (3 mg/kg) set by European commission (1986) with the exception of sites Mallam madori close (MMC), Opposite Police Station (OPS), Mallam madori Road before bridge (MMR), Adjacent Baptist Church (ABC), Police Station road Junction (PSR), Poly Junction (POJ) welding sites and the Control site (Table: 3). The high concentrations of Cd at some study areas could be attributed to metallic alloys used during the process of smelting, soldering, and welding. Cd exhibited lower levels of contamination than those of the other metals studied. The mean value obtained in soils of auto mechanic sites in Makurdi by Aloysius *et al*., (2013) (12.79 - 17.90 mg/kg) and in Owerri Municipal by Okoro *et al*., (2013) (8.83 - 18.67 mg/kg) in a similar studies were higher than those reported in this study. The results were also below those reported in soil of abandoned mechanic workshops in Umuahia metropolis by Abii (2012) (19.4 - 25.6 mg/kg), but above those reported in Abbatoir dumpsite in Yauri, Kebbi state by Yahaya *et al*., (2009) (0.14 - 7.00 mg/kg), and in municipal waste dumpsites in Benin city by Osaze *et al*., (2013) (0.009 - 0.016 mg/kg).

(Mean Pb concentrations)

Lead concentration in most of the study areas was generally below the standard limits (300 mg/kg) set by European commission (1986). The exceptionally high value in sites Masallaci Street (MAS) (1220.45 mg/kg) at 0 – 5 cm and Gulubi Junction (GUJ) welding sites (958.40 mg/kg) at 5 – 10 cm depths, could be attributed to the metals fabrication and smelting activities taken place in the welding workshops. It is possible that these high levels of Pb are elevated by the amount of waste such as scraps from metals, liquid emission from welding machine, used welding electrodes indiscriminately dumped by smelters and welders in the study area. The levels of Pb recorded in this study are above those recorded in soils of auto mechanic sites in Akure by Oguntimehin and Ipinmoroti, (2008). Values of (1.23 - 3.43 mg/kg) reported by Adewole *et al*., (2010) in automobile workshops in Ile-Ife; 25.85 - 38.83 mg/kg by Abii (2012) in Umuahia metropolis and 33.64 - 117.45 mg/kg by Atiemo *et al*., (2012) in Accra are lower than those reported in this study. However, concentration ranges of 283 - 665 mg/kg reported by Aloysius *et al*., (2013) in automobile workshops in Makurdi; 693 - 2917 mg/kg by Okoro *et al*., (2013) in Owerri municipal and 1162 mg/kg by Nwachukwu *et al*., (2011) in auto mechanic village, Owerri were higher than the concentration range reported in this study.

(Mean Ni concentrations)

The mean Ni concentration recorded at control site was the lowest at both depths (Tables: 3). The nickel concentration in the workshops soil was mostly above standard limits (75 mg/kg) set by the European commission for soil (1986) thus implying high contamination of the metal in the soil. This could be attributed to the indiscriminate disposal of spent electrodes by welders and various paint wastes use by welders, which have contributed to the contamination of the soil samples (Udousoro *et al*., 2010). The concentration range reported in this study was higher than concentration range values for soils of auto mechanic and refuse dumpsites in Makurdi by Luter *et al*., (2011) (4.20 - 48.6 mg/kg), Scrap dumpsites in Warri by Iwegbue *et al*., (2009) (16.52 - 17.38 mg/kg) and auto repair workshops in Iwo by Ipeaiyeda *et al*., (2008) (11.5 mg/kg) in a similar study. The mean nickel values in the control site were observed to be lower than those in the studied areas. In general, the concentrations of metals found in the soils of the study areas are higher than the control site while the concentration of some metals decreased with soil depth.

Analysis of variance (ANOVA) between the heavy metals in the soils of the study areas and the control sites reveal significant differences ($P<0.05$).

Table 3: Basic statistical parameters for the distribution of heavy metals in the investigated soil samples

	Soil (0 - 5 cm)					**Soil (5 - 10 cm)**				
Sites	**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
CONTROL	**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

(Correlation Analysis of Soil Heavy Metals)

Heavy metals, pH, EC and CEC Correlation coefficient measures the strength of a linear relationship between any two variables on a scale of -1 (perfect inverse relation) through 0 (no relation) to +1 (perfect sympathetic relation). In this study, the raw data was used in calculating the correlation coefficient using the Microsoft Excel computer software package (Microsoft corp., 2013 version). The correlation analysis between heavy metals in sample soils, pH, EC and CEC are shown in (Tables: 4 and 5). Some of the heavy metals are significantly correlated with each other so also the pH, EC and CEC are significantly correlated with each other at both depths.

Cr/Ni, Cu/Ni, Cd/Pb and Pb/Ni are correlated positively with each other at 0-5 cm depth with values +0.927, +0.800, +0.874 and +0.860, and also +0.770, +0.790, +0.771 and +0.910 at 5-10 cm depth respectively (P<0.01), indicating that they have the same source(s) of contamination in the environment. Furthermore, there was strong positive correlation (+0.819) between Cr and Cd, Cr and Pb (+0.788) at 0-5 cm depth and also between (+0.750) Cu and Pb at 5-10 cm also indicating that they have the same source(s) of contamination in the environment.

Table 4: **Correlations matrix of the physicochemical parameters and the metals of soil at 0 - 5 cm depth**

	pH	EC	CEC	Cr	Cu	Cd	Pb	Ni
pH	1.00							
EC	0.34							
CEC	0.75**	0.74**	1.00					
Cr	0.28	-0.09	0.27	1.00				
Cu	-0.09	0.19	-0.01	0.60	1.00			
Cd	0.18	-0.30	0.11	0.819**	0.41	1.00		
Pb	0.19	-0.05	0.29	0.788**	0.54	.874**	1.00	
Ni	0.14	0.04	0.23	0.927**	0.80**	0.79**	0.86**	1.00

****. Correlation is significant at the 0.01 level (2-tailed). *. Correlation is significant at the 0.05 level (2-tailed).**

Table 5: Correlations matrix of the physicochemical parameters and the metals of soil at 5 - 10cm depth

	pH	EC	CEC	Cr	Cu	Cd	Pb	Ni
pH	1.00							
EC	0.30	1.00						
CEC	0.71*	0.74**	1.00					
Cr	0.27	0.36	0.60	1.00				
Cu	-0.06	-0.11	-0.26	0.34	1.00			
Cd	0.27	-0.31	0.12	0.41	0.28	1.00		
Pb	0.05	-0.20	-0.02	0.53	0.75**	.771**	1.00	
Ni	0.07	0.05	0.16	0.77**	0.79**	0.60	0.91**	1.00

****. Correlation is significant at the 0.01 level (2-tailed), *. Correlation is significant at the 0.05 level (2-tailed)**

Table 6: ANOVA metal locations

	Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Test of within-subject Effects	metals	7920417.957	1.268	6244900.683	15.980	0.000
	metals * location	10258321.799	12.683	808823.488	2.070	0.053
	Error(metals)	10904130.517	27.903	390792.119		
Test of Between-Subjects Effects	Intercept	6423279.073	1	6423279.073	24.166	0.000
	location	4824071.844	10	482407.184	1.815	0.117
	Error	5847627.506	22	265801.250		

***There are significant differences (P<0.05) within the levels of metal pollution in each site.**

CONCLUSION

The soil heavy metals (Cr, Cu, Cd, Ni and Pb) analyses from the ten selected locations in old Panteka market industrial area was carried out in comparison with the control soil samples and the environmental soil guidelines. The results reveals that all the locations were considerably polluted with heavy metals and most of them have heavy metal concentrations above the intervention/alert level provided by the environmental protection agencies as compared with those of control. The results also shows that heavy metal availability and distribution pattern varies with location and depth as indicated by the wide range of concentration values observed for virtually all the heavy metals in the soils analyzed across the sample locations. The correlation analysis shows that most of the heavy metals are positively correlated with one another thus indicating there common environmental contamination origin.

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