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Impact of motor parks on the concentration of heavy metals in some selected urban areas of Benue State Nigeria

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ABSTRACT

The determination of Cd, Co, Cu, Mn, Ni, Pb and Zn in soils within motor parks in some selected local government areas of Benue state were carried out with Flame Atomic Absorption Spectrophotometric technique. The method developed by the United State Environmental Protection Agency for (total sobbed) heavy metals in soils, sediments and sludges was used in the preparation of the soil samples. Generally the ranges and mean concentrations (µg/g) of metals in motor park soils were 3.00-4.93 (4.37±0.49), 1.00-1.87 (1.46±0.31), 41.67-65.93 (52.46±7 .85),301.67-390.00(346.18±37.56), 14.20-19.13 (16.72±1.74), 205 .33-382.67 (251.22±41.96) and 103.33-171.67(136.25± 22.00) for Cd, Co, Cu, Mn, Ni, Pb and Zn respectively. The concentration of Pb was the highest. The degree of contamination by each metal was estimated by the enrichment factors. The enrichment factors obtained for Cd, Co, Cu, Mn, Ni, Pb and Zn in motor parks were 15.07, 1.78, 2.92, 2.41, 1.92, 76.36 and 13.58 respectively. The inter-element correlation was found among metals in the soils using Pearson's correlation co-efficient. There were positive correlations among the metals determined. Metals such as Pb, Cd, and Zn shows high degree of contamination, while Co, Cu, Mn and Ni shows low degree of contamination in the study sites.

Keywords: Heavy Metals; Motor Parks; Benue State.

INTRODUCTION

The rapid increase in man's agricultural, industrial and urban activities has principally led to the appearance of the modern environmental problems that are associated with pollution, of which heavy metals play a significant role [1,2]. There is a long history of association between modern civilization and metals whose accelerated use started during the industrial revolution of the nineteenth century. Since then, heavy metals have become very important for all aspect of life, because of a large range of metal products in use[3,4].

Trace metals are peculiar to all kinds of soils, sediments, waters and living organisms in a range of normal background concentrations [5], but when they exceed an optimum range of safe exposure, then the term "heavy metal pollution" is used. Thus of concern are their emission into the environment as a result of increase in industrial, man's agricultural and urban activities, which give rise to anomalous high concentrations of the metals relative to the normal background levels [6]. With urban development, there is high rate of vehicle usage resulting in increase in number of motor parks "garage", vehicle fuel filling station, servicing and repairing stations in the urban areas. As a means of transportation, the explosively rising urban population now relies heavily on automobiles which have

become a dominant source of pollution in many cities. At present, most of the gasoline used in Africa contains trace metal especially lead. The lead contents include 0.21-0.52gl^{-1} for regular brand to about 0.7-0.9gl^{-1} for supergrade gasoline in Nigeria [7,8]; 0.81-1.0gl^{-1} in Egypt [9]; 0.5-0.6 gl^{-1} in Libya [10] and 0.3-0.7 gl^{-1} in Ghana. The lead content of African gasoline is thus higher than the 0.15 gl^{-1} being adopted by the European Economic Community. In Canada, the Unites States and Japan, most of the gasoline is lead free. As the developed countries reduce or phase out the leaded gasoline, the consumption of lead in gasoline in Africa has risen and will continue to rise in relation to the global total indiscriminate (unregulated) disposal of automobile waste oils would represent an important source of lead and other trace metals on land especially the motor parks. As the motor parks increase as a result of increase in number of vehicles, measures must be taken to know the sources, significance and concentrations of these pollutants (heavy metals) to the environment.

This research is therefore based on the study and determination of various concentrations of metals such as Cd, Co, Cu, Mn, Ni and Zn in motor parks soil samples in Otukpo, Gboko and Makurdi Local Government of Benue State in Nigeria since some of these motor parks serve as market where food, fruit and vegetables are sold and also as a playing ground particularly for children that can ingest Pb directly from soil [11].

MATERIALS AND METHODS

Sampling spots of about 20-30 m apart from each other were mapped out for soil sample collection within each sampling sites. Samples were collected using clean stainless steel trowel from about 0-15cm depth. A soil sample from control sites were also collected from where farming, mining and industrial activities were absent. The collected soil sub-samples were thoroughly mixed, pooled together to make a composite of each soil sample.

The collected soil samples were air-dried for 2 weeks to remove excess moisture. Large soil clods were also crushed to facilitate the drying. The dried soil samples were crushed in a porcelain mortar with a pestle. The crushed soil samples were sieved through a 2 mm sieve made of stainless steel, for analyzing soil pH and particle size. Some portion of the individual sieved soil samples were further pulverized to a fine powder and passed through a 0.5mm sieve for analyzing organic carbon and total metal content. The pH of the soil samples was determined with pH meter Hanna (Model H1991000) according to standard analytical methods. Organic matter was determined using the chromic acid oxidation method [12]. Particle size distribution was determined by the hydrometer method as described by Bauyocos [13]. The exchangeable cation was determined by the method described by Hendershot [14].

The method developed by the United States Environmental Protection Agency for (total sobbed) heavy metals in soil, sediments and sludge (USEPA SW-846, method 3050) [15], was used in the preparation of the soil samples for the determination of total metal content in this study. One gram (1g) of the soil sample was weighed into a beaker for acid digestion. Analar grade nitric acid, hydrogen peroxide (about 30%) and concentrated Hydrochloric acid were used for the digestion. The digest was filtered through whatman filter paper. Each filtrate was collected in 100ml volumetric flask and deionized water was used to rinse the filter paper into volumetric flask. Each filterate was later made up to 100ml with deionized water. Standards were prepared with serial dilution techniques within the range of each metal determined. The standards used were Analar grade; the instrument was first calibrated with stock solutions of the prepared standards before analyzed using flame atomic absorption spectrophotometer. After every five samples analyzed using AAS, the first sample was repeated for quality check. Only when the result was within 10% of earlier readings did the analysis proceed further. The data obtained in the study were analyzed using Pearson correlation analysis.

The enrichment factors for the soils were calculated according to the following equation

$$EFc = (Cx/C\mathit{Fe})soil/(Cx/C\mathit{Fe})Earth's\ crust$$

Where (Cx/C*Fe*) soil is the ratio of concentration of the element being determined (Cx) to that of Fe (C*Fe*) in the soil sample and (Cx/C*Fe*) earth's crust is the ratio in the reference Earth's crust [16,17,18].

RESULTS AND DISCUSSION

Soil Characteristics of Motor Park

The pH values ranged from 6.20-7.50, 6.80-7.20 and 6.80-7.50 for Otukpo, Gboko and Makurdi motor park soil samples respectively (Tables 1,2,3,4). All the soils studied from the motor park were either weakly acid or neutral.

The soil organic carbon concentrations ranged from 0.88-1.60, 0.77-0.92 and 0.90-1.52 for Otukpo, Gboko and Makurdi respectively. The soils from the three study areas were generally low in organic carbon contents. Most of the soil samples studied from Otukpo, Gboko and Makurdi motor park soil samples have organic carbon values of less than 2.00%. The clay contents ranged from 7.20-14.20%, 8.20-13.20% and 7.20-14.20%for Otukpo, Gboko and Makurdi motor park soils respectively. The cation exchange capacity ranged from 12.80-19.40meq/100g, 15.60-20.50meq/100g and 10.20-20.50meq/100g, for Otukpo, Gboko and Makurdi respectively.

Heavy Metal Concentrations

The results of heavy metal concentrations in the motor park soil samples are presented in Tables(5,6,7,8). The soil samples from motor park sites in the three major cities (Otukpo, Gboko and Makurdi) of Benue state revealed a clear elevated levels of these heavy metals (Cd, Co, Cu, Mn, Ni, Pb and Zn). The mean concentrations of heavy metals obtained from the control sites were much lower than those obtained from the soils of the motor parks under consideration. This reflects a general and diffuse contamination of soils of these motor parks by heavy metals. Out of the heavy metals considered, lead shows the highest pollution in the three urban areas studied. The overall results ranged from 3.00-4.93 µg/g, 1.00-1.87 µg/g, 41.67-65.93 µg/g, 301.67-390.00 µg/g, 14.20-19.13 µg/g, 205.33-382.67 µg/g and 103.33-171.67µg/g for Cd, Co, Cu, Mn, Ni, pb and Zn respectively.

Generally, in the three urban area studied, the concentrations of the heavy metals were extremely high especially Pb, Cd, Cu and Zn. This is an indication that these heavy metals are the primary contaminant in the motor park soils which was also reflected in the low level of these metals obtained from the control sites in comparison with those obtained from the study sites. Also, the degrees of heavy metals pollution in motor park soils which were determined by its accumulation factors were also high. From the mean results and accumulation factors, there is a clear indication that Pb, Cu, Cd and Zn are the great contaminant in the motor park soils where exhaust from vehicles and gasoline combustion primarily cause air pollution with the heavy metals especially lead particles reaching soils through dry and wet depositions [17,18]. Studies have shown that motor vehicles constitute principal source of this metals [19,20,21]. Soil Pb concentrations greater than 1.0mg/kg generally indicate a local source of pollution [22]. The high lead contents in motor park soil samples could further be linked up with the automobile tail-pipe which accounts roughly two-thirds emission of Pb into the atmosphere. It was reported that Nigeria still run gasoline of Pb concentrations of 0.66g per litre and it is estimated that about 2800 metric tones of vehicular gaseous Pb emission is deposited to urban areas in Nigeria annually [20]. Although the mean concentrations of Mn were found to be very high in the motor park soils, this metal may not be regarded as a primary contaminant in the study area, this is reflected in its accumulation factors which primarily determine its extent of contamination. The accumulation factors of Mn in the motor park soils were 7.60, 8.28 and 7.88 for Otukpo, Gboko and Makurdi respectively. Also the mean concentration of Mn obtained from all the sites (346.18±37.56µg/g) falls within the acceptable limits proposed by E.U, ICRCL and UNEP limits. Hence it could be said that Mn originates from parent material in the soil. Copper is not regarded as soil contaminant in the motor park soils. Its mean concentrations and accumulation factors were found to be very low in motor park soil samples.

The mean concentration of Zn in the motor park soil samples was 136.252±22.00µg/g. This was also found to be very high in comparison with those obtained from control sites. This clearly shows that Zn, which seems to be mainly associated with traffic auto-mobile source, can also be derived from tyre consumption. Zn can also be considered as one of the heavy metals which are components of tyres and engines and can be released during abrasion and wears. However, Zn cannot also be regarded as one of the prominent contaminants like Pb in the motor park soil because the mean metal content obtained for Zn in the motor park soils falls below some of the proposed ranged for Zn values in uncontaminated soil. The accumulation factor of Zn was much lower than that of Pb (Table 9).

The concentrations of Ni and Co were very low in the motor park soil samples so also their accumulation factors which does not have much variation. From these observations, Ni and Co does not contribute much towards the contamination of areas under study. The correlations were established among the various metals under consideration

(Table 10). There were positive correlations between pairs of Cd/Co, Co/Cu, Cd/Zn, Mn/Pb, Cd/Cu, Ni/Zn and Pb/Zn in motor park soils confirming their probable common origin.

Enrichment factors

If an enrichment factor is greater than unity, this indicates that the metal is more abundant than that found in the earth's crust. However, enrichment factors less than 5 may not be considered significant although they are an indicator of metal accumulation, because such small enrichments may arise from differences in the composition of local soil material and the reference earth's crust used in EFc calculations. If the EFc values are greater than 5, in this case they are considered to be soil pollution for related metals. Pb, Cd and Zn have the highest EFc values i.e 76.36, 15.07 and 13.58 for Pb, Cd and Zn respectively. These high EFc value indicate that the source of accumulation of Pb, Cd and Zn originates mainly from anthropogenic contributions. The Pb showed high EFc which may be a pollution indicator for soils polluted by Pb to some extent, mainly originated from traffic, since soil samples were collected from motor parks. The important contributors of Pb in soils are the parent geological materials from which soils are derived, smelters, coal combustion and the widespread use of leaded petrol. Pb mainly enters soils by means of atmospheric dry and wet depositions and the disposal of sewage sludge. As a consequence of Pb and materials containing Pb, substantially elevated levels of this element may be found in some local soils [23,24].

Cd and Zn also have high EFc values. There is much concern about the levels of Cd present in the environment, since it's a cumulative poison for mammals. Its main ways of entering the environment as a waste product are especially from metal refining and electroplating, and also from the chemical and paint industries [25,26]. Zn is also surface contaminant of studied soil samples from motor parks. Its accumulation may occur from atmospheric deposition originating from smelting activities (in association with lead),galvanized iron and steel, alloys, batteries, brass, rubber manufacture, mining and old tyres [27]. Enrichment factors for Co, Cu, Mn and Ni varied from 1.78-2.92, which indicates that the soils were not polluted by these metals. However Co, Cu, Ni and Mn have EFcs somewhat higher than unity i.e.1.78, 2.92, 2.24 and 1.92, respectively, but these may not be a pollution indicator for the soils.

Table 1: Soil Characteristics of Otukpo Motor Parks

Sample Sites	pH	O.C	Sand (%)	Silt (%)	Clay (%)	C.E.C meq/100g
A	6.80	1.60	71.10	15.70	14.20	12.80
B	6.20	0.80	75.10	16.70	13.20	13.60
C	7.00	1.40	71.10	14.70	14.20	19.40
D	7.20	1.20	78.10	14.70	7.20	15.60
E	7.50	1.30	73.10	14.70	12.80	16.20
cont 1	7.20	0.60	74.40	10.40	15.20	14.20
cont 2	6.10	0.95	71.40	10.40	18.20	13.40
cont 3	6.90	0.94	72.40	13.40	14.20	12.80

Table 2: Soil Characteristics of Gboko Motor Parks

Sample sites	pH	O.C	Sand (%)	Silt (%)	Clay (%)	C.E.C meq/100g
A	6.90	0.90	74.10	17.70	8.20	20.50
B	6.80	0.85	73.10	13.70	13.20	19.20
C	7.10	0.77	76.10	15.70	8.20	18.20
D	7.20	0.85	69.10	17.70	13.20	17.20
E	6.80	0.92	74.10	16.50	9.40	15.60
cont1	6.90	0.98	69.40	12.40	18.20	14.50
cont2	7.20	0.85	70.40	13.40	16.20	16.20
cont3	7.40	0.60	70.70	14.90	14.40	15.60

Table 3: Soil Characteristics of Makurdi Motor Parks

Sample sites	pH	O.C	Sand (%)	Silt (%)	Clay (%)	C.E.C meq/100g
A	7.50	1.52	68.10	23.70	8.20	10.20
B	7.20	0.90	71.10	19.70	9.20	18.40
C	6.80	1.40	78.10	14.70	7.20	20.20
D	7.20	0.95	73.10	14.10	12.80	15.60
E	7.40	0.98	78.10	14.10	7.80	18.20
cont1	7.20	0.85	70.70	13.70	15.60	17.20
cont2	7.00	0.70	70.90	13.50	15.60	16.20
cont3	6.90	0.94	73.70	9.60	16.70	15.20

Table 4: The ranges and mean of soil properties of motor parks in the study area

		Parameters					
Town		**pH**	**O.C**	**sand**	**silt**	**Clay**	**C.E.C**
OTUKPO	Range	6.20-7.50	0.80-1.60	71.10-78.10	14.70-16.70	7.20-14.20	12.80-19.40
n=5	Mean	6.94	1.26	73.7	15.3	12.32	15.52
	S.D	0.49	0.3	2.97	0.89	2.93	2.58
Gboko	Range	6.80-7.20	0.77-0.92	69.10-76.10	13.70-17.70	8.20-13.20	15.60-20.50
n=5	Mean	6.99	0.86	73.3	16.26	10.44	18.14
	S.D	0.18	0.06	2.59	1.66	2.57	1.87
Makurdi	Range	6.80-7.50	0.90-1.52	68.10-78.10	14.10-23.70	7.20-14.20	10.20-20.50
n=5	Mean	7.22	1.15	73.7	17.26	9.04	16.52
	S.D	0.27	0.29	4.39	4.3	2.22	3.9
All soil	Range	6.20-7.50	0.77-1.60	68.10-78.10	13.70-23.70	7.20-14.20	10.20-20.50
n=15	Mean	7.04	1.09	73.57	16.27	10.6	16.73
	S.D	0.34	0.28	3.16	2.64	2.77	2.91

n=number of soil within the site
S.D= standard deviation

Table 5: Total Metal Contents (µg/g) of Otukpo Motor parks

Sample sites	**Cd**	**Co**	**Cu**	**Mn**	**Ni**	**Pb**	**Zn**
A	3.00	1.00	41.67	310.67	15.00	217.33	103.33
B	4.27	1.27	65.93	387.33	18.53	205.33	160.00
C	4.20	1.20	52.93	371.33	14.33	262.00	114.33
D	4.00	1.00	44.20	313.00	17.20	225.33	135.67
E	4.80	1.80	52.50	306.67	18.33	275.33	124.67
cont1	0.35	0.80	18.00	145.00	10.20	3.80	10.50
cont2	0.30	1.00	17.50	144.80	9.80	3.60	11.20
cont3	0.20	1.00	17.80	143.50	11.50	3.50	11.80

Table 6: Total Metal Contents (µg/g) of Gboko Motor parks

Sample sites	**Cd**	**Co**	**Cu**	**Mn**	**Ni**	**Pb**	**Zn**
A	4.47	1.53	52.80	306.67	17.67	232.00	111.67
B	4.83	1.87	60.53	390.00	18.33	257.33	133.33
C	4.33	1.33	65.87	376.67	16.67	382.67	160.67
D	4.20	1.20	48.60	305.33	15.67	242.00	151.67
E	4.40	1.40	54.13	381.67	17.67	239.33	171.67
cont1	0.30	0.80	19.20	142.50	9.50	3.50	9.50
cont2	0.37	0.60	17.20	140.80	8.10	3.00	8.50
cont3	0.25	0.90	16.90	144.20	7.90	2.50	10.00

Table 7: Total Metal Contents (µg/g) of Makurdi Motor parks

Sample sites	Cd	Co	Cu	Mn	Ni	Pb	Zn
A	4.13	1.80	60.60	370.33	18.27	258.00	126.67
B	4.80	1.80	42.67	301.67	14.20	252.00	114.33
C	4.87	1.87	49.20	380.67	19.13	245.00	162.00
D	4.93	1.53	50.27	380.00	15.40	208.67	154.00
E	4.33	1.33	44.93	310.67	14.33	266.00	119.67
cont1	0.35	0.80	17.90	146.20	9.00	3.50	9.70
cont2	0.30	0.60	18.50	145.50	10.00	3.20	8.60
cont3	0.20	0.80	18.60	141.10	8.60	3.00	10.50

Table 8: Summary of total metal contents(µg/kg) of the motorpark in the study area

Town	metal	Range	mean/S.D
Otukpo	Cd	3.00-4.80	4..05±0.66
	Co	1.00-1.80	1.25±0.33
n=5	Cu	41.67-65.93	51.45±9.50
	Mn	306.67-387.33	337.80±38.40
	Ni	14.33-18.53	16.68±1.92
	Pb	205.33-275.33	237.06±30.08
	Zn	103.33-160.00	127.60±21.73
Gboko	Cd	4.20-4.87	4.45±0.24
	Co	1.20-1.87	1.47±0.26
n=5	Cu	48.60-65.87	56.39±6.81
	Mn	305.33-390.00	352.07±42.33
	Ni	15.67-18.33	17.20±1.04
	Pb	232.00-382.67	270.67±63.29
	Zn	111.67-171.67	145.80±23.69
Makurdi	Cd	4.13-4.93	4.61±0.36
	Co	1.331.87	1.67±0.23
	Cu	42.67-60.60	49.52±6.92
n=5	Mn	301.67-380.67	348.67±39.14
	Ni	14.20-19.13	16.27±2.29
	Pb	208.67-266.00	245.93±22.22
	Zn	119.67-162.00	135.33±21.34
all soil	Cd	3.00-4.93	4.37±0.49
	Co	1.00-1.87	1.46±0.31
	Cu	41.67-65.93	52.46±7.85
n=15	Mn	301.67-390.00	346.18±37.56
	Ni	14.20-19.13	16.72±1.74
	Pb	205.33-382.67	251.22±41.96
	Zn	103.33-171.67	136.25±22.00

n= number of soil

Table 9: Factors of accumulation of heavy metals in motopark in the study site

Town	Metal	
Otukpo	Cd	14.46
	Co	1.13
n=5	Cu	2.90
	Mn	2.34
	Ni	1.96
	Pb	68.25
	Zn	11.43
Gboko	Cd	14.35
	Co	3.17
n=5	Cu	2.47
	Mn	8.28
	Ni	2.02
	Pb	90.22
	Zn	15.62
Makurdi	Cd	14.86
	Co	2.29
	Cu	2.70
n=5	Mn	2.24
	Ni	1.77
	Pb	76.06
	Zn	14.1
all soil	Cd	15.07
	Co	1.78
n=15	Cu	2.92
	Mn	2.41
	Ni	1.92
	Pb	76.36
	Zn	13.58

Table 10: Elemental correlation coefficient among heavy metals in motorparks soil

Town	metal	Cd	Co	Cu	Mn	Ni	Pb	Zn
Otukpo	Cd		0.791*	0.592*	0.22	0.598*	0.590*	0.489
	Co			0.405	-0.096	0.536*	0.685*	0.131
	Cu				0.808	0.516*	-0.091	0.757*
	Mn					-0.02	-0.238	0.512*
	Ni						-0.117	0.786*
	Pb							-0.416
	Zn							
Gboko	Cd		0.996*	0.376	0.518*	0.873*	-0.176	0.444
	Co			0.341	0.452	00878*	-0.207	-0.517*
	Cu				0.737*	0.311	0.835	0.167
	Mn					0.532*	0.412	0.482
	Ni						0.241	-0.353
	Pb							0.362
	Zn							
Makurdi	Cd		0.197	-0.522*	0.172	-0.105	-0.703*	0.570*
	Co			0.307	0.325	0.642*	0.028	0.570*
	Cu				0.692*	0.689*	-0.045	0.212
	Mn					0.777*	-0.570*	0.848*
	Ni						0.012	0.596*
	Pb							-0.668*

**indicates the significance value*
Correlation is significant at 0.05 level

CONCLUSION

The results obtained from the analysis of topsoils collected from motor parks in various location in Otukpo, Gboko and Makurdi areas of Benue state in Nigeria indicated that the concentration of Cd, Co, Cu, Mn, Ni, Pb and Zn were higher than those of control soil metals contents. The degree of contamination of Pb was the highest. Cd and Zn also

showed high degree of contamination in motor parks soils. From this reason, it could be predicted that the sources of contaminations of Pb, Cd and Zn are probably from anthropogenic sources while those of Co, Cu, Ni and Mn may be from parent material in the soil. The only observed contaminants were Pb, Cd, Cu and Zn and their concentrations and enrichment factors were high in all the soils studied. The results do not provide information about changes in the levels of inorganic soil contaminants over time, but they do provide baseline data for comparisons in the future. Hence, overall levels of Pb, Cd, Cu and Zn contaminations are those which call for closer monitoring in sites under considerations.

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