International Journal of Innovation and Applied Studies
ISSN 2028-9324 Vol. 13 No. 2 Oct. 2015, pp. 472-480

http://www.ijias.issr-journals.org/

Physico chemical Characterization of Playgrounds Soils of public Schools in Owerri Metropolis, Imo State, Nigeria

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ABSTRACT: Soil characteristics and metals contents are important components for playground safety, but these are lacking in third world countries. In the present study thirty six soils samples from nine preselected public schools playgrounds were characterized using standards methods. Results revealed poorly equipped and maintained playgrounds with pH < 7 for all playground soils indicating acidic soils while organic matter ranged from Ikenegbu primary school (0.2 %) to World Bank Primary school (2.8%), sodium adsorption ratio ranged from Model Nursery school (0.41 $(Cmolkg^{-1})^{05}$) to Shell camp primary (0.77 $(Cmolkg^{-1})^{05}$). Other physicochemical characteristics had values comparable to those of typical acid sand derived soils whose textural class is sandy loam. Electrical conductivity varied widely amongst playgrounds ranging from Housing Estate primary school (3.2 S/cm) to Shell Camp Primary school (9.5 S/cm) indicating presence of some soluble inorganic salts. These soils characteristics therefore constitute major favorable conditions for the release of toxic metals in the soil or runoffs.

KEYWORDS: Characteristics, visual, soil, playgrounds.

1 INTRODUCTION

Over the past few decades environmental quality of urban soil has been closely related to human health and so people have become more concerned about the potential pollution of soil around them [1, 2]. Soil pollution arising from socio-economic activities of man may threaten human health if not properly checked [3]. Knowledge of soil characteristics and heavy metal levels is important for safety policy formulation and awareness in children playground. Soil characteristics such as pH, exchangeable properties and base saturation are influenced heavy metal contents. Solubility and percolation of heavy metals into deeper horizons are increased by low pH. Children are perhaps the worst hit due to a lot of factors militating against them ranging from small size to childhood vulnerability and contents of airborne particles originating from soil [4]. Children's nervous and digestive system are still developing and so are susceptible to metal and organic substance intake [5]. Children have the propensity to explore the world through their mouth. They are exposed to heavy metals via absorption through skin, food, ingestion of treated materials e.g. wood, contaminated soil and inhaling of contaminated air. Infant and children are particularly susceptible to neuron-toxicological damage from metal exposure throughout their ongoing intellectual development. The following factors aggravate metal toxicity particularly in children [6, 7].

Heavy metals refers to a hazardous [8] group of metals and metalloids with a specific gravity that is at least 5 times that of water [9] often toxic even at low concentrations, bioaccumulative and non biodegradable [10].

Unlike most organic pollutants, heavy metals are elements which occur naturally in the earth's crust are influence by physicochemical characteristics of soil. They are therefore found naturally in soils and rocks with a subsequent range of natural background concentrations in soils, sediments, waters and organisms. Anthropogenic releases can give rise to higher concentrations of the metals relative to the normal background values, resulting to pollution. The most important anthropogenic release of heavy metals to the environment come from metalliferous mining and smelting, agricultural inputs (pesticides and fertilizers), irrigation and application of sewage water and sludge, fossil fuel combustion and metallurgical industries [11].

Pica behavior has been identified as one major way by which children take in these heavy metals from playground soils [12]. No doubts then that surface soils are most likely to be contacted by children than soils within the profiles.

African children are more likely to perform pica activities than their counterparts elsewhere as a result of hunger, poor parental attention, warm climate that encourages outdoor activities, poor environment and non regulated play at playgrounds. All these factors generally support the existence of a huge gap of knowledge about children playgrounds in Nigeria and Owerri Municipal in particular. Therefore the importance of this work, the first of its kind as far as could be established cannot be overemphasized.

The Focus of this study was therefore to examine some characteristics of soils in surface soils of children's playgrounds and discuss their influence on heavy metals amongst public schools in Owerri municipal.

2 MATERIALS AND METHODS

2.1 STUDY AREA

The study area is Owerri municipal in Imo State, southeast Nigeria, bounded by latitudes $4^{o}40^{1}$ and $8^{o}15^{1}$ N and longitudes $6^{o}40^{1}$ and $8^{o}15^{1}$E. It lies within the humid tropics. Owerri municipal is one of the three local government areas (LGAs) that make up Owerri city, the capital of Imo state of Nigeria set in the heart of the Igboland. A greater proportion of the land surface of Imo State is of flat topography. The climate of Imo State is typically humid tropics characterized by 9 months of rainfall (rainy season) and 3 months of dryness (dry season) [13]. Rainfall distribution is bimodal and averages about 2500 mm per annum, while the mean annual temperature ranges from 28 to 37°C [14]. The State has rainforest vegetation characterized by multiple tree species. Economic activities are majorly buying and selling while there are no industries involved in large scale production except few printing presses.

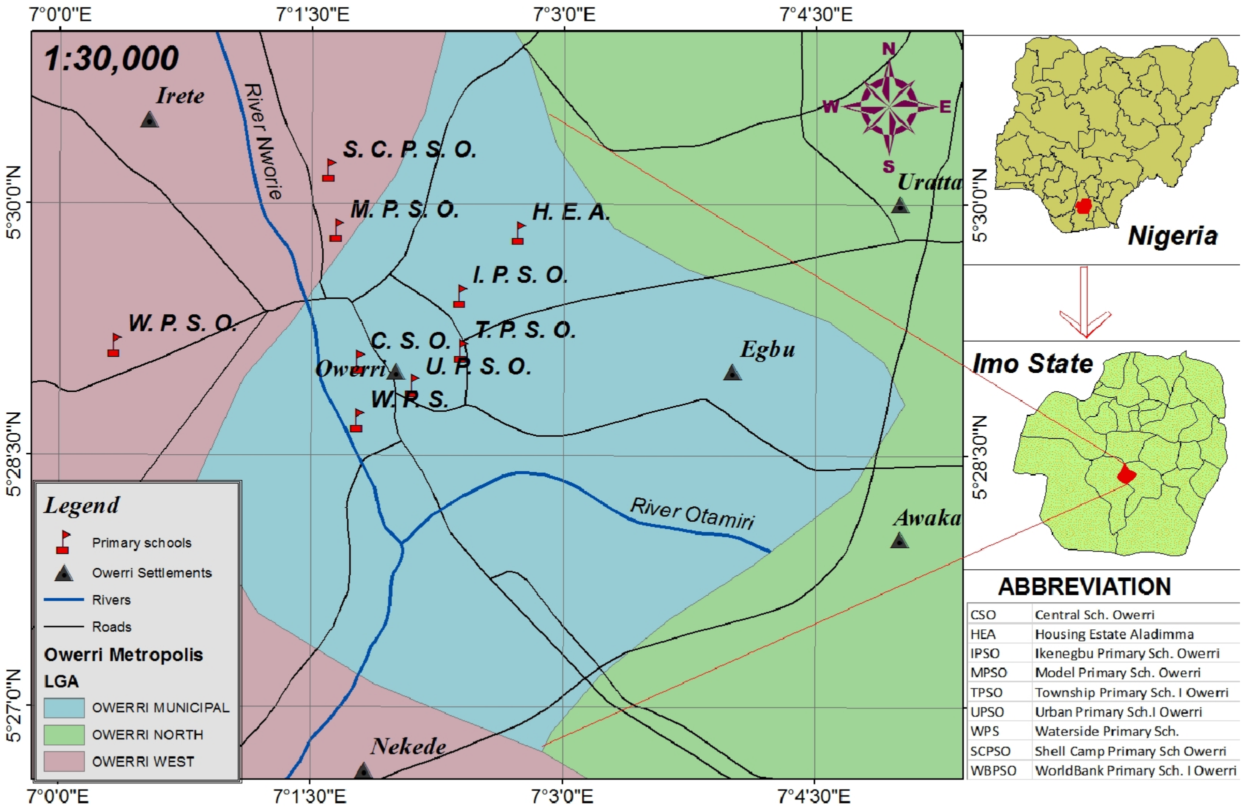

Fig. 1: map of owerri metropolis showing sampling location

2.2 SAMPLING

Nine different sampling sites were taken from playgrounds along major roads connecting Owerri metropolis in Imo state as follows: Surface soil or dust samples at 0-5 cm depth were collected in the months of January (dry season) of 2012. At each sampling site, a "W" shaped line was drawn on a 2 x 2m surface along which samples were collected from five points into previously treated polythene containers using a perforated container to allow water to drain in the rainy season. Samples were sundried for two days, then oven dried at 50^{o}C for 12days; grind in acid-washed porcelain mortar with pestle. The soil samples were pooled together, treated to coning and quartering to obtain a small laboratory sample. The samples were sieved through a 125 µm sieve in order to normalize variations in grain size distributions and then stored in polythene containers with caps till further analysis [15].

2.3 PHYSICOCHEMICAL PROPERTIES

The pH values of the soil samples was determined using a Jenway 3505 pH meter TS-2 in deionized water (50 ml), after stirring the air dried sample portion of 20 g for an hour. Conductivity was determined with a Electrical Conductivity meter. After calibration using standard KCl solution the electrical conductivity was measured by dipping the electrode into the 1:2 soil-water suspension used for pH determination. Particle size was determined by method of Gee and Or, [16,17]. Organic matter content was determined as weight loss after heating sample at 500^{o}C for 2 hours [17].

2.4 STATISTICAL ANALYSIS

The data was reported as mean ± standard deviation of three individual readings. The comparison of means of different groups was made using statistical software package SPSS, version 17. Level significant was at $p < 0{\cdot}05$.

3 RESULTS AND DISCUSSION

3.1 VISUAL CHARACTERISTICS OF PLAYGROUNDS

Table 1. Visual Characteristics of Playgrounds in the dry season

Play ground	Defined/Undefined	Vegetation	Soil color	Moisture	Soil odor	Constitution	Land use
HEO	Defined	Dry grass patches	Brown	Dry	Odorless	Uniform	Residential Estate
MNO	Defined	Dry grassy Cover	Brown	Dry	Odorless	Debris	Motor park
SCP	Undefined	Bare soil	Reddish	Dry	Odorless	Uniform	Police station
CSO	Undefined	Patches of dry grass	Dark	Damp	Dirty odor	Debris	Ekeonunwa Market
TSO	Undefined	Patches of dry grass	Brown	Dry	Odorless	Debris	Motor park and Banks
WSP	Undefined	No cover	Brownish	Dry	Dirty odor	Debris	River Nworie
WBP	Undefined	Dry grass cover	Reddish	Dry	Dusty odor	Debris	Residential and market
IKS	Defined	Dry grassy	Dark	Dry	Dusty odor	Debris	IMSU and High traffic
UPS	Undefined	Patches of dry grass	Brown	Dusty	Dusty odor	Debris	Busy junction

Table 1 lists the playgrounds and gives description of immediate surroundings. The dominant cover of these playgrounds and types of schools were chosen to obtain a wide coverage of the various types found in the study location. Most playgrounds were dirty and old with dilapidated equipment (when available) showing that little or no attention is paid to these playgrounds. Visual characteristics of all nine playgrounds as could be observed in the dry season show that playgrounds were most often covered by patches of dry grass in the dry season which starts growing with onset of rains. Most playgrounds were dry and dusty in the dry season. The surfaces were usually sandy loam and in a most cases were covered with soil and debris. However, the organic nature of a few playgrounds covers was in contrast to the minerals-based covers such as reddish soil, sand and gravel. This may lead to alteration of retention characteristics of playground cover thus impacting on the occurrence and distribution of pollutant and moisture [18,19]. It was noted that depending on the playground and the number of children in the school most play grounds were small. In most cases playgrounds were an open field with 22% of playgrounds having some kind of curb, demarcating it from the rest of the school open field. Where the number of pupils was high there was less grass and special spots were places under swings. CSO playgrounds had moist sticky and dark soil. Krishna [20] proposed that playgrounds with high moisture are likely to have less heavy metal as a result of leaching processes. Even though all playgrounds in both seasons had debris, it was observed that there was little debris in rainy season. As could easily be observed, children at these playgrounds were from low income parents and continued their play long after school hours. Propelled by hunger and no parental guidance these children frequently involved in pica activities. 40% of playgrounds were covered with grass. This presented little problems on sampling the soil. Whereas 60% were covered with sand there by providing differences in the materials to analyze; this ranged from soil with high mineral content to sandy loam (mineral based).

3.2 PARTICLE SIZE DISTRIBUTION AND SOIL TEXTURE

Particle size showed that sand was the dominant particle ranging from 63% at HEO to 84% at 1ks. This is not surprising as most soils in the region are predominantly sandy [21]. Loam particle size percent range from 14% at CSO to 26% at HEO while clay particle percent ranged from 03% at TSO to 11% at HEO except for IKS that had zero percent clay. High clay content is responsible for water retention characteristics which in turn causes leaching of pollutants such as heavy metals [22].

Table 2. Particle size distribution and soil texture

Playground	% Sand	% Loam	% Clay	Soil texture
HEO	63	26	11	sandy loam
MNO	74	20	06	sandy loam
SCP	68	24	08	sandy loam
CSO	82	14	04	sandy loam
TSO	79	18	03	sandy loam
WSP	70	23	07	sandy loam
WBP	67	25	08	sandy loam
IKS	84	16	00	sandy
UPS	65	25	10	sandy loam
Mean	72.4±8.17	21.2±4.38	6.3±3.5	sandy loam

Researchers' maintain that smaller particle size is more likely to be inhaled or ingested thereby causing respiratory and associated problems. Smaller particles are associated with high pollutant concentrations [23].

Ogundiran and Afolabi [24] related particle size and heavy metals and concluded that smaller particles have greater total metal concentration than larger particles. It is thus important to encourage the covering of children's playground as these are less likely to be inhaled or accidentally ingested. Larger particles are less likely too to adhere on hands of children thereby further reducing the chances of being ingested by hand-to-mouth activity. All nine playgrounds studied showed high percent sand thereby being advantageous as cover for playgrounds in Owerri municipality. Particle size distribution varied narrowly with sand being the dominant particle. These differences in soil particle size between playgrounds of the same location could be attributed to slight differences in the parent material of soil [25] for playgrounds where sand has been used as a cover. Therefore sand could be periodically replaced with new sand of large particle sizes. The textual class of most playgrounds was sandy loam except for IKS that was sandy.

3.3 Physicochemical Characteristics Of Playgrounds Soil

Physicochemical characteristics of the investigated playground soils for the dry season are shown on table 3. Playground soils showed temperatures ranging from 23^oC to 26^oC with CSO and TSO having highest values for the dry season (table 3). Soil temperatures are significant in their influence on soil characteristics. High temperature reduces growth of microorganism, and has been associated with soil acidity [26].

The pH of soils from the nine playgrounds in this study ranged from 4.6 to 5.4 with a mean value of 4.96. All playground soils were acidic pH < 7. This agrees with reported pH values of soils within Imo state. The predominant parent material underlying Imo State from which most of the soils are formed are the coastal plain sands popularly known as "Acid Sands" [27,28]. Soils pHs showed little differences ($p>0.05$) from one another. It is proposed that this could be the result of same mineralogy [29]. These values represent typical south eastern Nigeria soils in which excessive precipitation which leads to leaching loses of most basic cations [30]. At lower pH metals solubility tends to decrease and absorption reactions become more important than precipitation and complexation reactions. This encourages percolation of metals into deeper soil horizon [31].

Playground soil electrical conductivities (EC) also differed significantly among the nine playgrounds ($p < 0.05$). EC varied widely ranging from 3.2 S/cm at IKS to 5.8 S/cm at TSO. EC values indicate ionic concentration of soils. It relates to dissolved solutes and usually correlates strongly to soil texture and Cation exchange capacity (CEC). The CEC of metals depends on the density of ionic strength of the surfaces of soil colloids and on the relative charges of metal species in soil solution. The low EC is in conformity with the low cation exchange capacity [32]. It is observed that HEO showed an out layer with EC of 8.2 S/cm. Boulding [33] classified EC of soils as: non saline <2; moderately saline 2-8; very saline 8-above; extremely saline >16. From result of the study, the EC is classified as moderately saline since the mean for playgrounds is 5.5 S/cm.

Percent moisture in investigated playground soils ranged from IKS (8.5%) to SCP (11.4%). Generally these values are high compared to values normally reported for soils in the dry season. High soil moisture has been linked to larger soil particles and leaching processes. Moisture has been known to reduce dust while organic matter is effective in trapping moisture [34] Kucheker *et al*., 2009). Therefore high moisture content of playgrounds is advantageous to children as this reduces chance of ingestion or inhalation.

The extent to which soil constituents can act as cation exchangers is called cation exchanger capacity. Playground soils showed CEC range of 20.66 at CSO to 26.12 at UPS. Values CEC less than 20 mg/kg are low and could be due to highly weathered soils. The mean value of CEC for soils in playground within Owerri municipal is 23.43mg/kg which is considered moderate [35]. These values suggest that soils contained low colloids and organic matter except for WSP and MNO with CEC of 0.84 and 0.97 respectively.

Table 3. Characteristics of investigated soil playgrounds in the dry season

Soil Xteristics	HEO	MNO	SCP	CSO	TSO	WSP	WBP	IKS	UPS	Mean
Temp (°C)	24	25	24	26	26	23	24	23	25	24.44±1.13
pH	5.4	4.8	4.8	5.2	4.5	4.7	5.4	5.2	4.6	4.96
EC. (S/cm)	3.2	4.8	4.5	4.7	8.2	5.7	4.7	5.8	3.6	5.5
Moisture (%)	10.7	9.2	11.4	10.3	8.9	9.1	8.7	8.5	9.2	9.56
O.M (%)	2.2	2.4	1.4	1.4	1.2	2.3	2.8	0.2	1.8	1.74
Na^+ (mg/kg)	1.5	1.20	1.96	1.38	1.98	1.33	1.58	1.58	1.75	1.58
K^+ (mg/kg)	5.28	6.00	5.68	3.78	5.67	5.42	4.82	8.90	5.33	5.65
Mg^{++} (mg/kg)	7.77	8.62	7.83	7.25	7.65	7.84	7.76	6.33	9.32	7.82
Ca^{++} (mg/kg)	8.35	8.37	7.96	8.25	8.69	6.58	9.56	8.88	9.72	8.48
CEC	22.9	24.19	23.43	20.66	23.99	21.17	23.72	25.69	26.12	23.54
Ca/Mg	1.07	0.97	1.01	1.11	1.14	0.84	1.23	1.40	1.04	1.09
SAR$(Cmolkg^{-1})^{05}$	0.52	0.41	0.52	0.50	0.69	0.49	0.54	0.57	0.56	0.53

EC: electrical conductivity; OM: Organic matter; CEC: cation exchange capacity

Table 4. Characteristics of investigated soil playgrounds in the dry season

Soil Xteristics	HEO	MNO	SCP	CSO	TSO	WSP	WBP	IKS	UPS	Mean
Temp (°C)	25	24	25	27	28	25	25	26	26	25.67
pH	5.9	6.3	6.7	5.8	5.7	6.2	6.4	5.8	5.3	6.01
EC. (S/cm)	8.2	6.8	9.5	4.7	8.2	5.7	4.7	5.8	3.6	6.4
Moisture (%)	20.2	16.2	21.4	18.3	16.4	14.3	18.7	18.2	16.8	17.83
O.M (%)	1.2	1.8	0.8	1.6	1.2	1.3	1.5	0.2	1.8	1.27
Na^+ (mg/kg)	1.85	1.72	1.96	1.38	1.55	1.12	1.27	1.49	1.98	1.59
K^+ (mg/kg)	5.71	6.55	6.78	7.78	6.62	5.92	5.89	7.71	7.83	6.69
Mg^{++} (mg/kg)	7.74	7.89	6.42	5.98	7.60	7.38	7.75	7.30	8.65	7.41
Ca^{++} (mg/kg)	7.30	7.87	6.42	7.90	7.60	6.98	7.76	8.23	8.52	7.62
CEC	22.06	24.03	21.58	23.04	23.37	21.40	22.67	24.73	26.98	23.32
Ca/Mg	0.94	0.99	1.00	1.32	1.00	0.87	1.00	1.13	0.98	1.03
SAR$(Cmolkg^{-1})^{05}$	0.68	0.62	0.77	0.52	0.56	0.42	0.46	0.53	0.65	0.58

The mean percent organic matter for public schools playground soils in Owerri municipality was 1.51. However the range of OM was 0.2% from IKS to 2.8% at WBP. This significant variation could be due to the fact that IKS soil had predominantly sand (mineral base) whereas WBP playgrounds were close to dumpsites. Organic matter in soil usually range from 1-10% [36] and may encourage absorption of heavy metals onto reactive sites of humic acids such as carboxylic acids. As a result of the significance of organic matter in metal adsorption, organic matter has been used as a simple pollution index for soil [37]. High organic matter invariably shows increasing metal contents in the soil. All playgrounds showed OM values typical of coastal plains acid sand derived soils.

Calculated Ca/Mg ratios for MNO (0.97) and WSP (0.84) playgrounds were bellow unity in the dry season while HEO (0.94), MNO (0.99), WSP (0.87) and UPS (0.98) where equally bellow unity in the rainy season. Ca/Mg ratios above unity indicates that soils are strongly weathered a characteristic of tropical soils. However, calcium and magnesium values were much similar while values for potassium were generally lower for all playgrounds except for IKS (8.90 mg/kg).

3.4 Sodium Absorption Ratio

Sodium is one of the most studied elements because of its toxic effects both to soil texture and crops. High concentration of sodium disperses soil colloidal particles (destroying soil structure), rendering the soil hard and resistant to water penetration. In the presence of moisture and exchangeable sodium, clay particles disperse rather than cling together as small peps (friable soil aggregates). This reduces water movement (permeability) and aeration in the soil. Soils with a poor structure will have a coarse blocky or powdery texture and surface crusts will form after rain or irrigation.

$$SAR = \frac{Na}{\frac{\sqrt{(Ca + Mg)}}{2}} \qquad (1)$$

The sodium adsorption rations were calculated according to equation 1. SAR ranged from 0.41 at MNO to 0.69 $(Cmolkg^{-1})^{05}$ at TSO in the dry seasons and from $0.42(Cmolkg^{-1})^{05}$ at WSP to $0.77(Cmolkg^{-1})^{05}$ at SCP in the rainy seasons. The mean of SAR for all nine playgrounds in Owerri was 0.56. This value is much lower than typical range of 2.17-8.0 $(Cmolkg\text{-}1)^{05}$. The reason for this is not yet understood. Higher values of SAR indicate loamy sand, clay loam and clay soil [37]. However, values of adsorption ratios showed in table 3 and 4 indicate that the textual class was neither of the above class. This agrees with the textual class established through particle size distribution. The adsorption of sodium causes the release of calcium in order that soil can maintain its electrical neutrality. In view of this, the sodium adsorption ratios was low hence a corresponding high value of calcium in the soils. Sodium adsorption ratio is of increasing importance as an index for measuring salinity. Threshold value reported in literature is 12 $(Cmolkg\text{-}1)^{05}$ [38]. Comparing results of this work with this value shows that playground soils in Owerri municipal have very low SAR.

4 CONCLUSION

Soil physicochemical parameters were comparable to values reported by other workers and background values, suggesting that soils have not been polluted while values of determined parameters represent typical south eastern Nigeria soils with excessive precipitation. Further investigation is deemed necessary to study the sites that may require urgent attention and periodic studies are recommended in other to procure enough data for planning.

ACKNOWLEDGMENT

This work is completed as part of PhD thesis in the department of Pure and industrial chemistry, University of Port Harcourt. We thank members of the Research in Analytical Chemistry and Environment Pollution Studies (RACEPS) and Doctoral students of Professor M. Horsfall Jnr and Professor A. I. Spiff.

REFERENCES

[1] W.L.Annao, D. A. K.Nurdans, C. C.Cheung, W. Mingh, “Heavy Metals Concentrations of Surface Dust from e-Waste Recycling and Its Human Health Implications in Southeast China.”*Environmental science and technology, vol.* 42, no. 7, 2671- 2680, 2008.

[2] H. M. Zakir, N. Shhikazono and K. Otomo, “Geochemical Distribution of Trace metalsand Assessment of Anthropogenic Pollution in Sediments of Old Nakargawa River, Tokyo, Japan.” *American Journal of Environmental Sciences,* vol. 4, no. 6, pp. 654-665, 2008.

[3] J. Sheppard, Environmental Toxic: Growing up on chemical- Our children’s Toxic Environmental. 2005 *http//www.healthychild.com.* 5th May 2013

[4] J. W. C. Wong and N. K. Mak, “Heavy metal pollution in children playgrounds in Hong Kong and its health implications.”*Environemtal Technology,* no.18 pp. 109–115, 1997.

[5] C. F. Bearer, “Environmental health hazards how children are different from Adults: The future of Children Critical issuesfor Children and Youths.” Vol. 5, no. 2. 1995. Sumer/ fall.http://www future of children.Org/pubs-info 28-25/ pubs-info.htm? docid=70953.

[6] H.W. Mielke, “Multiple metal accumulation as a factor in learning achievement within various New Orleans elmentary school communities,” *Enviromental Research*, vol. 97 no. 1 pp. 67-75, 2004.

[7] D. Jarosinska, M. Biesiada and M. Miszynska-Grace “Enviromental burden of disease due to lead in Urban Children from Silesia, Poland. *Science of the Total Enviroment*, vol. no. 367 pp. 71-78, 2006.

[8] K. Ljung, O. Schinus and E. Otabbong “Metal in soil of children’s Urban environment in the small northern European city of Uppsala,” *Science of the Total Environment,* vol. 366 no. 2-3 pp. 749 – 759, 2006.

[9] M. Horsfall, (Jnr.) and A.I. Spiff, “Speciation and Bioavailability of Heavy Metals in Sediment of Diobu River, Port Harcourt, Nigeria,” *Eurpean Journal of Scientific Research, vol.* 6 no. 3 pp. 20-36, 2005.

[10] W. Zhu, B. Bian and L. Li, "Heavy metal contamination of road – deposition sedimemt in a medium size city of China. "*Environment Monitoring and Assessment,* vol. 147, no. (1-3), pp. 171-181, 2008.

[11] A.O.Ano, A.S Odoekelem and P.O. Ekwueme **"**Lead and Cadmium Levels in Soils and Cassava (*Manihot Esculenta Gnantz*) Along Enugu Port Harcourt Expressively In Nigeria" *Electronic*, *Journal of Environment, Agriculture and Food Chemistry, vol.* 6 no. 5, pp. 2024 – 2031. 2007.

[12] A. K. Krishna, and P. K. Govil, *"*Soil contamination due to heavy metals from an industrial area of Surat, Gujarat, Western India. *Environ Monit Assessement*, no. 124, pp. 263–275, 2007.

[13] H.W. Mielke, M.A.S. Laidlaw and C. Gonzales, "Lead (Pb) legacy from vehicle traffic in eight California urbanized areas: continuing influence of lead dust on children's health," *Science of the Total Environment,* vol. 423. No. 2-3 pp. 856-862, 2010.

[14] E.U. Onweremadu, J.U. Amaechi and B.N. Ndukwu, "Vertical Distribution of Cadmium and Lead on Soils Affected by Metropolitan Refuse Disposal in Owerri, Southeastern Nigeria," *Iranica Journal of Energy and Environment,* vol. 2 no. 1 pp. 62-67, 2011.

[15] Q. M. Jaradat, K.A Monani, "Contamination of roadside soil, plant and air with heavy metal in Jordan, a comparative study" *Turkish Journal of Chemistry,* vol. 23 pp. 209-220, 1999.

[16] G.W. Gee, and D. Or, Particle size analysis, part 4. Physical methods. Soil Sci. Soc. Am. Book Series No. 5, ASA and SSSA, Madison, W.I., pp. 255-293, 2002.

[17] B. W. Tukura, J.A. Kagbu and C.E. Gimba. "Correlation Analyses of Organically Bound Trace Metals and Sediment in Kubanni, Dam, Zaria, Nigeria." *Journal of Environmental Science and Technology*, no. 4 pp. 437-443, 2011.

[18] X. Wang, T. Sato, B. Xing, and S. Tao, "Health Risks of Heavy Metals to the General Public in Tianjin, China via Consumption of Vegetables and Fish." *Science of the Total Environment*, no. 350 pp. 28-37, 2005.

[19] O.E. Popoola, O. Bamgbose, O.J. Okonkwo, T.A. Arowolo, O.Odukoya and O. Popoola, "Heavy Metals Content in Playground Topsoil of Some Public Primary Schools in Metropolitan Lagos, Nigeria" *Research Journal of Environmental and Earth Sciences, vol.* 4 no. 4 pp. 434-439**,** 2012.

[20] E. De-Miguel, I. Iribarren, E. Chacon, A. Ordonez, S. Charlesworth, "Risk-based evaluation of the exposure of children to trace elements in playgrounds in Madrid (Spain)," *Chemosphere*, no. 66 pp. 505–513, 2007.

[21] S.A. Osakwe and F. Egharevba, "Sequential fractionation of cadmium, copper, lead and chromium, in soils around municipal solid waste dumps in Agbor, Nigeria," *Journal of Chemical Society of Nigeria, vol.* 33 no. 2 pp. 139-147, 2008.

[22] O.O. Aluko, and P.A. Oluwande. "Characterization of Leachates from a Municipal Solid Waste Land Fill Site in Ibadan, Nigeria". *Journal of Environmental Health Research*, Vol. 2 pp. 83-84, 2003.

[23] C.A.Biney, A.T.Amuzu, D. Calamari, N. Kaba, I.L Mbome, H. Naeve, P.B.O. Ochumba, O. Osibanjo, V. Radegonde, And M.A.H Saad,. "Review of heavy metals in the African aquatic environment," *Ecotoxicology and Environmental Safety, Vol.* 28 no. 2 134-159, 1994.

[24] O.O. Ogundiran and T.A. Afolabi, "Assessment of physicochemical parameters and heavy metal toxicity of Leachates from municipal solid waste open dumpsite," *International Journal Environment, vol.*5 no. 2 pp. 243-250, 2008.

[25] S.L Ng, "Heavy metal contents and magnetic properties of playground dust in Hongkong,"*Enviromental Mointoring and Assessment*, vol. 89 no. pp. 221-232, 2003.

[26] M. Aliyu, Y. I. Zakari, I.G.E. Ibeanu, and T.C. Akpa, "Evaluation of lead concentration levels of children's playground in Kaduna state schools,'' *Bayero Journal of Pure and Applied Sciences*, vol. 2 no. 2 pp105 – 109, 2009.

[27] S.O. Orajaka, *Geology. In: Nigeria in maps: Eastern States*. in: Ofomata, G. E. K. (Ed.). Ethiope Publishers. Benin city Nigeria, 5-7. 1975.

[28] O. E. Orisakwe, J. K. Nduka, C. N. Amadi, D.O. Dike, and O. Bede, "Heavy metals health risk assessment for population via consumption of food crops and fruits in Owerri, South Eastern, Nigeria" *Chemistry Central Journal*, vol. 6 no.77 pp. 231-238 2013.

[29] W. Mielke, "The Urban environment and children's health: soils as an integrator of lead, zinc and cadmium in New Orleans, Louisiana, USA," *Environmental research,* vol. 81 no. 2 pp. 117-129, 1999.

[30] A.D. Miller, D.R. Keeney, Methods of Soil Analysis. Part 2: Chemical and Microbiological Properties. 2nd ed. American Society of Agronomy, Madison, WI,. 224, 1999.

[31] C.N. Mbah and M.A.N. Anikwe, "Variation in heavy metal contents on roadside soils along a major express way in South east Nigeria," *New York Science Journal*, vol. 3 no. 10 pp. 106-110, 2010.

[32] B.J. Alloway, Heavy Metal in solid, 2nd edition, Blackie and Sons, Glasgo, pp. 96- 153, 1995.

[33] J.R. Boulding, *Description and Sampling of Contaminated Soils*. 2nd edn. Lewis Publishers: New York, NY.1994.

[34] D. Singh, P.K. Chhonkar, R.N. Pandey, *Soil, plant & water analysis – A method manual*. IARI, New Delhi. 1999.

[35] C.S Chukuma, "Evaluating Baseline data for Trace elements, pH, organic matter content and bulk density in agricultural soils in Nigeria," *Water, air, soil pollution*, no. 86 pp.13-34, 1996.

[36] B. J. Alloway, and D. C. Ayres, Chemical principles of Environmental pollution, 2nd edition, Blackie Academic and professional, London. pp. 157 – 245. 2002

[37] N. P. Finžgar, D. L. Tlustoš, "Relationship of soil properties to fractionation, bioavailability and mobility of lead and zinc in soil" *Plant Soil Environ*ment, vol. *53*, no. 5 pp. 225–238, 2007.

[38] S. Mohsen, R. Majid and B. G. Khabbaz, "Prediction of Soil Exchangeable Sodium Percentage Based on Soil Sodium Adsorption Ratio," *American-Eurasian Journal of Agriculture and Environmental Science,* vol. 5 no. 1 pp. 01-04, 2009.

[40] E.U. Onweremadu, "Physico-chemical charaterisation of a farmland affected by wastewater refuse dump soil treated with cassava mill in relation to heavy metals" J. Zhejiang U, Journal of Agriculture and Environmental Technology, vol. 9 no. 3 pp. 366-372, 2008.

[41] M.C.H Lim, G.A. Auoko and L. Morawska, "Characterization of elemental and polycyclic aromatic hydro carbon composition of Urban air in Brisbane. *Homaspheric Environment*, vol. 39 no. 3 pp. 463 – 476, 2005.