Seasonal Variations of pH and Heavy Metals Content in Soil of Selected Housing Estates in Ogun State, Nigeria

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ABSTRACT: There is a necessity to assess soil properties with the view to determining soil qualities relative to pollution and sustainability of ecosystem functions and plant productivity regardless of the scale. Soil samples (six points per site at 0-15 cm depth) from six selected housing estates across Ogun State were assessed for soil pH and heavy metals pollution in two dry and rainy seasons. The soil samples were digested using standard methods and analysed for seven selected metals: Mn, Fe, Cu, Zn, Ni, Pb and Cd using AAS. The data obtained were subjected to descriptive and inferential statistics. Concentrations (mg/ kg) of the analysed metals were observed to vary from the lowest in the 2nd rainy season to the highest in 1st dry season respectively as Pb: 3.57 ± 0.02 to 39.87 ± 0.47, Cd: 0.32 ± 0.03 to 2.65 ± 1.02, Mg: 11.94 ± 0.76 to 204.50 ± 15.02, Fe: 22.79 ± 0.45 to 303.50 ± 16.52, Cu: 0.95 ± 0.21 to 6.02 ± 1.12, Zn: 0.12 ± 0.04 to 12.75 ± 0.68, and Ni: 2.38 ± 0.33 to 33.89 ± 0.37. There were indications that the soil samples were comparatively less polluted in the rainy seasons.

Eco-toxicologists have always relied on the knowledge of chemical and physical properties of soils to the susceptibility of soil to withstand pollution. Soils are usually regarded as the ultimate sink for heavy metals discharged to the environment and can be sensitive indicators for monitoring contaminants (Nwachukwu *et al.,* 2010). Soil function would be described in terms of physical, chemical and biological properties as well as processes and compared with certain definable standard to determine whether soil is being improved or degraded by anthropogenic activities. Soils heavy metal accumulation trends may not be detected on time, because metal contamination may not lead to immediate concern in terms of toxicity, except in the case of hot spot pollution. However, the ubiquitous character and the increase of heavy-metal which flows through the soil system may cause serious problems for soil fertility, ground water quality and food chains. The presence of heavy metals in different foods constitute serious health hazard depending on their relative level e.g. cadmium injures the kidney and cause symptoms of chronic toxicity including impaired kidney function, poor productive capacity, hypertension and tumor while chromium and copper in particular cause nephritis, anuria and extensive lesion in kidney (Ismail *et al.,* 2006). Excess level of heavy metals has caused the disruption of natural terrestrial ecosystems. A study on elemental levels in some selected arable agricultural soil in South West, Nigeria, concluded that sources of metals in farmlands are suspected to be from different sources such as fertilizer, vehicular emission and aerial deposition (Olatunji *et al.,* 2013). The adverse effects possible from metal pollution are not only in the soil accumulation where their levels are toxic to plants and obliterate surface or ground water quality but also in the food chain to influence clinical health risks when consumed food grown on metal-contaminated soils. Soil pollution from heavy metals has recorded increasing attention in recent decades throughout the world. Some heavy metals like Cd is known to be rare in nature and required by plant and animal in minute quantity, they can be found in very low concentration. They are strongly toxic and can pose an environmental threat at high concentration. Heavy metals are markedly affected by soil redox potential and undergo both oxidation and redox depending on soil condition.

This has important adverse effects for the availability and toxicity of many heavy metals. Contamination of the ecosystem by toxic metals during man's activities poses serious concern because heavy metals are not biodegradable and are persistent in the ecosystem. Once metals are introduced and contaminate the environment they will remain for a very long time, they do not degrade easily like carbon-based organic molecules (Nwadinigwe *et al.,* 2014). Heavy metals are continuously introduced to soil via several pathways including industrial activities, irrigation, fertilization, atmospheric deposition and point source where metals are produced as a result of refining and refinishing products. Therefore, the problem of soil contamination by heavy metals is receiving global attention and the extent of soil pollution by heavy metals, and base metal ions some of which are soil micronutrients, is very alarming. The study thus assessed soil pH and heavy metals pollution in six housing estates for two dry and rainy seasons across Ogun State, Nigeria.

MATERIALS AND METHODS

Samples collection and analyses Soil samples were collected from six points at 0-15 cm depth per site and bulked. This was done across the six selected housing estates in Ogun State. The samples were observed to be air-dried for a week in the dry but two weeks in the wet seasons. The soil samples were sieved through 2 mm mesh (Towolawi *et al.,* 2017) and digested using the method of Nurunnahar *et al.* (2012) with nitric, sulphuric and perchloric acids in ratio 5:1:2. Metals in the digested soil samples were analysed with Atomic Absorption Spectrometer (Buck Scientific, Model 210VGP, CT, USA). The soil pH was read according to the method of Bada *et al.* (2014).

Statistical analyses: The obtained data were subjected to descriptive (mean and standard deviation) and inferential (ANOVA and Duncan Multiple Range Test) statistics using IBM SPSS Version 22.

RESULTS AND DISCUSSION

Results of the levels of heavy metals during the 1st dry and rainy season are represented in Tables 1 and 2 while 2nd dry and rainy season are shown in Tables 3 and 4. Levels of the analysed metals in this study were compared with the standard limits of some countries (Table 5).

Soil pH and Microelements Properties in the 1st Dry Season: From Table 1, the soil pH was observed to range from 4.31 ± 0.13 in Laderin to 6.23 ± 0.10 in Ilaro significantly ($p < 0.05$). The soil ExcH results (mg/ kg) were observed to range from 0.30 ± 0.31 in Ijebu-Ode to 0.60 ± 0.27 in Shagamu with no significant ($p > 0.05$) difference, while the soil AcidAl (mg/ kg) concentration was observed to be from 0.16 ± 0.01 in Obada-Oko to 0.57 ± 0.27 in Shagamu significantly ($p < 0.05$). The level of Pb was detected to range significantly ($p < 0.05$) from 9.54 ± 0.06 mg/ kg in Shagamu to 39.87 ± 0.47 mg/ kg in Obada-Oko.

The soil concentrations of Cd (mg/ kg) were determined to be lowest: 0.87 ± 0.09 in Arigbajo and highest: 2.65 ± 1.02 in Shagamu with no significant ($p > 0.05$) difference. The level of Mn (mg/ kg) was found to be between 50.18 ± 3.19 in Laderin and 204.50 ± 15.02 in Shagamu with high level ($p < 0.05$) of significances. The concentrations of Fe (mg/ kg) were observed to range significantly ($p < 0.05$) from 95.75 ± 1.89 in Shagamu to 303.50 ± 16.52 in Ijebu-Ode. Concentrations of Cu and Zn (mg/ kg) were detected to be lowest: 2.53 ± 0.57 and 0.17 ± 0.06 in Shagamu and highest: 6.02 ± 1.12 and 12.75 ± 0.68 in Ijebu-Ode. There were significant ($p < 0.05$) differences in the Cu and Zn soil levels. The levels of Ni (mg/ kg) in Ilaro soil were detected to be the least: 9.98 ± 1.41 and Arigbajo the highest Ni: 33.89 ± 0.37.

Table 1: Soil Micronutrients (mg/ kg) and pH in the 1st Dry Season

Estates	pH	Pb	Cd	Mn	Fe	Cu	Zn	Ni	ExcH	AcidAl
		Toxic Metals			**Heavy Metals**					
Shagamu	4.96 ± 0.05^b	9.54 ± 0.06^a	2.65 ± 1.02^a	204.50 ± 15.02^d	95.75 ± 1.89^a	2.53 ± 0.57^a	0.17 ± 0.06^a	30.86 ± 0.93^d	0.60 ± 0.27^a	0.57 ± 0.27
Ijebu-Ode	5.41 ± 0.05^c	31.75 ± 1.50	2.03 ± 0.23^a	96.25 ± 4.52^b	393.50 ± 16.52^e	6.02 ± 1.12^c	12.75 ± 0.68^c	23.47 ± 0.63^c	0.30 ± 0.31^a	0.23 ± 0.02^a
Laderin	4.31 ± 0.13^a	17.78 ± 0.15^c	1.89 ± 0.30^a	50.18 ± 3.19^a	150.25 ± 8.02^b	3.12 ± 0.70^{ab}	2.83 ± 0.15^d	21.60 ± 0.83^{bc}	0.47 ± 0.11^a	0.26 ± 0.01^a
Arigbajo	6.15 ± 0.09^c	24.51 ± 0.22^d	0.87 ± 0.09^a	140.00 ± 8.76^c	239.25 ± 9.22^d	4.03 ± 0.95^b	1.40 ± 0.07^c	33.89 ± 0.37	0.52 ± 0.29^a	0.18 ± 0.01^a
Obada-Oko	5.61 ± 0.15^d	39.87 ± 0.47^f	2.10 ± 0.11^a	97.75 ± 4.39^b	127.25 ± 8.88^b	3.24 ± 0.48^a	0.99 ± 0.08^{bc}	21.38 ± 1.61^b	0.46 ± 0.06^a	0.16 ± 0.01^a
Ilaro	6.23 ± 0.10^c	$12.77 \pm .57^b$	2.61 ± 0.11^a	141.50 ± 3.70^c	208.50 ± 25.95^c	3.77 ± 0.02^{ab}	0.49 ± 0.07^{ab}	9.98 ± 1.41^a	0.41 ± 0.25^a	0.18 ± 0.02^a

Results in Mean ± SD, same superscripts down the column are not significantly different (p < 0.05)

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Table 2: Soil Micronutrients (mg/ kg) and pH in the 1st Rainy Season

Estates	pH	Toxic Metals			Heavy Metals					
		Pb	Cd	Mn	Fe	Cu	Zn	Ni	ExcH	AcidAl
Shagamu	7.29 ± 0.07^b	3.71 ± 0.02^a	1.03 ± 0.40^b	50.58 ± 3.72^d	23.68 ± 0.47^a	0.98 ± 0.22^a	0.13 ± 0.03^a	7.63 ± 0.23^d	0.75 ± 0.33^a	0.70 ± 0.34^b
Ijebu-Ode	6.33 ± 0.19^a	6.91 ± 0.06^c	0.73 ± 0.12^b	12.41 ± 0.79^a	37.16 ± 1.98^b	1.21 ± 0.27^{ab}	2.10 ± 0.11^d	5.34 ± 0.21^{bc}	0.58 ± 0.14^a	0.32 ± 0.02^a
Laderin	7.96 ± 0.07^c	12.34 ± 0.58^e	0.79 ± 0.09^b	23.81 ± 1.12^b	97.33 ± 4.09^e	2.34 ± 0.44^c	9.46 ± 0.50^e	5.80 ± 0.16^c	0.37 ± 0.38^a	0.29 ± 0.03^a
Arigbajo	9.04 ± 0.15^e	9.53 ± 0.08^d	0.34 ± 0.03^a	34.63 ± 2.17^c	59.17 ± 2.28^d	1.56 ± 0.37^b	1.04 ± 0.05^c	8.38 ± 0.09^e	0.64 ± 0.36^a	0.22 ± 0.02^a
Obada-Oko	9.17 ± 0.15^e	4.96 ± 0.22^b	1.02 ± 0.04^b	35.00 ± 0.92^c	51.57 ± 6.42^c	1.46 ± 0.01^{ab}	0.36 ± 0.05^b	2.47 ± 0.35^a	0.51 ± 0.30^a	0.23 ± 0.03^a
Ilaro	8.25 ± 0.22^d	15.49 ± 0.18^f	0.81 ± 0.04^b	24.18 ± 1.09^b	31.47 ± 2.20^b	1.26 ± 0.19^{ab}	0.74 ± 0.06^{bc}	5.29 ± 0.40^b	0.57 ± 0.07^a	0.19 ± 0.02^a

Results in Mean ± SD, same superscripts down the column are not significantly different (p < 0.05)

Table 3: Soil Micronutrients (mg/ kg) and pH in the 2nd Dry Season

Estates	pH	Toxic Metals			Heavy Metals					
		Pb	Cd	Mn	Fe	Cu	Zn	Ni	ExcH	AcidAl
Shagamu	5.71 ± 0.09^e	22.22 ± 0.20^d	0.78 ± 0.08^a	126.93 ± 7.94^c	216.92 ± 8.36^d	3.65 ± 0.86^b	1.27 ± 0.07^c	30.73 ± 0.33^e	0.48 ± 0.27^a	0.16 ± 0.01^a
Ijebu-Ode	5.22 ± 0.14^d	36.14 ± 0.43^e	1.90 ± 0.10^b	88.63 ± 3.98^b	115.37 ± 8.06^b	2.94 ± 0.43^{ab}	0.90 ± 0.07^{bc}	19.38 ± 1.46^b	0.43 ± 0.05^a	0.15 ± 0.01^a
Laderin	5.79 ± 0.09^e	11.58 ± 0.52^b	2.37 ± 0.10^b	128.29 ± 3.35^c	189.04 ± 23.53^c	3.41 ± 0.02^{ab}	0.44 ± 0.06^{ab}	9.05 ± 1.27^a	0.38 ± 0.23^a	0.17 ± 0.02^a
Arigbajo	4.61 ± 0.05^b	8.65 ± 0.06^a	2.40 ± 0.93^b	185.41 ± 13.62^d	86.81 ± 1.71^a	2.29 ± 0.52^a	0.15 ± 0.05^a	27.98 ± 0.85^d	0.56 ± 0.25^a	0.53 ± 0.25^b
Obada-Oko	5.03 ± 0.05^c	28.79 ± 1.36^f	1.84 ± 0.21^b	87.27 ± 4.10^b	356.77 ± 14.98^e	5.46 ± 1.02^c	11.56 ± 0.61^e	21.27 ± 0.57^c	0.28 ± 0.29^a	0.22 ± 0.02^a
Ilaro	4.00 ± 0.12^a	16.12 ± 0.14^c	1.71 ± 0.27^b	45.49 ± 2.90^a	136.23 ± 7.27^b	2.83 ± 0.63^{ab}	2.56 ± 0.14^d	19.58 ± 0.75^{bc}	0.43 ± 0.10^a	0.24 ± 0.01^a

Results in Mean ± SD, same superscripts down the column are not significantly different (p < 0.05)

Table 4: Soil Micronutrients (mg/ kg) and pH in the 2nd Rainy Season

Estates	pH	Toxic Metals			Heavy Metals					
		Pb	Cd	Mn	Fe	Cu	Zn	Ni	ExcH	AcidAl
Shagamu	9.22 ± 0.16^e	9.17 ± 0.08^d	0.32 ± 0.03^a	33.32 ± 2.08^c	56.94 ± 2.19^d	1.51 ± 0.35^b	1.00 ± 0.05^c	8.07 ± 0.09^e	0.52 ± 0.31^a	0.25 ± 0.02^a
Ijebu-Ode	9.36 ± 0.16^e	4.78 ± 0.21^b	0.98 ± 0.04^b	33.68 ± 0.88^c	49.62 ± 6.18^c	1.41 ± 0.01^{ab}	0.35 ± 0.05^{ab}	2.38 ± 0.33^a	0.38 ± 0.24^a	0.26 ± 0.03^a
Laderin	8.32 ± 0.24^d	14.91 ± 0.18^f	0.78 ± 0.04^b	23.26 ± 1.05^b	30.29 ± 2.11^b	1.21 ± 0.18^{ab}	0.71 ± 0.08^{bc}	5.09 ± 0.38^b	0.45 ± 0.08^a	0.22 ± 0.02^a
Arigbajo	7.24 ± 0.08^b	3.57 ± 0.02^a	0.99 ± 0.38^b	48.67 ± 3.58^d	22.79 ± 0.45^a	0.95 ± 0.21^a	0.12 ± 0.04^a	7.34 ± 0.22^d	0.64 ± 0.27^a	0.49 ± 0.38^b
Obada-Oko	6.16 ± 0.22^a	6.65 ± 0.06^c	0.71 ± 0.11^b	11.94 ± 0.76^a	35.76 ± 1.91^b	1.17 ± 0.26^{ab}	2.02 ± 0.11^d	5.14 ± 0.20^{bc}	0.45 ± 0.16^a	0.36 ± 0.02^a
Ilaro	7.99 ± 0.08^c	11.87 ± 0.56^e	0.76 ± 0.09^b	22.91 ± 1.08^b	93.65 ± 3.93^e	2.25 ± 0.42^c	9.10 ± 0.48^e	5.58 ± 0.15^c	0.32 ± 0.23^a	0.32 ± 0.03^a

Results in Mean ± SD, same superscripts down the column are not significantly different (p < 0.05)

Soil pH and Microelements Properties in the 1st Rainy Season: The results in Table 2 showed that the soil pH was observed to range from 6.33 ± 0.19 in Ijebu-Ode to 9.17 ± 0.15 in Arigbajo significantly (p < 0.05). The pH of the 1st dry season was observed to range from acidic to slight acidic (4.31 ± 0.13 - 6.23 ± 0.10) while the 1st rainy season ranged from slight acidic to alkaline (6.33 ± 0.19 – 9.17 ± 0.15). The soil ExcH results (mg/ kg) were observed to range from 0.37 ± 0.38 in Laderin to 0.75 ± 0.33 in Shagamu with no significant (p > 0.05) difference. The soil AcidAl (mg/ kg) concentration was observed to be from 0.19 ± 0.02 in Ilaro to 0.70 ± 0.34 in Shagamu significantly (p <

0.05). The acidic cations (ExcH and AcidAl) were higher in the 1st rainy season than the 1st dry season in each estate. The level of Pb was detected to range significantly (p < 0.05) from 3.71 ± 0.02 mg/ kg in Shagamu to 15.49 ± 0.18 mg/ kg in Ilaro. The soil concentrations of Cd (mg/ kg) were determined significantly (p < 0.05) to be lowest: 0.34 ± 0.03 in Arigbajo and highest: 1.03 ± 0.40 in Shagamu. Concentrations of the toxic metals (Pb and Cd) were observed to be lower in the 1st rainy season than the 1st dry season. This showed that the estate housing had not contributed to the levels of toxic metals in all the estates assessed. The level of Mn (mg/ kg) was found

to be between 12.41 ± 0.79 in Ijebu-Ode and 50.58 ± 3.72 in Shagamu with high level (p < 0.05) of significances. The concentrations of Fe (mg/ kg) were observed to range significantly (p < 0.05) from 23.68 ± 0.47 in Shagamu to 97.33 ± 4.09 in Laderin. Concentrations of Cu and Zn (mg/ kg) were detected to be lowest: 0.98 ± 0.22 and 0.13 ± 0.03 in Shagamu and highest: 2.34 ± 0.44 and 9.46 ± 0.50 in Laderin. There were significant (p < 0.05) differences in the soil concentrations of Cu and Zn. The levels of Ni (mg/ kg) in Obada-Oko soil were detected to be the least: 2.47 ± 0.35 and Arigbajo the highest Ni: 8.38 ± 0.09. It was observed that heavy metals levels were lower in the 1st rainy season than the 1st dry season.

Soil pH and Microelements Properties in the 2nd Dry Season: It showed in Table 3 that the soil pH was determined to range from 4.00 ± 0.12 in Ilaro to 5.79 ± 0.09 in Laderin. The soil pH was significantly (p < 0.05) different. The range of pH was observed to be more acidic (4.00 ± 0.12 to 5.79 ± 0.09) in the 2nd dry season than (4.31 ± 0.13 to 6.23 ± 0.10) in the 1st dry season. The soil ExcH results (mg/ kg) were observed to range from 0.28 ± 0.29 in Obada-Oko to 0.56 ± 0.25 in Arigbajo with no significant (p > 0.05) difference. The soil AcidAl (mg/ kg) concentration was detected to be from 0.15 ± 0.01 in Ijebu-Ode to 0.53 ± 0.25 in Arigbajo significantly (p < 0.05). The level of Pb was detected to range significantly (p < 0.05) from 8.65 ± 0.06 mg/ kg in Arigbajo to 36.14 ± 0.43 mg/ kg in Ijebu-Ode. The soil concentrations of Cd (mg/ kg) were determined to be lowest: 0.78 ± 0.08 in Shagamu and highest: 2.40 ± 0.93 in Arigbajo with significant (p < 0.05) difference. The level of Mn (mg/ kg) was found to be between 45.49 ± 2.90 in Ilaro and 185.41 ± 13.62 in Arigbajo with high level (p < 0.05) of significance. The concentrations of Fe (mg/ kg) were observed to range significantly (p < 0.05) from 86.81 ± 1.71 in Arigbajo to 356.77 ± 14.98 in Obada-Oko. Concentrations of Cu and Zn (mg/ kg) were detected to be lowest: 2.29 ± 0.52 and 0.15 ± 0.05 in Arigbajo and highest: 5.46 ± 1.02 and 11.56 ± 0.61 in Obada-Oko. There were significant (p < 0.05) differences in the soil concentrations of Cu and Zn. The levels of Ni (mg/ kg) in Laderin soil were detected to be the least: 9.05 ± 1.27 and Shagamu the highest Ni: 30.73 ± 0.33. It was observed that though the range of pH was more acidic in the 2nd dry season than in the 1st dry season, the range of concentrations of metals (toxic and heavy) detected were lower in the 2nd dry season than in the 1st dry season. This implied that the more acidic the soil pH the less adsorbed these metals were to the soil and the metals were in turn available for plant accumulation.

Soil pH and Microelements Properties in the 2nd Rainy Season: It could be observed in Table 4 that the soil pH was determined to range from 6.16 ± 0.22 in Obada-Oko to 9.36 ± 0.16 in Ijebu-Ode significantly (p < 0.05). It was observed there was no different between the range of pH of the 1st and 2nd dry seasons: slightly acidic to alkaline (6.16 ± 0.22 - 9.36 ± 0.16). The 2nd dry season was acidic (4.00 ± 0.12 - 5.79 ± 0.09) while the 2nd rainy season ranged from slightly acidic to alkaline (6.16 ± 0.22 - 9.36 ± 0.16). The soil ExcH results (mg/ kg) were observed to range from 0.32 ± 0.23 in Ilaro to 0.64 ± 0.27 in Arigbajo with no significant (p > 0.05) difference. The soil AcidAl (mg/ kg) concentration was observed to be from 0.22 ± 0.02 in Laderin to 0.49 ± 0.38 in Arigbajo significantly (p < 0.05). The soil acidic cations (ExcH and AcidAl) were lower in the 2nd rainy season than the 1st rainy season. The level of Pb was detected to range significantly (p < 0.05) from 3.57 ± 0.02 mg/ kg in Arigbajo to 14.91 ± 0.18 mg/ kg in Laderin. The soil concentrations of Cd (mg/ kg) were determined significantly (p < 0.05) to be lowest: 0.32 ± 0.03 in Shagamu and highest: 0.99 ± 0.38 in Arigbajo. Concentrations of the toxic metals (Pb and Cd) were observed to be lower in the 2nd rainy season than the 1st rainy and 2nd dry seasons. This showed that the housing estate anthropogenic activities had not contributed to the levels of toxic metals. The level of Mn (mg/ kg) was found to be between 11.94 ± 0.76 in Obada-Oko and 48.67 ± 3.58 in Arigbajo with high level (p < 0.05) of significance. The concentrations of Fe (mg/ kg) were observed to range significantly (p < 0.05) from 22.79 ± 0.45 in Arigbajo to 93.65 ± 3.93 in Ilaro. Concentrations of Cu and Zn (mg/ kg) were detected to be lowest: 0.95 ± 0.21 and 0.12 ± 0.04 in Arigbajo and highest: 2.25 ± 0.42 and 9.10 ± 0.48 in Ilaro. There were significant (p < 0.05) differences in the soil Cu and Zn concentrations. The levels of Ni (mg/ kg) in Ijebu-Ode estate soil were detected to be the least: 2.38 ± 0.33 and Shagamu the highest Ni: 8.07 ± 0.09. The levels of heavy metals were observed lower in the 2nd rainy season than either the 1st rainy or 2nd dry seasons. Comparing the metal concentrations in this study with the heavy metals thresholds in agricultural soil (Table 5), it could be inferred that the limits were not exceeded except the range of Cd concentrations (0.87 ± 0.09 - 2.65±1.02) that exceeded the Tanzania Cd standard in agricultural soil (1.00 mg/ kg) (EPMC, 2015). This implied that none of the soil samples of the assessed housing estates was polluted, with probable less health risk from microelements. Accumulation of metals in the soil and sediment is dependent on a number of external environmental factors such as pH for adsorption caused by the variation in grain size distribution (Inengite *et al.*, 2010).

Table 5: Concentrations (mg/ kg) of heavy metals comparing with standards of some countries

Country	Pb	Cd	Mn	Fe	Cu	Zn	Ni
1st Dry Season	9.54 ± 0.06 - 39.87±0.47	0.87 ±0.09 - 2.65±1.02	50.18 ± 3.19 - 204.50 ± 15.02	95.75 ± 1.89 - 303.50±16.52	2.53±0.57 - 6.02±1.12	0.17 ± 0.06 - 12.75±0.68	9.98 ± 1.41 - 33.89±0.37
1st Rainy Season	3.71 ± 0.02 - 15.49±0.18	0.34±0.03 - 1.03±0.40	12.41 ± 0.79 - 50.58 ± 3.72	23.68 ± 0.47 - 97.33±4.09	0.98±0.22 - 2.34±0.44	0.13 ± 0.03 - 9.46 ± 0.50	2.47 ± 0.35 - 8.38 ± 0.09
2nd Dry Season	8.65 ± 0.06 - 36.14±0.43	0.78±0.08 - 2.40±0.93	45.49 ± 2.90 - 185.41±13.62	86.81 ± 1.71 – 356.77 ± 14.98	2.29±0.52 - 5.46±1.02	0.15 ± 0.05 - 11.56±0.61	9.05 ± 1.27 - 30.73±0.33
2nd Rainy Season	3.57 ± 0.02 - 14.91±0.18	0.32±0.03 - 0.99±0.38	11.94 ± 0.76 - 48.67 ± 3.58	22.79 ± 0.45 - 93.65 ± 3.93	0.95±0.21 - 2.25±0.42	0.12 ± 0.04 - 9.10±0.48	2.38 ± 0.33 - 8.07 ± 0.09
Australia	300	3			100	500	60
Canada	200	3	-	-	150	500	100
China	80	0.3-0.6	-	-	50-200	200-300	40-60
Germany	1000	5	-	-	200	600	200
Tanzania	200	1	-	-	200	150	100
Netherlands	530	13	-	-	190	720	100
NZ	160	3	-	-	$>10^4$	-	-
UK	-	1.8	-	-	-	-	230
USA	200	0.48	-	-	270	1100	72

Source: EPMC (2015)

The ranges of pH in this study corroborated the previous study, where pH values of soil for wet and dry seasons were observed to be 6.23 and 6.11 with average pH of 6.17 (slightly acidic). A pH range of 5.90 - 7.29 with mean value of 6.84 ± 0.28 was also recorded. The slightly acidic pH is peculiar to Nigerian soil and sediment (Ndimele and Kumolu-Johnson, 2012). A lower range of pH (2.90 – 4.60) and (3.10 - 4.60) during dry and wet seasons had been previously reported. High acidity of soil had thus been attributed to a combination of possible oxidation of FeS_2 in the soil to produce sulfuric acid. Solubility, toxicity and or availability of the heavy metals cations (Cd^{2+}, Cr^{3+}, Cu^{2+} and Zn^{2+}) to organisms decrease as soil pH increases (become less acidic). The effect of soil pH is profound on the solubility of minerals and is regarded as a useful indicator of other soil parameters. Most minerals are more soluble or available in acidic soils than in neutral or slightly alkaline soils (Ololade *et al.,* 2010). Levels of metals found in soil are dependent on the prevailing pH condition of the hypolimnion water column. Low pH (acidic) condition affects metal speciation and may enhance metals' solubility and possible leaching into the water column. Levels of the assessed micro elements in this study were detected to be low; this indicated possible low or no health risks to corroborate Nwadinigwe *et al.* (2014) who reiterated that metal concentrations below the thresholds indicated low health risk effects to the domestic animals, plants and human being.

Conclusion: Soil metal contents were observed to vary and levels were higher in the dry than in the wet seasons. The soil samples were comparatively less polluted. Available water and growing of crops in all the assessed housing estates could hardly pose metal pollution health risks. Communities could be helped with environmental samples (soil, water and plant) assessment to ensure good health and well-being for all at all stages of lives (Sustainable Development Goal 3).

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