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The Impact of Nigerian Flood Disaster on the Soil Quality of Farmlands in Oshimili South Local Government Area Of Delta State, Nigeria.

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ABSTRACT
Soil samples from flood disaster affected farmlands in Oshimili South Local Government Area of Delta State, Nigeria, were collected and analyzed for their physicochemical characteristics and heavy metal levels, in order to assess the impact of the flood disaster on the soil quality of the farmlands. The pH values in all the sites ranged from 5.20 to 6.10 with mean value of 5.45 indicating that the soils were moderately acidic. The electrical conductivity values which ranged from 52.80 to 89.40 with mean value of 69.70µScm^{-1} imply significant presence of soluble inorganic substances with their respective ions. Total Organic Carbon and Total Nitrogen values ranged from (%) 0.38 to 1.76 and 0.021 to 0.143 with mean values of 1.08 and 0.09% respectively suggesting presence of some organic matters and compostable materials in the soils. Phosphorus content of the soil samples ranged from 17.21 to 37.20$mgkg^{-1}$ with mean value of 24.68$mgkg^{-}$ which may be attributed to some submerged food crops like cassava tubers lost to the flood. Cation Exchange Capacity values ranged from 5.50 to 16.24 with mean value of 12.83$Cmolkg^{-1}$, which are suggestive of the soil capacity to adsorb metals. The mean heavy metal concentrations were ($mgkg^{-1}$) 33.57 for Fe, 5.03 for Zn, 5.99 for Cu, 12.78 for Mn, 3.91 for Co, 0.55for Ni, 0.40 for Cr and 0.43 for Pb. The levels were in the abundance trend of Fe > Mn > Cu, Zn > Co > Ni > Pb > Cr. The geoaccumulation index values of the metals in the soils revealed that the soils were practically uncontaminated by Ni, Cr, and Pb, slightly contaminated by Fe, Zn and Co and generally slightly contaminated by Cu. Contamination/Pollution index values indicate that all the metals studied were in the range which showed very slight contamination except Cu and Mn whose values were generally in the range of slight contamination. The over all results from the study indicated that the soils in all the sites were contaminated with heavy metals. However, the metal concentration levels found in this study do not pose any health hazard since the levels were below DPR target limits, and common range for agricultural soils.
Keywords: Nigerian flood disaster, soils, farmlands, heavy metals, physicochemical characteristics, pollution.

INTRODUCTION

There have been reports about natural disasters in various parts of the world resulting to tremendous loss of lives and property. Some recent ones include earthquakes in Netherlands, Mexico, Georgia, New Zealand and Japan; flooding in Russia, Philipines, Australia, Brazil, China, Indonesia, Iran, Iraq, Kenya, Sudan, Syria, Central Europe etc.; erupting volcanoes in Fuego, Santiago, Batu Tara, Ulawun, Gamalama, etc., tropical cyclones in American Samao, to name but a few.

When we were sympathizing with those countries devastated by these natural disasters, little did we know that our country Nigeria will have her own turn in 2012. The unprecendented flood in Nigeria was noticed from July (especially in coastal areas) and receded towards early November after destroying and devastating lands, buildings, displacing millions of people and claiming many lives. In some areas both lands and buildings were completely submerged and the whole town overtaken by flood.

In Delta State, fourteen Local Government Areas were affected and the worst hit are those from Isoko, Ughelli, Ndokwa East and Oshimili South communities.

The swift current and waves of the flood excervated, exhumed and eroded coastal lands, carrying many things from municipal refuse dumps, mechanic dumps and workshops and other suspected heavy metal polluted items as the current moved and these were finally deposited on other places including farmlands as the flood receded. These loads especially those transported from suspected polluted sites are likely to contain some heavy metals.

Heavy metals get into the environment in different ways with industrial, agricultural and household wastewaters, atmospheric deposits, or in the process of extraction of natural resources (Dupicius et al., 2011). Since soils serve as sinks or reservoirs for heavy metals, they accumulate gradually and after a long time they may exceed their threshold limits. The pollution of the environment with heavy metals has become a world-wide problem in recent years (Benjamin and Nwashot, 2003) because they are non-biodegradable and are toxic to flora and fauna in the ecosystem (Krissanakriangkral et al., 2009; Ozturk et al., 2009).

The physicochemical parameters of soils have been reported to have a profound influence on the mobility and bioavailability of heavy metals (Tukura et al., 2007). In view of the above, the study was therefore aimed at investigating the physicochemical properties as well as the heavy metal levels in these flood affected farmlands, not only to provide their post flood baseline data but also to assess the human health and ecological risks associated with the soils in the areas of study.

MATERIALS AND METHODS

Description of Study Area

Oshimili South Local Government Area of Delta State is made up of Asaba, Oko, Okwe and their environs, with Asaba as the Headquarter. It lies on the latitude $6^0 34^1$ - $6^0 45^1$E and longitude $5^0 59^1$ - $6^0 18^1$N. It has an average annual rainfall of about 8667mm. The rain is heaviest in July with a short break in August. It has an average temperature range of 39 – 44^0C. The area has a rich deposit of alluvial soil which is very good for cultivation and the main occupations of the inhabitants are farming, fishing and trading. However, with Asaba as both State Capital and Local Government headquarter, there is gradual drift from agricultural to commercial and administrative activities in the city.

Sample Collection

Soil samples were collected from the flood affected farmlands in different towns in Oshimili South Local Government Area of Delta State, using soil auger. In each town samples were collected from three different farmlands. The soil samples collected from the three farmalands were bulked and true representative sample from the farms in each town was taken after a series of coning and quatering (Oguntimehin and Ipinmoroti, 2007). Control samples were collected from soils from three different areas which were not affected by the flood. The three control samples were also bulked and composite or representative sample was labeled as control sample.

The soil samples were air-dried for a period of one week in a clean well-ventilated laboratory (Boulding, 1994), crushed in a porcelain mortar and sieved through a 2mm stainless sieve. The samples for metal analysis were digested using a mixture of 2cm^3 of 60% perchloric acid, 15cm^3 of concentrated nitric acid, and 1cm^3 of concentrated sulphuric acid (Burrell, 1974). The digested samples were analysed for metals using Atomic Absorption Spectrophotometer (Perkin Elmer Model A. Analyst 2002) fitted with deuterium lamp for background correction.

Soil pH was measured in a soil water ratio of 1:2.5 (Davey and Conyers, 1988). Total Organic Carbon (TOC) was determined by the method described by Nelson and Sommers (1982), Total Nitrogen (TN) was estimated using microkjedahl method (Bermmer, 1965), Electrical Conductivity (EC) was determined by the method of Chopra and Kanzar (1988), Cation Exchange Capacity (CEC = Na + K + Mg + Ca) was carried out by the method of Jackson (1960) while Available Phosphorus was determined by the method of Bray and Kurtz (1945). All the reagents used in this study were of pure analytical grade and were checked for possible trace metal contamination. All glasswares were previously soaked in 14% nitric acid for 24 hours to remove entrained metals, washed with detergent and rinsed with deionized water. Quality control was assured by the use of duplicates, standard reference materials and procedural blanks.

Results and Discussion

Physicochemical Properties of the Soil Samples

The physicochemical properties of the soil samples are presented on Table 1.

Table 1: Physicochemical properties of the soil samples

Sample sites		pH	E.C uScm	TOC %	TN %	P $mgkg^{-1}$	Ca	Mg meq	Na	K	CEC $Cmolkg^{-1}$	NO_3 $mgkg^{-1}$	SO_4^{2-} $mgkg^{-1}$
A	Asaba Head Bridge East	6.10	61.50	1.25	0.098	37.20	7.04	1.84	0.24	0.15	9.27	0.76	0.09
B	Asaba Head Bridge West	5.00	62.60	0.77	0.054	17.21	8.56	6.24	0.26	0.23	15.29	0.50	0.76
C	Asaba Cable Point Flood Plain	5.30	80.60	1.06	0.089	22.51	10.23	5.36	0.26	0.3	16.24	0.04	0.15
D	Dkwe Asaba Side Flood Plain	5.80	65.30	0.70	0.051	26.17	8.64	4.16	0.25	0.15	13.20	0.13	0.11
E	Okwe Oko Side Flood Plain	5.30	62.20	0.90	0.076	21.90	6.56	5.12	0.24	0.18	12.10	0.82	0.08
F	Oko Anala	5.50	91.90	1.50	0.124	27.98	10.96	4.40	0.26	0.35	15.97	0.11	0.19
G	Oko Amakom	5.50	64.10	0.38	0.021	27.50	3.52	1.60	0.26	0.12	5.50	0.52	0.09
H	Oko Ogbele	5.20	52.80	0.86	0.063	18.34	9.68	2.56	0.29	0.28	12.81	0.62	0.82
I	Oko Odifulu	5.60	66.60	1.76	0.143	27.20	10.08	3.12	0.22	0.17	13.59	0.58	0.18
J	Asaba Mile Five Flood Plain	5.20	89.40	1.60	0.131	20.78	9.12	4.56	0.35	0.26	14.29	0.53	0.27
	Mean±S.D	5.45 ±0.32	69.7 ±12.99	1.08 ±0.44	0.09 ±0.04	24.68 ±5.85					12.83 ±3.29	0.46 ±0.27	0.27 ±0.28
	Control												
	Asaba not Submerged	7.50	68.80	0.61	0.043	35.06	7.28	0.80	0.29	0.10	8.47	0.56	0.10
	Asaba Mile Five not Submerged	6.90	95.70	0.23	0.015	38.27	3.12	2.64	0.24	0.09	6.09	0.21	0.08
	Okwe not Submerged	6.80	53.50	0.92	0.074	38.53	5.68	1.52	0.21	0.18	7.59	1.00	0.05
	Mean	7.07 ±0.38	72.67 ±21.36	0.59 ±0.35	0.044 ±0.03	37.29 ±1.93	5.36	1.65	0.25	0.12	7.38 ±1.20	0.59 ±0.40	0.08 ±0.03

The pH values of the soils studied in all the sites ranged from 5.20 to 6.10 with mean value of 5.45 ± 0.32 indicating that the soils were moderately acidic. These values are in the same range with the values reported by Oviasogie and Omoruyi, (2007), Oviasogie and Ofomaja, (2007), Osakwe, (2012) but lower than the values reported by Jung, (2008), Obasi et al., (2012). Soil reaction (pH) conditions a mobile form of heavy metal amounts and organic substances in soils and sediments acting like a buffer and storing these materials for a long time (Liu et al., 2009; Dumcus et al., 2011). Normally with decrease in soil pH, the competition between H^+ and the dissolved metals for ligands becomes more and more significant and it subsequently decreases the adsorption abilities and bioavailability of the metals and then increases the mobility of heavy metals (Peng et al., 2009). The pH values obtained in this study sites indicate a generally high tendency for high availability of these metals, hence, this is a natural mechanism increasing the risk of at least plant uptake.

The electrical conductivity (EC) values ranged from (μScm^{-1}) 52.80 to 89.40 with mean value of 69.7±12.99 indicating reasonable or significant presence of anions such as nitrite, sulphates, chlorides and nitrates etc. (Fullen et al., 1995). This observation is corroborated by the trend of these anions (NO_3^- and SO_4^{2-}) as revealed in their analytical determinations in the present study (Table 1). These values are in the same range with the values reported by Iwegbue et al., (2006), Osakwe (2013); but higher than the values reported by Obasi et al., 2012 and lower than the values reported by Akpoveta et al., (2010). Total Organic Carbon (TOC) and Total Nitrogen (TN) values ranged from (%) 0.38 to 1.76 and 0.021 to 0.143 with mean values of 1.08±0.44 and 0.09±0.04 respectively. Similar values for both TOC and TN have been reported (Oviasogie and Omoruyi, 2007). Presence of organic matter could be attributed to dead animals and vegetation which decayed in the flood and later deposited on the soil when the flood was receding. Phosphorus content of the soil samples ranged ($mgkg^{-1}$) from 17.21 to 37.20 with mean value of 24.68 ± 5.85. These values are within the range reported by Iwegbue et al., (2006) but lower than the values reported by Oviasogie and Omoruyi (2007) and higher than the values reported by Eddy et al., 2006). The relatively high values of phosphorus recorded in this study is not surprising since cassava tuber is a rich source of phosphorus (Jung et al., 2002) and some of these farms were submerged with the food crops on them lost to flood. In acidic soils, phosphate in the soil is usually tied up or fixed by either Fe or Al which are abundant in acidic conditions. Phosphorus which is one of the macronutrients needed by plants, is essential for the seeds, and development of fibrous root system in plant (Isirimah et al., 2003). Cation exchange capacity (CEC) values ranged from ($cmolkg^{-1}$) 5.50 to 16.24 with mean value of 12.83±3.29. This is consistent with the values reported by Abollino et al., (2002), Obasi et al., (2012). These values are however higher than the values reported by Isirimah (1987), Oviasogie and Omoruyi (2007), lower than the values reported by Iwegbue et al., (2006). Cation exchange capacity (CEC) gives the soil a buffering capacity which may slow down the leaching of nutrient cations and positively charged pollutants because they affect both soluble and exchangeable metal levels (Yoo and James, 2002).

Heavy Metal Concentrations

The heavy metal concentrations of the soil samples are presented on Table 2 .

Table 2: Heavy metal concentrations in the soil samples in $mgkg^{-1}$

Sample sites		Fe	Zn	Cu	Mn	Co	Ni	Cr	Pb
A	Asaba Head Bridge East	30.58	3.35	1.64	14.57	3.52	0.41	0.31	0.19
B	Asaba Head Bridge West	29.61	4.18	6.18	13.42	3.62	0.59	0.41	0.39
C	Asaba Cable Point Flood	30.65	4.83	8.13	23.16	4.24	0.71	0.48	0.28
D	Plain	32.07	3.99	3.52	8.80	3.10	0.19	0.37	0.52
E	Dkwe Asaba Side Flood	45.98	3.71	7.52	7.25	4.03	0.32	0.31	0.52
F	Plain	34.61	10.10	9.73	4.16	4.03	1.03	0.41	0.57
G	Okwe Oko Side Flood Plain	34.70	1.67	2.48	2.19	3.31	0.29	0.23	0.36
H	Oko Anala	32.18	5.59	4.32	16.48	3.85	0.23	0.39	0.58
I	Oko Amakom	34.32	4.38	1.93	11.41	3.52	1.01	0.36	0.55
J	Oko Ogbele	31.03	8.47	14.40	26.35	5.89	0.71	0.70	0.30
	Oko Odifulu								
	Asaba Mile Five Flood Plain	33.57	5.03	5.99	12.78 ±	3.91	0.55	0.40	0.43
		±4.72	±2.49	±4.06	4.28	±0.41	±0.18	±0.13	±0.13
	Mean±S.D								
		10.92	2.56	0.48	2.64	2.48	0.50	0.11	0.18
	Control	7.07	2.46	0.90	0.97	3.31	0.94	0.09	0.20
	Asaba not Submerged	12.71	2.88	0.25	3.67	2.90	0.36	0.08	0.18
	Asaba Mile Five not								
	Submerged	10.23	2.63	0.54	2.43 ±1.36	2.90	0.60	0.09	0.19
	Okwe not Submerged	±2.88	±0.21	±0.32		±0.42	±0.45	±0.02	±0.01
	Mean								

All the metals analysed for, were detected in all the soil samples except and their mean concentrations were significantly higher than the mean values obtained in the control sites.

Iron

Iron concentrations ranged from ($mgkg^{-1}$) 29.61 to 45.98 with mean value of 33.57±4.72. These values are lower than the values reported by Osakwe (2010), Okoye and Agbo (2011), but higher than the values reported by Ajibola and Ozigis (2005), Okorie and Egila (2012). Iron had the highest concentrations in all the sites. This is not surprising because it has been confirmed that natural soils contain significant concentration of iron (Ademoroti, 1996, Aluko and Oluwande, 2003). The observed high concentrations of Fe in both the flood submerged soils and control soil can be attributed to its ability to form complexes and the manifestation of different oxidation states (Motelica-Heino et al., 2003, Mahimairaja et al., 2005, Okorie and Egila, 2012).

Zinc

Zinc levels were in the range from ($mgkg^{-1}$) 1.67 to 8.47 with mean value of 5.03±2.49. Similar levels have been reported (Kaur and Mehra, 2012). These levels are however lower than the levels reported by Jung (2008) and higher than the levels reported by Adaikpoh et al., (2005). The sources of zinc in both soils and water bodies could be submerged mechanic dumpsites, sewage effluents and paints washed off by flood from building walls and some submerged idols painted with multicolours (Boxall et al., 2000, Reddy et al., 2012). Zinc is one of the micronutrients essential for normal plant growth (Jung, 2008).

Copper

Concentrations of copper ranged from ($mgkg^{-1}$) 1.93 to 14.40 with mean value of 5.99±4.06. These values are within the range reported by Oviasogie and Omoruyi, (2007), Al-Trabiusy et al., 2013 but higher than the values reported by Kaur and Mehra, (2012), Ekpete et al., (2013) and lower than the values reported by Urunmatsoma and Ikhoria, (2005), Jung, (2008), Jacob et al., (2013.) Electrical cables, metal bearing wears and babbit metal bushings could be possible sources of copper in these soils. Large amount of copper wire are used in telephone, as well as in television set, motors and generators and in houses for piping water. It is a micronutrient which can be deficient in some soils leading to severe loss of yield in several crops, especially cereals (Alloway, 1990). At lower concentrations, Cu ions cause headache, nausea, vomiting and diarrhea and at high concentration it cause anemia, gastrointestinal disorder and also leads to liver and kidney malfunctioning in extreme cases (USEPA, 1999)

Manganese

Manganese concentrations in all the samples ranged from (mgkg^{-1}) 2.19 to 26.35 with mean value of 12.78±4.28 These values are in the same range with the values reported by Osakwe (2010) but higher than the values reported by Ayodele and Gaya, (1994), Eddy et al., (2006) and lower than the values reported by Osakwe (2013), Al-Trabulsy et al., (2013). Although manganese is a component of subsoil material in form of oxide (Levy et al., 1992), its presence can also be attributed to discarded used batteries, metal rails, machinery parts and wastes from welding works, which might have been transported and deposited by the flood. Several common pesticides used fairly extensively in agriculture and horticulture contain some level of manganese. Manganese is frequently found in iron-bearing waters and is present most frequently as manganese ion (Kaur and Mehra, 2012). It can also enter river through industrial effluents (Sehgal et al., 2012). High concentrations of manganese result in kidney failure, liver and pancreas malfunctioning but its optimum concentration is very much essential for respiratory enzymes and connective tissues development (Kaur and Mehra, 2012). High concentration of manganese in form of dust or fumes results to a disease called metal fume fever (M.F.F) which is self limiting inhalation syndrome seen in workers exposed to metal fumes and it is characterized by fever, headache, fatigue, dyspnea, cough and metallic taste (Soghovan, 2011).

Cobalt

The levels of cobalt observed in all the soil samples ranged from (mgkg^{-1}) 3.31 to 5.89 with the mean value of 3.91±0.41. These values are in the same range with the values reported by Al-Trabulsy et al., (2013). The values are relatively low compared with values reported by Oguntimehin and Ipinmoroti, (2007). Cobalt enters water bodies from the effluents coming from industries dealing with corrosion and wear-resistant alloys. The other sources of cobalt contamination are colours and pigments used to colour glass and ceramic objects, lithium-cobalt batteries and permanent magnets. Petroleum based industries are also possible sources of cobalt contamination into the environment. Earlier research findings confirm that cobalt is carcinogenic in nature and in low concentration, it causes vomiting, weakness, giddiness, lack of concentration, hearing impairment, thyroid problems, memory loss, and cardiovascular disease (Kaur and Mehra, 2012).

Nickel

Nickel levels in all the sites ranged from (mgkg^{-1}) 0.19 to 1.03 with mean values of (mgkg^{-1}) 0.55± 0.18. These values are significantly lower than the values reported by many other researchers (Urunmatsoma and Ikhoria, 2005, Iwegbue et al., 2006, Oguntimehin and Ipinmoroti, 2007, Al-Trabulsy et al., 2013). The major sources of nickel contamination in the soil are metal plating industries, combustion of fossil fuels (Khodadoust et al., 2004). It is released into the air by power plants and trash incinerators and settles to the ground after undergoing precipitation reactions (Wuana and Okieimen, 2011). Other sources of nickel contamination of soils are cocoa plant foods (nuts) and hydrogenated oils. Industries dealing with electrical equipment and household appliances, catalysts, pigments, batteries (NiCad) are also sources of nickel contamination in the environment (Kaur and Mehra, 2012). Studies have reported pregnancy complication in nickel exposure leading to an increased rate of spontaneous abortion and high incidence of birth malformation, cardiovascular and muscloskeletal defects (Chashschin et al., 1994).

Chromium

The concentrations of chromium ranged from (mgkg^{-1}) 0.23 to 0.70 with mean value of 0.40±0.13. Similar ranges of values have been reported (Okoye and Ugwu, 2011). These values are significantly lower than the values reported by some other researchers (Asaah et al., 2006; Oguntimehin and Ipinmoroti, 2007) but higher than the values reported by Osakwe, (2012) in a similar study. The major source of chromium is disposal of chromium containing wastes especially industrial effluents (Smith et al., 1995). High level of chromium in industrial effluents has been reported by Rawat et al., (2003). Chromium is commonly found at contaminated sites in form of chromium (VI) and it is the dominant form of chromium in shallow aquifers where aerobic conditions exist (Waana and Okieimen, 2011). Chromium is associated with allergic dermatitis in humans (Scragg, 2006). Epidemiological studies have shown that some chromium components have carcinogenic effects (Moore and Ramamoorthy, 1984).

Lead

The concentrations of lead in the soils studied ranged from ($mgkg^{-1}$) 0.19 to 0.58 with mean value of 0.43±0.13. These values are significantly lower than the values reported by other researchers in similar studies (Tukura et al., 2007; Nnabo et al., 2011; Okoye and Agbo, 2011) but higher than the levels reported by Kaur and Mehra, (2012). Several lead compounds are used in the manufacture of some paints and dyes, insecticides, lead batteries, ceramics, glass plumbing fixtures and rubber products. In some cases, lead is used to stabilize the land pipes/plastic pipes that result in lead contamination of the drinking water (Pillai, 1983). Another well known source of lead contamination of the soil is through vehicular emission because of the tetraethyl lead content of gasoline as an additive. Lead accumulates in the body organs (i.e. brain), which may lead to poisoning (plumbism) or even death. Gastrointestinal tract, kidneys and central nervous system are also affected by the presence of lead. Children exposed to lead are at a risk for impaired development, lower Intelligent Quolient (IQ), shortened attention span, hyperactivity and mental deterioration (Wuana and Okieimen, 2011).

Geoaccumulation Index

The geoaccumulation index (Igeo) was used in determining metal pollution in soils following the formula proposed by Singh (2001) It is expressed as

$$Igeo = \frac{\log_2 Cm}{1.5\ Bn}$$

Where Cm = Measured concentration at sampling point
Bn = Background concentration value for the element
1.5 = The background matrix correction factor due to lithogenic effects.

The geoaccumulation index consists of seven grades (0-6) ranging from uncontaminated to very highly contaminated. These seven descriptive classes are as follows;

<0 = practically uncontaminated
0-1 = uncontaminated to slightly contaminated
1-2 = moderately contaminated
2-3 = moderately to highly contaminated
3-4 = highly contaminated
4-5 = highly to very highly contaminated
>5 = very highly/strongly contaminated

The control samples were taken to represent the background.

The geoaccumulation index values are presented on Table 3.

Table 3: Geoaccumulation index of the metals in the soil samples

	Fe	Zn	Cn	Mn	Co	Ni	Cr	Pb
A	0.32	0.44	0.88	1.06	0.42	-1.43	-12.07	-8.28
B	0.31	0.52	3.25	1.03	0.43	-0.84	-9.21	-4.69
C	0.32	0.57	3.73	1.24	0.48	-1.04	-7.57	-6.34
D	0.33	0.50	2.25	0.86	0.37	-2.67	-10.21	-3.24
E	0.36	0.48	3.59	0.78	0.46	-1.82	-12.07	-3.24
F	0.33	0.85	4.04	0.56	0.46	0.05	-9.21	-2.62
G	0.33	0.19	1.62	0.31	0.40	-1.98	-15.14	-5.07
H	0.33	0.63	2.60	1.11	0.45	-2.35	-9.71	2.72
I	0.33	0.54	1.17	0.96	0.42	0.02	-10.50	-2.97
J	0.32	0.78	4.75	1.29	0.59	-0.54	-3.64	-6.00

These values show that the soils were practically uncontaminated by nickel, chromium and lead but were slightly contaminated by iron, zinc and cobalt in all the sites and manganese in some sites. Copper showed generally highly contaminated except in few sites, where it showed slightly to moderately contaminated.

Contamination/Pollution Index (C/P)

This was calculated as follows, following Lacatusu (2000) scheme.

$$C/P = \frac{\text{Concentration of the metal in soil}}{\text{Target value}}$$

The target value was obtained by using the standard formulated by the Department of Petroleum Resources of Nigeria (DPR) for maximum allowed concentration of heavy metals in soils. The values are as follows (ppm) 0.8 for Cd, 100.0 for Cr, 85.0 for Pb, 35.0 for NI, 140.0 for Zn, 20.0 for Co, 0.30 for Hg, 36.0 for Cu, 476.0 for Mn and 5000.0 for Fe.

The significance of interval of contamination/pollution index (Aiyesanmi, 2008), are given below.

C/P	Significance
<.1	Very slight contamination
0.10-0.25	Slightly contamination
0.26-0.5	Moderate contamination
0.51-0.75	Severe contamination
0.76-1.00	Very severe contamination
1.10-2.0	Slight pollution
2.1-4.0	Moderate pollution
4.1-9.0	Severe pollution
9.1-16.0	Very severe pollution
>16.0	Excessive pollution

The values less than 1 define contamination range while greater than 1 define pollution range.

The Contamination/Pollution Index values of the metals are presented on Table 4.

Table 4: Contamination/Pollution Index values of the heavy metals in the soil samples

Sites	Fe	Zn	Cu	Mn	Co	Ni	Cr	Pb
A	0.006	0.024	0.046	0.031	0.176	0.012	0.003	0.002
B	0.006	0.030	0.172	0.028	0.181	0.017	0.004	0.005
C	0.006	0.035	0.226	0.049	0.212	0.020	0.005	0.003
D	0.006	0.029	0.098	0.018	0.155	0.005	0.004	0.006
E	0.009	0.027	0.209	0.015	0.202	0.009	0.003	0.006
F	0.007	0.072	0.270	0.008	0.202	0.029	0.004	0.007
G	0.007	0.012	0.069	0.005	0.166	0.008	0.002	0.004
H	0.006	0.040	0.120	0.035	0.193	0.007	0.004	0.007
I	0.007	0.031	0.054	0.024	0.176	0.029	0.004	0.006
J	0.006	0.061	0.400	0.055	0.295	0.020	0.007	0.004

On individual basis, the values for all the metals studied were in the range that showed very slight contamination (<0.1) except copper and manganese whose values were generally in the range of slight contamination (0.10-0.25). However, copper showed moderate in site J.

CONCLUSION

The results from this study showed that soils of the natural flood disaster affected farmlands in the study area were generally acidic, contained significant amounts of dissolved inorganic substances and had capacity to adsorb metals. There was also an indication of presence of some degradable and compostable materials in addition to organic matter contents. The following trend of heavy metals concentration was established Fe > Mn > Cu > Zn > Co > Ni > Pb > Cr. The computed values of geoaccumulation and contamination/pollution indeces suggested that the heavy metal enrichment were only at contamination range and did not reach pollution range. The concentration levels of the metals fell below the Department of Petroleum Resource (DPR) target limits and common range for agricultural soils and so do not pose any significant threat to biota.

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