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Post Flooding Effect on Soil Quality in Nigeria: The Asaba, Onitsha Experience

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ABSTRACT

This study focuses on the post effect of flooding on soil quality parameters in agricultural farmlands in Nigeria. Soil samples were collected from farmland in Alihame Agbor, Ika South local government area of Delta state, Okwei in Asaba, Oshimil South local government area of Delta state and fegge in Onitsha South local government area of Anambra state. Farmlands in Asaba and Onitsha were used for the post flooding study, while farmland in Agbor served as control since it was not affected by flooding. Soil physicochemical parameters such as pH, electrical conductivity, total organic carbon, total organic matter, total nitrogen, total phosphorus, cation exchange capacity, moisture content and metals (Cd, Pb, Cu, Mn, Ni and K) which were used as index for assessing the effect of flooding on soil quality were analyzed using standard methods. Significant effect of flooding was observed on soil properties on the flood affected farmlands when compared to the control farmland, which was statistically justified at 95% confidence limit ($p \leq 0.05$). There were considerable decreases ranging from 4% to 53% at $p \leq 0.05$ in the values of pH, total organic carbon, total organic matter, total nitrogen, total phosphorus and cation exchange capacity on the flood affected farmlands when compared to the control farmland; except for electrical conductivity where an increase of 54% and 92% at the flood affected farmlands in Asaba and Onitsha respectively was observed when compared to the control. Higher moisture contents were also recorded of up to about 17% and 45% at the flood affected farmlands in Asaba and Onitsha respectively, when compared to the control. Reduced concentrations ranging from 25% to 49% of essential micronutrients such as Mn, Ni and K were observed on the flood affected farmlands, reflecting the negative impact of the flood. Undesirable effect of the flood was also observed in the flood affected farmlands when compared to the control farmland as increased concentrations ranging from 18% to 114% of Cd, Pb, and Cu, were recorded. The findings of this study revealed significant impacts of the resulting flood on soil quality of the affected farmlands with major attendant effect of the flood felt on farmland in Asaba. As a consequence, measures should be put in place by government and concerned agencies to avoid future flooding of farmlands so as not to further expose the natural quality of these farmlands to the degradative and devastating effect of such flooding.

KEYWORDS

1. Introduction

Developing countries like Nigeria and other nations experience some ecological and environmental challenges such as flooding which has advert effects on the industrial, agricultural and social-economic growth and development of such nations.

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Flooding results in shortage of food crops due to loss of entire harvest and the destruction of soil quality. When a soil is flooded (anaerobic conditions), microorganisms use the available soil O_2 to survive. Free O_2 in the soil is usually depleted within a couple of days after flooding. The longer the soil is flooded, the lower the soil O_2 levels become more reduced [1]. Oxygen deficiency is likely the most important environmental factor that triggers growth inhibition and injury in flooded plants [2].

Despite the significant consequences of flooding on the environment, flood plays an important role in maintaining key eco-system function and biodiversity in many natural systems. Flood deposits organic materials, minerals, and essential nutrients from rivers and oceans into land which makes the soil richer, fertile and productive. Increased fish production is also a positive environmental consequence which can help boost a nation's economy. However, these environmental benefits come at a high price when excessive flooding occurs, since natural systems can no longer be resilient to the effects of large and excessive floods.

Nigeria's rainy season spans between May to September and suffers from seasonal flash floods. These flash foods are sometimes lethal, especially in the rural areas or overcrowded slums, where drainage is poor or does not exist at all [3]. Heavy rainfall at the beginning of July to September 2012 caused water reservoirs to overflow and authorities were obliged to open dams (Lamingo dam and Lagdo Dam in the Northern Province of Cameroun) to relive pressure in both Nigeria, neighboring Cameroon and Niger, leading to destroyed river banks and infrastructure, loss of property and livestock, and flash floods in many areas. Two major flood events took place between the months of September and October 2012 in Nigeria, the Ladgo Dam Flood and Niger-Benue Flood (Lokoja and River Benue-Niger adjoining States) [4]. The significance of the year 2012 flood disasters in Nigeria lies in the fact that they were unprecedented in the past forty years. The 2012 Nigeria floods which are the worst in over forty years began in early July 2012 and have killed 363 people, and displaced over 2,100,000 people as at 5th November 2012 [5]. Out of Nigeria's 36 states, 32 have been affected by the floods with states badly affected such as Adamawa, Taraba, Delta, Anambra, Lagos, Edo, Niger, Cross-River, Bayelsa, Rivers, Plateu, and Benue States.

The devastating impact of flooding and its attendant negative effect on agricultural soils, consequently leading to deterioration in soil quality underscore and necessitate the need for this research study. This study therefore focuses on the post effect of Nigeria major flooding in 2012 on soil quality parameters in agricultural farmlands from two neighboring states, Okwei at Asaba, Delta State and Fege at Onitsha, Anambra State respectively; so as to provide a quick estimation and evaluation of its effect on the soil for agricultural purposes.

2. Material and Methods

2.1. Study Area/Site Characteristics

Soil collected from farmland in Alihame, Agbor was used as the standard and control for assessing the post flooding effect on soil quality parameters on soil samples taking from farmlands in Fege, Onitsha and Okwei, Asaba respectively, since Agbor did not experience the environmental problem of flooding. A pre flood assessment of the affected soil would have ordinarily been conducted to determine the soil quality state prior to the flooding, which would have otherwise been used as a standard and control for the study. But since there was no premonition of the natural disaster occasioned by the flood, it was practically impossible to conduct a prior investigation of soil quality parameters in the soil before the flooding, as no human can predict naturally causes; hence the use of soil collected from farmland in Alihame, Agbor which was not affected by the flood as control and standard for the study.

Agbor is the administrative headquarters of Ika south local government area and is located in the northern part of Delta State, South-South, Nigeria. It lies within the coordinates of longitude 6°05'N to 6°16'N and latitude 6°07'E to 6°12'E of the equator, with a mean annual temperature range of 28°C - 34°C. Asaba is the administrative capital of Delta State, situated in the South-South region of Nigeria. It lies within the coordinates of longitude 6°73'N and latitude 6°20'E of the equator, with a mean annual temperature range of 25.9°C - 28.9°C. Onitsha is a major commercial city located in Anambra state, South-East Nigeria. It lies within the coordinates of longitude 6°78'N and latitude 6°17'E of the equator, with a mean annual temperature range of 25.4°C - 28.9°C.

2.2. Sampling

Soil samples were representatively collected with a soil auger at surface and subsurface depth (0 - 30 cm) from cultivated farmlands in Alihame, Agbor, Owei in Onitsha and Fege in Asaba respectively. Collection of the soil samples were carried out within the month of January 2013, two month after the nationwide flooding that rocked the entire country. Soil samples were representatively collected from five different spots at every 100 meters distance apart within the flood affected and unaffected sampling areas respectively. Soil samples collected from the individual locations were bulked, thoroughly mixed and stored in clean polythene bags prior to laboratory analysis.

2.3. Soil Characterization/Physicochemical Analysis

Soil physicochemical characteristics such as pH, cation exchange capacity, total organic carbon, total organic matter, total nitrogen, total phosphorus, potassium, moisture

content, soil conductivity and heavy metals (Mn, Pb Ni, Cd, Cu) were determined in the control soil from Agbor which was unaffected by flood and the flood affected soils from Asaba and Onitsha respectively. Soil pH was determined electrometrically following the procedure outlined by Mylavarapus and Kennelley [6]. Total organic carbon and matter were determined by the wet dichromate acid oxidation method of Nelson and Sommers [7]. Total Nitrogen was determined using the method of Radojevic and Bashkin [8]. Total Phosphorus was determined by Bray and Kurtz method [9]. Electrical conductivity was carried out as described by Chopra and Kanzer [10]. Potassium was determined spectrophotometrically using the method outlined by Macgill [11]. Cation exchange capacity and moisture content were also determined using the method outlined by Macgill [11]. Heavy metals were subjected to nitric acid digestion [12] so as to convert all the metals present in the sample into such a form that they can be analyzed by the atomic absorption spectrophotometer, before determining the metals spectrophotometrically.

2.4. Quality Control

Appropriate quality control measures and recovery studies were carried out. All reagents used in this study were of pure analytical grade and were checked for possible trace metal contamination. All glass wares for metal analysis were previously soaked in 14% nitric acid (v/v) for 24 hours to remove all entrained metals, washed with detergents and rinsed with deionised water. Blank runs were conducted to reduce the occurrences of determinate errors. Procedural blank and working standard solutions for nickel, copper, lead, cadmium, manganese and potassium were prepared by diluting concentrated stock solution with distilled water. A known standard was run after every three parameters to check the reliability of the analytical instrument. The reliability of the entire procedure was carried out by spiking already analysed samples with known metal standards and re-analysed. The percentage recovery achieved for each metal were 94.6%, 92.5%, 96.8%, 93.3%, 94.3% and 95.7% for nickel, copper, lead, cadmium, manganese and potassium respectively. Triplicate analyses were performed on all the samples to yield a mean which was used to determine trueness and also standard deviation of the mean to measure precision [13,14].

2.5. Statistical Treatments

Samples were prepared in replicate of three to provide data for statistical treatment as shown in **Table 1** of result. Standard deviation, relative standard deviation and coefficient of variation (CV) calculations were used to checkmate indeterminate (random) error as seen in **Table 1**. Sets of replicate results obtained from the study were found to have measurement uncertainty of less than 0.01% and precision of 100% in terms of their coefficient of variations in all cases, since their coefficient of variation values were all less than ten as presented and shown in

Table 1. Statistical treatment using coefficient of variation (C.V) for data's of soil parameters for all samples.

Parameters	Agbor soil	Relative standard deviation	C.V	Onitsha soil	Relative standard deviation	C.V	Asaba soil	Relative standard deviation	C.V
pH	7.8 ± 0.04	0.005	0.5	7.10 ± 0.03	0.004	0.4	6.7 ± 0.09	0.01	1
T.O.C	1.30 ± 0.01	0.008	0.8	1.25 ± 0.05	0.04	4	1.12 ± 0.08	0.07	7
T.O.M	2.24 ± 0.03	0.013	1.3	2.16 ± 0.01	0.005	0.5	1.93 ± 0.06	0.03	3
T.N	11.54 ± 0.08	0.007	0.7	5.34 ± 0.06	0.01	1	6.42 ± 0.09	0.01	1
T.P	22.45 ± 0.06	0.003	0.3	18.54 ± 0.03	0.002	0.2	16.42 ± 0.01	0.0006	0.06
C.E.C	29.53 ± 0.01	0.0003	0.03	21.53 ± 0.02	0.0009	0.09	18.24 ± 0.05	0.003	0.3
E.C	73.2 ± 0.04	0.0005	0.05	140.8 ± 0.01	0.00007	0.007	112.8 ± 0.05	0.0004	0.04
M.C	9.85 ± 0.09	0.009	0.9	11.5 ± 0.06	0.005	0.5	14.25 ± 0.03	0.002	0.2
Potassium	12.88 ± 0.03	0.002	0.2	6.54 ± 0.01	0.002	0.2	7.28 ± 0.05	0.007	0.7
Manganese	54.88 ± 0.05	0.0009	0.09	40.12 ± 0.05	0.001	0.1	32.48 ± 0.04	0.001	0.1
Nickel	14.11 ± 0.04	0.003	0.3	$\mathbf{10.52} \pm 0.02$	0.002	0.2	8.29 ± 0.03	0.004	0.4
Cadmium	5.25 ± 0.03	0.006	0.6	7.51 ± 0.01	0.001	0.1	6.21 ± 0.08	0.01	1
Copper	18.51 ± 0.03	0.002	0.2	24.55 ± 0.01	0.0004	0.04	27.21 ± 0.03	0.001	0.1
Lead	2.11 ± 0.02	0.009	0.9	4.52 ± 0.05	0.01	1	3.82 ± 0.04	0.01	1

Table 1. Coefficient of variation for any measurement must be less than ten to give very good measurement precision [15]. The statistical results for coefficient of variation in this study indicate very good precision for all the triplicate measurements as the variation between triplicate values were very insignificant. Therefore the results are said be of very high precision. Pearson and spearman's correlations as well as paired sample statistics using T-Tests were used in analyzing the results.

3. Results and Discussion

Physicochemical characteristics of the soil in the control farmland and flood affected farmlands are presented in Table 2.

The mean pH values for soil samples collected from farmlands in Fege, Onitsha and Okwei, Asaba were found to be 7.10 and 6.70 respectively, as against that for the control soil from Farmland in Alihame, Agbor which was 7.80, accounting for a 14% and 9% decrease respectively. The control soil was weakly alkaline than those of the flood affected farmland areas. Slightly alkaline soils as observed in the control soil are necessary for improved soil quality since studies have shown decreased toxic metal availability with increasing pH [16]. The post effect of flooding on the affected farmlands (fege onitial, and okwei asaba soil) is evident in the reduction in pH values, tending the soils towards acidity. Soil saturated with water causes pH reduction due to organic acid produced from fermentation. The pH of alkaline soils declines and pH of acid soils increases. Soil pH determines nutrient availability and the potency of toxic substances

as well as the physical properties of the soil. Soil pH is a major factor influencing the availability of elements in the soil for plant uptake [17]. Many metal cations are more soluble and available in the soil solution at low pH (below 5.5) including Cd, Cu, Hg, Ni, Pb, and Zn [18]. pH in acidic range affects the solubility of minerals and nutrient availability in flood affected soils. The pH is not only essential for determining the availability of many soil nutrients, but also in determining the fate of many soil pollutants, their breakdown and possible movement through the soil [15]. Soil acidity is one of the major problems for agricultural production in many parts of the world [19]. Continuous flooding on farmlands will inevitably result in gradual decrease in soil pH, thereby tending the soil towards increased acidity which is a problem for agriculture. The observed pH reduction in the flood affected soils is similar to the findings of Kalshetty, *et al.*, [20] where pH of cultivated soil reduced on flooding from river Krishna in Bagalkot District, Karnataka State, Southern India. However the reduced pH values of the flood affected soils fell within prescribed legal limit of 6.5 - 7.5 [20].

Electrical conductivity (EC) values for the control soil was found to be 73.2 µS/cm, while the flood affected farmland in Onitsha and Asaba were found to be 140.8 µS/cm and 122.8 µS/cm; accounting for a 92% and 54% increase respectively. Electrical conductivity (EC) is a measure of ionic concentration in the soils and is therefore related to dissolve solutes such as ions and salts. It is a measure of the soil salinity. The resulting flood on the affected soils drastically increased their electrical con-

Table 2. Physicochemical characteristics of the soil in the control farmland and flood affected farmlands.

Parameters	Agbor Soil	Onitsha soil	Asaba soil
pH	7.8 ± 0.04	7.10 ± 0.03	6.7 ± 0.09
Total organic carbon (%)	1.30 ± 0.01	1.25 ± 0.05	1.12 ± 0.08
Total organic matter	2.24 ± 0.03	2.16 ± 0.01	1.93 ± 0.06
Total Nitrogen (mg/kg)	11.54 ± 0.08	5.34 ± 0.06	6.42 ± 0.09
Total Phosphorus (mg/kg)	22.45 ± 0.06	18.54 ± 0.03	16.42 ± 0.01
Cation Exchange capacity (meq/100 g)	29.53 ± 0.01	21.53 ± 0.02	18.24 ± 0.05
Electrical conductivity (µS/cm)	73.2 ± 0.04	140.8 ± 0.01	112.8 ± 0.05
Moisture content	9.85 ± 0.09	11.5 ± 0.06	14.25 ± 0.03
Potassium	12.88 ± 0.03	6.54 ± 0.01	7.28 ± 0.05
Manganese	54.88 ± 0.05	40.12 ± 0.05	32.48 ± 0.04
Nickel	14.11 ± 0.04	10.52 ± 0.002	8.29 ± 003
Cadmium	5.25 ± 0.03	7.51 ± 0.01	6.21 ± 0.08
Copper	18.51 ± 0.03	24.55 ± 0.01	27.21 ± 0.03
Lead	2.11 ± 0.02	4.52 ± 0.05	3.82 ± 0.04

ductivity values as seen in the result presented in **Table 2**. This is due to the exogenous input of salts, ions and total dissolved solids carried by the flood from the ocean into the soil. The EC values recorded are considered normal since as a point of reference, EC values less than 250 (umhos/cm) are indicative of soils which have low salinity hazards to plants [21]. However excessive salt accumulation can damage crops and soil structure. Damage to salt sensitive crops can be expected when soil electrical conductivity reaches 2 dS/m or 2000 µS/cm [22]. Therefore constant flooding of such soil should be checked and avoided to prevent excessive accumulation of ions in the soil, resulting in high salinity hazards to plants. The increased EC values on the flood affected farmlands are similar to the findings of Kalshetty, *et al.*, [20] where EC values of cultivated soil increased tremendously on flooding from river Krishna in Bagalkot District, Karnataka State, Southern India.

Total organic carbon in the control farmland was 1.3%, while the affected farmlands in Onitsha south and Asaba were found to be 1.25% and 1.12%; accounting for a 4% and 14% reduction respectively. Total organic carbon (TOC) is a measure of organic content in soils, sediments and water [23], and contributes significantly to acidity through contributions from organic acids and biological activities. A slight reduction in total organic carbon was observed in the flood affected farmlands, which could be adduced to the effect of flooding; as most soil organic content such as organic acids and humus which are the sole source of organic carbon could have been leached out by the impact of the flood. Decreased organic carbon content of soil adversely affects soil quality and fertility since organic carbon is required to stimulate microbial respiration and activities. The reduced organic carbon content in the flood affected farmlands is at variance with the findings of Kalshetty, *et al.*, [20] where increased organic carbon content was observed in flood affected cultivated areas in India. Though, the reduced organic carbon content in the flood affected farmlands fell within prescribed legal limit since they were greater than 0.75% [20].

Total organic matter in the control farmland was 2.24%, while the affected farmlands in Onitsha south and Asaba were found to be 2.16% and 1.93%, giving a 4% and 14% decrease respectively. A reduction in soil organic matter observed in the affected farmlands is not a healthy development for agricultural soils because organic matter contains humus which is the store and supplier of plant nutrients [24]. It is very essential and important in maintaining soil fertility. Organic matter is an energy supplier (electron donor) for microbial processes [25] which can adsorb or form complexes with potentially toxic metals and other compounds decreasing their availability to plant and microbial life [26]; so a reduction is disadvantageous for agricultural soils. Organic

matter in soil can be decomposed into large organic molecules and mineralised further to inorganic nutrients. The large organic molecules are also humified to fulvic and humic acids [27]. The decomposition rate is often lower in anaerobic flooded conditions than in aerobic non-flooded conditions. Soil organic matter also contains positive and negative charges for cation and anion exchange, so a reduction implies low exchange capacity of the soil resulting in less availability of minerals and nutrients.

Nitrate levels were found to be 11.54 mg/kg, 5.34 mg/kg and 6.42 mg/kg for the control farmland, flood affected farmlands in Onitsha and Asaba respectively, reflecting a 54% and 44% reduction respectively in the flood affected farmlands. During a flood event, the ammonium concentration (NH_4^+) in a soil will increase, due to a net increase of ammonification and strong limitation of (aerobic) nitrification processes [28]. The NH_4^+ concentrations may reach levels toxic for plants during extended flooding periods; however, the toxicity thresholds are different for plant species [29]. When available oxygen is depleted in a flooded soil and nitrate is available, denitrification, the reduction of NO_3^- to NO, N_2O, or N_2, primarily occurs. Denitrification is an anaerobic process in which nitrate serves as the terminal electron acceptor, and generally some source of organic carbon is the electron donor (also H_2 may serve as a donor). Denitrification is carried out by obligate respiratory bacteria belonging to the genera *Agrobacterium*, *Alcaligenes*, *Bacillus*, *Paracoccus denitrificans*, *Pseudomonas* and *Thiobacillus* [30] with the process occurring primarily by facultative anaerobes. In this process, nitrate is oxidized to nitric oxide, then nitrous oxide, and then fully oxidized to dinitrogen, accounting for the nitrate reduction; NO_2^- -- > NO-- > N_2O-- > N_2.

The reduction in nitrate levels on the flood affected farmlands is similar to the findings of Kalshetty, *et al.* [20] where reduced nitrate levels were also observed on flooding of cultivated areas from river Krishna in Southern India. Nitrate content is an important soil parameter that enhances soil quality, fertility and productivity.

Depletion in the phosphorus level was also observed from 22.45 mg/kg in the control farmland to 18.54 mg/kg and 16.42 mg/kg in the flood affected Onitsha farmland and Asaba farmland soils, accounting for a 17% and 27% decrease respectively. Possible leaching of available phosphorus as phosphate in the soil by the flood could account for this observation, since in water columns, anaerobic conditions renders it soluble (http://depts.washington.edu/ehuf475/outsoil.htm). Phosphorus reduction in the flood affected farmlands is in strong contrast with the findings of Kalshetty, *et al.*, [20] where increased phosphorus levels were seen in flood affected cultivated soils in India.

An increase in the concentration of Pb, Cd, and Cu

were observed in the flood affected farmlands from Pb (2.11 mg/kg), Cd (5.23 mg/kg) and Cu (18.5/mg/kg) in the control farmland to 114% of Pb (4.52 mg/kg,) 43% of Cd (7.5/mg/kg,), 33% of Cu (24.53 mg/kg) in the flood affected farmland at Onitsha; and 81% of Pb (3.82 mg/kg), 18% of Cd (6.21 mg/kg), 47% of Cu (27.21 mg/kg) in the flood affected farmland at Asaba. The increased concentration of Pb, Cd, and Cu observed on the farmlands affected by flood could be due to lithogenic input of these metals and their salts from the ocean which was carried by the flood into the soil. The flood and its resulting high moisture content of the soil could have created favorable conditions in the soil for the metals to be present in forms that are highly available. This could be supported by the findings of Abeh et al., [31] who reported that metal concentrations could be in forms that can easily be made available under favorable conditions. Although lead and copper in the analyzed soils were within acceptable limits [32-34], an increase in concentrations in the flood affected soils is a potential environmental risk and threat if such flood continues in the future, since it has been established from the findings of this study that flooding resulted in increased levels of these metals. Increased levels of copper in the flood affected farmlands are in strong contrast with the findings of Kalshetty, et al., [20] where reduced levels were seen in flood affected cultivated soils in India.

The concentration of cadmium in the soils exceeded recommended standards [32-34], therefore further increase in cadmium concentrations in the flood affected soils as seen in the result is a serious environmental problem that emanated from the effect of the flooding.

A decrease in concentration was observed for manganese, nickel and potassium from Mn (54.88 mg/kg), Ni (14.11 mg/kg) and K (12.88 mg/kg) in the control farmland to 27% of Mn (40.11 mg/kg), 25% of Ni (10.52 mg/kg), 49% of K (6.54 mg/kg) in the flood affected farmland at Onitsha, and 41% of Mn (32.48 mg/kg), 41% of Ni (8.28 mg/kg), 44% of K (7.28 mg/kg) in the flood affected farmland at Asaba. The value for Mn, Ni and K in the analyzed soils all fell within acceptable limits [32-34]. But a reduction in Mn and Ni concentration in the affected soils on account of the flooding effect is not a healthy development because these are essential micronutrients required in the soil for improved soil productivity. Reduced levels of manganese and potassium in the flood affected farmlands are in strong contrast with the findings of Kalshetty, et al., [20] where increased levels were seen in flood affected cultivated soils in India.

Floods are expected to alter nutrient availability of soils, due to leaching of water soluble nutrients and due to the chemical composition of transported material deposited in the layer of the soil. Potassium is a macronutrient that is not only required for healthy plant growth in the soil, but also for proper microbial functioning; there-

fore a reduction in potassium levels in the flood affected soils is a negative impact on soil quality.

An increase in moisture content was observed from 9.85% in the control farmland to 11.50% and 14.25% in the affected farmlands at Onitsha and Asaba, giving a 17% and 45% decrease respectively. The increased moisture content was due to the high retention of water brought about by the flooding. Flood increases the water holding capacity and water availability for plants [35].

Excess moisture content is undesirable because it reduces the amount of available oxygen for aerobic respiration.

Cation exchange capacity were found to be 29.53 meq/100 g, 21.53 meq/100 g and 18.24 meq/100 g for the control farmland, flooded farmland in Onitsha and flooded farmland in Asaba, reflecting a 27% and 54% decrease respectively. Cation exchange capacity is a measure of its ability to hold, release and exchange positively charged nutrients (cations). It is also a measure of how many negatively charged sites are available in the soil. The reduced cation exchange capacity levels in the flood affected farmlands could be due to the impact of the flood, as compounds formed as a result of positively charged nutrient held to the negative sites of the soil could have been leached away resulting in few negative sites available for cation exchanges. Reduced organic matter in the flood affected soils could have also accounted for the reduction in cation exchange capacity, since organic matter contributes to the cation exchange capacity of the soil by increasing adsorption sites for cations [36].

Reduced cation exchange capacity is not favorable for agricultural soil because it limits the availability of essential positively charged macro and micro nutrients to be adsorbed on soil particles, since few negatively charged sites will be available to attract them. The reduction in cation exchange capacity levels on the flood affected farmlands is similar to the findings of Kalshetty, et al., [20] where reduced levels were also observed on flooding of cultivated areas from river Krishna in Southern India.

Significant variations were observed at 95% confidence limit when the data's obtained from the flood affected farmlands were correlated and compared with data's obtained from the control farmland using paired sample T-test statistics ($p \leq 0.05$) and Pearson/Spearman correlation ($p \leq 0.01$) respectively, reflecting significant effect and impact of the flood on the physicochemical properties of the affected farmlands.

3.1. Comparative Evaluation of the Post Effect of Flooding on the Different Farmlands

As evident in Table 2, soil parameters such as pH, total organic carbon, total organic matter, total phosphorus

and cation exchange capacity in flood affected farmland soil collected from Asaba suffered more of the flooding effect as there were considerable reduction in their observed values at $p \leq 0.01$ when compared to similar parameters in flood affected farmland soils from Onitsha, as against the values in the control farmland at Agbor that was not flooded. The observed high moisture content in Asaba farmland when compared to farmland in Onitsha justifies and accounts for the major effect seen in Asaba farmland soil.

The resulting flood showed more impact on the availability of essential micronutrients in farmland soil collected from Asaba when compared to that from Onitsha, as an evaluation of the metal concentrations showed lower concentrations of manganese and nickel in Asaba farmland, except for potassium which gave reduced concentration value in Onitsha farmland soil. Less availability of essential micronutrients is not good for agricultural soils. Increase level of copper in farmland soil from Asaba when compared to farmland soil in Onitsha also reflected a higher impact of the flooding on its metal content, since the concentration of copper in the flooded farmland soil in Asaba was tending towards undesirable level [33,34].

On the other hand, lead and cadmium gave higher concentrations in Onitsha farmland soil as compared to farmland soil in Asaba on account of the flood, reflecting higher impact of the flood in these metal levels present in the flood affected farmland in Onitsha.

Nitrate levels were found to be lower in farmland soil from Onitsha as compared to that in Asaba, showing higher impact of the flood in the nitrate content of the Onitsha farmland. Electrical conductivity values were seen to be higher in farmland soil from Onitsha than that in Asaba, showing higher impact of the flood in the conductivity level of Onitsha soil.

Out of fourteen soil quality parameters studied, nine of these parameters (pH, total organic carbon, total organic matter, total phosphorus, cation exchange capacity, moisture content, manganese, nickel and copper) had more significant effect of the flood on Asaba farmland, accounting for a 64.3% net effect when compared to Onitsha farmland which had more effect on only five parameters (total nitrogen, electrical conductivity, lead, cadmium and potassium), accounting for a 35.7% net effect from data's available. The overall statistics showed that cultivated farmland in Asaba, Delta State had more post flooding effect when compared to cultivated farmland in Onitsha, Anambra state; which may primarily be due to the Asaba farmland proximity to the river Niger, since the flood in this area was due to an overflow from the river Niger.

4. Conclusion

It is seen from the results of the study that the September-2012 flooding of farmland soils from Okwei, Asaba in Oshimilli South local government area of Delta State and fege, Onitsha in Onitsha South local government area of Anambra state, South-South and South-East Nigeria showed significant effect on the soil properties thereby affecting the quality of the soils in the aforementioned areas, when compared to similar properties in flood unaffected farmland soil from Alihame, Agbor in Ika South local government area of Delta State which was used as the control. There were considerable decreases ranging from 4% to 53% in the values of pH, total organic carbon, total organic matter, total nitrogen, total phosphorus and cation exchange capacity on the flood affected farmlands when compared to the control farmland; except for electrical conductivity where an increase of 54% and 92% at the flood affected farmlands in Asaba and Onitsha respectively was observed when compared to the control. Higher moisture contents were also recorded of up to about 17% and 45% at the flood affected farmlands in Asaba and Onitsha respectively when compared to the control. Reduced concentrations ranging from 25% to 49% of essential micronutrients such as Mn, Ni and K were observed on the flood affected farmlands, reflecting the negative impact of the flood. Undesirable effect of the flood was also recorded in increased concentrations ranging from 18% to 114% of Cd, Pb and Cu, in the flood affected farmlands as compared to the control farmland.

The findings of this study revealed significant impacts and effects of the resulting flood on soil quality parameters in farmland soils collected from Asaba and Onitsha respectively, with a major attendant effect of the flood felt on farmland in Asaba. Although soil quality was adversely affected in the two flooded farmland areas under consideration, farmland in Asaba suffered more of the flood impact from data's available.

5. Recommendation

The finding of this study suggests that measures should be put in place by government and concerned agencies to help reduce the probability of such heavy floods in the future to avoid future flooding of farmlands, so as not to further expose the natural quality of these farmlands to the degradative and devastating effect of such flooding.

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