INDUSTRIAL IMPACT ON PHYSICO-CHEMICAL PROPERTIES IN SOIL SAMPLES OF NNEWI-NORTH LOCAL GOVERNMENT AREA, ANAMBRA STATE, SOUTHEAST NIGERIA

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DOI: 10.29322/IJSRP.12.05.2022.p12526
http://dx.doi.org/10.29322/IJSRP.12.05.2022.p12526

Paper Received Date: 21st April 2022
Paper Acceptance Date: 7th May 2022
Paper Publication Date: 14th May 2022

Abstract- This study determined the Industrial impact on physico-chemical properties in soil samples of Nnewi-North, Anambra State, Nigeria. Soil samples were collected quarterly from four villages and used to conduct the physical and chemical properties. Analytical methods were employed for the determination of these physico-chemical properties. The pH value ranged from 6.64-7.11 and 6.00-6.46 during the raining and dry season respectively. The soil pH increased with increase in rainfall being more acidic in the dry season than in the rainy season. The mean pH value was higher during raining season than in dry season with Uruagu soils (7.11) having the highest value. The mean EC value and OM content were higher in dry season than in raining season with the highest value of EC found in Umudim soils (1.30 dScm-1) and OM found in Nnewichi soils (1.51%). The mean sand and silt content were also higher during the raining season than in dry season with the highest value of sand content found in Uruagu soils (68.11%) and silt content (30.12%) in Umudim soils. Whereas mean clay content was highest during the dry season than in raining season with the highest value found in Uruagu soils (11.58%). The soils pH, EC and OC/OM were all affected by industrial activities in the area because most of these values were higher than the values obtained from control sites. Soil amendments should be encouraged to ensure soil fertility by application of recommended inorganic fertilizers and organic matter so as to further support growth of crops such as cocoyam, yam, cassava and so on.

I. Introduction

Industrialization is essential for economic growth of any nation as it acts as a vehicle for development. Modern life style with increasing population and industrial growth has impacted negatively on the environment at global scale [1]. To fulfil the basic requirements of increasing population, different types of industries have been set up in different regions of our country, Nigeria. These include pulp and paper, textile, cement, petrochemical, metal processing, food processing, fertilizer, sugar, pharmaceutical, distilleries among others. Heavy metals are in various raw materials, such as fossil fuels and metal ores, as well as in industrial products. Some trace metals are emitted entirely or partially from raw materials during the high-temperature production of industrial goods, combustion of fuels, and incineration of municipal and industrial wastes, entering the ambient air with exhaust gases [2]. Atmospheric emissions from industrial complexes are considered as the main source of the environmental pollution. These emissions travel along vast areas by the effect of the meteorological factors and be accumulated in soil, plant, animal and may reach the food chain [3].

Plants, like all other living things, need food for their growth and development. Plants require 16 essential elements. Carbon, hydrogen, and oxygen are derived from the atmosphere and soil water [4]. The remaining 13 essential elements (nitrogen, phosphorus, potassium, calcium, magnesium, sulfur, iron, zinc, manganese, copper, boron, molybdenum, and chlorine) are supplied either from soil minerals and soil organic matter or by organic or inorganic fertilizers. For plants to utilize these nutrients efficiently, light, heat, and water must be adequately supplied [4]. Agriculture alters the natural cycling of nutrients in soil. Intensive cultivation and harvesting of crops for human or animal consumption can effectively mine the soil of plant nutrients. In order to maintain soil fertility for sufficient crop yields, soil amendments are typically required. Early humans soon learned to amend their fields with animal manure, charcoal, ash, and lime ($CaCO_3$) to improve soil fertility. Today, farmers add numerous soil amendments to enhance soil fertility, including inorganic chemical fertilizers and organic sources of nutrients, such as manure or compost, often resulting in surplus quantities of primary macronutrients. The efficiency of fertilizer application and use by crops is not always optimized, and excess nutrients, especially N and P, can be transported via surface runoff or leaching from agricultural fields and pollute surface and groundwater [5,6]. The study of metal concentration in soils and plants are used not only to determine pollution levels but also for risk assessment and implication on human and animal health. Studies have shown that different plants have varying abilities and preferences for metals in soil. This is influenced by various factors including types of plants, nature of soils, climate and agricultural practices [7].

Cultural practices and control of diseases and insects also play important roles in crop production. Each type of plant is unique and has an optimum nutrient range as well as a minimum requirement level. Below this minimum level, plants start to show nutrient deficiency symptoms. Excessive nutrient uptake can also cause poor growth because of toxicity. Therefore, the proper

amount of application and the placement of nutrients is important. In addition to the levels of plant-available nutrients in soils, the soil pH plays an important role in nutrient availability and elemental toxicity [4].
Nnewi-North Local Government Area is known to be an area with a large number of industries which include petrochemical, metal fabrication, food processing, automobile spare parts industries among others. Apart from meeting the environmental impact assessment (EIA) conditions required for the setting of new industry or factory, most industries in this part of the world never bother on the disposal of their wastes. However, there has not been work carried out to holistically evaluate the impact of industries on physico-chemical properties in soil samples of Nnewi-North. It was against this backdrop that this work was carried out. The aim of this study was to assess the impact of industries on physico-chemical properties in soil samples of Nnewi-North Local Government Area.

II. MATERIALS AND METHODS

Study Area

Nnewi is the second largest city in Anambra state, southeastern Nigeria (figure 1). Nnewi-North Local Government Area is commonly referred to as Nnewi central, and comprises four autonomous quarters: Otolo, Uruagu, Umudim, and Nnewichi [8]. Its geographical coordinates are $6^0$1'0" North and 6^0 55'0" East. The city is located east of the Niger River, and about 22 kilometers south east of Onitsha in Anambra state, Nigeria [9]. Nnewi is home to many major indigenous manufacturing industries. Nnewi is part of eastern Nigeria's industrial axis and acts as sophisticated networks expanded to include an international dimension through trading relations with exporters from Asia [8]. Over the last decades, the town of Nnewi has experienced relatively rapid industrialization. In excess of twenty medium-to-large scale industries have been established across a variety of sectors. The Nnewi-North LGA is associated with several industrial processes such as lead batteries, paint and several manufacturing industries which are known to release heavy metals into the environment. Infact, Nnewi is usually referred to as the Japan of Nigeria because of its high industrialization and has about thirty giant manufacturing plants and over a hundred cottage industries [10].

Since 1970, Nnewi residents have controlled approximately 80 to 90 percent of the motor parts trade in Nigeria. Nkwo Nnewi Market is the major import and wholesale point for motor spare parts in Nigeria [8]. There are also many informal manufacturing activities in the production of motorcycle parts in Nnewi [8]. The first indigenous wholly Made-in-Nigeria motorcycle was manufactured in Nnewi by the National Agency for Science and Engineering Infrastructure (NASENI) [8]. By 1940, Nnewi residents were at the center of an international trading network that dominated the supply of motor parts in Nigeria. The town subsequently became a center for commerce and industry, and is known to have one of the largest automotive parts markets in Africa [11].

III. SAMPLE COLLECTION AND PRESERVATION

Soil samples were collected from four areas in Nnewi-North Local Government Area. The four areas include Otolo, Uruagu, Umudim, and Nnewichi (figure 2). Control soil samples were collected from Ebonato. Triplicate samples (15-20cm depth), from each study site and control site were collected ten meters apart in a straight form using a stainless steel knife and pooled into polythene bags labelled with site locations. The soil samples were collected twice in rainy and dry seasons. In the laboratory, the soil samples were mixed thoroughly to obtain a composite sample for each site. The composite samples were air-dried for seventy-two hours at room temperature, ground in a glass mortar with pestle and passed through 2.0mm sieve, further pulverized to a fine powder and passed through 0.5mm sieve for the physico-chemical properties analysis [12]. This ensured that the analyte is not lost and good results were achieved. A description of the sampling sites is listed in Table 1.

Determination of Moisture Content.

The moisture content was determined according to the method described by [13]. 10.0g of a representative sample of the soil was placed in a clean dry crucible of known weight. The crucible was placed in an oven maintained at 110±5^{0}C for two hours until a constant weight (W_3) was obtained. The loss in weight was determined and the % Moisture was calculated as follows:

$$\% \text{ Moisture} = \frac{(W_2 - W_3)}{(W_3 - W_1)}$$

Where W_2=weight of crucible with sample before oven drying, W_3= weight of crucible with sample after oven drying, W_1=weight of empty crucible.

Determination of pH in Soil ($H_2$0)

The pH of soil samples was determined according to [14] at a ratio of 1:2.5. Ten grams (10.0g) of the air dried sample were weighed into 100ml beaker and 25ml of distilled water was added and stirred. The suspension was allowed to stand for 30mins with occasional stirring with glass rod. The pH of the soil supernatant suspension soil was then determined using a pH meter.

Determination of Electrical Conductivity

The electrical conductivity was determined according to the method of [15]. Ten grams (10.0g) of the air dried sample were weighed into 100ml beaker and 20ml of distilled water was added and stirred. The suspension was allowed to stand for 30mins with occasional stirring with glass rod to dissolve the soluble salts. The conductivity meter was calibrated with 0.01M Potassium Chloride Reference Solution to obtain the cell constant of 1.413dScm^{-1}. Then the electrode was gently lowered into soil suspension and reading was taken.

ISSN 2250-3153

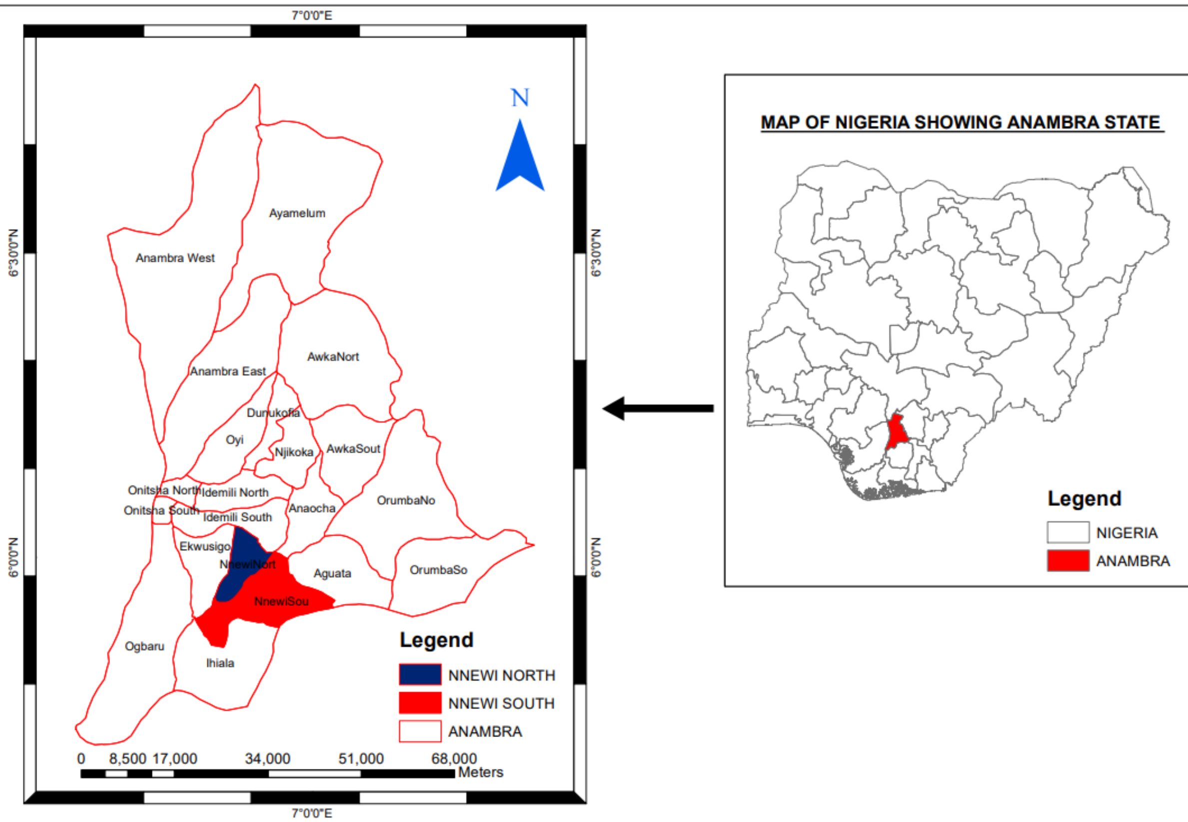

FIGURE 1: MAP OF ANAMBRA SHOWING NNEWI-NORTH

Table 1 Description/Identification of Sampling Sites

S/N	Areas	Code	Sample site address	The Coordinates	Number of samples
1	Otolo	OTN	Otolo North	$05^{o}59.282^{I}N/06^{o}57.656^{I}E$	9
2	Otolo	OTS	Otolo South	$06^{o}00.342^{I}N/06^{o}55.264^{I}E$	9
3	Otolo	OTE	Otolo East	$05^{o}59.768^{I}N/06^{o}56.716^{I}E$	9
4	Otolo	OTW	Otolo West	$06^{o}01.258^{I}N/06^{o}55.958^{I}E$	9
5	Uruagu	URN	Uruagu North	$06^{o}02.512^{I}N/06^{o}52.800^{I}E$	9
6	Uruagu	URS	Uruagu South	$06^{o}01.059^{I}N/06^{o}54.175^{I}E$	9
7	Uruagu	URE	Uruagu East	$06^{o}02.225^{I}N/06^{o}54.038^{I}E$	9
8	Uruagu	URW	Uruagu West	$06^{o}01.575^{I}N/06^{o}56.032^{I}E$	9
9	Umudim	UMN	Umudim North	$05^{o}59.009^{I}N/06^{o}54.209^{I}E$	9
10	Umudim	UMS	Umudim South	$06^{o}00.860^{I}N/06^{o}54.927^{I}E$	9
11	Umudim	UME	Umudim East	$05^{o}59.662^{I}N/06^{o}53.915^{I}E$	9
12	Umudim	UMW	Umudim West	$05^{o}59.928^{I}N/06^{o}54.594^{I}E$	9
13	Nnewichi	NNN	Nnewichi North	$06^{o}01.647$lN/$06^{o}55.738^{I}E$	9
14	Nnewichi	NNS	Nnewichi South	$06^{o}02.462^{I}N/06^{o}55.530^{I}E$	9
15	Nnewichi	NNE	Nnewichi East	$06^{o}01.654^{I}N/06^{o}55.165^{I}E$	9
16	Nnewichi	NNW	Nnewichi West	$06^{o}02.210^{I}N/06^{o}55.823^{I}E$	9
17	Ebenato	EBN	Ebenato North	$05^{o}57.440^{I}N/06^{o}57.446^{I}E$	9
18	Ebenato	EBS	Ebenato South	$05^{o}55.675^{I}N/06^{o}57.318^{I}E$	9
19	Ebenato	EBE	Ebenato East	$05^{o}56.962^{I}N/06^{o}57.446^{I}E$	9
20	Ebenato	EBW	Ebenato West	$05^{o}56.886^{I}N/06^{o}57.305^{I}E$	9

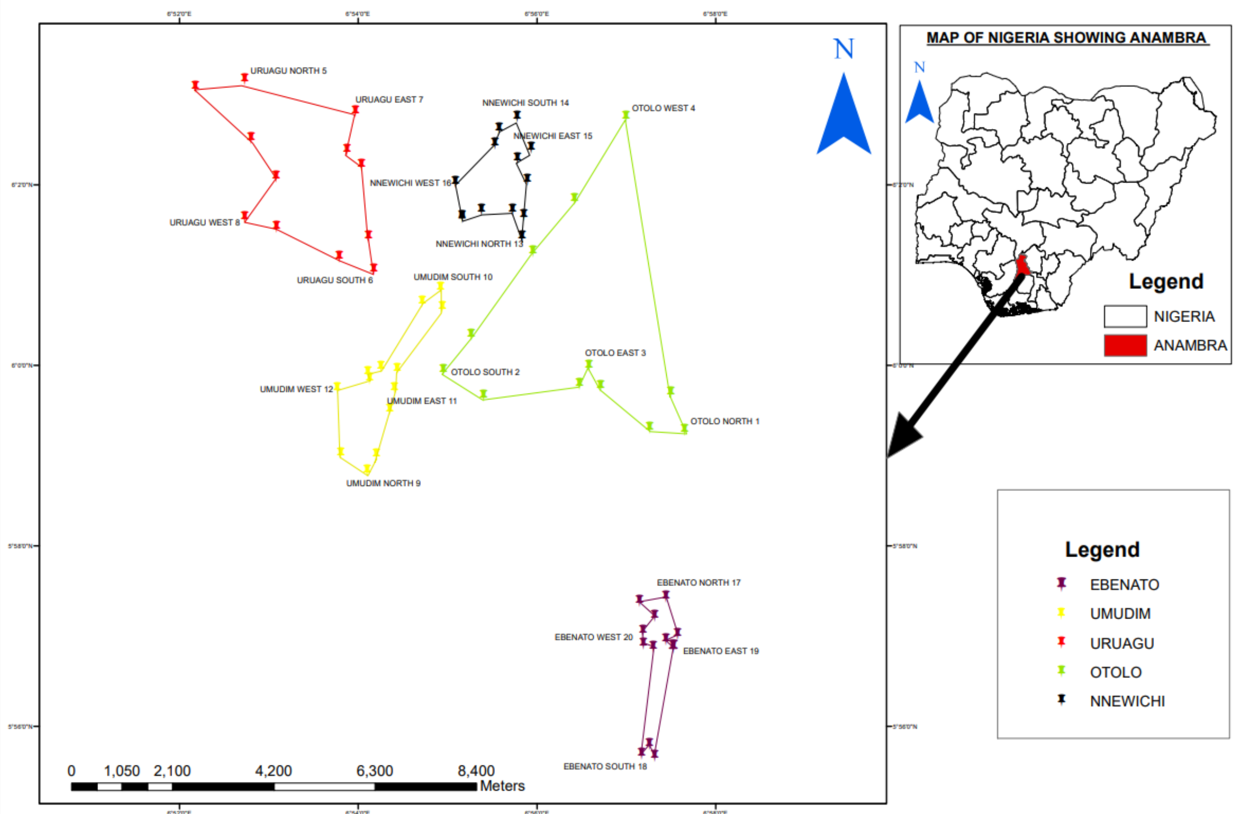

FIGURE 2: MAP OF THE STUDY AREA SHOWING SOIL SAMPLING POINTS

Determination of Particle Size.

Particle size analysis was determined according to the method of [16]. 50.0g of the soil sample was weighed into a 1000ml measuring cylinder and 3ml of 1M Na0H measured into each cylinder. The cylinder was made up to the mark with distilled water. The mixture was shaken and left for 40 seconds before dipping the hydrometer into it to determine the sandy content while the clay and silt was determined after 3 hours' interval (for the mixture to settle down) through the same process. The temperatures were then recorded simultaneously. % sand, % clay and % silt were calculated as follows.

$$S = \frac{R-RL \pm T \times 100}{W}$$

Where, R=Hydrometer reading, RL=Calibration correction, T=Temperature correction for 40 seconds and 3 hours respectively at corresponding temperature readings T_1 and T_2, W=air dry weight of soil sample.

Determination of Organic Carbon

The Organic carbon content of soils was determined by the [17] method. About 1.0g of soil sample containing organic carbon was placed in a 250ml conical flask and 10ml of 1M potassium dichromate solution was added and the content swirled gently. Later it was swirled rapidly and 20ml of concentrated sulphuric acid was added directing the steam into the suspension. The flask was immediately swirled gently until the soil and the reagent were mixed. Then more vigorously for 1 minute. The flask was kept on a head table for 30 minutes. 150ml of distilled water was added and 10ml of phosphoric acid and 10 drops of diphenalamine indicator were also added. The content was titrated with 0.5N ferrous sulphate solution with end point indicating a change from greenish to turbid blue then to deep green.

$$\% \text{ Carbon} = \frac{(B-T) \times (F \times 0.03 \times 1.33 \times 100)}{W}$$

Where, B = Volume of $FeSO_4$ used in titration of the blank
T= Volume of $FeSO_4$ used in titration of soil sample
F= Strength of $FeSO_4$ which is given by

$$S_2 = \frac{V_1 S_1}{V_2}$$

S_2= F
V_2= Blank
S_1= Strength of K_2CrO_7
V_1= Volume of K_2CrO_7
W= Weight of soil

IV. RESULTS AND DISCUSSIONS

Soil pH

Tables 2-5 summarize the physicochemical properties of the soil during the raining and dry season as well as the combined seasonal data for the studied area. The pH of the soil ranged from 6.00-7.11 with the mean value of 6.52±0.39, moving from moderately acidic to neutral (Table 5). Generally, the soil pH during the dry season were slightly acidic with the soil pH of Uruagu being the highest with a value of 6.46±0.64 (Table 3). Ebenato had the highest soil pH of 8.43±0.74 during the raining season. The soil pH of the studied area was more acidic in the dry season than in the rainy season. Nnewichi had the lowest soil pH of 6.64±0.84 during the raining season (Table 2) compared to Otolo with a soil pH of 6.00±0.50 which was the lowest during the dry season. The result of soil reaction indicated that the soil pH was moderately acidic to neutral across the study area. The trend in this result showed that acidity increases with decrease in soil moisture. The soils were acidic during the dry season and as the rainy season increases, pH values also increase even reaching to moderately alkaline. This trend can be attributed to the fact that increased moisture in the soil dissolves more soluble salts for instance, exchangeable Ca^{2+} and Mg^{2+} which has the potential to increase pH to a neutral value (6.00-7.11) thus, reducing acidity [18].

Table 2 Mean Physicochemical Properties of Soils during the Raining Season

Parameter	Location					
	Otolo	Uruagu	Umudim	Nnewichi	Mean±sd	Ebenato
pH (1:2.5)	6.77±0.41	7.11±0.90	6.70±0.50	6.64±0.86	6.80±0.20	8.43±0.74
EC ($dScm^{-1}$)	1.11±0.12	1.12±0.10	1.13±0.14	1.12±0.10	1.12±0.006	1.02±0.03
OM (%)	0.98±0.16	1.20±0.20	1.22±0.19	1.24±0.21	1.16±0.12	0.72±0.03
MC (%)	13.27±2.71	10.58±0.60	12.56±2.35	12.44±4.99	12.21±1.14	9.70±3.33
Sand (%)	66.29±4.11	68.11±6.94	60.45±2.92	66.31±1.06	65.29±3.33	67.21±0.43
Silt (%)	28.91±2.98	28.62±6.36	30.12±2.12	27.26±1.86	28.73±1.17	29.43±2.36
Clay (%)	4.8±1.13	3.27±0.57	9.43±5.04	6.43±0.80	5.98±2.63	3.36±1.92
Textural Class	SL	SL	SL	SL	SL	SL

NB: EC = Electrical conductivity, OM = Organic matter, MC = Moisture content, SL = Sandy loam

Table 3 Mean Physicochemical Properties of Soils during the Dry Season

Parameter	Location					
	Otolo	Uruagu	Umudim	Nnewichi	Mean±sd	Ebenato
pH (1:2.5)	6.00±0.50	6.46±0.64	6.18±0.66	6.33±1.03	6.24±0.19	6.62±0.26
EC ($dScm^{-1}$)	1.26±0.09	1.24±0.05	1.30±0.21	1.28±0.11	1.27±0.02	1.05±0.14
OM (%)	1.44±0.19	1.35±0.12	1.45±0.05	1.51±0.04	1.43±0.06	1.18±0.09
MC (%)	5.37±1.20	5.02±1.44	4.77±1.20	5.05±0.86	5.05±0.24	5.06±1.33
Sand (%)	62.54±4.72	66.28±4.37	59.85±1.19	66.86±1.64	63.88±3.29	68.24±1.41
Silt (%)	29.58±1.15	22.14±10.33	30.03±2.25	25.85±2.70	26.90±3.68	26.76±1.41
Clay (%)	7.88±3.56	11.58±5.96	10.12±1.06	7.29±1.06	9.22±1.99	5.00±0.00
Textural Class	SL	SL	SL	SL	SL	SL

NB: EC = Electrical conductivity, OM = Organic matter, MC = Moisture content, SL = Sandy loam

Table 4 Statistics for Physicochemical Properties of Soils during the Seasons

Parameter	Rainy Season Mean±sd	Range	Dry season Mean±sd	Range
pH (1:2.5)	6.80±0.20	6.64-7.11	6.24±0.19	6.00-6.46
EC ($dScm^{-1}$)	1.12±0.006	1.11-1.13	1.27±0.02	1.24-1.30
OM (%)	1.16±0.12	0.98-1.24	1.43±0.06	1.35-1.51
MC (%)	12.21±1.14	10.58-13.27	5.05±0.24	4.77-5.37
Sand (%)	65.29±3.33	60.45-68.11	63.88±3.29	59.85-66.86
Silt (%)	28.73±1.17	27.26-30.12	26.90±3.68	22.13-30.02
Clay (%)	5.98±2.63	3.27-9.43	9.22±1.99	7.29-11.58
Textural Class	SL	-	SL	-

NB: EC = Electrical conductivity, OM = Organic matter, MC = Moisture content, SL = Sandy loam.

Table 5 Statistics for Combined Physico-chemical Properties of Soils in the Studied Area

Parameter	Mean±sd	Range
pH (1:2.5)	6.52±0.39	6.00-7.11
EC ($dScm^{-1}$)	1.19±0.10	1.11-1.30
OM (%)	1.29±0.19	0.98-1.51
MC (%)	8.63±5.06	4.77-13.27
Sand (%)	64.58±0.99	59.85-68.86
Silt (%)	27.80±1.29	22.13-30.12
Clay (%)	7.59±2.28	3.27-11.58
Textural Class	SL	-

NB: EC = Electrical conductivity, OM = Organic matter, MC = Moisture content, SL = Sandy loam

However, in the control site which had a lower moisture content, the high pH value could be attributed to low organic matter content in the soil which produce less carbonic acid thus leading to high pH value [18,19].

Ratio of mixing between soil and water has the potential of altering the soil reaction. When the soil exchange site is rich in basic cations, such as Ca, Mg and Na, the possibility of raising the soil pH is high especially under continuous or prolonged moist condition in the soil. This assertion is in consonance with [18] as well as [19]. Also, the porous nature of the soil texture being dominated by sand particles permits excessive leaching of basic cations beyond the rhizosphere, thus creating acidic soils that are dominated by acidic cations such as H^+ and even Al^{3+}. These findings agree with [20].

Seasonal variation is important in the distribution of elemental cations in the soil and this in turn influences changes in the soil reaction. Also, relatively lower pH values observed during the dry season especially from the industrial areas samples suggested the decomposition of organic matter that releases carbon (iv) oxide which reacts with soil water to form carbonic acid which eventually reduces soil pH [21]. This low pH enhances heavy metal solubility and mobility in the soil [21]. Heavy metal mobility decreases with increasing soil pH, hence all the industrial sites sampled had relatively lower pH values than the control site and had high concentration of heavy metals. This variability further suggests the effect of pH on the availability of heavy metals. It is noteworthy that pH is an important soil property, having great effects on solute concentration and sorption/desorption of contaminants in soils. The low pH enhances metals transportation and distribution in soils [22].

Electrical Conductivity (EC)

The distribution of electrical conductivity (EC) of the soil of the studied area ranged from 1.11-1.13dScm^{-1} with a mean value of 1.12±0.006 for the raining season and a range of 1.24-1.30 dScm^{-1} and a mean value of 1.27±0.02 for the dry season (Table 4). The soil of Umudim had the highest EC of 1.30±0.21 and a least level was found in the soil of Ebenato (1.05±0.14) during the dry season (Table 4.2). Generally, the soil EC were lower during the raining season (Table 2).

The result showed that EC was higher in the dry season samples than in the rainy season. This implied that seasonal variation caused some changes or fluctuation in the status of electrical conductivity of the soil leading to increased EC as the soil gets drier. Electrical conductivity is the rate at which a soil conducts electricity or allows electric current to flow through it [23]. It is in essence a measure of the amount or preponderance of soluble salts in the soil solution. The trend in the soil showed an increase in the concentration of EC in the soil with change in season from rainy to dry season. This can be attributed to fluctuating moisture status in the soils as is also being reported by [24]. In some instance, changing human activities or anthropogenic activities can cause changes in soil EC owing to deposition or indiscriminate disposal of industrial wastes that may contain soluble salts [24].

Organic Matter

Soil organic matter of the studied area ranged from 0.98-1.24% OM with a mean value of 1.16±0.12 (Table 4) during the raining season The values ranged from low to moderate. Ebenato had the least value of 0.72±0.03 whilst Nnewichi had the highest value of 1.24±0.21 during the raining season. The dry season levels were higher than the levels recorded in the raining seasons.

Organic matter is the remains of plants and animals either decomposed or partially decomposed that is housed in the form of humus and measured as organic carbon. It is the store house of plants nutrients especially nitrogen, phosphorus and potassium as well as calcium and sulphur. Also it supplies some essential micronutrients required by plants for better growth and development. In the soil, it also serves as food for microbes and some meso organisms such as earthworms and some species of termites [19, 23]. The result showed generally that organic matter was more in the soils of Umudim and Nnewichi especially during the dry season. In all the sampling seasons, however, the control site Ebenato had the least in terms of organic matter content. It can be noted that organic matter was generally moderate in all the locations. In the lower slope position, materials are washed from upper slope and adjacent lands are being deposited and consequently increasing organic matter level. This assertion agrees with [23,25].

It can be seen that the content of organic matter in the soils across the four locations increased with change in season with the dry season producing highest content of organic matter in the soils in all the locations. This can be attributed to relative dryness in the soil that reduces the rate of mineralization and losses to leaching that is obvious during the rainy season [25]. In the rainy season, organic matter is easily taken up by plants roots and also lost to leaching and surface erosion which may be relatively slower in the dry season [25]. This could account for the reduced organic matter content of the soils during the rainy season.

The increase in organic matter content could also explain the reduction in pH values of the soils during the dry season. This is because presence of high amount of organic matter in the soil could lead to the formation of organic acids in the soil thus reducing the pH values of the soil. This assertion agrees with [25,26]. It is important to note that soil organic matter influences many physical and chemical conditions in the soil such as increased soil aggregation, increased moisture and nutrient holding potential of the soil and a general decrease in soil bulk density thus improving aeration status of the soil [18,20]. Also, organic matter in the soil could result in the formation of important compounds with some metal oxides in the soil. This is important in remediating heavy metals pollution or contamination in the soil since organic matter can bind the heavy metals and reduce its mobility in the soil as well as restrict or localize the contamination [26,27].

Soil Moisture Content (MC)

The moisture content of the soil of the studied ranged from 4.77-13.27% with a mean value of 8.63±5.06, moving from low to moderates (Table 5). Generally, the soil moisture during the raining season were higher, ranging from 10.58-13.27% with a mean value of 12.21±1.14 whist the dry season ranged from 4.77-5.37% with a mean value of 12.21±1.14 (Table 4). Otolo had the highest soil moisture content of 13.27±2.71 during the raining season (Table 2) compared to Umudim with a soil MC of 4.77±1.20 during the dry season (Table 3). Seasonal variation in soil moisture content indicate that soil moisture content was higher in the soils during the rainy season than in the dry season. These findings were similar to the report of [28]. The soil moisture values were rated low to moderate [26] and this may be attributed to low clay content in the soil as reported by [29]. Soil moisture content is the amount of water that is available in the soil and occupies the macro pores of the soils depending on the level of availability [30]. This is expected as rainfall is an important source of soil water under natural setting except where irrigation is practiced. Also, the low moisture content of 5.05% during the dry season in the soil can be attributed to the sandy nature of the soils which makes it porous and prone to excessive loss of moisture to evaporation, deep percolation which recharges the ground water table and aquifers as well as absorption by plants roots. This result agrees with [19,23]. It is important to note here that the soils would require irrigation especially during the early raining season as well as in the dry season as a security against inevitable moisture shortage in the soil, especially for crop production.

Soil Texture

The textural distribution of the soils showed that the soils of the area were generally determined as Sandy loam during the raining season having a sand proportion that ranged from 60.45-68.11% with a mean sand content of 65.29±3.33. Silt in the soils of the area ranged from 27.26-30.12 % with a mean value of 28.72±1.17 while clay content ranged from 3.27-9.43 % with a mean value of 4.8±1.13 % (Table 2). In the dry season also, soil texture was uniformly sandy loam with a high proportion of sand particles, moderate silt and low clay content. The sand content of the soils ranged from 59.85-66.86% with a mean value of 63.88±3.29. Silt in the soils of the area ranged from 22.13-30.02 % with a mean value of 26.90±3.68 while clay content ranged from 7.29-11.58% with a mean value of 9.22±1.99 during the dry season. There were no changes in the texture of the soils between the dry and raining season. Sand and silt particles were observed to be high while clay was very low in all the soils across the different locations and seasons. This finding agrees with [31] when he reported on the soils of the south eastern Nigeria as being predominantly sandy. Again, the soil textural class was generally sandy loam in both seasons. Soil texture being the relative proportion of sand, silt and clay in a soil sample is a permanent property that changes little or not at all regardless of time and land use types. Hence the soil texture remained the same in both seasons. This assertion agrees with [19,23] who noted that soil texture is a physical property of the soil that is relatively permanent and does not change with time. The slight change observed in Uruagu during the third quarter of the year where the texture changed from sandy loam to loamy sand can be attributed to possible sampling error due to season which are common possibilities, as exact spots sampled previously may not be easily established with precise accuracy. This assertion agrees with [32]. Soil texture plays an important role in mobility of metals in soils. As a result of the non-significant variations in the particle distribution it is expected that the concentrations of elements of interest, Cu, Zn, Mn, Ni, Co and Cd may increase with depth, possibly due to leaching from the surface [33].

V. CONCLUSIONS

An effluent is an inevitable product of industrial process. Effluent of different industries may vary in composition depending upon the source of production. Effluent may contain essential nutrients and some toxic substances. The available macronutrients and micronutrients of effluents can increase soil fertility. On the other hand, the heavy metals and toxic components can accumulate in soil. The process of metal uptake, accumulation and distribution in plants is strongly influenced by the soil characteristics including pH, cation exchange capacity (CEC), organic matter, metals content, solubility sequences and plant species [34]. The soils of the studied area were generally sandy loamy in texture with high sand content, moderate silt and very low clay content. This makes the soils porous and susceptible to leaching, erosion and loss of nutrients. The soil pH varied from moderately acidic to neutral (6.00-7.11) from the various locations and these are considered as normal for agricultural production. The organic matter contents were generally low to moderate in all the soils of the studied area whereas the electrical conductivity of the soils increased as the dry season increased. The soils pH, EC, and OC/OM were all affected by industrial activities in the area because most of these values were higher than the values obtained from control sites.

VI. RECOMMENDATIONS

There would be need for;

- Monitoring, educating and training of farmers on the levels of application of agrochemicals such as fertilizers, pesticides and herbicides since the effects of agrochemicals are often a result of improper use or improper choice of products in relation to the local conditions.
- There should be an increase in the public awareness with regard to the risk of the adverse health effects that could possibly arise from the environmental pollution by heavy metals.
- Since no industry is established in Nigeria without an Environmental Impact Assessment (EIA) study report, so there is need for the regulatory agency to monitor regularly the probable levels of wastes/effluents discharged by these industries after establishment to know whether the companies are keeping to terms.

ACKNOWLEDGMENT

With gratitude to God who made me what Iam today, I would like to express my profound appreciation to my supervisor, Prof. S.E Kakulu whose patience, encouragement, constructive criticism, understanding, remarks and accessibility have made this work a huge success.

Special thanks and appreciation goes to Mr Donatus Idowu whose effort alone made this noble dream of mine a reality. I cannot thank him enough because his efforts are immeasurable.

I would like to acknowledge the contributions of my able and dynamic friends; Dr. Chris Obudu of Dept. of Vet. Medicine University of Abuja, Mr Barnabas of Soil Science Department, Mr Asuquo, Dr. Afam Ikejiani, Amala Nzeribe, Dr. Sunny Adedeji and Barrister Peter Enya. All those who have contributed in one way or the other to the success of this work, may God bless you.

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