EFFECTS OF FARMING ACTIVITIES ON WATER QUALITY DYNAMICS OF OBINNA RIVER WATERSHED, ADANI UZO-UWANI LOCAL GOVERNMEMT AREA OF ENUGU STATE, NIGERIA

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ABSTRACT
Pollution from Agricultural activities has continued to affect the environment in Nigeria. The study looked at the effects of farming activities on the water quality of Obinna River watershed. Surface water and sediments were sampled during farming and non-farming seasons and these samples were analyzed for hardness, ammonia, dissolved oxygen (DO), turbidity, nitrates, phosphate and chemical oxygen demand (COD); and for some heavy metals (Fe, Cd, Cr, Pb, Cu, Zc and Ni). The result showed that most of the parameters for water were within the permissible limit except dissolved solids, ammonia, nitrogen, turbidity and phosphate with highest mean value of 9.72mg/l, 13.57mg/l, 6.33mg/l and 9.42NTU respectively which exceeded the WHO permissible limit of 6mg/l, 0.2mg/l, 5mg/l and 5NTU respectively. Sand was predominant (69.03%) in sediments with highest mean particle size distribution, followed by silt (11.70%) and clay (15.76%) across the two seasons. The highest mean concentration of heavy metals in water from Obinna River across the two seasons was Cd (0.09), Cr (0.06), Cu (0.04), Fe (0.37), Pb (0.14) and Zn (0.08) while the sediment values were Cd (0.85), Cr (0.40), Cu (2.83), Fe (4.08), Pb (0.15), Zn (0.22), and Ni (0.35) mg/kg. A farming range of 300-400m from the river in a frequency of 234 at 59.5% was observed. The surface water was free of algae cover although scanty colonies were found downstream. Natural origins, fertilizer application and domestic waste were identified as the major sources of heavy metals in soils. Monitoring to manage this watershed was recommended.

Key words: Pollution, Farming, Watershed, Water Quality, Heavy Metals, Sediments.

INTRODUCTION
Water comprises about 70% of the Earth's surface making it one of the valuable natural resources on Earth (Krantz, *et al.*, 2011). Of this amount, about 97.5% is salt water and only about 2.5% is fresh water, while only 0.3% of that water is available for human use (Sandi, 2012). Currently humans appropriate 54% of all the accessible freshwater contained in rivers, lakes and underground aquifers and by 2025 this will increase to 70% (United Nations/World Water Assessment Program (UN/WWAP) 2003). Water is an essential element to all forms of life for various purposes such as drinking for humans and livestock, irrigation for agricultural crops, recreation, cleaning as well as a reproductive medium and a habitat for aquatic organisms (Ninhoskinson, 2011). Water makes up 50 to 90% of the body weight of most living organisms. It is also essential as transportation medium and for metabolic processes of most living organisms, (Sandi, 2012).

Water pollution has become predominant with serious injurious consequences which need concern to obtain a clean and healthy environment. Water pollution decreases the use of water economically and increases vulnerability to human health and other aquatic forms of life. Although human beings profit immeasurably from water, they are actually one of the main causes of water pollution through industrial wastes, agricultural effluents and mining waste generation (Ninhoskinson, 2011). It is estimated that with increase in population and by extension human activities, the demand for water will surpass available natural supply by the turn of the 21st century. This constitutes an economic challenge that can only be met by careful planning and intensifying research on sustainable water use practices in agriculture, (Cillie and Coombs, 1979).

Agricultural activities are the major source of nitrate and phosphate pollution of surface water (Taiwo *et al.*, 2012). Nitrate may arise from the excessive application of fertilizers or from leaching of wastewater or other organic wastes into surface water and ground water (WHO, 2006). Taiwo, *et al.*, (2012) noted that nutrient fortification is predominant in most rivers in Nigeria. Increasing the nutrient (phosphorous and nitrate) concentrations in freshwater can lead to eutrophication in lakes and rivers as a result of a decrease in the amount of oxygen available to aquatic life, and other aquatic organisms (Revanga, 2000). It causes quality degradation of 40% of the lakes and also causes deterioration in groundwater and wetland (US Environmental Protection Agency, 2013). Agricultural pollution has increased year by year and became increasingly a prominent pollution problem which contributes to poor water quality and water quality is a problem in many areas of the world. Environmental Canada (2001) identified 15 threats to sources of drinking water and organisms in aquatic ecosystems. These include: water borne pathogens; algal toxins and taste and smell problem; persistent organic pollutant and mercury; endocrine disrupting substance; nutrients; aquatic acidification; ecosystem effects of genetically modified organisms; municipal waste water effluents; industrial point sources discharges; urban runoff; landfills and water disposal; agricultural and forestry land use impact; natural sources of trace element contaminants and impact of dams, diversions and climate change are also identified causes.

It is therefore of paramount importance that enough information is gathered to understand the major causes of water pollution especially around Obinna River and that is what this study seeks to do.

STUDY AREA

Obinna River watershed in Adani town, Uzo-Uwani Local Government Area of Enugu State is located between latitudes 6^{o} 03'N and 6^{o} 44'N and longitudes 7^{o} 01'E and 7^{o} 03'E as shown in Figure 1. It is bounded to the north by Nsukka Local Government Area, to the east by Udi Local Government Area and to the south by Ayamelum Local Government Area in Anambra State. Adani community has a total population of 43264 (forty-three thousand, two hundred and sixty four) persons in 2021 projected from the National population census (NPC, 2006).

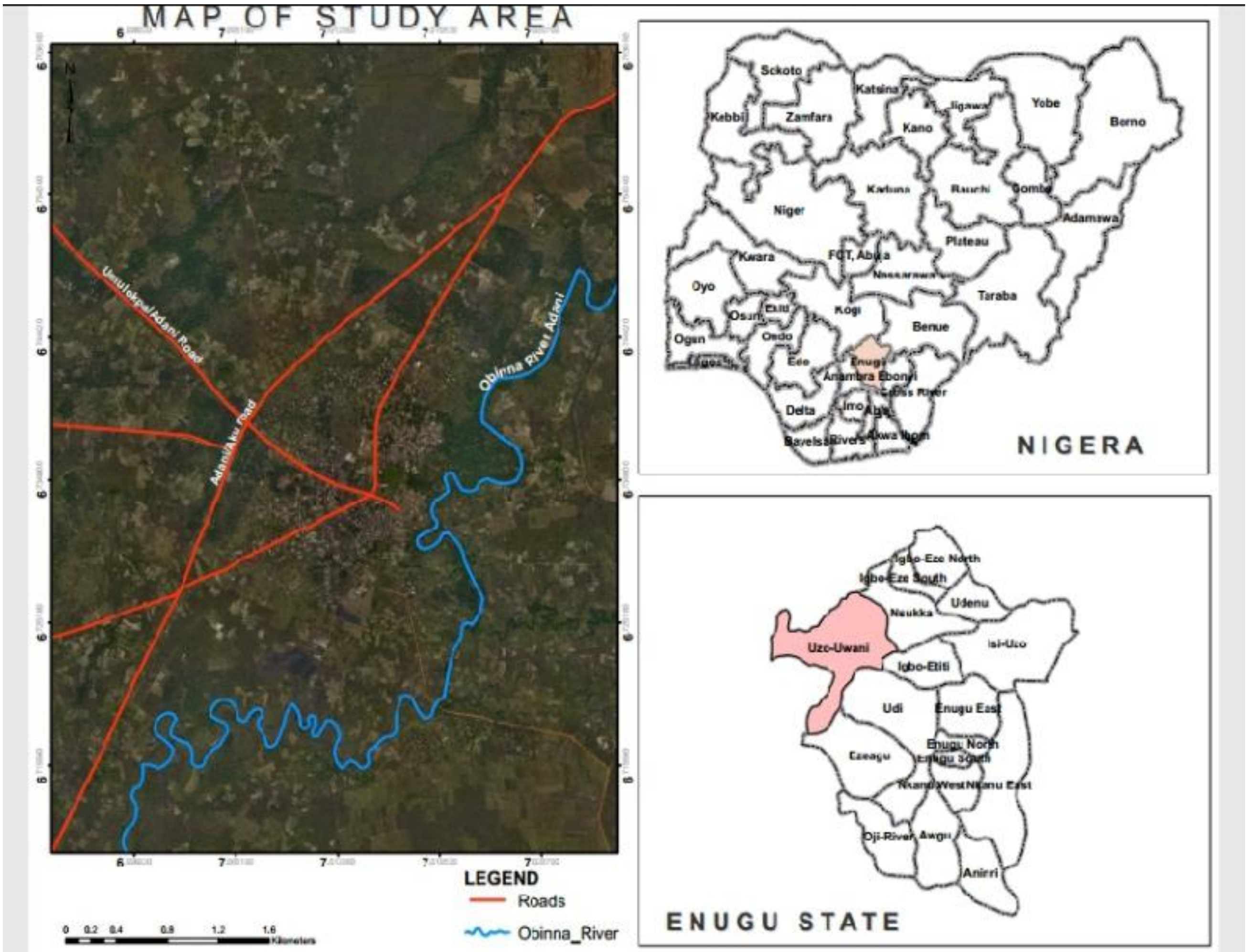

Figure 1: Obinna River Watershed

The climate of Adani in Uzo-Uwani Local Government Area of Enugu State belongs to the tropical wet-and-dry savanna. Two main seasons prevail in this area; dry season and wet season. It experiences an average of eight months rainfall between March to October and four months dry season between November to February. It has an average rainfall amount vary between 1800metres and 2000 meters (Anyadike, 2002). Adani is characterized by mean annual rainfall of between 2250 millimeters, which arrives intermittently and becomes very heavy during the rainy season. The area has high relative humidity during the wet season between March and October and low values during the dry season. The average temperature of the area is about 27^{0}C, with variations throughout the year. Other weather conditions affecting the area include Harmattan, a dusty trade wind lasting for a few weeks during the dry season.

Adani community is largely made up of farmers. Adani residence relied on agriculture as a major source of income since 1950s and suitable soil and favorable climate conditions enable the area to produce many forms of cash crop. Additionally a smaller proportion of livestock farming exist (Ajani *et al*., 2015). Fishing activities carried out in Obinna River watershed and some depressions pits and canals by different methods which include pumping out water from those depressions and the use of hooks, line, and sinker.

MATERIALS AND METHODS

The water samples were collected at three (3) selected points (sample stations) as S_1, S_2, S_3 and control site in both farming and non-farming season. Sample S_1 is a point upriver; before the entering point of pollution sources, S_2 is mid-river; at the point of entry of pollution sources, S_3 is downriver; point after the entering point of pollution sources while the control site was another water body where farming activities were not carried out. At each sampling station, samples were collected three times with the aid of polyvinyl chloride (PVC) plastic water bottles. The sample container was pre-cleaned, dried and stored in a dust free environment. These samples were homogenized and properly labeled and transported in an iced chamber to the laboratory.

Determination of pH: The pH of the water samples was determined using the H**anna** microprocessor pH meter. It was standardized with a buffer solution of pH range between4-9.

The Total Dissolved Solids (TDS) was determined using the Gravimetric Method. **A** portion of water was filtered out and 10ml of the filtrate measured into a pre-weighed evaporating dish. Following the procedure in determination of total solid. Therefore, the total dissolved solid content of the water calculated.

Turbidity: This was determined using a standardized Hanna H198703 Turbidimeter. The samples were poured into the measuring bottle and the surface of the bottle was wiped with silicon oil. The bottle was then inserted into the turbidimeter and the reading was obtained.

Electrical Conductivity (EC):

A high powered microcomputer conductivity meter HANNA HI 9828 with a degree of accuracy of 0.01 was used to measure the conductivity of the water samples in the laboratory within two hours of collection. Triplicate values were taken in units of micro Siemens per centimeter.

Chemical Oxygen Demand (COD)

Chemical oxygen demand was measured using open reflux method. 50ml of sample was homogenized at high speed for 2minutes.

Total Hardness

The total hardness was determined using complexometric titration.

Determination of phosphates:

This was determined by Molybdate yellow method using the spectrophotometer (Blakemore and Daly, 1981).

Determination of mineral nitrogen:

Ammonium nitrogen, nitrite nitrogen and nitrate nitrogen was determined by the Semi-micro Kjedahl method of (Bremmer and Mulvancy 1982)

Determination of chloride: this was done using the Argentometric method (Bingham, 1982).

Determination of calcium and magnesium: This was determined by the vesenate EDTA complexometric titration method.

Determination of potassium: This was determined by the flame photometric method.

Heavy Metal analysis: The determination of heavy metals cadmium (Cd), lead (Pb), chromium (Cr), iron (Fe) and copper (Cu) in sampled water was performed by atomic absorption spectrophotometry.

RESULTS AND DISCUSSIONS

1. Physiochemical parameters

The result of physicochemical analysis of three selected stations in Obinna River during farming and non-farming season is presented in Table 1 and 2 respectively. The results also present the comparison of the physical and chemical parameters of the River at the two seasons.

Table 1: The mean concentration of physico-chemical parameter of water in Obinna River during farming season

Sample	pH	Ec	Hardness	COD	DO	Ca	Mg	K	Na	NH_3N	NO_3N	PO_3	Cl	Turbidity	TDS
S1	6.27± 0.23[b]	24.42 ± 0.01[b]	15.26± 0.01[c]	48.14 ± 0.03[c]	8.52± 0.01[b]	7.66± 0.57[a]	3.41± 0.36[b]	1.36 ± 0.20[b]	3.30 ± 1.17[b]	11.10± 0.10[b]	7.00± 1.00[b]	6.00± 1.00[b]	52.46 ± 0.56[c]	16.43± 0.14[d]	214.83 ± 1.51[d]
S2	6.29± 0.07[b]	13.48 ± 0.24[b]	12.05± 0.03[b]	13.41 ± 0.01[b]	10.89 ± 0.05[b]	10.01 ± s0.01[b]	2.09± 0.01[a]	1.40 ± 0.10[b]	4.20 ± 0.10[b]	28.23± 0.20[c]	9.63± 0.28[b]	8.46± 0.20[c]	42.28 ± 0.87[b]	7.14± 0.12[c]	124.83 ± 1.00[c]
S3	6.52± 0.46[a]	53.71 ± 0.56[c]	15.32± 0.03[c]	16.93 ± 0.03[b]	13.47 ± 0.06[c]	12.05 ± 0.04[b]	4.38± 0.43[c]	0.66 ± 0.03[b]	2.71 ± 0.14[b]	9.40± 0.40[b]	4.20± 0.10[b]	5.80± 0.08[b]	35.65 ± 3.51[a]	6.33± 0.25[b]	29.33± 0.45[a]
Control	5.34± 0.51[a]	7.49± 0.05[a]	0.96± 0.01[a]	3.94± 0.01[a]	1.94± 0.01[a]	3.66± 0.57[a]	2.17± 0.22[a]	0.43 ± 0.04[a]	1.50 ± 0.10[a]	5.53± 0.20[a]	2.66± 0.29[a]	3.66± 0.57[a]	35.33 ± 1.05[a]	2.26± 0.14[a]	40.40± 0.34[b]
Mean	6.11	24.78	10.90	20.61	8.71	8.35	3.01	0.96	2.93	13.57	5.87	5.98	41.43	8.04	102.348
WHO	6.5-8.5	1000	100	-	6	150	50	12	200	0.2	50	5	250	5	500
CV (%)	8.60	82.80	62.40	93.00	56.80	43.20	36.30	51.10	38.70	74.10	52.50	32.80	19.40	74.50	84.30

Different alphabet superscripts in the same column means there is a significant difference at p>0.05 between treatments while same alphabetical superscripts in the same column means no significant difference at p>0.05: between treatments. CV=coefficient of variation, COD= chemical oxygen demand, DO= dissolved oxygen, NH_3N=ammonia-nitrogen, $N0_3$= nitrate, $P0^3_4$=phosphate, TDS= total dissolved solids.
Source: Author's research, (2023)

Table 2: The mean concentration of physico-chemical parameters of water in Obinna River during non-farming season

Sample	pH	Ec	Hardness	COD	DO	Ca	Mg	K	Na	NH_3N	NO_3N	PO^3_4	Cl	Turbidity	TDS
S1	5.21± 0.12^{b}	27.21± 0.05^{c}	13.32± 0.04^{b}	56.23± 0.06^{d}	9.43± 0.05^{b}	8.01 ± 0.47^{b}	4.43 ± 0.43^{b}	1.21 ± 0.13^{c}	3.21± 1.12^{b}	17.12± 0.20^{b}	6.89± 2.00^{c}	7.00± 2.00^{b}	51.36± 0.31^{b}	19.12± 0.12^{b}	234.23 ± 1.20^{d}
S2	6.32± 0.03^{b}	15.32± 0.31^{b}	14.04± 0.07^{b}	15.32± 0.04^{b}	11.21± 0.06^{c}	9.00 ± 0.03^{a}	2.23 ± 0.05^{a}	1.43 ± 0.12^{d}	3.12± 0.14^{b}	22.14± 0.20^{c}	8.61± 0.21^{d}	8.10± 0.31^{c}	4.18± 0.76^{a}	6.12± 0.14^{ab}	121.98 ± 1.00^{c}
S3	7.14± 0.32^{b}	58.21± 0.41^{d}	16.21± 0.05^{c}	14.83± 0.02^{b}	16.21± 0.07^{d}	13.21± 0.05^{b}	5.33 ± 0.32^{c}	0.57 ± 0.01^{b}	1.56± 0.13^{a}	6.21± 0.20^{a}	5.11± 0.20^{b}	6.10± 0.09^{b}	31.21± 4.31^{a}	8.31± 0.32^{ab}	21.38± 0.36^{a}
Control	4.12± 0.31^{a}	6.21± 0.07^{a}	0.89± 0.03^{a}	3.43± 0.05^{a}	2.04± 0.04^{a}	2.54 ± 0.43^{a}	2.21 ± 0.25^{a}	0.45 ± 0.03^{a}	1.41± 0.20^{a}	4.99± 0.10^{a}	2.54± 0.12^{a}	4.13± 0.63^{a}	21.34± 0.65^{a}	4.12± 0.24^{a}	35.12± 0.43^{b}
Mean	5.70	26.74	11.12	22.45	9.72	8.19	3.55	0.92	2.33	12.62	5.79	6.33	27.02	9.42	103.18
WHO	6.5-8.5	1000	100	-	6	150	50	12	200	0.2	50	5	250	5	500
CV (%)	23.10	84.80	62.30	103.20	60.40	53.60	44.50	52.30	41.80	66.40	44.80	26.50	72.90	71.00	95.00

Different alphabet superscripts in the same column means there is a significant difference at p>0.05 between treatments while same alphabetical superscripts in the same column means no significant difference at p>0.05: between treatments. CV=coefficient of variation, COD= chemical oxygen demand, DO= dissolved oxygen, NH3N=ammonia-nitrogen, N03= nitrate, P034=phosphate, TDS= total dissolved solid.
Source: Author's research, (2023)

Hydrogen ion concentration (pH): The mean values of pH observed at upper, middle and downriver were 6.27, 6.29 and 6.51 respectively with grand mean value of 6.11 during farming season. This shows a pH consistency across the three sampled stations.

The pH of the three selected stations for non-farming season ranged from 5.21 – 7.14, thus indicating slightly acidic to neutral. The mean values recorded for upper, middle and downriver were 5.21, 6.32 and 7.14 respectively with grand mean value recorded 5.70. The pH of water sample collected from Obinna River varied across the selected stations for the two seasons with highest and lowest value recorded in upper river with value of 5.21 and middle river with value of 7.14 in non-farming. The values obtained from control area in farming and non-farming season were 5.34 and 4.12 respectively, indicating that the water is acidic. The value observed at upper and middle river for the two seasons was below the acceptable limit of 6.5 – 8.5 by (WHO, 2011) while the values obtained at downriver for the two seasons fall within the recommended limit of (WHO, 2011). These levels of acidification could influence the aquatic biota especially the primary producers which include the algae, macrophytes, fishes and even the water birds (Ormerod and Tyler, 1989; Jenkins et al., 2013)

pH is the measure of hydrogen ion concentration or hydroxide ion concentration in a solution and is a significant indicator which determines the suitability of water for various purposes (Yogendra and Puttaiah, 2008).Water with a pH outside the normal range can adversely affects growth and development aquatic life (Bolowa and Gbenle, 2012; Morrison et al., 2001).
The findings from this study for the two seasons were different from the findings of (Ayode and Nathaniel, 2018; Oluyemi *et al.,* 2010) who reported pH of 6.95 – 7.88 in tropical man-made lake Osun state, southwestern Nigeria. The result does not compare well with the threshold limit of 6.5 – 8.5 (Venkatesharaju, 2010). For non- farming season similar ranges were reported at river Siluko in Ondo State (5.70 – 7.20) by (Ekhotor *et al.,* 2011) and Eruvbi River, Edo state (Imoobe and Koye, 2011; Anyanwu, 2012). WHO (2007) stated that low pH can enhance corrosive characteristics resulting in contamination of drinking water and adverse effect on its taste and appearance. The low pH observed in the current study for the two seasons could be as a result of human activities, these activities may have caused dearth of some aquatic life forms (Jenkins et al, 2013). Consumption of acidic water could have adverse effects on the digestive and lymphatic systems of human. Consumption of low pH water could lead to acidosis which results in peptic ulcer (USEPA, 2023).

Electrical conductivity (EC): the concentration of EC of the sampled River during farming season for the upper, middle and downriver recorded 24.42, 13.48 and 53.21µs/cm respectively. Meanwhile, the concentration during non-farming season at upper river recorded 27.46µs/cm, middle river 15.32µs/cm and downriver had mean value of 58.21µs/cm. The highest value was recorded at middle river with value of 13.48µs/cm during farming season. The range of EC of the samples were 13.48-53.71µs/cm in farming season and 15.32-58.21µs/cm in non-farming season. The values obtained for the two seasons were high when compared with the control mean value of 7.49 and 6.21µs/cm. The grand mean value of 24.79µs/cm and 26.74µs/cm were obtained during farming and non-farming season respectively. None of the stations of the river water samples analyzed for EC was above the recommended limit of 1000µs/cm set by WHO (WHO, 2011) guidelines. The water conductivity values measured for the non-farming season were higher than the farming season. This may be attributed to excessive evaporation of water from the river during dry season, which might have consequently increased the concentration of the dissolved salts, also when compared to the work of (Fakayode, 2005) who studied Alaro River in Ibadan; values obtained in the studied River were lower in wet season. The values of EC obtained in the study are within the range of 28-68µs/cm reported for Siluko river (Ekhoto *et al.,* 2011), Uto River (42.5-59.7µs/cm) and Ogba river (40.8-50.6µs/cm) reported by (Ogbeibu and Anagboso, 2004; Anyanwu, 2012). An extremely high concentration of conductivity has also recorded in Modjo River (14330 ± 1182.3µs/cm) in Ethiopia (Seyoum *et al.,* 2003) and Sebeta River (19397.8 ± 3.02µs/cm) in Ethiopia (Getachew, 2013). These values were extremely higher when compared with result of the current study in Obinna River. Conductivity measurement is used routinely in many industrial and environmental applications as fast, inexpensive, and reliable way of measuring the ionic content in a solution (Gray, 2005). It is related to the amount of dissolved minerals in water, but it does not give an indication of which element is present but higher values of EC is a good indicator of presence of contaminants such as sodium, potassium, chloride or sulphate (Orebiyi, *et al.,* 2010).

Hardness: Mean value of hardness in Obinna River during farming; the upper, middle and downriver were 15.26, 12.05 and 15.32mg/l respectively. The non-farming season recorded 13.32mg/l at Upper River, 14.04 mg/l and 16.21mg/l was recorded downriver. The control area recorded 0.96mg/l at farming season and 0.89mg/l during non-farming season. The highest numerical value was recorded downriver with mean of 16.21mg/l in non-farming season while the lowest was obtained at middle river with value of 12.05mfg/l in farming season. The total hardness of the water was observed below WHO standard of 100.0mg/l (WHO, 2011). The values of hardness observed in this study were lower when compared with the value range of 45.5 – 105.0mg/l reported for Ogun River, Ogun state by (Dimowo, 2013). The variation in the hardness of water may be attributed to the presence of dissolved basic salts that may dissolves in water. The river under is not harmful to local inhabitant; it is largely suitable for direct use by the communities that use it for laundry work and bathing.
Hardness is most commonly associated with the ability of water to precipitate soup. As hardness increases, more soap is needed to achieve the same level of cleaning due to the interactions of the hardness ions with the soap. Chemically, hardness is often seen as the sum of polyvalent cation concentration dissolved in water (Wilson, 2010). In fresh waters, the principal hardness-causing ions are calcium and magnesium, strontium, iron, Barium and manganese ions (USEPA, 1976).

Chemical oxygen demand (COD): COD of water from Obinna River as presented in Tables 1 and 2 for the two season shows that the concentration of COD in the river during farming season recorded 48.14mg/l at upper river, 13.41mg/l at middle river and 16.93 of downriver and 56.23, 15.32, and 14.83mgt/l were recorded during non-farming season for upper, middle and downriver respectively. The values of COD varied from 13.41 – 48.14mg/l in farming season and 14.83–56.23mg/l in non-farming season. The highest value of 56.23mg/l was recorded in non-farming season while the minimum value of 13.41mg/l was obtained at middle river in farming season. The result obtained in the current study was different when compared with the work of (Ayohan, *et al.,* 2016) whose findings were 19.14 – 115.16mg/l in Benin River. The COD test is a measure of the relative oxygen depletion effect of a waste contaminant. Therefore, COD is commonly used to ascertain the degree of organic compound present in water, which makes COD an indicator of organic pollution of surface water (Kumar, *et al.,* 2011).

Dissolved Oxygen (DO): Concentration of DO ranged from 9.43mg/ to 16.21mg/l across the river during farming season and it recorded 8.52mg/l at Upper River to 13.49mg/l at downriver of non-farming season as presented in Tables 1 and 2. Seasonal variation is observed in DO concentration with higher values recorded in the farming season, this could be due to increased aeration and continuous recharge of the water bodies as a result of rainfall, a situation which was also observed by (Adefemi, *et al.,* 2007) who reported that DO concentration of Asejire lake attained its peak at the height of rainy season. This study revealed that the values of DO across the upper, middle and downriver were high. According to WHO (2011), DO standard for drinking water is 6mg/l whereas for sustaining fish and aquatic life is 4 to 50mg/l (Rao, 2005). Surface water quality recommended value for DO by WHO for domestic uses is 10mg/l; however the values of DO from upper of the two seasons fell short of this recommended standard. This could be as a result of increase in plant and algal growth on the surface water due to indiscriminant dumping of agricultural waste and run-off. DO is the oxygen present in dissolved form in a water body. It is an important water quality parameter and has special significance for aquatic organism in natural water (Willok, *et al.,* 1981). It regulates the distribution of flora and fauna (Yogendra and Puttaiah, 2008). Its deficiency has an adverse effect on the river as the health of river largely depends on it (Venkatesharaju, 2010). Agricultural waste around the river bank, leading deoxygenating of the river as reported by (Morrison, *et al.,* 2001).

Calcium concentration values of water from Obinna River for the farming season ranged from 7.66–12.03mg/l and the values at the upper, middle and downriver were 7.66, 10.01 and 12.05mg/l respectively. Meanwhile, the values for non-farming ranged from 8.01-13.21mg/l with the values at the upper, middle and down river recorded 8.01, 9.00 and 13.21mfg/l respectively in Tables 1 and 2. These values were higher than the control mean value of 3.66mgg/l recorded in farming and 2.54mg/l that were observed in non-farming season. The mean values of calcium concentration of the samples were lower than the 75.00mg/l permissible limit of WHO (2011) guideline.

The findings if this work if similar when compared to the findings of (Agu, *et al.,* 2014) who reported 8.00 - 8.81mg/l from the same river. Calcium compounds occur naturally in surface water and their concentration are determined mainly by carbonate balance (Gakzynska, *et al.,* 2013). Grochowska and Tampyrk (2009) determined the calcium content of lake water in the range of 14.9 – 69.8mg/l. Calcium is one of the most important nutrients required by the organism, it helps in maintaining the structure of plant cell (Fasano, et al., 2002).

Magnesium: Magnesium concentration values of water from Obinna River during farming season ranges from 2.09 – 4.38mg/l and the values at the upper, middle and downriver recorded 3.41, 2.09 and 4.38mg/l respectively in Table 1. However, in non-farming season the magnesium concentration Ranges from 2.23 – 5.33mg/l and the values at upper, middle and downriver recorded 4.43, 2.23 and 5.33mg/l in Table 2 respectively. The control mean values recorded 2.17 and 2.21mg/l during farming and non-farming season respectively. The mean values of Mg concentration of the water were lower than the WHO limit of 50.00mg/l set standards (WHO, 2011). The result of this finding is higher than the findings of (Agu, *et al.,* 2014) who reported 0.49 – 0.51mg/l of magnesium concentration from the same river. Mg is usually less abundant in water than calcium, because it is found in lower amount the earth crust compared with calcium. Mg and Ca level in surface water could be significantly influenced by organic compound present in runoff water (Kolanek and Kowalski, 2002). Mg and Ca are found naturally in surface water, their presence in water is often closely related to the type of landuse in the catchment area (Wons, *et al.,* 2012). Magnesium is the 8^{th} most abundant element on the earth crust and natural constituent of water. It is an essential for proper functioning of living organisms and found in minerals like dolomite, magnetite etc (Muhammed, *et al.,* 2013).

Potassium (K): the mean values of potassium in Obinna river during farming seas were 1.36, 1.40 and 0.66mg/l at upper, middle and downriver respectively while non-farming season recorded upper river 1,21mg/l, middle river 1.43mg/l and downriver 0.57mg/l in Tables 1 and 2 respectively. The mean concentration of K during farming season ranged from 0.66 – 1.40mg/l and 0.57 – 1.43mg/l in non-arming season. These values were different from o.43 and 0.45mg/l observed in control area at each season. The mean values of potassium concentration in water were lower than the WHO limit of 10mg/l for potassium concentration (WHO, 2011).

This current finding was lower than the findings of (Agu, *et al.,* 2014) who reported 90 – 100mg/l potassium concentration in the same river. K is one of the most important macronutrient necessary for plant growth, which is absorbed in the form of K^+ ions.

Naturally, source of K in natural water includes; hydrolytic decomposition of magma rocks due to weathering, erosion of sedimentary rock, forest fire runoff and agricultural sewage.

Sodium (Na): the concentration of sodium in water from Obinna River during farming season ranged from 2.27 – 4.20mg/l and the value at upper, middle and down river recorded 3.30, 4.20 and 2.27 respectively. However, sodium content in the water during non-farming season ranged from 1.56 – 3.32 and the values at upper, middle and downriver were 3.21, 3.21 and 1.56mg/l respectively as presented in Tables 1 and 2. The Na content was significantly different at different stations in the river for the two seasons. Agu, *et al.,* (2014) reported 55.00 – 80.00mg/l which was not in corroboration with this finding in the same study area. The sodium concentration in the water was observed to be lower than WHO permissible limit of 200.00mgl (WHO, 2011 the variation in the sodium content may be attributed to the presence of higher dissolved basic salt which may dissolves in water.

Ammonia-Nitrogen (NH_3N): The observed values of ammonia in water from Obinna river during farming season recorded the maximum numerical value of 28.23mg/l at middle river and the lowest numerical value of 9.40mg/l at downriver. The values at the upper, middle and downriver recorded 11.10, 28.23 and 9.40mg/l respectively. The values of ammonia concentration in water during non-farming season recorded the maximum numerical values of 22.14 at middle river and lower value of 6.21mg/l at downriver. The values obtained upper middle and downriver were 17.12, 22.14 and 6.21mg/l respectively. In the current study, the concentration of ammonia-nitrogen in the river decreased with increase in distance from effluent discharge point for the two seasons. Concentration of ammonia-nitrogen in water was observed to be above the WHO admissible limit of 0.2mg/l (WHO, 2011) standard for surface water.
The reduction of ammonia downriver of the effluent discharge point can be attributed to the fact that at high pH most ammonia will be in gaseous state, therefore, the gas volatilizes as the river flows. Ammonia is much more toxic in alkaline water than in acidic water because free ammonia in high pH values is more toxic to aquatic biota than when it is in the oxidized form (Seyoum, *et al.,* 2003). The high content of ammonia-nitrogen in Obinna River can be attributed to the use of artificial fertilizer by the local community.

Nitrate (NO_3N): The concentration of nitrate in Obinna River during farming season ranged from 4.20 – 9.63mg/l and 5.11 – 8.61mg/l in non-farming season as shown in Tables 1 and 2. The maximum concentration of nitrate was recorded 9.63mg/l at middle river in farming season minimum concentration of 4.20mg/l at downriver of the same season. The concentration of nitrate was below the permissible limit of 50.00mg/l set standard by (WHO, 2011).
The results of this current study was higher when compared with the impacted Sebeta River with maximum nitrate content of 4.99mg/l (Admasu, 2007) and 4.17- 8.27mg/l reported by (Getachew, 2013). The result of this study was also higher than the findings of 0.03 0.04mg/l reported by (Agu, *et al.,* 2014) on the same river. Nitrate concentration in normally low but increased level might be due to agricultural runoff, contamination by human or animal waste.

Phosphate; The concentration of phosphate in water sample from Obinna River during farming season ranged from 5.80 – 8.46mg/l and values at upper, middle and downriver recorded 6.00, 8.46 and 5.80mg/l respectively in Table 1. Meanwhile, the phosphate content of the water during non-farming season ranged from 6.10 – 8.10 with the values at upper, middle and downriver recorded 7.00, 8.10 and 6.10mg/l respectively in Table 2. It recorded control mean values of 3.66mg/l in farming season and 4.13mg/l in non-farming season. The highest concentration of phosphate was recorded at middle river with mean value of 88.40mg/l in farming season. This is attributed to the discharge of domestic waste, runoff fertilizer from farmlands and biological process.
The values of phosphate were significantly different at the three stations of the river. This study showed that phosphate values were higher than 5mg/l permissible limit of WHO standard (WHO, 2011). The values of phosphate in the current study were slightly different from the range of 3.92 – 7.21mg/l reported by (Agu, *et al.,* 2014) on the same study river. But the values were high when comparing with 0.14 – 0.52mg/l reported by (Ekhator, *et al.,* 2010). However, the current study was lower in comparison to the range of 7.4 – 22.7mg/l reported at Kaduna River (Mahre, *et al.,* 2007). The values of phosphate observed in the studied river tend to increase towards the discharge point and start to decrease down the river. The phosphate levels are generally high, which could explain the observed blue-green algae growth in the river (Mahre, et al., 2007).

Chloride: Chloride concentration in the sample from Obinna River during farming season ranged from35.63 – 52.46mg/l while its values in non-farming season ranged from 4.18 – 51.36mg/l. the maximum numerical value was recorded 52.36mg/l at Upper River during farming season and the minimum numerical value of 4.18mg/l was obtained at middle river of non-farming season. The control mean value of 35.33 and 21.34mg/l were recorded in farming and non-farming season respectively. It was also observed that the values of chloride varied across the three stations of the two seasons. The mean values of chloride content of the water from Obinna River was

below the WHO set standard of 250mg/l (WHO, 2011).
The findings were below when compare with the finding of (Agu, *et al.,* 2014) who reported 345.9 – 354.6mg/l o the same river. The variation in the chloride content may be attributed to the anthropogenic origin (Tukura, *et al.,* 2012). Chloride is aqueous anions in all natural waters, its concentration varying very widely and reaching a maximum in sea water. It was observed that chloride is among most abundant chemical parameter in the studied river. Chloride is sourced from the rocks, herbicides and pesticides, agricultural runoff and sea salts. Chloride is more stable in water but its concentration is unaffected by most natural or biological processes; their amount in water is a useful measure in water sample (Tukura, et al., 2012).

Turbidity: Turbidity values ranged from 6.33 – 16.43NTU with the mean values for upper, middle and downriver recorded 16.43, 7.14 and 6.33NTU during farming season respectively. Turbidity values in non-farming season ranged from 6.12- 19.12NTU with mean values for upper, middle and downriver recorded 19.12, 6.12 and 8.31NTU as shown in Table 2. The turbidity of the river decreases down the river and values obtained were significantly varied across the three stations for the two seasons. The turbidity values observed in this study were higher than the WHO standard limit of 5NTU (WHO, 2011).
The findings in the current study were different from the findings of (Eze, *et al.,* 2021) who reported 4.50 – 48.70NTU in Onuiyieke River, Imo State, Nigeria. The high values of turbidity observed in the present study could possibly due to disposal of waste into the water body and effects of runoff water which carries with it several compound (bacteria, suspended solids etc). These compounds can impede the rays of light entering the river (Chinwe, *et al.,* 2010).

Total Dissolved solids (TDs): TDS values ranged from 29.33 – 214.83mg/l, the values for upper, middle and downriver recorded 21.83, 124.83 and 29.33mg/l during farming season respectively. However, TDS values during non-farming season ranged from 21.38 – 234.25mg/l with mean values for upper, middle and downriver observed to be 234.23, 121.89 and 21.38mg/l as in Table 2. The mean value of 40.40 and 35.25mg/l were observed at control area in farming and non-farming season respectively. The high values of TDS observed at Upper River for the two seasons could be attributed to the geologic material that water passes through in the saturated and unsaturated zone and the quality of infiltrating water (Oram, 2014). The values of TDS recorded in the current study were within the stipulated limit of 500mg/l (WHO, 2011) guideline.

2. Concentration of heavy metals

The mean concentrations of heavy metals in water samples from Obinna River during farming and non-farming seasons were presented in Tables 3 and 4 respectively.

Table 3: Mean concentration (mg/l) of heavy metals in water of Obinna River during farming season

Sample	Cd	Cr	Fe	Pb	Zn	Cu
Down River	0.10±0.00^{b}	0.06±0.00^{ab}	0.83±0.01^{c}	0.38±0.01^{b}	0.10±0.00^{b}	0.06±0.00^{b}
Middle River	0.03±0.01^{ab}	0.04±0.00^{ab}	0.34±0.01^{b}	0.08±0.00^{ab}	0.03±0.00^{a}	0.02±0.01^{a}
Upper River	0.04±0.00^{ab}	0.11±0.00^{b}	0.18±0.00^{a}	0.08±0.00^{ab}	0.02±0.00^{a}	0.02±0.00^{a}
Control	0.02±0.00^{a}	0.01±0.00^{a}	0.11±0.00^{a}	0.01±0.00^{a}	0.14±0.01^{b}	0.03±0.00^{a}
Mean	0.05	0.06	0.37	0.14	0.07	0.03
WHO	0.003	0.05	0.3	0.010	3.00	2.00
CV (%)	75.70	76.40	88.90	120.00	79.10	58.20

Table 4: Mean concentration (mg/l) of heavy metals in water from Obinna River during non-farming season

Sample	Cd	Cr	Cu	Fe	Pb	Zn
Down River	0.20±0.01^{b}	0.05±0.00^{a}	0.07±0.00^{b}	0.18±0.01^{c}	0.31±0.01^{c}	0.12±0.00^{b}
Middle River	0.04±0.02^{a}	0.03±0.00^{a}	0.03±0.01^{a}	0.32±0.01^{b}	0.09±0.02^{b}	0.04±0.01^{a}
Upper River	0.05±0.00^{a}	0.10±0.00^{b}	0.04±0.00^{a}	0.21±0.00^{a}	0.08±0.00^{b}	0.03±0.00^{a}
Control	0.07±0.00^{a}	0.02±0.00^{a}	0.02±0.00^{a}	0.15±0.00^{a}	0.01±0.00^{a}	0.13±0.01^{a}

Mean	0.09	0.05	0.04	0.22	0.12	0.08
WHO	0.003	0.05	0.3	0.010	3.00	2.00
CV (%)	82.70	71.20	54.00	34.50	106.10	65.40

Different alphabet superscripts in the same column means there is a significant difference at $p>0.05$ between treatments according while same alphabetical superscripts in the same column means no significant difference at $p>0.05$: between treatments. Cd= cadmium, Cr= chromium, Cu= copper, Fe= iron, Pb= lead and Zn= zinc

The cadmium (Cd) concentration values of water from Obinna River during farming season ranged from 0.03 – 0.10mg/l, the mean values for upper, middle and downriver recorded 0.04, 0.03 and 0.10mg/l respectively in Table 3. Meanwhile, the Cd concentration in non-farming season ranges from 0.04 – 0.20mg/l with the mean values for upper, middle and downriver recorded 0.05, 0.04 and 0.20mg/l respectively in Table 4. The mean values of Cd concentration in the river across the two seasons were higher than the WHO limit of 0.003mg/l for Cd concentration in drinking water (WHO, 2011).

The current findings were similar to the findings of (Nwachukwu, *et al.*, 2014) who reported 0.001 – 0.090mg/l Cd on their study of Ezu, Obinna and Iyiakoro River. Oluyemi, *et al.*, (2010) observed different values which was 0.77 – 2.24mg/l of cadmium. The high concentration of Cd in water source in the current study could be possibly due to natural processes, anthropogenic activities, human activities and their agricultural methods (WHO, 1998a, b; Patrick, *et al*., 2002; Ejikeme, 2003). Cadmium is present as a pollutant in phosphate fertilizers and also found in PVC product, color pigment alloys and re-chargeable nickel-cadmium batteries. These Cd containing products are not recycled but dumped together with household waste at the river bank, thereby polluting the water environment.

Chromium (Cr): Cr concentration values in water from the river under study ranges from 0.04 – 0.11mg/l with mean values for upper, middle and downriver recorded 0.11, 0.40 and 0.06mg/l in farming season respectively in Table 3. The concentration of Cr in water during non-farming season ranged from 0.03 – 0.10mg/l and the values for upper, middle and downriver were 0.10, 0.03 and 0.05mg/l respectively in Table 4. The values chromium observed in the present study were significantly different across the river for the two seasons.

The values of Cr concentration of the river across the two seasons were higher than the WHO limit of 0.005mg/l for Cr level in drinking water (WHO, 2011) except for the middle river that recorded a lower value for the two seasons. The values of Cr in the current study were similar when compare with the findings of (Nwachukwu, *et al.*, 2014) who reported 0.01 – 0.44mg/l in the study of Ezu, Obinna and Iyiakoro rivers. Chromium is an essential micronutrient for animals and plants, and is considered as a biological and pollution significant element.

Copper (Cu): Concentration of Cu in the water from Obinna River during farming season was observed in Table 3. The mean value of Cu recorded 0.02mg/l at Upper River, 0.02mg/l for middle river and 0.06mg/l for downriver. The values ranged from0.02–0.06mg/l. meanwhile, the concentration of Cu in non-farming season recorded 0.04mg/l for Upper River, 0.03mg/l for middle river and 0.07mg/l for downriver. The mean values ranged from 0.03-0.07mg/l. the highest value recorded at downriver with mean value of 0.07mg/l in non-farming season while the lowest value was recorded 0.02mg/l at Upper River in farming season. The control area recorded 0.03 and 0.02mg/l in farming and non-farming season respectively. None of the stations of the river analyzed for Cu shows above the recommended limit of 2.0mg/l set by WHO (WHO, 2011) guideline. Therefore, the values recorded at the two seasons showed concentration below the standard recommended for surface water.

The current findings were similar to the findings of (Nwachukwu, *et al.*, 2014) who reported 0.02 – 0.45mg/l of Cu in the study of Ezu, Obinna and Iyiakoro River. There is an indication of the presence of Cu in river but observed in a low concentration. The low values observed in the river provide an indication that there is a low usage of Cu containing materials and potential contamination by Cu within the river is minimal. Considering the guideline, the river water can be considered wholesome with respect to Cu content. This implies that the water may be safe from Cu pollution.

Iron (Fe): The concentration of iron in the water from Obinna river during farming season were presented in Table 3; the mean values of Fe recorded 0.18mg/l at upper river, 0.34mg/l for middle and 0.83mg/l for downriver. The values ranges from 0.18 – 0.83mg/l. the concentration of iron in non-farming season recorded 0.21, 0.32 and 0.18mg/l for upper, middle and down river respectively. The values ranged from 0.18–0.21mg/l in Table 4. The highest value recorded 0.83mg/l at downriver in farming season while the lowest value was obtained at upper and downriver with equal value of 0.18mg/l in the two seasons. The control area recorded 0.11 and 0.15mg/l in farming and non-farming season respectively. The iron concentrations in the river across the two seasons were within the admissible limit of 0.3mg/l set standard by (WHO, 2011) except the values obtained downriver of farming season that exceed the permissible limit by WHO.

The current findings were different from the findings of (Agu, et al., 2014) who reported 0.00– 0.1mg/l of Fe on the same river. The high content of Fe downriver may be due to agricultural sewage intrusion that flows down the river. However, lower Fe concentration were observed upper river may be probably due to Fe tendency to form complex compound with anions and Fe in its lower oxidation is easily soluble and could settle on the river bed. Iron is an important metal in both plants and animals, especially in the cellular processes (Lovell, 1989). Iron is an important metal in both plants and animals, especially in the cellular processes (Lovell, 1989). Fe in surface water generally present in ferric state. Fe is found I in natural freshwater but have no health-based guideline value. It's an essential and no-conservative trace element found in significant concentration in drinking water.

Lead (pb): Concentration of Pb in water from Obinna river during farming season ranges from 0.08 – 0.38mg/l with the mean value for upper, middle and down river recorded 0.08, 0.08, and 0.38mg/l respectively in Table 3. The Pb concentration in non-farming season ranged from 0.08 – 0.31mg/l and the mean values for upper, middle and downriver recorded 0.08, 0.09 and 0.31mg/l respectively in Table 4. The highest value of 0.38mg/l was recorded down the river in farming season and lowest value of 0.08mg/l was observed at Upper River in the two seasons. The control area recorded equal value of 0.01mg/l in the two seasons. The concentration of Pb observed in the current research showed that the values of Pb were higher than the WHO permissible limit of 0.01mg/l (WHO, 2011).

The findings of this report were different from the findings of (Agu *et al.,* 2014) who reported a higher value of 18.9- 39.7mg/l of Pb in the same river. Tadesse, *et al.,* (2018) reported 0.07 – 0.16mg/l in Rebu River, Ethiopia. Generally, pb showed high concentration across the stations of the river water analyzed for the two season and this might be due to agricultural activities practiced around the river bank which contributed to the observed high levels of Pb, since Pb can occur as impurities in fertilizer and metal based pesticides and compost manure (Tadesse, *et al.,* 2018). Lead is the most significant of all the heavy metals because it is toxic, very common and harmful even in a small amount (Gregoriaadou, *et al.,* 2001)

Zinc (Zn): Concentration of Zn in the water from Obinna River during farming season was presented in Table 3. The values of Zn ranged from 0.02 – 0.10mg/l with the mean values for upper, middle and downriver recorded 0.02, 0.03 and 0.10mg/l respectively. The Zn concentration during non-farming season ranged from 0.03 – 0.12mg/l with mean value of o.03mg/l obtained upper river, 0.04mg/l at middle river and 0.12mg/l down the river as shown in Table 4. The control mean values of 0.14mg/l and 0.13mg/l were observed in farming and non-farming season respectively. However, the values of Zn in the water were lower than 3.0mg/l WHO recommended safely thresholds limit for drinking water (WHO, 2011).

The findings of present study is lower when compare with the findings of Tadesse, *et al.,* 2018) and (Admasu, 2007) who reported 0.21 – 0.39mg/l in Rebu river and 0.0869 – 0.1469mg/l in Awash River respectively. The lower concentration of Zn observed might be attributed to the formation of some insoluble salts with certain anions that might be discharged from agricultural effluent. Zn is one of the important trace elements that play a vital role in the physiological and metabolic process in many organisms. Nevertheless, higher concentration of Zn can be toxic to the organism (Rajkovic, *et al.,* 2008). Zinc is a metal which show fairly low concentration in surface water due to its restricted mobility from the natural sources (Rajappa, *et al.,* 2010).

CONCLUSION

Water and its management will continue to be a major issue, which will definitely have profound impact on our lives and that of our planet Earth than ever before. Everyday water systems all over the world receive polluting runoffs of fertilizer, pesticides and sewage. Obinna River flows through Adani community and along its channel, extensive farming activities take place. Most runoff from the surrounding farms carry fertilizer and other chemicals' effluent from the farm and where discharged into Obinna River. This study was carried out to evaluate the effects of farming activities on Obinna River through the analysis of the physicochemical properties of surface water and the investigation carried out yielded the following conclusions; The overall mean concentration observed for surface water parameters indicate levels that were within the water quality guidelines with the exception of dissolved solids, ammonia-nitrogen, phosphate and turbidity. Therefore, the obtained results confirmed the need to keep the concentration of the physicochemical parameters in surface water of this catchment area under control, especially considering increasing trends of these nutrients which can lead to increasing environmental overload and to rapid development of eutrophication.

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