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Physicochemical analysis of water from river Niger at Isimmili Idemmili Onitsha, Anambra state, Nigeria

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Abstract
This study was aimed at investigating the physicochemical properties of water collected from River Niger at Isimmili Idemmili Onitsha, Anambra State, Nigeria. A total number of twenty sampling points were made into five composite samples labeled [001], [002], [003], [004] and [005] respectively, and analyzed following standard procedures. The mean concentrations of the pH, temperature, turbidity, conductivity, alkalinity ranged from 5.35±0.35 – 6.6±0.28, 28±1.41 – 31±1.41, 6.5±0.71 – 11±1.41, 78.5±0.71 – 100.5±0.71, and 9±1.41 – 13±1.41 respectively. Similarly, the values of total hardness, total solute, total suspended solute, total dissolved solute, dissolved oxygen, biochemical oxygen demand and chemical oxygen demand ranged from 163.5±4.94 – 284±5.65, 415±21.21 – 725±35.36, 365±7.07 – 625±35.36, 560±28.28 – 815±21, 8±1.41 – 12.5±0.71, 6.5±0.71 – 10±1.41 and 12±1.41 – 22.5±2.12 respectively. For anions, the mean concentrations of nitrates, sulphates and phosphates were found to range from 55.5±0.70 – 97.5±2.12, 99±1.41 – 120±1.41, and 118.5±2.12 – 150±1.41 respectively. While fluorides and chlorides ranged from 18.5±0.71 – 36.5±0.71, and 72.5±3.54 – 98±1.41 respectively. This results show that while some parameters such as pH and COD were below permissible limits, others such as temperature, TDS, DO, sulphate, phosphate, and fluoride were found to be above the WHO permissible limit. This is a sign that water from this river is significantly polluted and poses some potential public health concern. Therefore, proper remediation techniques and adequate treatment of the water before use either for fishing activities or domestic applications is strongly recommended.

Keywords: water, quality, physicochemical, parameters

Introduction
Water is an invaluable resource in the world we live. Both industrial and biological systems depend on it for efficiency and productivity. Our local communities depend on traditional sources of water such as rivers, lakes, rain water and boreholes for consumption, fishing, farming and other domestic and industrial applications. In the West African sub-region, millions of inhabitants of cities and local communities rely on River Niger and its tributaries for home use, livelihood, and hydroelectric power generation (Opuene and Okafor, 2007) [14]. It is expected that pollutants from wastewater and other anthropenic sources along the line are discharged directly into the river, often without consideration for the environmental and human health implication (Mohd *et al*., 2015) [10]. There was therefore need for us to study the water quality of this river and compare results obtained with international standards of global environmental protection agencies.

Materials and Methods
Description of Study Area
Isimmili Idemili Onitsha in Nigeria's Anambra State is the research area. Onitsha is situated between latitudes 5°221 and 6°481 and longitudes 6°321 and 7°201 in the Anambra State of eastern Nigeria. Onitsha, which is in the Anambra State, sits on the east bank of the River Niger and occupies a region of roughly 49,000 km^2. It is a major transportation hub in Nigeria and one of the most significant commercial hubs in sub-Saharan Africa. There are reportedly one million people living there. About 75 % of the labor force in Onitsha works in the tertiary sector, which includes industries like trading and services. Manufacturing and industrial work account for the remaining 25 % of the labor force.

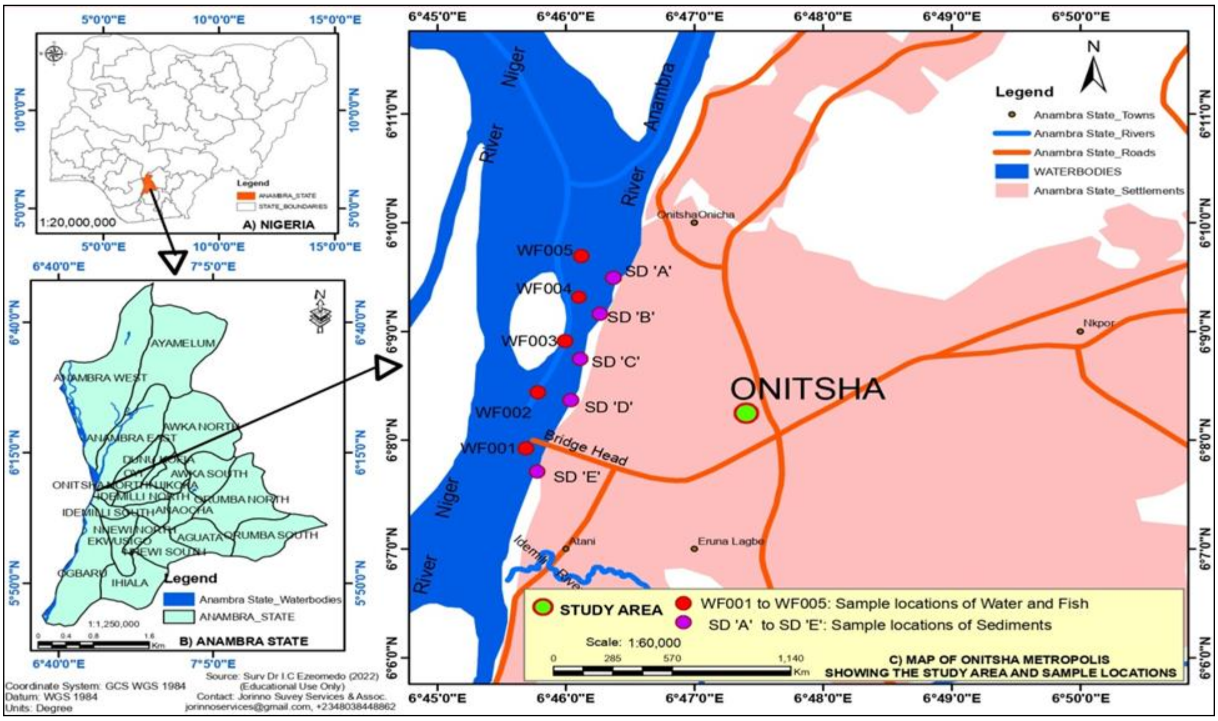

Fig 1: Map of Anambra State showing the sample locations in Rivers Niger at Onitsha

Sample collection

Twenty sample points were used to gather water samples, which were then combined into five composite samples of the River Niger at Onitsha: [001], [002], [003], [004], and [005]. At the river's Isimmili Idemmili segment, samples were taken at 2-kilometer intervals. In order to reduce surface film contamination of the water sample and prevent air entrapment, the water was collected using bottle containers by sinking the sampler below the water surface. Physico-chemical parameters such as temperature, pH, electrical conductivity, and total dissolved solids were examined in situ in the water samples using the appropriate digital readout meters. In the lab, the water samples that had been obtained were examined.

Physico-chemical Parameters

In the study, varous water characteristics, including color, temperature, pH, electrical conductivity, and total dissolved solids, were also measured using the following procedures:

Color Determination

The water sample was measured and given a separate label for about 20 mL. Then, 20 mL more of standard distilled water was measured and labeled individually. By comparing the color of the sample to the standard, the sample's color was ascertained.

Measurement of Temperature

A part of the water sample (approximately 1 liter) was used to measure temperature. The thermometer was submerged in the water for two minutes (until the reading stabilized) before the reading was recorded and stated in degrees Celsius.

Turbidity measurement

Nephelometer was used to calculate the water sample's turbidity level. Air bubbles were removed after vigorously shaking the water sample. The turbidity level was immediately recorded from the instrument after the sample was transferred and poured into the nephelometer tube.

Determination of pH

The pH of the samples was measured using a Metro Hm 632 pH meter. Before determining the pH, the electrode was first immersed in a known buffer solution and left to stand for two minutes to settle. Readings for repeatable results (at least 0.1 pH units) were then collected.

Electrical Conductivity Determination

When the conductivity probe was submerged in a sample of water, the voltage dropped due to the resistance of the water.

Determination of Total Solids

50 mL of the water sample was dried to a consistent weight in an oven at 103-105 ^{o}C after being allowed to evaporate in a dish that had been pre-weighed. The total solids are determined by the weight gain over the empty dish.

Total Dissolved Solids Determination
By calculating the difference between the weights of the total solids and the total suspended solids stated in the same units, the total dissolved solids were ascertained.

Determination of Total Suspended Solids
A typical glass fiber filter was used to filter 50 mL of the sample, and the residue that was left behind was allowed to dry at a constant weight between 103 and 105 ºC. The total suspended solids were calculated using the increase in the filter's weight.

Determination of Nitrates
50 mL of the water samples were mixed with a 2 mL aliquot of 0.1M NaOH solution and 1 mL of color development agent. The nitrate concentration was then calculated using a Perkin Elmer model lambda 45 (UV/Vis) spectrophotometer with a 1.0 cm quartz cell for absorbance measurement at a wavelength of 543 nm after the sample combination had stood for 20 min.

Determination of Phosphates
4 mL of ammonium molybdate reagent and around 4–5 drops of stannous chloride reagent were added to 50 mL of the filtered sample. The color generated is measured photometrically at 690 nm after roughly 10 minutes but before 12 minutes and a calibration curve is created. The same procedure is always used when running a reagent blank.

Determination of Sulphates
Filtering 100 mL of the material into a Nessler's tube with 5 mL of conditioning solution. Barium chloride crystals weighing about 0.2 g were added while being stirred constantly. One milliliter of the standard was combined with five milliliters of the conditioning reagent to make a working standard that contains 100 NTU. A Nephelometer was used to measure the turbidity that the standards and the sample produced, and the results were tabulated.

Determination of Chlorides
A conical flask was filled with a known volume of filtered sample (50 mL), to which 0.5 mL of potassium chromate indicator was added. The flask was then titrated against a standard silver nitrate solution until silver dichromate (AgCrO4) began to precipitate.

Determination of Dissolved Oxygen
The samples were gathered in BOD bottles, which were then sealed with 2 mL of manganous sulphate and 2 mL of potassium iodide. This is thoroughly combined, and the precipitate is then allowed to settle. At this point, 2 mL of concentrated sulfuric acid is added, and everything is thoroughly mixed to dissolve the precipitate. Starch is used as an indicator as 203 ml of the sample is measured into the conical flask and titrated against 0.025 N sodium thiosulphate. The transition from blue to colorless marks the point of completion.

Determination of Biological Oxygen Demand
A dissolved oxygen test kit was used to conduct the five-day biological oxygen demand test. The end dissolved oxygen level of a water sample that was incubated in a dark room for five days was compared to the initial dissolved oxygen level of a water sample that was taken right away to calculate the BOD level. The biological oxygen requirement of the water is given by the difference between them in mg/l.

Determination of Chemical Oxygen Demand
A Nessler's tube is filled with 15 mL of concentrated sulfuric acid, 0.3 g of mercuric sulfate, a pinch of silver sulfate, and 5 mL of 0.025 M potassium dichromate. 10 mL of the sample are thoroughly mixed.

Data Analysis
Each parameter's mean from the triplicate analysis was identified, and the mean's standard deviation was computed.

Results
The results of the the physicochemical parameters of water from River Niger at Onitsha such as pH, temperature, electrical conductivity, turbidity, DO, COD, BOD etc were studied. A total of 5 samples stations (001 -005) were studied and results recorded in table 1 below.

Table 1: Physicochemical properties of water from River Niger at Isimmili Idemmili Onitsha

Parameters	Sample-001	Sample-002	Sample-003	Sample-004	Sample-005	Control Sample
	Mean±S.D	Mean±S.D	Mean±S.D	Mean±S.D	Mean±S.D	
pH	6.6±0.28	5.7±0.14	5.8±0.14	5.35±0.35	6.25±0.49	8.31
Temperature	29±1.41	28±1.41	30.5±0.71	28±1.41	31±1.41	28.7

Turbidity (NTU)	6.5±0.71	8.5±0.71	11±1.41	7.5±0.71	8±1.41	1.10
Conductivity (µS/cm)	100.5±0.71	98±1.41	98±2.83	78.5±0.71	99±1.41	8.42
Alkalinity (mg/L)	12.5±0.70	12.5±2.12	9±1.41	13±1.41	12±1.41	8.17
Total Hardness (mg/L)	225±7.07	184±5.65	173.5±4.95	284±5.65	163.5±4.94	17.3
Total Solute (mg/L)	725±35.36	525±35.35	620±28.28	710±14.14	415±21.21	4.81
Total Suspended Solute (mg/L)	610±14.14	470±14.14	575±21.21	625±35.36	365±7.07	3.22
Total Dissolved Solute (mg/L)	815±21.21	620±28.28	690±14.14	770±14.14	560±28.28	5.94
Dissolved Oxygen (mg/L)	11±1.41	10±1.41	12.5±0.71	8±1.41	12±2.83	5.08
Biochemical Oxygen Demand (mg/L)	7.5±0.70	9.5±0.71	6.5±0.71	7±1.41	10±1.41	2.56
Chemical Oxygen Demand (mg/L)	21.5±2.12	22.5±2.12	16.5±2.12	12±1.41	17.5±0.71	6.70
Nitrate (mg/L)	55.5±0.70	84±5.66	94.5±6.36	74±5.66	97.5±2.12	1.32
Sulphate (mg/L)	110±14.14	99±1.41	112.5±0.70	116.5±0.71	120±1.41	0.57
Phosphate (mg/L)	142±2.83	150±1.41	126±7.07	131±2.83	118.5±2.12	0.87
Flouride (mg/L)	36.5±0.71	20.5±0.71	18.5±0.71	28.5±2.12	31.5±0.71	1.35
Chlorine (mg/L)	81.5±2.12	75.5±0.71	98±1.41	86.5±2.12	72.5±3.54	5.55

Key: Sample 001 = Sample Station 001, Sample 002 = Sample Station 002, Sample 003 = Sample Station 003, Sample 004 = Sample Station 004 and Sample 005 = Sample Station 005

Discussion

The mean concentrations of the physicochemical properties examined in River Niger are represented in Table 1. From the results, it can be seen that the pH values in all the samples studied ranged from 5.35±0.35 – 6.6±0.28 and were lower than the permissible limits of the National Standard for Drinking Water Quality, NSDWQ (Mohammadi *et al*., 2019) [9]. The pH of the studied water body is acidic. The estimated low pH of water could be linked to presence of humic acids from the demise of aquatic organisms occasioned by anthropogenic pollution (Ahiarakwem and Onyekuru, 2011; Akubugwo *et al*., 2013; Joseph *et al*., 2019) [1, 2, 8].

Temperature (°C) values in all the samples studied ranged from 28±1.41 – 31±1.41 and were slightly above the ambient temperature range. The temperatures in the present study may be due to an abrupt decrease in temperature where the sea impact is felt during high tide when the cooler sea water penetrates the lagoon or with increased solar radiation (Oluwafunmilayo *et al*., 2018) [12].

Turbidity (NTU) values in all the samples studied ranged from 6.5±0.71 – 11±1.41. Conductivity (µS/cm) values in all the samples studied ranged from 78.5±0.71 – 100.5±0.71 and were found to fall within the acceptable limit by the NSDWQ (Mohammadi *et al*., 2019; Eze *et al*., 2021b) [9, 5]. Alkalinity (mg/l) values in all the samples studied ranged from 9±1.41 – 13±1.41 and were within the acceptable limit by the WHO. Alkalinity in water is a measure of its acid-neutralizing or buffering capacity of the medium; keeping the water and its life forms safe from sudden shifts in pH (Duru *et al*., 2017).

Total hardness (mg/l) values in all the samples studied ranged from 163.5±4.94 – 284±5.65 and were within the acceptable limit by the WHO (WHO, 2006). According to Eze *et al*. (2021a) [4] water could be classified as a soft water when it forms lather readily with soap, and the degree of hardness is 0–50 mg/l. In all the samples studied, total solute (mg/l) values ranged from 415±21.21 – 725±35.36. Total suspended solute (mg/l) and Total dissolved solute values ranged from 365±7.07 – 625±35.36 and 560±28.28 – 815±21.21 respectively. It is crucial to highlight that the reported values exceeded the WHO permitted limit. This is a blatant sign of anthropogenic activity in the river under study. Additionally, drinking water with high levels of total dissolved solute (TDS) and total suspended solute (TSS) is bad for human body systems (Akubugwo *et al*., 2013; 41 Joseph *et al*., 2019; Eze *et al*., 2021a) [2, 8, 4].

Dissolved oxygen (mg/l) values ranged from 8±1 – 12.5±0.71 and were generally above the WHO limit except in sample-004. Worthy of note is that dissolved oxygen concentration greater than 5.00 mg/L supports aquatic life (Garg *et al*., 2010) [7]. Biochemical oxygen demand (mg/l) values ranged from 6.5±0.71 – 10±1.41 and were within the WHO limit. Obire *et al*. (2003) [11] noted that biochemical oxygen demand is essential for the self-purification process in water bodies. Chemical oxygen demand (mg/l) readings ranged from 12±1.41 – 22.5±2.12 and were less than the 200 mg/l WHO recommendation. Organic pollution in water is measured by the chemical oxygen demand (Atobatele *et al*., 2005; Oluwafunmilayo *et al*., 2018) [3, 12]. It is the amount of dissolved oxygen required to cause chemical oxidation of the organic material in water and is a key indicator of the environmental health of surface water (Oluwafunmilayo *et al*., 2018) [12]. Also, it is a measure of both organic and inorganic agents competing for Dissolved Oxygen in lake water. High chemical oxygen demand COD values indicate pollution due to oxidizable organic matter (Atobatele *et al*., 2005) [3].

The Nitrate (mg/l), sulphate (mg/l) and phosphate (mg/l) values were above the WHO limit, and ranged from 55.5±0.70 – 97.5±2.12, 99±1.41 – 120±1.41, and 118.5±2.12 – 150±1.41 respectively y. high nitrate concentration recorded in the River Niger implies that consumption of the water could lead to the development of methaemoglobinaemia (blue baby syndrome) in infants (Ahiarakwem and Onyekuru, 2011; Akubugwo *et al*., 2013; Joseph *et al*., 2019) [1, 2, 8]. Although sulphate is typically thought of as non-toxic, drinking water with high concentrations of sodium sulphate or magnesium sulphate may cause diarrhea and subsequent dehydration, especially in drinking water with more than 500 mg/L of sulphate (Oluwafunmilayo *et al*., 2018) [12]. The high phosphate in River Niger gave rise to the existence of blue-green algae on the surface of the river (Saleh *et al*., 2019; Mohammadi *et al*., 2019) [15, 9]. High phosphate levels in the river may also be linked to the ongoing use of phosphate-based fertilizers to the nearby agricultural areas (Eze *et al*., 2021a) [4]. Fluoride (mg/l) values ranged from 18.5±0.71 – 36.5±0.71, and exceeded the world health organization (WHO) acceptable limit for fluorides. This demonstrates the river is becoming contaminated by unlined trash dumps (Eze *et al*., 2020; Onwukeme and Eze, 2021) [6, 13]. Chloride (mg/l) values ranged from 72.5±3.54 – 98±1.41, and were found to fall within acceptable limits by the WHO. Although the concentration of chlorine in the studied river is not significantly high, it is of importance to state that the presence of chloride in river water samples is a sign of pollution due to human activities (Atobatele *et al*., 2005; Wu *et al*., 2009; Ahiarakwem and Onyekuru, 2011) [3, 1].

Conclusion

This investigation has demonstrated that all of the samples examined had pH levels that were acidic and below the NSDWQ's allowable limits. The WHO permitted level for Chemical Oxygen Demand was also discovered to be met. Similarly, the WHO-acceptable standard was met for turbidity, conductivity, alkalinity, total hardness, and biochemical oxygen demand. The temperature values, in contrast, were a little higher than the range of the ambient temperature. Sulphate, phosphate, fluoride, total dissolved solids, and dissolved oxygen all exceeded the WHO permitted limit. Also, it was determined that the chloride values were within WHO acceptable bounds. The findings of this study therefore show that this river's water is seriously polluted, and the presence of anions such nitrates, phosphates, fluorides, and chlorides in the river water is a direct effect of significant human activity in the studied area. To stop the spread of water-borne diseases among locals who depend on the river for fishing, domestic use, and irrigated farming, quick water filtration and remediation methods are advised.

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