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Surface Water Quality Assessment in Owerri West Local Government Area for Irrigation and Domestic Use

[1]Igbokwe, O.S., [1]Iwuchukwu, E.I. and *[2]Ibearugbulem, O.H.

[1]Department of Agricultural & Bio-Environmemtal Engineering, Federal Polytechnic Nekede, Owerri, Imo State, Nigeria.
[2]Department of Civil Engineering, Federal Polytechnic Nekede, Owerri, Imo State, Nigeria.
*ogediibearugbulem@gmail.com

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ABSTRACT

Assessment of water is not only for suitability for human consumption but also in relation to its agricultural, industrial, recreational, commercial uses and its ability to sustain aquatic life. Water quality monitoring is therefore a fundamental tool in the management of freshwater resources. The aim of this research work is to assess the surface water quality of Otamiri River in Owerri West Local Government Area for irrigation and domestic use. Standard analytical procedures were used in the determination of selected physical, chemical and biological water quality parameters of the samples. In May, June &July (2023) mean Temperature ranges from 26.6 to 28.0 ^{o}C, Calcium 6.2 mg/l to 12.2 mg/l, Nitrate 16.14 mg/ to 34.4 mg/l, total coliform count 15 to 35 MPN, chloride 2.5 to 10.5 mg/l, magnesium 2.9 to 3.7 mg/l, phosphate 0.9 to 1.6 mg/l, pH 6.1 to 6.5, BOD_5 7.7 to 13.9 mg/l, turbidity 24.5 to 61.7 mg/l, sulphate 30.1 to 45.4 mg/l, dissolved solid 50.3 to 144.8 mg/l and electrical conductivity 64.0 to 77.5 µS/cm but the WHO Standards for temperature, calcium, nitrate, total coliform, chloride, magnesium, phosphate, pH, BOD_5, turbidity, sulphate, dissolved solid and electrical conductivity were 40.0 ^{o}C, 50 mg/l, 10 mg/l, 1.0 MPN, 1.0 mg/l, 0.3 mg/l, 10.1 mg/l, 7.0, 4.0 mg/l, 5.0 mg/l, 200 mg/l, 200 mg/l and 100 µS/cm respectively. The results show that some sampling points fall within the WHO standards limits while others were far greater than the standard limits. The samples that are within the limits can sustain aquatic life and are safe for human consumption and Irrigation while those beyond the permissible limits are not potable enough and are harmful to ecosystem.

1. INTRODUCTION

Large quantity of water is needed for Domestic, irrigation, power generation, recreation, industrial and municipal purposes. The largest water requirement is for municipal use, but the standard of purity required for this purpose is quite different from that demanded for industrial and commercial use (Bhatia, 2009). Clean, fresh water is necessary for drinking, bathing, swimming, and food processing. Land uses generate physical, biological and chemical pollution that jeopardize water quality. Although some water pollution may occur naturally such as eroding stream banks, most water pollutants are the result of human activities (Daniels and Daniels, 2003; Akintola and Amadi, 2003). The impact of such polluted water on human health is quite enormous (Njoku and Osondu, 2007; Chukwu, 2008).

In Owerri municipal council, Otamiri river and underground water supply from private boreholes are the main sources of water for domestic and other uses, especially when the public water supply becomes epileptic. Otamiri River drains areas of diverse geology, soils and land use, and like other surface water, the river is liable to pollution from atmospheres and also from the composition of the soils and rocks through which the surface basin filters down into rivers. In addition, pollution of the river can result from human activities such as urban agriculture, dumping of solid waste, and discharge of effluent from industries into the river. Since Owerri urban and its environs depend partly on water from Otamiri River for their domestic uses, there is a need to assess the quality of the river water. Also, of importance are the influence of urban land use activities and seasonal variation on the quality of the water. The aim of this research work is to assess the surface water quality of Otamiri River in Owerri West Local Government Area, Imo State for irrigation and domestic use. Standard analytical procedures were used in the determination of selected physical, chemical and biological water quality parameters of the samples.

Assessment of water is not only for suitability for human consumption but also in relation to its agricultural, industrial, recreational, commercial uses and its ability to sustain aquatic life. Water quality monitoring is therefore a fundamental tool in the management of freshwater resources. To underpin its importance, World Health Organization (W.H.O), United Nations Environment Programme (UNEP), United Nations Educational, Scientific and Cultural Organization (UNESCO) and World Meteorological Organization (WMO) launched in 1977, a water monitoring programme to collect detailed information on the quality of global ground and surface water.

2. MATERIALS AND METHODS

2.1. Study Area

The study Area is Otamiri River near the Federal University of Technology (FUTO) in Owerri West Local Government Area of Imo State; South Eastern Nigeria. It lies within latitudes 5^0 22' and $5^0$39' and longitudes 6^0 08' and $06^0$41'. The choice of this location is because the River is very important to most inhabitants of the Local Government and it's environ and it cuts across many communities. A lot of activities take place in the river which includes sand mining, fishing, etc.

2.2. Sample Collection

Nine (9) labeled plastic bottles were used to collect the water samples at different points along the water way for laboratory analysis. Three (3) Samples were collected in the Month of May, 2023 (Labeled samples A, B and C), Three (3) Samples were collected in June, 2023 (Labeled Samples D,E, and F) and another Three (3) were collected in July, 2023(Labeled Samples G, H and I). These three Months were selected due to the fact that they have the highest rainfall duration in Owerri, Southeastern Nigeria according to the Nigeria Meteorological Agency (NIMET) Annual Forecast of 2022 and hence generate higher runoffs that could transport the pollutants which are later deposited at the water way; thereby, affecting the quality of the water.

2.3. Sample Analysis

The tests include pH, temperature, total hardness, calcium, magnesium, nitrate, dissolved oxygen, biological oxygen demand (BOD_5), lead, coliform bacteria tests, cadmium, sulphate, chloride, turbidity, phosphate alkalinity, dissolved solid and electrical conductivity. These analyses were carried out to ascertain the level of impurity, suitability and the type of treatment units required for Otamiri river/water Samples. The results obtained were compared with the WHO water standards. Standard analytical procedures were used in the determination of selected physical, chemical and biological water quality parameters of the sample. A Mercury thermometer with calibration 0-100 °C was used to measure the temperature of the water samples. The turbidity was measured using the ranch laboratory turbidity meter (2100 Amodel). The values were recorded after standardization. The pH was determined using electronic pH meter (Jaiswal, 2003). EDTA titrimetric method was used to determine the hardness of the samples. The total dissolved solid (TDS) were determined by the procedure described by APHA (1995) while the total suspended solids (TSS) was measured by gravimetric method. A self-contained Conductivity Bridge with suitable conductance cell was used in measuring electrical conductivity. Nitrate was determined using the phenol di-sulphuric acid method (APHA, 1995) while phosphate determination involved two steps: conversion of a given. Sulphate concentration were measured by turbid metric method according to Tabatabai (1974). The chlorides in the samples were determined by the Argent metric method. Alkalinity were also determined by titration method (APHA, 1995). Dissolved oxygen (DO) were measured by titrimetric method while biological oxygen demand (BOD) were determined by first incubating the sample for 5days in a BOD bottle, the BOD were then determined by measuring the DO of the sample before and after the five day incubation. The atomic absorption spectrophotometry procedure was employed in determining the following metals; Ca, Mg, Pb and Cd. The method used in determining the total coliform count were the membrane filter technique.

3. RESULTS AND DISCUSSION

The results of the physical, chemical and microbiological analysis carried out on the various water samples are shown in Tables 1 and 2, and Figures 1 to 5. The concentrations of the various water quality parameters varied with the sampling locations and months. There w an observable difference between the months of survey. The lower temperature recorded during the wet season could be attributed to the sampling period of the year. According, Ajayi and Osibanjo (1984), temperature levels are lower in the wet season than other seasons because of lower air temperature. However, the presentation of the Mean results for some selected concentrations of Otamiri water quality parameters for the Months of May (Samples A, B, and C) June (Samples D, E, and F) and July, (Samples G, H and I) 2023 respectively are depicted in Figures 1 through 5.

Table 1: Concentrations of Otamiri water quality parameters during the rainy season

Parameters	A	B	C	D	E	F	G	H	I	Average	WHO STD
pH	6.3	6.4	6.4	6.3	6.5	6.6	6.1	6.2	6.0	6.31	6.0-8.5
Temperature (°C)	27.2	26.4	27.5	28.4	27.8	27.7	26.9	26.3	26.6	27.2	<40 °C
Total hardness (mg/l)	24.6	78.6	55.1	40.5	60.3	33.0	49.2	72	42	50.59	100
Calcium(mg/l)	3.6	12.1	6.9	5.4	13.9	17.2	11.5	3.2	3.9	8.63	50
Magnesium (mg/l)	2.8	4.5	3.8	2.4	5.1	3.5	2.3	2.2	4.1	3.41	0.3
Nitrate (mg/l)	3.1	60.3	39.8	27.6	8.3	20.5	28.1	7.5	12.7	23.1	10
Dissolved oxygen (mg/l)	7.6	3.2	4.0	3.5	3.8	3.3	3.9	4.2	3.6	4.12	NS
BOD_5 (mg/l)	2.1	17.2	11.0	8.4	15.0	18.3	3.9	8.8	10.5	10.58	4.0
Lead(mg/l)	ND	ND	0.04	0.05	0.02	0.01	0.04	0.03	0.02	0.02	0.05
Total coliform (MPN/100ml)	9.2	58.8	37.0	22.3	10.7	13.4	20.9	18.0	27.4	24.19	1.0
Cadmium (mg/l)	0.02	0.01	ND	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.01
Sulphate (mg/l)	18	72.1	46.1	34	38	33	52	20.8	17.5	36.83	200
Chloride (mg/l)	5.2	22.1	4.3	9.3	1.8	1.5	3.3	2.6	1.7	5.76	1.0
Turbidity (mg/l)	2.3	8.3	62.8	50.0	75	60.2	50.4	40.3	25.6	49.66	5
Phosphate (mg/)	0.8	2.3	1.6	1.4	0.4	0.9	1.0	1.2	0.8	1.16	0.1
Alkalinity (mg/l)	3.4	25	17.6	10.3	13.4	11.6	18	19.5	13.2	14.67	NS
Dissolved solid (mg/l)	21.4	250	163	75	42	33.9	52	35	74.5	82.98	200
Conductivity(μS/cm)	7.3	140.2	85.1	61.2	72.3	58.4	95	100	28.6	72.01	100

NS=Not Specified, ND=Not Detected

In May (2023) mean Temperature was 27.0 °C, Calcium was 7.5 mg/l and Nitrate was 34.4 mg/l (Figure 1). In June (2023) mean Temperature was 28.0 °C, Calcium was 12.2 mg/l and Nitrate was 18.8mg/l

(Figure 1). In July (2023) mean Temperature was 26.6.0 ºC, Calcium was 6.2mg/l and Nitrate was 16.1 mg/l (Fig.1). However, the WHO Standards for Temperature, Calcium and Nitrate was 40^0C, 50mg/l and 10.0mg/l respectively. The lower temperature determined during the wet season agrees with the temperature values of some rivers in Southern Nigeria (Bieluonwu, 2005). Low water temperature has the effect of decreasing the efficiency of treatment process (Park, 2009). The Nitrate concentrations varied with the sampling locations and almost higher than the standard limits in all the sampling points A to I except in points A (3.1mg/l), E (8.3mg/l) and H (7.5mg/l) while the WHO Standard limit was 10mg/l. Nitrate concentration in the Otamiri river seems to reduce with increase in rainfall duration Ideriah *et al.* (2010) and they attribute it to the reduction of water volume in the dry or less rainfall season, and the dilution effect in the rainy season. The implications of river waters having high $N0_3$ concentrations is the stimulation of the growth of plankton and water weeds that provide food for fish. If algae grow too widely, oxygen levels will be reduced and fish will die. Park (2009) adds also that the guideline value for nitrate in drinking water is solely to prevent metamolobinaemia, which depends upon the conversion of nitrate to nitrite.

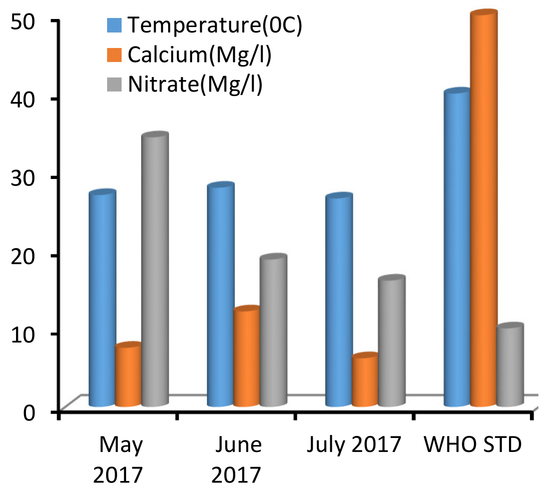

Figure 1: Levels of temperature, calcium and nitrate compared with WHO standard

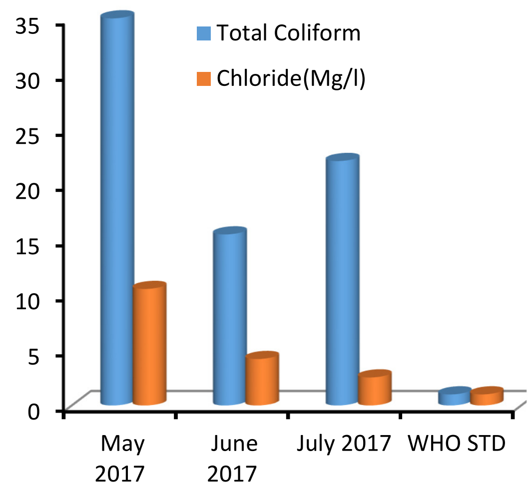

Figure 2: Level of total coliform and chloride compared with WHO standard

In May (2023) mean total coliform count was 35 MPN, chloride was 10.5 mg/l (Figure 2). In June (2023) mean total coliform was 15.5 MPN and chloride was 4.2 mg/l. In July (2023) mean Total Coliform stood at 22.5MPN and Chloride was 2.5 mg/l while the WHO Standards for Total Coliform count and Chloride was 1.0 MPN and 1.0 mg/l respectively. The water in the study area varied in their microbial quality especially the coliform group. The Total Coliform in the months of May, June and July 0f 2023 were higher than the WHO standard limits of 1.0 MPN. This variation was probably due to the level of municipal wastes received by the respective areas. This agrees with the report of Crowther *et al.* (2001) and Kistemann *et al.* (2002) that there were significant increases in organic and bacterial load after a rainstorm. All the Sampling points had total coliform count higher than the permissible limit of 1.0MPN/100ml and could be considered polluted. Bacteria polluted water causes both in humans and animals' numerous water-borne diseases, either as a result of ingestion or direct contact, or inhalation of aerosols generated by contaminated water. In May (2023) mean Magnesium was 3.7 mg/l, phosphate was 1.6 mg/l (Figure 3). June (2023) mean Magnesium was 3.7 mg/l and phosphate was 0.9 mg/l (Figure 3) and in July (2023), mean Magnesium was 2.9 mg/l and phosphate was 1.0 mg/l whereas the WHO standards for Magnesium 0.3 mg/l and phosphate was 0.1 mg/l respectively.

The PO_4 levels varied along the sampling locations and the range of values obtained in this study agrees with the moderate to high levels of PO_4 in Southern Nigeria rivers. Egborge *et al.* (1994) recorded a range of phosphate value of 0.01 – 7.40 mg/l for Yelwa river in Southern Nigeria. However, all the values were higher than the permissible limit of 0.1 mg/l. There was observable difference between the means phosphate of the Months of May, June and July 2023 values. The increase in the input of PO_4 from detergents used in car wash in the Federal University of Technology (FUTO) and student's laundry activities going on close to the Otamiri river. Although phosphates are not toxic and do not represent a direct threat to animals and other organisms, they represent a serious indirect threat to water quality (Dhameja, 2005).

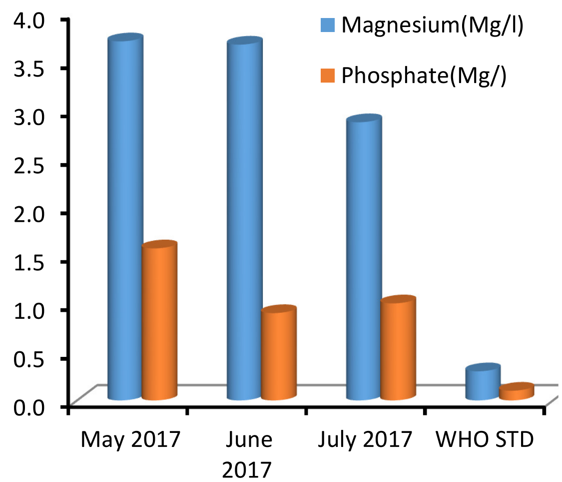

Figure 3: Levels of manganese and phosphate compared with WHO standard

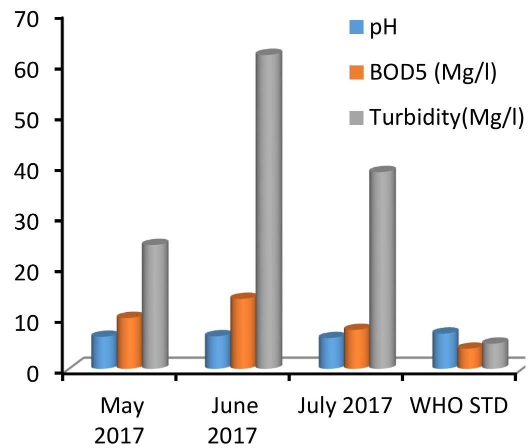

Figure 4: Level of pH , BOD5, and turbidity compared with WHO Standard

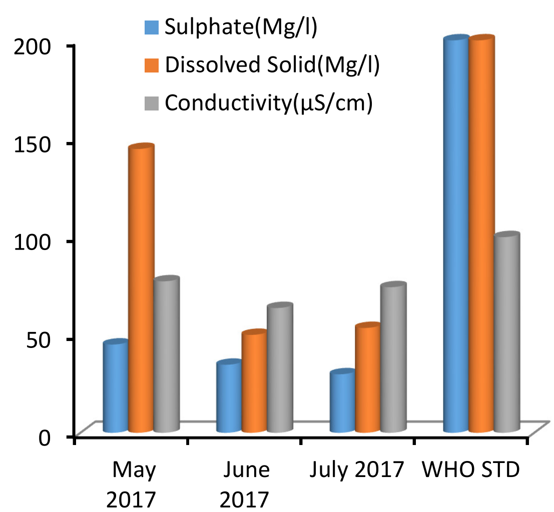

Figure 5: Levels of sulphate, dissolved solid and conductivity compared with WHO Standard

In May (2023) mean pH was 6.2, BOD_5 was 10.1 mg/l and Turbidity was 24.5 mg/l (Figure 4). In June (2023) mean pH was 6.5, BOD_5 was 13.9 mg/l and Turbidity was 61.7mg/l. In July (2023) mean pH was

6.1, BOD_5 was 7.7 mg/l and Turbidity was 38.8 mg/l (Fig.4). However, the WHO Standards for pH, $BOD_5$and Turbidity was 7.0, 4.0 mg/l and 5.0 mg/l respectively. The mean pH value of May (6.4), June (6.5) and July (6.1) were all within the WHO Standard limits of 6.0-8.5 for drinking water though the pH value for the month of June was slightly higher than May and July. However, the range of pH values recorded in Otamiri river (study area) is lower than the range reported for some Nigeria rivers like river Kaduna (6.4–7.2) and River Asa (6.8-9) (Adenji, 1990). The lower pH values obtained in the study could be linked to the predominant soil type in the river (Adeniji, 1978) or probably due to built-up of organic material. As organic substance decay, carbon dioxide forms and combines with water to produce weak acid "carbonic" acid. Some fish cannot tolerate low pH (USEPA, 1976).

Turbidity values are usually higher during the rainy season than the dry season and could be probably due to solid waste material and soil particles transported by runoff from urban activities into the river. Turbidity was significantly higher in locations C, E and G more than other locations in the months of May, June and July of 2023 and also WHO Standard limit for drinking water. This could be because the locations are contiguous to the urban area and receive direct impact of urban activities such as dumping of solid wastes and sand excavation from the river.

Drinking water should be free from turbidity on aesthetic grounds and (Park, 2009) opined that Higher turbidity affects fish and aquatic life by interfering with sunlight penetration. Other contributing factors are high turbidity and extent of mineralization. In May (2017) mean Sulphate was 45.4 mg/l, dissolved solid was 144.8 mg/l and Conductivity was 77.5 µS/cm (Figure 5). In June (2023) Sulphate was 35.0 mg/l, dissolved solid was 50.3 mg/l and Conductivity was 64.0 µS/cm. In July (2023) mean Sulphate was 30.1 mg/l, dissolved solid was 53.8 mg/l and electrical conductivity was 74.5 µS/cm. However, the WHO Standards for sulphate, dissolved solid and electrical conductivity was 200 mg/l, 200 mg/l and 100 sulphate were 45.4 mg/l, dissolved solid was 144.8 mg/l and Electrical Conductivity was 77.5 µS/cm respectively. The electrical conductivity values for the months of May, June and July were within permissible limits; though the values for the months of May and July were higher than June. This rise could probably be due to the impact of dissolved substances from municipal wastes dumped into the river, and also industrial effluent emptied into the water body.

4. CONCLUSION

Otamiri river is negatively impacted by various land use and human activities in the area. The research shows the influence of urban land use and rainy season months of May, June and July of 2023 on water quality parameters of Otamiri river. The results shows that some sampling points fall within the WHO standards limits while others were far greater than the standard limits. The samples that are within the limits can sustain aquatic life and are safe for human consumption and Irrigation while those beyond the permissible limits are not potable enough and are harmful to ecosystem. A management plan to restrict the dumping into the Otamiri is needed in order to reduce the impact on water quality and water-related health problems. This can be achieved through effective waste management strategy and provision of reliable public water supply. There are laws on ground to checkmate these anomalies; Government should enforce relevant laws to ensure that we have a healthy ecosystem and also save Otamiri river because of its economic importance to Obinze, Ihiagwa, Eziobodo, FUTO Communities and its environ.

5. ACKNOWLEDGEMENT

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6. CONFLICT OF INTEREST

There is no conflict of interest associated with this work.

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