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Waste Dumpsites and Potential Contamination of Ogbagiirigiri Well, Iyi Echu, Lolo and Uze Streams, Okigwe, Imo State Nigeria

Umeham Solomon Nnanna[1]; Dike Maduabuchi Chizuruoke[2]; Achonwa Juliet[3]

[1,2,3]Abia State University Uturu

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Abstract: The investigation targeted ascertaining the impact closed and open refuse dump sites had on three streams (Iyiechu, Lolo, Uze) and Ogbagirigiri well. The study was based on measurement of physico-chemical parameters of the water spources from November 2019 to October 2020, comparing with standards, other streams and calculation of the water quality index. Surface water temperature for the four ranged from 22°C (Lolo stream) to 38°C (Iyiechu stream). Values of electrical conductivity recorded in this study were below the limits of WHO, NIS and EU and also below the range of records for some Eastern Nigeria surface waters The highest and lowest mean values (1.40±0.61 µs/cm and 0.18±0.02 µs/cm) of conductivity were recorded in Ogbagirigiri well and Uze stream respectively. Total dissolved solids (TDS) recorded in this study was within the range of 2.45 and 19.40 were below WHO, NIS and FMEnv recommended limits and as well below the TDS values recorded in some Eastern water bodies The mean pH values observed during this study were 6.72±0.48, 6.73±0.78, 6.68±0.14 and 6.03±0.38 in Iyiechu stream, Lolo stream, Uze stream and Ogbagirigiri well respectively. The pH of the streams fell within WHO, NIS and FMEnv limits. The pH values of this study were in consonance with FEPA water quality guidelines for food beverage industry. 2003). Lower mean alkalinity values (38.75±11.3 mg/l and 45.00±14.46 mg/l) were recorded in Uze stream and Ogbagirigiri well respectively, while higher mean alkalinity values (52.08±26.75 mg/l and 47.92±15.14 mg/l) were recorded in Iyiechu and Lolo streams respectively. Ogbagirigiri well had the highest water hardness range from 60.00 – 360.00mgCaCO$_3$/l. and confers a hard water status to the well. The recorded mean values for hardness in all the sites were below NIS (2015) permissible limit. Dissolved oxygen (DO) was high in Uze (7.23±1.19mg/l) and Lolo (6.87±1.17mg/l) streams and low in Ogbagirigiri in (3.22±2.02mg/l), Iyi-echu (4.73±0.44mg/l) streams. Iyiechu and Uze streams had higher BOD values than Ogbagirigiri well and Lolo stream. The streams had same common order of dominance of cations which was Ca>Mg>Na>K, while in Ogbagirigiri well, it was Ca>Mg>k>Na. Iyiechu and Lolo streams followed a common order of dominance of anions which was Cl>S>N>Total P. The water quality index in stations Iyiechu and Lolo streams portrayed the effect of anthropogenic activities including uncontrolled waste disposal in and around the water bodies (especially in Iyiechu stream), pollutants from farmlands and sidewalks, wastewater from palm oil mill (especially in Lolo stream) etc. Ogbagirigiri well water has WQI of 84 which indicated a poor water quality which could be attributed to the poor sanitary and unhygienic practices in the site. Iyiechu stream, Lolo stream, and Ogbagirigiri well which are of poor quality for human consumption can serve other purposes like aquatic husbandry and other culinary concerns.

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I. INTRODUCTION

Waste generation, management and disposal are key to serious ecological, environmental and health problems faced by the Nigerian populace today. The population of Nigerian inhabiting cities and urban areas has more than doubled in the last ten years, the cities and the urban areas therefore have experienced a quantum jump in growth which has contributed markedly to the generation of both solid and liquid wastes. Improper solid waste disposal methods have contributed significantly to wide spread environmental pollution and diseases. Okigwe is the second largest city in Imo State of Nigeria. The city lies between the Port-Harcourt –Enugu – Maiduguri rail-line. The town lies between latitude 5^o 28' 58.80''N and longitude 7^o 32' 60.00''E. The open and closed dumpsites on the banks of Iyi-echu stream, Lolo stream both 1st order streams ramify into of 2nd and 3rd order streams cut across Okigwe metropolis. The dumpsites were partially closed since they still receive intermittent waste materials from residents who blatantly refuse to adhere to environmental laws. The Ogbagirigiri well is in close nexus with Iyi-echu stream and the inhabitants resort to it for drinking and culinary purposes with the belief that it was not as contaminated as iyi-echu stream. Uze is a near pristine-stream on Okigwe – Ogii road. These dumpsites whether closed or open are located in commercial areas with mechanic shades, banks, medical diagnostic laboratories, lock-up shops etc. Constituents of the dumps included rags, plastic

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containers, metal scraps from cars, empty water sachets, motor oil spills, cellophane bags, bottles etc.

When wastes are not properly managed, it affects the water bodies, especially, fresh water reservoirs. Contamination through seepage also contributes to alteration in quality and availability of water (Olawale, 2016).

Umeham (2014) reported that the sanitary quality of water is determined by the relative extent of the absence of suspended matter, colour, taste, unwanted dissolved chemical, bacteria indicative of faecal pollution and other aesthetically offensive objects. Healthy aquatic ecosystem is dependent on the physico-chemical and biological characteristics (Venkatesharaju *et al.*, 2010). To assess these characteristics, monitoring of these parameters is essential to identify magnitude and source of any pollution load. These characteristics can identify certain condition for the ecology of living organisms and suggest an appropriate conservation and management strategies (Prasanna and Rajan, 2010).

II. MATERIALS AND METHOD

The study area is Okigwe; a city located in Imo State, Nigeria. It lies between latitude 5.483°N and longitude 7.55°E of the Greenwich Meridian.

After Owerri and Orlu, Okigwe is the third largest city in Imo state which lies between the Port Harcourt-Enugu-Maiduguri rail lines.

This investigation was carried out from November 2019 and October, 2020. Four stations were chosen for this study – Station 1 Iyiechu stream is located along Ubaha road Okigwe. The dumpsite near the stream is an extensive one which has been in existence for a good number of years. Depositors dump waste in an uncontrolled manner and make very poor use of the available space, they sometimes dispose waste directly into the lotic stream. Constituents of dumped materials include plastics, food waste, metals, hard papers, animal wastes, etc. Flies, rodents and birds are frequent “visitors” while unpleasant sight and odour make road users, residents, garbage evacuators and even waste depositors uncomfortable. Station 2. Ogbagigirigiri well is a well water located near Iyiechu stream, along Ubaha road. The walls of the well at the time of sampling were covered with clumps and mats of mosses. The water was clear with a sandy substrate. Residents of that area fetch the water for cooking and washing as iyi-echu stream got increasingly putrefied. Station 3, Lolo stream is located at Okwueze Amuro in Okigwe. The water is brownish with sandy substrate. Activities like washing, bathing, swimming and occasional sand mining were observed in the stream. Lolo stream is the main source of water supply to the palm oil mill close to it and the water receives effluent from the mill. The green vegetation in the area are cassava plants in the farmlands, palm trees, grasses and bamboo trees which the leaves often shed into the stream.

Station 4, Uze is a near-pristine stream located along Okpara-Ogii road which took its source from Uturu. There has not been any form of solid waste disposal observed along the course of the flow of the stream from the origin to the sampling station except agricultural runoff which could contain pollutants like pesticides, herbicides or fertilizers. The water is used for drinking purpose. Activities like washing, bathing and periodic cassava fermentation were evident in the upper reaches.

Physical measurements were made in the field with hand held instruments while chemical analyses were carried out on samples collected and transported to the laboratories following standard methods as indicated on the table below.

Table 1 Methodology of Physical and Chemical Characteristics Determination

S/NO	PARAMETERS	MATERIALS/METHODS
1	Air-shade temperature(°C)	Celsius scale thermometer
2	Surface water temperature (°C)	Celsius scale thermometer
3	pH	pH meter (Eil Model 7070)
4	Electrical conductivity(μscm^{-1})	Conductivity meter (HANNA 9828)
5	Total dissolved solid (mgl^{-1})	Gravimetric method (Lind, 1979)
6	Total hardness (mgl^{-1})	Titration with EDTA (lind. 1979)
7	Chloride(mgl^{-1})	Titrimetric method (Mackereth, 1963)
8	Alkalinity (mgl^{-1})	Titration with dil.HCL
9	Dissolved Oxygen (mgl^{-1})	Titration with sodium thiosulphate (Wetzel & likens, 1979)
10	Biochemical Oxygen Demand(mgl^{-1})	Titration with sodium thiosulphate (Wetzel & Likens, 1979)
11	Nitrate (mgl^{-1})	Spectrophotometry (Mackereth, 1963)
12	Total Phosphorous (mgl^{-1})	Spectrophotometry (Mackereth, 1963)
13	Ortho-Phosphate phosphorous(mgl^{-1})	Spectrophotometry (Mackereth, 1963)
14	Silica (mgl^{-1})	Spectrophotometry (Mackereth, 1963)
15	Sulphate (mgl^{-1})	Spectrophotometry (Mackereth, 1963)
16	Potassium (mgl^{-1})	Flame absorption spectrophotometry (Wetzel & Likens, 2000)
17	Sodium (mgl^{-1})	Flame absorption spectrophotometry (Wetzel & Likens, 2000)
18	Zinc (mgl^{-1})	Atomic absorption spectrophotometry (Wetzel & Likens, 2000)
19	Iron (mgl^{-1})	Atomic absorption spectrophotometry (Wetzel & Likens, 2000)
20	Magnesium (mgl^{-1})	Atomic absorption spectrophotometry (Wetzel & Likens, 2000)

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21	Calcium (mgl^{-1})	Atomic absorption spectrophotometry (Wetzel & Likens, 2000)
22	Manganese (mgl^{-1})	Atomic absorption spectrophotometry (Wetzel & Likens, 2000)

The WQI was calculated using the Nigerian drinking water Quality Index method classified the water quality according to the degree of purity by using the most commonly measured water quality variables. The method has been widely used and the calculation of WQI was made by Tyagi *et al.*, (2013) using the following equation.

$$WQI = \sum QiWi / \sum Wi$$

The quality rating scale (Qi) for each parameter is calculated by using this expression:

$$Qi = 100[(Vi - Vo/Si - Vo)]$$

Where:

Vi is estimated concentration of the parameter in the analysed water

Vo is the ideal value of this parameter in pure water. Vo = 0 (except pH = 7.0 and DO = 14.6mg/l)

Si is recommended standard value of ith parameter.

The unit weight (Wi) for each water quality parameter is calculated by using the following formula:

Wi = K/Si

Where K= proportionality constant

III. RESULTS

Tables 2 and 3 show mean values and range of the measured physico-chemical parameters of the studied water sources respectively. The results of the various physico-chemical parameters of the four water sources in comparison with NIS (2015), WHO, EU, and FMEnv standards are presented in Table 4. Table 5 shows the concentration of the physico-chemical parameters of the three streams and a well in Okigwe in comparison with some streams in Eastern Nigeria. The concentrations of some parameters of four water bodies in comparison with FEPA water quality guidelines for food beverage industry are shown in Table 6. The seasonal variation of concentrations of the parameters of the studied water bodies are shown in Table 7. Analysis of Variance (ANOVA) showing the results of the wet and dry season variation of the concentrations of the parameters of the studied water bodies is shown in Table 8.

Tables 9, 10, 11 and 12 show the Water Quality Index of Iyiechu stream, Ogbagirigiri well, Lolo stream and Uze stream. While table 13 shows water quality rating as per Weight Arithmetic Water Quality Index.

Table 2 The Mean ± SD Values of Various Physicochemical Parameters of the Studied Water Bodies in Okigwe Metropolis.

Parameter	Iyiechu Stream	Lolo Stream	Uze Stream	Ogbagirigiri Well
Surface Water Temp. (°C)	26.65±4.06[a]	25.88±2.95[a]	26.95±2.15[a]	26.13±2.30[a]
Air Shade Temp. (°C)	27.47±1.83[a]	26.96±3.74[a]	27.83±1.75[ab]	29.93±2.41[b]
E. Conductivity (µs/cm)	0.43±0.21[a]	0.45±0.21[a]	0.18±0.02[a]	1.40±0.61[b]
TDS (mg/l)	8.83±0.81[b]	6.18±1.76[a]	4.82±1.69[a]	15.23±3.89[c]
pH	6.72±0.48[b]	6.73±0.78[b]	6.68±0.14[b]	6.03±0.38[a]
Alkalinity (mg $CaCO_3$/l)	52.08±26.75[a]	47.92±15.14[a]	38.75±11.3[a]	45.00±14.46[a]
Hardness (mg/l)	71.00±35.08[a]	55.67±25.15[a]	53.00±21.11[a]	146.00±79.84[b]
DO (mg/l)	4.73±0.44[b]	6.87±1.17[c]	7.23±1.19[c]	3.22±2.02[a]
BOD (mg/l)	1.68±1.22[b]	0.91±0.39[a]	1.20±0.62[ab]	0.89±0.84[a]
Chloride (mg/l)	48.78±6.18[ab]	52.32±8.08[ab]	55.60±13.59[b]	46.63±4.60[a]
T. Phosphorus (mg/l)	0.23±0.08[a]	0.24±0.03[a]	0.21±0.06[a]	0.21±0.05[a]
Potassium (mg/l)	1.89±1.15[b]	0.63±0.26[a]	0.06±0.03[a]	4.45±1.71[c]
Sodium (mg/l)	2.54±1.72[b]	1.13±0.28[a]	0.90±0.25[a]	3.76±2.56[b]
Iron (mg/l)	0.13±0.19[a]	0.12±0.09[a]	0.07±0.01[a]	0.17±0.21[a]
Magnesium (mg/l)	4.08±1.03[b]	3.93±0.78[ab]	3.39±0.49[a]	6.08±0.49[c]
Calcium (mg/l)	17.78±5.38[b]	17.89±6.39[b]	13.88±2.01[a]	26.27±2.54[c]
Manganese (mg/l)	0.05±0.02[b]	0.04±0.01[ab]	0.03±0.02[a]	0.08±0.01[c]
Silica (mg/l)	0.32±0.11[a]	0.26±0.07[a]	0.24±0.14[a]	0.70±0.14[b]
Nitrate (mg/l)	0.63±0.11[a]	0.61±0.07[a]	0.61±0.12[a]	0.89±0.31[b]
Sulphate (mg/l)	0.80±0.31[b]	0.79±0.05[b]	0.56±0.11[a]	1.20±0.21[c]

Mean values followed by different superscript within the same row are significantly different ($p < 0.05$).

Table 3 The Range of Values for Various Physicochemical Parameters of the Studied Water Bodies in Okigwe Metropolis.

Parameter	Iyiechu Stream	Lolo Stream	Uze Stream	Ogbagirigiri Well
Surface Water Temp.	23.00-38.00	22.00-30.00	24.00-30.00	24.00 -32.00
Air Shade Temp.	24.50-30.00	20.00-32.00	26.00-31.00	27.00-36.00

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E. Conductivity	0.22-0.75	0.22-0.74	0.15-0.20	0.86-2.32
TDS	7.60-9.60	3.84-9.20	2.45-7.30	9.74-19.40
pH	6.30-8.00	4.50-7.90	6.50-7.00	5.60-6.90
Alkalinity	15.00-100.00	20.00-75.00	25.00-60.00	20.00-70.00
Hardness	32.00-148.00	32.00-100.00	24.00-88.00	60.00-360.00
DO	4.27-5.53	5.00-8.35	5.70-8.94	2.12-9.55
BOD	0.20-4.47	0.20-1.42	0.61-2.37	0.24-3.45
Chloride	38.42-54.90	45.28-64.84	40.75-68.60	40.78-52.82
T. Phosphorus	0.14-0.38	0.18-0.27	0.14-0.29	0.12-0.26
Potassium	0.14-3.73	0.40-1.05	0.01-0.10	2.80-7.30
Sodium	0.67-4.72	0.80-1.46	0.54-1.19	1.20-8.60
Iron	0.06-0.74	0.05-0.28	0.06-0.10	0.074-0.820
Magnesium	3.16-5.83	2.78-4.93	2.84-4.16	5.24-6.80
Calcium	12.80-26.50	12.54-29.60	10.78-15.84	18.77-28.27
Manganese	0.014-0.09	0.02-0.06	0.01-0,07	0.072-0.09
Silica	0.20-0.62	0.17-0.35	0.14-0.49	0.52- 0.89
Nitrate	0.41-0.81	0.54-0.74	0.44-0.75	0.10-1.19
Sulphate	0.08-1.43	0.72-0.88	0.36-0.65	0.87-1.45

Table 4 The Results of Various Physicochemical Parameters of the Studied Water Bodies in Okigwe Metropolis in Comparison with NIS, WHO, EU and FMEnv Standards.

Parameter	**Iyiechu stream**	**Lolo stream**	**Uze stream**	**Ogbagirigiri well**	**NIS (2015)**	**WHO (2017)**	**EU (2014)**	**FMEnv (2001)**
Surface Water Temp.	26.65	25.88	26.95	26.13	Ambient	-	-	-
Air Shade Temp.	27.47	26.96	27.83	29.93	-	-	-	-
E. Conductivity	0.43	0.45	0.18	1.40	1000	400	2500	-
TDS	8.83	6.18	4.82	15.23	500	500	-	2000
pH	6.72	6.73	6.68	6.03	6.5-8.5	7.0-8.4	6.5-9.5	6.6-9.0
Alkalinity	52.08	47.92	38.75	45.00	-	-	-	-
Hardness	71.00	55.67	53.00	146.00	150	-	-	-
DO	4.73	6.87	7.23	3.22	-	5.0	-	-
BOD	1.68	0.91	1.20	0.89	-	4.0	-	30
Chloride	48.78	52.32	55.60	46.63	250	250	250	600
T. Phosphorus	0.23	0.24	0.21	0.21	100	200-400	5.0	5
Potassium	1.89	0.63	0.06	4.45	200	100	-	-
Sodium	2.54	1.13	0.90	3.76	200	150	50	100
Iron	0.13	0.12	0.07	0.17	0.3	-	0.3	0.3
Magnesium	4.08	3.93	3.39	6.08	20	50	100	80-100
Calcium	17.78	17.89	13.88	26.27	-	75	-	-
Manganese	0.05	0.04	0.03	0.08	0.2	0.05	0.05	-
Silica	0.32	0.26	0.24	0.70	-	-	-	-
Nitrate	0.63	0.61	0.61	0.89	50	50	50	20
Sulphate	0.80	0.79	0.56	1.20	100	-	250	-

Table 5 The Results of Various Physicochemical Parameters of the Four Water Sources in Okigwe Metropolis in Comparison with Some Other Water Bodies in Eastern Nigeria - (Ngwui and Eme Streams-Umeham and Elekwa, 2005; Utegbu Stream and Isi-Akwu Spring- Anya, 2013; and Okigwe – Iwuala *et al.*, 2019).

Parameter	**Iyiechu stream**	**Lolo stream**	**Uze stream**	**Ogbagirigiri well**	**Utegbu stream**	**Isi-Akwu spring**	**Ngwui stream**	**Eme stream**	**Okigwe**
Surface Water Temp.	26.65	25.88	26.95	26.13	28.6	29.3	30.0	30.1	27.407
Air Shade Temp.	27.47	26.96	27.83	29.93	29.6	29.0	-	-	-
E. Conductivity	0.43	0.45	0.18	1.40	15.2	224.6	43.0	13.0	45.714
TDS	8.83	6.18	4.82	15.23	10.8	159.3	53.0	52.0	29.714
pH	6.72	6.73	6.68±	6.03	4.3	5.7	4.8	5.1	6.643

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Alkalinity	52.08	47.92	38.75	45.00	9.2	76	-	-	-
Hardness	71.00	55.67	53.00	146.00	23.7	362.3	240.0	320.0	1.414
DO	4.73	6.87	7.23	3.22	9.4	7.3	-	-	5.786
BOD	1.68	0.91	1.20	0.89	3.6	2.8	-	-	2.029
Chloride	48.78	52.32	55.60	46.63	5.7	79.2	2.42	7.3	505.812
T. Phosphorus	0.23	0.24	0.21	0.21	0.3	0.1	0.14	0.2	-
Potassium	1.89	0.63	0.06	4.45	0.343	55.247	-	-	-
Sodium	2.54	1.13	0.90	3.76	1.62	46.82	3.05	1.00	-
Iron	0.13	0.12	0.07	0.17	0.09	0.03	0.20	1.50	-
Magnesium	4.08	3.93	3.39	6.08	0.03	11.20	0.35	0.20	-
Calcium	17.78	17.89	13.88	26.27	0.024	26.62	6.40	1.00	-
Silica	0.32	0.26	0.24	0.70	-	-	-	-	-
Nitrate	0.63	0.61	0.61	0.89	1.9	6.6	40.0	44.0	-
Sulphate	0.80	0.79	0.56	1.20	9.8	46.5	-	-	-

Table 6 Concentrations of the Physicochemical Parameters of the Studied Water Bodies in Okigwe Metropolis in Comparison with FEPA Water Guidelines for Food Beverage Industry (FEPA, 2001).

Parameter	**Iyiechu stream**	**Lolo stream**	**Uze stream**	**Ogbagirigiri well**	**Baking**	**Brewing**	**Carbonate beverage**	**Confecti-onary**	**Dairy**
Conductivity	0.43	0.45	0.18	1.40	13.0	-	-	-	-
TDS	8.83	6.18	4.82	15.23	-	800	850	100	500
pH	6.72	6.73	6.68±	6.03	-	7	6.9	7.0	-
Hardness	71.00	55.67	53.00	146.00	0	70	<250	-	80
Chloride	48.78	52.32	55.60	46.63	-	20.6	250	250	30
Total Phosphorus	0.23	0.24	0.21	0.21	-	-	-	-	-
Sodium	2.54	1.13	0.90	3.76	-	-	-	-	-
Iron	0.13	0.12	0.07	0.17	0.2	-	1.0	0.2	<0.3
Magnesium	4.08	3.93	3.39	6.08	-	30	-	-	-
Calcium	17.78	17.89	13.88	26.27	-	100	-	-	-
Nitrate	0.63	0.61	0.61	0.89	-	10	-	-	20

Table 7 Water Quality Index for Iyiechu Stream

S/No	**Parameters**	***Vi***	***Si***	***Qi***	***Wi***	***QiWi***
1	pH	6.72	7.5	56	0.133	7.448
2	E. Conductivity	0.43	1000	0.43	0.001	0.000
3	TDS	8.83	500	1.766	0.002	0.004
4	DO	4.73	5.0	102.8	0.200	20.56
5	BOD	1.68	4.0	42	0.250	10.50
6	Chloride	48.78	250	19.512	0.040	0.780
7	Nitrate	0.63	50	1.260	0.020	0.0252
8	Sulphate	0.80	100	0.80	0.010	0.008
9	T. Phosphorus	0.23	100	0.230	0.010	0.002

$\Sigma\, Wi$ = 0.666

$\Sigma\, QiWi$ =39.320

WQI = $\sum QiWi / \sum Wi$ = (39.328 / 0.666) = 59

Table 8 Water Quality Index for Ogbagirigiri Well

S/No	**Parameters**	***Vi***	***Si***	***Qi***	***Wi***	***QiWi***
1	pH	6.03	7.5	1.94	0.133	25.802
2	E. Conductivity	1.40	1000	0.14	0.001	0.000
3	TDS	15.23	500	3.046	0.002	0.061
4	DO	3.22	5.0	118.542	0.200	23.708
5	BOD	0.89	4.0	22.25	0.250	5.563

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6	Chloride	46.63	250	18.652	0.040	0.746
7	Nitrate	0.89	50	1.78	0.020	0.036
8	Sulphate	1.20	100	1.20	0.010	0.012
9	T. Phosphorus	0.21	100	0.21	0.010	0.003

$\Sigma\ Wi$ = 0.666

$\Sigma\ QiWi$ =55.931

WQI = $\sum QiWi / \sum Wi$ = (55.931/0.666) = 84

Table 9 Water Quality Index for Lolo Stream

S/No	Parameters	*Vi*	*Si*	*Qi*	*Wi*	*QiWi*
1	pH	6.73	7.5	54	0.133	7.182
2	E. Conductivity	0.45	1000	0.045	0.001	0.00
3	TDS	6.18	500	1.236	0.002	0.003
4	DO	6.87	5.0	145.729	0.200	29.146
5	BOD	0.91	4.0	22.75	0.250	5.689
6	Chloride	52.32	250	20.928	0.040	0.837
7	Nitrate	0.61	50	1.22	0.020	0.024
8	Sulphate	0.79	100	0.79	0.010	0.079
9	T. Phosphorus	0.24	100	0.24	0.010	0.002

$\Sigma\ Wi$ = 0.666

$\Sigma\ QiWi$ = 42.962

WQI = $\sum QiWi / \sum Wi$ = (42.962 / 0.666) = 65

Table 10 Water Quality Index for Uze Stream

S/No	Parameters	*Vi*	*Si*	*Qi*	*Wi*	*QiWi*
1	pH	6.68	7.5	140.00	0.133	5.320
2	E. Conductivity	0.18	1000	0.018	0.001	0.000
3	TDS	4.82	500	0.964	0.002	0.002
4	DO	7.23	5.0	76.77	0.200	0.154
5	BOD	1.20	4.0	30.00	0.250	7.500
6	Chloride	55.60	250	22.24	0.040	0.890
7	Nitrate	0.61	50	1.22	0.020	0.024
8	Sulphate	0.56	100	0.56	0.010	0.007
9	T. Phosphorus	0.21	100	0.21	0.010	0.002

$\Sigma\ Wi$ = 0.666

$\Sigma\ QiWi$ = 13.898

WQI = $\sum QiWi / \sum Wi$ = (13.898 / 0.666) = 21

Table 11 Water Quality Rating as Per Weight Arithmetic Water Quality Index (Tyagi et al., 2013).

Water Quality Index Level	Water quality status	Grading
0 – 25	Excellent water quality	A
26 – 50	Good water quality	B
51 – 75	Poor water quality	C
76 – 100	Very poor water quality	D
> 100	Unsuitable for drinking	E

IV. DISCUSSION

The surface water temperature for the four sample stations ranged from 22°C (Lolo stream) to 38°C (Iyiechu stream). This is close to that of Ewebiyi *et al* (2015) who reported a temperature range of 20.2°C and 31.3°C. Temperature values have no direct effect on human health and well-being, but control the rate of all chemical reactions, and affects fish growth, reproduction and immunity. (Eze and Chigbu, 2015) Values of electrical conductivity recorded in

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this study were below the limits of WHO, NIS and EU (Table 4) and also below the range of records for some Eastern Nigeria surface waters (Table 5). The highest and lowest mean values (1.40±0.61 µs/cm and 0.18±0.02 µs/cm) of conductivity were recorded in Ogbagirigiri well and Uze stream respectively.

Total dissolved solids (TDS) recorded in this study was within the range of 2.45 and 19.40 (Table 3) were below WHO, NIS and FMEnv recommended limits (Table 4) and as well below the TDS values recorded in some Eastern water bodies (Table 5). The noted values were quite low when compared to Adefemi *et al.,* (2007) who reported a range of 75-250 mg/l for samples from dams in Ekiti state, Nigeria. Dissolved solids determination is important in limnological studies, though no health effects has been associated with dissolved solids ingestion in water but excess amount might principally have organoleptic implications, disturb ecological balance and may cause suffocation to aquatic fauna (Pandey *et al*., 2012). Any variation in pH beyond acceptable range could be fatal to aquatic organisms. Thus, the mean pH values observed during this study were 6.72±0.48, 6.73±0.78, 6.68±0.14 and 6.03±0.38 in Iyiechu stream, Lolo stream, Uze stream and Ogbagirigiri well respectively. The pH of the streams fell within WHO, NIS and FMEnv limits. The pH values of this study were in consonance with FEPA water quality guidelines for food beverage industry, (Table 6). Prolonged intake of low pH water may predisposes one to dangers of acidosis, which according to health experts may lead to cancer or cardiovascular damage including the constriction of blood vessels and reduction in oxygen supply even at mild levels (Ogundipe and Obinna, 2008). Water pH is very important because it affects other pollutants in that when it is very acidic, metals such as zinc, aluminum, and copper are released causing them to accumulate in the food chain. Likewise, when it is more basic, it causes the accumulation of the unionized ammonia ions (NH_3) which are known to be very toxic to aquatic animals (Constable *et al*., 2003). Lower mean alkalinity values (38.75±11.3 mg/l and 45.00±14.46 mg/l) were recorded in Uze stream and Ogbagirigiri well respectively, while higher mean alkalinity values (52.08±26.75 mg/l and 47.92±15.14 mg/l) were recorded in Iyiechu and Lolo streams respectively. The high level of alkalinity recorded in Iyiechu stream could be attributed to allochthonous input of bicarbonate ions resulting from surface run-off and waste disposal in the water body. Akindele and Olutona (2014) recorded mean alkalinity values of 36.3±14.6 mg/l and 39.0±18.6 mg/l in Aiba and Onikan lotic systems in Iwo, Nigeria. Olorode *et al.,* (2015) recorded similar total alkalinity values of 58, 36, 30, 26, and 8mg/l for Otobiri, Imo, Okpoka, Onne and bonny rivers respectively.

The mean alkalinity level of Iyiechu stream (52.08±25.75mg/l) falls between 50 – 200mg/l, the stream water may be considered productive when used for aquaculture because of its medium productivity status portrayed by alkalinity level (Umeham and Etusim, 2004). Considering that the total alkalinity levels of Lolo stream, Uze stream and Ogbagirigiri well are less than 50mg/l, the stream waters may not be very productive when used for aquaculture; meanwhile, the waters can pose a danger of fish death because of high variable CO_2 supply.

The mean total hardness concentrations recorded in stations 1-4 are 71.00±35.08mg$CaCO_3$/l, 56.67±25.15mg$CaCO_3$/l, 53.00±21.11mg$CaCO_3$/l and 146.00±79.84mg$CaCO_3$/l respectively. Ogbagirigiri well had the highest water hardness range from 60.00 – 360.00mg$CaCO_3$/l. and confers a hard water status to the well, EPA (2001). The recorded mean values for hardness in all the sites were below NIS (2015) permissible limit (Table 4). Umeham and Elekwa (2005) recorded values as high as 240mg/l, 204mg/l and 320mg/l for Ngwui, Ikwu, and Eme streams respectively which are high compared to the results of the streams in this study. Though hardness has no adverse effect on humans, it may cause scale deposition in the water distribution system and more soap consumption which is economically wasteful (Umeham, 2014). Generally, the harder the water, the lower the toxicity of metals to aquatic life (Navneet and Sinthan, 2010). Dissolved oxygen (DO) were high in Uze (7.23±1.19mg/l) and Lolo (6.87±1.17mg/l) streams and low in Ogbagirigiri in (3.22±2.02mg/l), Iyi-echu (4.73±0.44mg/l) streams. Iyiechu and Uze streams had higher BOD values than Ogbagirigiri well and Lolo stream, (Table 1). Decomposable organic matter from anthropogenic activities especially wastes disposal around these sites might exerted a high oxygen demand on these streams. Poor environmental sanitation ,unsafe hygiene practices and lentic nature are possible reasons for low DO recorded in Ogbagirigiri well.

Mean DO values recorded in Iyiechu stream and Ogbagirigiri well were below WHO (2017) recommended limit (5.0mg/l), while Lolo and Uze streams recorded DO values higher than WHO (2017) recommended limit (Table 3). Anya (2013) recorded DO levels (9.4mg/l; Utegbu stream and 7.3mg/l; Isi-Akwu spring) higher than the results of this study.

The recorded mean BOD values across all the sites (1.68±1.22mg/l; Iyiechu stream, 0.91±0.39mg/l; Lolo stream, 1.20±0.62mg/l; Uze stream, and 0.89±0.84mg/l; Ogbagirigiri well) in this present study were below WHO (2017) recommended limits (3.5mg/l) and as well below the results of Utegbu stream (3.6mg/l) and Isi-Akwu spring (2.8mg/l) (Anya, 2013).

The mean levels of chloride in this present study varied from 46.63±4.60mg/l (Ogbagirigiri well) to 55.60±13.59mg/l (Uze stream) (Table 2). The values of chloride recorded in this study falls within the WHO, NIS, and EU permissible limits (Table 4). The values also agree with FEPA standard for carbonate beverage (250mg/l) and confectionary (250mg/l) but above standard for brewing (20.6mg/l) and dairy (30mg/l) (Table 6). The values are quite high when compared to 5.7mg/l in Utegbu stream (Anya, 2013), 2.42mg/l and 7.3mg/l in Ngwui and Eme streams (Umeham and Elekwa, 2005), and low when compared to 505.812mg/l of Okigwe stream (Iwuala *et al.,* 2019).

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This study recorded mean values (0.23±0.08mg/l, 0.24±0.03mg/l, 0.21±0.06mg/l and 0.21±0.05mg/l) of total phosphate phosphorus in Iyiechu stream, Lolo stream, Uze stream and Ogbagirigiri well respectively (Table 2), and were below WHO, NIS, EU and FMEnv set limits (Table 4). These results agree with the documentation of Anya (2013) and Umeham and Elekwa (2005).

In this study, the highest (0.89±0.31 mg/l) nitrate concentration was recorded in Ogbagirigiri well, while the lowest (0.61±0.07 mg/l) nitrate concentration was recorded in Lolo stream. Nitrate values recorded in this study were below WHO and NIS recommended limits (Table 4). The values recorded in this study were lower than were recorded in some water bodies in Eastern Nigeria (Table 5). Nitrates are good indicators of eutrophication and can cause explosive growth of algal species which can rob the water of dissolved oxygen and can eventually kill fish and other aquatic life. High levels of nitrates in drinking water have been linked to serious illness and even death in infants (Auhwange *et al*., 2012).

The sulphate content of natural waters is an important consideration in determining their suitability for public and industrial supplies. Sulphate is one of the major anions in natural waters and is contributed by industrial and household discharges (Anyanwu and Umeham 2020). The highest mean sulphate level recorded in this study was 1.20±0.21mg/l (Ogbagirigiri well) while the lowest sulphate level was 0.56±0.11mg/l (Uze stream). Anyanwu and Umeham (2020) recorded a similar range of 0.1 – 0.9 in Eme River, Umuahia while Akankali *et al.* (2017) recorded a relatively higher range of 15.0–15.5 mg/l in Okoro Nsit stream in Akwa Ibom state in Nigeria. The values of sulphate (0.80mg/l, 0.79mg/l, 0.56mg/l and 1.20mg/l) recorded in this study were very low compared to NIS (2015) set limit (100mg/l) and did not reflect any anthropogenic impact. The highest and lowest mean values of manganese were recorded in Ogbagirigiri well (0.08±0.01mg/l) and Uze stream (0.03±0.02mg/l) respectively. The values of manganese recorded in the streams fall within EU (2014) and WHO (2017) recommended limits (0.05mg/l), while Ogbagirigiri well recorded values (0.8mg/l) above NIS (2015), WHO (2017), and EU (2014) set limits (Table 5) Manganese is essential in many chemical processes in the body including the processing of carbohydrates, cholesterol, and protein, thus anyone with manganese deficiency must take manganese supplements. Manganese is essential for bone health and development and is given to patients with osteoporosis and other bone conditions. However, manganese is also neurotoxic in large amounts. Manganese poisoning, also known as “manganism”, is a neurodegenerative disorder where patients will experience Parkinson-like symptoms (Chen 2018). High levels of manganese have also been shown to cause attention deficit hyperactivity disorder (ADHD) and learning disabilities (Farias *et al*. 2010). Because of this, it is important to monitor the levels of manganese in drinking water to ensure that consumption does not increase to a point where toxic effects may occur.

Although iron is present in our water, it is seldom found at concentrations greater than 10mg/l. In this study, the highest and lowest values of iron were recorded in Ogbagirigiri well (0.17±0.21mg/l) and Lolo streams (0.12±0.09mg/l). The level of iron measured in this study is in conformity with NIS (2015), EU (2014), and FMEnv (2001) recommended limits (0.3) and FEPA water guidelines for food beverage industry (Table 5). Similar results were documented by Anya (2013) and Umeham and Elekwa (2005) . Ogwo *et al.*, (2014) recorded 0.011 and 0.011mg/l values of iron upper stream and downstream respectively in Igwi River in Abia State University, Uturu. Iron is not considered hazardous to health. In fact, iron is essential for good health because it transports oxygen in the blood. Iron is considered an aesthetic pollutant because when its level in water exceeds the 0.3mg/l, it causes brown, red, or yellow staining of laundry, dishes, glassware, and household fixtures such as sinks and bathtubs. The water may also have an offensive odor and a metallic taste. Water system piping and fixtures can also become restricted or clogged.

In this study, mean silica values were recorded in the order 0.70±0.14mg/l > 0.32±0.11mg/l > 0.26±0.07mg/l > 0.24±0.14mg/l in Ogbagirigiri well > Iyiechu stream > Lolo stream > Uze stream respectively (Table 1). All natural water supplies contain some dissolved “silica” and most will also contain suspended or colloidal silica. Silica is an important trace mineral that provides strength and flexibility to the connective tissues of the body — cartilage, tendons, teeth, skin, bone, hair, and blood vessels. Silica is essential in the formation of collagen, the most abundant protein found in the body. Silica helps the heart and immune system. Silica can improve the heart health by reducing the risk of atherosclerosis, also known as hardening of the arteries.

The concentration of the major cations: sodium, potassium, magnesium and calcium in the studied water bodies were all within the WHO, NIS, EU and FMEnv permissible limits (Table 3). The streams had same common order of dominance of cations which was Ca>Mg>Na>K, while in Ogbagirigiri well, it was Ca>Mg>k>Na.

Ogbagirigiri well and Lolo stream recorded the highest mean levels of calcium (26.27 mg/l and 17.89 mg/l respectively) while Uze and Iyiechu streams recorded the lowest mean values (13.86 mg/l and 17.78 mg/l respectively). According to Kuriata-Potasznik and Szymczyk (2015), Magnesium and calcium are natural components of surface water, and their concentrations can be shaped by various factors, mostly the geological structure of a catchment area, soil class and type, plant cover, weather conditions (precipitation- evaporation, seasonal variations), land relief, type and intensity of water supply (surface runoffs and groundwater inflows), etc. The high calcium concentration in Ogbagirigiri well could be as a result of leaching of rocks – dissolution of calcium in rock and soil. Calcium content is a determinant of water hardness because it can be found in water as Ca^{2+} ions. Ogbagirigiri well has the highest value of calcium and consequently, it is the hardest of all the waters in this study as it also recorded the highest value for hardness (146.00 ± 79.89mg/l) (Table 2). The long-term ingestion of calcium might increase the blood calcium level i.e., creates the problem of hypercalcemia (Kozisek, 2003) while

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insufficient ingestion of calcium increases the risks of osteoporosis, nephrolithiasis, colorectal cancer, coronary artery disease, insulin resistant hypertension, stroke etc. (WHO, 2009). Concentration of magnesium in drinking water more than 125 mg/l may create cathartic and diuretic problems (Eaton *et al.,* 2005). The high concentration of magnesium in drinking water creates the irregular heartbeat, slow breathing, low blood pressure, and death whereas the low concentration of magnesium is associated with hypertension, metabolic syndrome, increased vascular reactions, coronary heart disease, type 2 diabetes mellitus, etc. The deficiency of magnesium affects the neurologic and neuromuscular function of the body which results into anorexia, muscular weakness, lethargy and unsteady gait.

The concentrations of the major anions: sulphate, nitrate, chloride and total phosphorus were within the WHO, NIS, EU and FMEnv permissible limits (Table 4). Iyiechu and Lolo streams followed a common order of dominance of anions which was Cl>S>N>Total P. In Uze stream, the concentration of nitrate was higher than that of sulphate which affected the common order of dominance of anions and changed it to Cl> N > S >Total P. Like in Iyiechu and Lolo stream, Ogbagirigiri well followed Cl>S>N>Total P order of dominance (Table 2).

Chloride is an element that commonly occurs naturally in natural waters and is most often found as a component of salt (sodium chloride), or in some cases in combination with calcium or potassium. Chloride is considered an aesthetic pollutant based on its potential for undesirable taste at concentrations above 250 mg/l and the increased risk of corrosion of pipe. At levels greater than 250 mg/l, sodium chloride can complicate existing heart problems and contribute to high blood pressure when ingested in excess.

Sulphates, salts of sulphuric acid are a combination of sulphur and oxygen and are a part of naturally occurring minerals in some soil and rock formations that contain water. Increased concentration of Sulphates in water gives a distinct rotten egg smell and the water can blacken silver ware and discolour copper and brass utensils, and as such is considered an aesthetic pollutant. ty to survive.

The results of the water quality index of the studied water bodies ranged from 21 – 84 (Tables 7, 8, 9 and 10).

Using weight arithmetic water quality index scale (Table 11) as a yardstick to measure the quality and potability of the waters in this study, Uze stream (a near-pristine stream which has not recorded any form of solid waste disposal along the course of the flow from the origin to the sampling station except agricultural runoff) had a WQI of 21, and fell under group A of the quality rating scale which indicated that the stream is of excellent water quality. Iyiechu and Lolo streams had a WQI of 59 and 65 respectively fell under group C of the quality rating scale which indicated that the stream is of poor water quality, while Ogbagirigiri well had a WQI of 84 fell under group D which indicated that the we[[water is of very poor water quality.

The index in stations Iyiechu and Lolo streams portrayed the effect of anthropogenic activities including uncontrolled waste disposal in and around the water bodies (especially in Iyiechu stream), pollutants from farmlands and sidewalks, wastewater from palm oil mill (especially in Lolo stream) etc. Ogbagirigiri well water has WQI of 84 which indicated a poor water quality which could be attributed to the poor sanitary and unhygienic practices in the site. Iyiechu stream, Lolo stream, and Ogbagirigiri well which are of poor quality for human consumption can serve other purposes like aquatic husbandry and other culinary concerns.

Anyanwu and Umeham (2020) recorded WQI range from 44.7 – 80.6 which portrayed the effects of sand mining activities in Eme River Umuahia, Abia State. Etim *et al*., (2013) also recorded WQI ranges of 38.52 – 48.67 and 55.05 – 84.94 in boreholes and streams respectively, in Niger Delta region of Nigeria, and concluded that the stream waters are not safe for human consumption. The WQI recorded in Iyiechu and Lolo streams (59 and 65, respectively) were within the range of what was recorded in Etim *et al*., (2013).

REFERENCES

[1]. Akankali, J. A., Idongesit, A. S., and Akpan, P. E. (2017). Effects of sand mining activities on water quality of Okoro Nsit stream, Nsit Atai Local Government Area, Akwa Ibom State, Nigeria. *International Journal of Development and Sustainability 6*(*7*): 451–462.

[2]. Akindele, E. O., and Olutona G. O. (2014). Water Physicochemistry and Zooplankton Fauna of Aiba Reservoir Headwater Streams, Iwo, Nigeria. *Journal of Ecosystems*. http://dx.doi.org/10.1155/2014/105405

[3]. Anya, C. B. (2013). The physicochemical hydrology of five water sources in Asaga Ukwu Community, Ohafia L.G. A., Abia State, Nigeria. M.Sc Dissertation, Abia State University, Uturu. 105 pp.

[4]. Anyanwu E. D. and Umeham S. N. (2020). Identifcation of waterbody status in Nigeria using predictive index assessment tools: a case study of Eme River, Umuahia, Nigeria. *International Journal of Energy and Water Resources 4(2)* 1-9.

[5]. Auhwange, B. A., Agbaji, E. B., and Gimba, E. C. (2012). Impact assessment of human activities and seasonal variation on River Benue, within Makurdi metropolis. *International Journal of Science and Technology, 2(5):*2224-3577

[6]. Ayoade, A. A., Fagade, S. O. and Adebisi, A.A. (2006). Dynamics of limnological features of two man-made lakes in relation to fish production. *African Journal of Biotechnology 5 (10):* 1013-1021

[7]. Bacher, M., Sztanke, K. and Pasternak, K. (2010). Plasma calcium and magnesium concentrations in patients with fractures of long bones treated surgically. *Journal of Elementology, 1(15):* 5-17.

[8]. Bala, U. and Bolorunduro, P. I. (2011). Limnological Survey and Nutrient load of Sabke Reservoir, Katsina State, Nigeria. *African Scientist, 11(3):* 163 – 168

ISSN No: -2456-2165 https://doi.org/10.38124/ijisrt/25nov1063

[9]. Cheesbrough, M. 2006. District laboratory Practice in Tropical Countries. Cambridge University Press. 62pp.
[10]. Chen, P., Bornhorst, J. and Aschner, M. (2018). Manganese metabolism in humans. Frontiers of *Bioscience (Landmark Ed). 1* (*23*):1655-1679.
[11]. Constable, M., Charlton, M., Jensen, F., McDonald, K., Craig, G. and Taylor, K. W., (2003). An ecological risk assessment of ammonia in the aquatic environment. *Human Ecological Risk Assessment, 6:*527-548
[12]. Eaton, A. D., Clesceri, L. S., Rice, E. W. and Greenberg, A. E. (2005). Standard method for the examination of water and wastewater, 21st Edn., American Public Health Association (APHA), Washington, DC. 8 pp.
[13]. Environmental Protection Agency (2001). Parameters Of Water Quality: Interpretation and Standards. Environmental Protection Agency, Ireland. 133 pp.
[14]. Etim, E. E., Odoh, R., Itodo, A. U., Umoh, S. D., & Lawal, U. (2013). Water quality index for the assessment of water quality from different sources in the Niger Delta Region of Nigeria. Frontiers in Science, 3(3), 89–95.
[15]. Farias, A. C., Cunha, A., Benko, C. R., McCracken, J. T, Costa, M., Farias, L. G. and Cordeiro, M. L. (2010). Manganese in Children with Attention-Deficit/Hyperactivity Disorder: Relationship with Methylphenidate Exposure. *Journal of Child and Adolescent Psychopharmacology 20* (*2*):113-8
[16]. Federal Ministry of Environment (2001). guidelines and standards for water quality in Nigeria. Published by the federal Ministry of Environment, p. 114.
[17]. Iwuala, C. C., Dozie, I. N. S., Udujih, H. I. and Udujih, O. G. (2019). Physiochemical Assessment of Drinking Water Sources in Imo State. *International Journal of Recent Scientific 10(12): 36225-36229*
[18]. Kozisek, F. (2003). Health significance of drinking water calcium and magnesium. *Environmental Research Section, 1(84): 219-227*
[19]. Kuriata-Potasznik, A. and Szymczyk, S (2015). Magnesium and calcium concentrations in the surface water and bottom deposits of a river-lake system. *Journal of Elementology, 20(3): 677-692*
[20]. Lind, O. T. (1979). Handbook of common methods in Limnology (2nd edition). Missouri: the C.V. Mosby Company, 119 pp.
[21]. Mackereth, F. J. H. (1963). Some Methods of Water Analysis for Limnologists. Fresh Water Biological Association, Ambleside. Scientific Publication. Pp 21-72.
[22]. Navneet, K., and Sinthan, D. (2010). Drinking water quality management through correlation studies among various physico-chemical parameters. *International journal of Environmental Science* 1(2) 253-259.
[23]. NIS (2015). Nigerian Industrial Standard (NIS 554). Nigerian Standard for Drinking Water Quality. Pp 17-22.
[24]. Nwoke, B. E. B. and Uwazie, D. U. (1991). Studies on the Blackfly Simulium (*Diptera simulidae*) of Imo state. The distribution of immature stages in Isuikwuato-Okigwe area. *The Nigerian Journal of parasitology, 12: 29-37*
[25]. Ogwo, P. A, Okoronkwo, C. U., Okereke, V. E. And Udensi, E. A. (2014). Evaluation of the Physicochemical and Heavy Metal Properties of Igwi-Stream in Abia State University, Uturu, Abia State, Nigeria. *Journal of Environmental Science, Toxicology and Food Technology 8(7): 54-57*
[26]. Olawale, A. S. (2016). Physicochemical Analysis of Water from Asa River, Ilorin, Nigeria. *Imperial Journal of Interdisciplinary Research 2(3): 122-129*
[27]. Olorode, O., Bamigbola, E. and Ogba, Ofonime (2015). Comparative Studies of Some River Waters in Port Harcourt Based on Their Physico-Chemical and Microbiological Analysis, Niger Delta Region of Nigeria. *International Journal of Basic and Applied Sciences, 3(3):* 29-37
[28]. Pandey, S. C., Singh, S. M., Pani, S. and Malhosia, A. (2012). Limnology: A Case Study of Highly Polluted Laharpur Reservoir, Bhopal, (M.P.) India. *Journal of Chemical, Biochemical and Physical Resources, 2(3):1560-1566*
[29]. Prasanna, M. and Ranjan, P. C. (2010). Physico-chemical properties of water collected from Dharma estuary. *International Journal of Environmental science, 1(3):334 – 342*.
[30]. Tyagi, S. B., Sharma, P. S. and Dobhal, R. (2013). Water Quality Assessment in Terms of Water Quality Index. *American Journal of Water Resources 1(3): 34-38.*
[31]. Umeham, S. N. and Elekwa, I. (2005). The hydrological status of Ngwui, Ikwu and Eme streams in Umuahia North LGA, Abia State, Nigeria. *Journal of the Environment 1(1): 31-36*
[32]. Umeham, S. N. and Etusim, P. E. (2004). Some aspects of the physicochemical hydrology of Nne-Osha Stream, Isuikwuato L.G.A., Abia State, Nigeria. *Journal of the Environment 5(1): 31-36*
[33]. Umeham, S. N., (2014). Water is Life, Water is Death, …an Ultimate Resource. 17th inaugural lecture series of Abia State University Uturu. Dawn Functions Nigeria Limited, Independence Layout, Enugu. 167 pp.
[34]. Venkatesharaju, K., Rarkumar, P., Somashekhar, R. K. and Prakash, K. L. (2010). Physico–chemical and Bacteriological Investigation on the River Cauvery of Kollegal stretch in Karnataka. Kathmanadu University. *Journal for Science, Engineering and Technology. 6(1):10 – 15*
[35]. Wetzel, R. G. (2001). Limnology: Lake and River Ecosystems. 3rd Edn. Academic press, San Francisco. 1006 pp.
[36]. Wetzel, R. G. and Likens, G. E. (2000). Limnological Analyses. Third Edition. ISBN 978-1-4757-3250-4. Springer, USA. Pp 1- 72.
[37]. WHO (2009). Calcium and Magnesium in Drinking-Water. Public Health Significance. Retrieved from who.int/publications/2009/9789241563550_eng.pdf. On 15 October, 2021

ISSN No: -2456-2165 https://doi.org/10.38124/ijisrt/25nov1063

[38]. WHO (2017). Guidelines for Drinking Water Quality. 4th edn. Retrieved from http://apps.who.int/iris/bitstream/10665/44584/1/9789241548151_eng.pdf on 15 October, 2021
[39]. WHO/UNEP (1997). Water Pollution Control - A Guide to the Use of Water Quality Management Principles. ISBN 0 419 22910 8. Pp 1-14.