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Assessment of the Potability of Nworie River in Owerri Municipal, Imo State, Nigeria.

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Authors's contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

ABSTRACT

A survey of Nworie River was conducted in order to establish the current pollution levels of the river. An attempt has been made to the assessment of the potability of Nworie River, to treat the water sample by chemical method. The physical, chemical and microbiological parameters were investigated on the water samples collected from three different locations namely upstream (NRSW1), midstream (NRSW2) and downstream (NRSW3) Nworie River and the mean concentrations were obtained. The turbidity value, 2-20-3.50 NTU; temperature, 28.50-29.00ºC; pH value, 6.18-6.49; electrical conductivity, 57.90-87.70µS/cm; TDS 26.63-40.34 (mg/l); TSS,

8.10-13.20 (mg/l); total alkalinity, 28.00-44.00 (mg/l); total hardness, 7.60-16.40 (mg/l); calcium hardness 6.98-16.40 (mg/l); magnesium hardness 0.00-0.77 (mg/l); DO, 2.10-2.60(mg/l); BOD, 3.00-5.80 (mg/l); COD, 0.00-48.22 (mg/l); chloride, 15.34-19.88 (mg/l); sulphate, 14.64-28.78 (mg/l); phosphate, 0.37-0.53 (mg/l); nitrate, 3.80-4.70 (mg/l); sodium, 0.00-0.0001 (mg/l); potassium, 2.5493-13.0172 (mg/l); iron, 0.0001-1.6815 (mg/l); and lead, 0.0001-0.0104 (mg/l). Total coliform count; E. coli; salmonella/shigella total count; vibrio total count; faecal coliform growth was confirmed; The results of the analysis were compared with the World Health Organization (WHO) standards and the water was found unfit for human consumption due to high pollution index of 2.15, high concentration of iron, low DO, high COD at the midstream, E. coli, and yeast/mould as a result of dumping of both organic and inorganic wastes into the Nworie River. The product-moment gave the correlation coefficient, r as -0.31, which implies that there is a low negative correlation between X, Y and Z i.e. between the upstream (NRSW1), midstream (NRSW2) and downstream (NRSW3) respectively of Nworie River water samples. Similarly, the test for significance using t-table at 19 degree of freedom at significant levels of 0.05, indicates that there is no significant difference between the mean concentrations of the upstream (NRSW1), midstream (NRSW2) and downstream (NRSW3) of Nworie River. The result of the treated water sample gave the following: The turbidity value,1.58 NTU; temperature, 29.00; pH value, 7.30; electrical conductivity, 116µS/cm; TDS 75.40 (mg/l); TSS, 10.00 (mg/l); total alkalinity, 50.00 (mg/l); total hardness, 3.47 (mg/l); calcium hardness 1.54 (mg/l); magnesium hardness 0.93 (mg/l); DO, 5.60 (mg/l); BOD, 0.25(mg/l); COD, 25.65 (mg/l); chloride, 25.56 (mg/l); sulphate, 0.00 (mg/l); phosphate, 0.60 (mg/l); nitrate, 5.00 (mg/l); sodium, 0.0001 (mg/l); potassium,11.00 (mg/l); iron, 0.2915 (mg/l); and lead, 0.0056 (mg/l). The results of the analysis were compared with the World Health Organization (WHO) standards and the water was found fit for human consumption due to the reduction in iron and COD level and the absence of E. coli and yeast/mould. The study shows the need for adequate waste management system in order to provide good quality water and to prevent the outbreak of pathogenic diseases in the area.

Keywords: Water Pollutant, Anthropogenic, Water Quality, Pollution Index, Microbial.

1. INTRODUCTION

Surface water is heavily exposed to contamination as this is the ubiquitous source for most of the water needs. This is as a result of population, heavy industrialization, rapid urbanization, anthropogenic activities and improper sanitation [1]. Therefore, improving the surface water quality is the top priority to effectively recover the global economy and realize social sustainable development [2], [3].

Once water is contaminated, it is very difficult, costly, and often impossible to remove the pollutants. Still today, 80 per cent of global wastewater releases untreated into the water bodies, containing everything from human waste to highly toxic industrial discharges [4]. It has been reported that, worldwide, around two million people die annually due to water-related diseases [5]. Diarrhea, which is mostly spread by enteroviruses in the aquatic environment, is the most prevalent illness brought on by water pollution [6]. Therefore, the physicochemical properties of surface water are constantly changing due to activities within and around it such as farming, fishing, indiscriminate dumping of wastes, exploration and exploitation of solid minerals etc. [7].

The pollution index approach, in comparison to other methods, is simple and conceptually clear, can quantitatively represent water quality, and the evaluation of result can more accurately reflect the degree of pollution of water bodies [8].

2. MATERIALS AND METHODS

2.1 Study Area

Nworie River is a freshwater stream about 9.2 kilometer that runs approximately 5km course across Owerri metropolis, the capital of Imo State, Nigeria, to the south behind Federal Medical Center (FMC) now Federal University of Technology Hospital (FUTH), Alvan Ikoku Federal College of Education before emptying into Otamiri River at Nekede in Owerri. Nworie River lies between latitude $5^{0}28^{I}$N and $5^{0}30^{I}$N and covers an area of about 24.88Km^{2}.

This river serves as a source of aquatic foods and water for domestic activities, urban agriculture as well as for other purposes. Auto-mechanic village, hospitals, car washing and laundry outfits are located along the banks of the river [9]. All the drainages in Owerri urban

and environs discharge untreated wastewater into the river or its tributary. When it rains, run-offs, erosional and sediments deposits from the degraded water shed in Owerri urban and environs gain unrestricted access into the river [10]. Similarly, in addition to sand mining activities that go on in the river, solid wastes are also dumped and incinerated at the river bank. These waste dumps could contain a wide variety of chemical substances that leach into the river.

Therefore, to maintain a safe and healthy environment, there is a need to determine the pollution level, nature of contaminants, assess the potability of Nworie River and carry out water quality test of the treated Nworie River.

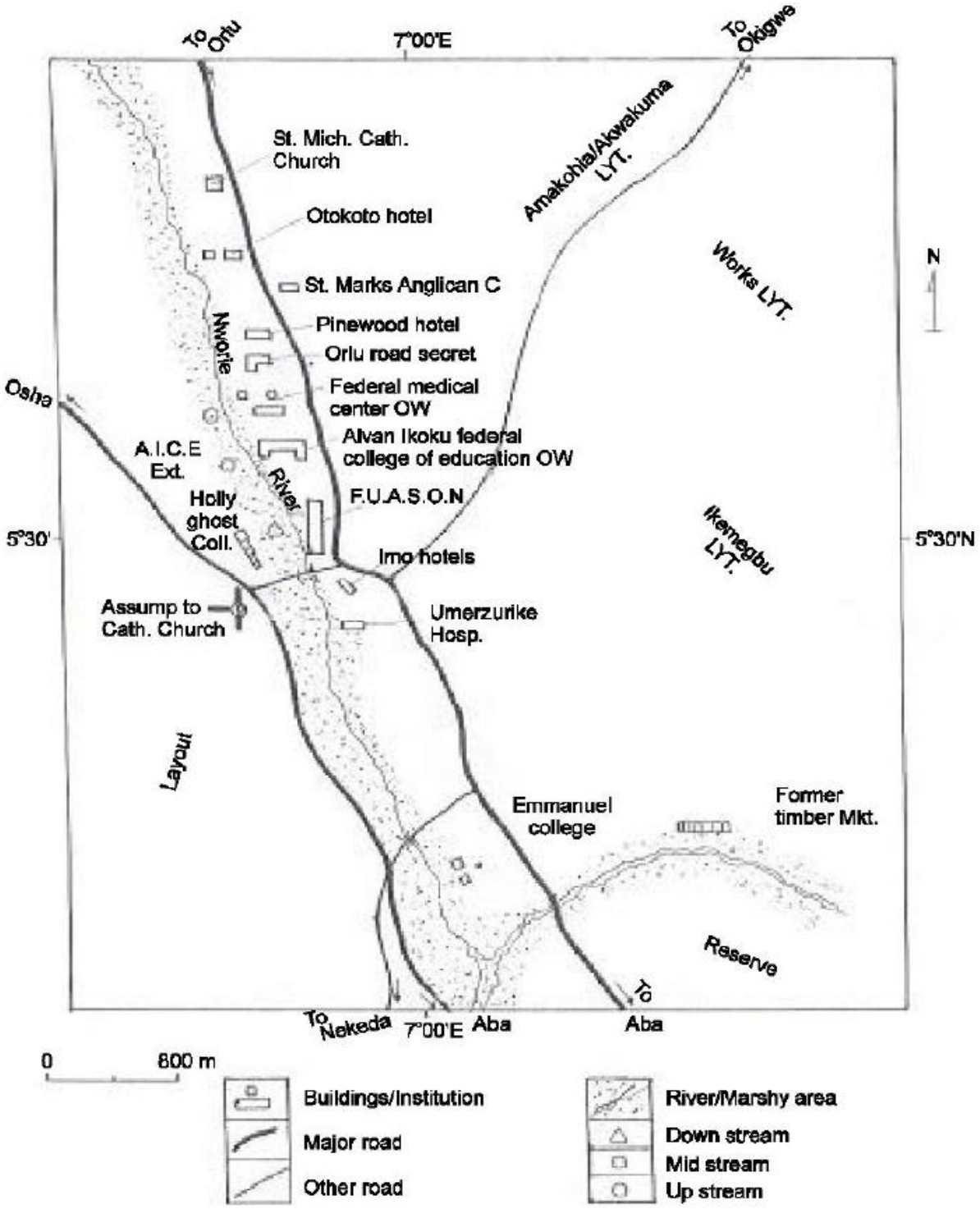

Fig 1. Map Showing Nworie River Owerri, Nigeria.

2.2 Sample collection

Twelve (12) were samples collected from three different points on the river from March – April. The water samples were collected with the aid of washed plastic gallons using detergent and

later in 2M hydrochloric acid to prevent impurities and rinsed with distilled water, deionized water and then the river water.

Firstly, four (4) water samples were collected upstream of Nworie River and were represented as Nworie River Water Sample 1 (NRWS1).

Secondly, four (4) water samples were collected midstream of Nworie River and were represented as Nworie River Water Sample 2 (NRWS2).

Thirdly, four (4) water samples were collected downstream of Nworie River and were represented as Nworie River Water Sample 3 (NRWS3).

Because the chemistry of surface water is sensitive to environmental changes these physical parameters were measured and recorded in situ; they are temperature, pH, and electrical conductivity and total dissolved solved. The other parameters were analyzed in the laboratory.

2.3 Analysis

2.3.1 Determination of Temperature (^{O}C) and Determination of pH

The temperature and pH of the water sample were taken in situ, at about 20cm below the water surface using the mercury-glass-thermometer and the pH meter of Jenway model 3015 using procedures by applying random sampling [11][12].

2.3.2 Determination of Electrical Conductivity

This was done using the electrical conductivity meter of Jenway model 4010 [13].

2.3.3 Determination of Total Dissolved Solid

This was done by evaporation method [13-16].

2.3.4 Determination of Total Suspended Solid

This was done by evaporation method.

2.3.5 Determination of Total Alkalinity

This was by titration method using methyl orange as indicator and H_2SO_4 as titrant [12].

2.3.6 Determination of Total Hardness

This was determined by titrimetric Method using erichrome black-T as indicator and EDTA as titrant [13].

2.3.7 Determination of Calcium Hardness

This was determined titrimetric Method using solochrome black-T as indicator and EDTA as titrant [12].

2.3.8 Determination of Magnesium Hardness

Magnesium hardness was determined by finding the difference between total hardness and calcium hardness in mg/l $CaCO_3$.

2.3.9 Determination of Dissolved Oxygen

The dissolved oxygen of each water sample was determined using HANNA HI 83200 test kit.

2.3.10 Determination of Biochemical Oxygen Demand

This was determined by incubation method in the dark to avoid photosynthetic bacterial degradation for five (5) days of ambient temperature. At the end of the fifth day, the dissolved oxygen content of these samples were re-determined using the above procedure for dissolved oxygen.

2.3.11 Determination of Chemical Oxygen Demand

This was done using Dichromate Reflux Method. Ferrous ammonium sulphate solution Fe $(NH_4)_2SO_4$ titrant and 0.25N potassium dichromate ($K_2Cr_2O_7$) with 4 to 5 drops of Ferrion indicator.

2.3.12 Determination of Chloride:

This was done by the Mohr's method using potassium chromate as indicator and silver nitrate as titrant [16].

2.3.13 Determination of Sulphate, Phosphate, Nitrate

These were done using the u-visible spectrophotometer of model DR 2000. These were determined using the Hatch corporation method. Sulphate was determined using sulfaver 4 sulphate, the phosphate was determined using the phosphaver 3 phosphate developer while nitrate was determined using the nitraver 5 nitrate, [16, 17, 18].

2.3.14 Determination of Metallic Ion

The metallic ions $Fe^{3+,}$ Pb^{2+}, Na^{+}, K^{+} were detected using the Atomic Absorption Spectrophotometer (AAS) UNICAM 919 model. Stock solutions from which working standards

were prepared by serial dilution as reported by Technical Bulletin [19] using various cathode tubes specific for each element determined.

2.3.15 Microbiological Methods Used for the Analysis of the Water Samples

Presumptive coliform count, feacal streptococci and clostridium welchii test method, vibrio and salmonella/shigella counts and Total plate count were determined.

2.3.16 Water Treatment Method

Preparation of calcium hypochlorate: 0.5g of chlorine and 0.5g calcium hydroxide was dissolved into 300ml of deionized water. 100ml of each water sample (up, mid and downstream) making a total of 300ml was measured into a beaker a measuring cylinder. This was aerated by repeated turning of the water into another beaker.

0.05g of aluminum sulphate (alum) was dissolved into the water sample and allowed to stay for about 3 hours. 5 drops of calcium hypochlorate and 3 of powdered activated carbon was added into the water sample and placed on a magnetic stirrer. Finally, the resulting solution was filtered three (3) times using a filter paper. The filtrate was collected and analyzed for physical, chemical and microbial parameters to ensure that the result is within the World Health Organization permissible limit.

3. RESULTS

TABLE 1: Physicochemical Data of Nworie River

PARAMETERS	NRWS1 UP	NRWS1 MID	NRWS1 DOWN	MEAN	STANDARD DEVIATION	WHO STANDARD
Appearance	Cloudy	Cloudy	Clear	Cloudy		Clear
Odour	Not offensive	Not offensive	Not offensive	Not offensive		odourless
Turbidity (NTU)	3.5	2.94	2.2	2.88	3.39	5
Temperature(°C)@29°C	29	28.5	29	28.83	33.3	25.30
pH	6.18	6.31	6.49	6.33	7.31	6.5-8.5

Electrical Conductivity (µS/cm)	57.9	64.3	87.7	69.97	82.3	1250
TDS (mg/l)	26.63	29.58	40.34	32.18	37.86	500
TSS (mg/l)	8.1	11.1	13.2	10.8	12.73	50
Total Alkalinity (mg/l)	28	39	44	37	43.5	100
Total hardness (mg/l)	7.6	9.6	16.4	10.74	13.73	100
Calcium Hardness (mg/l)	6.98	8.83	16.4	10.74	13.36	75
Magnesium Hardness (mg/l)	0.62	0.77	0.00	0.46	0.67	50
DO (mg/l)	2.3	2.1	2.6	2.33	2.71	9.2
BOD (mg/l)	5.8	3.0	3.0	3.93	4.82	6
COD (mg/l)	0.00	48.22	26.95	25.06	37.7	40
Chloride (mg/l)	19.88	18.46	15.34	17.89	20.79	250
Sulphate (mg/l)	14.64	21.05	28.78	21.49	25.8	250
Phosphate (mg/l)	0.53	0.5	0.37	0.47	0.55	250
Nitrate (mg/l)	3.8	4.3	4.7	4.27	4.95	45
Iron (mg/l)	< 0.0001	1.0329	1.6815	0.9048	1.3456	0.3
Sodium (mg/l)	< 0.0001	< 0.0001	< 0.0001	0.00	0.00	>250
Potassium (mg/l)	2.5493	12.0172	5.1694	6.912	9.6629	< 20
Lead (mg/l)	< 0.0001	0.0093	0.0104	0.0066	0.00949	0.05

Table 2: Computational of Pollution Index of Nworie River

PARAMETERS	RANGE	QUALITY (Ci) MEAN	MAXIMUM	WHO (Lij)	MEAN/WHO (Ci/Lij)
Appearance	Cloudy	Cloudy	Clear	Cloudy	
Odour	Not offensive	Not offensive	Not offensive	Not offensive	
Turbidity (NTU)	2.20-3.50	2.88	3.5	5	0.576
Temperature (ºC) @29ºC	28.50-29.00	28.83	29	25-30	1.0302
pH	6.18-6.49	6.33	6.49	6.5-8.5	0.844
Electrical Conductivity (µS/cm)	57.90-87.70	69.97	87.7	1250	0.05598
TDS (mg/l)	26.63-40.34	32.18	40.34	500	0.06436
TSS (mg/l)	8.10-13.20	10.8	13.2	50	0.216
Total Alkalinity (mg/l)	28.00-44.00	37	44	100	0.37
Total hardness (mg/l)	7.60-16.40	11.2	16.4	100	0.112
Calcium Hardness (mg/l)	6.98-16.40	10.74	16.4	75	0.1432
Magnesium Hardness (mg/l)	0.00-0.77	0.46	0.77	50	0.0092
DO (mg/l)	2.10-2.60	2.33	2.6	9.2	0.2533
BOD (mg/l)	3.00-5.80	3.93	5.8	6	0.655
COD (mg/l)	0.00-48.22	25.06	48.22	40	0.6265
Chloride (mg/l)	15.34-19.88	17.89	19.88	250	0.07156
Sulphate (mg/l)	14.68-28.78	21.49	28.78	250	0.08596

Phosphate (mg/l)	0.37-0.53	0.47	0.53	5	0.094
Nitrate (mg/l)	3.80-4.70	4.27	4.7	45	0.09489
Iron (mg/l)	0.0001-1.6815	0.9048	1.6815	0.3	3.016
Sodium (mg/l)	0.00-0.0001	0.00	0.0001	>250	0.00
Potassium (mg/l)	2.5493-13.0172	6.912	5.1694	< 20	0.3456
Lead (mg/l)	0.0001-0.0104	0.0066	0.0104	0.05	0.132
Total ∑ (Ci/Lij)					8.79575
Mean ∑ (Ci/Lij)/n					0.418845

$$Pij = \frac{\sqrt{(\max Ci/Lij)^2 + (\text{mean } Ci/Lij)^2}}{2}$$

$$= \frac{\sqrt{(3.016)^2 - (0.418845)^2}}{2}$$

$$= \frac{\sqrt{9.096256 + 0.175431134}}{2}$$

$$= \frac{\sqrt{9.271687134}}{2}$$

$$= 2.153100919$$

$$= \mathbf{2.15}$$

Where

Pij = Pollution Index = f{C_1/L_{1j}, C_2/L_{2j}, C_3/L_{3j},…, C_i/L_{ij},}

C_i = concentration of each parameter

L_{ij} = WHO Specification for each parameter

I = the number of ith item of the water quality

J = the number of C_1/L_{1j} shows the relative pollution contributed by the single item

Table 3: Microbial Analysis of Nworie River

MICROBIAL GROUP	UP STREAM		MID STREAM		DOWN STREAM	
	PLATE READING colonies	UNIT Cfu/100ml colonies	UNIT Cfu/100ml colonies	UNIT Cfu/100ml colonies	UNIT Cfu/100ml colonies	UNIT Cfu/100ml colonies
Coliforms:	6.00	4.00	10.00	5.00	Nil	Nil
E. Coli	10.00	10.00	6.00	3.00	3.00	3.00
Faecal Streptococci	5.00	6.00	5.00	6.00	4.00	Nil
Salmonella SP	3.00	2.00	Nil	4.00	2.00	Nil
Shigella SP	6.00	5.00	5.00	2.00	Nil	4.00
Vibrio SP	2.00	8.00	Nil	1.00	Nil	Nil
Clostridia SP	5.00	2.00	Nil	5.00	Nil	2.00
Yeast/Mould	3.00	3.00	2.00	2.00	1.00	1.00
TOTAL PLATE UNIT	40.00	30	36	28	10	10

Table 4: Concentration of Different Parameters of Treated Nworie River

PARAMETERS	TREATED WATER SAMPLE (NRSW1, NRSW2 & NRSW3)	WHO STANDARD
Turbidity	1.58	5
Temperature (^oC)	29.00	25-30
pH	7.30	6.5-8.5

Electrical Conductivity (µS/cm)	116	1250
TDS (mg/l)	75.40	500
TSS (mg/l)	10.00	50
Total Alkalinity (mg/l)	50.00	100
Total hardness (mg/l)	3.47	100
Calcium Hardness (mg/l)	1.54	75
Magnesium Hardness (mg/l)	0.93	50
DO (mg/l)	5.6	9.2
BOD (mg/l)	0.25	6
COD (mg/l)	25.56	40
Chloride (mg/l)	25.56	250
Sulphate (mg/l)	0.00	250
Phosphate (mg/l)	0.6	5
Nitrate (mg/l)	5.00	45
Iron (mg/l)	0.2915	0.3
Sodium (mg/l)	0.0001	>250
Potassium (mg/l)	11.00	< 20
Lead (mg/l)	0.0056	0.05

Table 5: Microbial Analysis of Nworie River Treated Water Sample (Upstream, Midstream and Downstream)

MICRO GROUP	PLATE READING	UNIT Cfu/100ml
Coliform: Other Coliform	Nil	Nil
E. Coli	Nil	Nil
Faecal Streptococci	Nil	Nil
Salmonella SP	Nil	Nil
Shigella SP	Nil	Nil
Vibrio SP	Nil	Nil
Clostridia SP	Nil	Nil
Yeast/Mould	Nil	Nil
TOTAL PLATE UNIT	Nil	Nil

Table 6: COMPUTATION OF X, Y, Z (i.e. MEAN CONCENTRATION OF FROM UPSTREAM-NWRS1, MIDSTREAM-NRWS2 AND DOWNSTREAM-NRWS3 RESPECTIVELY) BY PRODUCT -MOMENT

NRWS1 UPSTREAM, X	NRWS1 MIDSTREAM, Y	NRWS1 DOWNSTREAM, Z	XZY	X^2	Y^2	Z^2
3.5	2.94	2.2	22.638	12.25	8.6436	4.84
29	28.5	29	23968.5	841	812.25	841
6.18	6.31	6.49	253.083	38.1924	39.8161	42.1201
57.9	64.3	87.7	326504.469	3352.41	4134.49	7691.29
26.63	29.58	40.34	31776.439	709.1569	874.9764	1627.3156

8.1	11.1	13.2	1186.812	65.62	123.21	174.24
28	39	44	48048	784	1521	1936
7.6	9.6	16.4	1196.544	57.76	92.16	268.96
6.98	8.83	16.4	1010.788	48.7204	77.9689	268.96
0.62	0.77	0.00	0.00	0.3844	0.5929	0.00
2.3	2.1	2.6	12.558	5.29	4.41	6.76
5.8	3.0	3.0	52.2	33.64	9.00	9.00
0.00	48.22	26.95	0.00	0.00	2325.1684	726.3025
19.88	18.46	15.34	5629.547	395.2144	340.7716	235.3156
14.64	21.05	28.78	8869.190	214.3296	443.1025	828.2884
0.53	0.5	0.37	0.09805	0.2809	0.25	0.1369
3.8	4.3	4.7	76.798	14.44	18.49	22.09
< 0.0001	1.0329	1.6815	0.00	0.00	1.06688	2.8274
< 0.0001	< 0.0001	< 0.0001	0.00	0.00	0.00	0.00
2.5493	12.0172	5.1694	171.545	6.4989	169.4475	26.7227
< 0.0001	0.0093	0.0104	0.00	0.00	0.00008649	0.00010816
$\sum X =$	$\sum Y =$	$\sum Z =$	$\sum XYZ =$	$\sum X^2$	$\sum Y^2$	$\sum Z^2$
224.0093	312.1194	347.3313	448779.2091	6579.1779	10996.81487	14712.16931

$(\sum X)^2 = 118564.0442$
$(\sum Y)^2 = 2.014027785 \times 10^{11}$
$(\sum Z)^2 = 108564.0442$

To find whether there is correlation i.e. a linear relationship between water samples from upstream (NWRS1), midstream (NRWS2) and downstream (NRWS3) using the relation:

Correlation coefficient r = $\frac{N \sum XYZ - \sum X \sum Y \sum Z}{\sqrt{\{N \sum X^2 - (\sum X^2)^2\} \{N \sum Y^2 - N (\sum Y)^2\} \{N(\sum Z^2 - (\sum Z)^2\}}}$

r = $\frac{21(448779.2091) - (224.0093)(312.1194)(344.3313)}{\sqrt{(21x6579.1779)-50180.16649)(21x10996.81487)-97418.51986)(21x14712.16931)-(118564.0442)}}$

r = $\frac{-2.33810540.6}{\sqrt{138162.7359 \text{ x } 221191.5924 \text{ x } 190391.511}}$

r = $\frac{-2.33810540.6}{762787488}$

= $-0.3065212058 \text{ x } 10^{-1}$

= -0.31

The product-moment gave the correlation, r as -0.31, which implies that there is a low negative correlation between X, Y and Z i.e. between the upstream (NWRS1), midstream (NRWS2) and downstream (NRWS3) respectively of Nworie River water samples.

3.1 Test of Significant Relationship

It is used to test whether the relationship -0.31 is significant or not. If the sample size is small (below 30), the computed r is transformed to t-test and then use the t-table with degree of freedom, (df) = N-1 to obtain the critical value. The formula used for t-transformation is :

t = $r \sqrt{\frac{N-2}{1-r^2}}$

= $0.31 \sqrt{\frac{21-2}{1-(-0.31)^2}}$

= $-0.31 \sqrt{\frac{1}{1-0.0961}}$

= -0.31 x 4.570899929

r = -1.42

Then using t-table at degree of freedom of N-2 = 19 and significant levels of 0.05, the critical value of 1.729 was obtained. Since the computed value -1.42 is less than the table value of 1.729 at 0.05. This implies that there is no significant difference between the mean concentrations of the upstream (NWRS1), midstream (NRWS2) and downstream (NRWS3) of Nworie River.

4. DISCUSSION

Table 1 gives the mean concentration and the standard deviation of different parameters in the water samples. For water to be potable, the concentration of undesirable substances must not exceed the level set by the World Health Organization [20].

TURBIDITY: Ranged from 2.20-3.50 NTU which is within the World Health Organization permissible limit, with a mean value of 2.88 and a standard deviation of 3.889. Turbidity increases with colour intensity.

TEMPERATURE: Ranged from 28.50-29.00 which is within the World Health Organization permissible limit, with a mean value of 28.33 and a standard deviation of 33.30. The temperature is influenced by the intensity of sunlight. Temperature also determines the proliferation and survival rate of microorganisms [21].

pH: Ranged from 6.18-6.49 which is within the World Health Organization permissible limit, with a mean value of 6.33 and a standard deviation of 7.31. This can be attributed to the high levels of free CO_2. The pH also plays a role in shaping microbial structures and other biological activities in water [22].

Electrical Conductivity (EC): EC of the study area **r**anged from 57.90-87.70µS/cm which is within the World Health Organization permissible limit, with a mean value of 69.97 and a standard deviation of 82.30. This may imply that the river receives low amount of dissolved salt and inorganic substances [23].

Total Dissolved Solid (TDS): Ranged from 26.63-40.34 mg/l which is within the World Health Organization permissible limit, with a mean value of 32.18 and a standard deviation of 37.86. Total dissolved solid increases the hardness of water and natural water is usually made up of

carbonates and sulphates of calcium, magnesium, potassium, and sodium. There is no evidence of adverse effect of TDS of over 500mg/l, although about 600mg/l taste problem is likely to arise [17]. As TDS increases, the electrical conductivity increases. TDS indicates salinity behavior and is a measure of anthropogenic activity.

Total Suspended Solid (TSS): TSS ranged from 8.10-13.20 mg/l which is within the World Health Organization permissible limit, with a mean value of 10.80 and a standard deviation of 12.73. Large quantities of TSS reduce the respiration in aquatic organisms and promotes the growth of microorganisms.

Total Alkalinity: Ranged from 28.00-44.00 mg/l which is within the World Health Organization permissible limit, with a mean value of 37.00 and a standard deviation of 43.50.

Total Hardness: Ranged from 7.60-16.40 mg/l which is within the World Health Organization permissible limit, with a mean value of 11.20 and a standard deviation of 13.73.

Calcium and Magnesium: Calcium ranged from 6.98-16.40 mg/l with a mean value of 10.74 and a standard deviation of 13.36. While magnesium ranged from 0.00-0.77 mg/l with a mean value of 0.46 and a standard deviation of 0.67. Both calcium and magnesium concentrations are within the World Health Organization permissible limit. As such, there might be no detrimental effect on aquatic life and on humans who ingest foods harvested from the river. This observation was in agreement with the findings of [24].

Dissolved Oxygen: Ranged from 2.10-2.60 mg/l, with a mean value of 2.33 and a standard deviation of 2.71. DO is low as a result of decay of large quantities of organic material discharge into the river. Generally, a higher dissolved oxygen level indicates better water quality.

Biochemical Oxygen Demand: Ranged from 3.00-5.80 mg/l which is within the World Health Organization permissible limit of 6.00mg/l, showing that the water is not really polluted with a mean value of 3.93 and a standard deviation of 4.82. Low BOD is an indication of high oxygen content (DO) in water; this condition is comfortable for aquatic life. The BOD measures only the biodegradable part of organic wastes concentration [25].

Chemical Oxygen Demand: Ranged from 0.00-48.22 mg/l with a mean value of 25.06 and a standard deviation of 37.70. The midstream is slightly higher than the World Health Organization permissible limit of 40.00mg/l. The COD gives a rapid measure of oxidizable organic matter.

Chloride: Ranged from 15.34-19.88 mg/l which is within the World Health Organization permissible limit, with a mean value of 17.89 and a standard deviation of 20.79. The presence of chloride is due to agricultural run-off and the discharge of sewage and effluent, however, high chloride content in water causes digestive, renal and urinary disorders in people living in vicinity where chloride based effluent are discharged into the river. High concentration can also affect fish and other marine lives [26].

Sulphate: Ranged from 14.64-28.78 mg/l which is within the World Health Organization permissible limit, with a mean value of 21.49 and a standard deviation of 25.80. Sulphate occurs naturally in water as a result of leaching from gypsum and other common minerals. Discharge from domestic and agricultural wastes also increases its amount in water.

Phosphate: Ranged from 0.37-0.53 mg/l which is within the World Health Organization permissible limit, with a mean value of 0.47 and a standard deviation of 0.55. Phosphate concentration is as a result of agricultural run-off (fertilizer) from farms, detergents, domestic and industrial effluent discharged into water.

Nitrate: Ranged from 3.80-4.70 mg/l which is within the World Health Organization permissible limit, with a mean value of 4.27 and a standard deviation of 4.95. The presence of nitrate is an indication of wastes rich in nitrates and agricultural run-off. High nitrate content in water causes infant methaemoglobinaemia [27].

Sodium and Potassium: Sodium ranged from 0.00-0.0001 mg/l with a mean value of 0.00 and a standard deviation of 0.00. In other words, there is little or no sodium present in the up, mid and downstream. Many water bodies have sodium concentrations well below 50.00mg/l [28]. While potassium ranged from 2.5493-13.0172 mg/l with a mean value of 6.9120 and a standard deviation of 9.6629, there is little or no potassium present in the up, mid and downstream. The

presence of potassium is an indication of wastes rich in nitrates and agricultural run-off (NPK fertilizer).

Iron: Ranged from 0.0001-1.6815 mg/l with a mean value of 0.9048 and a standard deviation of 1.3456. The concentration of iron in midstream and downstream; 1.0329 and 1.6815 respectively is high and above the World Health Organization permissible limit, hence can cause serious health problem and distort the normal respirational pattern of fishes in the river [29]. The high concentration of iron in the midstream and downstream could be as a result of river dredging and dumping of metal scraps in the river. This is responsible for the brownish colour, impacts metallic tastes rendering it unfit for human consumption, corrosion and laundering problem.

Lead: Ranged from 0.0001-0.0104 mg/l with a mean value of 0.0066 and a standard deviation of 0.009490. The concentration is within the World Health Organization permissible limit. Lead usually gets into the water through mining, industrial wastes, discarded automobile batteries and the burning of gasoline. When lead is ingested, it causes anaemia, kidney disorder and sterility in man. For animals, loss of teeth and early death.

Table 2: Showed the pollution index of Nworie River to be 2.15 which is above the critical value of 1.0 [27] and so requires treatment.

Table 3: Upstream (NWRS1) and midstream (NRWS2) of Nworie River water sample showed that the appearance in terms of colour, turbidity was not satisfactory, the odour was satisfactory. From the microbiological test result, there were large presence of other feacal coliforms, E. coli, feacal streptococci, salmonella sp, shigella sp, vibrio sp, clostridia sp and yeast/mould, which denotes unsatisfactory result. Therefore, treatment should be carried out to get rid of the coliforms. The downstream (NRWS3) of Nworie River showed that the appearance in terms of colour, turbidity was satisfactory, the odour was satisfactory. However, from the microbiological test result, there were presence of feacal streptococci, salmonella sp, shigella sp, clostridia sp and yeast/mould which denotes unsatisfactory result [24].Therefore, treatment should be carried out to get rid of the coliforms.

Table 4 gives the concentration of different parameters of water samples from Nworie River after treatment. There is a remarkable reduction of total hardness, calcium and magnesium hardness, BOD, COD, chloride, nitrate, iron and lead. While the pH, electrical conductivity, phosphate, TDS, potassium and total alkalinity decreased slightly. Both sulphate and sodium were not detected. The increase and decrease in the concentration of different parameters could be attributed to the addition of alum, slaked lime and chlorine into the water sample.

Table 5 shows the following:

General appearance in terms of colour, odour and turbidity was satisfactory. From the microbiological test result, there was no presence of feacal coliforms and other microorganisms which denotes satisfactory result. However, all the parameters were within the World Health Organization permissible limit.

5. CONCLUSION

The pollution index calculation of 2.15 showed that Nworie River is polluted which was above the critical point of 1.0 [30], [31] and hence treatment was necessary to reduce the impurities. The pollution was as a result of uncontrollable loading of organic and inorganic wastes. This can be attributed to poor solid waste management in terms of methods of dredging, surface and underground effluent discharge points and agricultural run-off could be the contributing factor.

The results obtained from the treated Nworie River water sample was within the recommended range provided by the World Health Organization with iron being reduced to 0.2915. The microbiological test results showed that there was no presence of feacal coliforms which denotes satisfactory result. Therefore, the treated Nworie River could be used for drinking, industrial, agricultural and other purposes.

In an effort to protect the quality of Nworie River, more treatment plants is recommended to be sited in Owerri. More so, the treated water should be analyzed by physical, chemical and microbiological method to ensure that the parameters are within the World Health Organization permissible limit.

The product-moment gave the correlation as -0.31 which implies that there is a low negative correlation between X, Y and Z i.e. between the upstream (NRSW1), midstream (NRSW2) and downstream (NRSW3) respectively of Nworie River water samples.

Also, the test for significance using t-table at degree of freedom of N - 2 = 21 – 2 =19 at significant levels of 0.05, the critical value -1.42 is less than the table value of 1.729 at 0.05 significant level. Therefore, there is no significant difference between the mean concentrations of the upstream (NRSW1), midstream (NRSW2) and downstream (NRSW3) respectively of Nworie River.

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