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Dike MU
Department of Environmental Technology, Federal University of Technology Owerri, Nigeria.

Nevoh GO
Petroleum Analysis Laboratory, Petroleum Training Institute Effurun Warri, Nigeria.

Uzoma HC
Department of Environmental Management and Toxicology, Michael Okpara University of Agriculture, Umudike. Nigeria.

Correspondence
Uzoma HC
Department of Environmental Management and Toxicology, Michael Okpara University of Agriculture, Umudike. Nigeria.

Physico- chemical and biological assessment of river qualities in Owerri federal constituency of Imo state, Nigeria

Dike MU, Nevoh GO and Uzoma HC

Abstract
Comparative studies and analysis of the physico-chemical qualities of selected rivers in Owerri Federal Constituency of Imo State Nigeria was carried out with four rivers, Otamiri, Nworie, Emii and Onukwu-Emeke. Inventory of anthropogenic activities on the rivers were taken. Water samples were collected at three points (upstream, mid stream and downstream) from each of the rivers and analyzed using standard methods. The result of the analysis showed that; Otamiri had highest total viable bacteria (387 cfu/100ml). Nworie recorded highest colour (43.50 Pt/Co), BOD (0.84mg/l), COD (36.53) and lowest pH (6.18). the Emii River had highest values for TSS (171.69mg/l), turbidity (39.33 NTU) and total coliform (350 cfu/100ml) the Onukwu-Emeke seem to be most polluted and utilized with highest recorded values for temperature (32.6 ^{0}C), conductivity (146.70μS/cm), TDS (76.67mg/l), Nitrate (16.35mg/l), phosphate (28.34mg/l). sulphate (430mg/l), Total Hardness (103.79mg/l), iron (25.34) and copper (4.95). It is recommended that appropriate water treatment be carried out before use, water resources utilization be regulated and relevant laws enforced.

Keywords: comparative, quality, pollution, physico-chemical, rivers.

Introduction
Water is an essential resource that contributes to the environmental balance of the world. Over 70% of the earth surface is covered with water, which forms part of the hydrologic cycle. The earths water according to Montegomery (1997) [1] is always in motion forming a cycle called water cycle. Some of the water cycle reservoirs are oceans, glaciers, groundwater, lakes, soil moisture, atmosphere biosphere, streams and rivers (Obeta, 2012) [2]. Rivers and streams are large bodies of water confined within a channel by banks that flows into the sea, lake, another river and oceans. Cunningham (2003) [3] pointed out that riverlets accumulate to form streams and streams join to form rivers. Rivers are characterized by tributaries, unidirectional flow, linear form, fluctuating discharge, unstable channel and bed morphology (Barnes *et al.*, 1991) [4]. Harrison (2004) [5] listed Niger, Benue, Imo, Cross, Aba, Orashi, Aham, Njaba, Otamiri, Onukwu- emeke, Emii, Qua Iboe and Eke onumiri as some of the rivers in Nigeria.

River pollution is the alteration of river water composition or condition, directly or indirectly as a result of the activities of man, so that it is less suitable for any or all the purposes for which it would be suitable in its natural state. Water bodies exhibits the capacity of assimilating a certain amount of pollution without serious effects due to dilution and self purification factors (Tebbult, 1998) [6]. Since pollution alters waters suitability for various uses Hammer & Hammer (2004) [7] suggests that the control of water quality is essential to ensure efficient use of the resource. River pollution results in contamination of water supplies, restriction of recreational use, effects on aquatic life, creation of nuisances (appearance, odour) and hindrance & navigation. River quality is reduced by several sources, Hammer and Hammer (2004) [7] and Larkin *et al.* (1981) [14] identifies categories of river water pollution as oxygen demanding wastes, plant nutrients, infectious agents and disease causing organisms, synthetic organic compounds, inorganic minerals and chemical compounds, radioactive substances, sediments and heat.

Oxygen balance of water can be affected by substances which consume oxygen, prevent oxygen transfer across air-water interface or thermal pollution, Cunningham (2003) [3] noted that the effect of oxygen demanding wastes in rivers depends to a great extent on the volume, flow and temperature of the river. Phosphorus and Nitrogen are nutrients that stimulate plant growth, Botkin and Keller noted that nutrients are introduced into rivers from agro chemicals, organic materials, detergents and sewage. Increase in nutrient level and bio-productivity leads to eutrophication. This according to Cunningham (2003) [3] can cause undesirable algal & plankton blooms, odour, taste and toxicity. Organisms such as parasites, viruses, bacteria, fungi which cause water borne diseases find their ways to rivers untreated sewage and waste water (Cunningham, 2003) [3].

Symon *et al.* (2000) [9] defined water quality as the chemical physical and biological characteristics of water with respect to its suitability for a particular purpose.

The work is focused on the comparative analysis of the physico-chemical and Biological Qualities of major rivers (Otamiri, Nwaorie, Emii and Onukwu-Emeke) in Owerri Federal Constituency of Imo State.

Materials and methods

Description of Study Area

The study area is Owerri Federal Constituency; it comprises of Owerri Municipal, Owerri North and Owerri-West Local Government Areas of Imo State Nigeria. It is located on latitude $4^0$28' and $5^0$48' North of the Equator and longitude $5^0$23, and $7^0$36' East of the Greenwich meridian. It has urban and semi urban status with a population of about 400,000 people (National population census, 2006) [15]. The topography is gently rolling with elevation below 200m above sea level and classified as eastern coastal low land. It is drained extensively by a network of rivers namely; Otamiri, Nworie, Emii, Onukwu-emeke, Okita Nkwo, Uramiri ukwa and Umueka. The area is characterized by sub equatorial climate with annual rainfall above 2000mm and two major and minor seasons (dry, rainy, minor Dry and minor rainy). It has mean minimum and maximum temperatures of 24 – 32 ^{0}C, humidity ranges from 40%-90% with south westerly wind dominating. The vegetation is tropical rainforest `and a mix of savanna especially along the water courses, the soils are predominantly tertiary sands and clay, highly leached and slightly acidic. Economic activities in the area are dominated by subsistence agriculture, trading, sand mining, civil service, artisanship, transportation and fishing,

Water Sample Collection

Water samples were collected from three locations from each of the rivers representing upstream, midstream and downstream at an interval of 300m. Samples were collected beneath the water surface and stored in well labeled 2 litre plastic bottles. The samples for dissolved oxygen, and biochemical oxygen demand were collected with 250ml amber coloured BOD bottles and the samples for microbial analysis was collected with pre-sterilized bottles.

All the collected samples in plastic bottles were preserved, in an ice chest at 4 ^{0}C and transported to the UNIDO pollution Centre laboratory in Owerri for analysis.

Laboratory analysis

Parameters selected for analysis included; colour, pH, conductivity, total dissolved solids (TDS), total suspended solids (TSS), turbidity, nitrate, phosphate, sulphate, dissolved oxygen, BOD, COD, total hardness, iron, copper, total viable bacteria and total coliform.

Hach DR/2010 spectrophotometer was used to determine colour at program number 120 and waveling of 455nm. Suntex pH and temperature meter was used to determine the temperature and pH, the Suntex conductivity/TDS meter was used to determine the conductivity and TDS, HI 83200 multiparameter photometer by Hana instrument was used to determine the TSS, turbidity, nitrate, sulphate, phosphate, iron and copper, at the appropriate programme number and wavelength. Total hardness, dissolved oxygen, BOD & COD was determined using standard methods prescribed by APHA (2005). The surface plate method and multiple tube test was used to determine total viable bacteria and total coliform respectively.

Results and Discussion

Anthropogenic activities at Owerri Rivers

The major anthropogenic activities carried out around the rivers under study were found to be cassava fermentation, swimming, drinking water harvesting, fishing, defecation, farming, cloth washing, bathing, solid waste disposal, palm-wine tapping, lumbering, animal washing, sand and gravel mining, automobile washing, sewage and waste water disposal, food washing and transportation(table 1)

Table 1: Anthropogenic activities at Owerri Rivers

S/N	Activity	Frequency			
		Otamiri	Nworie	Emii	Onukwu Emeke
1	Cassava Fermentation	●●	●●	●● ●	●●●
2	Swimming	●●●	-	●●●	●●●●
3	Drinking water harvesting	●●●	●●	●●	●●●●
4	Fishing	●●	-	●●	●●●●
5	Defecation	●●●	●●●●	●●	●●
6	Farming	●●●	●●	●●●	●●●●
7	Cloth washing	●●●	●●●	●●●●	●●●●
8	Bathing	●●●	●●●●	●●●	●●●●
9	Solid waste disposal	●●●	●●●●	●●	●●●
10	Palm-wine tapping	●	●●●	●●	●●●
11	Lumbering	●	●●	●●	●●●
12	Animal washing	●●●	●●●●	●●●	●●●●
13	Sand and gravel mining	●●●●	-	●	●●●●
14	Automobile washing	●●●	●●●	●●	●●●
15	Sewage/waste water disposal	●●●●	●●●●	●●	●●
16	Food washing	●●●	●●●●	●●	●●
17	Transportation	●●●●	●●●	●●	●●●

● = occasional, ●●=regular, ●●●= frequent, ●●●●=very frequent and - = Nil.

Physico-Chemical and Biological Properties of Owerri Rivers

The physical, chemical and Biological properties of the rivers under study show that Otamiri had the highest total viable bacteria, Nworie had the highest colour, temperature, BOD and COD but slightly acidic, Emii water was acidic and had the highest TSS, Turbidity and total coliform. The Onukwu-Emeke river had the highest conductivity, TDS, Nitrate, Total Harness, phosphate, sulphate, iron and copper. See tables 2-6 and figures 1-7.

Table 2: properties of Otamiri River

S/N	Parameter	A	B	C	Mean
1	Colour (Pt/Co Units)	12	9	4	8.3
2	Temperature (°C)	26.6	27.3	27	26.9
3	pH	7.5	8	7	7.5
4	Conductivity (µS/cm)	121.8	96.3	86.4	101.5
5	Total Dissolved Solids(mg/l)	62.4	36.8	38.2	45.8
6	Total Suspended solids(mg/l)	3	1	1	1.7
7	Turbidity (mg/l)	24.26	15.85	9.96	16.69
8	Nitrate (mg/l)	18.45	11.24	5.65	11.78
9	Phosphate (mg/l)	1.23	3.05	2.7	2.33
10	Sulphate (mg/l)	4	2	1.28	2.43
11	Dissolved Oxygen (mg/l)	5.9	5.04	5.3	5.41
12	Biochemical Oxygen demand(mg/l)	0.6	0.5	0.54	0.55
13	Chemical Oxygen Demand (mg/l)	10.56	17.41	13.36	13.78
14	Total Hardness (mg/l)	20.8	18.35	17.12	18.76
15	Iron (mg/l)	0.9	0.7	6	2.3
16	Copper (mg/l)	5.64	3.65	2.45	3.91
17	Total Viable Bacteria (cfu/100ml)	400	400	360	387
18	Total Coliform Bacteria(cfu/100ml)	360	228	124	237

A = Upstream, B = Midstream, C = Downstream.

Table 3: properties of Nworie River

S/N	Parameter	A	B	C	Mean
1	Colour (Pt/Co Units)	35	49	52	45.33
2	Temperature (°C)	24.4	23	24.5	23.97
3	pH	5.9	6.4	6.45	6.25
4	Conductivity (µS/cm)	80	82	84	82
5	Total Dissolved Solids(mg/l)	40	41	42	41
6	Total Suspended solids(mg/l)	8	7.5	4	6.5
7	Turbidity (mg/l)	11	12	15	12.67
8	Nitrate (mg/l)	0.87	0.6	0.62	0.69
9	Phosphate (mg/l)	3.02	3	2.88	2.97
10	Sulphate (mg/l)	24	16	18	19.33
11	Dissolved Oxygen (mg/l)	5.05	5.1	5.24	5.13
12	Biochemical Oxygen demand(mg/l)	0.67	0.8	1.01	0.83
13	Chemical Oxygen Demand (mg/l)	26.13	44	46.92	39
14	Total Hardness (mg/l)	11.75	21.5	23.19	18.8
15	Iron (mg/l)	2.46	1.6	1.78	1.95
16	Copper (mg/l)	0.38	0.3	0.25	0.31
17	Total Viable Bacteria (cfu/100ml)	51	48	52	50.33
18	Total Coliform Bacteria(cfu/100ml)	25	62	67	51.33

Table 4: properties of Emii River

S/N	Parameter	A	B	C	Mean
1	Colour (Pt/Co Units)	10	10	5	8.33
2	Temperature (°C)	27	30	35	30.67
3	pH	5.42	5.37	5.32	5.37
4	Conductivity (µS/cm)	11	9	11	10.33
5	Total Dissolved Solids(mg/l)	7	6	7	6.67
6	Total Suspended solids(mg/l)	150	85	280	171.67
7	Turbidity (mg/l)	40	37	41	39.33
8	Nitrate (mg/l)	0.52	3.81	2.39	2.24
9	Phosphate (mg/l)	5.73	3.07	1.23	3.34
10	Sulphate (mg/l)	25.03	17.18	15.11	19.11
11	Dissolved Oxygen (mg/l)	6.2	6.1	6.1	6.13
12	Biochemical Oxygen demand(mg/l)	0.7	0.8	1	0.83
13	Chemical Oxygen Demand (mg/l)	5.14	8.76	6.86	6.92
14	Total Hardness (mg/l)	23.60	7.18	7.76	12.85
15	Iron (mg/l)	0.9	2.01	2.14	1.68
16	Copper (mg/l)	1.55	3.79	2.32	2.61
17	Total Viable Bacteria (cfu/100ml)	9	78	55	47
18	Total Coliform Bacteria(cfu/100ml)	70	900	80	350

Table 5: Properties of Onukwu Emeke River

S/N	Parameter	A	B	C	Mean
1	Colour (Pt/Co Units)	12	15	8	12
2	Temperature (°C)	30	32	36	32.6
3	pH	8	8.01	7.04	7.68
4	Conductivity (µS/cm)	115	130	195	146.7
5	Total Dissolved Solids(mg/l)	60	70	100	76.67
6	Total Suspended solids(mg/l)	37.45	43.7	49.93	43.7
7	Turbidity (mg/l)	24.02	18.03	16	19.35
8	Nitrate (mg/l)	19.04	16.01	14	16.35
9	Phosphate (mg/l)	31.01	28.01	26.01	28.34
10	Sulphate (mg/l)	140	450	300	296.67
11	Dissolved Oxygen (mg/l)	6	5	5.5	5.5
12	Biochemical Oxygen demand(mg/l)	0.5	0.34	0.57	0.47
13	Chemical Oxygen Demand (mg/l)	8.9	13.75	7.83	10.16
14	Total Hardness (mg/l)	85.7	123.96	101.7	103.79
15	Iron (mg/l)	28	25	23	25.33
16	Copper (mg/l)	5.2	7.16	2.5	4.95
17	Total Viable Bacteria (cfu/100ml)	98	178	115	130
18	Total Coliform Bacteria(cfu/100ml)	20	38	48	35

Table 6: properties of Owerri Rivers with WHO Limit

S/N	Parameter	WHO	Mean I	Mean II	Mean III	Mean IV
1	Colour (Pt/Co Units)	15	8.3	45.33	8.33	12
2	Temperature (ºC)	20-30	26.9	23.97	30.67	32.6
3	pH	6.5-8.5	7.5	6.25	5.37	7.68
4	Conductivity (µS/cm)	100	101.5	82	10.33	146.7
5	Total Dissolved Solids(mg/l)	250	45.8	41	6.67	76.67
6	Total Suspended solids(mg/l)	50	1.7	6.5	171.67	43.7
7	Turbidity (mg/l)	50	16.69	12.67	39.33	19.35
8	Nitrate (mg/l)	40	11.78	0.69	2.24	16.35
9	Phosphate (mg/l)	5	2.33	2.97	3.34	28.34
10	Sulphate (mg/l)	250	2.43	19.33	19.11	296.67
11	Dissolved Oxygen (mg/l)	6-110	5.41	5.13	6.13	5.5
12	Biochemical Oxygen demand(mg/l)	10	0.55	0.83	0.83	0.47
13	Chemical Oxygen Demand (mg/l)	40	13.78	39	6.92	10.16
14	Total Hardness (mg/l)	100	18.76	18.8	12.85	103.79
15	Iron (mg/l)	1	2.3	1.95	1.68	25.33
16	Copper (mg/l)	0.3	3.91	0.31	2.61	4.95
17	Total Viable Bacteria (cfu/100ml)	5-10	387	50.33	47	130
18	Total Coliform Bacteria(cfu/100ml)	0-2	237	51.33	350	35

I= Otammiri, II= Nworie, III = Emii, IV=Onukwu Emeke

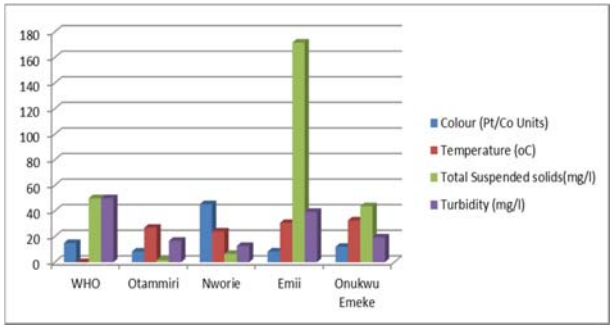

Fig 1: Variation of Colour, Temperature, TSS and Turbidity.

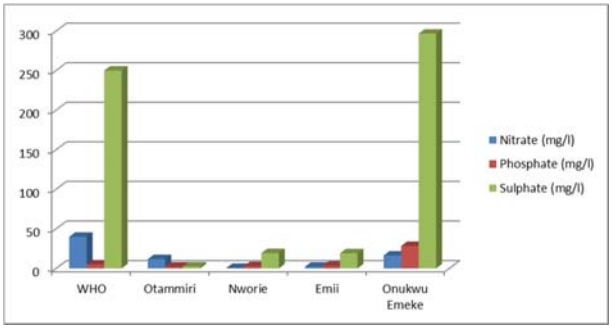

Fig 4: Variation of Nitrate, Phosphate and Sulphate

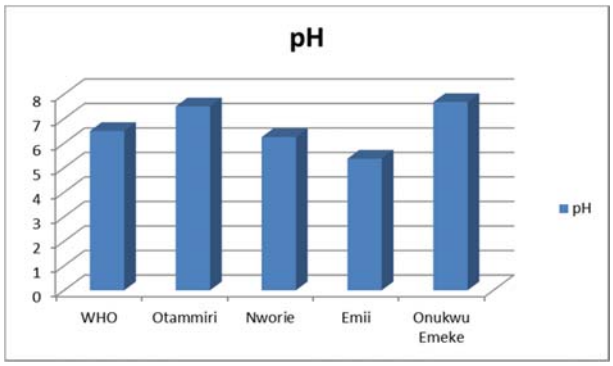

Fig 2: Variation of pH

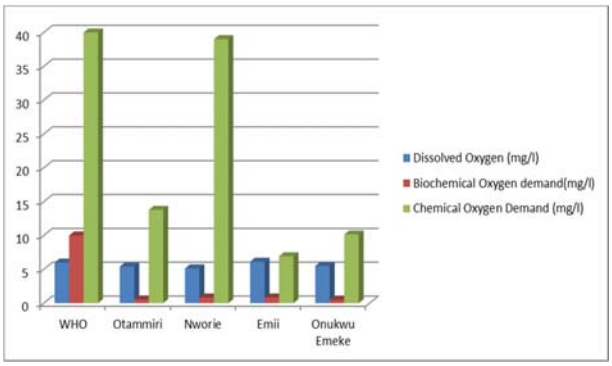

Fig 5: Variation of Dissolved, BOD and COD

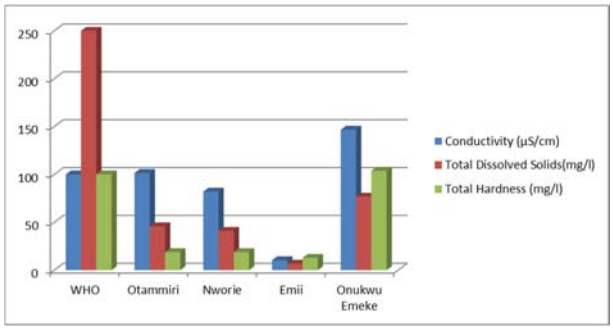

Fig 3: Conductivity, TDS and Total Hardness

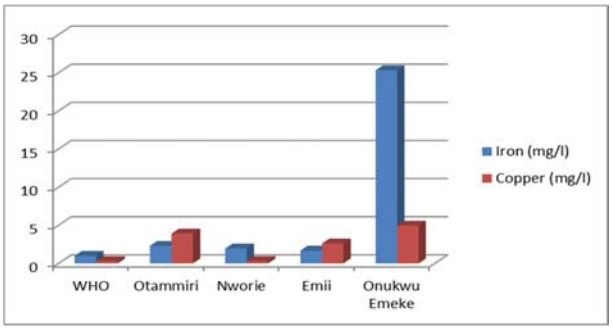

Fig 6: Variation of Iron and Copper

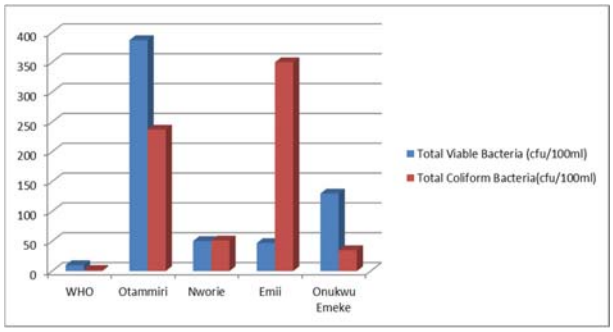

Fig 7: Variation of Total Viable and Total Coli form Bacteria

Discussion

Nworie: The colour of the rivers ranged from 8.33-43.50 pt/co units and it was highest in Nworie River, the river also recorded the highest values for temperature (24.45 ^{0}C), BOD (0.84mg/l), COD (36.53mg/l) and pH (6.18). the results could be attributed to several tones of bagasse, sugar cane peels and other solid wastes dumped in the river, sewage and waste water deposited at the Federal medical centre and Alvan Ikoku Federal College of Education ends, high level of defecation, barthing, animal washing, car washing and food washing by the dense municipal population. High temperatures stimulate growth of organisms, taste and odour and can cause intestinal irritation (Ezemonye, 2009) [8], colour reduces the aesthetics of a river (Ubuoh, 2010), BOD and COD reduces the dissolved oxygen creating oxygen demand problems as supported by Cunningham (2003) [3].

Otamiri: The properties of Otamiri show that the river had the highest total viable bacteria (387 cfu/100ml) which could be attributed to discharges of sanitary sewage into the river by the urban and semi urban residents whose population is becoming denser by the day due to urbanization and tertiary institutions populations along the river stretch. Other anthropogenic activities like; swimming, drinking water harvesting, defecation, farming, washing, bathing, and sand mining are likely to be contributors to the water quality variation.

Emii: The River showed that it had the most acidic pH, (5.37) as well as the highest TSS (171.67mg/l), turbidity (39.33mg/l) and total coliform (350cfu/100ml), the observed properties could be attributed to anthropogenic activities like: cassava fermentation, swimming, farming, bathing, cloth washing, animal washing etc.

Onukwu Emeke: The results show that Onukwu Emeke River recorded the highest conductivity (146.7µS/cm), TDS (76.67mg/l), Nitrate (16.35mg/l), phosphate (28.34mg/l), sulphate (296.67mg/l) Total Hardness (103.79mg/l), iron (25.34mg/l) and copper (4.95mg/l) which could be attributed to intensive agricultural activities, mining/quarrying, bathing and swimming, fishing & palm wine tapping, animal washing etc.

From table 1; the river was found to be the most intensively utilized. The high dependence on the river for drinking water supply calls for serious attention.

Temperature of the river influences other biochemical mechanisms which could lead to slow oxygen replenishment, decline in dissolved oxygen and stimulation of taste and odour (Ezemonye, 2009) [8].

BOD & COD directly affects the river Dissolved oxygen, which if lower than 5mg/l can affect the metabolic activities of aquatic organism leading to decline in fishes and growth of micro-organisms whose by products can cause foul odours in rivers and swimming (Metcalf and Eddy (1991) [11].

TSS and TDS: Solids in water could be suspended, colloidal or dissolved, they can form sediments of rivers, scums, precipitates and coagulates with the general effect on colour, appearance, turbidity, odour and Total Hardness making the water less attractive, it could cause interference with sunlight penetration leading to effects on ecological balance of the river (Biswas, 1988) [12].

Eutrophication of water bodies is a major challenge in environmental management, this study show that all rivers especially Onukwu-Emeke are rich in nutrients (Nitrates, phosphates and sulphates). Removal of the nutrients from the water causes or at least the limiting nutrient is a desired goal (Dike, 2006) [13].

Iron in water causes brownish stains when used for laundry. As the dissolved oxygen depletes a condition of solublization of iron in sediment can occur worsening the situation.

Conclusion

The river is an essential resource that requires sustainable management. Anthropogenic activities have continued to influence river quality around the globe hampering its utilization, for domestic, recreation, industrial, agricultural, cleaning and other purposes.

Owerri Federal Constituency Rivers including Otamiri, Nworie, Emii and Onukwu-Emeke are under the influence of anthropogenic activities like: cassava fermentation, swimming, drinking water, harvesting, fishing, defecation, farming, cloth washing, bathing, solid waste disposal, palm wine tapping, lumbering, animal washing, sand and gravel mining, automobile washing, sewage and waste disposal, food washing and transportation.

Properties such as colour, temperature, BOD, COD, pH, total viable bacteria, TSS, TDS, turbidity, total coliform, conductivity, Nitrate, phosphate, sulphate, Total Hardness, iron and copper where high and exceeded the WHO permissible limits in some of the rivers.

It is the recommendation of this research that:

- The excavation and quarrying activities at Onukwu-Emeke and Otamiri rivers be regulated and enforcement sustained to ensure efficient management of the water resource.
- The solid wastes dumped at Nworie and Otamiri be stopped and appropriate integrated waste management systems adopted.
- Sewage and waste water should be treated before disposal to rivers especially Nworie and Otamiri.
- Farming activities should be limited within 500m from the river banks and only organic farming should be allowed up 1km from river banks.
- Extant laws protecting inland water ways and other water resources should be renewed and enforced by the appropriate government agencies.
- Water from rivers should be treated to meet specific use especially for drinking purposes. To this end there is need for the expansion and replication of the Otamiri water works scheme to balance the rising population of residents.

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