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Predicting Effect of Refuse Dump on the Water Quality of Otamiri River

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ABSTRACT
This research is aimed at predicting effect of refuse dump on the water quality of Otamiri River which served for domestic uses among the rural inhabitants. Anthropogenic activities that goes on at its bank that serve as non-point source have raised much concern about the water quality of the river. Water samples were collected from nine (9) spatially referenced points within the river using the conventional WHO (2004) methods [1] and analyzed in line with APHA standard procedures for testing water in order to evaluate the water quality status of Otamiri River. Spatial variations in biological and physicochemical parameter were observed across the sampling locations. Maximum levels of pH and colour were recorded in sampling Location 1 (5.7 and 17.5Pcu respectively). Maximum levels of EC, Nitrate, Sulphate, TDS, TSS and TS were recorded in sampling locations 3 with the average value (79$\mu S/cm$, 5.1225 mg/l $N0^{-}_3$ 2.46mg/L, 52mg/L, 161mg/L and 109mg/L respectively). Maximum levels of COD in Location 2 (684mg/L). Maximum levels of Turbidity, PO_4^{-3} , SO_4^{-2} , DO and BOD_5 (8.34NTU, 0.443 mg/L, 2.22 mg/l, 15.18 mg/L and 12.21 mg/L respectively) were recorded in Location 5. The data analysis tool in Microsoft Excel was used to explore and study the interrelationship between the water quality index as dependent variable and some conservative parameters like (pH, EC, Tur, N0-3, TH, TDS, PO_4^{-3} , SO_4^{-2} , DO, BOD_5 and COD) as independent variables. Regression models were developed and they will help in determining the pollution concentration at any point within the river. As constant dumping of refuse at the site has increased the concentration of pollutants in the river water, even though some remain within established standards, water from Otamiri River requires elaborate treatment before it could be suitable for domestic purposes. Institutional and social familiarities were identified as cause of poor waste disposal problem.

KEYWORDS: Refuse Dump, Anthropogenic activities, Water pollution, Water Quality Parameter, Regression Analysis, Model Prediction.

I. INTRODUCTION

Water is essential for livelihood as well as socio-economic development of any community and it is estimated that approximately thirty three percent of the world's population use groundwater for drinking [2]. In Nigeria, individuals and establishment rely on either surface or groundwater for agricultural, industrial and public use because of its abundance, stable quality and also because it is inexpensive to exploit. However, the volume of water available to all life from these surface water bodies is always on a constant decline. This is due to various reasons ranging from global warming to anthropogenic activities which leads to pollution and it causes drastic reduction of surface water resources. Massive population growth, matched with increased waste generation has become a global challenge especially in the developing nations.

Owerri town is found in Imo State, south-eastern part of Nigeria and it is characterized by rapid population growth caused by natural increase and migration from nearby towns and rural villages. Such rapid increase in population together with increasing industrial activities, consumption pattern and expansion of town has generated large volume of solid and effluent from various sources. This in turn demands infrastructural provision, institutional setups and strong community participation. Most cities in Nigeria including Owerri are faced with waste management problems. Due to available space along Otamiri Riverbank, the Owerri Municipal Council in the year 2,000 approved the site as the official dumpsite for most of the solid waste collected from the municipality. The average quantity of solid

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waste generated in Owerri municipality in 2018 is 0.00974m^3 per capita per day [3] and solid waste has been dumped at this site for more than ten years, on a surface area approximately 11 hectares in size, 6 meters high and not compacted and capped. Nearly 30 tons of commingled wastes are dumped here daily. Waste components include metals (beverage cans, ferrous materials), used papers, rags, plastics, and organic materials (food remnants, dead leaves). A large quantity of decaying fruits and vegetables (oranges, tomatoes, cabbages, etc.) are dumped in the area. These include other elements with toxic properties (dry lead batteries, spent oils, used carbides, paints, and resins). All are dumped without any cover materials and they are constantly exposed to weather and climatic conditions. During the rainy season, for example, most of these materials are washed into the river after torrential rains. The organic matter and other soluble contents in the waste dump also produce leachate that ceaselessly seeps into the soil and the river. The dumpsite have then become a breeding ground for vectors, rodents, and pests [4].

Imo State Water and Sewerage Corporation (ISWSC) has warned that Otamiri River, being the main source of potable water to Owerri, may dry up, if residents in the capital city continue to pollute it. The ISWSC General Manager (GM), Emeka Ugoanyanwu, stated, “I expect Owerri people to take ownership of your rivers and start protecting them. Already, Okatankwo River is gone. Nworie and Otamiri are going. Start shouting against that. I want you, our traditional rulers, to let your people know. People have built houses on our waterways, throwing wastes in our rivers, constructing soak-ways, burying near the rivers. This is not good.” [5]. It is against this backdrop that this research was conducted to predict effect of refuse dump on the water quality of Otamiri River by comparing the levels of the contaminants against the set limit by regulating agencies and also developing regression model for predicting the WQI of the river at any point and time within the river reach.

II. MATERIALS AND METHODS

2.1 STUDY AREA

The study location is Otamiri River in Owerri, the capital city of Imo State, South-Eastern Nigeria. The Otamiri River originates from a forest north of Owerri Municipality and flows southwards through the Owerri metropolis before emptying into other water bodies in the Rivers State of Nigeria. The watershed covers about 10,000 km^2 with annual rainfall 2250 - 2500mm and has a mean slope of 38.5% draining about 18700 hectares of land. It is characterized by depleted rainforest vegetation, with mean temperatures of 27℃ throughout the year. It is joined by the Nworie River at Nekede in Owerri [7]. The river is of great significance to the people as a source of water for domestic use before the introduction of pipe-borne water in the communities.

Figure 1. A section of Otamiri river a some identified dump site Locations

Figure 2. Refuse dump site at Otamiri River

2.2. RESEARCH DESIGN

A semi-experimental field research design was applied in this research. It allows for collecting original data in a natural setting without introducing any compounding variables. A systematic point sampling design was adopted by selecting sampling locations at regular intervals as they are encountered. This approach often provides greater information because the sample is distributed uniformly over the entire study area and because of its ease of use in field studies.

2.3. SAMPLING LOCATION

Stream samples were collected at nine spatially sampling locations along the river reach using the conventional WHO [1] methods. A catchment area was selected as point of sampling collection. Water samples from Otamiri River were obtained at these locations; Egbu, which serves as our control, Akachi Wetheral, Nekede mechanical village, No 8 Nekede Old Road and Otamiri Hill Top Old Owerri / aba Road. The samples were collected at the early hours of the day.

The GPS mapping of the sampling location within the study location is represented in the table 1.

Table 1: The Points where the Samples were collected, its coordinates, distance from dump site and distance between each other

S/N	Location Name	Latitude/ Longitude	Elevation (m)	Time	Distance b/w dumpsite & point of sampling	Distance in-between Locations
1	Water Head Egbu	5°28'6.66"N 7° 3'28.91"E	58	1.05PM	No visible dump site	0m (Origin)
2A	Akachi Wetheral Road Point 1	5°28'18.65"N 7° 2'29.71"E	58	2.12PM	100m	1971m from Location 1
2B	Akachi Wetheral Road Point 2	5°28'11.67"N 7° 2'21.99"E	58	2.20PM		318m from Location 2A
3A	Nekede Mechanic Village Dump Site Point 1	5°27'55.10"N 7° 2'4.43"E	46	2.42PM	50m	1000m from Location 2B
3B	Nekede Mechanic Village Dump Site Point 2	5°27'44.00"N 7° 2'3.82"E	46	3.00PM		336m from Location 3A
4A	No. 8 Nekede Old Road Point 1	5°26'37.51"N 7° 1'20.26"E	57	4.03PM	No Visible Dumpsite	2511m from Location 3B
4B	No. 8 Nekede Old Road Point 2	5°26'28.79"N 7° 1'13.04"E	57	4.15PM		350m from Location 4A
5A	Otamiri Hill Top Old Owerri / Aba Point 1	5°26'2.29"N 7° 0'44.40"E	46	4.36PM	50m	1244m from Location 4B
5B	Otamiri Hill Top Old Owerri / Aba Point 2	5°25'54.69"N 7° 0'39.36"E	46	4.50PM		290m from Location 5A

2.4. INSTRUMENT FOR SAMPLE ANALYSIS

The sampling containers were unscrewed at a depth of 15-30cm below the surface of the water, facing the upstream direction and corked when filled while still underwater to prevent oxidation. A small air space of 2 to 3 cm above the sample was left in the container for proper mixing of the sample before analysis except for the water samples for biochemical oxidation demand (BOD) and dissolved oxygen (DO) determination. It was tightly closed and labelled. Bottles were rinsed with the river water before sampling. These were stored in the icebox to retard the biochemical activities and promptly transported to the laboratory.

2.5. LABORATORY SAMPLE ANALYSIS

The samples collected were analysed in line with standard methods mentioned in [8] and other conventional standard for water quality testing. The sample bottles were immediately corked underwater after sampling to prevent oxidation. The following parameters: pH, Temperature, Electrical Conductivity and Dissolved Oxygen using Digital Meters in the field. Serial dilution of the water samples was carried out using sterile distilled water. The standards reagents used in the analysis were prepared using double distilled water.

2.5.1. TEST OF BIOCHEMICAL OXYGEN DEMAND (BOD_5)

The BOD was evaluated by first diluting the sample and incubating it in the dark at 20°C for five days and measuring the amount of oxygen consumed. The BOD_5 is determined using DO meter calibrated in 5% sodium sulphate solution. The probe of the meter is then inserted into the sample. The reading was recorded in mg/l. the sample is then incubated in a 250mL wrinkle's

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bottle for a period of 5 days at 20^oC then the fifth day recorded by inserting the probe again into the sample. The difference in the DO_2 (5) and DO_2 (1) was recorded as BOD_5. $BOD_5 = DO_2(1) - DO_2(5)$.

2.5.2. TEST OF TURBIDITY NTU

Test method used was Nephelometric Method [9]. The Nephelometer was calibrated according to manufacturer's operating instructions. A standard run was done in each instrument range to be used. The sample was gently agitated and we waited until air bubbles disappears then sample was poured into cell and turbidity was read directly from the instrument display.

2.5.3. TEST FOR THE PRESENCE OF NITRITE

UV spectrophotometric test method was used in this study. 1ml of HCl was added to 50ml clear/filtered sample and mixed. Calibration standards was prepared in the range of 0-7 mg NO_3^- -N/L, by diluting to 50ml using volumes of standard solutions. Absorbance or transmittance was read against re-distilled water set at zero absorbance or 100 % transmittance. A wavelength of 220nm to obtain NO_3^- reading and a wavelength of 275nm was used to determine interference due to dissolved organic matter.

2.5.4. TEST FOR THE PRESENCE OF COLOUR PCU

Colour tests indicate the efficacy of the water treatment system. The sample was poured into a Nessler tube up to 50 mL mark. Similarly fill three to four tubes with colour standards which appear to correspond to the colour of the sample and it was compared with that of the standards by viewing vertically downwards while the tubes are placed on a white surface. We used a colour comparator stand. When the sample colour exceeds 70 units, it was diluted with distilled water in known proportions.

Calculation:
For diluted samples calculate colour units as:

$$\text{Colour Units} = \frac{A\ X\ 50}{B} \qquad (1)$$

Where: A = estimated colour of diluted sample; B = mL sample in 50 mL diluted sample.

2.5.5. TEST FOR THE PRESENCE OF SULPHATE

Test method used was Nephelometry method [10] and [9]. Nephelometer was standardized following manufacturer's instructions and the turbidity of sample-blank was measured (sample in which no $BaCl_2$ is added). 100ml of the sample was measured into a 250ml conical flask. 20ml of buffer solution was added and mixed. While stirring, add a spoonful of $BaCl_2$ crystals was added. It was stirred for 60 ± 2s. Turbidity of the sample was measured at 5±0.5 min after stirring ended. Prepared SO_4^{2-} standards was added at 5mg/l increments in the range of 0 to 40mg/lSO_4^{2-} according to standard protocol.

2.5.6. TEST FOR THE PRESENCE OF PHOSPHATE

Test method used was Ascorbic Acid Spectrophotometric method [11]. The sample was treatment by adding 50ml sample into a 125ml conical flask, 1 drop of phenolphthalein indicator was added. Red color was discharged by adding 5N, H_2SO_4. 8ml combined reagent was added and mixed. After 10 minutes, but not more than 30 minutes the absorbance of each sample was measured at 880nm. Reagent blank was used as reference. For correction of turbid or colored samples, a sample blank was prepared by adding all reagents except ascorbic acid and potassium antimony oxytartrate to the sample. Subtract blank absorbance from sample absorbance reading. To prepare calibration from a series of standards between 0.15 - 1.30 mg P/l range (for a 1 cm light path) distilled water blank with the combined reagent was used. A graph with absorbance versus phosphate concentration was plotted to give a straight line. Test at least one phosphate standard with each set of samples.

2.5.7. TEST FOR THE PRESENCE OF TOTAL SOLIDS

Test Method used was Gravimetric method [12] and USEPA [13]. An evaporating dish was dried at 104 ±1°C for 1h, cool and store in a desiccator. It was weighed immediately before use. The sample was stirred with a magnetic stirrer and while stirring, pipette a measured volume into the pre-weighed evaporating dish using a wide bore pipette. A sample volume was chosen to yield between 10 and 200mg dried residue. It was evaporated to dryness in an oven at 104 ±1°C. Successive portions was added to the same dish after evaporation. In order to prevent splattering, the oven temperature may be lowered initially by 2°C below boiling point and raised to 104°C after evaporation for 1h. It was cooled in a desiccator and weighed.

2.5.8. TEST FOR THE PRESENCE OF TOTAL SUSPENDED SOLIDS

The test method used was Gravimetric after Filtration method [12]. The filter paper was washed by putting it on filtration assembly and filtering 3 successive 20ml portions of distilled water and placed filter in an Aluminum dish and dry in oven at 104 ± 1°C for 1h. It was cooled in desiccators to balance temperature and weigh. The filtration apparatus was assembled with the washed, dried and weighed filter paper and wetted filter paper with a small amount of distilled water to seat it. The sample was stirred with a magnetic stirrer and while stirring pipette a measured volume on to the filter using a wide bore pipette. A volume was chosen to yield between 10 and 200mg dried solids. It was wash with 3 successive 10ml volumes of distilled water and suction was continued for about 3 min after filtration is complete. The filter was carefully removed and transfer to the aluminum-weighing dish. Dry, cool and weighed.

2.5.9. TEST FOR THE PRESENCE OF TOTAL DISSOLVED SOLIDS

Test method used was Gravimetric after Filtration method [12]. The filter paper was washed by inserting it in the filtration assembly and filtering 3 successive 20ml portions of distilled water and suction was continued to remove all traces of water. Afterward washings was discarded. The evaporating dish was dried at 104 ± 10°C for 1h, cool and store in desiccator and it was weigh immediately before use. Sample was stirred with a magnetic stirrer and while stirring pipette a measured volume on to the filter using a wide bore pipette. Sample volume was chosen to yield between 10 and 200mg dried residue. It was wash with three successive 10ml volumes of distilled water and suction was continued for about 3 min after filtration is complete. The total filtrate was transferred with washings to a weighed evaporating dish and evaporate to dryness in an oven at 104 ± 10°C. Successive portions to the same was added to the dish after evaporation in order to yield between 10 and 200 mg dried residue. To prevent splattering oven temperature was lowered initially by 20°C below boiling point and raised to 104 ± 10°C after evaporation for 1h. Cool in a desiccator and weigh.

2.5.9. TEST FOR THE PRESENCE OF TOTAL HARDNESS

The test method used was EDTA Tirimetric method [14] and [15]. 25 mL sample to 50 mL was diluted with distilled water and 1 to 2 mL buffer was added to give a pH of 10.0 to 10.1. Also 1 to 2 drops of indicator solution was added and it was titrated with EDTA titrant to change in colour from reddish tinge to blue. A sample volume was selected that requires less than 15ml EDTA titrant and complete titration was done within 5 min after buffer addition. Standardization was done to the EDTA titrant against standard calcium solution using the above procedure.

Calculation

Total hardness (EDTA),

$$mgCaCO_3/L = \frac{A\ X\ B\ X\ 1000}{ML\ OF\ SAMPLES} \qquad (2)$$

Where: A = mL EDTA titrated for sample and B = mg $CaCO_3$ equivalent to 1.00 mL EDTA titrant = 1.295

2.5.10. TEST FOR THE PRESENCE OF CHEMICAL OXYGEN DEMAND (COD)

Test method used was Titrimetry Method. 50 mL of sample or an aliquot diluted to 50 mL was added with distilled water in a 500 mL refluxing flask. 1g of HgSO4, few glass beads, and 5 ml sulphuric acid reagent was added, mixed and cooled. Also 25 mL of 0.0417M $K_2Cr_2O_7$ solution was added, mix and flask was connected to the condenser and turn on cooling water, add additional 70 ml of sulphuric acid reagent through open end of condenser, with swirling and mixing. It was reflux for 2 hours; cool, the condenser was washes down with distilled water to double the volume of contents and then cooled. 2 drops of Ferroin indicator was added and was titrated with FAS the remaining potassium dichromate, until a colour change from bluish green to reddish brown was obtained. We also reflux and titrate a distilled water blank with reagents. NOTE: 0.00417M $K_2Cr_2O_7$, and 0.025M FAS, was used when analyzing very low COD samples. The technique and reagents was evaluated by conducting the test on potassium hydrogen phthalate solution and grease was not added at the Leibig jacket to prevent jamming, water was used instead.

Calculation:

COD, mgO_2 /l = COD

$$mgO_2/l\ \frac{(A-B)X\ 8000\ COD}{ml\ Sample} \qquad (3)$$

Where: A = FAS used for blank, mL, B = FAS used for sample, mL and M = Molarity of FAS

2.5.11. TEST FOR THE PRESENCE OF MICROBIAL ANALYSIS OF WATER

Test Method used was Isolation and Counting - Serial dilution using Spread plate/pour

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plate method [16]. Samples was incubated by pipetting 1ml of each water samples into a test tube containing 9mLs of sterile distilled water and a 5 fold serial dilution of the water sample were prepared using sterile distilled water as the diluents. An aliquots (0.1mL) of each (10^{-3}, 10^{-5}) of the test tube were inoculated in a Nutrient agar plate, Macconkey agar plate, and Eoesin methylene blue plate by spread plate technique and incubated at 37°c for 24hrs for bacteria on the incubator. After incubation, colonies were observed on different plate and it was counted and recorded.

2.6. WATER QUALITY INDEX (WQI)

Water Quality Index (WQI) is calculated using the weighted arithmetic index method [17]. It is used to determine the effect of waste dumping on the immediate ground and surface water- bodies to the dumpsite, as it is deemed the most appropriate, based on the prevailing conditions.

The WQI is given as:

$$WQI = \frac{\sum_{i=1}^{n} qiwi}{\sum_{i=1}^{n} wi} \quad (4)$$

Where: q_i = quality rating (sub index) of i^{th} water quality parameter, w_i = unit weight of i^{th} water quality parameter; $\sum_{i=1}^{n} W_i$= 1: Also, q_i , which relates the value of the parameter in polluted water to the standard permissible value is obtained as follows:

$$q_i = 100\left(\frac{v_i - v_{io}}{si - v_{io}}\right) \quad (5)$$

Where;

v_i = estimated value of the i^{th} parameter, v_{io}= ideal value of the i^{th} parameter

s_i = standard permissible value of the i^{th} parameter. In most cases, v_{io}= 0 except for pH and DO

For pH, v_{io}= 7; For DO, v_{io}= 14.6mg/l

The unit weight (w_i =), which is inversely proportional to the values of the recommended standards is obtained as: $w_i = \frac{k}{s_i}$ (6)

Where k = $\frac{1}{\sum_{i=1}^{n} \frac{1}{s_i}}$

Table 2. Water quality rating as per weighted arithmetic method [18]

WQI	Rating of Water Quality	Grading
0 – 25	Excellent	A
26 – 50	Good	B
51 -75	Poor	C
76 – 100	Very Poor	D
Above 100	Unsuitable for Drinking	E

Where, wi = Average weight of parameter, Wi= Relative weight of parameter

2.7. Data Analysis

The linear regression is a statistical modeling method to explain the relationship between one or more independent variables and a dependent variable [19]. The WQI calculated values were used as the dependent variable and the values of the eleven physicochemical water quality parameters as the independent variables in stepwise MLR analysis to develop a WQM for the river can predict the value of the WQI of the river in order to simplify the monitoring process of the water quality. The statistical stepwise regression software package for Windows Copywriter by Erol A. Pekoz was used for the statistical analysis of the data.

III. RESULTS

3.1. Test Results

The test results of all the tested water quality parameters and their test methods

The Physico-chemical parameters and contaminants found in the samples from the predetermined spots in Otamiri River, Imo State, Nigeria are presented in Table 2.

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Table 3. Descriptive statistics of the physicochemical parameters

PARAMETERS	WATER HEAD EGBU LOCATION 1	AKACHI WETHERAL		NEKEDE MECHANIC VILLAGE DUMP SITE		NO. 8 NEKEDE OLD ROAD		OTAMIRI HILL TOP OLD OWERRI/ABA ROAD		TEST METHODS
		LOCATION 2A	LOCATION 2B	LOCATION 3A	LOCATION 3B	LOCATION 4A	LOCATION 4B	LOCATION 5A	LOCATION 5B	
pH	5.7	4.75	4.72	4.8	4.7	5.05	5	4.9	4.8	Potentiometric
Conductivity, µS/cm	40.5	40	40	80	78	67.5	67.1	67	66	Potentiometric
Turbidity, NTU	6.05	2.35	2.33	1.75	1.68	1.45	1.39	8.45	8.23	Nephelometric
Colour, PCU	17.5	7	7	6	6	5	4	13	12	Photometric
Tempreture	29.35	29.35	29.35	29.35	29	28.6	28.1	28.55	28.5	Eletrode Thermometer
Nitrate, mg/l $N0_3^-$	3.555	0.665	0.66	5.145	5.1	4.01	3.98	4.285	4.2	Diazotization
Total Hardness, mg/l $Ca/MgCO_3$	49.21	50.505	50	56.98	55.93	47.915	46.955	68.635	68.1	EDTA Titrimetric
Total Dissolved Solid, mg/l	26.325	26	25	52	52.9	44.06	43.55	43.55	41.33	Gravimetric
Phosphate, mg/l PO-34	0.33	0.315	0.31	0.36	0.36	0.37	0.33	0.445	0.44	Ascobic acid
Sulphate, mg/l SO_4^{-2}	2.3	ND	ND	2.46	2.4	0.16	0.12	2.7	2.2	Turbidimetric
Dissolved Oxygen, mg/l O_2	10.35	10.85	10.8	13.65	13.19	11.05	10.5	15.35	15.01	Eletrode Thermometer
Biochemical Oxygen Demand, mg/l BOD_5	5.75	6.5	6.3	8.45	8.32	6.7	6.2	12.9	12.21	Incubation & Electro-Membrane
Chemical Oxygen Demand, mg/l O_2	570	688	680	680	660	616	620	680	675	Titrimetric
Total Solid , mg/l	131	53	53	161	157	79	75	108	102	Gravimetric
Total Suspended Solid, mg/l	104.675	27	26	109	103	35.125	34.022	64.45	64.01	Gravimetric
Total Bacteria count , cfu/ml	1015000	500000	490000	1045000	1015000	650000	640000	4095000	3095000	Spread Plate
Total Coliform count, cfu/ml	4600000	3590000	359000	630000	625000	714000	7100000	4085000	4000000	Spread Plate
E. Coli Count, cfu/ml	1000000	8640000	8540000	1050000	1010000	3060000	3000000	1050000	1150000	Spread Plate
Total klebsiella count, cfu/ml	NG	2550000	2150000	51050000	50500000	5615000	5050000	5640000	50140000	Spread Plate

Note:
mg/l- milligram per litre ND- None Detected,
µS/cm- microSiemens per centimeter, NS – Not Stated
cfu/ml- colony forming per millilitre
NTU- nephelometry turbidity unit, PCU- platinum Cobalt Unit

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Table 4: Descriptive statistics of Physico-chemical parameters samples from site locations with WHO permissible limits [1].

PARAMETERS	Mean Value Location 1	Mean Value Location 2A	Mean Value Location 2B	Mean Value Location 3A	Mean Value Location 3B	Mean Value Location 4A	Mean Value Location 4B	Mean Value Location 5A	Mean Value Location 5B	WHO Permissible Standards.
pH	5.7	4.75	4.72	4.8	4.7	5.05	5	4.9	4.8	6.5 – 8.5
Electrical Conductivity, µS/cm	40.5	40	40	80	78	67.5	67.1	67	66	400
Turbidity, NTU	6.05	2.35	2.33	1.75	1.68	1.45	1.39	8.45	8.23	5
Colour, PCU	17.5	7	7	6	6	5	4	13	12	15
Tempreture	29.35	29.35	29.35	29.35	29	28.6	28.1	28.55	28.5	25
Nitrate, mg/l NO^-_3	3.555	0.665	0.66	5.145	5.1	4.01	3.98	4.285	4.2	50
Total Hardness, mg/l $Ca/MgCO_3$	49.21	50.505	50	56.98	55.93	47.915	46.955	68.635	68.1	500
Total Dissolved Solid, mg/l	26.325	26	25	52	52.9	44.06	43.55	43.55	41.33	500
Phosphate, mg/l PO-34	0.33	0.315	0.31	0.36	0.36	0.37	0.33	0.445	0.44	0.3
Sulphate, mg/l SO^{-2}_4	2.3	ND	ND	2.46	2.4	0.16	0.12	2.7	2.2	250
Dissolved Oxygen, mg/l O_2	10.35	10.85	10.8	13.65	13.19	11.05	10.5	15.35	15.01	6
Biochemical Oxygen Demand, mg/l BOD_5	5.75	6.5	6.3	8.45	8.32	6.7	6.2	12.9	12.21	10
Chemical Oxygen Demand, mg/l O_2	570	688	680	680	660	616	620	680	675	10 – 20
Total Solid , mg/l	131	53	53	161	157	79	75	108	102	500
Total Suspended Solid, mg/l	104.675	27	26	109	103	35.125	34.022	64.45	64.01	NG
Total Bacteria count, cfu/ml	1015000	500000	490000	1045000	1015000	650000	640000	4095000	3095000	Ns
Total Coliform count, cfu/ml	4600000	3590000	359000	630000	625000	714000	7100000	4085000	4000000	NS
E. Coli Count, cfu/ml	1000000	8640000	8540000	1050000	1010000	3060000	3000000	1050000	1150000	10
Total klebsiella count, cfu/ml	NG	2550000	2150000	51050000	50500000	5615000	5050000	5640000	50140000	NS

3.2. WATER QUALITY INDEX CALCULATION RESULTS

Using weighted arithmetic method, water quality index was calculated for Otamiri River from this research. The result is shown in table 4 to 9.

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Table 5. WQI result for Location 1

	LOCATION 1				
		S_i	q_i	w_i	$w_i q_i$
pH	5.7	7.5	76	0.133333	10.13333
Conductivity, µS/cm	40.5	400	10.125	0.0025	0.025313
Turbidity, NTU	6.05	5	121	0.2	24.2
Nitrate, mg/l N0-3	3.555	50	7.11	0.02	0.1422
Total Hardness, mg/l Ca/MgCO3	49.21	500	9.842	0.002	0.019684
Total Dissolved Solid, mg/l	26.325	500	5.265	0.002	0.01053
Phosphate, mg/l PO-34	0.33	0.3	110	3.333333	366.6667
Sulphate, mg/l SO-24	2.3	250	0.92	0.004	0.00368
Dissolved Oxygen, mg/l O2	10.35	6	172.5	0.166667	28.75
Biochemical Oxygen Demand, mg/l BOD5	5.75	10	57.5	0.1	5.75
Chemical Oxygen Demand, mg/l O2	570	15	3800	0.066667	253.3333
				4.0305	689.0347
				170.9551519	

Table 6. WQI result for Location 2

	LOCATION 2A				
		S_i	q_i	w_i	$w_i q_i$
pH	4.75	7.5	63.33333	0.133333	8.444444
Conductivity, µS/cm	40	400	10	0.0025	0.025
Turbidity, NTU	2.35	5	47	0.2	9.4
Nitrate, mg/l N0-3	0.665	50	1.33	0.02	0.0266
Total Hardness, mg/l Ca/MgCO3	50.505	500	10.101	0.002	0.020202
Total Dissolved Solid, mg/l	26	500	5.2	0.002	0.0104
Phosphate, mg/l PO-34	0.315	0.3	105	3.333333	350
Sulphate, mg/l SO-24	0	250	0	0.004	0
Dissolved Oxygen, mg/l O2	10.85	6	180.8333	0.166667	30.13889
Biochemical Oxygen Demand, mg/l BOD5	6.5	10	65	0.1	6.5
Chemical Oxygen Demand, mg/l O2	688	15	4586.667	0.066667	305.7778
				4.0305	710.3433
				176.2419832	

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			LOCATION 2B		
	value	S_i	q_i	w_i	$w_i q_i$
pH	4.72	7.5	62.93333	0.133333	8.391111
Conductivity, µS/cm	40	400	10	0.0025	0.025
Turbidity, NTU	2.33	5	46.6	0.2	9.32
Nitrate, mg/l N0-3	0.66	50	1.32	0.02	0.0264
Total Hardness, mg/l Ca/MgCO3	50	500	10	0.002	0.02
Total Dissolved Solid, mg/l	25	500	5	0.002	0.01
Phosphate, mg/l PO-34	0.31	0.3	103.3333	3.333333	344.4444
Sulphate, mg/l SO-24	0	250	0	0.004	0
Dissolved Oxygen, mg/l O2	10.8	6	180	0.166667	30
Biochemical Oxygen Demand, mg/l BOD5	6.3	10	63	0.1	6.3
Chemical Oxygen Demand, mg/l O2	680	15	4533.333	0.066667	302.2222
				4.0305	700.7592
				173.8640808	

Table 7. WQI result for Location 3

			LOCATION 3A		
	value	S_i	q_i	w_i	$w_i q_i$
pH	4.8	7.5	64	0.133333	8.533333
Conductivity, µS/cm	80	400	20	0.0025	0.05
Turbidity, NTU	1.75	5	35	0.2	7
Nitrate, mg/l N0-3	5.145	50	10.29	0.02	0.2058
Total Hardness, mg/l Ca/MgCO3	56.98	500	11.396	0.002	0.022792
Total Dissolved Solid, mg/l	52	500	10.4	0.002	0.0208
Phosphate, mg/l PO-34	0.36	0.3	120	3.333333	400
Sulphate, mg/l SO-24	2.46	250	0.984	0.004	0.003936
Dissolved Oxygen, mg/l O2	13.65	6	227.5	0.166667	37.91667
Biochemical Oxygen Demand, mg/l BOD5	8.45	10	84.5	0.1	8.45
Chemical Oxygen Demand, mg/l O2	680	15	4533.333	0.066667	302.2222
				4.0305	764.4256
				189.6602283	

		LOCATION 3B			
	value	S_i	q_i	w_i	$w_i q_i$
pH	4.7	7.5	62.66667	0.133333	8.355556
Conductivity, µS/cm	78	400	19.5	0.0025	0.04875
Turbidity, NTU	1.68	5	33.6	0.2	6.72
Nitrate, mg/l N0-3	5.1	50	10.2	0.02	0.204
Total Hardness, mg/l Ca/MgCO3	55.93	500	11.186	0.002	0.022372
Total Dissolved Solid, mg/l	52.9	500	10.58	0.002	0.02116
Phosphate, mg/l PO-34	0.36	0.3	120	3.333333	400
Sulphate, mg/l SO-24	2.4	250	0.96	0.004	0.00384
Dissolved Oxygen, mg/l O2	13.19	6	219.8333	0.166667	36.63889
Biochemical Oxygen Demand, mg/l BOD5	8.32	10	83.2	0.1	8.32
Chemical Oxygen Demand, mg/l O2	660	15	4400	0.066667	293.3333
				4.0305	753.6679
				186.9911673	

Table 8. WQI result for Location 4

		LOCATION 4A			
	value	S_i	q_i	w_i	$w_i q_i$
pH	5.05	7.5	67.33333	0.133333	8.977778
Conductivity, µS/cm	67.5	400	16.875	0.0025	0.042188
Turbidity, NTU	1.45	5	29	0.2	5.8
Nitrate, mg/l N0-3	4.01	50	8.02	0.02	0.1604
Total Hardness, mg/l Ca/MgCO3	47.95	500	9.59	0.002	0.01918
Total Dissolved Solid, mg/l	44.06	500	8.812	0.002	0.017624
Phosphate, mg/l PO-34	0.37	0.3	123.3333	3.333333	411.1111
Sulphate, mg/l SO-24	0.16	250	0.064	0.004	0.000256
Dissolved Oxygen, mg/l O2	11.05	6	184.1667	0.166667	30.69444
Biochemical Oxygen Demand, mg/l BOD5	6.7	10	67	0.1	6.7
Chemical Oxygen Demand, mg/l O2	616	15	4106.667	0.066667	273.7778
				4.0305	737.3008
				182.9303458	

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		LOCATION 4B			
	value	S_i	q_i	w_i	$w_i q_i$
pH	5	7.5	66.66667	0.133333	8.888889
Conductivity, µS/cm	67.1	400	16.775	0.0025	0.041938
Turbidity, NTU	1.39	5	27.8	0.2	5.56
Nitrate, mg/l N0-3	3.98	50	7.96	0.02	0.1592
Total Hardness, mg/l Ca/MgCO3	46.955	500	9.391	0.002	0.018782
Total Dissolved Solid, mg/l	43.55	500	8.71	0.002	0.01742
Phosphate, mg/l PO-34	0.33	0.3	110	3.333333	366.6667
Sulphate, mg/l SO-24	0.12	250	0.048	0.004	0.000192
Dissolved Oxygen, mg/l O2	10.2	6	170	0.166667	28.33333
Biochemical Oxygen Demand, mg/l BOD5	6.2	10	62	0.1	6.2
Chemical Oxygen Demand, mg/l O2	620	15	4133.333	0.066667	275.5556
				4.0305	691.442
				171.5524069	

Table 9. WQI result for Location 5

		LOCATION 5A			
	value	S_i	q_i	w_i	$w_i q_i$
pH	4.9	7.5	65.33333	0.133333	8.711111
Conductivity, µS/cm	67	400	16.75	0.0025	0.041875
Turbidity, NTU	8.45	5	169	0.2	33.8
Nitrate, mg/l N0-3	4.285	50	8.57	0.02	0.1714
Total Hardness, mg/l Ca/MgCO3	68.635	500	13.727	0.002	0.027454
Total Dissolved Solid, mg/l	43.55	500	8.71	0.002	0.01742
Phosphate, mg/l PO-34	0.445	0.3	148.3333	3.333333	494.4444
Sulphate, mg/l SO-24	2.7	250	1.08	0.004	0.00432
Dissolved Oxygen, mg/l O2	15.35	6	255.8333	0.166667	42.63889
Biochemical Oxygen Demand, mg/l BOD5	12.9	10	129	0.1	12.9
Chemical Oxygen Demand, mg/l O2	680	15	4533.333	0.066667	302.2222
				4.0305	894.9791
				222.0516402	

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	LOCATION 5B				
	Value	S_i	q_i	w_i	$w_i q_i$
pH	4.8	7.5	64	0.133333	8.533333
Conductivity, µS/cm	66	400	16.5	0.0025	0.04125
Turbidity, NTU	8.23	5	164.6	0.2	32.92
Nitrate, mg/l N0-3	4.2	50	8.4	0.02	0.168
Total Hardness, mg/l Ca/MgCO3	68.1	500	13.62	0.002	0.02724
Total Dissolved Solid, mg/l	41.33	500	8.266	0.002	0.016532
Phosphate, mg/l PO-34	0.44	0.3	146.6667	3.333333	488.8889
Sulphate, mg/l SO-24	2.22	250	0.888	0.004	0.003552
Dissolved Oxygen, mg/l O2	15.01	6	250.1667	0.166667	41.69444
Biochemical Oxygen Demand, mg/l BOD5	12.21	10	122.1	0.1	12.21
Chemical Oxygen Demand, mg/l O2	675	15	4500	0.066667	300
				4.0305	884.5032
				219.452485	

Table 10: Summary of the calculated Water Quality Index for the sampling locations

Samples Locations	1	2A	2B	3A	3B	4A	4B	5A	5B
WQI	170.955	176.241	173.864	189.660	186.991	182.930	171.555	222.051	219.456

3.3. REGRESSION ANALYSIS

The relationship between water quality parameters of the selected areas and also water quality index of each location is found out by using regression analysis. For finding out the relationship between them, the eleven parameters (pH, Conductivity, Turbidity, Nitrate, Total Hardness, Total dissolved solid, Phosphate, sulphate, DO, BOD and COD) are given as independent variable and water quality index is given as a dependent variable.

3.3.1. STEPWISE MULTIPLE REGRESSION

- Main Regression analysis window Select the path. Analyze - Regression - Linear. This brings us to the Linear Regression main dialog window.
- Data was keyed in the data page

Table 11: Data inputted in the stepwise regression software

WQI	pH	EC	Tur	Nitrate	TH	TDS	Phosphate	Sulphate	DO	BOD5	COD
170.955	5.7	40.5	6.05	3.555	49.21	26.325	0.33	2.3	10.35	5.75	570
176.241	4.75	40	2.35	0.665	50.505	26	0.315	0	10.85	6.50	688
173.864	4.72	40	2.33	0.66	50	25	0.31	0	10.80	6.30	680
189.66	4.8	80	1.75	5.145	56.98	52	0.36	2.46	13.65	8.45	680
186.991	4.7	78	1.68	5.1	55.93	52.9	0.36	2.4	13.19	8.32	660
182.93	5.05	67.5	1.45	4.01	47.95	44.06	0.37	0.16	11.05	6.70	616
171.555	5	67.1	1.39	3.98	46.955	43.55	0.33	0.12	10.50	6.20	620
222.051	4.9	67	8.45	4.285	68.635	43.55	0.445	2.7	15.35	12.90	680
219.456	4.8	66	8.23	4.2	68.1	41.33	0.44	2.2	15.01	12.21	675

- The regression page was opened and the data was assigned status as dependent variable (x) or independent variable (y).

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Table 12: Assigning if status to the inputted parameters

Status (x or y)	Variable name
y	WQI
x	pH
x	EC
x	Tur
x	Nitrate
x	TH
x	TDS
x	Phosphate
x	Sulphate
x	DO
x	BOD5
x	COD

➢ Options Window Selecting the Options pushbutton brings us to the Linear Regression: Options dialog window displayed. The top panel is now applicable as we are using the stepwise method. To avoid looping variables continually in and out of the model, it is appropriate to set different "significance" levels for entry and exit. Earning entry to the model is set at an alpha level of 0.5.

Table 13: Assigned maximum P-Value

The cutoff below is the maximum allowable p-value for an independent variable to be included with the stepwise algorithm	
Cutoff:	0.5

➢ Stepwise Multiple Regression Output The five ANOVAs that are reported correspond to four models, but don't let the terminology confuse us. The stepwise procedure adds only one variable at a time to the model as the model is "slowly" built. At the third step and beyond, it is also possible to remove a variable from the model (although that did not happen in our example).

Table 14: Model Output from the software

Dependent Var	WQI					
R-squared	0.99810					
Suggest add	WQI					
	Coefficient	Standard Error	t-stat	p-value	Lower 95%	Upper 95%
Intercept	-67.04020	0.00000	10.00000	0.00000	-67.04020	-67.04020
pH	36.63604	0.00000	10.00000	0.00000	36.63604	36.63604
EC	-0.52908	0.00000	10.00000	0.00000	-0.52908	-0.52908
Tur	-12.59829	0.00000	10.00000	0.00000	-12.59829	-12.59829
Nitrate	0.00000	0.00000	10.00000	0.00000	0.00000	0.00000
TH	5.92361	0.00000	10.00000	0.00000	5.92361	5.92361
TDS	-0.50094	0.00000	10.00000	0.00000	-0.50094	-0.50094
Phosphate	0.00000	0.00000	10.00000	0.00000	0.00000	0.00000
Sulphate	-7.26810	0.00000	10.00000	0.00000	-7.26810	-7.26810
DO	0.00000	0.00000	10.00000	0.00000	0.00000	0.00000
BOD5	7.80439	0.00000	10.00000	0.00000	7.80439	7.80439
COD	-0.31518	0.00000	10.00000	0.00000	-0.31518	-0.31518

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Of primary interest are the R Square and Adjusted R Square values, which is 0.99810. We learn that the weighted combination of the predictor variables explained approximately 100% of the variance of self-esteem.
Model Summary of the regression analysis is in the figure below.

Table 15. Model summary of Otamiri River from stepwise regression software

Status (x or y)	Variable name							
y	WQI	Dependent Var	WQI					
x	pH	R-squared	0.99810					
x	EC							
x	Tur							
x	Nitrate							
x	TH	Suggest add	WQI					
x	TDS							
x	Phosphate		Coefficient	Standard Error	t-stat	p-value	Lower 95%	Upper 95%
x	Sulphate	Intercept	-67.04020	0.00000	10.00000	0.00000	-67.04020	-67.04020
x	DO	pH	36.63604	0.00000	10.00000	0.00000	36.63604	36.63604
x	BOD5	EC	-0.52908	0.00000	10.00000	0.00000	-0.52908	-0.52908
x	COD	Tur	-12.59829	0.00000	10.00000	0.00000	-12.59829	-12.59829
		Nitrate	0.00000	0.00000	10.00000	0.00000	0.00000	0.00000
		TH	5.92361	0.00000	10.00000	0.00000	5.92361	5.92361
		TDS	-0.50094	0.00000	10.00000	0.00000	-0.50094	-0.50094
		Phosphate	0.00000	0.00000	10.00000	0.00000	0.00000	0.00000
		Sulphate	-7.26810	0.00000	10.00000	0.00000	-7.26810	-7.26810
		DO	0.00000	0.00000	10.00000	0.00000	0.00000	0.00000
		BOD5	7.80439	0.00000	10.00000	0.00000	7.80439	7.80439
		COD	-0.31518	0.00000	10.00000	0.00000	-0.31518	-0.31518

$$\mathbf{WQI = -67.04020 + 36.63604(pH) - 0.52908(EC) - 12.59829(Tur) + 5.92361(TH) - 0.50094(TDS) - 7.26810(Sulphate) + 7.804439(BOD_5) - 0.31518(COD)} \quad (7)$$

3.4. CORRELATION BETWEEN WQI AND WATER QUALITY PARAMETERS.

The result from the correlation of data after iteration using Microsoft excel package is represented in Table 16.
Table 16: Correlation coefficient between WQI and Water Quality Parameters

	WQI	*pH*	*EC*	*Tur*	*Nitrate*	*TH*	*TDS*	*Phosphate*	*Sulphate*	*DO*	*BOD_5*	*COD*
WQI	1											
pH	-0.30467	1										
EC	0.447517	-0.33711	1									
Tur	0.746058	0.255812	-0.10382	1								
Nitrate	0.420591	0.129542	0.871347	0.150195	1							
TH	0.970711	-0.31731	0.393089	0.768566	0.387757	1						
TDS	0.407869	-0.32632	0.996301	-0.13982	0.872472	0.357775	1					
Phosphate	0.968249	-0.14816	0.526894	0.732923	0.562262	0.901629	0.4896	1				
Sulphate	0.607375	0.158668	0.45625	0.589096	0.693142	0.704292	0.458172	0.617736	1			
DO	0.945808	-0.40514	0.598861	0.602559	0.540297	0.9658	0.569788	0.8920725	0.736097	1		
BOD_5	0.992667	-0.33406	0.459887	0.739885	0.427397	0.984755	0.42317	0.9472875	0.638726	0.962004	1	
COD	0.469506	-0.89994	0.162974	0.043013	-0.22246	0.526534	0.142163	0.2611733	0.03631	0.551708	0.501541	1

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IV. CONCLUSION

This study had examined the effect of refuse dump on water quality of Otamiri River. The study revealed that the river is acidic with pH of 4.94 and an average higher significant concentration of parameters such as Temperature, Phosphate, COD, Total Bacteria count, Total Coliform count, E.coli and Total Klebsiella in all the water samples used in the study. The principal component analysis revealed six major sources of pollution which includes, organic waste from households, industrial waste, runoff, fertilizer, sand dredging and dissolved salts.

This study focused on the estimation of water quality of Otamiri River using water quality index (WQI) model. The study used an empirically based water quality assessment model, WQI model integrated with global positioning systems (GPS) to provide useful information for the estimation of the water quality of Otamiri River at any standpoint. The average WQI of Otamiri River was found to be 188.188 in this study which means that the water is unsuitable for drinking without proper treatment. In order to ease the prediction of WQI of Otamiri River at any stand point, an empirical equation was derived from the data obtained from the water quality analysis obtained from the nine different water sample location within the study area. This equation only require the determination of eight parameters in order to determine the WQI at any point within the river. These include parameters include pH, Electrical Conductivity, Turbidity, Total Hardness, Total Dissolved Solid, Sulphate, Dissolved Oxygen and Chemical Oxygen Demand. The empirical equation derived for the determination of WQI is in equation 7. This regression model developed will help in determining the pollution concentration at any point within the river reach.

V. RECOMMENDATION

There is urgent need to look into the waste dump site and construct a standard environmental sanitary landfill than the unpleasing open dumping practice at Otamiri River watershed. Waste sorting policy should be introduced at point source to separate wastes as degradable and non-degradable. While degradable domestic wastes can be used as manure in farm land. Revitalizations and support of waste recycling and reuse at the waste dump is important. Also waste management policy and Law that exist in Imo State need appropriate implementation with honesty and truth. This Law or legislation regulating open dumping disposal should strive to make provision for the prosecution of an offender who embark on careless disposal of waste in the environment. And also adequate monitoring strategy should be implemented on the ecological integrity of the river watersheds. Mitigation and adaptation programs should be embraced to improve water quality resources of the river ecosystem in the region.

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