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Predictive Regression Models of Water Quality Parameters for river Amba in Nasarawa State, Nigeria

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ABSTRACT

The challenges of river water quality management are so enormous, due to the unpredictive modes of contamination. Monitoring different sources of pollutant load contribution to the river basin is also quite tasking, resulting to laborious and expensive process which sometimes lead to analytical errors. This study deals with the assessment of the physico– chemicaland bacteriological parameters of water samples from River Amba during the period of August 2017 to January 2018 and developing regression models. Water quality Parameters such as Temperature, Turbidity (NTU), Suspended solids (mg/l), Colour, Total solids, Total dissolved solids, Electrical conductivity (µs/cm), pH, Hardness, Chemical Oxygen Demand, Dissolved Oxygen (DO), and Total Coliform were obtained and compared with water quality standards. The results of the water quality analysis of the study in comparison with drinking water quality standard issued byWorld Health Organization(WHO) and National Agency for Food and Drug Administration Control (NAFDAC) revealed that most of the water quality parameters were not adequate to pronounce the water potable. Hence adequate water treatment processes should be employed to make the water fit for consumption and other domestic uses. Statistical analysis was done, in which the systematic correlation and regressionanalysis showed a significant linear relationship between different pairs of water quality parameters*.* The highest correlation coefficient between different pairs of parameters obtained is (r = 0.999), resulting from the correlation between TS and SS. Multiple regression analysis was also carried out and regression equations were developed. It was observed that the parameters studied had a positive correlation with each other.

KEYWORD: physio-chemical parameters,Regression models, Statistical study, standards, water quality.

I. INTRODUCTION

Water is an essential element that supports life. However, statistics reveal that, from the advent of the new millennium, one billion people lacked access to safe drinking water and 2.4 billion to adequate sanitation[15]. The resultant effect is that people source for various means of water supply of which streams and rivers are part of, especially in rural areas.With the emphasizes placed on the need for the potability of water, water quality monitoring network could serve as an important tool in the management and assessment of surface water quality which could be improved by means of accurate forecasts of surface water variables.The assessment of surface waterquality is not just meant for the suitability of human consumption but also in relation to agricultural, industrial, recreational, commercial uses and its ability to sustain aquatic life[20].Water quality monitoring is therefore a fundamental tool in the management of freshwater resources. To emphasize its significance, World Health Organization (WHO), UnitedNations Environment Programme (UNEP), United Nations Educational, Scientific and CulturalOrganization (UNESCO) and World Meteorological Organization (WMO) launched in 1977, a water monitoring programme to collect detailed information on the quality of global ground and surface water**.**

There are quite a number of literatures on water quality monitoring and assessment, suggesting all together, the possible increase in pollution loads in streams and rivers which resultantly changes or alters water quality parameters such as heavy metals, nutrients and organic matter, soluble ions, oil and grease, and organic chemicals such as pesticides and poly-nuclear aromatic hydrocarbons (PAHs),[20].Therefore, it is possible to control water pollution problems through monitoring as well as enforcement of emission standards by industries [4].

This could also be achieved by developing models that can assist in the monitoring and assessment of these water quality parameter.[13] pointed out that the systematic calculation of correlation coefficients between water quality parameter variables and linear or multiple regression analysis provide an indirect means for the rapid monitoring of water quality. Statistical correlation and regression analysis have been found to be a set of dependable tools for correlating different parameters and developing models which becomes a mechanism for prediction or forecasting [12]. This prediction and forecasting forms an integral part of surface water monitoring in the aspects of water resource impact assessment, environmental impact assessment, and pollution monitoring and control.

II. Materials and Methods

The Study Area

River Amba lies within the River Amba Basin. The catchment is situated within the capital territory of Lafia in Nasarawa State, 90 km North of Makurdi, capital of Benue State. The perennial River has a catchment area of 115 square kilometers.Lafia town through which River Amba encompasses is situated on longitude 08^{o}.30′ East and latitude 08^{o}.32′ North. The area is located in the middle climatic belt that is generally very warm and humid with dry and rainy seasons. It has a mean temperature range of 26^{0}C to 30^{0}C, a mean rainfall range of 1120 mm to 1500 mm, relative humidity of 60 – 80 % and falls within the Guinea Savannah kind of vegetation. The Amba River system rises as small tributaries, like the Dutse, BukanKwatu, and Angogo springs, from the Eastern Agyaragu-Obi minor highland areas. The rivulets join the mainstream of the River Amba which flows roughly East-West to the West where joining other tributaries, it empties through the major River Oriye, into the River Mada.

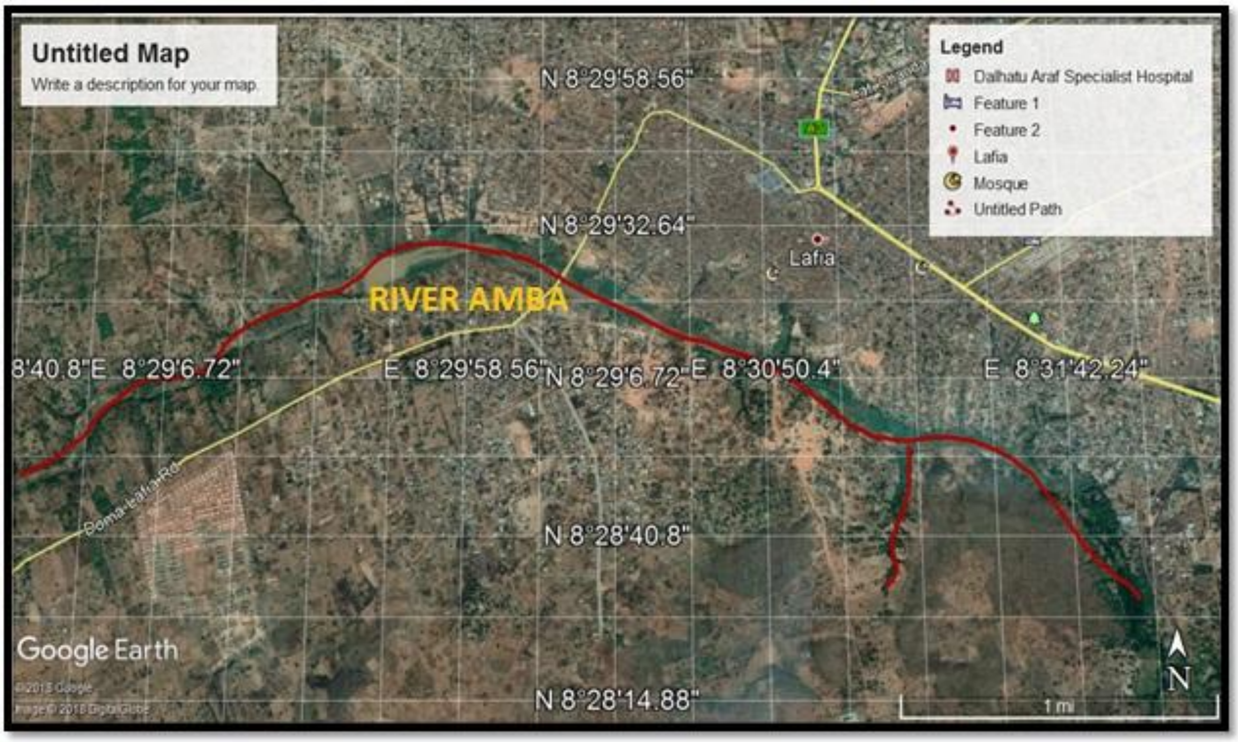

Figure 1: Google Earth Map Show RiverAmba

Sampling

Three sampling stations were chosen based on upstream, middle stream and downstream, and was represented as A, B and C. The stations were chosen at a distance of about ten meters apart to effectively cover the entire length of the river. Water samples for physico-chemical analysis were collected at subsurface from sampling stations one every sampling day. 250mL reagent bottles and 1000 mL plastic containers were washed, dried and corked, labeled and used for sample collection. Subsurface water samples were collected at a depth of about 10 – 20cm. Dark colored 250 mL glass bottles were used for the Dissolved oxygen (DO) and Biochemical Oxygen Demand (BOD) analysis while 1000mL plastic containers were used to collect water for the general purpose analyses. The sampling bottles and containers were rinsed three times with the river water at each sampling station before the collection of samples. Water samples were collected by lowering the sampling bottles or containers by hand to a depth of about 20cm below the surface level. Each sample container was treated according to the analysis required to be carried out on them. Testing was done once a month, for six months: from August 2017 to January 2018. A total of 135 samples were collected and analyzed monthly.

III. Methodology

Samples were collected and analyzed for 13physico-chemical parameters, such as Temperature (T), Turbidity (NTU), Suspended solids (SS), Colour (C), Total solids (TS), Total dissolved solids (TDS), Electrical conductivity (EC), pH, Hardness (H), Chemical Oxygen Demand (COD), Dissolved Oxygen (DO), and Total Coliform (TC).Temperature was measured at the point of sampling by the use of mercury-in-glass thermometer. A battery powered digital pH meter was used to measure the pH of the samples at the points of sampling. The values are reported to the nearest 0.1pH unit. The Colourof each water sample was measured using a Hach potable colorimeter model DR/890. The turbidity of the water samples was measured with the use of HACH 2100P turbidimeter. The readings were read off in nephelometric turbidity units (NTU).A high powered microcomputer conductivity meter JENWAY 40701 model H19032 with a degree of accuracy of 0.01 was used to measure the conductivity of the water samples. The instrument was standardized using potassium chloride solution of conductivities 500$\mu s/cm$ and 1500$\mu s/cm$. The unit is in micro siemens per centimeter. Total solids (TS) of the water samples were estimated by gravimetric methods. To determine (TS), 100mL of the unfiltered portion of the water sample was evaporated in a porcelain dish to dryness and washed. The dish was oven dried at a temperature of 105^0C, cooled in a desiccator to room temperature to a constant weight and the weight recorded. The weight difference between the weight of dish with 100mL of water and weight of dish after evaporation less weight of dish alone was considered as the weight of solids (TS). The level of dissolved oxygen (DO) in each sample was determined using Winkler's method. The BOD was determined using the 5 – day BOD dilution test, applying the iodometric method for the determination of dissolved oxygen (DO). The difference between the initial dissolved oxygen value measured on the first day and the value of dissolved oxygen determined after five days of incubation gave the BOD of the sample**.** The total coliform count of the water sample expressed in cfu/100 mL was determined using membrane filtration technique. The water sample was filtered through the membrane and then transferred to appropriate growth medium and after incubation and inoculation, the growth colonies were counted.

IV. Statistical analysis

Statistical analysis in the form of descriptive statistics, correlation and regression analysis of the physico-chemical and microbial properties of a river basin gives a fairly good amount of information like their average values and possible predictions. Pearson's correlation coefficient and linear regression were performed between pairs of water quality parameters. Significantcorrelation coefficient (r ≥ 0.7) and linear regression equations are summarized in Table 1 below.

Table 1: Significant correlations coefficient (r ≥ 0.7) and linear regressions

S/N	Pairs of Parameter	Correlation Coefficient (r)	Regression Equation	Regression Coefficient (R^2)
1	Temp – C	0.9349	C =291.35Temp - 9017.3	0.8741
2	Turb - TDS	0.9193	TDS = 0.015Turb + 40.35	0.8452
3	Turb – SS	0.9995	SS = 0.888Turb - 5.8585	0.999
4	Turb – TS	0.9833	TS = 1.035Turb + 10.759	0.9669
5	C- EC	0.9651	EC = 0.523C + 66.58	0.9314
6	TDS – SS	0.9303	SS = 10.543TDS - 414.54	0.8654
7	TDS – TS	0.9459	TS = 12.795TDS - 489.79	0.8948
8	SS – TS	0.9865	TS = 1.774SS + 17.286	0.9731
9	DO – BOD	0.9366	BOD = -36.238DO + 254.42	0.8772

Table 2 shows the water quality analysis viz., Mean, Standard Deviation (SD), Standard Error (SE) and Coefficient of Variation (CV). The Coefficient of Variation from Table 2 showed turbidity, suspended solids, total solids, and colourto be 53.7%, 56.6%, 50.6%, and 54.9%. While the Coefficient of Variation for pH, Turb, COD, BOD, DO, H, EC, TC were found to be 1.1%, 1%, 9.5%, 32.43%,20.48%, 44.74%, 10.2%, 3.9%, 15.8%, 11.9%, and 33% respectively. The coefficient of variation showed that there was significant variation in the value of some parameters measured for the six months. Though a considerable amount was not high, thus,the variation range is narrow.

Table 2: Descriptive Statistics of Water Quality Parameters of River Amba

Parameters	Maximum	Minimum	Range	Mean	SD	SE	CV (%)
T	210	60	150	131.8	70.8	28.9	53.7
SS	180	47.5	132.5	110.3	62.4	25.5	56.6
TDS	55.9	42.2	13.7	49.8	5.5	2.2	11
TS	227.1	58.6	168.5	147.2	74.5	30.4	50.6
TEMP	32.6	31.5	1.1	32.1	0.59	0.24	1
C	496	81.3	414.7	335.1	184	75.4	54.9
EC	96.6	71.7	24.9	84.1	10	4.1	11.9
pH	6.48	6.27	0.21	6.4	0.07	0.03	1.1
H	70	50	20	62	9.8	4	15.8
S	70	21	49	39.9	17.4	7.1	43.6
COD	152	119	33	136.3	13	5.3	9.5
$DO_{2(1)}$	5.3	4.9	0.4	5.1	0.2	0.1	3.9
DO2(2)	4.1	3.6	0.5	3.9	0.3	0.1	7.6
BOD	79	60	19	69	7.1	2.9	10.2
TC	1113	525	588	771	254.6	104	33

Multiple Regression Results

Multiple linear regression is a kind of modelling technique that allows one to establish a relationship between physico-chemical parameters by fitting a linear equation to the observed data set. In this study, multiple linear regression equations were developed to predict certain parameters based on the physico-chemical parameters analyzed. In determining what models would be appropriate in predicting certain parameters for water quality monitoring, stepwise regression method was applied to select the best possible fitted multiple linear regression model. The factor considered in estimating parameters of importance in the regression model is the p-value which must be less than 0.05 (i.e. P-value < 0.05). Table 3 shows the developed multiple regression models using stepwise method in multiple regression analysis.

One of the most commonly used criterion to evaluate the performance of a model is its coefficient of determination (R^2). This R^2 value also tells us how good the model fits with the data used to develop the models. The range of R^2 value for the multiple regression developed is from 0.7304 to 0.9999. The regression between turbidity, suspended solids, total solids, and temperature had a correlation coefficient of 0.999 (i.e. r = 0.999).

Table 3**:** Multiple Regression Equation using Stepwise method

S/N	Parameter	Regression Equation	Regression Coefficient (R^2)
1	Turb - SS,TS,Temp	Turb = -145.418 + 1.215(SS) -0.100(TS) + 4.919(Temp)	0.9999
2	SS - TS,Temp, Turb	SS = 119.273 + 0.083(TS) - 4.035(Temp) + 0.822(Turb)	0.9999
3	TDS - TS,Temp	TDS = 178.752 + 0.096(TS) - 4.462(Temp)	0.9922
4	TS – SS	TS = 17.236 + 1.177(SS)	0.9731
5	Colour - SS,TDS	Colour = 2497.424 + 6.858(SS) - 58.632(TDS)	0.8883
6	Sulphate – COD	Sulphate = -116.663 + 1.149(COD)	0.7304
7	DO - BOD,TC	DO = 6.764 - 0.027(BOD) + 0.000243(TC)	0.9824

Table 4: Correlation Coefficient Matrix of water quality parameters

	T	*SS*	*TDS*	*TS*	*TEMP*	*C*	*EC*	*pH*	*H*	*S*	*COD*	*DO2(1)*	*BOD*	*TC*
T	1													
SS	0.999493563	1												
TDS	0.919135091	0.930281	1											
TS	0.983253753	0.986443	0.945919	1										
TEMP	0.783114352	0.76691	0.516241	0.760147	1									
C	0.706902748	0.690825	0.407452	0.663636	0.934945	1								
EC	0.722168074	0.70656	0.443396	0.657	0.876003	0.965104	1							
pH	-0.72979493	-0.7206	-0.52929	-0.66816	-0.73751	-0.86501	-0.95706	1						
H	0.503890795	0.505237	0.527419	0.432526	0.123858	-0.02778	-0.01466	0.021393	1					
S	0.825888365	0.838142	0.886164	0.825173	0.403694	0.461555	0.556838	-0.7184	0.322042	1				
COD	0.954715659	0.957391	0.88601	0.972591	0.787209	0.76284	0.755671	-0.77556	0.263428	0.854643	1			
DO2(1)	-0.93719287	-0.94643	-0.94901	-0.96414	-0.62465	-0.59223	-0.58844	0.647348	-0.40049	-0.90917	-0.9657	1		
BOD	0.945282855	0.945812	0.849566	0.941368	0.788227	0.803438	0.827636	-0.86362	0.230022	0.877649	0.986819	-0.93658	1	
TC	0.05106811	0.034531	-0.1869	-0.03388	0.326464	0.558829	0.681432	-0.71225	-0.5092	0.145334	0.1331	0.055649	0.273715	1

* Correlations are significant at the 0.05 level (2 tailed) ** Correlations is significant at the 0.01 level (2 tailed)

V. Results and Discussion

Table 5: Comparison of Water Quality Parameters of River Amba with Water Standards

S/N	Parameters	WHO	NAFDAC	Present study value
1	Turbidity(NTU)	5	5	132
2	Suspended solids(mg/l)	5	-	112
3	Total dissolved solids (mg/l)	1200	500	50
4	Total Solids (mg/l)	-		147

5	Temperature(^{o}C)	25	Ambient	32.1
6	Colour	15	15	327
7	Electrical conductivity (µs/cm)	1250	1000	84
8	pH	6.5-8.5	6.5-8.5	6.4
9	Hardness (mg/l)	100	150	62
10	Sulphate (mg/l)	200	100	40
11	Chemical Oxygen Demand(mg/l)	100Below	-	136
12	Dissolved Oxygen($DO_{2(1)}$)(mg/l)	4below	-	5.1
13	Dissolved Oxygen($DO_{2(5)}$)(mg/l)	-	-	4
14	Biochemical Oxygen demand (BOD)mg/l	50below	-	69
15	Total Coliform per100ml of water	0	10	771

* WHO-World Health Organization, NAFDA- National Agency for Food and Drug Administration Control

Results of the analysis for the six months as reported in Tables 5 shows that the temperature of the water during the study period was in a range of31.2°C to 32.6°C on the average. The maximum value of temperature observed was in the month of October, while the minimum was in the month of January. The pH values varied from 6.27 to 6.48. The maximum and minimum pHvalue was observed in the month of January and September respectively. The electrical conductivity (EC) varied between 71.7µs/cm to 96.6µs/cm. The maximum value was recorded in the month of September and minimum in the month of January. The values of hardness were in a range of 50.0 mg/l to 70.0mg/l. The maximum value was recorded in the month of January and minimum in the month of August. The turbidity values were in a range of 60NTU to 210NTU. The maximum value was in the month of September and minimum in the month January. The SS values recorded were between 180 mg/l to 475 mg/l.The maximum value was recorded in the month of January while the minimum was in the month of September.

The DO values ranged between 4.9 mg/l to 5.3 mg/l. The maximum value was recorded in the month of January and the minimum was in the month of September. The BOD values were in a range of 60 mg/l to 79mg/l. The maximum value was recorded in the month of December and minimum in the month of January. The COD values were between 119 mg/l to 152 mg/l. The maximum value was observed in the month of Septemberand minimum in the month of January.

The sulphate values were in a range of21 mg/l to 70mg/l. The maximum value was obtained in the month of September and minimum in the month of August. The TDS values ranged between 42.2 mg/l to 55.9 mg/l. The maximum value was recorded in the month of September and minimum was in the month of August. The TS values were between 58.6 mg/l to 227.1 mg/l. The maximum value was observed in the month of Octoberand minimum in the month of January.

Physical Water Quality Parameters

Temperature

Table 5 shows in details the water quality parameters of the study in comparison with WHO and NAFDAC standards for acceptable drinking water. The temperature of potable water according to WHO and NAFDAC is 25^{o}C. The study has on the average for the six months a temperature of 32.1^{o}C. The temperature is higher than the acceptable temperature stipulated by these two bodies. Ascertaining the temperature of a river is very important because the temperature controls the rate of all chemical reactions that take place in the river, and it also affects the growth of fishes, its reproduction and immunity. Extreme temperatures or temperature fluctuations can be fatal to the fishes in the river. The high temperatures as observed during the study may be due to an increase in atmospheric temperature resulting from the anomalies caused by climate change. However, the observed range of the temperature allows for optimum proliferation of most of the bacterial especially when isolated from the water samples. Bacteria such as enterobateriaceac and mesophiles grow optimally at a temperature ranging from 20^{o}C to 32^{o}C [7].

Turbidity

The value of turbidity obtained during the study is 132NTU which is above the stipulated value of 5NTU by WHO and NAFDAC water standards. This signifies that the water is very turbid. Turbidity in water may be caused by the growth of Phytoplankton [6].One of the major causes of turbidity can be attributed to human activities around the river such as construction, mining, and agriculture which tend to disturb the stability of suspended particles in the water. The human activities commonly found around the banks of river Amba is rice milling, block making and agricultural activities such as sugar cane plantation. This can lead to high levels of sediments entering into the river during precipitation due to storms water runoff[5].

Total Dissolved Solids (TDS)

The quality of potable drinking water is mostly characterized by the level of total dissolved solids in the water. Hence, the need to ascertain the level of TDS in the water. The value of TDS concentration of the water under study is 50mg/l. In comparison with WHO and NAFDAC water quality standards, which stipulates that the value of total dissolved solids should be within a permissible minimum of 500mg/l and a permissible maximum limit of 1200mg/l, the water analyzed was observed to be low in total dissolved solids concentration. The presence of TDS in water may affect its taste. Water containing TDS concentrations below 1200mg/l is usually acceptable to consumers. However, water with an extremely low concentration of TDS may also be unacceptable to consumers because of it's flat, insipid taste and corrosive impact on water supply systems [22]. On the contrary, high (TDS) in water can result in the formation of an increased amount of residue which in turn renders the water unfit for consumption and could result in gastrointestinal irritations [1].

High levels of TDS in water may also be said to be objectionable to consumers owing to the resulting taste and to excessive scaling in water pipes, heaters, boilers, and household appliances [22]. Some dissolved organic matter can also contribute to an increased level of TDS which also indicates that the water is polluted [14]. While water with extremely low concentrations of TDS may also be unacceptable to consumers because of its flat and insipid taste. High TDS might be due to the presence of a large number of organic salts such as carbonate, bicarbonate sodium, potassium and calcium and also some non-volatile substance [17].

Suspended Solids(SS)

The value of suspended solids as presented in Table 5 is 112 mg/l which is above the value stipulated by WHO and NAFDAC standards presented in the same table. SS in water are indications of suspended and solid materials present in the water[16]. Suspended solids in rivers are mostly due to high levels of sediments carried by surface runoff into the water after precipitation. These includes runoff from natural and anthropogenic (human) activities in the watershed [21].

Electrical Conductivity (EC)

The electrical conductivity of water is synonymous to the amount of total dissolved salt (TDS) present in the water. In other words, it could be referred to as a direct function of total dissolved salts [9]. Electrical Conductivity of river Amba is 84.0µs/cm as presented in Table 5 which is not acceptable with the WHO and NAFDAC limits. When electrical conductivity is high, it increases the corrosive nature of water [14]. High electrical conductivity value might be due to the presence of a high amount of dissolved inorganic substances in ionized form. But it is not the case with this study. However, the water from River Amba can be classified as mesotrophic because it falls below the stipulated 1200µs/cm by WHO [8].

Chemical Water Quality Parameters

pH

The pH value of the water was also presented in Table 5. The pH of a water is considered an important water quality parameter because it supplies information regarding the acidity or alkalinity of water. The study has pH value of 6.4 which falls slightly below the range of 6.5 -8.5 prescribed by WHO and NAFDAC. The lower the pH value of a water the higher the corrosive nature of water. Dissolved gases such as carbon (IV) oxide, hydrogen sulphide, and ammonia also affect the pH of water. One of the significant environmental impacts of pH is the effect that it has on the solubility and thus the bioavailability of other substances [11].

Hardness

Ca and Mg salts are the two main causes of water hardness [10], and they have a detrimental effect on humans as it puts the heart at risk. The hardness of water above approximate values of 200mg/l may result in the formation of scales especially if the water is to be transported to consumers through pipes [19]. The result obtained for hardness is 62 mg/l as presented in Table 3 which is below the limit specified by WHO and NAFDAC.

The water from River Amba is considered free from hardness. Water hardness is mostly due to the presence of multivalent metal ions which comes from minerals dissolved in the water. One of the most prevailing impacts of water hardness on fishes and other aquatic life appears to be the effect some ions have on more toxic metals such as Lead, Cadmium, Chromium, and Zinc. Generally, the harder the water, the lower the toxicity of other metals to aquatic life [14].

Sulphate

The amount of sulphate ions obtained from the analysis of the water under study is 40mg/l. WHO and NAFDAC specified the range of 100 – 400mg/l for minimum and maximum tolerance of sulphate content in water. The amount of sulphate content in excess of the stipulated range can result in diarrhea. Hence, the value of the present study shows that the water is free from sulphate problems.

Chemical Oxygen Demand (COD)

The COD amount obtained from the study is 134mg/l which is well above the WHO and NAFDAC acceptable limits. COD is the amount of dissolved oxygen required to cause chemical oxidation of the organic material in water. High COD has an undesirable consequence on aquatic life [2].

Biological Water Quality Parameters

Dissolved Oxygen (DO)

Thedissolved oxygen content of River Amba is 5.1mg/l as presented in Table 5. This is slightly above WHO and NAFDAC standards of 4.0mg/l. DO is one of the most important water quality parameters. If in contact with a water body, it gives direct and indirect information about the reactions in the water such as bacterial activity, photosynthesis, availability of nutrients, stratification etc. Some of the effects of dissolved oxygen is that it corrodes water lines, boilers and heat exchangers, and affects the survival of marine animals at low levels [18]. Variation in dissolved oxygen might be due to temperature, photosynthesis, respiration, aeration, organic water and sediment concentration [3].

Biochemical Oxygen Demand (BOD)

The BOD concentration of the river presented in Table 5 is 69mg/l. As observed, it is higher than the value specified by WHO and NAFDAC standard. High BOD decreases the level of dissolved oxygen in water [17].

Coliform Count

The total coliform count for the sample considered was exceedingly higher than the value specified by WHO and NAFDAC. The value of the coliform count is 771per 100ml of water which is way higher than the value of 0 and 10 specified by WHO and NAFDAC respectively.

The result of the water quality analysis of the study in comparison with drinking water quality standard issued by WHO and NAFDAC revealed that most of the water quality parameters were not adequate to pronounce the water potable. Hence, the people consuming this water are at risk of contracting water-borne and/ or sanitation-related diseases as highlighted by the microbiological quality of the water they use for drinking and other domestic uses. Proper treatment of this river water is necessary for it to become potable.

VI. CONCLUSION

Water quality parameters like temperature, turbidity, suspended solids, Electrical conductivity, pH, COD, DO, BOD, and coliform count had values above that stipulated by the WHO and NAFDAC. Water quality parameters like TDS, Hardness, sulphate were observed to be within the permissible limit for both WHO and NAFDAC water quality standards.The people consuming this water are at risk of contracting water-borne and/ or sanitation-related diseases as highlighted by the microbiological quality of the water if used for drinking and other domestic uses.The generated water quality information indicates a high concentration of suspended solids. The proposed models are based on the generated data from the study at the river scale and would therefore be directly applicable to the study area. The models developed form a basic tool to support water quality monitoring and land use management in future.

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