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Water Quality Profile of Ekenwan River and Antibiotics Sensitivity Pattern of Its Isolated Bacteria

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ABSTRACT: This study was aimed at evaluating the water quality profile of Ekenwan River located in Edo-South, Nigeria and also to determine the antibiotics sensitivity pattern of its isolated bacteria. Water samples were collected from upstream and downstream stations of the river and they were designated as station A and station B respectively; standard analytical and bacteriological procedures were adopted. The pH of water samples for station A ranged from 5.11-5.86 while and station B ranged from 4.11-5.94. Also the electrical conductivity of the water samples from station A ranged from 61.5-210.3μS/cm while station B ranged from 65.2-286.9μS/cm. The results also showed that Ekenwa River had been relatively contaminated with heavy metals, with iron having the highest concentration (station A and B recorded 0.27-1.14mg/l and 0.38-1.85mg/l respectively). The total heterotrophic bacterial counts at Station A and Station B ranged from 5.1×10^4 – 10.5×10^4 cfu/ml and 0.7×10^4 – 17.3×10^4 cfu/ml respectively. The total coliform counts range at Stations A and B were from 10–40MPN/100ml and 17–90MPN/100ml respectively. The predominant bacterial isolates were species of *Bacillus* (17.3 %), *Enterobacter* (16.0 %), *Micrococcus* (13.3 %) and *Staphylococcus* (13.3 %). Results of antibiotic sensitivity pattern indicated varying activities and the most effective antibiotic was erythromycin. Arithmetic evaluation of Water Quality Index was 33.98 for station A (indicating good water quality) and 351.26 for station B (indicating water is unsuitable for drinking). This study indicated significant level of pollution due to various activities carried out along the River.

Keywords: Water quality, Antibiotic, Bacteria, Physicochemical, Heavy metal

Introduction:

Water is a vital commodity and its sources include rivers, streams, lakes, wells, boreholes, spring etc. According to the World Commission on Water for the 21st Century, more than half of the world's major rivers are so depleted and polluted that they endanger human health and poison surrounding ecosystems. The sources of water pollution vary and involve almost every significant human activity. These include mostly the dumping of domestic wastes, sewage, agricultural and industrial effluent into water bodies (Maitera *et al.,* 2010). Lack of adequate water for domestic, irrigation and other purposes in rural and urban centers is one of the most challenging problems in Nigeria today. All human usage of water, either for drinking, irrigation, recreation and industrial processes has some quality criteria requirements to make it acceptable (Adefemi *et al.,* 2007).
The availability of good quality water is an indispensable feature for preventing diseases and improving quality of life. Natural water contains different types of impurities are introduced in to aquatic system by different ways such as weathering of rocks and leaching of soils, dissolution of aerosol particles from the atmosphere and from several human activities, including mining, processing and the use of metal based materials (Patil *et al.,* 2012). The increased use of metal-based fertilizer in agricultural revolution of the government could result in continued rise in concentration of metal pollutions in fresh water reservoir due to the water run-off. Pathogenic bacteria are considered as etiological agents of infectious diseases to human and marine animals (Pereira *et al.*, 2007). The presence of bacteria, viruses, protozoa and helminthes in water can cause water borne diseases (Uzoigwe and Agwa, 2012). It is estimated that 80% of all illness in developing countries is related to water and sanitation, and

that 15% of all child deaths under the age of 5 years in developing countries results from diarrhoeal diseases (WHO, 2004).

This study was aimed at evaluating the physiochemical quality and antibiotics sensitivity of bacteria isolated from water samples from Ekenwan River located in Edo South, Nigeria.

Materials and methods

Sample collection: Water samples were collected from Ekenwan River at two stations designated as the upstream and downstream zone of the river. Water samples were collected from the river from November 2016 to March 2017 and were taken to the laboratory for both physicochemical, heavy metals and microbiological analyses.

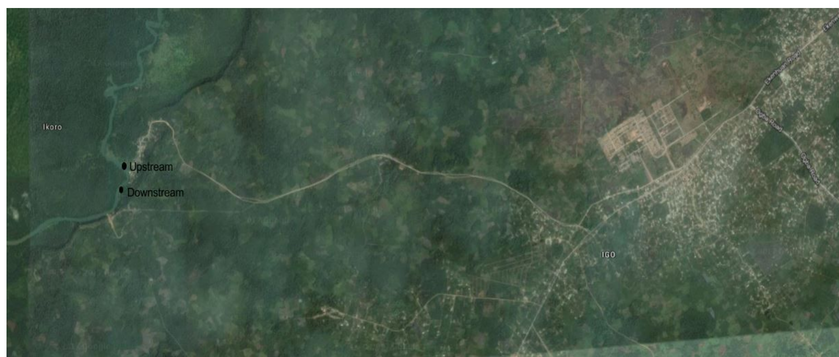

Fig 1: Map of Ekenwan River Source: Google map

pH: The hydrogen ion concentration (pH) of each sample were measured using a digital pH/temperature meter. The electrode probe was inserted into a glass beaker containing about 20 ml of the sample and the result was read from the screen and recorded. The pH meter was calibrated before and after each reading using freshly prepared neutral, acidic and basic pH buffers.

Electrical conductivity: The electrical conductivity of each water sample was determined using a portable conductivity meter. 50 ml of the sample was collected with a beaker and the plastic electrode probe was inserted into the sample and the result in microsiemens ($\mu s/cm^{-1}$) read from the screen. The meter was calibrated using distilled water after each measurement (APHA, 1993).

Determination of Total Suspended Solids: About 25 ml of the sample was withdrawn into a conical flask with a pipette. It was filtered in a Gooch funnel fitted with glass fibre filter paper which has been pre-dried at 105 ºC.The glass fibre was carefully removed from the Gooch and dried to a constant weight at 105 ºC to obtain the weight of the suspended solids (Ademoroti, 1996).

Determination of the Total dissolved solids: The total dissolved solids of each sample were measured with a portable TDS meter. 100 ml of the sample was collected with a sterile glass beaker and the electrode probe was inserted into the sample and the result in mg/l was read from the screen. The meter was calibrated using distilled water after each measurement (APHA 1993).

Determination of turbidity: The turbidity of the respective water samples were determined using a spectrophotometer. 25 ml of the sample was dispensed into a curvette and placed in the light chamber and the absorbance was measured at 600 nm using distilled water as blank. The turbidity values were recorded in nepholometer turbidity unit (NTU) (APHA, 1993).

Determination of Dissolved Oxygen (DO): This parameter was determined using Wrinkler's method and several reagents were prepared; $MnSO_4$ solution, Alkali-Iodide-Azide solution, Concentrated H_2SO_4 solution, $Na_2S_2O_3$, 0.025 M and Starch solution. 250 ml DO bottles were filled to the brim with samples, taking care to minimize contact with air. 100 ml of both Alkali-Iodide-Azide solution and $MnSO_4$ solution were added to the bottles which were thoroughly shaken and upon settlement of the precipitate, 2 ml of concentrated sulphuric acid was added to dissolve the precipitate. 100 ml of the sample solution was measured to which 2 drops of starch indicator was added. The resulting dark blue solution was titrated against a colourless 0.0125M Thiosulphate solution (Ademoroti, 1996).

Calculation:

$$DO\ (mg/l) = \frac{16,000 \times M \times V}{V_1 - 2.0)}$$

where: M= molarity of the thiosulphate solution

V= volume of thiosulphate used for titration

V_1= volume of the bottle, with stopper in place.

Evaluation of the Biological Oxygen Demand (BOD): The respective samples were aerated using an air pump and a measured dilution of the water sample was done and seeding of the water sample was also conducted. Determination of the Dissolved Oxygen (DO_1) using Wrinkler's method on a suitable portion of the seeded water was carried out. An incubation bottle was filled to the brim with the remainder of the diluted water sample. The bottle was screw capped and incubated in the dark for 5 days at 20 ºC. On the 5th day, the DO value was determined. The BOD value was the result of the difference of the respective DO values divided by the percentage dilution (Ademoroti, 1996).

Calculation:

$$\text{BOD (mg/ml)} = \frac{(DO_1 - DO_5)}{\text{Percent dilution}}$$

Determination of Chemical Oxygen Demand (COD): The COD values for the water samples were determined using the colorimetric procedure as described by Ademoroti (1996). HACH COD reagents (high range), COD reactor (HACH) and HACH Spectrophotometer were utilized. A measured volume of the sample was added to 5 ml of high range COD reagent (HACH). This mixture was placed in a COD reactor for about 1 h and upon cooling, the absorbance of the mixture was read at 750 nm using a HACH Spectrophotometer.

Determination of Nitrate: Several reagents were prepared, which included: Stock nitrate solution, standard nitrate solution, sodium arsenite solution, brucine- sulphanilic acid solution, sulphuric acid solution and sodium chloride solution. The samples were pre-treated in order to remove any residual chlorine present. 10 ml of the sample was then placed in a test tube, followed by the addition of 2 ml NaCl solution, this mixture was swirled and 10 ml of H_2SO_4 solution was also added. The resultant solution was also swirled and allowed to cool. A sample blank was also prepared. To the first test tube containing the mixture of the sample, NaCl and H_2SO_4, 0.5 ml of brucine–sulphanilic acid reagent was added and the test tube was swirled and left to cool for about 20 min. The test tubes were allowed to develop colour and the absorbance reading of the solution was taken at a wavelength of 650 nm using a spectrophotometer (Ademoroti, 1996).

Determination of heavy metals: The concentrations of the respective heavy metals (Fe, Mn, Zn, Cu, Cd, Ni, and Pb) present in the water samples were determined with the aid of an Atomic absorption spectrophotometer.

Enumeration of mean heterotrophic bacterial and fungal counts: Serial dilution of the respective surface water samples was done up to 10^{-6} with sterile Peptone water utilized as diluent. The mean viable heterotrophic bacterial and fungal counts were determined using pour plate technique with nutrient agar (NA) utilized as general purpose medium respectively (Harley and Prescott, 2002). The sterilized molten NA was dispensed into Petri dishes containing 1ml of the diluted aliquot appropriate dilution for the isolation of the heterotrophic culturable bacteria. The Nutrient Agar plates were incubated at 35 ºC for 48 h. The resultant bacterial colony counts on the agar plates was enumerated manually and recorded. The bacterial isolates were further identified by the identification schemes of Holt *et al.* (1994) and Aneja (2003).

Determination of total coliform and E. coli counts: The method as described by Cheesebrough (2006) was used for the determination of the total coliform and fecal coliform (*Escherichia coli*) contents of the respective sample. Each count was conducted in three stages.

Determination of antibiotic sensitivity pattern of the water borne bacterial isolates: The antibiotic sensitivity pattern (antibiogram) of the isolates was determined using the disc diffusion method as described by Harley and Prescott (2002). The bacterial isolates were transferred to sterile Nutrient broth under aseptic conditions and incubated overnight. The turbidity of the broth cultures was adjusted to match an opacity standard ($BaSO_4$ turbidity standard). The resulting broth culture had a microbial cell density of about 10^8 cfu. Nutrient agar plates were prepared and appropriately labelled. These plates were inoculated with the standardized bacterial broth cultures by spread plate technique (Harley and Prescott, 2002). The inoculated plates were left to dry for 15 min. Commercially available antibiotic discs containing varying concentrations of various types of antibiotics was placed at adequate distances on each of the seeded agar plates with the aid of sterile forceps under aseptic conditions. The antibiotic discs were; Ciprofloxacin (CPX) (10 μg), Chloramphenicol (CH) (30 μg), Sparfloxacin (SP) (10 μg), Amoxacillin (AM) (30 μg), Augmentin (AU) (30 μg), Gentamicin (CN) (30 μg), Septrin (SXT) (30 μg), Pefloxacin (PEF) (10 μg), Streptomycin (S) (30 μg), Erythromycin (E) (10 μg), Ampiclox (APX) (30 μg), Zinnacef (Z) (20 μg), Ofloxacin (OFX) (5 μg) and Recephin (R) (25 μg). These plates were incubated for 12 h. The resultant visible zones of inhibition were measured using a ruler (Harley and Prescott, 2002).

Statistical analysis: The non-parametric analogue of the unpaired student T-test; Mann-Whitney test was utilized to determine if the differences between the respective microbial and physicochemical data recorded for the surface water samples collected at the upstream and downstream sections of the river was statistically significant (α=0.05).

Evaluation of the water quality index of the sampled surface waters: The water quality index value for surface water sample sourced from the upstream and downstream sampling points were determined using weighted arithmetic method as described by Chatterjee and Raziuddin (2002).

Results and discussion:

Analytical results of physico-chemical parameters (Table 1) revealed that pH of water samples for station A range from 4.96-5.86, while that of station B ranged from 4.11-5.94. The pH of water is a reflection of its acidity and alkalinity level and it is an important parameter when considering the quality of any water for human consumption (Raji *et al.,* 2015). The fluctuations in optimum pH ranges may lead to an increase or decrease in the toxicity of poisons in water bodies (Rajiv *et al.,* 2012).

Table 1: Physicochemical analysis of water samples from Ekenwan River

Parameter		Month Nov. 2016	Dec. 2016	Jan. 2017	Feb. 2017	March 2017	Mean ± S.D	WHO Standard (2004)
pH	A	5.32	5.11	5.86	5.11	4.96	5.27±0.35	6.5-8.5
	B	5.41	4.94	5.94	4.82	4.11	5.04±0.68	
EC (µS/cm)	A	61.5	91.3	156.2	193.2	210.3	142.5±64.30	NA
	B	65.2	128.2	183.5	211.6	286.9	175.08±83.93	
Turbidity (NTU)	A	1.5	1.5	1.1	2.7	2.2	1.80±0.64	5.0
	B	3.4	1.9	1.5	4.4	2.9	2.82±1.16	
TSS (mg/l)	A	6.1	2.7	1.6	3.7	8.3	4.48±2.71	500
	B	9.8	5.4	2.4	6.2	9.3	6.62±3.03	
TDS (mg/l)	A	31.8	44.9	78.1	97.6	105.2	71.52±32.19	500
	B	33.7	65.1	91.8	104.8	143.5	87.78±41.38	
DO (mg/l)	A	5.2	6.1	6.8	5.9	6.1	6.02±0.57	NA
	B	4.9	5.3	5.9	5.5	5.0	5.32±0.40	
BOD_5 (mg/l)	A	1.6	2.4	1.1	2.6	1.6	1.86±0.62	NA
	B	3.3	3.9	2.7	3.8	2.7	3.28±0.58	
COD (mg/l)	A	8.9	13.2	5.4	19.3	15.4	12.44±5.44	NA
	B	15.1	24.8	8.2	42.4	36.2	25.34±14.21	
Nitrate (mg/l)	A	2.37	1.90	0.82	3.95	2.48	2.30±1.13	50.00
	B	7.11	5.27	1.21	7.12	6.10	5.36±2.45	

KEY: A = Upstream water sample, B = Downstream water sample, S.D = Standard Deviation, EC= electrical conductivity, Col= colour, TDS= Total dissolved solids, TSS = Total suspended solids, DO= Dissolved oxygen, BOD_5 = Biological oxygen demand, COD= Chemical Oxygen demand, THC = Total hydrocarbon content, NA= Not available

Electrical conductivity measures of water samples from Ekenwan River revealed that values for station A ranged from 61.5-210.3µS/cm while that of station B ranged from 65.2-286.9µS/cm. Turbidity value ranged from 1.1-2.7NTU and 1.5-3.4NTU for station A and station B respectively. The results of Total Suspended Solute (TSS) and Total Dissolve Solute (TDS) were observed to be higher in Station B. The ranges were 1.6 – 8.3 (mg/l) (Station A), 2.4- 9.8 (mg/l) (Station B) for Total Suspended Solute (TSS) and 31.8 – 105.2 (mg/l), 33.7-143.5 (mg/l) (Station B) for Total Dissolve Solutes (TDS). Dissolved oxygen in this study was observed to range from 5.2-6.8 and 4.9-5.9 in stations A and B respectively. The low dissolved oxygen content may be due to high decomposition of organic matter, which indicates a high pollution load in the water. Biological oxygen demand (BOD_5) of water samples range from 1.1-2.6 and 2.7-3.9 in stations A and B respectively. BOD result from this study indicated higher pollution rate at station B compared to station A. Chemical Oxygen Demand (COD) of water samples from station A and B was revealed to range from 5.4-19.3 and 8.2-42.4 respectively. BOD_5 and COD are used to determine the amount of organic as well as inorganic content in the water. High BOD and COD could be due to acidification of water by elevated microbial degradation of organic debris and concentrated dissolved solids during various seasons (Hemant *et al.,* 2012). Results from this study indicated a low concentration of nitrate when compared with WHO standard. The ranges were 0.82 – 3.95 (mg/l) (Station A) and 1.21-7.12 (mg/l) (Station B).

The results also showed that Ekenwan River had been contaminated with heavy metals (Table 2). The iron concentration in water sample from Ekenwan River at station A and B recorded 0.27-1.14mg/l and 0.38-1.85mg/l respectively. Similar study by Hong *et al.* (2014) revealed Fe concentration of water sample from River Benue as 0.293mg/l. Sources of Fe that are obvious in river water might be from weathering processes of soil formation, municipal drain water, leachate from refuse dump sites which are discharged into river water bodies (Hong *et al.,* 2014). Zinc concentration at station A and B recorded 0.09-0.28mg/l and 0.12-0.95mg/l respectively. Zinc is one of the most common elements in the earth crust that are found in various component of air, soil, food and water in the environment which plays active role in the enzymatic reaction. The range of Zn in

water samples in the study of Hong *et al.* (2014) ranged from 0.0002 – 1.66 mg/l. The manganese concentration at station A and B recorded 0.014-0.083 mg/l and 0.039-0.115 mg/l respectively. Manganese is one of the essential nutrient elements required for the growth and wellbeing of plants and animals. Water body containing excessive level of manganese may impair objectionable staining properties on cloth washing operations (Hong *et al.,* 2014). The copper concentration range from 0.007-0.027 mg/l (Station A) and 0.016-0.041mg/l (Station B). Copper has been classified as one of the essential element required by man to promotes activity of enzyme systems in human body however, it becomes toxic to man when ingested in excess of tolerable limit (Amoo *et al.,* 2005). Continuous use of this copper elevated level water to grow crops might infiltrate into the ground and contaminate ground water especially in shallow ground water level or vegetables might take up to a phytotoxic level and gain entrance into the food chain, thereby putting consumers to risk of gastrointestinal disorder. The cadmium concentration in water sample from Ekenwan River at Station A and B recorded 0.008-0.018 mg/l and 0.017-0.033 mg/l respectively. The value is above the WHO standards of 0.03mg/l bench mark for drinking water. Using this water for drinking without adequate treatment may be toxic to kidney and other body organs. The major route through which Cd enters the aquatic ecosystems is through the discharge of wastewaters from electroplating, chemical industries, hazardous wastes, fireworks and cadmium batteries (Hong *et al.,* 2014). Lead (Pb) is well known as cumulative poison that has several deleterious effects on public health even at trace concentration in the body. It causes cancer, interfere with vitamin D metabolism, and affect mental development in infants, toxic to the central and peripheral nervous systems. In this study, a range of 0.009 – 0.021 mg/l and 0.014 – 0.048 mg/l was obtained for Pb concentration in water samples from station A and B respectively. Some of the values were higher than 0.01mg/l set by WHO, (2004) bench mark for drinking water.

Table 2: Heavy metal analysis of water samples from Ekenwan River

Parameter		**Month**					**Mean ± S.D**	**WHO Standard (2004)**
		Nov. 2016	**Dec. 2016**	**Jan. 2017**	**Feb. 2017**	**March 2017**		
Fe	A	0.69	0.42	0.27	1.14	0.74	0.65±0.33	0.30
	B	1.23	0.91	0.38	1.85	1.24	1.12±0.54	
Mn	A	0.073	0.053	0.014	0.052	0.083	0.06±0.03	0.1
	B	0.131	0.082	0.039	0.094	0.115	0.09±0.04	
Zn	A	0.28	0.13	0.09	0.20	0.22	0.18±0.08	5.00
	B	0.95	0.22	0.12	0.75	0.64	0.54±0.35	
Cu	A	0.027	0.016	0.007	0.019	0.023	0.02±0.007	1.0
	B	0.051	0.032	0.016	0.022	0.041	0.03±0.014	
Cd	A	ND	0.008	0.011	0.018	0.009	0.01±0.0064	0.03
	B	ND	0.017	0.025	0.033	0.025	0.02±0.013	
Pb	A	0.009	0.010	ND	0.014	0.021	0.01±0.008	0.01
	B	0.014	0.039	ND	0.059	0.048	0.03±0.024	

KEY: A = Upstream water sample, B = Downstream water sample, S.D = Standard Deviation, ND = Not detected, Fe = Iron, Cl = Chloride, P = Phosphorus, NO_2 = Nitrite, NO_3 = Nitrate, Mn = Manganese, Zn= Zinc, Cu = Copper, Cr = Chromium, Cd = Cadmium, Ni =Nickel, Pb = Lead, V = Vanadium , NA= Not available

Heterotrophic bacterial counts were in the magnitude of 10^4 (Table 3). The total heterotrophic bacterial counts of water samples collected at Station A (upstream) and Station B (downstream) ranged from 5.1×10^4 – 10.5×10^4 cfu/ml and 0.7×10^4 – 17.3×10^4 cfu/ml respectively. The total coliform counts of water samples collected at Station A (upstream) and Station B (downstream) ranged from 10–40 MPN/100 ml and 17–90 MPN/100 ml respectively. *Escherichia coli* counts of water samples collected at Station A (upstream) and Station B (downstream) ranged from 2–14 MPN/100 ml and 6 –20 MPN/100 ml respectively (Table 3). Faecal coliforms counts/100 ml should be zero for water to be considered as no risk to human health (Rajiv *et al.,* 2012). Therefore the observation of faecel coliforms in water samples from Ekenwan River is indicative of faecal contaminants and thus considered unfit for drinking. It is a common practice for people living along the river catchment to discharge their domestic and agricultural wastes into rivers. Wild and domestic animals seeking drinking water can also contaminate the water through direct defecation and urination (Karikari and Ansa-Asare, 2006).

Table 3: Heterotrophic microbial and coliform counts of the various water samples

Sampling month	Sample code	Mean HBC (x 10^4 cfu/ml)	TCC (MPN/100ml)	*E. coli* count (MPN/100ml)
November	A	5.2	18	11
	B	0.7	30	20
December	A	5.1	10	4
	B	8.4	17	9
January	A	5.9	20	2
	B	1.02	40	6
February	A	7.0	17	6
	B	13.7	50	10
March	A	10.5	40	14
	B	17.3	90	20

KEY: A = Upstream water sample, B = Downstream water sample, HBC = Heterotrophic bacterial count, TCC = Total coliform count

Identified bacterial isolates (Table 4) were *Staphylococcus aureus, Escherichia coli, Bacillus* sp*., Streptococcus faecalis, Micrococcus* sp., *Enterobacter aerogenes, Citrobacter* sp., *Klebsiella* sp. and *Pseudomonas aeruginosa.* The bacterial isolates with the highest percentage frequency of occurrence (table 4) were species of *Bacillus* (17.3 %), *Enterobacter* (16.0 %), *Micrococcus* (13.3 %) and *Staphylococcus* (13.3 %).

Table 4: percentage frequency of occurrence of bacterial isolates

Bacterial isolates	Number of bacterial isolates	% Frequency of occurrence
Staphylococcus aureus	10	13.3
Bacillus sp.	13	17.3
Streptococcus faecalis	5	6.7
Micrococcus sp.	10	13.3
Klebsiella sp.	7	9.3
Escherichia coli	7	9.3
Enterobacter aerogenes	12	16.0
Citrobacter sp.	7	9.3
Pseudomonas aeruginosa	4	5.3
	n=75	100

Antibiotic susceptibility test using several standard antibiotics against bacterial isolates indicated varying activities (Table 5). The most effective antibiotic was erythromycin which exhibited a 26.0mm zone of inhibition against *Streptococcus faecalis.* The least effective antibiotics were ampiclox, amoxicillin, rocephin, streptomycin which all exhibited 10mm zone of inhibition against several bacterial isolates.

Table 5: Zone of inhibition (mm) for antibiotic sensitivity test

Gram +ve	PEF (10µg)	CN (10µg)	APX (30µg)	Z (20µg)	AM (30µg)	R (25µg)	CPX (10µg)	S (30µg)	SXT (30µg)	E (10µg)
taph. aureus	0.0	16.0	0.0	18.0	0.0	20.0	24.0	13.0	0.0	15.0
Bacillus sp.	15.0	12.0	0.0	12.0	0.0	20.0	20.0	10.0	0.0	20.0
Strept. faecalis	12.0	18.0	0.0	14.0	0.0	17.0	20.0	15.0	0.0	26.0
Micrococcus sp.	16.0	20.0	0.0	20.0	12.0	19.0	22.0	12.0	0.0	18.0
Gram -ve	**SXT (30µg)**	**CH (10µg)**	**SP (10µg)**	**CPX (10µg)**	**AM (30µg)**	**AU (30µg)**	**CN (10µg)**	**PEF (30µg)**	**OFX (10µg)**	**S (30µg)**
Klebsiella sp.	0.0	15.0	18.0	20.0	0.0	0.0	20.0	11.0	24.0	15.0
E. coli	0.0	0.0	15.0	18.0	0.0	0.0	15.0	0.0	20.0	10.0
Enterobacter aerogenes	0.0	0.0	10.0	22.0	0.0	0.0	18.0	10.0	22.0	13.0
Citrobacter sp.	10.0	17.0	15.0	20.0	10.0	10.0	22.0	12.0	25.0	10.0
Pseud. aeruginosa	0.0	0.0	15.0	15.0	0.0	0.0	15.0	0.0	20.0	15.0

KEY: **SXT**= Septrin, **CH**= Chloranphenicol, **SP**= Sparfloxacin, **CPX**= Ciprofloxacin, **AM**= amoxicillin, **APX** = Ampiclox, **CN**= Gentamycin, **R** = Rcephin. **Z**= Zinnacef, **PEF**= Pefloxacin, **AU** = Augmentin, **OFX**= Ofloxacin, **E**= erythromycin, **S**= Streptomycin.

Evaluation of Water Quality Index indicate values of 33.98 and 351.26 for Station A and B respectively (Table 6). Comparison of the WQ1 status (Chatterjee and Raziuddin, 2002) of the stations showed Station A to be of good quality for drinking whereas Station B with greater dispersion was found unsuitable for consumption.

Table 6: water quality index of Ekemwan River

Parameter	Station A (Upstream)					Station B (downstream)				
	V_i	S_i	W_i	q_i	W_iq_i	V_i	S_i	W_i	q_i	W_iq_i
pH	5.27	6.5-8.5	0.22	115.8	25.4	5.04	6.5-8.5	0.22	756	165.6
EC (µS/cm)	142.5	250	0.37	57.0	21.15	175.1	250	0.37	700.3	259.8
TDS (mg/l)	71.5	500	0.004	0.14	0.001	87.8	500	0.004	17.6	0.07
TSS (mg/l)	4.48	500	0.004	0.9	0.003	6.62	500	0.004	1.32	0.005
DO (mg/l)	6.02	5	0.37	0.89	0.33	5.32	5	0.37	96.7	35.9
BOD_5 (mg/l)	1.86	5	0.37	0.37	0.14	3.28	5	0.37	65.6	24.4
Nitrate (mg/l)	0.11	50	0.04	0.002	0.00	0.18	50	0.04	0.36	0.014
			ΣW_i =1.38		ΣW_iq_i =46.9			ΣW_i =1.38		ΣW_iq_i =485.9
WQI	$(\Sigma W_iq_i / \Sigma W_i)$ = 46.9/1.38 = **33.98**					$(\Sigma W_iq_i / \Sigma W_i)$ = 485.9/1.38 = **351.26**				
Ranking	Good					Unsuitable for drinking				

Conclusion

The physicochemical and microbial analysis of water samples obtained at station B indicated significant increase in the level of contaminants due to various anthropogenic carried along Ekenwan River. Findings made in the course of this study would help in the assistance of water quality monitoring and management in order to improve the quality of water in maintaining better sustainable quality of this natural endowment.

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