DETERMINATION OF PHYSICOCHEMICAL CHARACTERISTICS OF EFFLUENTS FROM BREWERY EFFLUENT CONDUITS IN BENIN CITY AND THE RECEIVING WATERS OF IKPOBA RIVER

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ABSTRACT

Effluents samples collected from effluent carrying conduits and water samples from effluent receiving Ikpoba River were analyzed for fourteen analytical parameters: Temperature, pH, conductivity, turbidity, TSS, TDS, DO, BOD_5 COD, Phenol, phosphate, total hardness, Ca- hardness and Mg- hardness. Results for some effluent physicochemical parameters: pH (10.3±0.30), TSS (380±320 mg/L), TDS (1930±270 mg/L), BOD_5 (940±260 mg/L) and Phenol (4.01±0.32 mg/L) are known to exceed effluent guideline showing that the effluent has capacity to pollute the receiving river water. Results for the analysis of physicochemical parameters of the receiving river water also showed that average values for several of them exceed national and international guidelines for drinking water. All values of physicochemical parameters exceed one or the other guidelines for non- drinking uses of water.

Keywords; Effluent; Brewery; physicochemical parameters; Ikpoba River.

INTRODUCTION

Establishment of industries in an area is always welcomed because of the economic enhancement it gives to the people of the area. It brings increase in the number of people who are gainfully employed and an improvement in infrastructural facilities in the area. These benefits are however most of the time accompanied by some adverse effects especially the degradation of the immediate environment (water, sediment, soil and vegetation). The environment receives effluents or emissions from these industries. Brewery effluents typically here the following characteristics: suspended solids (10 - 60 mg/l), Biological oxygen Demand (1000 - 1500 mg/L), chemical oxygen Demand (800 - 3000 mg/L), Nitrogen (30 - 100 mg/L) and phosphorus (10 - 30 mg/L) (World Bank, 1997). Not all the organic materials in an effluent are dissolved in it. Some remain as particulate matter. Analysis of water receiving industrial or urban effluents has revealed that such effluents have the ability to pollute such water bodies. An analytical study of Ogunpa River water in Nigeria which receives industrial and urban effluents by Onianwa *et al.* (2001) shows ranges of values for the following analytical parameters: Temperature (26 - 32^oC), PH (6.6-8.1), TS (160 - 1480 mg/L), TSS (10 - 270 mg/L), TDS (0.1 - 5.9 mg/L) DO (0.20 - 8.30 mg/L), BODs(13 - 560 mg/L), COD (11.9 - 224 mg/L), C (70.5 - 688 mg/L) and alkalinity (1.76 - 28.0 mg $CaCO_3$/l). Ajayi and Adelaye (1977) studying the same river (Ogunpa) had earlier also recorded values of for pH (7.7), TDS (414 mg/l), DO (2.5 mg/l) BOD_5 (16.4 mg/l), Cl, (50.8 mg/l) PO_4^{-3} (2.36 mg/l) and alkalinity (25.6 mg $CaCO_3$/L).

A study of the New Calabar River a river that receives effluents from industrial concerns in the Niger Delta of Nigeria by Odukuma and Okpokwasili (1997) showed ranges for analytical parameters studied to be: TDS (6.50 - 4010 mg/l), DO (3.40 - 9.10 mg/l) COD (10 - 1000 mg/l) AAS analysis of heavy metals in Warri river and Odube creek (Egborge 1991) revealed concentrations of zinc to be 0.002 - 0.06 mg/L and iron to be 0.002 - 0.38mg/L). Ikpoba River flows through the northern part of Benin city, almost near the centre of the city. It serves the people in some stretch of the river for domestic use which includes for drinking and for cooking especially in times of scarcity or shortage of pipe borne water. Outside Benin city both Upstream and downstream, the adjoining land are use for crop farming. Among the arable crops grown the area are Yam (*Dioscorea sp.*), cassava (*Manihot esculanta*), Maize (*Zea mays*)

and Tomatoes (*Solanum lycoperscium*). The tree fruit crops include Mango (*Magnifera indica*), Oilpalm (*Elaeis guineensis*) and coconut (*Cocus nucifera*). Fishing also takes place in the both within and outside the city. The river also rives industial and domestic effluents. There is currently scarcity of information on the effect of industrial activities on the pollution potentials of Ikpoba River. The objectives of the present study included the determination of the values of some selected physicochemical parameters in the effluents collected from effluent conduits of two breweries in Benin City and the receiving water of Ikpoba River and also attempted explanations of the observations made. The results from the study will assist relevant environmental protection authorites in establishing the pollution status of the receiving river water and the states of the effluents entering into the river (i.e. the level of treatment given to effluent before discharge) in order to make adequate plans for the mitigation of any adverse effect that may be suffered by the environment in the area.

MATERIALS AND METHODS

Description of study area:

The twin breweries of Guinness PLC and Bendel brewery in Benin City lie to the south of the city. They also lies south of Ikpoba River. Effluents from the two breweries flows northwards through conduits to get to the river (Fig 1: Map of study area (a section of Benin City).

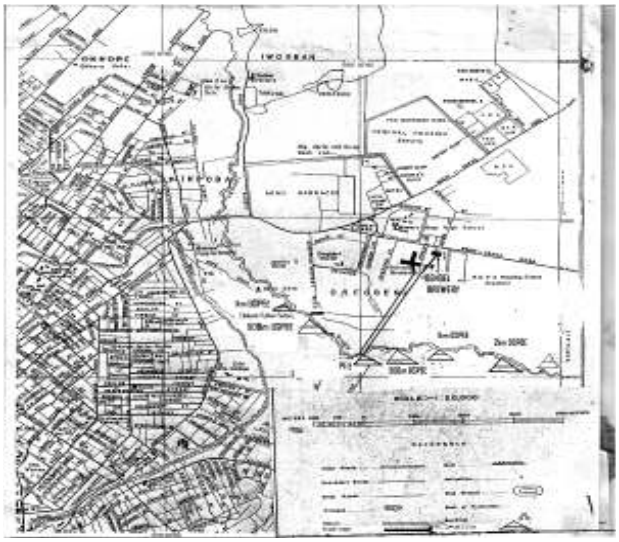

Fig. 1: *Map of Study Area (A Section of Benin City showing Part of Ikpoba River)*
Source*: Ministry of Land and Survey, Edo State, Nigeria*

Design of study:

Effluent and water samples were collected twice every season (Rainy and dry season) for three years starting from July 1998 to Dec. 2000. Parameters analyzed for are: temperature, pH, conductivity, Turbidity; total suspended solid (TSS) total dissolved solids (TDS) biochemical oxygen demand (BOD), chemical oxygen demand (COD), phenol, phosphate (PO_4^{-3}) , total hardness (T- hardness), Mg- hardness and Ca-hardness

Collection/preservation of samples: Time-composite samples of effluents were taken from the effluent conduits by taking grab samples with plastic containers every 10 minutes and by adding successive samples to the bottle holding previous grab samples, this lasted up to 1hr 10 min. (i.e. seven grab samples) and these composites samples were made by mixing in the bottle and storing in a cooler containing ice-blocks at temperature below 4 ^oC. Effluent samples were collected at the point of discharge of effluents (PDE) into the river. Grab samples were collected from Ikpoba River at the point of entry of effluents into the river (PEE), 500 m downstream and 1.5 km downstream (this makes up the study area). Grab samples were also collected at 500 m and 1km up stream (this makes up the control area). River water samples were collected at the surface and at half-depth. Water samples were also stored in coolers containing ice blocks at temperature below 4 ^oC before transferring samples to the laboratory.

Analytical Procedures:

Temperature was determined at the site by dipping the bulb of a mercury thermometer below the surface of water sample collected with a glass beaker. The pH of water samples was also determined at site with a portable pH -meter (model wp pH test 1) with the glass electrode well dipped below the surface of water in a beaker. The pH meter had earlier been standardized by pH-buffer solutions of pH= 7 and pH = 4. The conductivity was determined with a conductometer as described in standard methods (APHA-AWWA-WEF, 1995). The turbidity was determined by the nephelometric method using a laboratory nephelometer (APHA-AWWA-WEF, 1995).TSS was deter-

mined by filtering a measured volume of water sample using a gooch crucible-sunction pump system and drying the filtered solids at 103 ^{o}C- 105 ^{0}C. The TDS was determined by evaporating the filtrate obtained from the TSS determination procedure to dryness and then drying the residues to constant weight at 180^{o}C as described in standard methods (APHA-AWWA-WEF, 1995). The DO was determined with the iodometric method (with azide modification). Proper preservation of samples at point of collection was carried out as described in standard methods (APHA-AWWA-WEF, 1995). The 5-day BOD test was employed in the determination of BOD_5. The appropriate dilution water check was carried out. Details of experimentation is as contained in standard methods (APHA-AWWA-WEF, 1995). The open reflux method as described in standard methods was used in the determination of COD (APHA-AWWA-WEF, 1995).Phenol was determined by the IR-Spectrophotometric method as described by Simard et al. (1951). Phosphate was determined using the vanadomolybdophosphoric acid colorimetric method. Calibration curves for a set of standard phosphate solutions was also prepared and used. Details of experimentation are as contained in standard methods (APHA-AWWA-WEF, 1995). Total Hardness was determined by the EDTA titrimetric method and the indicator used was Eriochrome black T. Titration was done at PH=10.0±0.1 (APHA-AWWA-WEF, 1995). Calcium Hardness was also determined using the EDTA titrimetric method using murexide (ammonium purpurate) indicator and titration was done at PH of 12 to 13. Details of experimentation are as described in standard methods (APHA-AWWA-WEF, 1995). The determination of magnesium Hardness was achieved by the calculation method: magnesium hardness is estimated as the difference between total hardness and calcium hardness as $CaCO_3$ since suitable inhibitors were used in the total hardness titration (APHA-AWWA -WEF, 1995).

Quality assurance programme:

A quality assurance programme which included observation of general laboratory precautions and cleanliness, establishment a good representative sampling programme, Determinations of blanks and analysis duplicates was carried out. In addition to all these the following were also carried out:

a) ***Determination of glucose- glutamic acid check for BOD_5 determinations***: The mean for five determination of BOD_5 for 2% 1:1 mixture of glucose and glutamic acid was compared to the theoretical BOD_5 value of 2% glucose- glutamic acid (198 mg/L) using a student's t-test: There was no significant difference between the mean of BOD_5 determination for the mixture in the study and the theoretical value for BOD_5 for 2% glucose-glutamic acid solution at 95% confidence level. The mean BOD_5 of five determination was found to be 201±10

b) ***Determination of % recovery of COD in standard KHP solution***: COD was determined on a set of standard potassium hydrogen phthalate (KHP) solutions prepared by dissolving 425mg of dried (dried to constant weight at 120^{o}c) and properly ground KHP in distilled water and made up to IL. Percentage recovery of KHP solution was calculated as follows

$$\%\text{Recovery} = \frac{\text{COD of KHP Soln. x 100}}{\text{Theoretical COD of KHP}}$$

(The theoretical COD of KHP Solution = 500mg/L)

A mean percentage recovery of 93.5±4.1 % was obtained showing that the method used for the analysis is a good one.

Statistical analysis: Values for the various physicochemical parameters were given as mean ± standard deviation. Th seasonal mean values for three years were compared using Analysis of Variance (ANOVA-single factor). The mean values for study area were also compared with the mean values of control area using T-test (two sample, assuming equal variance).

RESULTS AND DISCUSSION

The values of the physicochemical parameter did not vary significantly in the seasons for the three years studied when the values of all the physicochemical parameters for the three years (Table 1) were compared using analysis of variance (ANOVA- single factor).

A comparison of values of the physicochemical parameters in the study area with those of the control area (i.e. upstream from the point of entry of effluents into the river PEE) (Table 3) shows that the values were higher in the study area than in the control area except for total hardness and calcium hardness. The differences are statistically significantly different in the cases of TSS, TDS, BOD_5 and COD when compared using T-test (two sample, assuming equal variances). It is noteworthy , that the pH is higher in the study area (9.41±0.12) than in the control area (6.40±26), this must be due to the influence of the effluents. The means pH of the effluents is (10.3±0.3 mg/L). Also the DO of the study area water (6.09±0.45 mg/L) is lower than the DO of the control area water (6.65±0.19 mg/L). This must be as a result of oxygen demanding materials present in water of the study area (BOD_5 = 349±230mg/l) and COD= 500±370 mg/L) as compared with water of the control area (BOD_5 = 124±39 mg/L, COD = 173±58 mg/L). The difference between the study area water (Downstream from PEE) and the control area (upstream from PEE) must have been brought about by the entering of effluents into the river at the point at which it did since there are no other major point sources of pollutants within the stretch of the river studied.

The values of the following physicochemical parameters in effluents (Table 2) exceeds the values for effluent guidelines of FEPA (1991) (FEPA is now Federal Ministry of Environment): temperature (36.2±0.84 ^oC),

Table 1: Average values of the physicochemical parameters in the seasons

Parameters	First Rainy season	First dry season	Second Rainy season	Second dry season	Third Rainy season	Third dry season
Temperature ^oC	29.3±2.5	28.6±2.0	29.0±3.6	27.2±1.8	29.8±5.3	28.0±1.0
pH	6.37±0.64	6.73±0.49	6.63±0.49	6.71±0.46	6.73±5.3	6.73±0.67
Conductivity ($uscm^{-1}$)	116±66	107±56	107±68	102±53	109±68	105±57
Turbidity (NTU)	41.3±8.2	39.5±7.5	40±15	37.3±7.6	41±16	39±11
TSS (mg/L)	323±420	304±410	316±420	265±350	311±420	284±370
TDS (mg/L)	713±0.470	567±440	624±400	514±420	562±390	567±440
DO (mg/L)	6.13±0.76	6.30±0.61	5.87±0.45	6.27±0.25	6.17±0.35	5.83±0.29
BOD_5 (mg/L)	376±300	323±270	390±250	301±250	382±270	320±290
COD (mg/L)	555±410	490±430	482±460	476±430	503±430	487±440
Phenol (mg/L)	1.55±0.87	1.14±0.64	1.61±0.71	1.13±0.67	1.40±0.69	1.36±0.52
Phosphate (mg/L)	1.62±0.39	1.37±0.60	1.68±0.35	1.40±0.89	1.68±0.35	1.85±0.42
Total hardness (mg/L)	38.7±2.4	32.6±3.5	38.9±3.4	32.2±3.8	39.3±5.7	33.0±4.6
Ca Hardness (mg/L)	33.3±2.3	27.1±6.3	31.5±0.7	23.7±3.4	30.7±1.2	26.6±5.6
Mg Hardness (mg/L)	5.38±0.11	5.8±2.8	7.4±2.8	8.4±1.7	8.73±4.5	6.8±1.9

Table 2: A comparison of the mean physicochemical parameters of effluent with FEPA interim effluent limitation guidelines

PARAMETER	Values of Parameters in effluent	INTERIM EFFLUENT LIMITATION Guidelines in Nigeria for all categories of industries (surface water discharge) (FEPA, 1991)
Temperature ^oC	36.2±0.84	40
pH	10.3±0.30	6-9
Conductivity ($uscm^{-1}$)	354±17	No guideline
Turbidity (NTU)	84±11	No guideline
TSS (mg/L)	380±320	30.0
TDS (mg/L)	1930±270	2,000
DO (mg/L)	3.87±0.47	No guideline
BOD_5 (mg/L)	940±260	50.0
COD (mg/L)	1750±240	No guideline
Phenol (mg/L)	4.01±0.31	0.2
Phosphate (mg/L)	1.38±0.31	5.00
Total hardness ($mgCaCO_3/L$)	25.5±2.9	No guideline

Table 3: Comparison of the mean values of physicochemical parameter of study area with those of control area

PARAMETER	STUDY AREA	CONTROL AREA
Temperature ^{o}C	28.7±2.7	26.6±0.77
pH	9.41±12	6.40±0.26
Conductivity ($uscm^{-1}$)	108±52	66.5±4.6
Turbidity (NTU)	39.6±9.9	36.7±5.9
TSS (mg/L)	*300±340	71.1±6.1
TDS (mg/L)	*590±360	250±73
DO (mg/L)	6.09±0.45	6.65±0.19
BOD_5 (mg/L)	*349±230	124±39
COD (mg/L)	*500±370	173±58
Phenol (mg/L)	1.37±0.61	0.84±0.15
Phosphate (mg/L)	1.59±0.48	0.85±0.15
Total hardness ($mgCaCO_3/L$)	35.8±4.7	36.7±2.2
Ca Hardness ($mgCaCO_3/L$)	28.8±4.7	31.6±1.9
Mg Hardness ($mgCaCO_3/L$)	7.1±2.7	5.1±2.1

*Statistically significantly different from control ($p<0.05$)

pH (10.3±0.3), TSS (380±320 mg/L), BOD_5 (940±260 mg/L) and phenol (4.01±0.31 mg/ L), which means that the effluents from the breweries has the capacity to pollute any body of water that receives it.

A comparison of values of the physicochemical parameters with national and international guidelines for drinking water (Table 4) shows that the pH of study area water is higher than the pH range for USEPA (secondary maximum contaminant level (SMCL) (6.5-8.5), Canadian maximum admissible level (MAL) (6.5-8.5), FEPA permissible limit standards (6.5-8.5). which shows the water is too alkaline for drinking. The turbidity value for study area water (39.6±9.9 NTU) exceeds National drinking water standard for Nigeria (SON) (5.00 NTU) and FEPA permissible limit standards (1.00 NTU). The mean TSS value (300±340 mg/L) exceeds FEPA permissible limit standards (10.0 mg/L). The average TDS value (590±360 mg/L) exceeds USEPA (SMCL) value (500 mg/L), the Canadian maximum acceptable concentration (MAC) (500 mg/L) and FEPA permissible limit standards (500 mg/L). The DO of study area water (6.09±0.45 mg/L) is less than the FEPA permissible limit standards (7.50 mg/L), while the BOD_5 value for study area water (349±230 mg/L) if far above FEPA permissible limit standards for BOD (0.00 mg/L or ND). The mean value of phenol in study area (1.37±0.061 mg/L) exceeds value of WHO'S 2006 drinking water standards (0.20 mg/L) (for 2,4,6,-trichloro phenol), SON National drinking water standards (0.02 mg/L) for 2,4,6 -trichlorophenol) and FEPA permissible limit standards (0.01 mg/L) (for 2,4,6-trichlorophenol).

The average values of the physicochemical parameters of the study area water were also compared with guideline values for non-drinking water uses. The mean pH value for study area water (9.41±12) is higher than guideline range for aquatic life rearing water by California state water quality control board (CSWQCB) (6.5 - 8.5),(Van der Leeden *et al.,* 1990), irrigation water by FAO (1985) (6.5 - 8.1), power generating water by CCREM. (1987) (8.8 - 9.4), livestock rearing water (limiting threshold) by Ontario Ministry of environment (6.0 - 8.50) (Van der Leaden *et al.* 1990), Beverage industry (food canning, freeing Dried, Frozen fruit) water by CCREM (1987) (6.5 – 8.5**),** and iron and steel industry water by CCREM (1987) (6.8 – 7.0). The mean values for turbidity for study area water (39.6±9.9 NTU) exceeds Guideline values for beverage industry (food canning, freezing dried, frozen fruits) water by CCREM (1987) (5.00 NTU) and pulp and paper industry by CCREM (1987) (10.0 mg/L). The mean TSS value for study area water (300±340 mg/L) is higher than guideline value for power generating water by CCREM (1987) (0.05 mg/L),

Table 4: A comparison of values of physicochemical parameters measured in water with national and international guideline for drinking water

PARAMETERS	Values for receiving water	WHO's drinking water standard (who, 2006)	National drinking water standard (SON, 2007)	USEPA contaminant level (MCL) USEPA, 2004	Canadian max. acceptable concentration (CCREM, 1987)	EEC man Admissible level (sayre, 1988)	FEPA permissible (FEPA, 1991)
Temperature ^{o}C	28.7±2.7	No guideline	Ambient	No guideline	No guideline	No guideline	No guideline
pH	9.41±12	No guideline	No guideline	6.5-8.5	5.5-8.5	6.5-8.5	6.5-8.5
Turbidity (NTU)	39.6±9.9	No guideline	5.00	No guideline	No guideline	No guideline	1.00
TSS (mg/L)	300±340	No guideline	No guideline	No guideline	No guideline	No guideline	>10.0
TDS (mg/L)	590±360	No guideline	No guideline	500	500	No guidelines	500
DO (mg/L)	6.09±0.45	No guideline	No guideline	No guideline	No guideline	No guideline	7.5
BOD_5 (mg/L)	349±230	No guideline	No guideline	No guideline	No guideline	No guideline	0(22-25^{o}c)
Phenol (mg/L)	1.37±0.61	0.20	0.20	No guideline	No guideline	No guideline	0.01
Phosphate (mg/L)	1.59±0.48	No guideline	No guideline	No guideline	No guideline	No guideline	>5.00
Total hardness ($mgCaCo_3$/L)	35.8±4.7	No guideline	150	No guideline	No guideline	No guideline	200

**Secondary maximum contaminant level (SMCL) (non-enforceable) **2,4,6-trichlorostenol*
FEPA = Federal Environmental Protection Agency (Now ministry of Environment)
WHO = world Health Organization
USEPA = United State Environmental Protection Agency
SON = Standard Organization of Nigeria
CCREM = Canadian Council of Resource and Environment ministers
EEC = European economic commission (now European Union)

Table 5: Comparison of values for physicochemical parameters in receiving water with guideline for non-drinking water uses.

PARAMETERS	Mean values for receiving water	CSWQCB guideline for Aquatic life water (Fresh water) (Van der Leeden *et al*., 1990)	Guideline for irrigation water (FAO,1985)	Guideline for power generation water (CCREM,1987)	Guideline for livestock water (limitingThresh-old) (Ontario Ministry of Environment, 1980)	CSWQCB Guideline for recreational water (water contact limit) (Van der Leeden *et al.,* 1990)	Guideline for Beverage industry (foodcanning, freezing, dried, frozen fruits) (CCREM, 1987)	Guideline for pulp and paper industry (fine paper) (CCREM, 1987)	Guideline for iron and steel industry (CCREM,1987)
Temperature ^{o}C	28.7±2.7	34.0	No guideline	No guideline	No guideline	30.0	NO guideline	No guideline	No guideline
pH	9.41±12	6.5-8.5	6.5-8.5	8.8-9.4	6.0-8.5	6.0-10.0	6.5-8.5	No guidelines	6.8-7.0
Conductivity ($uscm^{-1}$)	108±52	3000	No guideline	No guideline	No guideline	No guideline	No guideline	No guideline	No guideline
Turbidity (NTU)	39.6±9.9	No guideline	No guideline	No guideline	No guideline	No guideline	<5.00	>10.0	
TSS (mg/L)	3000±340	No guideline	No guideline	<0.05	No guideline	100	<10.0	>10.0	
TDS (mg/L)	590±360	2000	>2000	<0.5	No guideline	No guideline	<500	>200	
DO (mg/L)	6.09±0.48	No guideline	No guideline	<0.007	No guideline	No guideline	No guideline	No guideline	No guideline
COD (mg/L)	500±370	No guideline	No guideline	<1.0	No guideline	No guidelines	No guidelines	No guideline	No guideline
Phosphate (mg/L)	1.59±0.48	No guideline	No guideline	No guideline	500	No guideline	<250	No guideline	>175
Total hardness ($mgCaCO_3/L$)	35.8±4.7	No guideline	No guideline	<0.07	No guideline	No guideline	<250	>100	>50.0
Ca Hardness ($mgCaCO_3/L$)	28.8±4.7	No guideline	No guideline	<0.01	500	No guideline	<100	No guideline	
Mg Hardness ($mgCaCO_3/L$)	7.1±2.7	No guideline	No guideline	<0.01	250	No guideline	No guideline	No guideline	No guideline

Table 6: Classification of surface water quality (Prati et al., 1971)

Condition Index	Excellent 1	Acceptable 2	Slightly polluted 4	Polluted 8	Heavily polluted >8
PH	6.5-8.0	6.0-8.4	5.0-9.0	3.9-10.1	<3.9>10.1
(BOD_5) (ppm)	1.5	3.0	6.0	12.0	>12.0
COD (ppm)	10	20	40	80	>80
Permanganate (mg/L) O_2(kubel test)	2.5	5.0	10.0	20.0	>20.0
Suspended solids (ppm)	20	40	100	278	>278
NH_3 (ppm)	0.1	0.3	0.9	2.7	>2.7
NO_3 (ppm)	4	12	36	108	>108
Cl (ppm)	50	150	300	620	>620
Fe (ppm)	0.1	0.3	0.9	2.7	>2.7
Mn (ppm)	0.05	0.17	0.5	1.0	>1.0
ABS (ppm)	0.09	1.0	3.5	8.5	>8.5
CCE (ppm)	1.0	2.0	4.0	8.0	>8.0

recreational water (water contact limit) by California State water quality control board in 1963 (Van der Leeden *et al*., 1990) (100 mg/L), Beverage industry (food canning, freezing, dried, frozen fruits) water (10.0 mg/L) by CCREM (1987) and pulp and paper industry (fine paper) (10.0mg/L) by CCREM (1987). The mean TDS value for study area water (590±360 mg/L) exceeds guideline for power generating industry water (0.05 mg/L) by CCREM (1987), Beverage industry (food canning, freezing, dried frozen fruits) water (500 mg/L) and pulp and paper(fine paper) (200 mg/L) by CCREM (1987). The mean COD value for study area water (500±370 mg/L) also exceeds guideline for power generating industry water (1.00 mg/L) by CCREM (1987).

The water of study area was classified into class V using the Prati classification table (Table 6) for classification of surface water using a single index (Prati et al., 1971) this is based on the average value of BOD_5 (349±230 mg/L) of study area water. Therefore the foregoing results indicate that the Ikpoba River water may be regarded as heavily polluted The water will require very rigorous treatment before it can be used for drinking purpose. .

A comparison of the water quality characteristics of the Ikpoba river water with water quality characteristics of rivers studied in other places. Table 7 shows that the temperature of study area water (28.7±2.7 ^{o}c) is comparable with values of temperature obtained for Benin River (27.6±1.6 ^{o}C) and Ona/Ogunpa River (26 - 32^{o}) The pH of study area water (9.41±12) is than those for Benin River (5.9±1.1), Ogunpa river (7.7), Ona/Ogunpa rivers (6.6 - 8.1), Crooked Creek (6.68±0.67) and Niger River (at Patani) (6.3). The pH is higher for Ikpoba River probably as a result of the brewery effluents which it receives and which have a high mean pH value (10.3±0.84). The TSS value of study area water (300±340 mg/L) is moderately higher than those for Benin River (80.4±130 mg/L) and Ona/Ogunpa rivers (10 -270 mg/L). The average TDS value for study area river (590±360 mg/L) is comparable with those for Benin River (3300±7700 mg/L), New Calabar River (6.50-4010 mg/L), Ogunpa River (414 mg/L), and crooked creek (200±200 mg/L). The average BOD_5 value for study area water (349±230 mg/L) is comparable with that for Ona/Ogunpa River (13 - 560 mg/L) but higher than that for Ogunpa (16.4 mg/L). The mean COD value for study area water (500±370 mg/L) is comparable with those for New Calabar River (10 - 1000 mg/L) and Ona/Ogunpa Rivers (11.9 - 224 mg/L).

The mean DO value for study area water (6.09±0.48 mg/L) is comparable with those for Benin River (4.9±10 mg/L), New Calabar River (3.40 - 9.10 mg/L), and Ona/Ogunpa River (6.2 - 8.3 mg/L). The mean value for

Table 7: Water quality characteristics of rivers standard elsewhere compared with Ikpoba River

River	Major activities	Temp. ^{O}C	pH	TSS (mg/L)	TDS (mg/L)	BOD_5 (mg/L)	COD (mg/L)	DO (mg/L)	Phenol (mg/L)	PO_4^{3-}(mg/L)	Reference:
Benin	Industry & petroleum prospecting	27.6±1.6	5.9±1.1	80.4±130	3300±7700			4.7±1.0	-	-	Courant *et al.* 1987
New Calabar River	Industry & pet. Prospecting	-	-	-	6.50-4010	0.25-4.20	10-1000	3.40-9.10	-	-	Odokuma & Okpokwasili, 1997
Ogunpa	Industries/ urban area		7.7		414	16.4		2.5		2.36	Ajayi & Adeloya 1977
Ona/Ogunpa	Industries & urban Area	26-32	6.6-8.1	10-270	0.1-5.9	13-560	11.9-224	0.2-8.3	-	-	Oniawa *et al.*, 2001
Crooked Greek	milling A smelting		6.68±0.67	7.1±7.7	200±200	-	10±16	-			Jennet & toil, 1979
Niger River (Patani)	Oil prospecting	-	6.3	-	30.0	-	-	-	-	-	Asonye *et al.* 2007
Ikpoba River	Industries (Breweries)	28.7± 2.7	9.41±12	300±340	590±360	349± 230	500±370	6.09±0.48	1.37± 0.61	1.59±0.48	Present study

phosphate in study area water (1.59±0.48 mg/ L) is also comparable with that obtained for Ogunpa River (2.36 mg/L). Thus the values obtained for all the water characteristics in the study area are generally comparable with corresponding water characteristics obtained for rivers elsewhere except for a few of them where the results are higher for the study area water.

CONCLUSION

Samples of effluents and samples of water from the receiving river (Ikpoba River) were collected and subjected to different analytical procedures to determine values of various physicochemical parameters. A comparison of value of physicochemical characteristics of effluents with the interim effluent guideline of FEPA (Now Federal Ministry of Environment) (1991) shows that the values of some of the physicochemical parameters were higher than guideline values. This indicates that the effluents in the effluent conduits of the breweries were not properly treated before discharge or since the effluents were not collected from the breweries directly their integrity may have been tampered with by discharge of external substances into the effluent conduits by those living around it.. The effluents from the conduits are thus capable of polluting any receiving water body. Also a comparison of values of the physicochemical characteristics of the receiving river water with (i.e. the study area) with national and international guidelines for drinking water and guideline for non-drinking water uses showed they were generally higher than guideline values. The values for study area water are also generally higher than values of water of control area. The water is thus polluted with respect to its uses for drinking and other selected non-drinking uses. Classification of water based on a single index puts water of study area in class v which means that the water can only be used for drinking purpose after rigorous treatment.

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