Pollution survey of Ikpoba River, Benin City, Nigeria.

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Abstract: There have been some growing apprehensions about the level of effluent loading in Ikpoba River and the concomitant implications to human health and safety of aquatic communities. This paper is on the analysis of samples of river water and canalized effluent stream carried out in order to ascertain if the fears are mere obsession. The research results confirm overloading and suggest that the fears are real.

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Introduction

Flowing rivers, if not overloaded with pollutants, can dilute many wastes and can renew their supply of dissolved oxygen gas through exposure to the atmosphere. In Nigeria, there appears to be covert overloading of rivers with untreated industrial and municipal effluents in defiance of National Environmental Standard and Regulation Enforcement Agency (NESREA) applicable legislation on pollution of surface waters. The need therefore for regular environmental audit, such as this study is destined to achieve, becomes imperative.

Shell Petroleum Development Company (SPDC) realizes the great importance of maintaining a balance in ecosystem and therefore set up a product safety and environmental conservation committee with specific guidelines on environmental management.

The company undertakes regular research on health, safety and environment (HSE). On its part, the Federal government has set up statutes and regulations relating to the environment.

The major laws on the environment in Nigeria are:

i. The Nigeria Environmental Standard and Regulations Enforcement Agency Act 2007 (NESREA Acts);
ii. The Environmental Impact Assessment Act (EIA Act); and
iii. The National Oil Spill Detection and Response Agency Act 2005 (NOSDRA Act).

The NOSDRA Act established the National Oil Spill Detection and Response Agency. This is responsible for the coordination and implementation of the National Oil Spill Contingency Plan for the country.

The different states of the federation have also enacted environmental laws that are largely tailored to address their specific environmental challenges.

The treatment disposal aids/reuse of brewery waste had been investigated by several researchers, like, Tonnesen (1996), Boon and Borne (1997), Tomas (1997), Eguaje (1993), Tattersal (1996), Driessen and Vereijken (2003) etc.

The works, Metcalf and Eddy (1991), Bowden and Brown (1984), and Decoopman (1996) deal on technological methods of waste disposal. Ashman (1974) identified various industrial wastes control equipment and their use in control of dust in industrial processes. Tomlinson (1974) classified waste disposal as an additional burden on the cost of production and recommended that the treatment process adopted should give the optimum solution to the waste problem at minimum cost. Alao et al (2010) presented a study on the impact assessment of brewery effluent on water.

Majority of the literature cited above deal with brewery waste management in general. In particular, the work Eguaje (1993), Oguzie and Okhagbuzo (2010), Ekhaise and Anyasi (2005) are seminal to the current study; they deal with effluent loading in Ikpoba River and the environmental impact implication.

The motivating objective of this study is to carry out a stratified environment audit of Ikpoba River by making measurements of existing point source effluent streams and their contamination in the river. In this research setting, we investigate the pollution problem caused primarily by apparent effluent overloading from point sources and other secondary non-point sources such as abattoirs, feedlots, runoffs from land, public sewer line discharges and those from University of Benin

Teaching Hospital (UBTH) sewage, all flowing into the river.

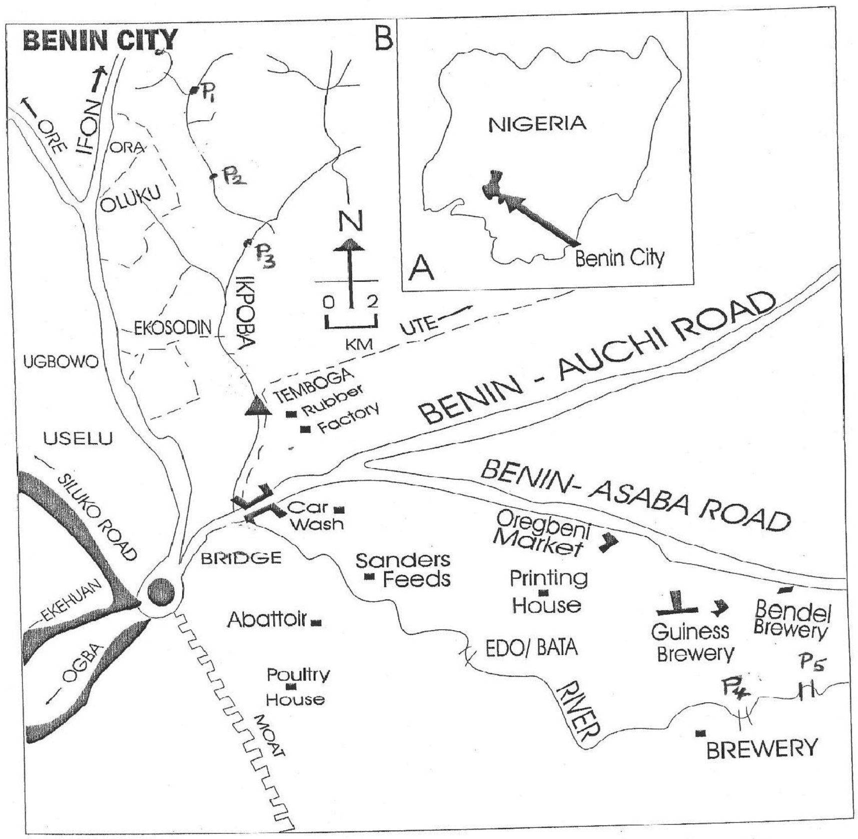

Figure 1. The study area. **A)** Nigeria showing Benin City; **B)** The river studied showing four sampling stations.
Source: Federal Survey Nigeria

Methodology

Data for this study consisted of collection of samples of wastewater at primary point sources namely P4 and P5 which are brewery effluents. However, some samples of river water were collected some 250m upstream to investigate the contamination level of point sources 1-3, see fig. 1. The total brewery effluent discharged per day is the parent population for brewery effluent analysis while the Ikpoba River constitutes the entire population for the river water analysis. Samples of these two are the major sources of experimental data. The effluent line from each brewery are linked and discharged via a common line to the river.

Samples and Sampling Method

Four sampling points were selected for this study. Effluent sample point was selected at effluent discharge point of each brewery to Ikpoba River. Two other sample points for river water sample, one located 250 metre upstream of the first brewery and another 250m downstream of the second brewery, were selected, comprising 4 sampling points on the whole. Samples were collected with wide mouthed 1-litre sample can with cover at about 5-6 metres from the river bank using a canoe. To obtain sample, the cover lids were removed and the container plunged below the water surface, neck down wards. The container was then titled until the neck pointed slightly towards the current. After filling the container, they were brought out rapidly and covered back. The sample container used to obtain sample were previously washed with distilled water and further rinsed with water collected at sample point before sample collection.

Sampling was carried out on a weekly basis for a period of 6 weeks from December 2010 to January 2011. Labelling of sample container was done for easy identification. The samples were taken to the chemical laboratory where they were cooled in a freezer until physicochemical analysis was carried out. It is important to state that the samples were collected in the hours of 10.00am and 12.00 noon believing that effluent discharge and concentration are constant. It was also believed that the river water does not exhibit sudden change in flow and quality so that any sample obtained at any time on a particular day is a true sample.

Effluent parameters of interest in the study include: Temperature, pH, turbidity, dissolved oxygen (DO), Biochemical Oxygen Demand (BOD), and Chemical Oxygen Demand (COD).

Procedure for sample analysis

Effluent parameters were obtained as follows:

i. ***Temperature***

The temperature was measured using calibrated mercury in glass thermometer (0-50^{o}C) to the nearest ± 0.1^{o}C. The thermometer was dipped about 15cm below the water surface and read 3 minutes later.

ii. ***pH.***

An HACH pH meter was used for pH determination. The pH reading for each sample was determined at the time of collecting the sample according to the procedure of HATCH (1991)

iii ***Turbidity***

The turbidity was measured onsite using a microprocessor turbidimeter (HACH Company, model 2100P).

iv. ***Dissolved oxygen (DO):***

Dissolved oxygen was determined by the Azide Modification method of APHA (1989).

v ***Biochemical Oxygen Demand (BOD)***

The standard bottle method (Mara, 1978) was used to measure the BOD

vi **Chemical Oxygen Demand (COD):**

COD was analyzed using the open reflux method (APHA, 1989)

Method of data analysis

The statistical tool employed in data analysis include t-test statistic for determination of significant difference between the samples obtained from upstream and downstream respectively.

The means of each brewery effluent samples was compared with NESREA's maximum contaminant level (MCL) and then between the two samples means.

Validation of instrument

The following precautions were observed in carrying out the effluent analysis to enhance experimental accuracy while operating the various apparatus used.

(i) temperature reading were taken some minutes after dipping the mercury bulb;

(ii) the pH probe was dipped below the liquid surface of the beaker containing the effluent;

(iii) Each sample collected for analysis was obtained after rinsing the sample containers with distil water and some quantity of the sample obtained at the sample point.

(iv) During the incubation period for obtaining the oxygen concentration in BOD measurements, the sample bottles were stored in a dark place to prevent light penetration into it and temperature was maintained at 20°C for the 5 days incubation period.

The river water sample data analysis was conducted with t-test statistics for two population means (variance unknown but equal).

Figure 2: Measurement Point along the river

Since the samples taken at A and B respectively, came from the same population, with the variance unknown, it is expected that they would certainly have the same $\sigma^{2,}$ even though S_1 and S_2 (the sample variances may differ).

Hypothesis;

H_o: $\mu_1 = \mu_2$

H_1: $\mu_1 \neq \mu_2$

Test statistic, $$t = \frac{\bar{x}_1 - \bar{x}_2}{S\sqrt{\left(\frac{1}{n_1} + \frac{1}{n_2}\right)}}$$

Where $$S^2 = \frac{(n_1 - 1)S_1^2 + (n_2 - 1)S_2^2}{n_1 + n_2 - 2}$$

Given two small samples from normal population (river) with same variance, σ^2

Results

Table 1 Shows Results of Effluent Analysis. With a pooled average of 32.0°C (B1) has an average temperature of 36.2°C while the second, (B2) effluent has an average temperature of 33.05°C. The results show that there is a marked departure of breweries effluent temperatures from the legal limit set by NESREA. Moreover, the first brewery's effluent temperature appears significantly higher than the other. One possible explanation of this marked difference is that the breweries with higher effluent temperature probably have higher concentration of caustic soda in their waste water resulting in greater exothermic manifestation of heat. This is expected because the two breweries have different work and safety practices.

pH effect

The pH was alkaline for both breweries; it was in the range: 8.9 ≤ pH ≤ 10.9 with a mean of pH = 10.4. Specifically, the pH range for the first brewery B1 is: 8.9 ≤ pH_{B1} ≤ 11.0 with a sample mean of 10.85. The second brewery had a range: 11.3 ≤ pH_{B2} ≤ 10.3. It is obvious from table 1 that the mean pH value for both breweries exceed the NESREA legal limit of pH = 9.0.

The high alkaline nature of the effluent may be due to large usage of alkaline chemicals in the process line (see Shobo and Adegbite, 1981)

Turbidity effect
The wastewater was characterized by high turbidity whose values ranged from 28.5 – 40.3 NTU with a sample mean of 49. The high turbidity values of effluent may be attributed to the high level of organic matter and total solids. NESREA has not specified any upper limit for turbidity values but EPA, USA specified 5 NTU.

Dissolved Oxygen, DO
The effluent samples had low levels of dissolved oxygen in the range of 0.8 -2.4mg/I with a sample mean of 1.87mg/L for the first brewery while the second brewery had a range of 0.2 – 1.3mg/L. the low dissolved oxygen may be attributed to a high rate of oxidation stemming from the degradation of organic matter and thermal pollution from hot wash water and cooling water being discharged. High temperature serves to decrease the stability of oxygen. Leclerc (1964).
The sample means of dissolved oxygen obtained for both breweries fell short of NESREA standard of beyond 3mg/L for DO. The second brewery, as against the first, had a lower sample mean of DO.

BOD Effect.
The 5-day BOD of the brewery effluent was in the range of 1040-1290mg/L with sample mean of 1215mg/L (ppm) for the first brewery while the second brewery (B2) was in the range of 1190-1450mg/L with a sample mean of 1347mg/L. both breweries sample mean exceeded NESREA standard of 30mg/L for BODs. The significant variation in the levels of the parameter may be ascribable to the differences in composition of the brewery effluent. Adegbite (1981) obtained similar result for industrial effluent and gave similar inferences.

COD effect
The COD of the brewery effluent was in the range of 1700-2100mg/L with a sample mean of 2009mg/L for the first brewery while the second brewery had values in the range of 2048 – 2380mg/I with a sample mean of 2181mg/L. Both breweries effluents exceeded NESREA standard of 80mg/L COD. The high COD values which parallel the BOD values (5-day BOD) may be due to the aggregate concentration of bio-degradable and non-biodegradable component of the waste water.

Results of River water Data Analysis
i. Temperature of river water;

$t_{cal} = - 1.356 > t_{10,0.05} = - 2.23$

t_{cal} falls within acceptable region, we therefore accept H_o and conclude that there is no significant difference between the temperature of sample water at upstream and downstream. Reference to figure 2, we notice that no account of mass and heat transfer, the high temperature at point source cools off to ambient before reaching 250m.

pH value and turbidity
The pH: t_{cal} 1.125 $>t_{10,0.05} = -2.23$

The turbidity: $t_{cal} =-110 > t_{10,0.05} = -2.23$
Since the calculated t – values fall into the acceptable region; we therefore fail to reject the null hypothesis and therefore conclude that the pH and turbidity values are not significantly different from the point source respectively.

Dissolved oxygen, DO
$t_{cal} = 3.46$ $t_{10,0.05} = 2.23$
We therefore fail to reject the null hypothesis, Ho and therefore incline to believe that the DO values at upstream and downstream are significantly different. A possible explanation for this discrepancy can be ascribed to the distance downstream and hence longer time it takes for biochemical degradation to reach completion. The dead organic matters required reasonable quantity of DO to decompose and the microbial organism also require dissolve oxygen (BOD) to survive and bring about biodegradation. The combined effect of all these leads to excessive and prolonged consumption of DO thereby creating an oxygen sag curve occasioned by the septic zone created by biodegradation.

v. **COD POLLUTION SURVEY OF IKPOBA RIVER**

$t_{cal} = -9.2 < t_{10,0.5} = 2.23$

We, as in the immediately previous case fail to accept the null hypothesis that the mean of the COD concentration at upstream and downstream are the same and therefore conclude that there is significantly difference between COD of river water at 250m upstream and that at 250 metre downstream of the effluent point source. The difference in values stems from the reason adduced in the case of DO.

Conclusion;
If $t_{cal} > t(n_1+n_2-2)$, 0.05, fail to accept H_o; otherwise conclude that significant differences exist between

the sample means.

Table 1. Results of Effluent Analysis.

	BOD at 20°C(mg/L) over 5 days		COD at 20°C (mg/L)		DO at 20°C ppm		pH (Dimensionless)		Temp. (°C)		Turbidity (NTU)	
	B1	B2	B1	B2	B1	B2	B1	B2	B1	B2	B1	B2
	1200	1300	1950	2100	0.8	0.2	10.3	10.8	34.0	37.0	28.5	42.5
	1250	1350	2100	2230	1.2	0.6	10.9	11.3	35.0	38.0	34.9	46.3
	1156	1450	2080	2380	1.6	0.7	11.0	10.9	34.5	36.0	40.3	44.5
	1040	1390	1700	2225	1.9	0.5	8.9	10.3	36.0	40.3	40.9	49.6
	1290	1280	2064	2048	2.4	0.8	10.8	10.9	33.0	34.0	33.2	34.5
	-	-	2160	2100	1.5	1.3	10.6	10.7	35.0	37.0	30.5	56.6
Mean, x	**1215**	**1347**	**2009**	**2181**	**1.57**	**0.683**	**10.4**	**10.9**	**34.6**	**36.2**	**33.05**	**49.5**
(NESREA) standard	30		80		3.0		9.0		32.0		-	
USA standard					9.0		7.6				5	

DO = 5.0: seriously polluted
DO = 4.0: gravely polluted
The table above shows that the general temperature of brewing effluent is relatively high; the temperature regime is 33 °C- 36 °C

Discussion

The author has characterized the effluents produced by two beverage-producing firms and established that there appears to be effluent overloading in the river studied. Besides, the results of the effluent analysis suggest that the effluent parameters have values that exceeds the maximum contaminant level MCL specified by NESREA.

It is important to stress that the study did not examine the effluents for pollutants such as dichlorodiphenyltrichloroethane (DDT), Coliform bacteria, radioactive substances, inorganic chemicals and synthetic organic chemicals (SOC) which might be present in the sewer lines and runoff waters that drain into the river. However, the observed contaminants concentrations are in the region of harmful limit and therefore appear hazardous to human health, aquatic communities and livestock physical well being.

Perhaps it is significant to note that the observed trend is not a destiny; we can say no and resolve to reverse it. The authors' warning of threat to lives is not a forecast of doom but the birth pangs of a new world environmental order.

Conclusion

The results of this study have evidently established a case of effluent overloading in the river studied. The concentration of the effluent parameters analyzed was seen to be within harmful limit and exceeds NESREA stipulated legal limits. Further research might be necessary to refute or confirm the results reported

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