

Research Article

Evaluation of the Effects of Industrial Wastewater Discharge on Surface Water (A Case study of Nigeria Breweries Plc Enugu)

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ABSTRACT

The need to undertake an evaluative effect of industrial wastewater discharge on surface water with a case study of Nigerian Breweries Plc Enugu into the Ajali River was borne out of the need to ascertain the level of Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total suspended Solids (TSS) etc and other characterized effluent been discharged into the water body that determines the level of use and quality of this water for irrigation purposes, human consumption and safe ecological habitation of aquatic lives.

To achieve this, laboratory analysis was carried out on the Ajali River and the wastewater discharged from the industry and it was confirmed not to have exceeded the benchmark for required discharge of wastewater into streams and rivers as stipulated by some regulatory bodies.

In conclusion, treatment measures and regulatory policies were suggested to checkmate the abuse of this water bodies and the danger it might likely pose to aquatic ecological system if regulatory standards were not complied with.

Keywords: Evaluation, Effects, Industrial Wastewater, Discharge, Surface Water, Case Study, Nigeria, Breweries, Enugu

INTRODUCTION

The problem posed by the pollution of the environment due to man's (anthropogenic) activities is fast becoming a point that should not be overlooked in today's world (Okereke, 2007). There are tendencies that suggest that pollution (air, water and land) is fast becoming a modern day evil that has come to live with us and are raking in some dangerous effect on human health and well-being.

Nevertheless, while some areas been polluted due to domestic or municipal activities seem to be controlled other forms of pollution arising from man's continual activities in agricultural, industrial and hospitals (biomedical) are on the increase.

Brewery wastewater effluent is highly variable in quality and composition. The pollution discharge from brewery plant effluent comes from the losses in the beer production process and from the clean-in-place (CIP) system located in the brewing house, cellar house and bottling house.

In the examination of wastewater, about 40% of the filterable solids are organic in nature while 75% are suspended solids (Metcalf and Eddy, 1991). The major organic matter in wastewater are protein, carbohydrate and fats and oil, they are however composed of carbon, oxygen, hydrogen, nitrogen and sulphur.

The most widely used analytical method of wastewater organic measurement are the BOD, COD, Total Organic Carbon (TOC), pH, Electrical Conductivity (EC), Sodium Absorption Ratio (SAR). While the BOD is a measure of the amount of dissolved oxygen used by the micro organism in the oxidation of organic matter, COD on the other hand measures the total oxygen required for chemical oxidation of organic matter to carbon dioxide and water.

These makes the proximity of the brewery industries to the receiving water body of importance when considering the toxicity, turbidity and pollution defect in BOD, COD etc of the water for agricultural and aquatic lives relevance; there is however the need to re-cycle or convert these waste water to new useful materials amidst the fear of its eventual diminution in the supply of raw materials.

These are further complemented if a waste water treatment plant is installed to treat brewery wastewater prior to discharge to water bodies. These can be carried out with either the conventional method or the advanced treatment method (Tchobanoglous et al, 2003).

MATERIALS AND METHODS

The water samples used for these analyses were those collected from Nigeria Brewery Enugu effluent discharge point and water from Ajali River some miles away from the discharge point.

The forms of analytical processes used in this work were of the standard used by American Standards of Testing Materials (ASTM), American Public Health Association (APHA) American Petroleum Institute (API) and Federal Environmental Protection Agency (FEPA) Nigeria.

RESULTS

The results of the analysis carried out on the wastewater effluent from Nigerian Brewery Enugu and that some distance away from its point of discharge into the Ajali River and its comparison with the World Health Organisation (WHO) and Federal Environmental Protection Agency (FEPA) standards are shown in table 1. In order to carry out an elaborate and an all encompassing evaluative effect of industrial wastewater discharge into surface water in order to meet the set objectives of this work some other standardized requirements were also used in addition to table 1, these requirements are presented as appendices A – J.

TABLE 1: Qualitative Analysis Of Brewery Effluent From Nigerian Brewery Enugu And Ajali River And Its Comparison With Who And Fepa Standards

A	CHEMICAL TEST	SAMPLE A (EFFLUENT)	SAMPLE B (AJALI RIVER WATER)	WHO STANDARD	FEPA STANDARD
1.	BOD at 20 ^o c of do	26.40	8.20		30
2.	COD	14.80	1.30		80
3.	DO	2.70	5.30		Not < 2
4.	Oil and Grease	1.90	1.10	Nil	10
5.	Alkalinit	360.00	50.00	-	NS
6.	Acidity	41.50	28.50	-	NS
7.	Zn	0.01	<0.01	-	<1
8.	Fe ^{3t}	28.04	1.82	0.3	20
9.	Ca ^{2t}	NS	NS	200-600	200
10.	Mg ^{2t}	8.76	4.85	NS	200
11.	Na ^t	41.23	5.00	75	NS
12.	Pb	0.003	0.002	-	<1
13.	Ni	0.01	V0.01	-	<1
14.	Nitrogen	2.10	0.48	4-4.5	20
15.	Chloride	6.50	6.00	75	600
16.	50 ₄ ³⁻	34.00	35.00	-	500
17.	PO ₄ ³⁻	64.50	15.00	NS	5
18.	Boron	NS	NS	NS	5
19.	Mn	NS	NS	-	5
20.	Bicarbonate	628.30	27.50	NS	NS
B	PHYSICAL TEST				
21.	Colour	5.49	328.30	5	25
22.	pH at 25 ^o c	7.10	7.90	6.5-8.5	6-9
23.	Temp(0oc)	7.10	7.90	6.5-8.5	6-9
24.	Odour	Objectionable	Unobjectionable	Odourless	Odourless
25.	TSS	38.50	1520.00	Nil	30
26.	TDS	558.00	45.80	50	2000
27.	Total Hardness	50.00	15.00	-	NS
28.	SAR	14.84	17.33	NS	NS
29.	Conductivity at 25o (ps/cm)	1108.00	89.00	NS	NS
30.	Turbidity (NTU)	33.10	1464.00	-	NS
31.	ESP	17.10	19.55	-	NS
C	BIOLOGICAL TEST				
32.	Faecal Coliforms	0.00	0.00	NS	400MPN/100ml

* All units are in mg/l except stated otherwise.

** NS-Not stated

DISCUSSION

The values of BOD, COD, DO and TDS (from table 1) fall within the limit set by FEPA for both aquatic habitation and human consumption. However, on further analysis, the turbidity and TSS values of the Ajali River can pose serious injurious effect on aquatic lives if preventive measures are not taken to forestall the washing of large and heavy materials alongside small clay dirt particles into the water course.

The values of faecal coliform, colour, odour, temperature, pH, Nitrogen or Nitrates, Sulphates etc of the brewery effluent poses no further treat to aquatic lives as it conforms to standard as shown in table I and appendices I and J. These values however slightly deviated in the Ajali River.

A further analytical study to determine the quality level of the Ajali River for irrigation and other agricultural purposes showed that from table 1 and appendix F, the river can be used for saline soil without an increase in the soil salinity. Appendices B, C and F when compared with results in table 1 for Exchangeable Sodium Percentage (ESP) shows that the Ajali River falls within Class 1 water with an ESP Limit of 0.60 and an excellent-to-good remark in its use for irrigation water.

The values of the total dissolved salts (TDS) and conductivity (table 1) of the Ajali River are satisfactory as it lies within 0-700 ppm (for TDS), 0-1000 micromhos per cm and less than $250\mu\text{ s/cm}$ (appendices B and C) for excellent-to-good irrigation water. The water also has low salinity ($< 250\mu\text{ s/cm}$) in conformation with appendix B. It equally has no restriction for use as irrigation water since its TDS value $< 450\text{ mg/l}$ (appendix E).

For an evaluation of essential elements and soluble salts needed for the soil, minor elements like iron and zinc required for irrigation water were 1.82 mg/l and less than 0.01 mg/l (table 1). Both elements met the requirement 20 times on fine textured neutral to alkaline (pH of 6-8.6) (Appendix A). Elements like sodium, chloride, nitrogen (nitrates) and bicarbonate have the following degree of restriction on use (Appendix E).

- Sodium: the water can be used for surface irrigation but has a slight-to-moderate restriction for sprinkler irrigation.
- Chloride: has a slight-to-moderate restriction on surface and sprinkler irrigation.
- Bicarbonate: With a value of 27.50 mg/l (table 1) for the Ajali River has a severe restriction on use (appendix E) for both surface and sprinkler irrigation.
- Nitrogen (nitrate): has no restriction on use.
- Sulphate: The river water is considered excellent-to-good water for irrigation (appendix C) since its sulphate value of 35.00 mg/l (table 1) lies between (0-192) mg/l (appendix C).

Other elements like lead, nickel, sodium, manganese etc which from appendix H are non-essential to plants but are needed for other purposes which could be of importance to certain plants like sugar, beets and for the growth and health of human and animals that consume them.

CONCLUSION AND RECOMMENDATION

The BOD, COD, DO, Oil and grease and TDS values of 26.40 mg/l , 14.80 mg/l , 2.7 mg/l , 1.9 mg/l , and 558 mg/l for the brewery effluent discharge were within limits set by FEPA for effluent discharge into surface waters from industries. The brewery effluent had tolerable amounts of trace element needed for the aquatic lives macro-minerals requirement. This was practically demonstrated in a fish pond close to the brewery discharge which was used to test the effluent water effect on aquatic lives. The effluent at the point of discharge however requires the water to be treated before it would satisfy WHO standard for drinking water.

On the other hand, the Ajali River water met the FEPA limit with BOD- 8.2 mg/l ; COD- 1.3 mg/l ; DO- 5.3 mg/l ; Oil and grease – 1.1 mg/l and TDS - 45.8 mg/l for aquatic lives habitation. However, parameters like odour, colour, turbidity and TSS were unsatisfactory with FEPA and WHO standard for both drinking water and agricultural purposes (like aquaculture, although slightly) at such would require some treatment.

Other parameters like SAR, ESP, pH, Electrical conductivity, Total hardness, Trace elements, TDS, Acidity and soluble salts were satisfactorily met by the Ajali River water in line with Appendices A-J and at such, the water can be used for irrigation purposes.

In the light of the above and to ensure that our surface waters are safe from the hazards of effluent discharge from industries there is a clarion call for legislation and regulation by Governments of Nigeria to further checkmate industries and companies operating in its shores as most of them conform to this maxim "think global and act local".

In furtherance of this regulation and legislation, the following control measures are recommended

- 1) **Brewery water consumption limit:** This regulatory measure ensures that maximum limit is set for water consumption in breweries. This ensures cost efficiency and responsible discharge of waste water into water bodies.
- 2) **Effluent discharge limits:** In accordance with FEPA discharge standard, routine check-up should be made by FEPA on Industries with a view to ensuring their compliance. In cases where the effluent fails

to meet these standards, further treatment processes should be used before discharge, otherwise strict penalty and fines should be administered on defaulting industries.

- 3) **Implementation schedule:** Although Nigeria Brewery PLC Enugu has a state-of-the art Wastewater Treatment Plant (WWTP) and On Site Sewage Facilities (OSSF) required to meet the FEPA effluent discharge. In cases where new breweries or industries are to be set up, they should have an efficiently and sophisticated WWTP and OSSF which are to be monitored regularly within a stipulated time frame. This should also apply to existing industries nationwide.

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APPENDIX A: Recommended Maximum Limit of Trace Elements in Irrigation Water (Mg/L)

PARAMETERS	PERMANENT IRRIGATION TO ALL SOIL	IRRIGATION UP TO 20 TIMES ON FINE TEXTURED NEUTRAL-TO- ALKALINE (PH.OF 6.0-8.6)
Aluminum	0.50	20.0
Arsenic	0.10	2.0
Beryllium	0.10	0.50
Boron		
Sensitive Crops	0.75	2.0
Semi /sensitive Crops	1.00	-
Tolerance crops	2.00	
Cadmium	0.01	0.05
Chromium	0.10	1.00
Cobalt	0.05	5.00
Copper	0.20	5.00
Fluoride	1.00	15.00
Iron	5.00	20.00
Lead	5.00	10.00
Lithium (citrus)	0.75	0.075
Manganese	0.20	10.1
Molybdenum	0.01	0.05
Nickel	0.02	2.00
Selenium	0.02	0.02
Zinc	2.00	10.0
Vanadium	0.10	1.00

Source: National Academy of Science and Engineering, 1972

APPENDIX B: Classification of Irrigation Water Based on Salinity Level

S/N	SALINITY LEVEL	ELECTRICAL CONDUCTIVITY
1.	Low salinity	<250 μ S/cm
2.	MEDIUM salinity	250-750 μ S/cm
3.	High salinity	750-2250 μ S/cm
4.	Very high salinity	>2250 μ S/cm

Source: Calvin, 1969

APPENDIX C: Standards for Irrigation Water

TOTAL DISSOLVED SALATS (TDS) P.P.M	ELECTRICAL CONDUCTIVITY. (MICROMHOS PER CM)	EXCHANGE ABLE SODIUM PERCENTAGE (ESP)	CHLORIDE (P.P.M)	SULPHATE (P.P.M)	BORON (P.P.M)	REMARK
0-700	0-1000	0-60	0-142	0-192	0-0.5	Excellent to good
700-2000	1000-3000	60-75	142-355	192-480	0.5-20	Good to injurious
Over 2000	OVER 3000	Over 75	Over 355	Over 480	Over 2.0	Unfit for irrigation

Source: Arora, 2007

APPENDIX D: Quality Classification of Water for Irrigation

CLASS OF WATER	PERCENTAGE OF SODIUM	SPECIFIC CONDUCTANCE μ S/cm $\times 10^3$ AT 25 $^{\circ}$ C	BORON (mg/L)		
			SENSITIVE CORPS	SEMI SENSITIVE CROPS	TOLERANCE CROPS
EXCELLENT	<20	<250	<0.33	<0.67	<100
GOOD	20-40	250-750	0.33-0.67	0.67-1.33	1.00-2.00
PERMISSIBLE	40-60	750-2000	0.67-1.00	1.33-2.00	2.00-3.00
DOUBTFUL	60-80	2000-3000	1.00-1.25	2.00-2.50	3.00-3.75
UNSUITABLE	>80	>3000	>1.25	>2.50	73.75

Source: Wilcox, 1972

APPENDIX E: Guideline for Interpretation of Water for Various Forms Of Irrigation

POTENTIAL IRRIGATION PROBLEMS	UNIT	DEGREE OF RESTRICTION ON USE		
		None	Slight-to-moderate	Severe
Salinity				
Electrical Conductivity ECW	dS/m	<0.7	0.7-0.3	>3.0
Total dissolved salts	Mg/L	<450	450-2000	>2000
Infiltration				
SAR at 0-3		ECW=0.9	0.2-0.7	<0.2
SAR at 3-6		EW=1.2	0.3-1.2	<0.3
SAR at 6-12		ECW=1.9	0.5-1.9	<0.5
SAR at 12-20		ECW=2.9	1.3-2.9	<1.3
SAR at 20-40		ECW=5	2.9-5	<2.9
Specific ion toxicity				
Sodium (Na ⁺)				
Surface irrigation	Mg/L	>3	3.9	<9
Sprinkler irrigation	Mg/L	>3	>3	-
Choloride (Cl)				
Surface irrigation	Mg/L	<4	4.0-10.0	>10
Sprinkler irrigation	Mg/L	<3	>3.0	-
Boron	Mg/L	<0.7	0.7-3.0	>3.0
Miscellaneous effects				
Nitrogen (N03-N)	Mg/L	<5	5.3	>30
Bicarbonate (He03)	Mg/L	<1.5	1.5-8.5	>8.5
pH		6.5-8.4	6.5-8.5	6.5-8.5

Source: Maltheus, F.A.G and Walid, H.S, 2000

APPENDIX F: Classification of Soil Based on Alkali and Saline Level

TYPES OF SOIL	ELECRICAL CONDUCTIVITY (MICROMHOS/CM) AT 25°C	EXCHANGEABLE SODIUM PERCENTAGE	pH VALUE
Saline	>4000	>15	8.50
Saline-alkali	>4000	>15	About 8.50
Alkali	<4000	>15	Between 8.5 and 10.0

Source: Arora, 2007

APPENDIX G: ESSENTIAL ELEMENTS NEEDED IN A SOIL

S/N	COMPONENTS OF THE ELEMENTS
Group 1	Water and air elements: Natural, Oxygen Hydrogen and carbon
Group 2	Fertilizer elements: Nitrogen, Phosphors, Surplus and Potassium.
Group 3	Lime elements: Calcium and Magnesium
Group 4	Minor elements: Iron, Manganese, Boron, Zinc, Copper and Molybdenum

Source: Arora, 2007

APPENDIX H: Non Essential Elements Not Needed By Plants but for Other Purposes

S/N	COMPONENT OF ELEMENT	RELEVANCE
Group 1	Sodium, Silicon, Cobalt, Titanium and Nickel	(1) Sodium requires for growth of sugar beets (2) Silicon required for strengthening of small grain plant straw
Group 2	Chlorine, iodine, cobalt and sodium	Required for human and animals health and growth
Group 3	Selenium, leads, arsenic, thallium, fluorine and molybdenum	No required for plant and injurious to human beings and animals that consumes them
Group 4	Sodium, Chlorine, Fluorine, nickel, lead, arsenic, selenium, aluminium, manganese and chromium	Not relevant to plants growth. Moreover at a significant quantity are toxic to plants.
Group 5	Lithium, strontium, tin, radium, beryllium, vanadium, Barium, mercury, silver and bromine	Not needed by plants growth (essentially),but their occurrence in some plant stimulate their growth, they are considered as impurities in plant food.

Source: Arora, 2007

APPENDIX I: Secondary Standard of Microorganism in Drinking Water

Contaminate	MGLC Mg/L	MCL(mg/L)	Potential health effects from ingestion of water	Sources of contaminants in drinking water
Total coliforms (including faecal coliform and E.coli)	Zero	5%	Not a health threat itself, it is used to indicate whether other potential harmful bacteria may be present	Coliforms are naturally present in the environment, as well as feces, faecal coliforms and E.coli only come from human and animal fecal waste
Giardia lamblia	Zero	TT	Gastrointestinal illness (e.g. diarrhea, cramps, vomiting)	Human and animal faecal waste
Heterotrophic plate count	n/a	TT	HPC has no health effect, it is an analytical method used to measure the varieties of bacteria that are common in water. The lower the concentration of bacteria in drinking water, the better maintained the water system is.	HPC measures a range of bacteria that are naturally present in the environment.

Source: United State EPA, 2005

APPENDIX J: Secondary Standard Of In Organic Chemicals For Drinking Water

Contaminant	MGLC Mg/L	MCL(mg/L)	Potential health effects from ingestion of water	Sources of contaminants in drinking water
Nitrate	10	10	Infants below the age of six months who drink water containing nitrate in excess of the MCL could become seriously ill and, if untreated, may Die. Symptoms include shortness of breath and blue- baby syndrome	Run off from fertilizer use, leaching from septic tanks sewage, erosion of natural deposits.
Nitrate measured as (nitrogen)	1	1	Applicable to that of nitrate as shown above	Applicable to that of nitrate as shown above
Fluoride	4.0	4.0	Bone disease (pain and tenderness of the bones) children may get mottled teeth	Water additives which promotes strong teeth; erosion of natural deposits discharge from fertilizer and aluminum factorized
Lead	Zero	TT action level of 0.015	Infants and children delays in physical or mental development; children could show slight deficits in attention span and learning abilities. Adults: kidney problems' high blood pressure.	Corrosion of house hold plumbing systems, erosion of natural deposit.
Mercury (Organic)	0.002	0.002	Kidney damage	Erosion of natural deposit discharge from refineries and factories, runoff from land fill crop lands.
Copper	1.3	TT action level of 1.3	Short term; exposure gastrointestinal distress. Long term exposure: liver or kidney damage	Corrosion of house hold plumbing systems; erosion of natural deposits.

Source: United State EPA, 2005

MCL: Maximum Contaminant Level

MCLG: Maximum Contaminant Level Goal

TT: Treatment Technique

EPA: Environmental Protection Agency