Assessment of Brewery Effluents Quality Discharged into Treatment Ponds in Uyo, Akwa Ibom State, Nigeria

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Abstract
The brewery effluent discharged with the sole aim of undergoing natural treatment was assessed seasonally for its quality using APHA standard method for the analysis of the water samples. The results obtained were compared with the Federal Ministry of Environment (FMENV) limits and were found to be significantly higher than the FMENV limits. Significant seasonal variations were recorded between the wet and dry seasons for the analysed parameters in the effluents. A consistently high level of the parameters was recorded across the two seasons (wet/dry). The generally significantly higher results obtained from this research compared with the FMENV limits; portends hazards to human health as the water from this treatment pond eventually gets discharged into the natural water bodies, thereby polluting surface and ground water sources used for arable and aquaculture/ capture fisheries for food purposes. These contaminants adversely impacts humans when they get into the food chain through bio-accumulation and bio-magnification processes. Measures to abate aquatic pollution from this and similar facilities within the Niger Delta region, such as setting up of standard effluent treatment plants and regulations/enforcement are recommended.

Key words: *Brewery, Effluent quality, Treatment ponds, Assessment and Seasonal*

Introduction

Adekunle *et al*. (2008); Oluwayemisi and Fagade (2012) referred to pollution as the introduction of contaminants into water body, and it is anything provoking offensive conditions in water body and affecting adversely any uses to which the water was meant. Omoleke (2004) reported that pollution can cause a change in environment which is detrimental to most autochthonous life. The problems facing the environment are vast and diverse. Water pollution is serious problem globally involving the discharge of dissolved or suspended substances into groundwater, streams, rivers and oceans. A major source of pollution in developing countries is industrial activities and this has gradually increased the problem of waste disposal. Increased industrial activities have led to pollution stress on surface water both from industrial, agricultural and domestic sources. Untreated liquid wastes from processing factories located in cities are discharged into inland water bodies resulting in stench, discoloration and a greasy oily nature of such water bodies (Olajumoke *et al*., 2010).

Over the last few decades, the adverse impacts of industrial wastes and/or pollutants on the environment have increasingly become a major concern of regulatory agencies and businesses. 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; Egwuonwu *et al*., 2012). 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 have 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 (Egwuonwu *et al*., 2012).

Brewery plants have been known to cause pollution by discharging effluent into receiving stream, ground water and soil. Water consumption for breweries generally ranges 4-8 cubic meters per cubic meter of beer produced. Production steps include malt production, wort production and beer production. Untreated effluent typically contains suspended solids in range 10-60mg/l per litre, BOD in range 1000- 1500mg/l, COD in range 1800-3000mg/l and nitrogen in range 30-100mg/l.Effluents from individual process steps are variable. For example bottle washing produces large volume of effluent that, however, contains only a minor part of total organics discharged from brewery. Effluents from fermentation and filtering are high in organics and BOD and low in volume, accounting for about 3% of total waste volume but 97% of BOD. Brewery effluent contains organic material such as spent grains, waste yeast, spent hops and grit. Effluent pH averages about 7 for combined effluent but can fluctuate from 3-12 depending on the use of acid or alkaline cleaning agent (Olajumoke *et al*., 2010). In the examination of wastewater, about 40% of the filterable solids are organic in nature while 75% are suspended solids (Tchobanoglous *et al*., 2003; Egwuonwu *et al*., 2012). The major organic matter in wastewater are protein, carbohydrate and fats and oil, they are however composed of carbon, oxygen, hydrogen, nitrogen and sulphur.

Sewage or wastewater sludge is a rich source of organic matter and nutrients, this wastewater contains all the substances that enter in human metabolism, such as food, beverages, pharmaceuticals, a great variety of household chemicals and the substances discharged from trade and industry to the sewer system [Jakubus and Czekala, 2001; Kroiss, 2003; Lasheen *et al*., 2003; Olowu *et al*., 2012].

Within a management hierarchy, pollution prevention should be the top priority and should include: prevention and reduction, recycling and reuse, treatment, and disposal (Dickens, 1993). Consequently, pollution prevention planning becomes of major importance in minimizing adverse environmental impacts resulting from industrial activities. A primary component of a pollution prevention program is the development of a pollution prevention plan.

Thus there is need to prevent and control the pollution of surface and ground water since the public health and wellbeing of the people have a direct link with the availability of adequate quantity of good quality water. `The aim of this study is to assess the characteristics of fast-changing parameters in brewery effluents discharged into treatment pond.

Methodology

Study Area

The study area is in equatorial West Africa, which comprises the region lying between latitude 5⁰ 14ᴵ and 38ᴵᴵNorth of the equator, and longitude 7° 37ᴵ, 33ᴵ, and 34ᴵ on the Atlantic Coast of Africa.

The brewery is located at Aka Offot Industrial Layout, Uyo Local Government Area of Akwa Ibom State, Nigeria. The Brewery was inaugurated in 1974. The brewery is a Nigeria-based company, which is engaged in brewing business. The Company's principal activity is to carry on the business of brewing and marketing of alcoholic and non-alcoholic beverages in Nigeria, as well as provide contract brewing and packaging services to Nigerian Breweries Plc. The Company is involved in the brewing and marketing of Lager Beer and Malt. The Company operates in the Nigeria geographical segment. Its Malt is a flavored beer with a golden color and aroma. The Company's Malt is available in approximately 60 centiliters (cl) bottles (12 Bottles per Crate). A range of products are produced.

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POND-1 receives raw effluent from the brewery processes which over time spills or drains into POND-2. The major visible composition of effluents is spent grains and petroleum product. While in POND-1, a lot of bio-transformation processes are believed to have taken place. Because of the daily flow of raw effluent into POND-1 which having filled to capacity, overflows it’s bound into POND-2. The edge of the POND-1 is covered with the spent petroleum product and as the effluent is aging, algal growth (called laema) develops and covers both ponds. It is from these ponds the vegetable farms around are watered.

Fig. 1: Map showing the Study Area- Champion Brewery Treatment Ponds

Sampling of Breweries Wastewater Effluent

Two season sampling was conducted with wet season carried out in July, 2016 and dry season sampling in December, 2016. Treatment Ponds 1 and 2 were directly sampled for *in situ* water quality parameters: pH, Temperature, Electrical Conductivity (EC), Total Dissolved Solids (TDS), Dissolved Oxygen (DO) and Turbidity, using highly sensitive, well calibrated portable meters, and water samples were collected using sterile 1litre containers for physicochemical analysis including Sulphate, Chemical Oxygen Demand (COD), Biological Oxygen Demand (BOD_5), Oil and Grease (O/G), Zinc, and Copper. Samples were transported in an ice pack to the laboratory and stored at 4 ^oC. Samples for heavy metal content were fixed with nitric acid, while samples for oil and grease analysis were collected in water tight glass container and preserved with sulphuric acid. Samples for BOD_5 determination were collected in amber bottles.

Physicochemical Analysis

Physicochemical properties of water samples was determined by standard methods for Examination of Water and Wastewater (APHA, AWWA and WEF, 2012).

Statistical Analysis

Using the data below, a data analysis was conducted using SPSS (10.7 Version) to find out if there is any significant difference (variation) in the Physicochemical Characteristics of each of the Breweries Wastewater Effluent parameters in wet and dry season. To make the analysis easily understood, Independent t-test was used to test for the significant differences between each of the parameters in both seasons.

Results and Discussion

The results (as indicated in figure 2 and tables 1 and 2) revealed high pollution level on the recipient environment. This however, varied with season and the age of the pond. During wet season, POND-1 was alkaline in nature owing to its reception of fresh effluent, and this became slightly acidic in POND-2. A reverse is the case with the dry season as both ponds were highly acidic. The mean values of BOD, COD, electrical conductivity as well as total dissolved solids were higher than the regulatory limit in both ponds. The sulphate content was well within the given limit of 250mg/l in both ponds. Zinc was found to be below the FMENV limit, while copper rose above the stated limit in POND-1 and POND-2.

Statistically, the result shows that the mean pH parameter during the wet season was 7.32 with a standard deviation of 1.15 and that of the dry season was 5.53 with a standard deviation of 0.39. The calculated t-value of 3.621 was obtained with 10 degree of freedom and the p-value of 0.005. since $P<0.05$ (level of significance), it means that there was a significant differences in the pH level of physicochemical characteristics of the Breweries Wastewater Effluent between the wet and dry season. However, the pH level during the wet season (7.32) was significantly higher than that of the dry season (5.53). The observed pH mean values from POND-1 were found to be alkaline as in being fresh effluent and as the age of the effluent increases the pH becomes low especially during dry season indicating high acidic content. Olorode and Fagade (2012) reported low pH in brewery effluent obtained from streams in western region of Nigeria. They attributed the low pH to some chemicals preservatives used in brewery such as sulphur dioxide and carbon dioxide which in turn form trioxosulphate(iv) and carbonic acid, on reaction with water respectively.

Omoleke (2004); Olorode and Fagade (2012) described the temperature and the Dissolved Oxygen as allied parameters stating that the higher the temperature, the lower the dissolved oxygen and higher the BOD. As shown above, the mean temperature in the wet season was 30.067°C with a standard deviation of 0.82 while during the dry season the mean temperature increased to 33.73°C with a standard deviation of 0.42. The calculated t-value was -9.72 with 10 degree of freedom. Most importantly, the p-value of 0.000 was obtained. Hence, since the result shows that there is a significant variation in the temperature reading between the wet and the dry season. Temperature during the dry season was significantly higher than the temperature during the wet season. There is a great variation in dissolved oxygen between the two seasons; with the significant level of 0.000, it clearly shows that there is a great difference in the level of dissolved oxygen between wet and dry season. During the wet season, the mean was 5.77mg/l while the dry season was 1.48mg/l meaning that it was higher during the wet season than the dry season. Statistically, with the p-value of 0.216, it is established that there is no significant differences in the biological oxygen demand between the two seasons. Despite having the mean of the biological oxygen demand in the wet season to be 35.47mg/l against the dry season with 43.92mg/l, the p-value claimed that there was no significant seasonal variation in the biological oxygen demand.

During the wet season, the mean of the chemical oxygen demand was 43.00mg/l while during the dry season, it increases to 64.32mg/l with the p-value of 0.44, showing a significant difference in chemical oxygen demand between the two seasons. It was high during the dry season than the wet season. These values are lower than the 150mg/l set by FMENV. In a similar study, Alao *et al*. (2010), found high COD content in the effluent and they suspected chemical additives to be responsible for the high content.

The result $P>0.987$ (significant level) shows that there was no significant difference in the turbidity level between the wet and dry season. During wet season, the turbidity mean level was 143.12NTU while that of the dry season was 143.8167NTU meaning that there were no significant differences between the two seasons. Turbidity levels in both seasons were higher than the FMENV limit of 5NTU.

When comparing the differences in total dissolved solids between the two seasons, the mean value for wet season was 1206.20mg/l with a standard deviation of 215.71 while that of dry season is 1725.15mg/l with 321.62 as the standard deviation. A t-test value of -3.28 was gotten and with the p-value of 0.008. $p<0.05$ meaning that there was a significant difference in the total dissolved solids between the wet and dry season. Thus, the value was significantly higher during the dry season than the wet season.

In the same vein, when comparing the differences in electrical conductivity between the two seasons, the mean for wet season is 1721.00µS/cm with a standard deviation of 305.65 while that of dry season is 2464.48 µS/cm with a standard deviation of 459.45. A t-test value of -3.300 was achieved and with the p-value of 0.008, the result was significant at 2-tailed test. Meaning that there was a significant different in the electric conductivity between the wet and dry season. Thus, the value was significantly higher during the dry season than the wet season. Nweke and Sander (2009) observed that the chloride content is directly proportional to the electrical conductivity which is quite in support of this work.

From the result, the mean value of sulphate during wet season (50.13mg/l) was lower than during the dry season (63.77mg/l). But be as it may, the p-value of 0.284 summarized it all that there is no seasonal variation in sulphate. The measured values were below the FMENV limit of 250mg/l.

The edge of the POND-1 is lined by spent petroleum product. This seems to trap trash, plants, and other materials, causing foul odours. From the result, the p-value is 0.097 (p>0.05) which means that there was no significant difference in oil and grease parameter reading between the wet and dry season. But, oil and grease reading was a little higher during the dry season (21.05mg/l) than the wet season (11.97mg/l). These values are above the FMENV limit of 10mg/l. Osinbanjo *et al*. (2011); Bedu-Addo and Akanwarewiak (2012) reported that oil and grease has potential to cause environmental pollution.

From the result, the p-value of 0.017 (p<0.05) shows that there is a significant different in copper between the wet and dry season. However, the mean value of 11.11mg/l during wet season and 22.07mg/l during the dry season shows that copper was significantly higher during the dry season. While testing for the seasonal changes in zinc, it was gathered that the mean value of zinc during the wet season was 1.37mg/l while during the dry season it increased to 2.11mg/l. meaning that there was a great increase in zinc level during the dry season. The p-value of 0.045 (p<0.05) proved that there is a significant variation in zinc level between wet and dry season. The results also showed that the ponds are highly contaminated with copper as confirmed by Kabata-Pendias and Pendias (2001); Olowu *et al*. (2012). Adewuyi *et al*. (2010) reported copper concentration levels above normal range are highly unsafe and pose health risks to the environment. Still on heavy metal content of the effluent, zinc concentration was observed to be within the FMENV limit of 3.00mg/l in all seasons.

Table 1: Wet Season Physicochemical Characteristics of Breweries Wastewater Effluent

Parameter	**Pond₁**			**Mean**	**Pond₂**			**Mean**	**FMENV Limit**
	1	**2**	**3**		**1**	**2**	**3**		
pH	7.67	8.45	8.82	8.31±0.59	6.23	6.31	6.46	6.33±0.12	6.5-8.5
Temperature (ºC)	30.1	31.5	29.7	30.4±0.94	29.4	30.4	29.3	29.7±0.61	-
Elect. Conductivity (µS/cm)	2100.2	2017.6	1800.4	1972.7±154.9	1345.6	1620.5	1441.7	1469.266±139.5	1000
Total Dissolved Solids (mg/l)	1470.1	1412.3	1260.3	1380.9±108.4	941.9	1134.4	1009.2	1028.5±97.7	500
Dissolved Oxygen (mg/l)	4.3	6.3	5.8	5.47±1.04	5.4	6.6	6.2	6.066±0.61	-
Turbidity (NTU)	181.3	205.6	210.4	199.1±15.60	88.3	94.6	78.5	87.133±8.11	5
Chemical Oxygen Demand (mg/l)	55.3	51.6	53.3	53.4±1.85	32.4	32.6	31.8	32.266±0.42	150
Biological Oxygen Demand (mg/l)	33.8	41.6	45.2	40.2±5.83	22.5	27.1	21.1	23.566±3.14	10
Oil and Grease (mg/l)	16.7	19	15.2	16.97±1.91	8.3	6.4	6.2	6.966±1.16	10
Sulphate (mg/l)	70.5	62.4	62.8	65.2±4.57	34.2	36.3	34.6	35.033±1.12	250
Zinc (mg/l)	1.233	2.341	1.823	1.799±0.55	0.321	1.121	1.424	0.955±0.57	3.00
Copper (mg/l)	15.131	14.134	15.32	14.862±0.64	7.214	7.434	7.462	7.37±0.14	1.00

Table 2: Dry Season Physicochemical Characteristics of Breweries Wastewater Effluent

Parameter	Pond1			Mean	Pond2			Mean	FMENV Limit
	1	2	3		1	2	3		
pH	5.37	5.07	5.14	5.19±0.16	5.77	6.01	5.82	5.866±0.13	6.5-8.5
Temperature (ºC)	33.4	34	33.8	33.733±0.31	34.4	33.2	33.6	33.733±0.61	-
Elect. Conductivity (µS/cm)	2722.1	3010.3	2884.1	2872.166±144.5	2000.4	2008.4	2161.6	2056.8±90.8	1000
Total Dissolved Solids (mg/l)	1905.5	2107.2	2018.9	2010.533±101.1	1400.3	1405.9	1513.1	1439.766±63.6	500
Dissolved Oxygen (mg/l)	1.8	1.4	1.7	1.633±0.21	1.1	1.5	1.4	1.333±0.21	-
Turbidity (NTU)	211.5	217.3	224.6	217.8±6.56	78.2	66.1	65.2	69.833±7.26	5
Chemical Oxygen Demand (mg/l)	78.6	82.4	85.3	82.1±3.36	48.3	44.7	46.6	46.533±1.80	150
Biological Oxygen Demand (mg/l)	50.5	49.7	50.8	50.333±0.57	35.3	38.4	38.8	37.5±1.92	10
Oil and Grease (mg/l)	30.6	30.8	31.2	30.866±0.31	11.6	10.7	11.4	11.233±0.47	10
Sulphate (mg/l)	86.5	85.3	85.8	85.866±0.60	41.3	42	41.7	41.666±0.35	250
Zinc (mg/l)	2.341	2.456	2.715	2.504±0.19	1.723	1.672	1.744	1.713±0.04	3.00
Copper (mg/l)	28.162	30.441	30.482	29.695±1.33	14.223	14.425	14.661	14.436±0.22	1.00

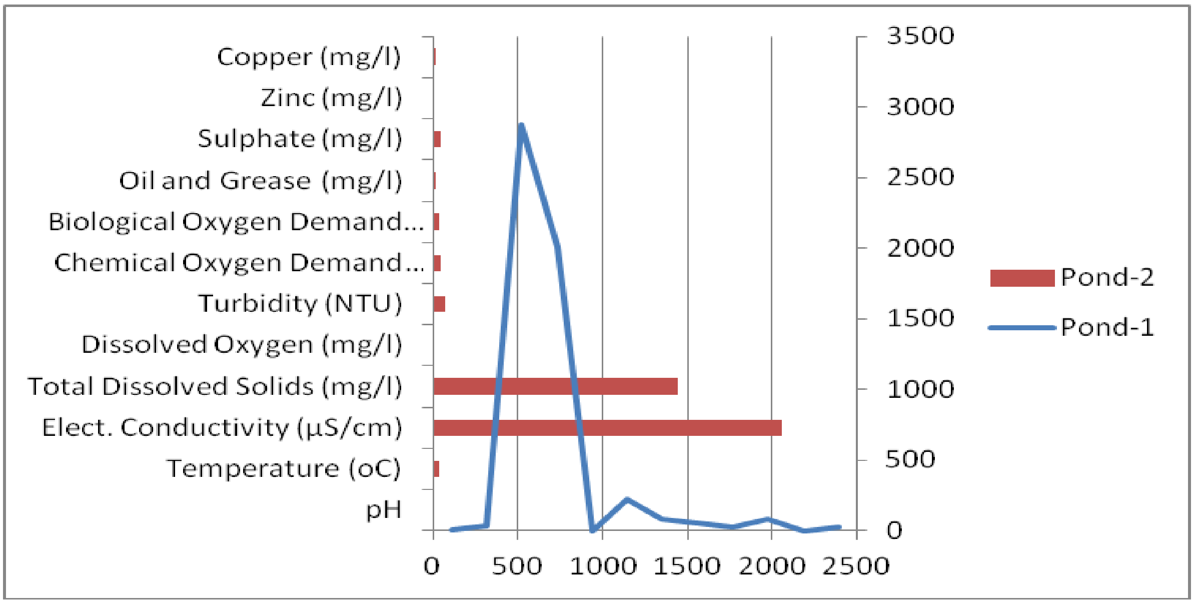

Fig. 2: Bar Chart showing Physicochemical Characteristics of POND-1 and POND-2

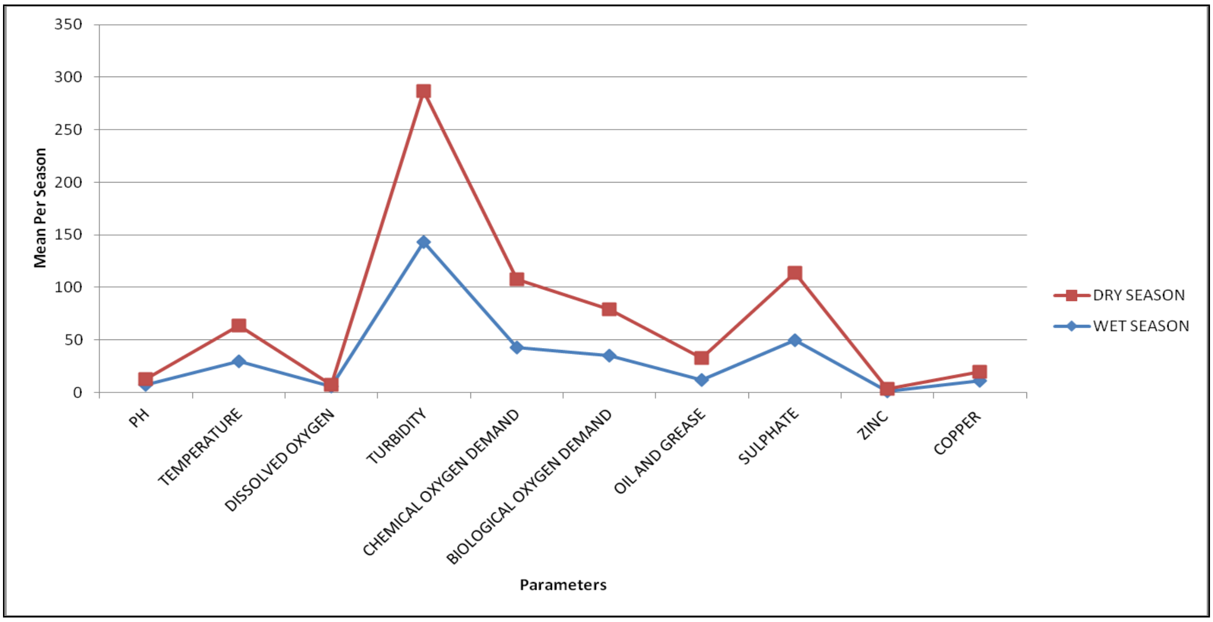

Fig. 3: Graph showing the seasonal variation in the physicochemical characteristics of Breweries Wastewater Effluent

Conclusion

This work analyzed the physicochemical parameters that are present in receiving ponds and the results obtained from the study showed that the effluent's treatment methods/facilities currently obtainable within the facility are not adequate. As shown in figure 3, parameters including temperature, copper, zinc, sulphate, oil and grease, biological oxygen demand, chemical oxygen demand, turbidity, total dissolved solids and electrical conductivity were all higher during the dry season when compared with the wet season. While pH and dissolved oxygen recorded high values during the wet season in comparison. It is therefore concluded that there is a great significant variation in the physicochemical characteristics of the breweries wastewater effluent between the wet and dry season and that the treatment ponds are polluted regardless of season. Consequently, when such polluted water is eventually released into the public drain, they contaminate ground water resources and even open waters such as rivers and streams. These aquatic resources are sources of water for fish from aquaculture and capture fisheries for food fish. Invariably, these contaminants pose a threat to human health when fishes captured from such facilities are eaten by man, through bio-accumulation and bio-magnification processes.

Recommendations

Based on the findings from this study, the following are recommended;

- Effective treatment plants of brewery effluents for this plant and other similar plants within the region should be installed within the facilities to ensure that effluents are treated to required standards prior to discharging them into the environment.
- Adequate regulations leading to strict sanctions to prevent pollution of the environment should be enacted and implemented to ensure a basis for enforcing compliance where necessary.
- Routine biological monitoring of aquatic resources for contaminants from water bodies within the catchment area influence of the brewery/other industrial effluents discharges should be put in place, in order to forestall human consumption of contaminated aquatic food resources such as fish.
- Proper medical surveys should also be conducted within the catchment area of the

Industries discharging such effluents and records properly analyzed. This will enhance early detection of such poorly managed industrial effluents treatment ponds, as a basis for applying both environmental and health remedial measures.

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