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Impact of Brewery Effluent Discharge into Niger River (A Case Study of Interfact Brewery Plc Onitsha Anambra State, Nigeria)

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Abstract
In this study, effluent discharged from brewery was collected to assess its impact on the water quality of Niger River, Onitsha. The values of the effluent discharge from brewery were compared with values recorded for its receiving river. Parameters investigated include total suspended solid (TSS), Biological Oxygen Demand (BODs), Chemical Oxygen Demand (COD), pH, Temperature, conductivity and Dissolved Oxygen (Do). ANOVA test was used for the analyses of these parameters, with the exception of the pH, all the parameters measured from the brewery effluent site as well as in the river indicated higher levels than those permitted by the Nigerian industrial standard and WHO. The study revealed that effluent from the wastes treatment plant has higher BODs (142 Mg/L) and COD (400Mg/L) than those of receiving river (88.6 Mg/L and 198.22 Mg/L means) respectively. The indicators of all pollutions exceed the WHO and Nigeria industrial standard recommendations. It is therefore, being recommended that the brewery authorities as well as the Nigerian industrial standard must ensure that the brewery effluents meet quality standards. This action is urgently warranted as high level pollution of the industrial effluents cause environmental problems which will affect plants, animals and human lives.

Keywords: *Impact, Brewery effluent, Discharge, Niger River, Interfact Plc, Onisha.*

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I. Introduction

The brewing industry is one of the largest users of water. Even though substantial technological improvements have been made in the past, it has been documented that approximately 3 to 10 litres of waste effluent is generated per litre of beer (Genner, 1988). An investigation was conducted to assess the water quality, the amount of oxygen, water temperature and the COD, BOD (Chemical oxygen demand, Biological oxygen demand and conductivity of the river Niger where at different intervals one of the major environmental issues associated with the disposal of brewery waste water is water pollution. The brewery effluent finds its way to the water bodies and due to its' organic load, the oxygen budget in the receiving water body is depleted and can lead to death of aquatic life. The indiscriminate disposal of brewery effluent in the soil may result in accumulation of salts and will lead to ground water pollution as a result of leaching due to the presence of high concentration of sodium in the effluent (Abida and Harikrishna, 2008).

Waste water from industry may include sanitary waste of employees, processing waste from manufacturing plants, water emanating from washing the factory floor as well as those utilized in various process systems (Awaleh and Soubaneh, 2014).
This may vary widely depending on the size of the industry and what is being produced.

Brewery effluent is the resulting liquid flow from a wastewater treatment system of a brewery factory. The quality of brewery effluent can fluctuate significantly as it depends on various different processes that take place within the brewery and that the organic components in brewery effluent are generally easily biodegradable since these mainly consists of sugars, soluble starch, ethanol, volatile fatty acids as well as solids which are mainly spent grains, waste yeast and turbo (Oriessen and Vereijeken, 2003). It has been reported that untreated brewery effluent typically contained suspended solids (10 – 60mgL^{l-}). Biological Oxygen Demand (BOD) (1000 – 1500mgL^{l-}), Chemical oxygen Demand (COD) (800 – 3000mgL^{l-}), nitrogen (30 – 100mgL^{l-}), and phosphorus (10 – 30mgL^{l-}). (Orhue et al;2005).

However, not all the organic materials will remain as particulate. In all these activities, there is the production of large quantities of waste which needs to be treated before discharge. Study has shown that, the quality and the kind of waste produced depend on a large extent on the frequency of production and cleaning of the vessels employed in production. (Gamper – Rabindranath and Finger, 2013). When these wastes are not effectively treated before discharge they could pollute the receiving waters accepting these discharges. It is an undeniable fact that the water resources of our planet, a basic and most important of our existence, are the most threatened aspect in life existence in 1978, the UN reported consumable water levels at 2.7% of earth's water with ground water being a major contributor. Present estimates quantify consumable water levels at 1% of the earth's water resources and ground water levels are increasingly being threatened by pollution directly and indirectly (Kumar and Simeetha, 2014).

Sustainable utilization of the earth's water is defined as the use of water resources which imposes no cost what so ever on future generations, either through depletion of the resources or through a reduction in its quality. (Ekhaise and Anyasi, 2005).

Aim and Objectives

The aim of this study is to evaluate the relationship between river water contamination and indiscriminate discharge of brewery effluent.

The objectives of the study include the following:

1) to ascertain the level of pollution of the river due to the effluent discharge.
2) to assess the waste generated from a brewery company.
3) to determine the oxygen sag
4) to suggest or recommend the best ways of discharging effluent in the river.
5) to suggest ways of enforcing the methods of effluent discharge.
6) to determine the effect of effluent discharge on aquatic organisms.

Area of Study

The research is based on the analysis of the different samples collected at intervals; the point of discharge, the point of entry the river at 25m, 50m, 100m, 200m and 300m that was collected at the river Niger, bridgehead Onitsha, Anambra state, (where interfact PLC Discharges their wastewater).

Significance of the Study

1) To help bring to the notice of the company the effect of its wastewater on the receiving water.
2) To proffer solution on the best ways of discharging effluent into the river.
3) To serve as a reference to all who will handle similar future assessments.

Scope of the Study

The parameters investigated were:

1. Oxygen (mg/lit)
2. Dissolve Oxygen (Do)
3. Temperature (^oC)
4. Conductivity (Ms/cm)
5. Ph.
6. BOD (Biological Oxygen Demand)
7. COD (Chemical Oxygen Demand)

Limitations of the Study

During the period of the investigation, we encountered the following challenges:

1. **Finance:** the cost of carrying out the practical was very high; cost of hiring a boat was also high.
2. **Difficult in getting a boat:** the boat owners refused to release their boat, because of long stretch of hire, it will take to carry out the practical.
3. **Fear of wild aquatic animal:** If for any reason the encounter any wild aquatic animal in the sea, it results to cape siding of the boat.
4. **Sea wave:** There was a high sea wave which boat was on motion, this could had caused accident
5. **Power Supply:** it was difficult to get 5 days steady power supply to carry out BOD practical.
6. **Method of collecting samples:** Some of us do not know how to swim if any happened inside the sea, the result could had been very bad.
7. **Lack of rescue team**: there was no provision for rescuing team incase anything happened.

Marine outfalls are now commonly used for the disposal of treated domestic and industrial effluents globally (Ferraro, Swartz al et. 1991). Worldwide experience has shown that an effective outfall can be a cost-effective and reliable strategy to dispose of the treated effluents properly with minimal environmental impact. Recent thriving examples include the Deep Tunnel Sewage System (DTSS) in Singapore (PUB. Singapore's national water agency 2015), Harbor Area treatment Scheme (HATS) in Hong Kong (Xu, al et 2011), and

National Marine Plan in Scotland's Marine Atlas (Baxter, Boyd, Cox, Donald, Malcolm, Miles, Miller and Moffat 2011). Different treatment levels are adopted in the various cases with full considerations of the assimilation ability of the coastal water environment around the outfall location.

Despite the general success, the use of marine outfalls for the disposal of treated effluents (especially for industrial effluents) continues to receive extensive negative publicity (Nigam, Saraswat and Panchang 2006). A few exceptional examples of poorly or inadequately designed outfalls are also widely broadcasted, further tainting the reputation of the outfall option (Pearce. 1981). For example, a large scale environmental protest was launched against a proposed industrial outfall in Qidong, China, in July, 2012, although the representatives of the paper and pulp mill guaranteed that the effluents would be treated to meet discharge standards (Deng and Yang. 2013). The outfall project was eventually forced to be permanently cancelled due to public fears.

With the current focus on sustainability and scarcity of water, every drop of water should ideally be reclaimed, and this has already been achieved in some cases (Grace. 2009). However, the use of treatment technology alone can increase the overall environmental impact, materials, and energy costs. For example, the cost of preliminary treatment is about one tenth that of secondary (biological) treatment (Roberts, al et. 2010). Therefore, preliminary treatment (with additional chemical enhancement) with an effective outfall and diffuser that complies with the requirements might be more cost-effective and environmentally friendly (Grace, 1995). Furthermore, secondary treatment does not remove large quantities of dissolved inorganic nitrogen, and it is expensive to adopt tertiary treatment for this objective due to high infrastructure costs (NRC- National Research Council 1993). In other words, to properly consider the balance between the treatment technology and outfalls, many factors need to be comprehensively evaluated within a vigorous regulatory framework, including social, economic, public health and environmental constraints (Tate P M, al et. 2016). System assessment tools are helpful to evaluate the balance. For example, life cycle assessment (LCA) can be useful as an information tool for the examination of different options for strategic planning.

II. Materials And Methods

Study Area

Niger River in Onitsha Anambra State, Nigeria was chosen for this study. This is because Niger River is the principal river of West Africa, extending about 4180km, its drainage basin is 2117700km^2, it source is in the Guinea Highlands in Southeastern Guinea. It runs in a crescent through Mali, Niger on the border with Benin and then through Nigeria, discharging through a massive delta into the Gulf of Guinea in the Atlantic Ocean (Oloruntoyin, 2016).

Onitsha is a city located on the eastern bank of the Nigeria river in Nigeria which lies on the geographical co-ordinate of (6^0 10^1 0^{11}N, 6^0 47^1 0^{11}E). A metropolitan city, Onitsha is known for its river part and as an economic hub for commerce, industry and education. It is the largest river part city in Nigeria, Bank of Niger river (in Onitsha) is where Hero brewery Plc. is sited and thus will be first line of receiving pollutants from the brewery Niger River serves as source of drinking water for some communities downstream and as river part.

Sampling points

With the help of a global positioning system (GPS), sampling point was taken from where effluent from interfact Plc exits the company's waste treatment plant, and six (6) other points along the Niger river (downstream) were selected. These include sampling point where effluent from the brewery exits (point of entering) as well as zero metre, 25 metres, 50 metres, 100 metres, 200 metres and 300 metres along Niger River.

Sampling

With the help of labeled 500mL transparent sterile sampling bottles, effluent from the factory out fall (pipe) and water samples along the designated points of the river were collected. Conductivity, PH, temperature and do (dissolved oxygen) were measured in-situ using PC 300 water proof handheld PH/conductivity/temperature meter. Another set of samples were collected in similar sterile labeled bottles for BOD, COD, and suspended solid (SS) analyses. These were tightly covered, stored in a cool ice chest and hurriedly transported to the laboratory for analysis. Data was collected between April – May, 2019.

Laboratory Analysis

Physico-chemical analysis of the water samples were carried out in the laboratory by instrument and non-instrument methods. Parameters investigated include: Total suspended solid (TSS), Biological Oxygen Demand (BODs), Chemical Oxygen Demand (BODs), Chemical Oxygen Demand (COD). These were analyzed using the standard procedure mention in (AWWA/APHA, 1992).

Data Analysis

Data for physico-chemical parameters were compared between values of parameters collected from the brewery effluent and that of the means of water samples collected from the different portions of the river using one way ANOVA Test.

With sample degree of freedom = Total degree of freedom minus between sample degree of freedom = 55-7 = 48.

Table 1: ANOVA TABLE

Between Samples	Difference sum of square	Degree of freedom	Variance estimate
Between samples	288203.2	7	41171.89
Within samples	118112.71	48	2460.68
Total	**406315.91**	**55**	**43632.57**

Calculated F = $\frac{Greater\ variance\ estimate}{Less\ variance\ estimate}$

$$\frac{4117.89}{2460.68} = 16.73$$

III. Results

Analysis of results based on some physic-chemical parameters with respect to temperature and PH between effluent from the brewery and that of water samples collected from the exit point and six (6) different sampling points along the river did not show any significant difference ($P>0.05$) PH of the effluent from the exit point of the brewery waste treatment plant is 7.3 and the mean PH of the sample collected along the river is 7.9. This parameter fell within the World Health Organization and Nigerian Industrial Standard permissible guideline for drinking water (i.e. 6.5 to 8.5).

The temperature of the effluent from the exit point of the brewery waste treatment plant is 33^0C while the mean temperature of the samples collected

Table 1: Comparative Analysis of some physicochemical parameters of effluents from brewery into the Niger River.

Parameter	Exit point of effluent	0 meter	25m	50m	100m	200m	300m	Mean Values
pH	7.3	7.1	8.2	8.1	8.2	7.9	8.1	7.8
Temperature (^{o}C)	33.0	33.6	30.9	31.0	31.0	30.9	31.3	31.7
Conductivity ($\mu s/cm$)	14.23	12.70	0.61	0.42	9.39	0.34	0.29	5.4
BOD (Mg/L)	142	91.60	73.20	48	104	93.60	121.20	96.2
COD (Mg/L)	400	93.33	104	112	237.33	282.66	360	227.0
DO (Mg/L)	9.0	8.0	7.5	4.0	6.1	4.0	4.5	6.2
Total Suspended Solid (TSS) (Mg/L)	**33.42**	**3.002**	**10.44**	**14.42**	**15.30**	**23.08**	**20.30**	**17.14**
Total coliform (MPN/100ML)	**12.1**	**122.1**	**24.1**	**140.1**	**96.2**	**102.2**	**112.1**	**86.99**

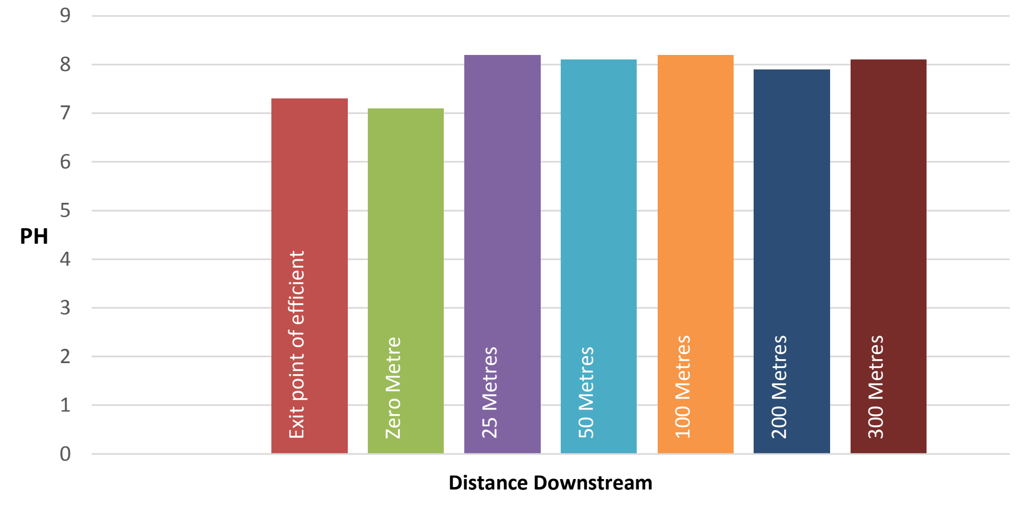

Fig. (1) PH Level

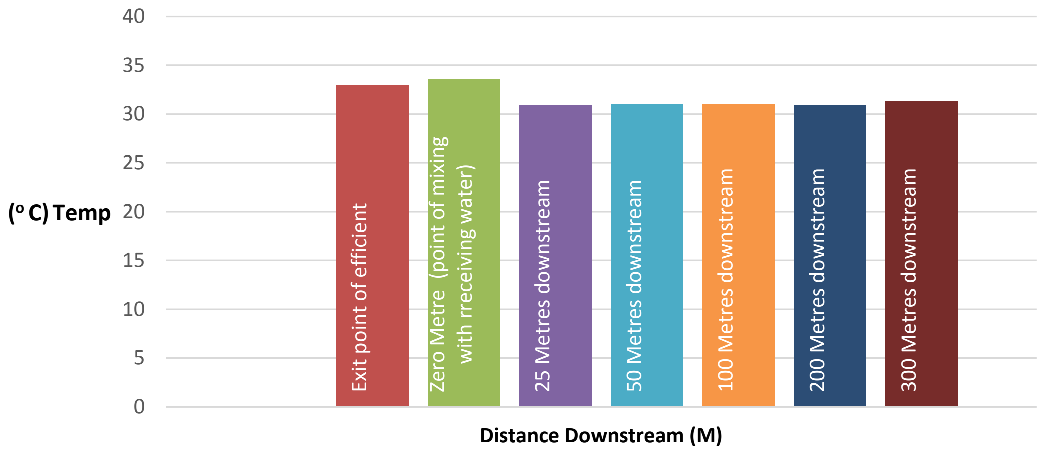

Fig. (2) Temperature Values

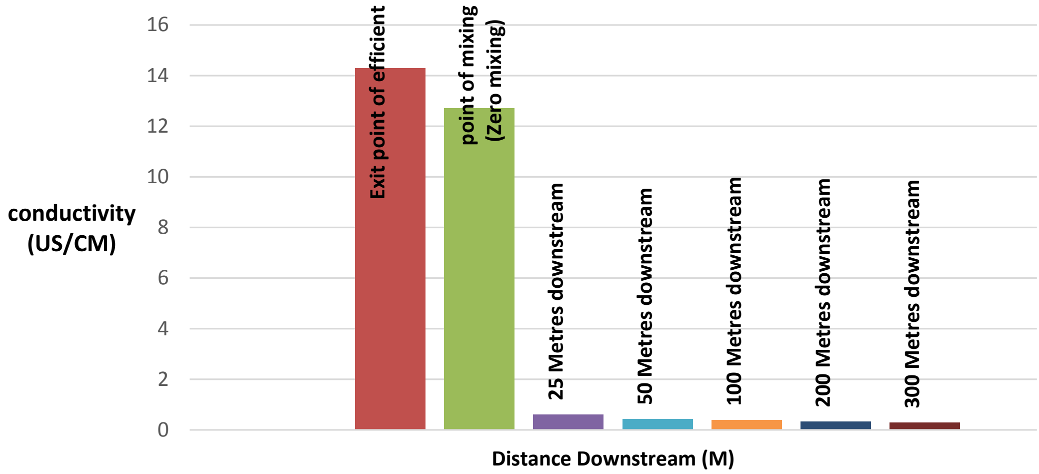

Fig. (3) Conductivity parametre

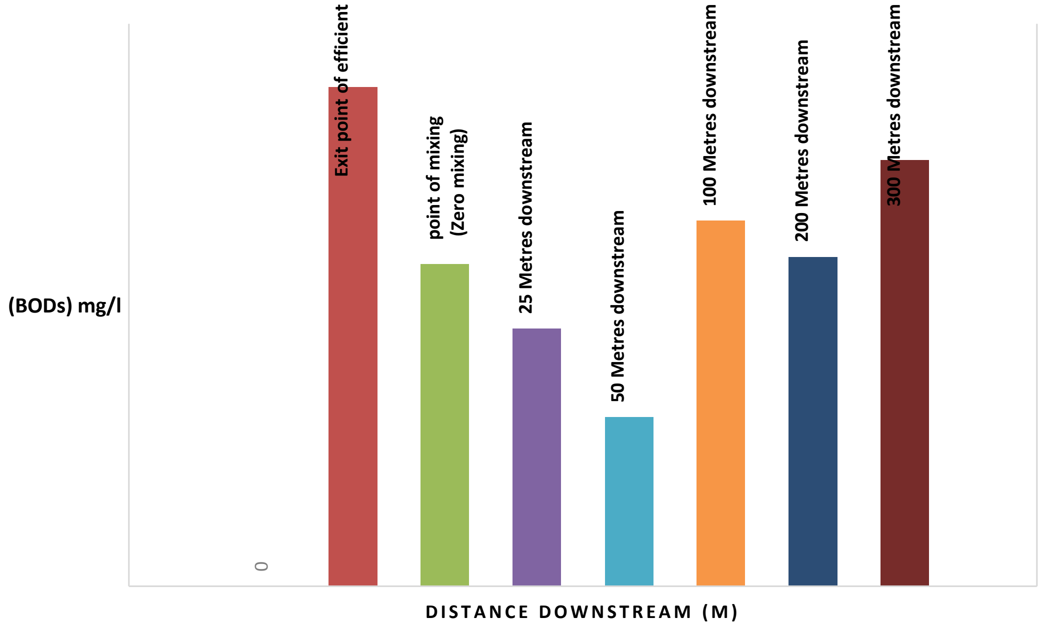

Fig. (4) bods (mg/l) parametre

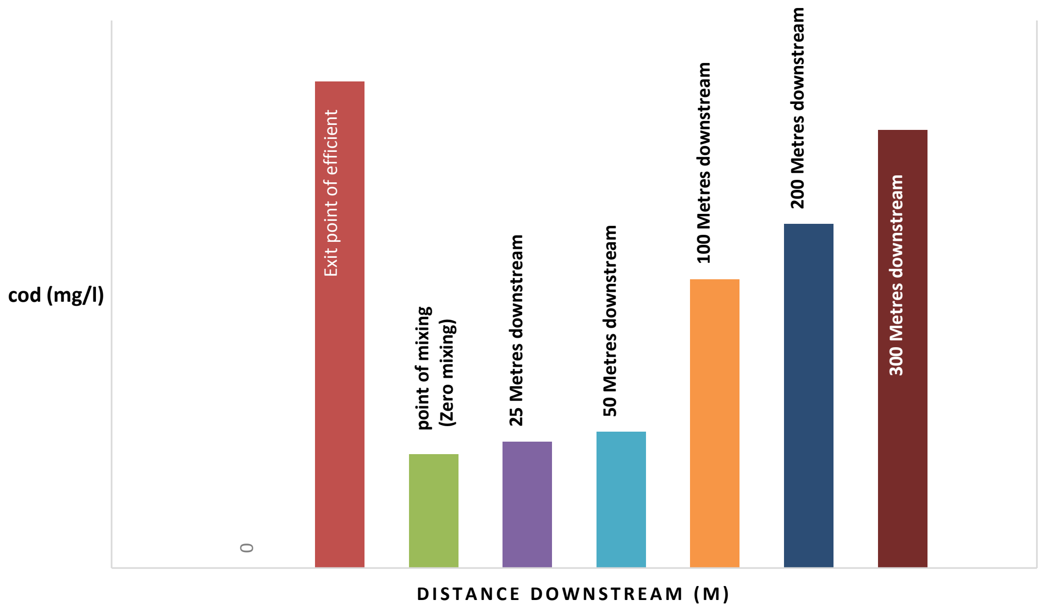

Fig. (5) cod parametre

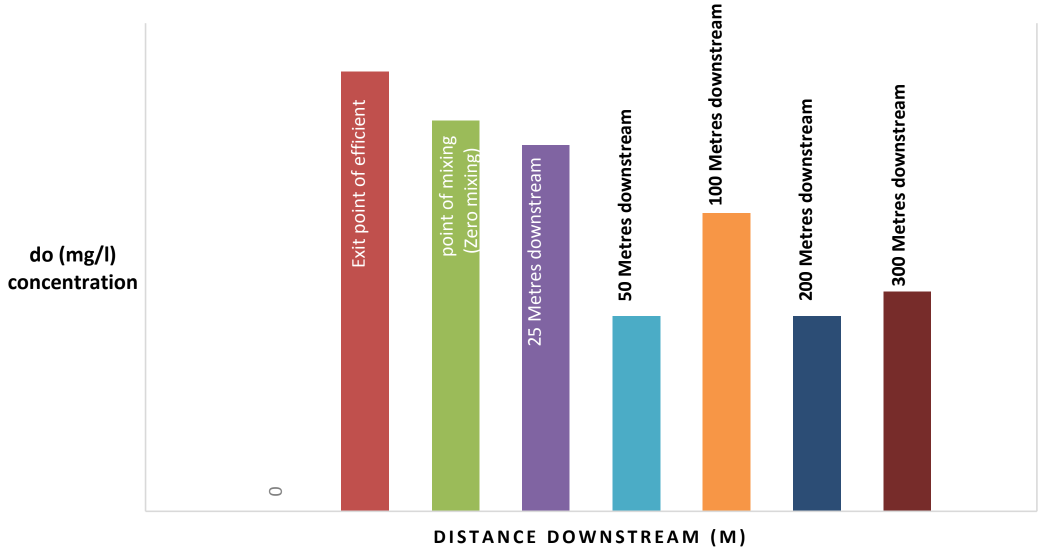

Fig. (6) do parametre

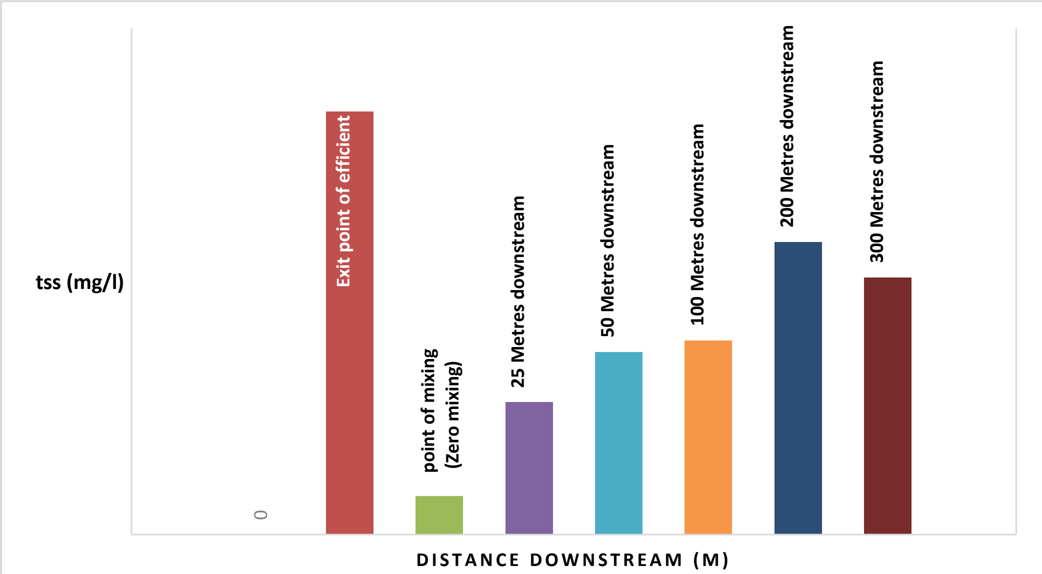

Fig. (7)

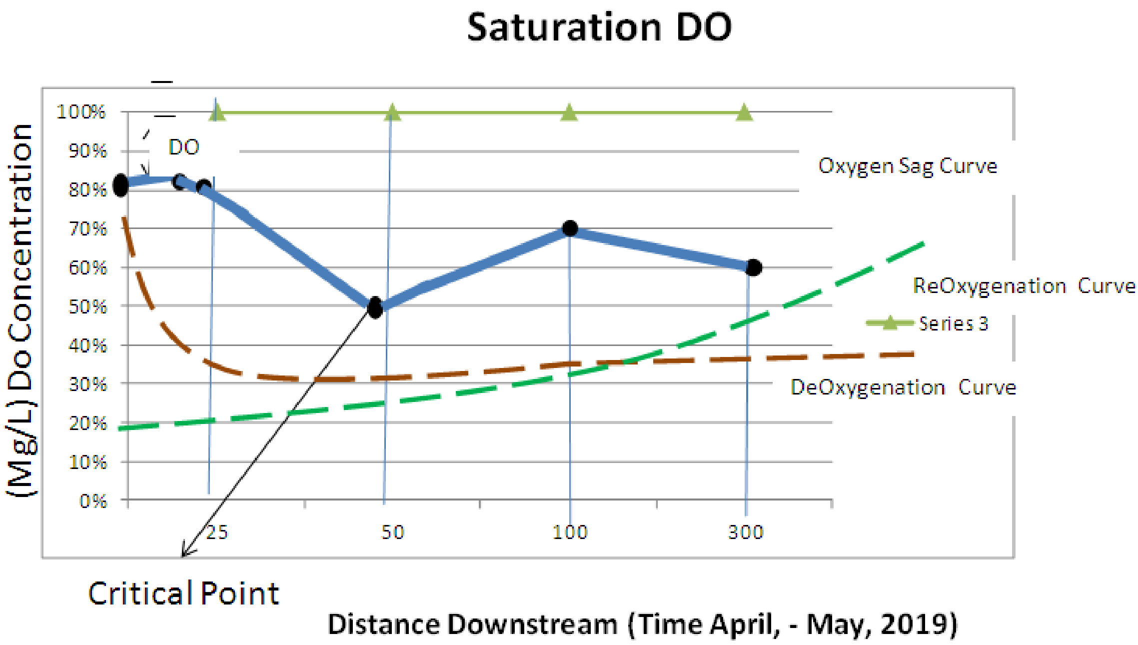

Fig 8: De-oxygenation, re-oxygenation and oxygen sag curve.

along the river is 31.5oC as shown in the table 1. This difference was not significant (P>0.005).

The analysis of the electrical conductivity of the effluent from the exit point of the treatment plant is higher (14.28Ns/cm). The mean electrical conductivity of samples collected along the river (2.5 Ns/cm). This difference was statistically significant downstream as shown in Table 1.

The analysis of the total suspended solids for both effluents from the brewery and that of water collected from the river were assessed during the study. Results of the analysis of the samples showed that levels of this parameter were very low downstream (14.42 Mg/L mean) compared to that of the effluent from the brewery (33.42 Mg/L) as shown in table 1. The difference was statistically significant (P<0.05).

The analysis of demand for oxygen showed that the Biological oxygen demand (BOD) of the brewery effluent was higher (142 Mg/L) than that of water sample collected downstream (88.6 Mg/L mean). The

difference was statistically significant ($P<0.05$). This parameter exceeds the recommendation of the World Health Organization (20Mg/L). This difference was statistically significant ($P<0.05$) as shown in table 1.
The analysis of Dissolved Oxygen (DO) showed that the dissolved Oxygen of the brewery effluent was higher (9.0 Mg/L) than that of water sample collected downstream (5.7Mg/L). This difference was not significant at the upstream

IV. Discussion

The non-significance difference between the pH and temperature of the brewery effluent with respect to levels recorded from the six (6) sampling points along the river offered a great relief as extremes of pH could lead to an unsafe working environment, affect biological treatment systems and damage the sewer network due corrosion. In addition pH extremes could affect the availability of plants nutrients as well as bring about heavy metal pollution and growth of algae as well as microbial proliferation. This was consistent with a study conducted by a group of workers published in 2005 where effluent discharge from brewery recorded a pH level that feel within recommended value (Orhue et al 2005). High temperature could contribute to oxygen depletion in two ways. First, relatively small increase in temperature kills species of fish and increases the rate of decay. In addition to this, high temperature raise the metabolic rate of surviving fish, leaving to increase in oxygen consumption which will invariably lead to oxygen depletion (Sharda et al 2013). This was in line with the present study.

A failing sewage system could raise the conductivity because of the presence of chloride, phosphate and nitrate. On the other hand an oil spill would lower the conductivity because oil does not conduct electrical current very well (Nigrude et al 2013). This implies that the level of conductivity measured was indication of the effluents from the brewery being rich in salts. This is not good for irrigation, drinking and washing purposes and this was in agreement with the present study.

This significant higher BOD of the effluent from the brewery compared to downstream points (Zero metre to 3000m) of the river could be attributed to the inefficiency of the waste treatment plants. The results based on BOD, suggest that the brewery is discharging, organic pollutants into the river leading to eutrophication and the promotion of the growth of algae (Safari et al 2013). Research has further shown that the concentration of Biological Oxygen Demands (BOD) in wastewater treatment plant effluents could significantly influence the dissolved oxygen rate in receiving water bodies and this was consistent with our study.

The study reported relatively high bacteria pollution level and this development obviously could not be ignored. This is a matter of great concern as the communities that depend on the river as sources of drinking water downstream could be at very high risk of infection and diarrheal related diseases. This study has shown that the effluent parameters from the treatment plant at the brewery did not meet both the World Health Organization (WHO) and Nigerian Industrial Standard recommendation.

Table 2: WHO and NIGERIAN INDUSTRIAL STANDARD FOR COMPARISM OF RESULTS

Parameter	**Mean values Results**	**WHO standard 2011**	**Nigerian Industrial Standard**
pH	7.8	6.5 – 8.5	6.5 – 8.5
Temperature (^oC)	31.7	- 40	Ambient
Conductivity (µs/cm)	5.4	- 100	1000
BOD_5(Mg/L)	96.2	7.5	7.5
COD (Mg/L)	227.0	40	40
DO(Mg/L)	6.2	Preferably at least 5	Atleast 5
Total suspended solid (Tss) (Mg/L)	17.14	500	500
Total coliform (MPN/100mL)	86.99	0.2	10

V. Recommendation

Since most of the physic chemical parameters indicators of pollution exceed the WHO and Nigerian Industrial Standard, it is therefore being recommended that the brewery authorities as well Federal Environmental Protection Authority (FEPA) of Nigeria must ensure that the brewery effluents meet quality standards. This action is urgently warranted as high level pollution of the industrial effluents causes environmental problems which will affect plants, animals and human lives.

VI. Conclusion

The study revealed that effluent from the waste treatment plant from the brewery was technically inefficient with respect to most of the physic chemical parameters. These parameters exceed the WHO and FEPA recommendations.

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