ASSESSING SOME PHYSICOCHEMICAL CONSTITUENTS OF ABATTOIR EFFLUENTS AND ITS IMPACT ON THE DISSOLVED OXYGEN OF IKPOBA RIVER IN BENIN CITY, NIGERIA

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Abstract: This study focused on the impact of Abattoir effluent on the dissolved oxygen (DO) of Ikpoba River with a special interest on the critical oxygen deficit and its time of occurrence. Abattoir effluent and river water were sampled for some physico-chemical parameters analysis. River flow velocity and depth were also determined. These parameters were inputted intoO'Connor and Dobbins; and Streeter and Phelps models to generate the requisite outputs. The re-aeration and de-oxygenation rates were 0.28 day^{-1}and 0.37 day^{-1}; the biochemical oxygen demand (BOD) of effluent, river's upstream and downstream were 108.4, 2.2 and 4.6 mg/l, respectively. The critical oxygen (D_c) deficit was 5.7 mg/l at 0.61 days and the minimum DO was 2.4 mg/l. This revealed a high effluent and downstream BOD with serious impact on the river DO. Consequently, the de-oxygenation rate in the river dominated the re-aeration rate and portrayed the river to be in danger of pollution. However, the study showed that the river's self-purification capacity was not overwhelmed. The effluent treatment facilities were recommended to reduce the effluent BOD load and the consequent self-purification stress induced on Ikpoba River.

Keywords: Ikpoba River, Abattoir effluent, dissolve oxygen, pollution

Introduction

Water is vital for any country's socio-economic development; it is a need for all living organisms; and river water is essential for humans because of its use for domestic, irrigation, drinking purposes and aquatic life (Sinha, 2019). Water body quality is explained with a set of variables known to be physical, chemical and biological in nature. These parameters of water are important tools for the management of water resources (Khalil *et al.*, 2010); and dissolved oxygen is a vital signal of river biological health (RajwaKuligiewicz *et al.*, 2015).

According to Olomukoro and Dirisu (2012), more than 76% Nigerian rural communities source their water from surface water bodies. These water bodies are often subjected to wastewater from industrial, domestic and commercial sources with varied strength and compositions (Benka-Coker and Ojior; 1994; Atikpo and Anyata, 2008; Ezeoha *et al.*, 2011) through which they have subsequently experienced severe pollution (Dimitrovska *et al*., 2012). Abattoir waste was discovered to be very rich in animal blood usually with high oxygen demand (Ezeoha *et al.*, 2011) and it is a type of commercial effluent.

The study by Benka-Coker and Ojior (1994) on the weight of continual discharge of untreated abattoir wastewater on Ikpoba river water quality showed a rise in heterotrophic bacterial population from 10^4 per millilitres $(ml)^{-1}$ to 10^7 $(ml)^{-1}$ and a drop in the river DO from 7.2 mg/l to about 2.4 mg/l on interacting with the commercial wastewater. The study of the impact of discharged raw abattoir effluent on Ikpoba river water quality by Tekenah *et al.* (2014) showed quality reduction in the water and impairment of the health of people depending on the water for use.

The study on the impact of commercial (abattoir) wastewater on Ikpoba river water quality by Atuanya *et al.* (2012) showed strong positive correlation between commercial effluents with the altered quality of the river water. The study showed that the abattoir effluent had negative impact on the water because of significant alteration in the water quality at the downstream compared with the upstream water quality.

Oguzie and Okhagbuzo (2010) studied the effect of brewery effluent on Ikpoba River water quality and discovered similar findings to that of Atikpo and Anyata (2008) that habitat was threatened by the pollution impact of the waste.

In line with the findings of Olomukoro and Dirisu (2012) that more than 76% Nigerian rural communities source their water from surface water bodies, the communities located close to Ikpoba River heavily depend on the river as their source of water for domestic use (Atikpo and Anyata, 2008). This Ikpoba River is in the order of four (4º) stream. It flows from it sources (Ishan plateau) at an elevation of about 230 m above sea level through Benin City (Lat 6.5º N long 5.8º E) from North to South. The river's catchment has an average annual rainfall of 2.095 m and an average daily temperature of 27°C from the range of 24 to 30°C (Benka-Coker and Ojior, 1994).

Flowing water bodies can handle inputted waste through the process of self-purification – thus, flowing river cannot be permanently polluted unless it self-purification capacity is overwhelmed or suppressed (Ambasht and Ambasht, 2014). Dissolved oxygen (DO) is the most significant factor among others for ensuring the self-purification and quality of river water. Flowing from this knowledge, the study by Streeter and Phelps (1925) on the relationship between DO and the decayed organic waste gave birth to the classical river dissolved oxygen sag model which is of immense significance in analyzing and monitoring river water quality.

The aim of this work is to study the quality of Ikpoba river water DO relationship with the pollution load of effluent from abattoir with the objective of monitoring the critical oxygen deficit (D_c) and the time t_c to reach the D_c using the model developed by Streeter and Phelp (1925) and to show the current oxygen sag curve.

Materials and Methods

Materials and equipments

These include pH meter, DO and BOD bottles, cork, dye, stop watch, planimeter, DO and BOD analyzers, thermometer, Canoe (Boat).

Method

For the purpose of data acquisition, water samples were collected from three sampling points in the river and analyzed in the laboratory. The first point was located at Ikpoba Bridge at a distance of 20m upstream of the abattoir effluent outfall. The second point was located at the effluent channel at the point of effluent outfall and the third point at 20 m downstream of the abattoir effluent outfall.

The sampling was conducted in triplicate with clean Do and BOD bottles for 29 days in the month of February, 2020 and analyzed. The river depth, flow velocity and temperature were also determined and recorded. The respective average data values were inputted in to Equations (1), (2). (3), (4) and (5) to determine the de-oxygenation rate and re-aeration (re-oxygenation) rate constants; critical oxygen deficit; and the time to reach it (Streeter and Phelps, 1925; O'Connor and Dobbins 1958; Chiejine *et al.*, 2015).

$$k_1 = \left(-\ln\frac{L_t}{L_o}\right)(1.056)^{T-Tw} \quad (1)$$

$$k_2 = 3.93V^{\frac{1}{2}}\frac{(1.047)^{(T-Ti)}}{H^{\frac{3}{2}}} \quad (2)$$

$$D_o = C_s - C_a \quad (3)$$

$$t_c = \frac{1}{k_2-k_1}\ln\left\{\frac{k_2}{k_1}\left(1 - D_o\frac{(k_2-k_1)}{k_1 L_o}\right)\right\} \quad (4)$$

$$D_c = \frac{k_1}{k_2}L_o e^{-k_1 t_c} \quad (5)$$

Where: k_1 is the deoxygenation constant (day^{-1}), k_2 is the reaeration (re-oxygenation) constant (day^{-1}), H is depth of river in (meters), V is velocity of flow in river in (ms^{-1}), D_c is the critical Do of the river in (mg/l), t_c is the time to reach the critical Do, k_2 is re-aeration rate constant.

Results and Discussion

Table 1 shows the flow velocities at the sampling points while Figs. 1 and 2 show the physical and chemical characteristics of both river water and abattoir effluent. The wastewater flowed into the river from the Abattoir with a velocity of 0.43 m/s and at temperature of 28.7°C. This flow velocity of the effluent was higher than the river flow velocity values of 0.28 and 0.27 m/s (Table 1) at upstream and downstream, respectively. The effluent temperature of 28.7°C was higher than the respective temperature values of 25.2 and 26°C at upstream and downstream (Fig. 1). This difference in flow velocities and temperature values suggested that the effluent might have impact on the quality state of the river since flow velocity of a river water plays an important role in its self-purification process because it affects the rate of river re-oxygenation (Benka-Coker and Ojior, 1994). Re-oxygenation rate is dependent on solubility of oxygen in river water, and the temperature ofriver water affects the rate of oxygen solubility in it (RajwaKuligiewicz *et al.*, 2015; Sincero and Sincero, 2016), this solubility has inverse relationship with river water temperature (Sincero and Sincero, 2016).

Table 1: Average flow velocity of river

Sampling Points	First	Second	Third
Average Flow Velocity	0.28 ms^{-1}	0.43 ms^{-1}	0.27ms^{-1}

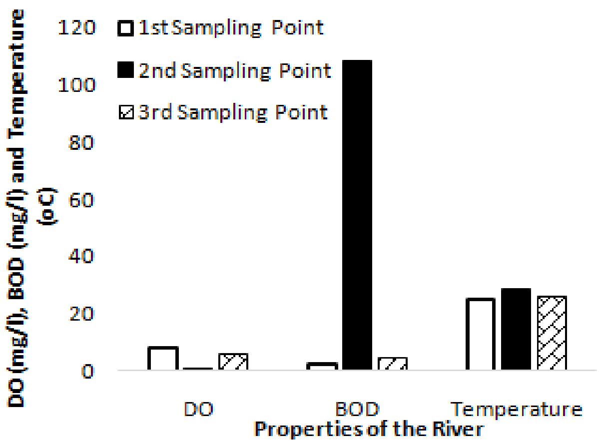

Fig. 1: Variations of DO, BOD and temperature with sampling points

The average depth of the river was found to be 3.8 m. The Abattoir effluent BOD of 108.4 mg/l was higher than 4.6 and 2.2 mg/l determined at the downstream and upstream sampling points respectively. DO value of 8.1 mg/l was determined at the first sampling point (20 m upstream the effluent outfall). This was higher than a DO of 5.97 mg/l at the third sampling point (20 m downstream the outfall of waste effluent); and 0.9 mg/l of the raw effluent (Fig. 2). The higher DO at the upstream location is an indication that the downstream DO was dropped by the abattoir waste discharged from the channel. Sincero and Sincero (2016) and Susilowati *et al.* (2018) have pointed out that waste reduces river DO through waste oxidation and decomposition by micro-organisms.

The study of relationship between the observed DO and BOD values at the different sampling points revealed that DO and BOD were inversely related. This can be relied on to say that the reason for the very low DO of effluent is as a result of its high BOD value, and the higher BOD at the downstream point of the river dropped the DO at that point consequently. BOD reduces the DO of river through the biodegradation activities of microorganisms (Susilowati *et al*., 2018).

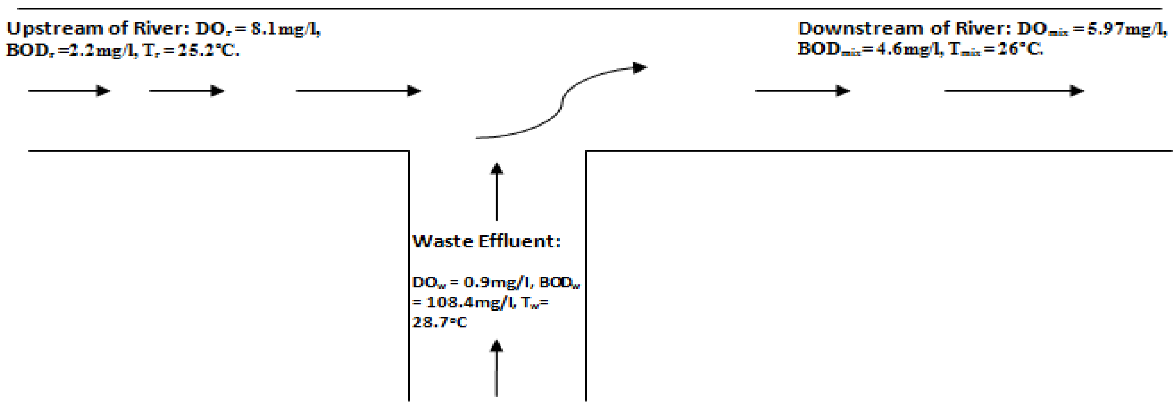

Fig. 2: Some physico-chemical characteristics of waste effluent and Ikpoba River

Where: DO_r, DO_w, DO_{mix} areDO of the river upstream, wastewater and downstream respectively; BOD_r, BOD_w, BOD_{mix} are BOD of the river upstream, wastewater and downstream, respectively; and T_r, T_w, T_{mix} are temperature of the river upstream, wastewater and downstream, respectively.

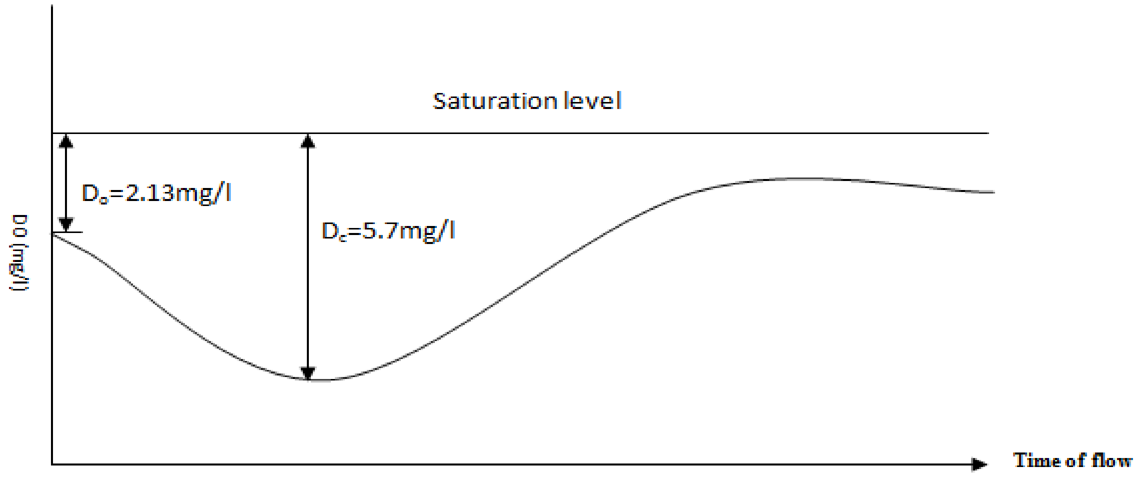

Fig. 3: Oxygen sag curve for Ikpoba River

The study revealed a greater de-oxygenation rate of 0.37 day^{-1} compared to the determine re-oxygenation rate of 0.28 day^{-1}. This indicated a drop in DO due to the interplay of the higher de-oxygenation and lower re-aeration rates of the river. The initial oxygen deficit (D_o) and ultimate BOD (L_o) were determined as 2.13 and 5.46 mg/l, respectively (Fig. 3). The interactions of the aforementioned values inputted into equations (3), (4) and (5) yielded a critical oxygen (D_c) deficit of 5.7 mg/l, t_c of 0.61 days and minimum DO of 2.4 mg/l (Fig. 3). These are indications that the river DO suffered negative impact from the discharged abattoir effluent.

Conclusion

This work studied the impact of Abattoir effluent on the DO of Ikpoba River. The results showed a high effluent and downstream BOD which affected the DO of the River. Consequently, the de-oxygenation rate in the river dominates re-aeration rate, thus portrayed the river to be in danger of pollution; however, the River's self-purification capacity was not overwhelmed. This means that the river had strength to purify itself to regain its quality status. The study however recommends the installation of effluent treatment facilities to reduce the effluent BOD load before discharging into Ikpoba River. This will reduce self-purification stress induced on the river.

Conflict of Interest

Authors declare that there is no conflict of interest.

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