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Effects of Beverage Industry Effluents on the Physicochemical Characteristics of a Receiving Creek in Port Harcourt, Rivers State

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Abstract The food and beverage industry discharges large amounts of effluents into surrounding water bodies and these discharges constitute a source of pollution in the environment. These effluents, either treated, poorly treated or untreated have the potential to impact negatively on the physicochemical characteristics of a receiving water body. There is thus the need for continuous monitoring of water bodies receiving effluents from beverage industries. To this end, the effects of effluents from a beverage industry on the physicochemical characteristics of a receiving creek in Port Harcourt were studied. The impact of the effluent was monitored for eight (8) months. Effluent samples were collected at pre and post-treatment points in the factory. Other sampling points were at the point of effluent discharge into the receiving creek as well as at the upstream and downstream reaches of the discharge point. Analysis of samples followed standard procedures. Data obtained showed that levels of most physicochemical characteristics exceeded permissible limits which implied that effluents from the industry were poorly treated before they were discharged into the receiving creek.

Keywords Beverage Industry, Physicochemical Characteristics, Receiving Creek

Introduction

In Nigeria, surface waters which hitherto served as the main sources of water for domestic purposes have gradually become recipients of domestic and municipal wastes as well as effluent discharge from industries. Ground water sources have become the main sources of water for domestic use. There is however, a link between surface water and ground water; thus any damage to the surface water may invariably affect the aquifers of the ground water. Although water bodies are natural drainage systems through which wastes are evacuated from the environment, domestic wastes can be decomposed naturally in water bodies over time thereby posing little or no threat to water quality. Industrial wastes, on the other hand, may contain harmful substances which may not be readily broken down and thus impact negatively on the quality of the receiving water body, thus indiscriminate discharge of industrial wastes into water bodies has contributed greatly to the deterioration of water bodies in general.

The food and beverage industry is known to generate huge amounts of effluents due to its utilization of large volumes of water in the production of beverages. It has been reported that alcoholic beverages for example contain over 90%of water and about 10% of additives [1]. The process of makingnon-alcoholic beverages involves malting and milling of cereal grains after which they are mashed to extract fermentable sugars and filtered to get clear wort. The process of making alcoholic beverages involves the fermentation of clear wort by the addition of yeast, the crude product is filtered to remove particles such as spent yeast and trub and packaged for consumption [2]. A number of studies [3-6] have reported on the negative impact of effluent discharges from the brewing industry on receiving water bodies, thus impairing the use of water bodies for domestic purposes.

Port Harcourt is one of the industrialized cities in Nigeria. It is the hub of oil and gas industries as well as several manufacturing industries. Effluents from these industries are discharged into surrounding water bodies such as Okujagu, Amadi-ama, Weja and Oginigba creek. Most of the industries are situated at Trans Amadi Layout of the city. The beverage industry under study has an effluent treatment plant installed in the factory, after treatment effluents from these industries are discharged into the Ogingba creek. Some activities that take place in the around the creek include; fishing, farming and dredging. The creek is also a site for recreation and a source of drinking water to animals. A physical inspection of the creek shows that it is highly coloured, turbid and exudes a bad odour. Although some studies have been conducted along the stretch of the stream [7-8], there seem to be no records on the effects of the beverage industry effluents discharged into the stream. This is the thrust of this study.

Study Area

The study area (figure 1) covered a beverage industry and the adjoining water body, the Oginigba creek, in Port Harcourt metropolis. Trans Amadi industrial area is situated in Oginigba community, the water body flows through the community and finally empties into the Bonny River [9]. After treatment effluents are discharged into the stream at the contact point station C. The creek used to be the main source of potable water in the community, however with increased anthropogenic activities, such as fishing and farming as well as the establishment of industries, the inhabitants now rely on ground water as source of potable water.

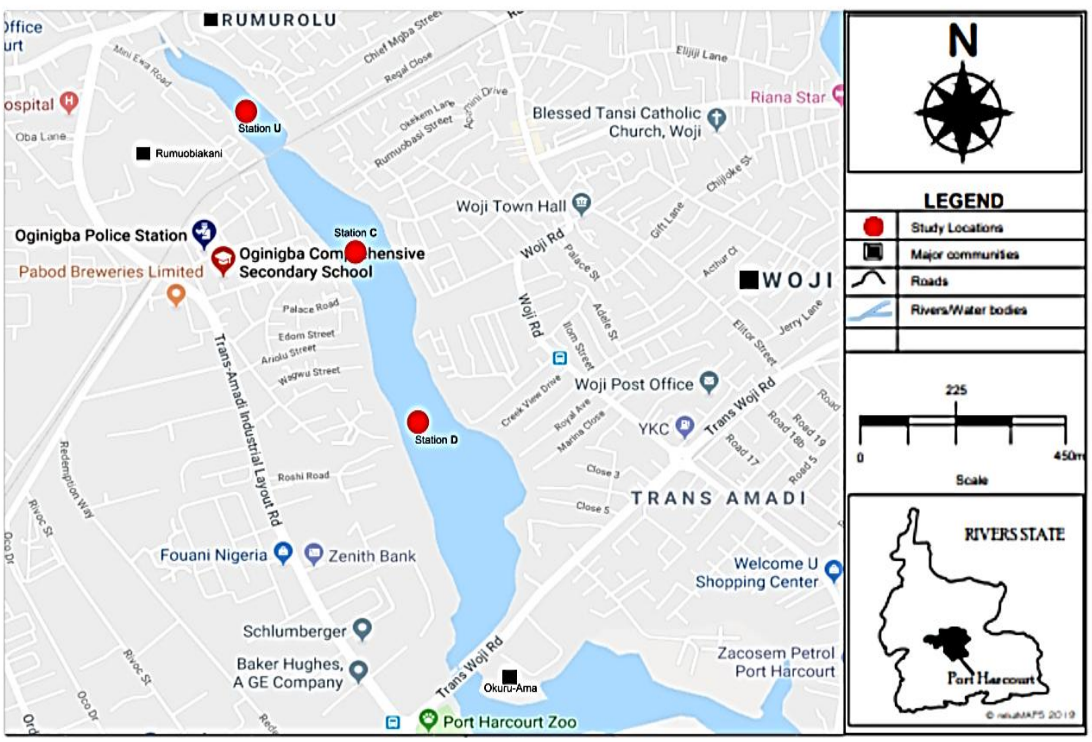

Figure 1: Map of Study Area Showing Sampling Points

Methodology

Two sets of samples were collected: (i) effluent samples from the industry and (ii) surface water from the stream. In the industry, effluent samples were collected before (A) and after treatment (B) in the industry into thoroughly cleaned 1 liter polyethylene bottles, placed in an ice chest and transported to the laboratory for analysis of physicochemical characteristics. At each station in the stream (Upstream, U; discharge point C; downstream, D) certain parameters such as temperature, electrical conductivity, pH, Total Dissolved Solids, salinity, were measured in-situ using appropriate pieces of equipment. Dissolved Oxygen (DO) and Biological Oxygen Demand (BOD) samples were collected into amber bottles and analyzed following Winklers method. Samples for the analysis of Chemical Oxygen Demand (COD), alkalinity and hardness were collected into thoroughly cleaned plastic bottled and analyzed titrimetrically. On the other hand analysis of sulpate, nitrate, phosphate ions in the samples were determined spectrophotometrically. Total hydrocarbon carbon content (THC) was extracted with toluene and measured spectrophotometrically. Colour was measured with a colorimeter and turbidity was measured with a turbidity meter. Iron, Chromium and Copper levels were also determined spectrophotometerically.

Data Analysis

MS-Excel was used to analyze the data while T-test was used to determine the significant difference of concentrations for various parameters. Differences in concentration levels obtained for a given parameter along sampling locations were considered significant if calculated T-values were <0.05.

Results and Discussion

The results for the effluents samples; before (A) and after (B) treatment in the industry are presented in table 1.

Table 1: Mean levels of physicochemical characteristics in effluents from the industry before and after treatment

STATIONS PARAMETERS	A	B	WHO	FMENV
Temperature (^oC)	29.25±2.44	29.86±2.21	10-30	<40
Conductivity (µS/cm)	1432.50±1124.32	796.75±402.80	100	-
Colour (PtCo)	1569.50±1219.86	1087.75±272.75	18	18
pH	9.19±2.44	7.69±0.24	6.5-8.5	6-9
DO (mg/L)	4.77±1.39	3.09±1.27	7.5	7.5
BOD (mg/L)	1.27±1.16	1.24±1.19	<40	50
COD (mg/L)	257.88±170.03	123.52±25.82	80	80.1
Phosphate (mg/L)	0.76±15.93	0.39±0.40	5	5
Nitrate (mg/L)	2.77±0.81	2.29±0.34	10	20
Sulphate (mg/L)	29.74±19.38	18.86±12.77	400	500
Fe (mg/L)	3.11±1.40	2.85±2.24	0.0	1.0
Cu (mg/L)	0.13±0.08	0.06±0.04	1.0	<1.0
Cd (mg/L)	0.03±0.90	0.02±0.08	0.03	-
Ni (mg/L)	0.15±0.51	0.14±0.09	0.01	-
Pb (mg/L)	0.33±0.06	0.26±0.11	0.1	-
Zn (mg/L)	0.42±0.01	0.41±0.08	5	-
Cr (mg/L)	0.98±0.26	0.20±1.03	0.05	<0.01
THC (mg/L)	3.14±0.58	1.94±0.71	10	

Electrical conductivity values ranged from 796.75±402.80µS/cm in station B to 1432.50±1124.32µS/cm in station A, the pH levels of the effluent ranged from 7.69±0.24 in station B to 9.19±2.44 in station A, while hardness values ranged from 63.39±15.93mg/L in station A to 36.61±33.10mg/L in station B, chemical oxygen demand levels ranged from 123.52±25.82mg/L in station B to 257.88±170.03mg/L in station A. Phosphate values ranged from 0.39±0.40mg/L in station B to 0.76±15.93mg/L in station A, while sulphate levels ranged from 18.86±12.77mg/L in station B to 29.74±19.38mg/L in station A. Copper and chromium values ranged from 0.06±0.04mg/L in station B to 0.13±0.08mg/L in station A and 0.20±1.03mg/L in station B to 0.98±0.26mg/L in station A respectively while THC levels ranged from 1.94±0.71mg/L in station B to 3.14±0.58mg/L in station A.

Table 2 shows the mean levels of physicochemical characteristics in effluent samples collected after treatment station B compared with effluent discharge into the stream station C. Electrical conductivity values ranged from 796.75±402.80µS/cm in station B to 2422.61±109.20µS/cm station C, while turbidity levels ranged from 40.90±24.94NTU in station B to 70.55±3.31NTU in station A, the pH values ranged from 7.69±0.24 in station B to 9.19±2.44 in station C, alkalinity levels ranged from 59.50±47.74mg/L in station C to 104.63±31.03mg/L in station B, hardness values ranged from 63.39±15.93mg/L in station B to 121.70±65.69mg/L in station A while chemical oxygen demand levels ranged from 115.78±26.07mg/L in station C to 123.52±25.82mg/L in station B. Phosphate and sulphate values ranged from 0.39±0.40mg/L in station B to 1.91±1.15mg/L in station C and 18.86±12.77mg/L in station B to 75.36±51.60mg/L in station C respectively. Iron and chromium levels ranged from 2.85±2.24mg/L to 0.88±0.24mg/L and 0.98±1.01mg/L to 0.01±0.01mg/L in station B and C respectively. While cadmium, nickel, lead and zinc values ranged from 0.02±0.08mg/L to 0.07±0.00mg/L, 0.14±0.09mg/L to 0.28±0.08mg/L, 0.26±0.11mg/L to 0.50±0.08mg/L and 0.41±0.08mg/L to 18.15±0.15mg/L in station B and C respectively.

Table 2: Mean levels of physicochemical characteristics in the surface water of Oginigba stream; upstream, point of contact, downstream

Stations **Parameters**	**U**	**C**	**D**
Temperature (^{o}C)	30.86±1.15	30.30±0.47	29.66±0.74
Conductivity (µS/cm)	2506.63±663.21	2422.61±109.20	1328.90±1077.30
Colour (PtCo)	533.13±472.91	889.63±181.18	194.38±168.83
pH	6.03±0.60	5.96±0.26	6.19±0.05
DO (mg/L)	2.24±0.97	4.22±0.05	4.51±1.37
BOD (mg/L)	0.76±0.84	1.50±0.70	1.01±1.16
COD (mg/L)	158.18±23.31	115.78±26.07	67.11±35.58
Phosphate (mg/L)	1.19±0.78	1.91±1.15	0.36±0.22
Nitrate (mg/L)	1.92±0.64	2.79±0.48	1.38±0.22
Sulphate (mg/L)	39.48±29.28	75.36±51.60	6.64±3.20
Fe (mg/L)	0.93±0.31	0.88±0.24	0.95±0.06
Cu (mg/L)	0.07±0.02	0.08±0.09	0.12±0.09
Cd (mg/L)	0.07±0.01	0.07±0.00	0.05±0.21
Ni (mg/L)	0.26±0.60	0.28±0.08	0.21±0.07
Pb (mg/L)	0.45±0.81	0.50±0.08	0.44±0.31
Zn (mg/L)	0.50±0.08	18.15±0.15	31.85±0.05
Cr (mg/L)	0.04±0.01	0.01±0.01	0.01±0.01
THC (mg/L)	14.48±19.30	2.54±2.79	0.44±0.23

The pH of the effluent before treatment was alkaline, after treatment the pH of the effluent became neutral, similar observations were made by other researchers [2, 5, 10] whose reports suggest that pH of effluents from beverage industries are unstable due to the various processes involved in the production processes. However, the pH of the effluents is within permissible limits but varied significantly (p=0.01). The value for DO decreased from 4.77±1.39 mg/L in station A to 3.09±1.27 mg/L in station B, the values were found to be within permissible limits and thus pose no threat to the receiving environment. Egwuonwu *et al* [4] reported that extremely high DO values in brewing effluents are a result of yeast load, spent grain and trub that are untreated or poorly treated before discharge, thus if DO levels are untreated could have a negative impact downstream when discharged. There was a slight decrease in BOD_5 of the effluents from 1.27±1.19 mg/L in station A to 1.24±1.19 mg/L in station B after treatment, although BOD varied significantly (p=0.05)it was well within the permissible limits. Sulphate varied significantly at (p=0.03) although it was within permissible limits of discharge however, accumulation over time could lead to algae boom and oxygen deficiency.

In the water body, the downstream of the effluent discharge recorded the least values for most of the parameters measured according to Table 2, this observation can be explained by the dredging activity going on at the downstream reach of the effluent discharge which induced some form of purification of the water body at the downstream. Temperature, electrical conductivity, turbidity, chemical oxygen demand and total hydrocarbon content all displayed a decreasing trend from upstream to downstream. Electrical conductivity in the creek displayed the following trend U>C>D, the mean values obtained for conductivity at Station U was higher than C and D, and varied significantly at (p=0.02). The conductivity at station C can be attributed to the presence of chemicals used in treatment of brewery process water as well as cleaning reagents which contain sodium hydroxide and chlorine [11]. At the effluent discharge point in the creek, the pH is more acidic than station U and D with a mean level of 5.96±0.26, as the effluents leave the factory according to table 4.2 the pH of station B is neutral but becomes acidic at station C and also varied significantly (p=0.00, t-test), this shows that the stream is acidic and thus neutralizes the basicity of the effluent upon contact with the creek at the discharge point. This is in line with reports of some researchers who reported acidic pH at the effluent discharge point [5,12]. The stream was generally acidic but the influence of the effluents made station C more acidic and varied significantly at (p=0.00). Station D recorded the highest value for DO with mean a level of 4.51±1.37mg/L, this shows that there are less oxygen consuming activities going on around the area thus there is more oxygen available to support aquatic life downstream than Station U and C. DO varied significantly (p= 0.00).Several studies on the impact of brewery effluent discharge on receiving water body reported that BOD_5 was highest at the effluent discharge point in the stream, due to the presence of spent yeast, grain, spent hops and trub which have the potential to consume oxygen during their decomposition [6, 13]. The high values recorded for COD in the effluent samples indicates the presence of a heavy load of organic substances such as spent yeast and grain and inorganic contaminants which could make the stream unsafe for domestic use. Although phosphate, nitrate and sulphate were within permissible limits, it was observed that the discharge point recorded the highest values for the nutrients with mean values of 1.91±1.15mg/l, 2.79±0.48mg/L and 75.36±51.60mg/L respectively. If left unchecked could accumulate overtime and cause algae and plant bloom which in turn could lead to oxygen depletion in the water body [3, 14]. There was no particular trend observed in the distribution of the metals however it was noted that copper, nickel, lead and zinc recorded higher values at the discharge point than upstream and downstream and exceeded permissible limits, while iron and chromium were significantly higher at station C (p=0.03 and p=0.02). Malu *et al* [15] reported that the presence of metals in brewery effluents is a result of herbicides and bactericides used in the cultivation and preservation of cereal grains a well as transportation.

Conclusion

It was observed that in spite of the treatment of the effluents in the industry, some physicochemical parameters still exceeded permissible limits. In the stream, although the levels of the physicochemical parameters at the point of contact were significantly higher than the upstream, the parameters at the downstream reach were within permissible limits due to the dredging activity taking place downstream that causes the some form of purification downstream. The effluent discharged into Oginigba creek is having a negative impact on the quality of the water body in the creek.

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