Physicochemical Characteristics of Wastewater from Brewery in Port Harcourt, Nigeria

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Abstract- This work examined some physicochemical parameters of effluents from a Brewery Industry in Port Harcourt. This company discharged effluent in non-compliance with the Nigerian National Regulations as confirmed from the Biochemical Oxygen Demand (BOD) having 11.6 for sample 1, 10.8 for sample 2 and 7.3 for sample 3 and Chemical Oxygen Demand (COD) ranging from 11.6 for sample 1, 10.8 for sample 2 and 7.3 for sample 3. From the results of the elemental analysis of the Industrial effluent of the company, the values for Cd, Cr, Pb and Fe did not fall within the range of the limit set by WHO. The study has shown that the Brewery Industry effluent had their BOD, COD, pH and Colour above the required WHO standard. This undoubtedly has negative impacts both on the environment and living things including humans. Since the results of analyses have shown that the Brewery Industry effluents are not well treated, it has been recommended that Regulatory agencies of states and Nigeria should monitor and ensure compliance of proper effluent treatment by Industries. These confirmed results posed health risks to several rural communities which rely on the receiving water bodies as their primary source of domestic water. There is need for the intervention of appropriate regulatory agencies to ensure production of high quality treated final effluents. This scenario is typical of most industries in developing nations where enforcement of environmental regulations is deficient. To avoid pollution, Regulatory Authorities should closely monitor compliance by industries.

Indexed Terms- Quality Assessment, Physicochemical Characteristics, Wastewater, Brewery Industry

I. INTRODUCTION

Rivers, lakes and other water bodies serve as a cheap source of effluent disposal by most industries especially in developing countries like Nigeria [1]. Unarguably, these effluents which are composed mainly of waste water from washing and cooling processes, fluids from machine leakages, reagents and various chemicals, frictionally generated metal particles, scraps, bacteria, grease, heat, dust, minerals and organic matter when they find their way into rivers, they pose a serious threat to the aquatic life, plants and animals, human which are at the peak of the food chain are equally affected. Heavy metals like lead are very poisonous; compounds like nitrates when in high concentration are very toxic especially to babies [2]. There is therefore every need to carry out a research to find out the elements and compounds present in the effluents of Brewery industries.

The term effluent can be defined as liquid waste flowing out of a factory, farm, commercial establishment, or a household into a water body such as a river, lake, or lagoon. In various under-developed countries, untreated sewage and industrial effluents are utilized for the cultivation of crops and vegetables. It is common practices in Nigeria where farmers suppose it to be a source of irrigation and nutrients for cultivation while administrators assume it as a low-cost method of disposal [3]. Environmental pollution is one of the chief causes of sickness in our society. Industrial effluents unfortunately have their final destinations in streams, which serve as the main source of water supply to most rural communities. There is need to monitor the effluents discharged by industries to ensure that they comply with regulatory standards. Industries are the major sources of pollution in all environments. Wastewater from industries includes employees' sanitary waste, process wastes from manufacturing, wash waters and relatively

uncontaminated water from heating and cooling operations. High levels of pollutants in wastewater systems causes an increase in biological oxygen demand (BOD), chemical oxygen demand (COD), total dissolved solids (TDS), total suspended solids (TSS), toxic metals such as Cd, Cr, Ni and Pb and faecal coli form and hence make such water unsuitable for drinking, irrigation and aquatic life [4]. Irrigation water that contains a certain ion at the concentration above threshold value can cause plant toxicity problem. It can result in impaired growth, reduced yield, change in morphology of plants and even its death. These heavy/trace metals when taken with plants by human can enter into human cell and cause different health impacts [5]. The problem of the industry's treatment plant also may cause the wastewater as well as the sediment to accumulate pollutants discharged from the plant. Due to this, this study will attempt to overcome the above problems which may come from improper treatment of the wastewater from Brewery Industry.

Water pollution, particularly surface water results from all activities of man involving indiscriminate waste disposal from industry such as effluents into waterways, waste, agricultural waste, and all forms of man's activities that results in contamination of the surface water. Pollution is caused when a change in the physical, chemical or biological condition in the environment harmfully affect quality of human life including other animals' life and plant [6]. Industrial, sewage, municipal wastes are been continuously added to water bodies hence affect the physicochemical quality of water making them unfit for use of livestock and other organisms [7]. Industrial effluent is unwanted water generated from industrial activities and are inappropriately discharged into the environment or receiving stream. Its characteristics provide basic information about the integrity of the rivers and streams into which they are discharged. Effluent discharge into the environment with enhanced concentration of nutrient, sediment and toxic substances may have a serious negative impact on the quality and life forms of the receiving water body when discharge untreated or partially treated [8]. Water pollution by effluent has become a question of considerable public and scientific concern in the light of evidence of their extreme toxicity to human health and to biological ecosystems [9]. The occurrence of

heavy metals in industrial and municipal sewage effluents constitute a major source of the heavy metals entering aquatic media.

The world health organization [10] and other concerned organization including local organizations have established international standard of chemical bacteria quality for portable drinking water and other water uses as an aid to the improvement of safe sanity quality. Exposure to Lead causes a variety of health effects, and affects children in particular. Water is rarely an important source of lead exposure except where lead pipes, for instance in old buildings, are common. This is non-essential for plants and animals and is toxic by ingestion-being a cumulative poison, producing damaging effects on the kidney, liver, tissues, blood vessels, nervous system and depresses sperm count.

Therefore, for evaluating present and future sustenance of the surface water for social-economic growth (since the pollution of water in a place can lead to the contamination of water body at other remote regions), the level or concentration of physicochemical parameters which determines the use of particular water must be periodically monitored.

Brewery, the alcohol producing industry, is one of the major polluting industries. It involves the making of fermented alcoholic beverages, such as beer and ale from cereal grains. There are two major steps involved in the process of malting and brewing. Brewery wastes are composed mainly of liquor pressed from the wet grain and wash water from the various departments. After the distillation of the alcohol process, the residue remains is referred to as "distillery slops", or "still bottoms". The brewing industry consumes much water about 10 gallons of processed water / gallon of product. The Biochemical Oxygen Demand levels are quite high, as are the total solids, typically about half the BOD and over 90% of the suspended solids are generated in the brewing operation. There are also solid wastes spent grains hop and sludge's, which are formed in this and the malting steps that must be disposed off. Disposal of such effluent without any prior treatment into water courses causes serious pollution problems [11]. Such wastes when discharged into open drain undergo aerobic decompositions and create obnoxious odorous conditions. The

indiscriminate disposal of untreated wastewater into water courses or into land invariably pollutes the ecosystem [12]. It also poses adverse effects to the aquatic fauna and flora and also to the ground water. Hence treatment of brewery effluent is a very important consideration before its disposal.

Though there are many physical and chemical treatment methods available, scientists have found that in managing certain wastes, the best option is the biological treatment which is more efficient and consumes no energy [13]. Since the complete degradation of organic chemicals in the natural ecosystem is primarily carried out by biological methods, bio technological application uses biological method or their enzymes for waste treatment [11]. Degradation of industrial effluents using microbes, Eichhornia sp and Perna viridis were carried out by many researchers [14].

Taste and odours are subjective properties which are difficult to measure. The unpleasant smells associated with polluted rivers/streams are due to the decomposition of organic compounds of nitrogen, phosphorus and sulfur. Humans and other animals have developed senses that enable them to evaluate the portability of water by avoiding water that is too salty or putrid [15].

The alkalinity of water is a measure of its capacity to neutralize acids. Although alkalinity is primarily a term invented by oceanographers [16]. It is also used by hydrologists to describe temporary hardness. Moreover, measuring alkalinity is important in determining a stream's ability to neutralize acidic pollution from rainfall or wastewater. It is one of the best measures of the sensitivity of the stream to acid inputs [17]. Although not all organic matter is biodegradable, the BOD test is still the widely accepted method of measuring organic matter. The BOD indicates the pollution of water by oxygen depletion [18].

II. MATERIALS AND METHODS

A. Description of Study Area
International brewery is located in Trans-amadi, Port Harcourt, Nigeria. Port Harcourt City is situated in the east of Rivers State, while Rivers State is a coastal city located in the Niger Delta region of Nigeria. It covers an area of about 2600 km^2 with a population of 1,382 592 according to the 2006 Nigerian census. The annual mean temperature ranges from 22 to 32. The alternate effects of the tropical maritime and continental air mass produce two distinct seasons namely, wet and dry. The hot and humid tropical climate promotes bio-degradation of wastes.

B. Water Sampling
The wastewater from the international brewery from Port Harcourt was collected from three (3) different points. Sample one (1) was taken from the untreated plant, sample two was taken after it has been treated and sample three was taken at the point of discharge. It was collected with 250 ml polyethylene bottles which were washed with detergent and rinsed with distilled water. Samples were analysed immediately and kept in the refrigerator in pre-rinsed plastic containers having airtight plastic covers for preservation. The parameters tested are: pH, Turbidity, Odour, Colour, Temperature (^{o}C), Total Suspended Solid (TSS), Total hardness (TH), Total Dissolve Solids (TDS), Dissolved Oxygen (DO), Sulphate (SO_4^-), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Chromium (Cr), Chloride (Cl), Cadmium (Cd), Iron (Fe) and Lead (Pb), Oil and grease. Analysis of the metals Pb, Cr, Fe and Cd were done using atomic absorption spectrometer. Atomic Absorption spectrophotometer was used to determine the concentration of each heavy metal under specific wavelengths. The samples (100 ml each) were digested with 5ml of nitric acid (HNO_3) to liberate organic molecule from the samples, and heated at the temperature range of 45°C to 65°C before being taken to sensitive laboratory. Chemical parameters were detected through different titrations applicable to each variable. The results obtained were compared with stipulated standard set by World health organization [10].

C. Methods
The adopted methods of analyses for the examination of all parameters in wastewater were in accordance with the procedure recommended in standard Methods for the examination of wastewater [19]. All samples were analysed for selected physical, chemical and heavy metals parameters.

III.   RESULTS AND DISCUSSION

A. Results

The results of the physicochemical parameters obtained from the brewery effluent are summarized in Table 1. The values obtained are compared with WHO standard.

Table 1: Physicochemical Results of Samples.

S/N	Parameters	Sample 1	Sample 2	Sample 3	WHO [10]
1	Odour	Beer	Beer	Slight sweet	Odourless
2	Colour	Brown	Slightly Brown	Slightly brown	Colourless
3	Turbidity (NTU)	0.343	0.272	0.128	5
4	pH	8.5	5.5	9.0	8.5
5	TDS (mg/l)	6.25	2.5	0	1000
6	TSS (mg/l)	65	45	15	1000
7	Total Hardness (mg/l)	200.00	20.00	40.00	100
8	Chloride ion (mg/l)	30	20	40	250
9	Cr (ppm)	7.0048	4.2454	1.8901	0.05
10	Fe (ppm)	2.80673	1.63544	1.38241	0.003
11	Pb (ppm)	1.16134	2.28910	1.09318	0.03
12	Cd (ppm)	0.37490	0.13692	0.15083	0.003
13	NO_3 (mg/l)	6.068	0.596	0.196	0.03
14	Oil and grease (mg/l)	75.00	5.00	10.00	10
15	SO_4^{2-} (mg/l)	0.37	0.32	Nil	250
16	DO (mg/l)	6.3	4.2	6.9	100
17	BOD (mg/l)	11.6	10.8	7.3	2
18	COD (mg/l)	146.42	120.53	98.34	80

B. Discussion of Results

The result of the physicochemical analysis of the industrial effluents (Table 1) showed a wide variation in comparison with the approved standard set by World Health Organization (WHO).

The results obtained shows that Brewery effluent has odour in it from the three samples and did not reach the standard set by WHO (odourless). The effluent too also contain colour from the three samples which did not conform to the standard set by WHO (colourless). The Turbidity of the effluent of the Brewery industry was well below the standard set by WHO 5mg/l.

The pH value of the Brewery effluent at the point of discharge (9.0) indicates high alkalinity compared with WHO approved limit of 8.5, the slight acidity of the effluent in sample 2 was probably due to high concentration of hydrogen ion [H+] at the point of discharge. When effluent with low pH have their ways into water bodies, it causes growth inhibition of bacteria species in the receiving water body. The ineffectiveness of the effluent treatment plant of the Brewery industry could be attributed to the high acidity of their effluent.

The BOD values of the company exceeded the WHO approved limit of 2mg/L. High BOD values are hazardous for the survival of the aquatic biota in the receiving stream because oxygen is utilized by aquatic species to oxidize organic matter. The value of Total Dissolved Oxygen (TDS) for the Brewery industry is within the limit stated by WHO 1000mg/l. Chemical Oxygen Demand (COD) for the Brewery effluent was high (more than two times the WHO limit of 80mg/l). This showed that the effluent was seriously contaminated with organic pollutants, since COD is indirectly used to measure the number of organic compounds in water.

The resources of NO_3 come from oxidation of other form of nitrogen like ammonic, nitrite, to nitrate. In the

present study the concentration of NO_3 for Brewery effluent after treatment fall within the approved limit set by WHO (0.03 mg/l) as shown in Table 1. The Brewery effluent recorded very low dissolved oxygen (DO), because it carried inorganic and organic matter and in decomposition of organic matter DO was consumed by microorganisms.

The value of Total Dissolved Oxygen (TDS) for the Brewery Effluent is within the limit stated by WHO (1000 mg/L). TDS is a measure of the combined content of all organic and inorganic substances contained in water.

The hardness of the industrial effluent was 200mg/l from the untreated plant of the Brewery industry. Hardness was very high compared with the 100mg/l permissible limit for drinking water set by WHO, after treatment it reached the limit set by WHO. Hard drinking water is generally not harmful to health, but can cause calcification of taps, boilers, kettles and other equipment used for handling water.

The SO_4^{2-} ion concentration in the studied wastewater samples was found to be within the permissible limit set by WHO which is 250 mg/L. The value obtained from wastewater collected from the 3 samples for TSS is within the permissible limit set by WHO. If this wastewater is applied directly to agricultural field or discharged into rivers and stream, this could make it unsuitable for aquatic life. For the total dissolved solids (TDS), values obtained for all samples assayed were within the permissible limit which is 1000mg/L. From the analysis high value of chromium was found in the Brewery Effluent which is not up to the standard which is 0.05ppm.

High Concentration of Cadmium was obtained compared to WHO permissible limit of 0.00ppm. Cadmium causes respiratory and kidney problems. The concentration of Pb in discharges of Brewery effluent was high compared to the WHO standard From the analysis the concentration of Iron from the Brewery Effluent was high compared to the standard set by WHO as shown in Table 1.

IV. CONCLUSION AND RECOMMENDATIONS

A. Conclusion

The study has shown that the Brewery Industry effluent had their BOD, COD and Colour above the required WHO standard. This undoubtedly has negative impacts both on the environment and living things including humans. This investigation has demonstrated that the effluent from the International Brewery in Port Harcourt is polluting the environment; even though most of the parameters investigated were within acceptable effluent quality limits.

B. Recommendations

Based on the outcome of this study, the following recommendations are necessary:

i   It is recommended that International Brewery has to improve by correcting their treatment process.
ii The Municipal community is also advised to institute sensitization meetings with the promoters of this industry on proper wastewater handling and treatment. Penalties for pollution should be proportional to the degree of pollution.
iii Since the results of analyses have shown that the Brewery Industry effluent are not well treated, it has been recommended that Regulatory agencies of states and Nigeria should monitor and ensure compliance of proper effluent treatment by industries.
iv Since industries cannot be isolated from national development, there is no way it can be stated here that industry should be stopped for operations. It is obvious from the discussion that enough attention has not been paid to the environmental sector, which is the basis of good environmental quality in Port Harcourt. Dissemination of environmental health related information to create awareness about the dangers involve in environmental degradation, if not taking proper care of and enforcement of all the environmental management policies.
v   This study shows that wastewater treatment before disposal, should be taken as serious as possible.

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