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Full Length Research Paper

Determination of the pollution loads of Brewery X and the impacts of the pollutant on the Sisai River

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Determining pollution load is not a common practice in most Ghanaian industries. This paper is aimed at providing a comprehensive picture of the environmental impacts on the Sisai River as a result of the pollutant loads from a Brewery X located in the Ashanti Region of Ghana. The effluent flow rate, effluent parameters concentrations and pollutant loads were determined using standard procedures. The effluent from Brewery X had a mean daily flow rate of 1035.85 m^3/day, mean Biochemical oxygen demand (BOD) of 1800.70 mg/l, chemical oxygen demand (COD) of 2844.33 mg/l, TSS of 129.32 mg/l, respectively and p values/rating for all effluent parameters of ($p < 0.0001$*). The presence of the effluent in the Sisai River will lead to oxygen depletion, increase in plant and animal biomass, reduction of the amount of light available for aquatic vegetation, decrease in species diversity and changes in the dominant biota.**

Key words: Effluent, environmental impact, pollution load, eutrophication, Sisai River.

INTRODUCTION

Since the early 70s, the Institute of Aquatic Biology in Achimota, Accra, has performed special research projects on pollution problems and monitored chemically, biologically and bacteriologically some rivers (Institute of Aquatic Biology, 1970; 1974). A study by Antwi (1973) also found chemical pollution in some rivers and streams. Untreated wastes from processing factories located in cities are discharged into inland water bodies resulting in stench, discolouration and a greasy oily nature of such water bodies (Mombeshera, 1981). These wastes pose serious threat to associated environment including human health risks (Khan et al., 1997). Industrial effluents contain toxic and hazardous materials from the wastes that settle in rivers as bottom sediments and constitute health hazards to the urban population that depend on the water as source of supply for domestic uses (Akaniwor et al., 2007).

The mining, textile and oil exploration industries readily come to mind when issues concerning polluters are to be discussed. The brewing industry probably does not. There has however, been a shift in this mentality since 1992 when the Colorado-based Coors Brewing Company became the first major brewery in the United States to do a comprehensive, voluntary investigation of its Volatile Organic Compound (VOC) emissions (Volokh, 1997). Irrespective of the location and equipments in a brewery, beer preparation always use up a lot of water and generates large volumes of wastewater.

Micro organisms gradually break down the organic component of wastewater produced during beer production consuming oxygen and subsequently polluting rivers, lakes, streams and deep-water aquifers (www.oasisenviro.co.uk/eutrophication.html). Brewery effluents are high in carbohydrates; nitrogen and cleaning/washing reagents which have been proved to be water pollutants. The introduction of wastewater, high in organic matter and essential nutrients, bring about changes in the microflora. Ekhaise and Anyansi (2005) reported high counts of bacterial population in Ikpoba River in Benin City Nigeria receiving a brewery industrial effluent. Similar results were reported by Kanu et al. (2006) of the effect of brewery discharge into Eziama River, Aba, Nigeria.

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In Ghana, the Environmental Protection Agency (EPA) Act 490 and Environmental Assessment Regulations 1999 (LI, 1652) are some drivers that are suppose to regulate the discharge of emissions from industries by setting standards and ensuring compliance. As to whether Brewery X complies with standards outlined by the EPA is worth investigating.

The study determined the pollution loads from Brewery X and assessed the impacts of the pollutant on the Sisai River.

MATERIALS AND METHODS

An anonymous and non-linked methodology was used.

Study area

Brewery X is situated in the Kumasi Metropolis. It shares boundaries to its south and east with timber processing companies, and shares a boundary to its west with a timber haulage company. It is separated from the Kaase Industrial area, which is to its north, by a street. The climatic data obtained from the Kumasi Airport was sourced to represent conditions at Brewery X. The study area falls within the wet semi-equatorial climatic region of Ghana with two rainfall maxima. Inter Tropical Boundary (ITB) influence the climate conditions of the area. The North-east trade winds are associated with a dry cool wind known as the harmattan, which affects the Ashanti Region of Ghana during the months of November to March. The first major rainy season occurs between May and July while the second is from September to October; attaining a maximum in June. The rainfall in the Brewery X vicinity is often intense and torrential. The resultant runoffs are very intense and accompanied by massive erosion of loose topsoil. The mean monthly rainfall ranges from 16.9 to 207.6 mm (Meteorological Office, Kumasi Airport). The mean monthly relative humidity in the area generally increases from the dry month of January to a maximum in August. The relative humidity value in the area ranges mainly from 70 to 80%, with daily temperature values varying from 24.4 to 28°C (Meteorological Office, Kumasi Airport).

Collection and analysis of water samples

Waste water samples (effluent) were collected into sterilized bottles over a fifteen week period and transported under dark conditions to the Ghana Water Company laboratory, for analysis. Physico-chemical parameters such as biochemical oxygen demand (BOD_5), total suspended solids (TSS), chemical oxygen demand (COD), phosphate, and oil/grease were used to determine the water quality and pollution loads from Brewery X. Standard methods as stated in Eaton et al. (1995) were used for determination suspended solid, BOD, COD and ammonia concentrations as well as temperature and pH. Standard methods as stated in the DR/2000 Spectrophotometer Procedures Manual by HACH Company, USA, were used to determine the concentrations of phosphorus and nitrate.

Measurement of effluent flow and velocity floats trial

The Community Clean Water Institute Volunteer Water Quality Monitoring Program Sampling and Analysis Methods (CCWI, 2011) methodology was used.

Flow Rate = ALC / T

Where, A = average cross-sectional area of the channel (channel width multiplied by average water depth), L = length of the channel, C = a coefficient or correction factor of 0.8 for rocky-bottom Channels, and T = time in seconds for the float to travel the length of L.

Pollution load

The pollution load was obtained by multiplying the mean daily flow by the mean daily effluent concentration and dividing by a thousand

RESULTS

The effluent from Brewery X had a mean daily flow rate of 1035.85 m^3/day. The concentrations for all effluent measured with the exception of nitrate as shown in (Table 1) were significantly higher than the EPA permissible levels. The COD and nitrate concentrations were the least compliant and the most compliant respectively with EPA permissible limits with the COD concentration exceeding the EPA value by more than 11-fold. The mean effluent concentrations of the main pollution indicators, together with the daily flow rate of the effluent, were used in calculating the daily pollution load discharged into the Sisai River from Brewery X (Table 2). Phosphate and COD were the pollutants with the least and most pollutant loads of 3.67 and 2946.30kg/day, respectively discharged into the Sisai River.

DISCUSSION

The effluent from brewery activities is likely to have serious environmental consequences when discharged untreated (Institute of Aquatic Biology, 1970, 1974; Parawira et al., 2005; Al-Rekabi Wisaam et al., 2007; Brewers of Europe, 2002). With a daily pollutant load of 133.88 mg/l for TSS, 1865.26 mg/l (BOD), 2946.30 mg/l (COD), 3.67 mg/l (Phosphate), 40.35 mg/l (Oil/Grease), respectively (Table 2) and ($P < 0.0001$) for all measured effluent parameters (Table 1), the Sisai River will be depleted of dissolved oxygen and noxious conditions will be created (Parawira et al., 2005; Osibanjo et al., 2011). There will be stimulation of aquatic plant growth and subsequently eutrophication of the Sisai River.

The breakdown of spent yeast, wort, trub and kieselguhr generated by Brewery X will deplete dissolved oxygen needed to sustain aquatic life in the Sisai River ($P< 0.0001$***) as depicted by (Table 2); consequently there will be suffocation of aquatic life which will result in putrefaction producing foul odour and killing living organisms in the river as confirmed by (Kunze, 2004; Osibanjo et al., 2011).

High concentrations of suspended solids with a mean value of 129.32mg/l, ($p < 0.0001$) as shown in (Table 1) and pollutant load 133.88kg/day (Table 2) as a result of spent grains, kieselguhr, surplus yeast, trub and label

Table 1. Descriptive statistics of effluent parameters with reference to EPA Permissible Levels.

Parameter	Min.	Max.	Mean	95% CI	EPA standard P value
TSS (mg/l)	67.9	140.90	129.32	119.47-139.04	50 P < 0.0001***
BOD (mg/l)	1274.09	2580.37	1800.70	1550.00-2051.43	50 P < 0.0001***
COD (mg/l)	1876.22	3849.65	2844.33	2508.36-3180.30	250 P < 0.0001***
COND (µS/cm)	1448.87	2945.90	2171.83	1969.29-2374.39	1,500 P < 0.0001***
OIL/GREASE (mg/l)	11.20	65.00	38.95	30.70 - 47.17	5 P < 0.0001***
Nitrate (mg/l)	0.37	0.92	0.60	0.52 - 0.69	50 P < 0.0001***
Phosphate (mg/l)	2.20	4.58	3.54	3.11 - 3.98	2 P < 0.0001***

Data presented in means, Min: minimum, Max: maximum, EPA Standard, CI: confidence interval, BOD: biochemical oxygen demand, COD: chemical oxygen demand, COND: conductivity. *p < 0.05, **p < 0.01, ***p < 0.001.

Table 2. Mean daily flow and pollution loads,

Effluent parameter	Mean daily flow (m^3/day)	Mean effluent conc. (mg/L)	Pollutant load (kg/day)
TSS		129.25	133.88
BOD		1800.70	1865.26
COD	1035.85	2844.33	2946.30
Phosphate		3.54	3.67
Oil/grease		38.95	40.35

Data presented in mean daily flow, mean effluent concentration, pollution load, TSS: total suspended solids, BOD: biochemical oxygen demand, COD: chemical oxygen demand.

pulp in the effluent of Brewery X will cause the colour of the Sisai River to darken thereby reducing the amount of light available for aquatic vegetation, algae and mosses to photosynthesize. Reduced plant matter means less food and habitat for herbivorous organisms such as snails, insects, fries and fingerlings. As photosynthesis slows, less oxygen is released into the water during the daytime and can lead to many plants dying off. As the dead plants decompose, bacteria will use up even more oxygen from the water (Osmond et al., 1995).

The darkening of the Sisai River will make the river warmer than usual due to the fact that darker materials absorb more heat from sunlight as compared to lighter ones. This will lead to a drop in oxygen levels and a rise in hydrogen sulphide concentration which can be toxic to all forms of life in the Sisai River. During the breakdown of the yeast, trub and spent grains which form the bulk of SS in the Sisai River, oxygen will be used up and this will deprive the surrounding water of oxygen. This will give the Sisai River an unpleasant smell and destroy aquatic life (Lenntech, BV).

The presence of phosphate in the Sisai River as a result of chemicals like phosphoric acid used in the clean-in-place (CIP) units by Brewery X will drastically densify vegetation along banks of the Sisai River and subsequently lead to eutrophication (Passant et al., 1993; UNEP, 1996; SEPA, 1991). Plankton and algae will become increasingly abundant and dead plants and animals will accumulate at the bottom layers of the river. If the water becomes completely de-oxygenated, as a result of the eutrophication, hydrogen sulphide, toxic to all higher forms of life will be formed. In all, heavy eutrophication will lead to a reduction in the number of plant and animal species in the Sisai River.

Fatty organic materials from petroleum are not quickly broken down by bacteria and can cause environmental pollution. When large amounts of oils and greases are discharged to receiving waters, they increase BOD and they may float on the surface and harden, causing aesthetically unpleasant conditions. The daily oil/grease load of 40kg/day from Brewery X into the Sisai River will trap trash, plants, and other materials, causing foul odours, attracting flies and mosquitoes and other disease vectors (http://www.danpatch.ecn.purdue.edu/~epados/septics/w water.htm). The oil/grease will increase BOD of the Sisai River. High BOD will lead to oxygen depletion, which can have severe consequences on fish life in the Sisai River (Osibanjo et al., 2011). If the dissolved oxygen (DO) value falls below the minimum oxygen requirement for particular species of fish in the Sisai River, they will be subjected to stress, which will result in mortality (Chapman and Kimstach, 1992).

Conclusion

The presence of the effluent in the Sisai River will lead to oxygen depletion, increase in plant and animal biomass, reduction of the amount of light available for aquatic vegetation, decrease in species diversity and changes in the dominant biota in the Sisai River. This will impact negatively on the water quality of communities which depend on the Sisai River as their source of water. Even though BOD is not a pollutant itself, it is a measure of organic pollution of the effluent from Brewery X. All the BOD_5 values obtained were beyond the EPA maximum permissible discharge level of 50mg/l. Brewery X is therefore non compliant for the effluent parameter BOD and can be said to be polluting the Sisai River.

REFERENCES

Akaniwor JO, Anosike EO, Egwim O (2007). Effect of Indomie industrial effluent discharge on microbial properties of New Calabar River. Sci. Res. Essays 2(1):001-005.

Al-Rekabi Wisaam S, Qiang H, Qiang WWu (2007). Improvements in Wastewater Treatment Technology. Pakistan J. Nutr. 6(2):104 -110

Antwi LAK (1973). Chemical pollution of some rivers and streams in Ghana. Proceedings of the First Technical Meeting of the Ghana Working Group on the Environment, Accra, 17 November 1972. Achimota, Ghana Working Group on the Environment. pp. 63–72.

Brewers of Europe (2002). Guidance Note for Establishing BAT in the Brewing Industry. The Brewers of Europe. Brussels:. http://www.brewersofeurope.org/asp/publications/publications.asp. Accessed 18 November 2010

Chapman D, Kimstach V (1992). The Selection of Water Quality in Water Quality Assessments. Chapman and Hall Ltd., London. pp. 51-119.

Community Clean Water Institute (CCWI) (2011). Measuring stream flow. Citizen Monitoring Handbook. Community Clean Water Institute, Sebastopol, California, USA. p 20.

DR Spectrophotometer Procedures Manual (2000): 293-615.

Eaton AD, Clesceri LS, Greenberg AE, Franson MA (1995). Standard Methods for the Examination of Water and Wastewater, 19^{th} Ed. America Public Health Association (APHA), American Works Association (AWWA) and Water Environmental Federation (WEF). pp. 2-69.

Ekhaise FO, Anyansi CC (2005). Influence of breweries effluent discharge on the microbiological and physiochemical quality of Ikpoba River, Nigeria. Afr. J. Biotechnol. 4:1062-1065.

Institute of Aquatic Biology, CSIR (1970). Fourth annual report, 1969–70. Annual Report of the Institute of Aquatic Biology, CSIR, Accra. (4):109 p.

Institute of Aquatic Biology, CSIR (1974). Fifth annual report, 1973. Annual Report of the Institute of Aquatic Biology, CSIR, Accra. (5):101 p.

Kanu I, Achi OK, Ezeronye OU, Anyanwu EC (2006). Seasonal variation in bacterial heavy metal biosorption in water samples from Eziama River near soap and brewery industries and the environmental health implications. Int. J. Environ. Sci. Technol. 3(1):95-102.

Khan MA, Rahman A, Lee HK (1997). Domestic water contamination in rapidly growing mega cities of Asia: Case of Karachi, Pakistan. Environ. Monit. Assess. 44: 339–60. http://dx.doi.org/10.1023/A:1005747732104

Kunze W (2004). Technology Brewing and Malting, International edition. VLB Berlin, Germany. English translation of the 7^{th} revised Edition of Technologie Brauer und Mälzer (2004).

Lenntech BV. General effects of eutrophication. http://www.lenntech.com/eutrophication-water-bodies/eutrophication-effects.html. Accessed on December 10, 2010.

Mombeshera G, Ajayi SO, Osibanjo O (1981). Pollution studies on Nigerian river: Toxic heavy metal status of surface water in Ibadan City. Environ. Int. 5:49-53.

Moore ML (1989). NALMS management guide for lakes and reservoirs. North American Lake Management Society. Madison, WI. http://www.nalms.org. Accessed 5 June 2010.

Oasis Environmental Limited http://www.oasisenviro.co.uk/eutrophication.html.. Accessed on November 18, 2010.

Osibanjo O, Daso AP, Gbadebo AM (2011). The impact of industries on surface water quality of River Ona and River Alaro in Oluyole Industrial Estate, Ibadan, Nigeria. Afr. J. Biotechnol. 10(4):696702

Osmond DL, Line DE, Gale JA, Gannon RW, Knott CB, Bartenhagen KA, Turner MH, Coffey SW, Spooner J, Wells J, Walker JC, Hargrove LL, Foster MA, Robillard PD, Lehning DW (1995). WATERSHEDSS: Water, Soil and Hydro-Environmental Decision Support System. http://h2osparc.wq.ncsu.edu. Accessed on December 10, 2010.

Parawira W, Kudita I, Nyandoroh MG, Zvauya R (2005). A study of industrial anaerobic treatment of opaque beer brewery wastewater in a tropical climate using a full scale UASB reactor seeded with activated sludge. Process Biochem. 40:593–599.

Passant NR, Richardson SJ, Swannell RPJ, Gibson N, Woodfield MJ, van der Lugt JP, Wolsink J, Hesselink GM (1996). Emissions of Volatile Organic Compounds (VOCs) from the Food and Drink Industries of the European Community. Atmosph. Environ. 27A(16):2555-2566.

SEPA (Swedish Environmental Protection Agency) (1991). Breweries and soft Drinks Factories. Industry Fact Sheet, 071-SNV/br, SNV19345. Swedish Environmental Protect Agency, Solna, Sweden. p 12. http:// www.p2pays.org/ref/32/31844.pdf. Accessed 6 March 2010.

United Nations Environmental Programme, UNEP (1996). Environmental Management in the Brewing Industry. UNEP Technical Report No. 33. United Nations, France. 106p

Volokh A (1997). Carrots over Sticks, The case for environmental self-audits. Washington Monthly, June 1997. http://www. volokh.com/sasha/audit.html. Accessed 5 June 2010.