IMPACT ASSESMENT OF BREWERY EFFLUENT ON WATER QUALITY IN MAJAWE, IBADAN, SOUTHWESTERN NIGERIA.

[1,2]ALAO Olajumoke*,[1,2]AROJOJOYE Oluwatosin , [1]OGUNLAJA Olumuyiwa.,[1]FAMUYIWA Abimbola.

1 Department of Biochemistry, Lead City University, Ibadan
2 Department of Biochemistry, University of Ibadan.
olajualao @yahoo.co.uk.

ABSTRACT: Impact of brewery effluent on water quality in Majawe was investigated. Water quality assessment was carried out on samples collected at 4 different sampling points; effluent discharge point, 500 meters away and two other discharge points downstream. The physicochemical parameters analysed were pH, temperature, alkalinity, electrical conductivity, TSS (total soluble solids),TDS (total dissolved solids), BOD (biological oxygen demand),COD(chemical oxygen demand),DO (dissolved oxygen), and concentration of chloride, iron, magnesium, calcium, cadmium, lead, arsenic and mercury. The pH of samples ranged from 6.56 to 7.17 ,temperature ranged from 24.5^{o}C to 27^{o}C , alkalinity ranged from 95.10mgl^{-1} to 407.21mgl^{-1}, electrical conductivity ranged from 23.3µScm^{-1} to 686 µScm^{-1}, total hardness ranged from 58mgl^{-1} to 210.56mgl^{-1},TDS (total dissolved solids) ranged from 119.7mgl^{-}1 to 331mgl^{-1}, TSS (total suspended solids) from ND to 554mgl^{-1} BOD (biological oxygen demand) ranged from 0.92mgl^{-1} to 785.7mgl^{-1}, COD (chemical oxygen demand) ranged from 2.2mgl^{-1} to 896.3mgl^{-1}, DO (dissolved oxygen) ranged from 2 mgl^{-1} to 6.8mgl^{-1}, calcium ranged from 28.24 mgl^{-1} to 90.47 mgl$^{-1,}$ magnesium ranged from 54.39mgl^{-1} to 75.31mgl^{-1}, phosphate ranged from ND to 0.21mgl^{-1} and nitrate ranged from 11.2mgl^{-1} to 47.3mgl^{-1}. The heavy metals: cadmium, arsenic and mercury were not detected in most of the samples; lead was detected in surface water and brewery effluent, 0.01mgl^{-1} to 0.7mgl^{-1} respectively. The physicochemical parameters studies shows that surface water and brewery effluent deviated from the WHO and FMENV standards but ground water sample was in line with the standards. Taken together these findings show that there is contamination of surface water by brewery effluent, however groundwater was non-toxic and therefore safe for drinking purposes. [Researcher. 2010;2(5):21-28]. (ISSN: 1553-9865).

Key words: Pollution, water, effluent, assessment, brewery and Majawe

1. Introduction

The problems facing the environment are vast and diverse .Environmentalists have expressed concerns about issues such as global warming, depletion of the Ozone layer, population growth, destruction of rain forests, air pollution, water pollution groundwater depletion and contamination. Water pollution is serious problem globally involving the discharge of dissolved or suspended substances into groundwater, streams, rivers and oceans. A major source of pollution in developing countries is industrial activities and this has gradually increased the problem of waste disposal. Increased industrial activities have led to pollutional stress on surface water both from industrial, agricultural and domestic sources (Ajayi and Osibanjo 1981). Untreated wastes from processing factories located cities are discharged into inland water bodies resulting to stench, discoloration and a greasy oily nature of such water bodies (Mombeshora,1981). These wastes pose serious threat to associated environment including human health risks (Rahman et al. 1997).Thus there is need to control the pollution of surface and ground water since the public health and wellbeing of the people have a direct link with the availability of adequate quantity of good quality water. Pollution of the aquatic environment has been defined by UNESCO /WHO/UNEP as the introduction by man directly or indirectly of substances or energy into the marine environment which results in such deleterious effects as harm to the living resources, hazards to human health, hindrance of marine activities including fishing and impairment of quality for use of sea water. Industrial activities and urbanization in developing countries including Nigeria has gradually led to increased problem of waste disposal. Increase in crude oil exploration, refining and activities of other industrial establishments in the Niger Delta has resulted in the wide-scale contamination of most of its creeks, swamps and rivers with hydrocarbon and dispersant products (Kobayashi and Rittman, 1982.

Manmade pollution of water is divided into two kinds: point source is caused by discharge of pollutants from specific location for example discharge from factories sewage treatment plants and oil tankers into rivers, and non-point source occurs from rainfall or melting of snow and the run-off washes away pollutants into lakes, rivers and coastal waters. Industries vary in size, nature of products, characteristics of waste discharged and the receiving environment. The major industrial categories in Nigeria are metals and mining, food, beverages and tobacco; breweries, distilleries, textile, leather products, wood processing and manufacture, furniture, pulp and paper industries and chemical and allied industries. Industrial effluents contain toxic and hazardous materials from the wastes that settle in river water 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). Groundwater quality is defined based on a set of health and safety regulations for domestic use. Ground water used for public domestic supply must adhere to a set of regulatory objectives for health and safety than ground water used strictly for irrigation needs. Groundwater contamination occurs when man-made products such as gasoline, oil, fertilisers, pesticides and other chemicals get into groundwater and cause it to be unsafe and unfit for human use. Septic systems, hazardous waste sites and landfills are major targets of pollution because rainfall and groundwater leach these highly contaminated substances into rivers, stream and waterways (surface water) which are inadvertently used by people in that area. (Asonye et al, 2007).

Contamination of drinking water supplies from industrial waste is as a result of various types of industrial processes and disposal practices. Industries that use large amounts of water for processing have the potential to pollute waterways through the discharge of their waste into streams and rivers, or by run-off and seepage of stored wastes into nearby water sources. Other disposal practices which cause water contamination include deep well injection and improper disposal of waste in surface impoundments. Industrial waste consists of both organic and inorganic substances. Organic wastes include pesticide residues, solvents and cleaning fluids, dissolved residue from fruits and vegetables, and lignin from pulp and paper. This impacts high organic pollutants on receiving waters consequently creating high competition for oxygen within the ecosystem . (Osibanjo and Adie, 2007).Effluents can also contain inorganic wastes such as brine salts and metals. A number of toxic substances human beings encounter regularly may pose serious health risks. Pesticide residues on vegetable crops, mercury in fish and many industrially produced chemicals may cause cancer, birth defects genetic mutations or death. Discharge of metals and some non-metals into water bodies have serious environmental effects. Lead a prime environmental pollutant, is a multiorgan poison which in addition to well known toxic effects depresses immune status(Anetor and Adedeji, 1998), causes damage to the central nervous system, kidney and reproductive system.(Ademoroti,1998).Ingestion leads to a disease known as plumbism. It is also known to produce developmental neurotoxicity in particular infants and children are differentially sensitive to environmental lead exposure (Johnson, 1997). Lead is toxic to plants although a few are tolerant. In non-ferrous metal industries, and industries that produce batteries, pigments, stabilisers and plastics the primary heavy metals discharged are lead, zinc, and cadmium, also cement manufacture results in high emission of mercury as well as these heavy metals except zinc. Arsenic and Zinc gain access to the water environment through mining operations. Nickel and Cobalt are used in the electroplating industry. Effluents contain these heavy metals which are harmful to human health either through direct ingestion or from fish and other animals or plants. Heavy metals particularly arsenic, mercury and lead are environmental pollutants threatening the health of human population and natural ecosystem (Mercier et al ,1998) .

Brewery plants have been known to cause pollution by discharging effluent into receiving stream, ground water and soil. Water consumption for breweries generally ranges 4-8 cubic meters per cubic meter of beer produced. Production steps include malt production, wort production and beer production. Untreated effluent typically contains suspended solids in range 10-60mg/l per litre, BOD in range 1000-1500mg/l, COD in range 1800-3000mg/l and nitrogen in range 30-100mg/l.Effluents from individual process steps are variable. For example bottle washing produces large volume of effluent that, however, contains only a minor part of total organics discharged from brewery. Effluents from fermentation and filtering are high in organics and BOD and low in volume, accounting for about 3% of total waste volume but 97% of BOD .Brewery effluent contains organic material such as spent grains, waste yeast, spent hops and grit. Effluent pH averages about 7 for combined effluent but can fluctuate from 3-12 depending on the use of acid or alkaline cleaning agent. (World Bank, 1997).Drinking water should be odorless, tasteless, colorless and devoid of particulate matter (Emile et al., 1999). Chemical investigation of the water quality of some Nigerian rivers.(Ajayi and Osibanjo, 1981; Adeniji and Mbagu, 1983; Imevbore, 1970; Asuquo, 1989) reveals that water that was once an abundant natural resource is rapidly becoming scarce in quantity (high demand) and the quality is deteriorating in many places, owing to population. There is little knowledge about the effects of effluent discharge in some areas in the Country. The aim of this study is to screen ground water and surface water in Majawe area of Ibadan, Oyo state., and to evaluate the toxicological potential of brewery effluent and the pollution factors on water quality in Majawe, Ibadan, Southwestern Nigeria.

2. Materials and methods

2.1 Sampling:

Grab samples of effluents were collected at point of discharge and downstream, surface water was collected from the run-off of effluent and ground water samples were collected from tube wells located near the site of brewery. The physico-chemical characteristics analysed were pH, temperature, alkalinity, electrical conductivity, total soluble solids, total dissolved solids, biological oxygen demand, chemical oxygen demand, dissolved oxygen, concentration of chloride, iron, magnesium, calcium and , ,cadmium , lead, arsenic and mercury.

2.2 Quality assurance

Samples of organics such as DO (dissolved oxygen), COD(chemical oxygen demand)and oil and grease were collected using glassware while heavy metals and other parameters were collected in plastic containers. The plastic and glass containers were soaked in 1M HNO3 overnight (Onianwa, 2001) and washed with laboratory detergent, rinsed with tap water and finally with deionised water.

2.3 pH

pH of samples was noted using potentiometric method using pH meter already standardised by using buffer solutions of known value before analyses.(Skoog et al,1988).

2.4 Temperature:

Temperature was noted using thermometric method at the site of sampling using portable calibrated mercury thermometer (Jenway 3015 model)(EPA, 1998).

2.5 Electrical conductivity (EC):

EC is the measure of the ability of an aqueous solution to convey an electric current. This ability depends upon the presence of ions, their total concentration, mobility, valence and temperature. EC was determined by conductivity meter following the procedure of Richard (1954).

2.6 Total suspended solids (TSS):

Total suspended solids are the portion of solids that usually remains on the filter paper. Suspended solids consist of silt, clay, fine particles of organic and inorganic matter, which is regarded as a type of pollution because water high in concentration of suspended solid may adversely affect growth and reproduction rates of aquatic fauna and flora. For TSS analysis, known amount of sample was filtered through the pre weighed filter paper. Filter paper was then dried at 103-105^{o}C. TSS was determined by using following formula (Anon, 1992).

$TSSmgl^{-1}$ = (final – initial weight) (amount of sample)-1 × 1000

2.7 Total dissolved solids (TDS):

Total dissolved solids (TDS) are the measure of total inorganic salts and other substances that are dissolved in water. TDS was determined following the procedure of Richard (1954) by using Electrical Conductivity (EC) meter.

2.8 Biological oxygen demand (BOD):

Biological oxygen demand (BOD) is expressed as weight of oxygen consumed per unit volume of water during a defined period of time at a defined temperature was calculated following the procedure of Hamer (1986). For this the sample of waste was incubated for 5 days at 20 ^{o} C in the dark. The reduction in dissolved oxygen concentration during the incubation period yields a measure of the biochemical oxygen demand.

2.9 Dissolved Oxygen

Dissolved oxygen was determined by Winker's titration.

2.10 Chemical oxygen demand

The COD is determined by titration with (0.25M) Ferrous sulphate, using 1:10 phenanthroline.(United Kingdom, Dept of Environ, 1974).

2.11 Cations and Anions

Cations were analyzed using an atomic absorption spectrophotometer (Perkin - Elemer AAS3110), while anions were analyzed using the colorimetric method with UV,visible spectrophotometer (WPAS110). Temperature was noted using thermometric method at the site of sampling using portable calibrated mercury thermometer (EPA, 1998).

2.12 Heavy metals analysis:

For the analysis of heavy metals, Cadmium (Cd), Arsenic (As), Mercury (Hg) and Lead(Pb). Samples were analyzed on Atomic Absorption Spectrophotometer (Perkin Elmer model 2380) for concentration by using specific cathode lamp. AAS was calibrated for each element using standard solution of known concentration before sample injection (APHA, 19).

3. Results

Table 1: The physicochemical results of GW1, GW2, SW, BE and standards.

PARAMETERS	GW1	GW_2	SW	BE_1	FMENV	WHO	NAFDAC
Temperature (^oC)	24.7^0 C	24.5^0C	27^0 C	26.0^0 C	< 40		
pH (mgl^{-1})	6.56	6.60		7.17	6-9	7-8.5	6.5-8.5
Total Alkalinity (mgl^{-1})	96.44	95.10	357.2	407.21			
Conductivity ($uScm^{-1}$)	250	23.3	587.5	686	400		
Total Hardness(mgl^{-1})	105.67	101.12	210.56	58		100	100
TDS(mgl^{-1})	119.7	121.6	234.67	331	2000	100	
TSS(mgl^{-1})	ND	2.51	347	554	30		
Calcium Hardness	40.40	42.2	90.47	28.24	200	50	75
Magnesium Hardness	65.27	75.31	65.5	54.39	200	50	30
Chloride(mgl^{-1})	31.61	22.80	26.6	19.01		200	200
Oil and Grease (mgl^{-1})	0.01	0.03	0.45	0.95			
Phosphate(mgl^{-1})	ND	ND	0.21	0.07			
Nitrate(mgl^{-1})	17.95	11.21	47.3	34.5		50	
Cadmium(mgl^{-1})	ND	ND	ND	ND	<1		
Arsenic(mgl^{-1})	ND	ND	ND	ND	0.1	0.01	
Zinc(mgl^{-1})	0.00	0.00	ND	ND	<1		
Lead(mgl^{-1})	ND	ND	0.7	0.01	<1	0.01	
Mecury(mgl^{-1})	ND	ND	ND	ND	0.05	0.001	
Acidity(mgl^{-1})	ND	ND	ND	ND			
BOD(mgl^{-1})	0.94	0.92	785.7	632.8	50		
COD(mgl^{-1})	2.8	2.2	875.3	896.3	150	10-20	
DO(mgl^{-1})	6.8	6.5	3.2	2			

Key; TDS: total dissolved solids, TSS: total soluble solids, BOD: biological oxygen demand), COD: chemical oxygen demand, DO dissolved oxygen, GW1: Groundwater1, GW2: Groundwater2, SW: surface water and BE ; Brewery effluent.

Table 2: Heavy metal concentration.

Varible(mgl^{-1})	Max concentration
Arsenic	0.05
Cadmium	0.01
Chromium	0.05
Lead	0.05
Mercury	0.02
Silver	0.05
Zinc	5.0

FEPA/FMNEV: 1991

Figure 1. Physicochemical parameters of water samples

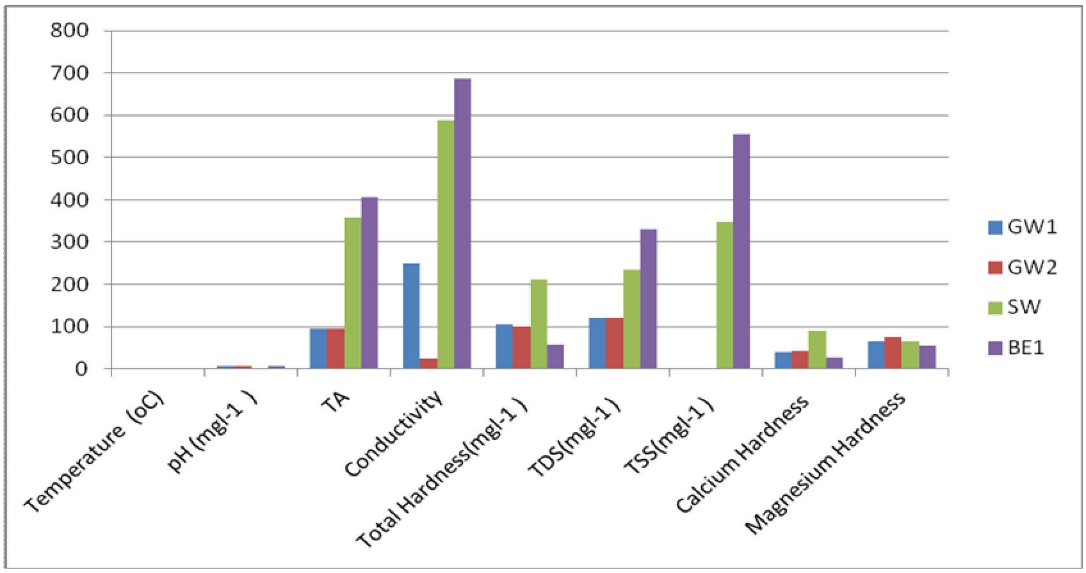

Table 3: Parameters used in classification of surface water quality.

Parameter	Class 1	Class 2	Class 3	Class 4	Class 5
pH	6.5 – 8.0	6.0 – 8.4	5.0 – 9.0	3.9 – 10.1	< 3.9 >10.1
DO(mgl^{-1})	7.8	6.2	6	1.8	< 1.8
BOD	1.5	3.0	6.0	12.1	> 12.1
NH3(mgl^{-1})	0.1	0.3	0.9	2.7	> 2.7
COD(mgl^{-1})	10	20	40	80	>80
SS(mgl^{-1})	20	40	100	278	>278

Value of Classes: Class 1 = Excellent; Class 2 = acceptable; Class 3 = slightly polluted; Class 4 = polluted; Class 5 = heavily polluted. (Source: Prati et al. (1971).

Figure 2: The Map of Majawe in Egbeda Local Government of Oyo State showing the Brewery and the surrounding environment.

4. Discussion

To evaluate the pollution extent samples were analysed for various physico-chemical parameters.).Sample pH range for this study was 6.25 to 7.17 as presented in Table1, GW1 (groundwater sample) had the lowest pH and brewery effluent (BE) had the highest pH. This result is in line with the FEPA/FMENV (Federal Environmental Protection Agency/ Federal Ministry of Environment, 1991), permissible limit of 6-9. All the pH values were within the permissible limits for industrial effluents set by FEPA (Table 1). The temperature range was 24.5^oC to 27^oC, this is also within the FEPA permissible limit of less than 40^oC. (Table 1).Samples of groundwater (GW1 and GW2) showed alkalinity values less than 100mg/l permissible limit set by WHO .But the surface water(SW) and BE (Brewery effluent) were higher than WHO limit , this is not surprising since the brewery process requires basic detergents for the cleaning stage.

Drinking water must be free of disease causing organism, poisonous substances and excessive amount of minerals and organic matter, and certain levels of minerals and dissolved substances are allowed (WHO, 1983).Hardness is predominantly caused by cations such as calcium and magnesium. Total hardness is defined as the sum of calcium and magnesium both expressed as $CaCO_3$ in mg/l. People with kidney and bladder stones should avoid high content of calcium and magnesium in water. Samples of groundwater and effluent were not hard, unlike surface water which appeared to be hard.105.2, 101.12 and 58 as compared with the FMENV permissible limit of 100. The nitrate concentration in the samples ranged from 11.2 to 47.3 with brewery effluent (BE) having the highest value, all the samples were within the FMENV permissible limit. The concentration of chloride and phosphate were within the FMENV limits.(Table 1)

The heavy metals cadmium, arsenic, zinc and mercury were not detected in the samples. The concentration of lead for surface water was 0.7, this exceeds the WHO permissible limit of 0.01 and FMENV limit of 0.05 (Table 2)

Brewery effluent contains organic materials like spent grains, waste yeast, spent hops and grit. Total suspended solids (TSS) range for samples is ND to 554 .GW1 and GW2 have TSS values of 0 and 2.51; this is within 30mg/l permissible limit set by FMENV. This can be explained by the fact that as the waste water permeates the ground the solid materials will be filtered out. .Whereas SW (surface water) and BE (brewery effluent) have much higher values (347 and 554) (Table 1) than the FMENV permissible limit. If this waste water 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) all the values were within the permissible limit set by FMENV.

Polluted water contains low levels of dissolved oxygen (DO) as a result of heavy biological oxygen demand(BOD) and chemical oxygen demand(COD) placed by effluents waste materials discharged into surface water. This makes water unsuitable for drinking, irrigation (Hari et al., 1994) or anyother use. The BOD for GW1(0.94) and GW2(0.92) were within the FMENV permissible limit and for SW (surface water) and brewery effluent (BE) the values were much higher, 785.7 and 632.8 when compared with the FMENV limit of 50. Similarly the COD for GW1 and GW2 was 2.8 and 2.2, while for SW (surface water) and BE (Brewery effluent) it was 875.3 and 876 which is much higher than the 150mg/l set by FMENV. This explains the dissolved oxygen (DO) for SW (surface water) and brewery effluent(BE) which is lower than the FMENV permissible limit 3.2 and 2.0 when compared with 5mg/l permissible limit s. These findings are in line with the study of Ipeayada and Onianwa, 2009. It is likely that the effluent on entering nearby stream will make oxygen depleted and may cause suffocation of fish and other aquatic organisms. On the evaluation of the surface water by the classification of Prati et al, 1971, it was found to be heavily polluted (Table 3). Unlike the brewery effluent and surface water the most of the physico-chemical parameters analysed for ground water were in line with the FMENV and WHO permissible limits, it can therefore be classified as safe for drinking purposes this is probably because the toxic level of substances in the effluent has not mixed up with ground water.

5. Conclusion.

The results of the physico-chemical analysis shows that the surface water in Majawe is polluted and this could be hazardous to human health when used primarily for domestic purposes. However, the physico-chemical parameters of ground water shows that the results are somewhat in line with the safe limit of FMENVA and WHO this could be due to the fact that the study was conducted during the rainy season.. Brewery effluent is a major source of environmental pollution through the discharge of the effluent into streams. Along with this another pollution factor posing a challenge to the Majawe environs is primarily the smell or odour of the brewery effluent when it is being discharged .I recommend there should be improved monitoring of surface water discharge and that further research should be done during the dry season.

6. Correspondence to:

Olajumoke Alao, Department of Biochemistry , Lead City University, Ibadan. P O BOX 18102 ,Dugbe, Ibadan, Oyo |State, Nigeria
Cellular phone : +2348034728112
Email: olajualao @yahoo.co.uk.

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