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Effluents Characteristics of Some Selected Food Processing Industries in Enugu and Anambra States of Nigeria

Emmanuel A. Echiegu* Jacob T. Liberty
Department of Agricultural and Bioresources Engineering, University of Nigeria, Nsukka, Nigeria
* E-mail of corresponding author: emmaechiegu@gmail.com

Abstract
There is an increasing awareness on the problems of environmental pollution not only in developing countries like Nigeria but worldwide. Among the sources of this problem is effluent discharge from industries, particularly food processing industries. To determine the extent of this problem in Anambra and Enugu States of Nigeria, some industries were purposively selected and their effluent characteristics studied. The industries include Premier Breweries and Life Breweries Plc, all in Onitsha, Anambra State, Anambra Vegetable Oil Production Company (AVOP) Plc, Nnachi, Enugu State, Diamond Breweries Ltd., 9th Mile Corner, Enugu State and Coca-Cola Bottling Company Plc, Ngwo, Enugu State. The effluents were collected and analyzed for solids, organics, nitrogen, pH and total coliform using standard procedure. The results showed that total solids (TS) varied 440 to 703 mg/L, total suspended solids (TSS) from 0 to 230 mg/L and total volatile solids (TVS) from 223 to 514 mg/L. The pH of the effluents varied from 6 to 8, the COD from 684 to 3,192 mg/L, the TKN from 5.6 to 33.6 mg/L and the total coliform from 43 to 150 MPN/100 mL of effluent sample. Compared to the effluent limitation guidelines given by Nigerian Federal Environmental Protection Agency, the TSS, and COD for most of the industries are well above the limits while the TKN, pH and coliform count are within the acceptable limit.
Keywords: Food processing waste, Effluents, Waste characteristics, Environmental pollution

1. Introduction

Man exerts many effects which directly or indirectly affects his environment. The development of industries and extensive urbanization means increased water consumption and pollution resulting from problems of waste disposal. Unfortunately, in most developing countries like Nigeria, effluent quality standards imposed by legislation (where they exist) are sometimes easily flouted (Okereke, 2007).

Industrial effluents are liquid wastes which are produced in the course of industrial activities. Over the years, the improper disposal of industrial effluents has been a major problem and a source of concern to both government and industrialist. In most cases the disposal or discharges of effluents, even when these are technologically and economically achievable for particular standards, do not always comply with pretreatment requirement and with applicable tonic pollutant effluent limitations or prohibitions. The consequence of these anomalies is a high degree of environmental pollution leading to serious health hazards.

Among the food processing industries commonly found in the study area are beer breweries, soft drink bottling companies, vegetable oil industries, etc. Brewery industries produce waste waters like spent cooling water, spent grain liquor, spent hop liquor, liquor from yeast recovery system and wash down waters. In most breweries in Nigeria, these various sources of wastewater are discharged from the industry through a common outlet. Wastes such as dry brewers grain and spent grain are used as animal feedstuff and therefore do not create disposal problems. Brewery wastewaters can be land applied after limited pretreatment (e.g. screening and equalization) if enough land area is available. This depends on which brewery streams are combined for land application, while specific quality characteristics can vary greatly (Otta and Cable, 1987).

The vegetable oil processing plants produce oil sludge's and other wastewaters that are normally land applied after limited pretreatment. However, considering the types and interactions of the numerous constituents of these complex waste streams and the necessity to avoid the environmental pollution problems that can result when these wastes are land applied, it is necessary that the characteristics of the effluents from breweries and other food processing industries in a developing country like Nigeria be investigated. The purpose of this study was therefore to investigate effluent quality of some food processing industries in Enugu and Anambra States of Nigeria.

The specific objectives of the study were:

(a) To identify some food processing industries in Enugu and Anambra state of Nigeria.
(b) To collect and characterize effluent samples from the selected industries with respect to:
    (i) Total Suspended solids (TSS)
    (ii) Total solids (TS)
    (iii) Total Volatile solids (TVS)
    (iv) Hydrogen-ion concentration (pH)
    (v) Total Kjeldahl Nitrogen (TKN)

(vi) Chemical Oxygen Demand (COD)
(vii) Coliform count measured as Most Probable Number (MPN).

2. Materials and Method

2.1 Study Area and Scope

Anambra and Enugu states are among the five states that make up the south-east geopolitical zone of Nigeria. Anambra lies around latitude 6° 20'N and 7° 00'E. With a population of 4,055,048 (2006 census) and a population density of 840/km^2, Anambra is the 10th populous state in Nigeria. It is a commercial nerve centre of the zone and home to Onitsha market which is reputed to be the largest market in West Africa. Located at the east bank of River Niger, the state hosts at least two breweries, a starch Processing mill, numerous bakeries, bottled water companies, etc.

Enugu State (Latitude 6° 30'N, Longitude 7° 30'E and 223 m above sea level) has Enugu city as its capital city. It has a land area of 7,161 km^2 and a population of 3,267,883 (2006 census). It is a major coal producing city and the administrative capital of the then Eastern Nigeria. It is also the home of many breweries and bottling companies as well as a vegetable oil processing company among others. Food processing industries in other states in the zone are not very much different from those of Anambra and Enugu States.

This study was limited to five purposively selected industries scattered within the two states. The industries include:

(a) Premier Breweries Plc, Onitsha, Anambra State.
(b) Life Breweries Plc, Onitsha, Anambra State.
(c) Anambra Vegetable Oil Production Company (AVOP) Plc, Nnachi, Enugu State.
(d) Diamond Breweries Ltd., 9th Mile Corner, Ngwo, Enugu State.
(e) Coca-Cola Bottling Company Plc, Ngwo, Enugu State.

Premier Brewery was established in 1977 by the then Anambra State government. At the time of this research, the installed capacity was 1.2 million hectoliter per annum. Apart from *Premier Special Brew* which was its star product, the company was also producing *Masters Lager Beer* and *Multimalt* – a malt drink. Inside the company, there was a well designed network of drainage channels with a common outlet from where the effluent left the company. The wastewater was discharged untreated into the River Niger.

Life Brewery was established in 1983, again by the then Anambra State government. At the time of the research, the company was operating at 85 % of its installed capacity of 400 000 hectoliter per anum. In addition to *Life Lager beer*, the company was also producing *Gintonic Wine* and *Savanna Soft Drink* – a pineapple juice drink. Effluents were discharged through drainage pipes which met at a common point before leaving the factory.

AVOP was established in 1976 by the government of the then Anambra State but commissioned in 1987. The company had an installed capacity of 42 000 mt of refined oil products per annum, including cooking oil, pure vegetable oil, margarine, bakers fat and soap. At the time of the study, the company was operating at 78 % of the installed capacity and production was limited to pure vegetable oil and soap. As with Life Brewery, effluents were discharged through a network of underground drainage pipe which met at a common point from where the effluent left the company. Outside the factory, the effluent is discharged untreated through public drains into surface streams.

Diamond Brewery was established as a private sector company in 1982 with a capacity of 386 000 hectoliters of drinks per annum. Its product included *Monarch Lager beer* and *Diamalt*. The company had no wastewater treatment plant and so its effluents were discharged through a common outlet point in the factory to the public sewer. Before the completion of this study the company was acquired by the Nigerian Brewery Plc.

The Coca-Cola bottling company is part of the international Coca-Cola chain. At the time of the study, the company was producing at 72 % of its installed capacity of 350 000 hectoliters per annum. The company is noted for three of their major products including *Coca-Cola, Fanta Orange* and *Sprite* as well as *Tonic Soda Water* and *Fanta Ginger Ale.* The company discharged their effluents through a common open channel to adjacent land outside the company premises.

The industries were identified to reflect the major food processing industries in the zone.

2.2 Method of Sampling

Wastewater samples were collected manually with sterilized plastic containers from the interception channels from where the effluent was discharged from the company's premises. For each industry, grab samples were taken once a week between the months of April and June and during the peak production periods of the day. The samples were taken at about 11.30 a.m. of the day (± 0.5 hours) for all the industries throughout the study period. A total of 60 samples were collected. The containers were labeled and transported immediately in a container of ice for physiochemical and bacteriological analysis. The samples were stored in a refrigerator at 4°C to avoid biological actions until the time of analysis and after each analysis in laboratory. The samples were analyzed in the Civil Engineering Laboratory of University of Nigeria, Nsukka. In the laboratory, visual analyses were made

and the results recorded as the physical characteristics of the sample. Some of the samples collected were a bit clear while some looked cloudy and all contained a lot of particles. The samples are relatively dilute mixture of wastewater from different sources of varying constituents.

2.3 Method of Analysis

The principal parameters used in the analysis to characterize the effluents are given in Table.1. The procedures used during the analysis are also given. Many of the parameters are interrelated

2.3.1 Solids

Solids determination was carried out following the procedure outlined in Standard Method (APHA, *et. al.,*1985). The total solid (TS) was determined gravimetrically by evaporating a known volume of the effluent sample to dryness at 104^{o}C in a ventilated oven until a constant weight was achieved. Total volatile solids (TVS) were determined by firing the residue at 600^{o}C for 1 hour in a muffle furnace and determining the loss in weight of the residue. Total suspended solids (TSS) were determined gravimetrically by filtering a known volume of the effluent sample using a vacuum filtration apparatus and *Whatman No. 40* filter paper, drying the residue and the filter paper at 104^{o}C and determining the mass of residue left on the filter paper.

2.3.2 pH

This was determined using a portable pH meter (HACH Senson 3).

2.3.4 Chemical Oxygen Demand (COD)

The COD of the samples were determined by refluxing a known volume of each sample with a known amount of potassium dichromate ($K_2Cr_2O_7$) in the presence of sulphuric acid (H_2SO_4), silver sulphate ($AgSO_4$) and mercuric sulphate ($HgSO_4$). The amount of dichromate left after the reflux was determined by titration against ferrous ammonium sulphate [$Fe(NH_4)_2(SO_4)_2.6H_2O$], using ferrroin as indicator as described by Standard Methods (APHA, *et. al.* 1985). Similar volume of blank sample consisting of distilled water was equally refluxed and titrated. The COD was computed from:

$$TS = \frac{(A - B) * N * 8000}{V_s} \text{ mg/L}$$

Where A = mL of [$Fe(NH_4)_2(SO_4)_2.6H_2O$] in a blank sample, B = mL of [$Fe(NH_4)_2(SO_4)_2.6H_2O$] in the effluent sample, N = normality of the titrant and V_s = the mL of sample.

2.3.5 Total Kjedahl Nitrogen (TKN)

This was determined by digesting a known volume of the effluent samples in the presence of H_2SO_4, K_2SO_4 and $CuSO_4$ until the ejection of SO_3 stopped and the solution became colourless or pale straw. The solution was then distilled after addition of phenolphthaline indicator and hydroxide thiosulphate reagents and the distillate collected and titrated with standard 0.02N H_2SO_4. A blank consisting of ammonia free water was equally digested, distilled and titrated and the TKN determined as described in Standard Method (APHA, *et. al.,* 1985)

2.3.6 Coliform Count

Multiple Tube Fermentation technique was employed to statistically estimate the number of coliform bacteria in a given volume of the samples following the method outlined in APHA, *et. al.* (1985). A three-fold dilution series was prepared for each sample using Lauryl Tryptose Broth (LTB) tubes for the presumptive test and Brilliant Green Bile broth (BGB) for the confirmatory test. After incubation at 37^{o}C for 12 – 48 ± 3 hours, the pattern of positives and negatives were noted and a standardized MPN table consulted to determine the most probable number of organisms (causing the positive results) per 100 mL of each of the effluent samples.

3. Results and Discussion

The results of the analysis are summarized in Table 2 which also shows a comparison of the result with the Nigerian Federal Environmental Protection Agency (FEPA) effluent limitation guidelines for all industrial wastes (FEPA, 1988 and 1991), together with the general standard for discharge of effluents into inland surface water (Chaterjee, 2010).

3.1 Solids Concentration

Suspended solids are a direct indication of the solids removable by plain sedimentation and also are an index of the sludge forming characteristics. The range of values of suspended solids in the analyzed samples ranged from 0 for AVOP to 230 mg/L for Premier Brewery (Figure 1). These values are far below the suspended solid concentration of 750 mg/L reported for raw brewery effluent by Otta and Kendal Cable (1987) and the value of 150 mg/L given by Chaterjee (2010) as the allowable standard for edible oil industry effluents. The effluent discharges from the three breweries are however higher than the 38.5 mg/L value reported for Nigerian Breweries Plc (makers of *Star Beer*) by Egwuonu, *et. al.*, (2012). The value for Coca-Cola (42 mg/L) is also higher than the value of 0.53 mg/L reported for the Nigerian Bottling Company plant in Maidugri, Nigeria by Arku, *et. al.* (2012). Except for AVOP, the suspended solids concentrations are also higher than the value of 30 mg/L given by Nigerian FEPA guidelines for discharge of industrial effluents into surface water. Also, the values for Diamond and Premier breweries are higher than the allowable value 100 mg/L given in the general

standard for discharge of effluents into inland surface water. All these indicate the need for treatment before the discharge of these effluents into surface streams. The total solids concentration ranged from 440 mg/L for Premier Brewery to 703 mg/L for Coca-Cola Company. They are all below the value of 2,030 mg/L given in the FEPA guideline. The volatile solids concentrations ranged from 223 to 514 mg/L.

3.2 Organics

COD is generally defined as the total quantity of oxygen required for complete oxidation of organic compound to carbon dioxide and water. It is an important rapidly measured parameter to determine the degree of pollution in an effluent (Metacalf and Eddy 2003) From the analysis, the COD values ranged from 684 mg/L for Coca-Cola Bottling Company to 3,192 mg/L for Premier Brewery (Figure 2). These values were all higher than the value of 14.8 mg/L reported for Nigerian Breweries Plc, Enugu by Egwuonu, *et. al.*, (2012), the FEPA guideline of 80 mg/L and the 250 mg/L given by General standards. Also, when compared to the value for edible oil industry effluent of 200 mg/L given by Chaterjee (2010) the COD for AVOP is seen to be much higher than the allowable value. If these effluents were discharged to the environment untreated, they will constitute pollutants which will directly or indirectly lead to the depletion of the natural oxygen resources and to the development of septic and hazardous conditions. The COD value of the effluent from Coca-Cola is very much smaller than the value of the other samples just like in the case of suspended solids but all of them signifies the need for treatment before disposal.

3.3 pH

The pH values ranged from 6 to 8 (Figure 3). The effluents from most of the breweries were slightly acidic or neutral while those of the non breweries were either neutral or slightly alkaline. The recorded pH values fell within the effluent limitation guidelines and discharge standard.

3.4 Nitrogen

Organic nitrogen and ammonia are essential nutrient for growth. Their oxygen content reduction potential and the fact that they can be toxic to aquatic life make them not desirable in drinking or recreational water. Their presence in the effluent in substantial amount, just like other tested parameter, signifies the need for treatment to avoid the associated adverse effects. The value of total kjeldahl nitrogen (TKN) concentrations ranged from 5.6 mg/L to 33.6 mg/L (Figure 4). The values for most of the industries are well within the value of 20 mg/L given by FEPA (1988). Also, all of the values are well below the value of 100 mg/L given by General Standard.

3.5 Pathogenic Bacteria

The samples tested gave the coliform bacteria concentrations ranging from 43 to 150 MPN/100 mL (Figure 5). This shows that all the samples are capable of causing pollution and probably contains human wastes which are the primary sources. FEPA guideline gave a maximum value of 400 MPN/100 mL while for the general standard the values ranged from 50 to 5000 MPN/100mL depending on the envisaged treatment and use of the surface water to which the effluent is discharged. Although the coliform counts for the industrial effluents are below the guidelines and standards, there is still the need for treatment to ensure that the surface water is pathogen free.

4.0 Conclusions and Recommendations

4.1 Conclusion

The results showed as follows:

(a) The COD values ranged from 2,166 to 3,192 mg/L for breweries and 684 to 1,026 mg/L for non brewery industries. The values were higher than that set in Nigerian FEPA guidelines for discharge of industrial effluents into surface water indicating the need for efficient treatment of the effluents by the industries before discharge into surface streams. Generally COD concentrations of the breweries were generally higher than that of the bottling company or AVOP.

(b) The TS ranged from 440 to 703 mg/L, TVS ranged from 223 to 514 mg/L while the TSS ranged 0 to 230 mg/L. While the values for the TSS was higher than the maximum limit set in FEPA Guidelines, the total solids concentration was well within the limit.

(c) The pH ranges from 6 to 7.5 for breweries and 7 to 8 for non-breweries. FEPA guidelines gave an acceptable range of 6 – 9 indicating that based on pH values alone the effluents can be discharged into surface streams without any negative impact.

(d) The coliform count, measured as MPN/100 mL ranged from 43 to 150 while the value for the TKN ranged from 5.6 to 33.6 mg/L.

4.2 Recommendation

The basic responsibility for pollution control in Nigeria lies with the federal and state Environmental Protection Agencies. To ensure that our surface waters are safe from the negative impacts of effluent discharge from industries, the following recommendations are made as a way of solving pollution problem caused by the increased industrialization.

(a) The FEPA guidelines should be reviewed to include effluent and other limitations for such specific

industries like breweries, vegetable oil and other food processing industries not already covered by the guidelines. Also limitations for many other relevant pollution parameters should be included.

(b) Federal and State Environmental Protection Agencies should carry out routine checks on industries especially food processing industries with a view to ensuring compliance.

(c) Finally, in the absence of standards for some certain pollution parameters, industries should set up their own in-house quality limits for these parameters as reported for the Nigerian Bottling Company, Maidugri by Arku *et. al* (2012).

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References

APHA, AWWA, and WPCF (1985) *Standard Method for the Examination of Water and Wastewater.* 16th Edition, American Public Health Association (APHA) Washington D.C.

Arku, A.Y., Musa, S.M., Maoke, A.L.E and Dibal, J.M. (2012) Re-examining raw effluents from Nigerian Bottling Company, Maidugri for Crop Irrigation. *Journal of Applied Hytotechnology in Environmental Sanitation* 1(1): 43 – 49.

Chaterjee, A.K. (2010). *Water Supply, Waste Disposal and Environmental Engineering*. Khanna Publishers, New Delhi.

Egwuonwu, C.C., Uzoije, A.P., Okafor V.C., Ezeanya, N.C and Nwachukwu, M.U. (2012) Evaluation of the effects of industrial wastewater discharge on surface water (A case study of Nigeria Breweries, Plc, Enugu). *Greener Journal of Physical Sciences* 2(3): 56 – 63.

FEPA (1991) *Guidelines and Standard for Environmental Control in Nigeria. Federal Environmental Protection Agency (FEPA)*. Government Printer, Lagos

FEPA. (1988). Effluent Limitation Guidelines in Nigeria for all Industries. *Federal Environmental Protection Act*. Second Schedule (Regulation 3). Government Printer, Lagos.

Metacalf and Eddy (2003). *Wastewater Engineering: Treatment, and Reuse.*, TATA McGraw-Hill Edition. TATA McGraw-Hill Publishing Company. New York.

Okereke, C.D. (2007). *Environmental Pollution Control*. 1st Edition. Barloz Publication, Owerri, Nigeria.

Otta, W. J. and Kendall Cable, J. (1987). Land application of waste from brewery and distilling plants. *Proceedings of the 1987 Food Processing Waste Conference*, Sept 1 – 2, 1987. Georgia tech Research Institute, Atlanta, Georgia. pp 129 – 144.

Dr. E.A. Echiegu (MNSE, MNIAE), a native of Abakaliki, Ebonyi State, Nigeria obtained a B.Sc. degree from the University of Ife (now Obafemi Awolowo University) Ile-Ife, Nigeria in 1982, an M.Eng degree from the University of Nigeria, Nsukka, Nigeria in 1986 and a Ph.D from the then Technical University of Nova Scotia (now Faculty of Engineering, Dalhousie University), Halifax, Nova Scotia, Canada in 1992, all in Agricultural Engineering. His major area of specialization is Farm Structures and Environmental Control Engineering. Currently a Senior Lecturer in the Dept of Agric and Bioresources Engineering, his areas of research include renewable energy applications in agriculture, agricultural waste management and environmental quality control in livestock and poultry structures. He is a member of the Nigerian Society of Engineers and Nigerian Institution of Agricultural Engineers. He has also held many public service appointments including that of Ebonyi State Commissioner (Minister) of Agriculture and Natural Resources.

J.T. Liberty, hails from Michika in Adamawa State, Nigeria. He obtained his B.Eng degree in Agricultural and Environmental Research Engineering from the University of Maidugri in 2010. He is currently a master of engineering degree student at the department of Agricultural and Bioresources Engineering, University of Nigeria, Nsukka.

Table 1: Principal parameters analyzed

Physical parameters	Chemical parameters	Bacteriological parameter
Suspended Solids (SS) Total Solids (TS) Volatile Solids (VS)	pH Total Kjedahl Nitrogen (TKN) Chemical Oxygen Demand (COD)	Coliform count

Table 2. Physiochemical and biological characteristic of effluents from the industries studied[1].

Parameters	Diamond Brewery	Coca-Cola Bottling Company, Plc.	Premier Brewery	Life Brewery	AVOP	General Standard[2] (max value)	FEPA[3] Guidelines (max. limit for discharge into surface water)
Suspended solids	121	42	230	100	0	100	30
Total solids	482	703	440	534	685		2,030
Volatile solids	223	514	349	362	310		NS
pH	7.5	8	6	6.5	7.0	5.5 – 9	6 – 9
COD	2166	684	3129	2348	1026	250	80
Total Kjedahl Nitrogen (TKN)	13.44	5.6	33.6	20.16	11.20	100	20
Coliform count (MPN/100 mL)	93	43	150	120	75	50 – 5000[4]	400

[1]All units are in mg/L except pH and Coliform count.
[2] General Standard for the Discharge of Effluents Into Inland Surface Water (Chaterjee, 2010).
[3] Nigeria Federal Environmental Protection Agency (1988)
[4]50mg/L for drinking water source without conventional treatment, 500 mg/L for outdoor bathing and 5000 mg/L for drinking water source with conventional treatment followed by disinfection.

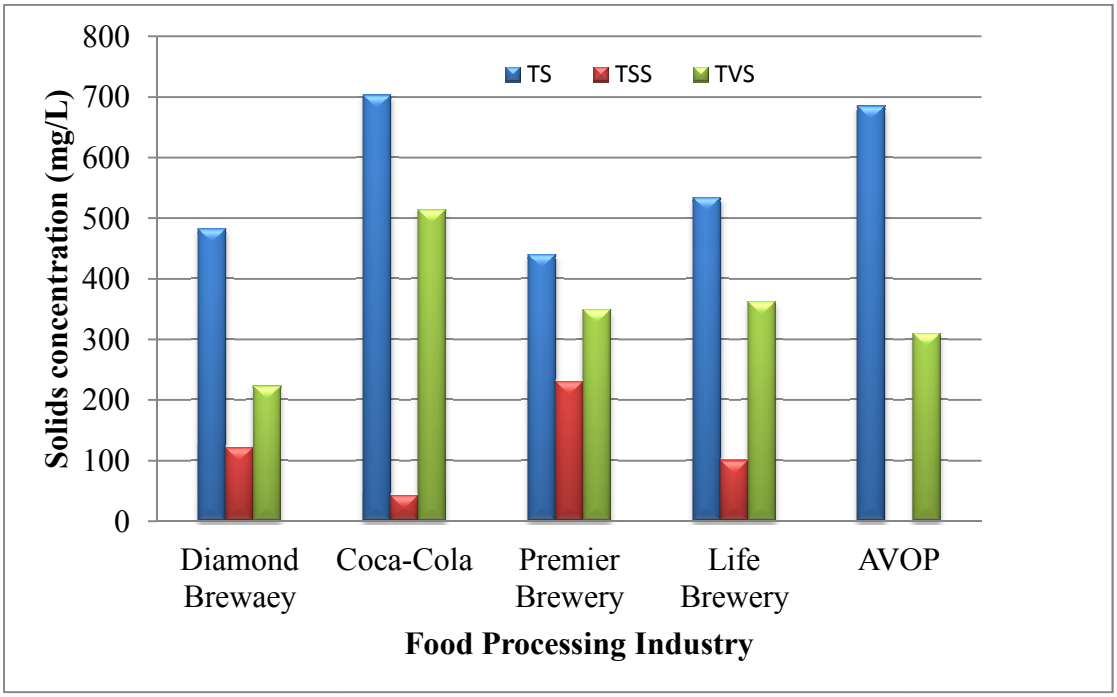

Figure 1. Solids concentration of the effluents.

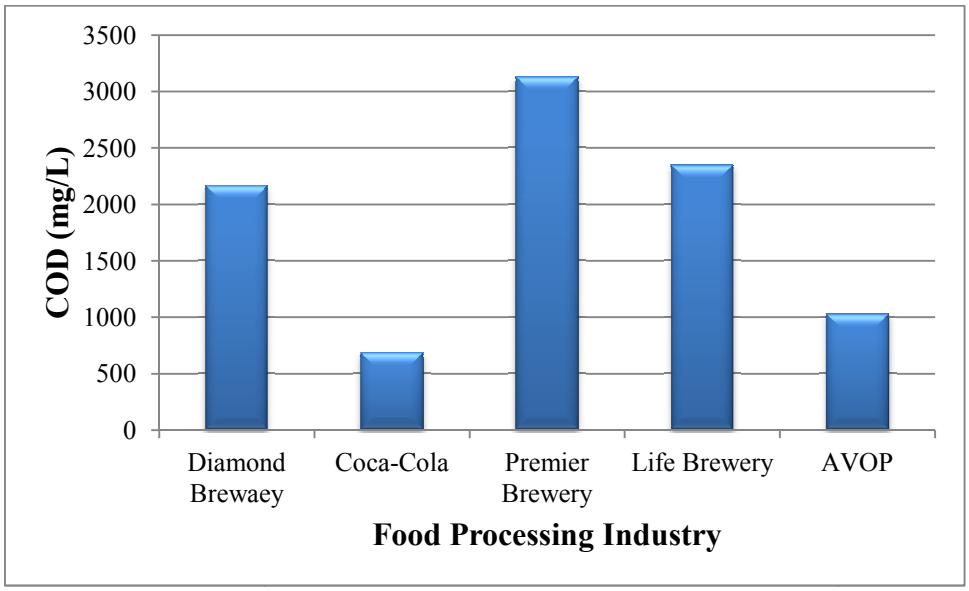

Figure 2. COD concentration of the effluents.

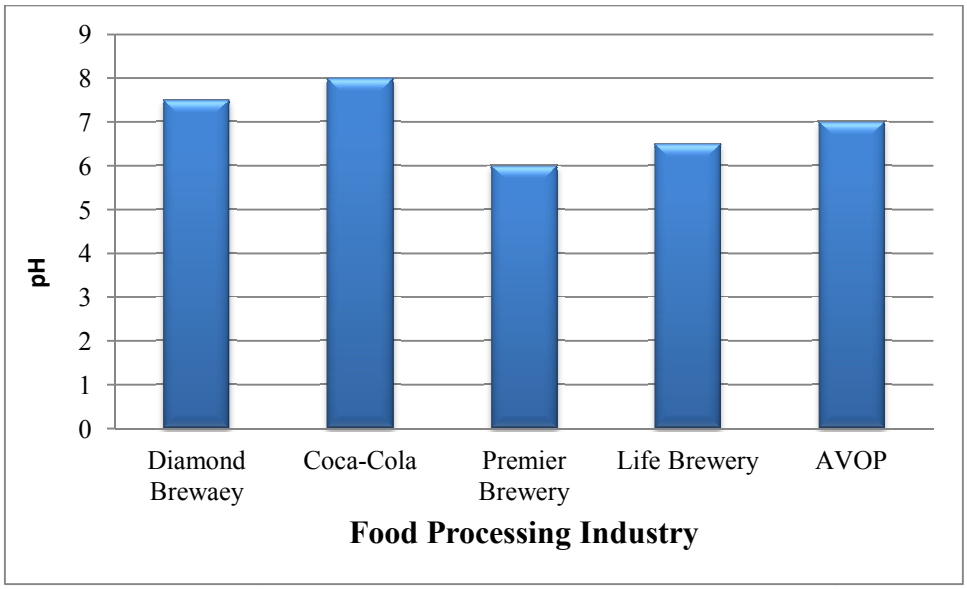

Figure 3.pH of the effluents.

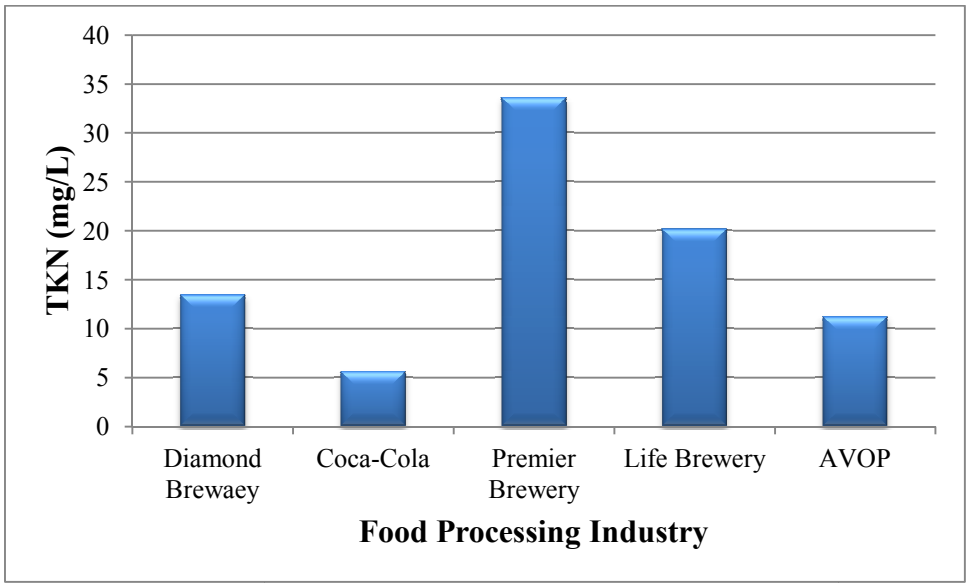

Figure 4. Nitrogen concentration of the effluents (Total Kjedahl Nitrogen).

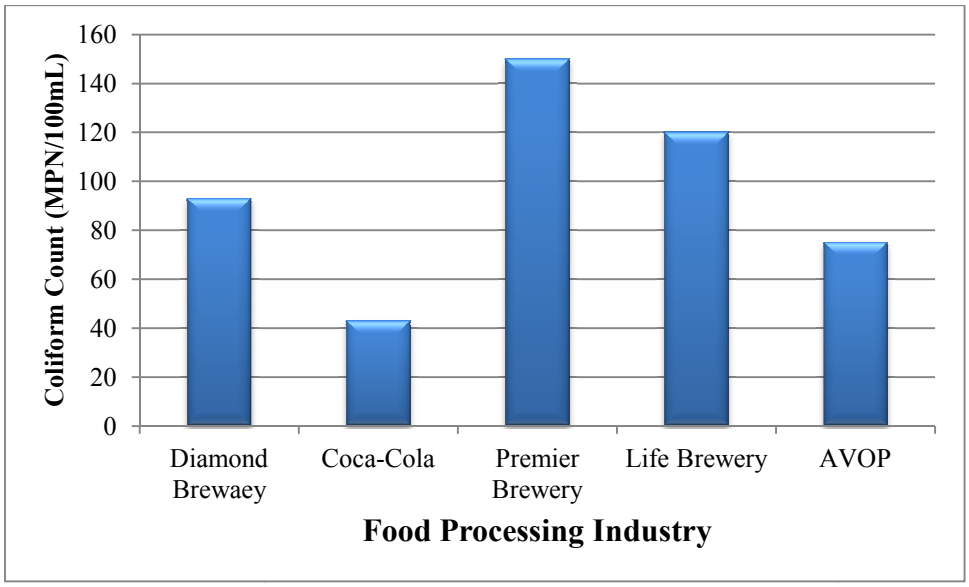

Figure 5. Coliform Count (MPN)