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# Quality of 7-Up Bottling Company Wastewater Treatment Plant Effluent Discharged to the Environment

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**Abstract**
The quality of the effluent exiting the wastewater treatment plant (WWTP) vis-à-vis the efficacy of the WWTP of 7-Up Bottling Company located at Ninth Mile Corner, Amaeke Ngwo, Enugu State was assessed in this study. The parameters assessed were pH, total dissolved solids, total suspended solids, biochemical oxygen demand, chemical oxygen demand, chloride, nitrate, phosphate, arsenic, aluminium, lead, coliform and E-coli. HACH DR spectrophotometric was employed for the analysis of the parameters except heavy metals and microbial analysis that were analyzed by means of Atomic Absorption Spectrometry and most probable number (MPN) techniques respectively. Appropriate quality control and quality assurance measures were in place. Obtained results indicated that the WWTP of 7-Up Bottling Company was able to reduce the concentration of some of the effluent biological and physico-chemical parameters entering the WWTP to varied degrees ranging from 30-60%. The pH, TDS, TSS, chloride, phosphate and total coliform values differ significantly for the effluent entering in comparison with those exiting the WWTP. However, with respect to BOD and COD, there are no significant differences. The quality of the effluent exiting the WWTP meets Nigeria Environmental Standards and Regulations Enforcement Agency (NESREA) limit with respect to all the physico-chemical parameters for which NESREA has established limits except TSS. The quality of the effluent exiting the WWTP as measured in this study indicated that the TDS and TSS mean values were below the 2013 Environmental Audit Report (EAR) whereas the 2013 EAR for chloride and phosphate values were higher than those of this study.
**Keywords**: Effluent, wastewater, soil chemistry, physico-chemical properties

## 1. INTRODUCTION

The capability of humans to transform their surroundings can be quite beneficial to everyone if this capability is judiciously harnessed. However, wrongful application of same capability can do colossal harm not only to public health but also the human environment. Since industrial revolution, the human society has been having the challenges of coping with the inevitable pollution problems associated with industrial production and service delivery. The production of goods and rendering of services in our society should be carried out in a manner that does not compromise public health and the environment. This must be the case not just for the present generations but for those of the future generations. This is the main thrust of the concept of sustainability.

Wastewater as effluent is discharged by so many industries into the environmental media such as soil and water bodies with significant adverse consequences. Wastewater has been reported to contain repulsive and potentially harmful substances that contaminate soil and aquatic ecosystems (Shaw and Schrudam, 2000; Haroon et al., 2013).

Wastewater composition is largely a function of the industry under consideration hence varying from industry to industry. Example, wastewater originating from beverage and dairy industries is most likely to be ladened with high levels of biochemical oxygen demand (BOD), chemical oxygen demand (COD), electrical conductivity etc (Sarkar et al., 2006). The high concentration levels of these parameters in the effluent have necessitated the use of wastewater treatment plants (WWTPs) to reduce their concentrations to levels that will be harmless to the receiving environment. However, if for any reason the WWTPs malfunctions and it is not detected, there will be a very high chance of the receiving environment being polluted. It has been reported that developing countries of the world often encounter this sort of challenge (Mekala et al., 2008). Consequently, it is very important to monitor the effluent exiting the WWTPs of bottling companies in Nigeria to ensure that the efficacy of the plants is not compromised.

The 7-Up Bottling Company is one of the largest bottling companies in Nigeria and produces several brands of soft drink with relatively high market share. The company has a WWTP with the following main components: (a) bar screen for removing floating materials (b) equalization/neutralization tank for surge control and pH correction (c) corrugate plate separator for the removal of oils, fats and solids (d) secondary biological treatment for removal of organic load hence removing the BOD (e) tertiary treatment for disinfecting the wastewater (f) sludge handling system for removal and safe disposal of produced sludge.

The 7-Up Bottling Company Plc commenced business in Nigeria in 1959 in Lagos. The company's expansion extended to 9$^{th}$ Mile Corner, Ameke Ngwo, in Udi L.G.A. Enugu State in 2003. Presently, the company has a production capacity of 31,000 cases and packs per day with sales volume between 27000 – 29000 cases and packs per day. The Company's products include: Pepsi, 7-up, Mirinda and Mountain Dew.

There have been some studies carried out in other parts of Nigeria assessing 7-Up Bottling Company's effluent quality and also in some other countries' Bottling Companies (Osho et al., 2010; Beah et al., 2017). However, there is no study reporting the efficacy of the 7-Up Bottling Company WWTP located at Amaeke Ngwo (Ninth Mile), Enugu State. It is important to assess the efficacy of the above plant in order to ascertain any potential threat to the environment arising from plant inefficiency.

Hence, the quality of the 7-Up bottling company effluent as treated by the WWTP and exiting same was assessed in this study in order to evaluate the efficacy of the WWTP five years after its installation and ascertain the potential threat to the environment arising from any identified inefficiency.

The authors of this work are not aware of any reported study on the assessment of the 7-Up bottling company effluent quality at Amaeke Ngwo, Enugu State.

The questions addressed by this study are:

- What is the quality of the effluent entering the WWTP in comparison with that exiting the plant via-a-vis the WWTP efficiency?
- How does the effluent quality exiting the WWTP compare with those of NESREA?

## METHODOLOGY

The study site is located at 9th Mile Corner, Ameke Ngwo, Udi, in Udi L.G.A of Enugu State, Nigeria, with geo reference: Latitude N:06$^{O}$26.664' and Longitude E:007$^{O}$23.724' which is where the 7-Up Bottling Company Plant is situated. The 7-Up Bottling Company Plant is lying opposite the Nigerian Breweries Plc (Ama Breweries). The following landmarks are within sight: Ama Breweries, Sharon Paints & Chemical, Andy Aluminum, Aqua Rapha Investment Ltd, Emucko Oil, Oando Petrol Station, Methodist Church, Redeemed Christian Church of God etc.

The wastewater samples were collected from the influent flow regime to the WWTP and the outlet flow regime of the plant every 4 h twice a day for two weeks in August 2016. The effluent exiting the WWTP is expected to have been treated by the WWTP. Grab sampling technique was employed in collecting the samples. The pH was measured in the field using a pH meter. Polyethylene bottles washed with dilute hydrochloric acid (HCl) and rinsed with de-ionized water were used for sample collection.

Total solids (TS), Total dissolved solids (TDS), total suspended solids (TDS), chemical oxygen demand (COD), biochemical oxygen demand (BOD), phosphate, nitrate, chloride, were measured at the Water Resources and Environmental Unit laboratory of the Department of Civil Engineering, University of Nigeria using HACH DR spectrophotometric method. Heavy metals such aluminium, lead, arsenic, and cadmium were determined using Atomic Absorption Spectrometry method was employed for the analysis of the parameters except heavy metals and microbial analysis. Heavy metals were analysed by means of. Appropriate quality control and quality assurance measures were in place. Coliform and E-coli were determined by means of microbial analysis as follows:

The spread plate method was employed in the culturing of the samples after serial dilutions. Nutrient agar was inoculated with $10^{-4}$ or more dilutions of the samples and incubated at 35$^{0}$C for 24 hr. Pure cultures of the isolates were obtained after several sub-culturing and identified following the procedure of Cowan and Steel (1985). The procedure of Holdeang and Collee (1997) was employed in the identification of the bacteria isolates. Total coliforms and E-coli were enumerated employing the most probable number (MPN) technique.

The WWTP efficiency was calculated based on the formula already reported in the literature (Kantachote et al., 2009; Edokpayi et al., 2015).

Removal efficiency = [(influent concentration – effluent concentration)/influent concentration]*100

Mini Tab version 17 statistical software was used in this study for all statistical analysis. Student 2- tailed t-test was employed to test for significant difference in effluent quality between the wastewater entering the WWTP and that exiting the plant whereas Student 1-tailed t-test was employed in testing whether there is significant difference between effluent quality exiting WWTP and NESREA standard.

The first null hypothesis which states that there is no significant difference between the quality of the effluent entering the treatment plant and that exiting the treatment plant was tested using 2-tailed-student t-test.

The second null hypothesis which states that there is no significant difference between the effluent quality post treatment and NESREA standard was tested using 1-tailed-student t-test.

The third null hypothesis which states that there is no significant difference between the values of the physico-chemical parameters reported in the 2013 7-Up Bottling Company Environmental Audit Report (EAR) and that of this study was also tested using 1-tailed-student t-test.

## RESULTS AND DISCUSSIONS

### *Effluent entering and exiting the WWTP*

The result of the physico-chemical and biological characteristics of the effluent entering and exiting the treatment plant is as presented in Table 1

Table 1 Parameters and their values characterizing the wastewater entering treatment plant and exiting same with the associated plant efficiency.

| Parameters | Effluent entering TP (Mean Values ±SD) | Effluent exiting TP (Mean Values ± SD) | P-Value | Efficiency (%) |
|---|---|---|---|---|
| pH | 11.42 ± 0.2 | 7.2 ± 0.15 | 0.00 | 100[a] |
| Total Dissolved Solid (TDS) (mg/L) | 389 ± 31.5 | 242 ± 15 | 0.018 | 38 |
| Total Suspended Solids (TSS) (mg/L) | 48.3 ± 3.5 | 31.7 ± 3.5 | 0.004 | 33 |
| Total solids (TS) (mg/L) | 437.5 ± 35 | 273 ± 18 | 0.019 | 38 |
| Biochemical Oxygen Demand (BOD) (mg/L) | 9 .03 ± 0.5 | 7.6 ± 0.3 | 0.191 | 15 |
| Chemical Oxygen Demand (COD) (mg/L) | 12.5 ± 0.5 | 11.3 ± 0.3 | 0.092 | 10 |
| Nitrate (mg/L) | 0.4 ± 0.2 | ND | | 100 |
| Phosphate (mg/L) | 2.1 ± 0.5 | 0.9 ± 0.5 | 0.028 | 58 |
| Chloride (mg/L) | 49.6 ± 6 | 32 ± 3 | 0.012 | 36 |
| Aluminium (mg/L) | ND | ND | NA | NA |
| Arsenic (mg/L) | 0.4 ± 0.2 | 0.2 ± 0.1 | 0.04 | 50 |
| Lead (mg/L) | ND | ND | NA | NA |
| Cadmium (mg/L) | ND | ND | NA | NA |
| Coliform (MPN/100 mL) | 9.7 ± 0.6 | 3.7 ± 0.6 | 0.00 | 67 |
| E-Coli (MPN/100 mL) | ND | ND | NA | NA |

[a:] Value is arbitrary given the achievement of pH of almost neutrality; TP=treatment plant. NA=not available; ND=not detected.

The pH of the effluent before treatment in the WWTP was alkaline whereas by the time the effluent had undergone treatment, the pH had dropped to a level of neutrality (Table 1). There is a significant statistical difference between the pH of the effluent entering the WWTP and that exiting the WWTP (P-value of 0.00; Table 1). It is therefore apparent that the effluent entering the treatment plant was almost hazardous but after treatment, it was no longer hazardous. This indicates that the WWTP as at the time of sampling was effective in neutralizing the alkaline wastewater. The WWTP efficiency with respect to pH adjustment is 100 % (Table 1).

The TDS of the effluent exiting the treatment plant is lower than that entering the treatment plant having been reduced by about 38 %. There is a statistical significant difference between the TDS of the effluent entering the WWTP and that exiting the WWTP (Table 1; P-value = 0.018). Depending on the ionic properties, excessive total dissolved solids can produce toxic effects on fish and fish eggs. Dissolved solids are also important to aquatic life by keeping cell density balanced. In distilled or deionized water, water will flow into an organism's cells, causing them to swell. In water with a very high TDS concentration, cells will shrink as water would pass from the cell to the water body by osmosis. These changes can affect an organism's ability to move in a water column, causing it to float or sink beyond its normal range. The TDS of the effluent exiting the WWTP is low and is not expected to generate the above adverse effects.

The concentration of TSS of the effluent exiting the WWTP is lower than that entering the WWTP and the difference is statistically significant (Table 1; P-value = 0.004). The WWTP was able to reduce the level of TSS in the wastewater to 38 %. High levels of TSS have adverse effect on water quality for various reasons. Example, high levels of TSS will increase water temperatures and decrease dissolved oxygen (DO) levels (Wetzel, 2001). Also, high levels of TSS can inhibit photosynthesis by blocking sunlight. This reduces plant productivity at the bottom of an ocean, lake or river (Hakanson, 2005). Without the needed sunlight, some aquatic plants below the water surface will not be able to continue carrying out photosynthesis and may die.

There is no significant difference in the BOD and COD of the effluent entering the WWTP in comparison with those exiting the WWTP (Table 1) although the BOD and COD levels of both the influent and effluent are not high. This implies that the WWTP is really not efficient in reducing the BOD level of the effluent at the concentration measured. BOD is a measure of the biodegradable organic load of the effluent whereas the COD is a measure of both biodegradable and non-biodegradable organic load of the effluent and may include some inorganic waste that is oxidizable. High levels of BOD and COD are inimical to water quality. Example, high BOD levels would lead to depletion of DO in water bodies which may ultimately lead to death of aquatic animals such as fishes. Given that the WWTP is not able to achieve any reduction in levels of the BOD and COD, the company should be mindful of the organic load level entering the treatment plant. Another viable option if not more viable is to put in place a stabilization pond that receives the effluent exiting the WWTP for reduction of the BOD level as the organic waste undergoes biodegradation by microbes in the pond.

Concentration of chloride in effluent is a measure of salinity to a good extent. The chloride level of the effluent exiting the WWTP is lower than that entering the WWTP having been reduced by 35 % (Table 1). The difference in the chloride levels is significantly different (P-value = 0.012; Table 1). High chloride level would lead to increased salinity which would at high level lead to adverse effect in cells in the aquatic environment as cell fluid is lost to osmosis. The chloride level exiting the WWTP is low and is not likely to cause any adverse effect to aquatic organisms.

The effluent exiting the WWTP is devoid of nitrates as the nitrate level was not within the detectable limit of the adopted laboratory method. However, the nitrate level of the effluent entering the WWTP has a mean value of 0.4 mg/L. Excessive nitrate in aquatic environment causes eutrophication with the consequent alteration of the ecosystem. Also, the presence of nitrate at high levels in water for drinking purposes can cause adverse health conditions such as methemoglobinemia also known as 'baby blue syndrome'. The measured low nitrate level implies that there is no risk of environmental pollution due to nitrates.

The phosphate level of the effluent exiting the WWTP is lower than that entering the WWTP having been reduced by 57 %. The difference between the phosphate concentration of the effluent leaving the WWTP and that entering the WWTP is statistically different (P-value = 0.028; Table 1). Like nitrates, phosphates are nutrients required by aquatic plants for growth and therefore are highly implicated in eutrophication. Infact, it could be the limiting nutrient required for eutrophication to take place. The phosphate level of the effluent exiting the WWTP is not high enough to constitute any environmental risk.

All the heavy metals tested such as cadmium and lead occurred at levels that are not detectable. Also, the level of aluminium which is not really a heavy metal is not detectable. However, arsenic which is considered under this group though technically speaking is not a metal occurred at measurable level. The WWTP was able to reduce the level of arsenic entering the treatment plant. Arsenic is toxic to aquatic and terrestrial biota even at very low concentrations although the toxicity varies with arsenic species.

Total coliforms level of the effluent leaving the WWTP was lower than that entering the WWTP having been reduced by 58 %. Total Coliforms are common in the environment and are generally not harmful themselves but serves as an indicator that the effluent may be contaminated with pathogenic organisms. Given that the total coliform level (MPN/100 mL) is low (4/100 mL), it is not expected that there would be any adverse health effect arising from the discharge of the effluent. There was no presence of E-coli in the effluent indicating very low chance of faecal contamination.

***Comparison of effluent quality with NESREA standard***

The comparison of the effluent quality with NESREA standard is as presented in Table 2.

Table 2: Mean values of the parameters of the effluent exiting WWTP in comparison with NESREA Standard. Values are reported as mean ± standard deviation of the mean.

| Parameters | Effluent exiting TP (Mean Values ± SD) | NESREA Limit | P-value |
|---|---|---|---|
| pH | 7.2 ± 0.15 | 6.5-8.5 | |
| Total Dissolved Solid (TDS) (mg/L) | 242 ± 15 | 500 | 0.026 |
| Total Suspended Solids (TSS) (mg/L) | 31.7 ± 3.5 | 25 | 0.081 |
| Biochemical Oxygen Demand (BOD) (mg/L) | 8.6 ± 0.3 | NA | |
| Chemical Oxygen Demand (COD) (mg/L) | 12.3 ± 0.3 | NA | |
| Nitrate (mg/L) | ND | 10 | |
| Phosphate (mg/L) | 0.9 ± 0.5 | NA | |
| Chloride (mg/L) | 32 ± 3 | 250 | 0.00 |
| Aluminium (mg/L) | ND | | |
| Arsenic (mg/L) | 0.2 ± 0.1 | NA | |
| Lead (mg/L) | ND | 0.5 | |
| Cadmium (mg/L) | ND | 0.1 | |
| Coliform (MPN/100 mL) | 3.7 ± 0.6 | 400 | 0.00 |
| E-Coli (MPN/100 mL) | ND | NA | |

Source: Field work, 2016; ND = Not detected; SD = Standard Deviation; NA = Not available

The effluent exiting the WWTP has pH within the NESREA standard as the treatment plant as at the time of this study was able to neutralize the alkaline wastewater to a level of neutrality (Tables 2). The TDS of the effluent exiting the WWTP is below the NESREA limit and is significantly different from the NESREA limit (Table 2; P-value = 0.026). The TSS of the effluent exiting the WWTP is above the NESREA limit but is not significantly different from the NESREA limit (Table 2; P-value = 0.081). At the current level of efficiency of the WWTP with respect to removal of suspended solids (SS) which is just 33%, the plant will be polluting aquatic environment. The treatment plant would need to be improved upon by some means to be able to achieve about 55-60 % reduction of the SS. If the holding time of the effluent in the WWTP is increased, there would be a good chance of having some of the SS settle for removal. NESREA has no limit set yet for BOD and COD but generally most regulatory bodies set BOD and COD limits at 30 mg/L and 250 mg/L respectively (Central Pollution Control Board , 2000). The BOD and the COD levels of the effluent exiting the WWTP are not considered to occur at levels that will pose any serious environmental threat. The chloride level of the effluent leaving the WWTP was below the NESREA limit and is statistically significantly different from the NESREA limit (Table 2). There are no concerns from the chloride levels of the wastewater.

NESREA has no limit set yet for arsenic but generally most regulatory bodies set arsenic limit at 0.1 ppm respectively. The arsenic level exiting the WWTP is at a level of concern. Give or take, the arsenic level would have to be monitored by the company.

The total coliform level of the effluent leaving the WWTP was far below the NESREA limit and is statistically significantly different from the NESREA limit (Tables 2). There are no concerns arising from the total coliform levels of the wastewater.

## 5. CONCLUSION

It has been established in this study that the wastewater treatment plant (WWTP) of 7-Up Bottling Company was able to reduce the concentration of some of the effluent physico-chemical parameters entering the WWTP to varied degrees ranging from 30-60 %. The two-tailed student t-test indicated that some of the physico-chemical parameters differed significantly for the effluent entering and exiting the WWTP. Example, the pH, TDS, TSS, chloride, phosphate and total coliform values differ significantly for the effluent entering and exiting the WWTP. However, with respect to BOD and COD, there are no significant differences. The first null hypothesis postulated for this study states that there is no significant difference between the quality of the effluent entering the treatment plant and that exiting the treatment plant. This study indicates that the null hypothesis can only be accepted with respect to BOD and COD but rejected with respect to pH, TDS, TSS, chloride, phosphate and total coliform.

The quality of the effluent exiting the WWTP meets NESREA limit with respect to all the physico-chemical parameters for which NESREA has established limits except TSS. The second null hypothesis postulates that there is no significant difference between the effluent quality post treatment and NESREA standard. It is only with respect to TSS that this null hypothesis can be rejected as the TSS value for the effluent exiting the WWTP differs significantly from NESREA limit.

The quality of the effluent exiting the WWTP as measured in this study indicated that the TDS and TSS mean values were below the 2013 EAR whereas the 2013 EAR chloride and phosphate values were higher than those of this study. The third null hypothesis postulates that there is no significant difference between the values of the physico-chemical parameters reported in the 2013 7-Up Bottling Company Environmental Audit Report (EAR) and that of this study. It is only with respect to BOD that there exists no statistical significant difference between the 2013 EAR and this study.

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