International Journal of
Science and Engineering Investigations vol. 10, issue 114, July 2021
Received on July 16, 2021 ISSN: 2251-8843

Efficacy of Wastewater Treatment of a Nigerian Food and Beverage Processing Industry

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Abstract- Efficient treatment of wastewater generated from food and beverage industries is vital in sustaining the ecosystem. In this study, water samples from wastewater treatment plant of a food and beverage industry were collected in triplicates and characterized for physicochemical and heavy metals to ascertain the efficacy of wastewater treatment before discharge. Results obtained revealed high reduction in the effluent concentration of TSS, TDS, Zinc, and Copper with removal efficiency of 95, 90, 77, and 63% respectively while EC, DO and temperature had reduction efficiency of 33, 9, and 3 % respectively. All parameters analyzed were within the permissible threshold of the National Environmental Standards and Regulations Enforcement Agency (NESREA) discharge standard. The wastewater treatment plant of the food and beverage industry is efficient for the removal of physicochemical and heavy metal parameters analyzed. The effluent can be reused for toilet flushing and suitable for agricultural and irrigation purposes, having fallen within the required threshold.

Keywords- *Wastewater, Treatment Plant Efficiency, Food and Beverage Industry, Effluent Discharge*

I. Introduction

This Food and beverage industry is one of the most essential components of several economies across the world today. It has a unique role in expanding economic opportunity because it is universal to human life and health. Large volume of water is utilized in food and beverage processing which result to generation of large volume of wastewater that requires treatment before disposal due to high level of pollution characterized by high concentration of suspended solids, nitrogen, chemical oxygen demand (COD), biochemical oxygen demand (BOD), and heavy metal concentrations amidst others. In many cases, worldwide industrialization through the food & beverage industry, has put enormous emphasis and pressure on natural resources, causing different annihilating environmental and human catastrophe, contributing immensely to ecological degradation and pollution issues of varying intensity. It is widely accepted that there is inadequacy and lack of regulation and monitoring of environmental standards in most developing countries, and where they were established, the control measures adopted are inept. Apparently, it is justifiable by the absence of the genuine and all-inclusive system of monitoring of industrial wastewater disposal and enforcement of compliance with the industrial standards (Aluyor and Badmus, 2003).

Indiscriminate disposal of wastewater poses a detrimental risk to groundwater and surface water (Olaoye *et al.* 2015, Olaoye *et al.* 2018). Nigeria, generally known to have one of the largest economies in the Africa continent, will start to experience expeditious growth in population, urbanization, and industrial advancement if wastewater prevention, control, treatment and management laws are adequately put in place and enforced. This development will contribute to the corresponding escalation of wastewater generation in the urban areas, which would elevate great agitation about environmental pollution resulting from the wastewater appropriately discharged to the vulnerable environment (Adewumi and Oguntuase, 2016). Since the discharge of sewage has become a menace in Nigeria, there has been a restriction to disposal of wastewater till it meets a harmless level to eradicate pollution; the National Environmental Standards and Regulations Enforcement Agency (NESREA) has established guidelines and standards for industrial emission and effluent discharges from food, beverages and tobacco industries. This enactment was postulated to ensure full compliance on their effluent discharge, which involves treating the effluent to the required standard level prior to discharging into the environment (NESREA, 2009).

Indiscriminate effluent discharge from food and beverage industries had been reported to be one of the leading causes of environmental pollution. Accumulation of discharge over time has been reported to contaminate water, plant and soil and is a public health concern today. Osho *et al.,* 2010 investigated wastewater effluents from two food and beverage industries in Nigeria and observed that most of the microbial, physicochemical and heavy metals tested were above the recommended discharge standard. Uzochukwu *et al*., 2018 assessed the physicochemical and heavy metals of 7-Up bottling company, Enugu, Nigeria and observed that TSS, phosphate and chlorine levels in effluent were above NESREA standard. Joe et al. 2017 analyzed physicochemical parameters from another food bottling company and reported that trace metals and electrical conductivity (EC) were above the permissible limit similarly Adeyeba 2016 studied the effect of effluent discharge into nearby river from three food companies and observed high concentration of BOD5 and COD which poses negative effects on the environment, man and plant alike. In this study, influent and effluent wastewater samples from a Nigerian food and beverage industry were characterized for physicochemical and heavy metal content in order to ascertain the efficiency of the wastewater treatment plant of the food processing industry before discharge.

II. MATERIALS AND METHOD

A. *Study Area and Sample Collection*

The study site is located at Shagamu – Benin expressway, Ijebu-ode, Ogun State, Nigeria, with geographical reference: Latitude N: 06°49'00" and Longitude E: 03°51'03". The study site is bounded by the Ago-Iwoye, by the east with Ijebu-Ode, and it is bounded by the South and West by Ososa and Okun-Owa, respectively.

Wastewater samples were collected in plastic bottles which had previously been washed with dilute hydrochloric acid solution and rinsed with demineralized water. The sample bottles were rinsed three times before the collection of the water samples. Influent flow regime and effluent flow regime were collected in triplicates once a week for two months (January to February 2021) during high level production. Grab-type sampling technique was used. The pH, temperature, electric conductivity, and dissolved oxygen were all measured on the field with individual portable meters, namely pH meter, conductivity meter, and dissolved oxygen meter, respectively. The concentration of physicochemical parameters was determined and measured using Hanna multi-parameter probe, standard gravimetric and titration method and colorimetric chemical analytical methods. The five day biochemical oxygen demand (BOD5) was quantified after five days of incubation at 20 °C. All parameters were quantified in line with APHA (American Public Health Association) 2011 methods for water and wastewater. The Total Dissolved Oxygen (TDS), Total Suspended Solid (TSS), Sulphate, Nitrate, Phosphate, biological oxygen demand (BOD), and chemical oxygen demand (COD) were measured at the Fatlab Nigeria limited, Agbowo, Ibadan, Nigeria.

For the heavy metals such as copper (Cu), zinc (Zn), Manganese (Mn), lead (Pb), chromium (Cr), cobalt (co), cadmium (Cd) and nickel (Ni) were analyzed using Atomic Absorption Spectrophotometer . Calibration curves were plotted for each of the metals separately by running various concentrations of standard solutions at specified wavelengths

B. *Treatment Efficiency*

The Wastewater Treatment Plant's efficiency was estimated from the formula;

$$\text{Removal efficiency} = \frac{I_C - E_C}{I_C} * 100$$

Where I_C = Influent concentration

E_C = Effluent concentration

The mean and standard deviation of the physicochemical parameters and the heavy metals of the individual sample of influent and the final effluents were calculated using descriptive statistics. One-way analysis of variance (ANOVA) was used to test the significance difference at $p < 0.05$.

The concentration of the effluent were compared with the National Environmental Standards and Regulations Enforcement Agency (NESREA) discharge standard.

III. RESULTS AND DISCUSSION

A. *Wastewater Treatment Plant (WWTP)*

The wastewater treatment process of the food and beverage industry is presented in Figure 1. The wastewater generated by the food and beverage industry comes from the bakery plant, beverage plant, sewage plant and cafeteria. The bakery plant serves as the production site of sausages. The beverage plant is the point for the production of different flavored soft drinks. Wastewater from all other industrial activities (cleaning and washing of raw materials, machines and equipment etc.) are diverted to the sewage plant while the cafeteria houses the food and snack bar. These wastewater are collected together in the influent pit (Figure 1). Solid debris larger than 30mm like nylon, bottles, bottle caps, nose mask etc. are removed in the grit channel, the wastewater further moves to the sand trap designed to reduce the wastewater flow speed for easy collection of settled sediments and larger material. The separation of oil is done in the oil trap before being transferred to the pump-pit where the adjustment of pH is maintained between 6-8 with the addition of both caustic soda and sulfuric acid. Water from the pump-pit with suitable pH value, void of large particles and oil is lifted (by pumps) into the Equalization (EQ) tank, just before the entering of wastewater to the EQ is a static filter which filters tiny particles such as threads, strands of hair etc. The pH value of 6-8 is maintained in the EQ which automatically inject chemicals stored in the dosing station to achieve this standard pH level. The water is then transferred into the sequential batch reactor 01 (SBR01). The system is aerated (stirred by means of blower) 16 hours daily. Bacteria are cultured here and required to feed on the wastewater to breakdown the organic materials in the wastewater. The Waste water is then further transferred into the second sequential batch reactor 02 (SBR02) to create space for incoming wastewater generated during production or housekeeping/cleaning processes. Both SBR 01 and SBR02 are employed to carry out the same function. The residual solid and semi-solid materials left from the industrial wastewater treatment processes are diverted to the sludge tank. High volume of sludge helps the microbial breakdown of macro molecules in the processed wastewater. Water from the SBR02 which are expected to have been void of activated sludge and clear is transferred to the buffer tank. The last stage of filtration is with the sand filter where the wastewater passes through sand medium for final wastewater purification. The filtrate from the sand filter is finally transported to the clear water tank which holds the water temporarily with limited chlorination of clarified effluent before final discharge.

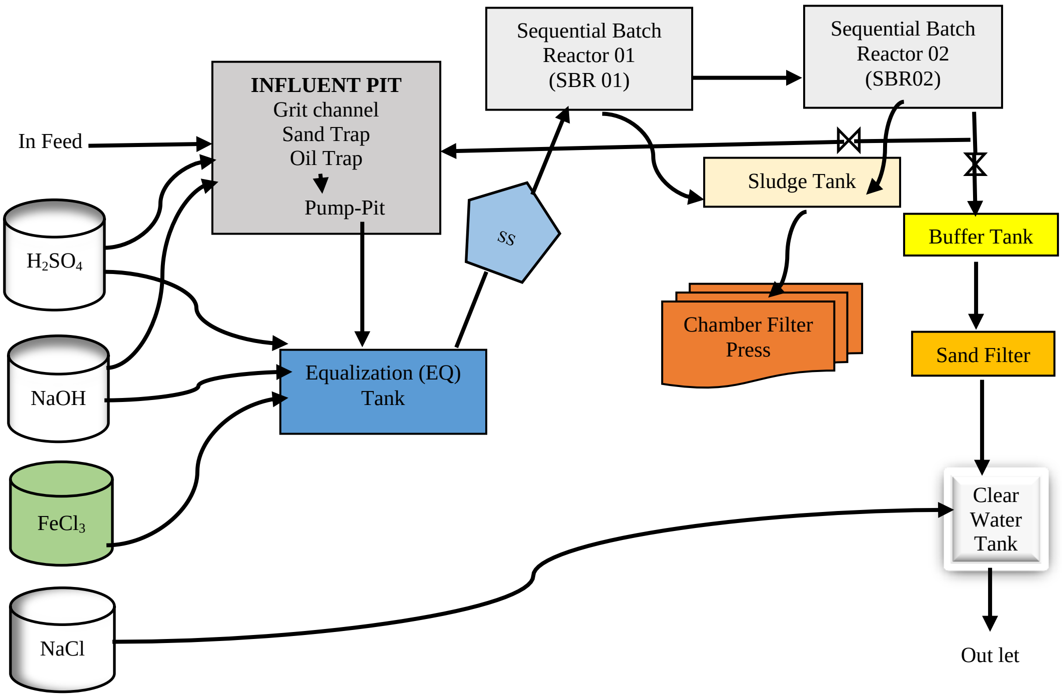

Figure 1. Wastewater Treatment Process

B. *Influent and Effluent Characteristics of the WWTP*

The concentration of influent, which is the raw wastewater entering the treatment plant and the effluent exiting the treatment plant is as presented in Table 1.

The pH of the influent was found to be slightly acidic, and after the treatment has been undergone, the effluent values were relatively neutral. The pH balancing at the equalization tank section must have been a major contributor to this change. There was no significance difference between the influent and effluent composition for the pH ($p = 0.3632$). The results obtained for the pH test agree with research carried out by Joe et al., 2017. Average effluent pHs from 11 food processing industries investigated by Noukeu *et al.* 2016 were between 4.07 and 7.63.Abdallh et al. 2016 recorded pH value between 5.52 – 6.46 at the effluent of a food industry investigated in Egypt. Average pH value ranging from 6.90 and 8.71 from influent and effluent discharge point shows that the effluent was adequate for discharge. Alkaline pH was observed at the discharge point.

The influent temperature was reduced by 3% by the WWTP. There was no significant difference in the influent and effluent temperature ($p > 0.05$). Wastewater temperature is one of the most vital parameters that can affect biological treatment, aquatic life, and general water usage. Intensified temperature is most liable to result in the sudden change in fish species habituating in a water body, oxygen solubility in water, and most importantly, it a great determinant in the dissolved oxygen level of wastewater (Kolhe and Pawar, 2011).

Electric conductivity (EC) is a measure of the ability of water to pass through an electric current. The influent sample has a high electric conductivity compared with the effluent being discharged to the environment. The electric conductivity has no significant statistical difference between the influent entering the plant and the effluent being discharged by the plant ($p = 0.7244$). The EC obtained is in contrast with the previous study by Imoobe and koye, 2011. Noukeu *et al.* 2016 observed EC values ranging from 339 – 1487 µS/cm from eleven food industries investigated.

The nitrate level of the influent is lower than that of the effluent exiting the WWTP, this could be attributed to the release of nitrogen that occurs at the sequential batch reactor after which the cultured bacteria has died off. There is significant difference between the influent and effluent nitrate levels ($p = 0.0563$). Nitrates are important nutrients in plants, but could be detrimental when in excess in water body. When combined with phosphorus, nitrate in higher quantities can speed up eutrophication, causing rapid growth in aquatic plants and changes in plants and animals that reside in the river. This change affects temperature, dissolved oxygen, and other parameters. High nitrate can lead to hypoxia (low levels of dissolved oxygen) and can become poisonous to the aquatic inhabitants at higher concentrations (10 mg/L or higher) under certain conditions. Previous work of Noukeu *et al.* 2016 obtained nitrate value ranging from 0.106 – 2629 mg/L at the effluent wastewater discharge point.

The sulphate level at the influent is slightly the same as that of the WWTP's effluent. There is no significance difference in the influent and effluent sample ($p = 0.1397$). The total dissolved solids (TDS) encompass the measurement of organic material, inorganic salts, and other dissolved materials in water or wastewater. The TDS of the influent sample was reduced by

90 percent before the effluent exit. There is a significance difference between the influent and effluent samples for the TDS with p = 0.0483. Excessive TDS can cause toxicity to aquatic life through increases in salinity, changes in the ionic composition of the water, and the toxicity of individual ions. Average TDS ranging from 20.43 – 1486.3 mg/L had been reported by Noukeu *et al.* 2016 from eleven food processing industries investigated.

The total suspended solids (TSS) of the influent show a high reduction of 95 percent removal before exiting the WWTP. There is no significance difference in the influent and effluent sample for the TSS (p = 0.3803). A high level of TSS may result in a decrease in dissolved oxygen level and increases the water temperature. It may lead to the death of the aquatic lifes living in such water. A high level of TSS also affect the photosynthesis process in plants. Average TSS observed from the influent and effluent discharge point were 0.025 and 0.0013 mg/L. These were lower than the recommended discharged value. Abdallh *et al.* 2016 observed higher TSS values ranging from 200 – 560 mg /L from the food industry investigated.

The phosphate concentration of the influent is lower than that of the effluent. There is no significant difference in the influent and effluent for the phosphate level (p = 0.4206). Low level is highly required to mitigate eutrophication of the receiving rivers or streams. When phosphate is at a very high level, it's most liable to cause an increase in purification costs, decreased recreationally and conservation value of impoundments, loss of livestock, and the possible lethal effect of algal toxins on drinking water.

The dissolved oxygen (DO) concentration was reduced by 9% before exiting the WWTP. There is no significance difference between the influent and effluent samples for the DO comparison (p = 0.4743). The mortality of fishes will rise, provided there is a steady drop in the DO level. Salmon fish, an example of freshwater fish, cannot reproduce at a DO level below 6 mg/L. Coastal fish in seas cannot survive in areas with DO lesser than 3.7 mg/L; some certain species move away from areas that have lower than 3.5 mg/l. At DO below 2.0 mg/L, and 1.0 mg/L invertebrates and benthic organisms evacuate the area (ALANBULMER).

The biological oxygen demand (BOD) for the influent and effluent sample is almost at the same level. There is no statistical difference between the influent and effluent composition for the BOD (p= 0.9798). The BOD5, which is the measure of oxygen required by bacteria while decomposing organic matter under aerobic conditions, may have some consequences. When present in high concentration may be detrimental to the aquatic organisms while low values is an indication of good water quality. Noukeu et al. 2016 investigated effluent from the food processing industry and obtained BOD5 ranging from 20.33 to 25044.67 mg/L at the effluent discharge point.

Chemical oxygen demand (COD) is the amount of oxygen required while oxidizing the organic content of a sample with high chemical oxidant under acidic conditions. The COD concentration of the influent is lower than that at effluent. There is no statistical significance difference between the influent and effluent samples for the COD comparison (p= 0.2826). The result is in contrast with a study carried out by Baharvand and Daneshvar, 2019 and Noukeu *et al.* 2016 who obtained COD values as high as 434.3 – 357725 mg/L from effluent discharge of the food industry investigated. A high concentration of COD might also be harmful to the environment and render water quality unsuitable for use.

The biochemical oxygen demand (BOD) and chemical oxygen demand (COD) values obtained in this study were lower than the permissible. However, Osho *et al.* 2010 observed higher values for BOD and COD from Sword food industry than 7-Up bottling company. Abdallh et al.2016 obtained BOD values between 518 – 2023 mg/L and COD values between 664 – 2600 mg/L from food processing industrial effluent investigated in Egypt.

The concentration of lead at the influent and effluent discharge point of the food and beverage industry were 0.17 and 0.05 mg/L respectively. Average effluent values observed were within the 0.05 mg/L standard value. Osho *et al.* 2010 recorded lead value between 4.83 and 6.75 mg/L from effluent discharge of Sword food industry and 0.12 and 0.14 mg/L from 7-Up Company. Noukeu *et al.* 2016 obtained concentration of Pb2+ ranging from 0.083 – 1.025 mg/L at discharge point of different food processing industries investigated. The efficiency of lead reduction was 71 % and shows no significance difference between influent and effluent sample (p = 0.52).

Concentration of copper ion at the discharge point was 0.015 mg/L lower than the recommended discharge values. Osho et al. 2010 obtained high value for copper ions (1.20 and 1.22 mg/L) from 7-Up company and 3.93 - 13.80 mg/L from sword food industry. The average concentration of zinc at the influent and effluent point were 0.082 and 0.019 mg/L. Zinc reduction level at the effluent discharge point was significant. Copper and zinc show a statistical significance difference between influent and effluent sample (p = 0.0083 and 0.0078 respectively). Their influent sample was also reduced by 63 and 77% respectively, before discharge.

Cadmium ion was not detected at the influent and effluent wastewater samples of the observed food and beverage industry. Previous works of Osho et al. 2010 observed high concentration of cadmium in the effluent of sword food industry as high as 7.20 and 8.10 mg/L as well as 0.1 and 0.09 mg/L from 7-Up industries. Concentration of cadmium ranging from 0.052 – 0.158 mg/L was reported by Noukeu *et al.* 2016 from eleven food processing industries investigated.

The concentration of Manganese shows no significance difference at the influent and effluent sample (p = 0.1293). Characterization was carried out for cobalt, chromium, cadmium, and nickel for both influent and effluent samples, but none was detectable. This revealed that wastewater samples were free of these heavy metals. Heavy metal pollution is extremely hazardous to groundwater, soil and plants.

TABLE I. AVERAGE CONCENTRATION OF INFLUENT AND EFFLUENT WASTEWATER

Parameter	Mean Influent ± SD	Mean Effluent ± SD	p-value	Efficiency (%)	NESREA standard
pH	6.90 ± 3.67	8.71 ± 0.22	0.3632	-	6-9
Temperature(°C)	30.08 ± 5.91	29.25 ± 0.97	0.7921	3	40
EC (µS/cm)	507.25 ± 906.02	339 ± 90.34	0.7244	33	
NO_3 (mg/L)	0.0023 ± 0.002	0.65 ± 0.55	0.0563	-	10
SO_4 (mg/L)	2.05 ± 0.036	2.08 ± 0.023	0.1397	-	250
TDS (mg/L)	0.032 ± 0.023	0.0033 ± 0.002	0.0483	90	500
TSS (mg/L)	0.025 ± 0.05	0.0013 ± 0.002	0.3803	95	25
PO_4 (mg/L)	0.063 ± 0.036	0.091 ± 0.053	0.4206	-	2
DO (mg/L)	8.20 ± 1.09	7.48 ± 1.53	0.4743	9	
BOD (mg/L)	5.83 ± 0.78	5.84 ± 0.21	0.9798	-	30
COD (mg/L)	18.05 ± 1.25	19.00 ± 1.03	0.2826	-	60
Copper (mg/L)	0.041 ± 0.11	0.015 ± 0.007	0.0083	63	0.50
Zinc (mg/L)	0.082 ± 0.031	0.019 ± 0.007	0.0078	77	2
Manganese (mg/L)	0.009 ± 0.010	0.031 ± 0.023	0.1293	-	0.20
Lead (mg/L)	0.17 ± 0.35	0.05 ± 0.1	0.52	71	0.05
Cobalt (mg/L)	ND	ND	-	-	0.05
Chromium (mg/L)	ND	ND	-	-	1
Cadmium (mg/L)	ND	ND	-	-	1
Nickel (mg/L)	ND	ND	-	-	0.05

SD = Standard deviation; ND =Not Detected
NESREA= National Environmental Standards and Regulations Enforcement Agency

C. *Comparison of effluent quality with NESREA standard*

The pH of the effluent sample being discharged is within the standard laid down by NESREA as outlined in Table 1. Proper monitoring of the treatment processing will further improve performance of the WWTP to ensure that the pH is maintained within this range. The temperature of the effluent composition also lies within the NESREA regulation standard. There was no guideline standard for the EC by NESREA, although it was below the permissible limit (750 µS/cm) set by (EPA, 2000). Nitrate, sulphate, total dissolved solids, total suspended solids, and phosphate are all below the NESREA permissible limits. Permissible limit for DO was not set by NESREA, however, healthy water should generally have DO concentrations above 6.5 – 8 mg/L and between 80 – 110%. DO level of the study was in agreement with research done by Emmanuel, et al., 2013. The BOD and COD concentration level was below the permissible limit of NESREA; the BOD and COD level does not pose any detrimental effect on the receiving environment. The concentrations of copper, zinc, and manganese at the effluent discharge point were lower than that of the NESREA limit. The concentration of lead ions was within the NESREA permissible limit. There should be further improvement of the WWTP to sustain the effluent concentration so as to ensure that the lead ions in discharged wastewater does not exceed the standard level. Cobalt, chromium, cadmium and nickel were not detectable at the inflow and outflow of the treatment system. Hence wastewater was discharge free of heavy metal pollution. This invariable shows that the effluent being discharged is within the recommended threshold.

IV. CONCLUSION

Efficient treatment of wastewater generated from food and beverage industries is vital in sustaining the ecosystem. Wastewater quality varies per product and produce of each industry and wastewater treatment processes differ from plant to plant due to variation and different techniques that may be involved. The effluent discharge by the food and beverage industry investigated in this study was found to have no negative impact on the receiving environment (soil and water) having mean pH, temperature, electrical conductivity, nitrate, sulphate, total dissolved solids, total suspended solids, phosphate, BOD, COD, copper, zinc, manganese at 8.70, 29.3°C, 309 µS/cm, 0.65 mg/L, 2.08 mg/L, 0.0033 mg/L, 0.0013 mg/L, 0.091 mg/L, 5.84 mg/L, 19 mg/L, 0.015 mg/L, 0.019 mg/L and 0.031 mg/L respectively which were all found to be within the NESREA standard. Other heavy metals analyzed were cobalt, chromium, cadmium and nickel but were not detectable. The wastewater treatment plant is highly efficient for the removal of physicochemical and heavy metals parameters investigated. The effluent can be reused for toilet flushing and suitable for agricultural and irrigation purposes, having fallen within the required threshold.

ACKNOWLEDGMENT

The author’s profound gratitude goes to the staffs and management team of the food and beverage industry investigated as a case study center for the privilege to undertake this study. All thanks to everyone that contributed immensely to this publication.

REFERENCES

[1] Abdallh M.N , Abdelhalim W.S and Abdelhalim H.S (2016) Industrial Wastewater Treatment of Food Industry Using Best Techniques, *International Journal of Engineering Science Invention*, Vol. 5(8), pp 15 – 28.

[2] Adewumi, J., & Oguntuase, A. (2016). Planning of Wastewater Reuse Programme in Nigeria, *Consilience*, pp 1-33.

[3] Adeyeba, A. J. (2016). Assessment of the Impact of Effluent Quality from Nigeria Bottling Company on Environment and Public Health. *Environmental science journal*.

[4] ALANBULMER. (2021, February 23). Retrieved from Active Angling New Zealand: https://activeanglingnz.com/2021/02/23/the-importance-of-dissolved-oxygen/

[5] Aluyor, E., & Badmus, O. (2003). Time Series Analysis of Pollutant Levels in Industrial Wastewater effluents – A Case Study of a Beverage Industry. *Nigerian Journal of Biomedical Engineering*, Vol. II(1), pp 19-32.

[6] APHA. (2011). Standard Methods for the Examination of Water and Wastewater. APHA, Washington DC.

[7] Baharvand, S., & Mansouri Daneshvar, M. R. (2019). Impact assessment of treating wastewater on the physicochemical variables of environment: a case of Kermanshah wastewater treatment plant, *Iran. Environ Syst Res*, Vol. 8 (18). https://doi:10.1186/s40068-019-014

[8] Emmanuel, O. A., Esi, A., Lawrence, D., Richard, A., & Gabriel, O. (2013). Water quality assessment of a wastewater treatment plant in a Ghanaian Beverage Industry. *International Journal of Water Resources and Environmental Engineering*, Vol. 5(5), pp 272-279. https://doi: IJWREE-23.03.13-0401

[9] EPA. (2000). Nutrient criteria technical guidance manual-rivers and streams. EPA-822-B-00-002. Washington DC.

[10] Imoobe, T. O., & koye, P. I. (2011). Assessment of the Impact of Effluent from a Soft Drink Processing Factory on the Physico-Chemical Parameters of Eruvbi Stream Benin City, Nigeria. *Bayero Journal of Pure and Applied Sciences*, Vol. 4 (1), pp 127-134.

[11] Joe, M. B., Abass, T. A., Abu, D. K., Abu, B. S., & Eldred, T. T. (2017). Wastewater Effluents at Sierra Leone Bottling Company Limited: Composition, Assessment and Removal Efficiency of Physico-chemical Parameters. *Journal of Water Resources and Ocean Science*, Vol. 6(3), pp 46-50. https://doi:10.11648/j.wros.20170603.11

[12] Kolhe, A. S., & Pawar, V. P. (2011). Physico-Chemical Analysis of Effluents from Dairy Industry, *Research in Science and Technology*, Vol.3(5), pp 29-32.

[13] NESREA. (2009, October 14). National Environmental (Food, Beverages and Tobacco Sector). Federal Republic of Nigeria Official Gazette, 96(65). Abuja: The Federal Government Printer, Lagos, Nigeria.

[14] Noukeu N.A.., Gouado I.,.Priso R.J, Ndongo D.,Taffouo V.D,.Dibong S.D and Ekodeck G.E (2016). Characterization of effluent from food processing industries and stillage treatment trial with Eichhornia crassipes (Mart.) and Panicum maximum (Jacq.), *Water Resources and Industry*, Vol.16, pp 1 – 18. https://doi.org/10.1016/j.wri.2016.07.001

[15] Olaoye, R.A and Oladeji, O.S. (2015). Preliminary assessment of effects of paint industry effluents on local groundwater regime in Ibadan, Nigeria, *International Journal of Engineering Research*, Vol. 4 (10),pp 518-522

[16] Olaoye, R.A., Oladeji, O.S., Olaniyan, O.S. and Salami, M. O. (2018). Remediation of Textile Wastewater Using Activated Rice Husk, *IOSR Journal of Engineering (IOSRJEN)*,Vol 8 (6), pp 8 -15

[17] Omole, D., & Longe, E. (2008). An Assessment of the Impact of Abattoir Effluents on River Illo, Ota, Nigeria. *Journal of Environmental Science and Technology*, 56-54.

[18] Osho A., Mabekoje O.O and Bello O.O (2010). Preliminary evaluation of wastewater effluents from two food companies in Nigeria, *African Journal of Microbiology Research*, Vol. 4(13) pp. 1395-1399

[19] Uzochukwu, C. U., Virginia, U. O.-D., and Johnson, O. (2018). Quality of 7-Up Bottling Company Wastewater Treatment Plant Effluent Discharged to the Environment, *Journal of Environment and Earth Science*, Vol. 8(6).

How to Cite this Article:

Olaoye, R. A., Daramola, A. M., Adejumobi, M. A., Ayanlere, S. A. & Sulaiman, Z. O. (2021). Efficacy of Wastewater Treatment of a Nigerian Food and Beverage Processing Industry. International Journal of Science and Engineering Investigations (IJSEI), 10(114), 20-25. http://www.ijsei.com/papers/ijsei-1011421-04.pdf