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Effect of the production processed effluence on the environment: A case study of a typical brewery industry in Nigeria

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ABSTRACT

This study investigates the effect of the production processed effluence on the environment, a case study of a typical brewery industry in Nigeria. Production process effluence remains a major environmental challenge in the brewing industry. The brewing industry generates different waste that affects the environment. In this study, waste samples including spent grain, hot trub, spent yeast, and wastewater was collected and prepared. The waste samples were analysed for moisture, carbohydrate, protein, fat, fibre, ash, and energy contents using proximate analysis. The wastewater sample was analysed for pH, temperature, chemical oxygen demand (COD), biochemical oxygen demand (BOD), total dissolved solids (TSD) and total suspended solids (TSS). The proximate analysis results showed %moisture (7.2, 9.37 & 8.82), %protein (20.16, 60.14 & 42.70), %carbohydrate (23.11, 20.0 & 36.13), %fat (6.30, 3.0 & 3.22), %fibre (38.27, 0 & 6.4), %ash (3.51, 5.43 & 2.10) and energy value (205.73, 89.25 & 246.51kcal/100g) for spent grain, hot trub and spent yeast respectively. The physicochemical analysis of the wastewater showed the value of pH (8.7), temperature (28.17°C), COD (2050.24mg/L), BOD (1247.23mg/L), TSD and TSS (255.32mg/L). Disposal of these wastes creates serious problems for the environment. Methods of mitigation include application in animal feed and biogas production, and treatment of wastewater before disposal. Integrated brewery processes for sustainable production are recommended.

1. Introduction

The rising global population has enhanced a greater demand for production goods that have impacted the environment greatly [1]. Whereas production forms the backbone for economic growth, the process directly consumes resources, produces wastes and impacts the environment [2]. About 70–80% of the worldwide environmental pollution is produced by the manufacturing sector [3]. Climate change, environmental pollution and energy shortages are among the problems faced as a result of production activities [4]. Although an increase in productivity is essential to reduce manufacturing costs, in terms of ecological impact, the rise in energy consumption and waste generation leads to an increase in CO_2 emissions and other environmental problems. Energy production as driven by the utilization demand is the main contributor to climate change [5]. According to Nicholas [6], energy-related carbon dioxide equivalent (CO_{2e}) emissions represent about 65% of the greenhouse gas emissions globally.

The brewing sector holds a strategic economic position. It produces the most widely consumed alcoholic beverage globally with over 168 billion litres sold, producing total global revenues of over $313 billion as of 2020 [7]. The brewing process utilises malted barley, hops, water, and yeast to produce alcohol. The production process comprises the blending of extract malt, hops and sugar with water, followed by the fermentation with yeast which is responsible for the formation of ethanol, CO_2 and by-products by its fermentative metabolism.

Olajire [8] studied the brewery industry and environmental challenges. The aim was to identify and suggest methods for sustainable process technology in breweries. The result shows that the reduction of heat energy used in the brew house using the technology is a significant contribution to the conservation of fossil fuel resources and significantly cuts CO_2 emissions. The natural step, especially the carbon footprint of a

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brewery can be optimized further with spent grains combustion and the use of solar thermal energy.

Harun et al. [1], investigated the influence of material selection and design on the environmental impact of the manufacturing process. The life-cycle assessment tool was employed to estimate the environmental impacts caused by manufacturing a simple jig. Two experimental studies were investigated to study the environmental effects of different materials, and the environmental impact of different designs. The results show a decrease in the rate of carbon emissions by 60% when aluminium was used instead of mild steel, and a decrease of 26% when the design was modified.

In [9], the author studied the features of beer industrial wastewater and its environmental effect. The emissions of beer wastewater were investigated. Results show that COD (22.08kg/KL), suspended solids (7.38kg/KL) and other organic pollutants emissions released in enormous quantities to the ecosystem have brought negative effects. The wastewater generated from the production of beer discharged in the environment caused by eutrophication was discovered to be the largest.

This study investigates the effect of the production process effluence on the environment, a case study of a typical brewery industry in Nigeria.

1.1. Brewing Production Process

In the brewing process, liquid containing sugars (wort) is used to produce beer through fermentation, a process in which yeast transforms sugars in the wort into ethanol and CO_2 as expressed in equation (1). In commercial production, the yeast works in anaerobic conditions to convert the sugar in the wort into ethanol and carbon dioxide. A typical fermentation process takes place in a week (7 days).

$$C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2 \quad (1)$$

There are seven (7) stages in the brewing process of beer (Fig. 1). The schematic of a typical brewery process is shown in Fig. 2. These are milling, mashing, lautering, wort boiling and hopping, fermentation and maturation, filtration, packaging and pasteurization. Guinness is one of the leading beverage companies in Nigeria, engaged in the brewing, packaging and marketing of alcoholic and non-alcoholic beverages. This project focuses primarily on the production process of alcoholic beverages (beer).

2. Materials and Methods

The study was conducted at Functional Food Research Laboratory (FFRL), Lagos state. For the experimental processes, the following materials and equipment were used as indicated in Table 1.

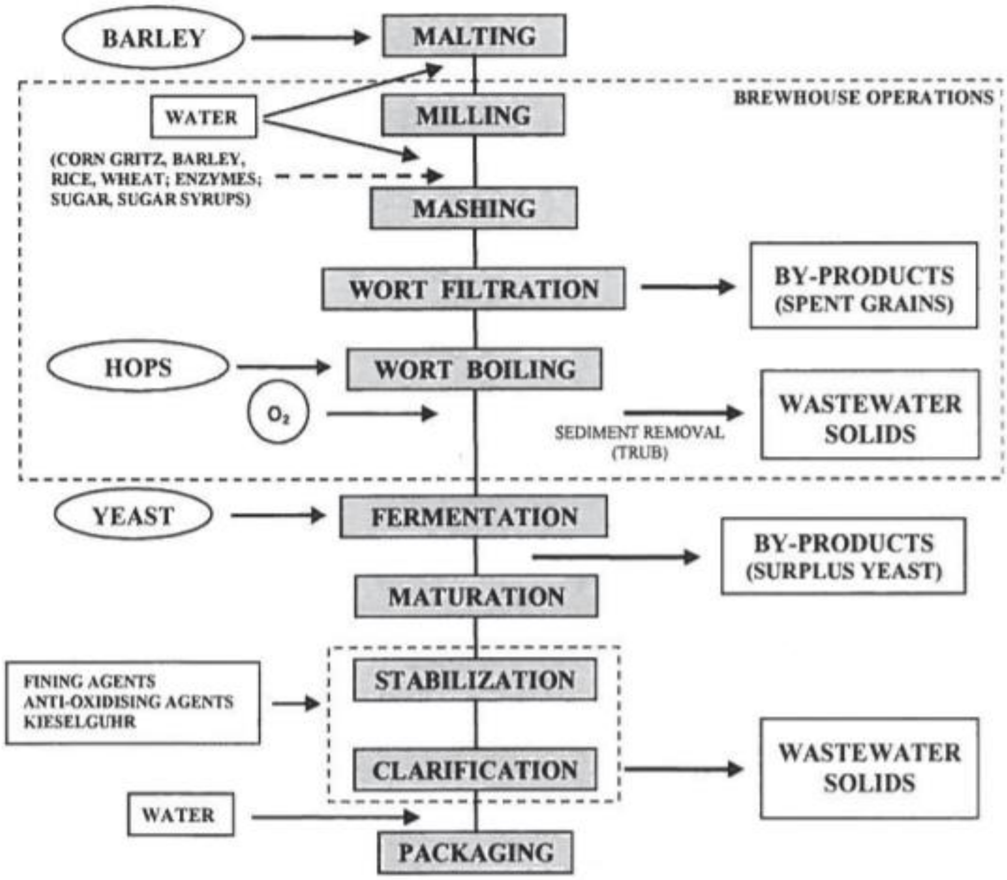

Fig. 1 Brewery production process [10].

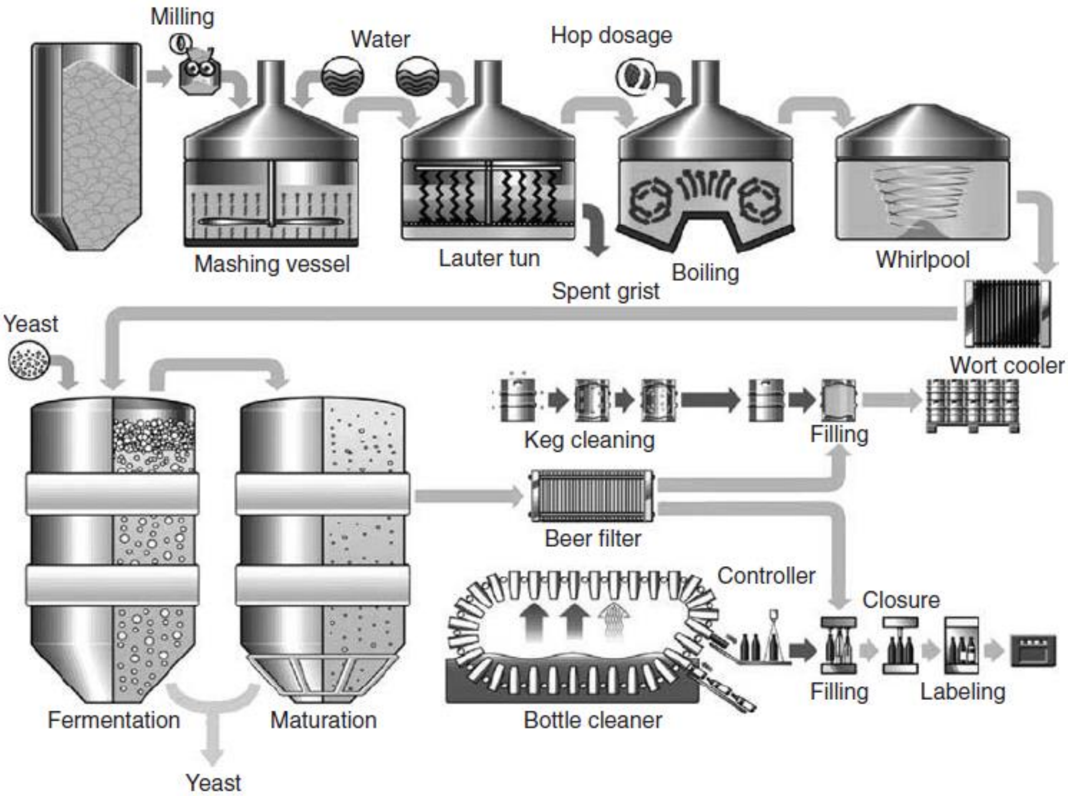

Fig. 2 Schematic of a typical brewery process [11].

A B C D

Fig. 3 Prepared samples

The methods used for this study involved sample collection, selection of experimental parameters, sample preparation and conduction of the experiments.

2.1. Sample Collection

In this study, four (4) samples were collected, which comprise solid and liquid waste materials waste generated in the brewing process. They include brewer's spent grain, hot trub, spent yeast and wastewater. All samples were sourced from a brewery industry in Benin city. The samples were collected immediately after their generation from the brewing process stages.

2.2. Selection of Experimental Parameters

For the experimental procedure, the spent grain, hot trub and spent yeast samples were analysed for moisture, carbohydrates, protein, fat, crude fibre, ash and energy contents. The wastewater sample was analysed for pH, temperature, chemical oxygen demand (COD), biochemical oxygen demand (BOD), total dissolved solids (TDS) and total suspended solids (TSS). These parameters were carefully selected to determine their levels in the samples.

2.3. Sample Preparation

To make possible storage of the solid waste for the period of study, 2kg of fresh brewers' spent grain, hot tub and spent yeast samples were measured and preserved by oven-drying at 78℃ for 12h. The samples were kilned to 6% moisture content and were ground into grist using a laboratory milling machine. The samples were weighed and filtered to homogenize each sample particle. The prepared samples were stored at room temperature for analysis. For the wastewater sample, the container for the collection was thoroughly cleaned with soap and water to remove any contaminant, and was filled with 1litre of wastewater sample and stored at room temperature for analysis. Four (4) samples were prepared, and for easy identification, the samples were labelled as shown in Table 2. The prepared samples are shown in Fig. 3(a-d).

Table 1. List of materials and equipment.

Materials	Equipment
Chemicals	Desiccator
Distilled water	Electronic balance
Filter paper	Laboratory oven
Hot trub	Muffle furnace
Spent grain	pH/temp meter
Spent yeast	Stirrer, crucibles and flasks
Wastewater	Type JW milling machine

Table 2. Experimental sampling.

Label	Sample
A	Spent grain
B	Hot trub
C	Spent yeast
D	Wastewater

2.4. Conduction of Experiments

For the experiment, two analytical techniques were employed, proximate and physicochemical analytical methods.

2.4.1 Proximate analysis of spent grain, hot trub and spent yeast waste

The proximate analysis was employed to estimate the relative amount of protein, fat, water, ash, and carbohydrate in each of the samples [12]. The individual constituent was analysed through physical and chemical processes, and approximating the sum of these constituents' values to 100%.

Determination of moisture content in the samples: To determine the moisture content in each sample, 5g of samples A, B and C were measured into separate crucibles using the weighing balance. The samples were heated in the oven at 105℃ to constant weight for 3h and then cooled in a desiccator and reweighed. Drying, cooling and weighing of the samples were performed repeatedly at hourly intervals until there was no further weight loss. The experiment was repeated three times and the average value was determined. The amount of moisture in each sample was determined using equation (2) [13].

$$\text{Moisture content (\%M)} = \frac{W_m}{W_s} \times 100 \quad (2)$$

Where, W_m and W_s are the weight of moisture and dry sample respectively.

Determination of ash content in the samples: To determine the ash content in the samples, 5g of each sample was measured into separate crucibles. The samples were incinerated in the furnace at 550°C in the absence of air to produce ash. The samples were cooled in a desiccator and weighed. The experimental procedure was repeated three times and the average value was determined and recorded. The weight of ash obtained in each sample was calculated using equation (3) [13].

$$\text{Ash content (\%A)} = \frac{W_a}{W_s} \times 100 \quad (3)$$

W_a and W_s are the weight of ash and weight of sample respectively.

Determination of protein content in the samples: In this process, 0.5g of each sample was mixed with 10mL of concentrated H_2SO_4 in a flask. The samples were diluted with water and neutralized with 45% NaOH. Finally, the samples were distilled in 40% boric acid, and the resulting distilled ammonium was titrated with H_2SO_4. A reagent blank was also titrated. The nitrogen and protein concentrations in each sample were determined using equations (4) and (5) respectively. The experimental procedure was repeated three times and the average value was determined and recorded.

$$\text{Nitrogen content (\%N)} = \frac{x}{1000cm^3}\left(\frac{(v_s - v_b)cm^3}{m}\right)\frac{14g}{moles} \times 100 \quad (4)$$

Where x, m, v_s and v_b are the moles of H_2SO_4, the mass of the sample, titration volume of sample and titration volume of the blank sample respectively. The protein contents in the samples were determined by multiplying the nitrogen value from the procedure by a factor of 6.25 (0.16g nitrogen per gram of protein).

$$\text{Protein (\%CP)} = 6.25(\text{\%N}) \quad (5)$$

Determination of fat content in the samples: The fat or ether extract (EE) procedure estimates the quantity of lipids in the samples. In this process, 5g of each sample was dried, ground and placed in an extraction flask containing 200mL of petroleum ether (organic solvent) for 4h. The solvent was heated, vaporized and condensed into a flask. The solvent recovered and the oil extract was left in the flask. The flask (containing the oil extract) was dried in the oven at 60°C for 30 minutes to remove any residual solvent. It was cooled in a desiccator and weighed. The weight of oil (fat) extract in each sample was determined by weighing in a balance and the value was calculated as a percentage of the weight of the sample analysed as expressed in equation (6). The experimental procedure was repeated three times and the average value was determined and recorded.

$$\text{Fat (\%CF)} = \frac{W_f}{W_s} \times 100 \quad (6)$$

W_f and W_s are weight of fat and weight of sample respectively.

Determination of crude fibre content in the samples: The crude fibre procedure estimates hemicellulose, cellulose and lignin in the samples. Samples A, B, C and D were prepared by performing the dry matter and then the fat extraction procedure described above on the samples. The residue was boiled in 150mL of H_2SO_4 solution for 30min, rinsed and dried. The samples were then boiled in 150mL of NaOH for 30min under the same condition. After washing in hot water, the samples were dried at 105°C and weighed. Finally, each sample was incinerated in the furnace to produce ash and was weighed. The weight of crude fibre content was projected as the difference between the pre-ash weight and the post-ash weight. The experimental procedure was replicated three times and the average value was established and recorded. The percentage of crude fibre in each sample was determined as follows:

$$\text{Crude fibre (\%CFb)} = \frac{W_{fb}}{W_s} \times 100 \quad (7)$$

W_{fb} and W_s are the weight of crude fibre and weight of sample respectively.

Determination of carbohydrate content in the samples: The carbohydrate content in each sample was determined by subtracting the percentage sum of moisture, crude protein, crude fat and ash from 100% as described in equation (8) [14].

$$\text{Carbohydrate (\%C)} = 100\% - (\%M + \%CP + \%CF + \%A) \quad (8)$$

Determination of energy value in the samples: As described by [15], the energy value in each sample was determined using equation (9).

$$\text{Energy value (kcal/100g)} = 5.7CP + 9CF + 4.1C \quad (9)$$

CP, CF and C are crude protein, crude fat and carbohydrate respectively, measured in grams.

2.4.2 Physicochemical analysis of wastewater

The wastewater sample was characterized using Physico-chemical analysis. The sample was analysed for parameters which include pH, temperature, TDS, TSS, COD and BOD [16].

Determination of pH and temperature of the wastewater: On-site measurement of pH and temperature of the wastewater sample was carried out using a pH-temp meter. The pH-temp meter was properly calibrated to an accuracy of 0.01. Three experimental replications were carried out and the average values were determined and recorded.

Determination of COD in the wastewater: The COD measures the amount of oxygen required to oxidize the chemical compounds present in the wastewater. In this process, 2.5mL of wastewater sample was oxidized by potassium dichromate solution ($K_2Cr_2O_7$) in 50% (by volume) sulfuric acid solution. The excess dichromate was titrated with standard ferrous ammonium sulphate using ferroin as an indicator. COD was determined from equation (10).

$$\text{COD (mg /L)} = \frac{[(A-B)\times M\times 8000)]}{\text{Volume of sample}} \quad (10)$$

Where, *A* is the volume of ferrous ammonium sulphate used for blank sample (mL), *B* is the volume of ferrous ammonium sulphate used for sample (mL), and *M* is the molarity of ferrous ammonium sulphate.

Determination of BOD in the wastewater: The BOD measures the amount of oxygen required by microorganisms to break down the organic matter. BOD determination was carried out by the dilution method. In this process, a 4mg/L wastewater sample was pipette into a BOD bottle containing aerated dilution water. The dissolved oxygen (DO) content was determined and recorded using a DO meter and the bottle was incubated in the dark for five days at 20°C. The final DO content was measured after 5 days of incubation, and the difference between the final DO reading and the initial DO reading was calculated and represents the BOD of the sample as presented in equation (11).

$$\text{BOD (mg/L)} = \frac{(DO_0 - DO_5)\times \text{volume of bottle}}{Volume\ of\ sample} \quad (11)$$

Given that DO_5 is the dissolved oxygen after 5 days, and DO_0 is the dissolved oxygen before incubation.

Determination of TDS in the wastewater: Total dissolved solids (TDS) are materials that are settled after 30min of collection. It was determined by the gravimetric technique. The collected wastewater sample was filtered into a flask using a filter paper. A known volume of the filtrate was poured into a dish and heated in an oven at a temperature of 180^{o}C. The obtained residue was then cooled in the desiccator and weighed to a constant weight. The TDS was calculated using equation (12).

$$\text{TDS (mg/L)} = \frac{(A-B)\times 1000}{Volume\ of\ sample} \quad (12)$$

Where, *A* is the weight of dried residue and evaporating dish, and *B* is the weight of the evaporating dish.

Determination of TSS in the wastewater: The TSS are materials which do not settle after 30min. TSS level was determined using the gravimetric method. In this process, a glass fibre filter was weighed and the wastewater sample was homogenized. The sample was filtered and the filter medium was dried in the oven at a temperature of 105^{o}C to constant weight. The filter paper was removed and allowed to cool at room temperature in a desiccator and weighed. The increase in mass of the dry filter paper was recorded and TSS was calculated using equation (13).

$$\text{TSS} = \frac{(A-B)\times 1000}{Volume\ of\ sample} \quad (13)$$

Where, *A* is the weight of the filter after filtration, and *B* is the weight of the filter before filtration.

3. Results and Discussion

3.1. Results of Proximate and Physicochemical Analysis of the Waste

Having analysed the waste using proximate and physicochemical analytical methods, the results are presented in Table 3 and Table 4 for solid waste and wastewater respectively.

Table 3. Result of the proximate analysis of the solid waste (dry matter basis).

Parameters	Waste Type		
	Spent grain	Hot trub	Spent yeast
Moisture (%)	7.20	9.37	8.82
Carbohydrate (%)	23.11	20.0	36.13
Protein (%)	20.16	60.14	42.70
Fat (%)	6.30	3.0	3.22
Fibre (%)	38.27	-	6.4
Ash (%)	3.51	5.43	2.10
Energy value (kcal/100g)	205.73	89.25	246.51

Table 4. Result of the physicochemical characteristics of the wastewater

Waste type	Parameter measured	Composition/value	WHO standards
	pH	8.7	6.5 – 9.0
	Temperature (°C)	28.17	35
Wastewater	COD (mg/L)	2050.24	250
	BOD (mg/L)	1247.23	100
	TDS (mg/L)	1268.25	1000
	TSS (mg/L)	255.32	35

3.2. Effect of Spent Grain on the Environment

Spent grain was generated in the mashing and lautering brewing process. As noted in Table 3, spent grain waste is rich in fibre (38.27%), carbohydrate content (23.11%), protein (20.16%), with traces of fat, ash, moisture and energy contents (205.73kcal/100g), on dry matter basis. These values obtained were consistent with the work of Fărcaş et al. [17]. Spent grain has nutritional values for both animals and humans. The characteristics, in addition to its low cost and availability, make spent grain appropriate for many applications, such as in animal feed production, human nutrition, energy production by direct burning or for biogas production by anaerobic fermentation, and support for cell immobilization. Dietary fibres have valuable effects in the prevention of several diseases, such as constipation, cardiovascular diseases, and diabetes [18]. However, from the analysis, spent grain on a wet matter basis, has an average moisture content of 77%. The high moisture and protein content make the waste susceptible to microbial growth and rapid spoilage resulting in a foul smell, thereby polluting the environment and extra energy is required to dry them. Spent grain can be rapidly colonized with bacteria and fungi. This poses a risk to the ecosystem if large quantities of the waste are dumped into the environment and left to decay [19].

3.3. Effect of hot Trub Waste on the Environment

Hot trub waste was generated during the boiling and clarification brewing process. As shown in Table 3, hot trub in dry matter is rich in proteins (60.14%) and carbohydrates (20%), with low moisture (9.37%), ash (5.43%) and fat (3%), and energy value of 89.25kcal/100g. These values obtained were in agreement with the result of [20]. Hot trub has a positive impact; however direct disposal of the waste to the environment poses serious problems. Hot trub poses a threat to the environment if disposed of untreated because the waste contains 2-methyl-3-butene-2-ol [17], a product of the degradation of acids in the waste. This can cause hypnotic and sedative qualities if consumed in large concentrations, so any downstream consumption of the waste exposes these risks.

3.4. Effect of Spent Yeast waste on the Environment

Spent yeast accounts for 15% of total by-products produced from the brewing process. From Table 2, on a dry matter basis, spent yeast has a high content of protein (42.70%), carbohydrate (36.13%) and energy value of 246.51kcal/100g. The high-water content (85%) combined with easily reacting degradable substance with odour problems in the waste. The main drawbacks of yeast waste are high contents of nucleic acids. For mono-gastric animals, nucleic acids cause a decrease in digestibility, resulting in a decrease in nutrition absorption and utilization. The cost of incinerating the waste is very high, it is difficult to dispose of the waste in the environment and landfilling can result in water erosion and nitrate leaching.

3.5. Effect of Wastewater pH on the Environment

From Table 4, the pH value obtained for the wastewater sample was 8.7, a measure of alkalinity. The pH obtained correlates with the pH range of 4.2-12 obtained for brewery wastewater in the study conducted by Driessen & Vereijken [21]. The wastewater pH obtained falls within the range of World Health Organization (WHO) standards for wastewater discharge (6.5–9). The alkaline nature of the company's wastewater could be attributed to the use of basic compounds like caustic soda for cleaning the bottles, calcium carbonate for water pre-treatment, ammonia for beer chilling, and other basic compounds like iron and titanium oxides used in the brewing process. Alkaline pH favours the precipitation of most metals as insoluble solids [3]. However, strong wastewater alkalinity can result in acid rain and is harmful to aquatic life.

3.6. Effect of Wastewater Temperature on the Environment

From the result of the analysis of Table 4, the wastewater temperature obtained was 27.2^{o}C, which fell below the WHO permissible discharge limit for brewery wastewater. However, the effect of temperature on aquatic lives can be either sub-lethal or lethal. Lethal temperatures are high enough to cause direct death to the aquatic animals, while sub-lethal temperatures do not cause direct death but can result in changes in behaviour such as migration, biochemical processes like higher metabolic activities and respiration, impaired growth and reproduction [22]. Every 10^{o}C increase in water temperature doubles the metabolic activities of aquatic animals resulting to water oxygen depletion. Warm water holds less oxygen needed for the survival of aquatic life. Wastewater treatment processes heavily rely on the use of bacteria to eliminate organic matters. The bacteria functions optimally at lower temperature values.

3.7. Effect of Wastewater COD on the Environment

The result of the analysis of Table 3 shows that brewery wastewater contains high organic components expressed as chemical oxygen demand (2050.24mg/L). This COD value greatly exceeded the WHO limit for wastewater discharge standard of 250mg/L. COD is generally easily biodegradable, and the presence of oxidizable compounds like soluble starch, sugars, ethanol, etc., are accountable for the high concentration of COD in the samples. Oxidizable substances require oxygen to be degraded and if discharged into drainage systems untreated, will result in putrefaction producing foul smells and mortality of living organisms. Removal of COD from the wastewater is important to avoid anaerobic conditions in the ecosystem of the receiving water. Brewery wastewater COD concentration of more than 800mg/L is more suitable for treatment using anaerobic digestion technology [23].

3.8. Effect of Wastewater BOD on the Environment

From Table 4, the results of the wastewater physicochemical analysis showed a 1247.23mg/L concentration of BOD, which greatly exceeded the WHO limits for wastewater discharge standard of 100mg/L for BOD [24]. The high concentration of the BOD was a result of all the organic compounds like ethanol, sugars, soluble starch, and volatile fatty acids utilised in the brewing process. Exposure to high BOD can lead to the production of pungent smells as the components react and methane builds up. The build-up of toxins leads to an increase in microbial pathogens, which can result in illnesses in humans living close to the point source (land or rivers) [25].

3.9. Effect of Wastewater TDS on the Environment

The wastewater physicochemical analysis showed a 1268.25mg/L concentration of total dissolved solids, which also exceeded the WHO limits for wastewater discharge standard of 100mg/L for TDS [26]. High TDS levels can adversely affect the aerobic oxygen intake by aquatic animals and the flow of water into and out of the marine organisms' cells. High TDS concentration can also impair the growth of aquatic life and mortality may occur. TDS affects water taste, odour and colour.

3.10. Effect of Wastewater TSS on the Environment

From Table 4, the wastewater physicochemical analysis showed a 255.32mg/L concentration of total suspended solids, which also exceeded the WHO limits for wastewater TSS discharge standard of 35mg/L. Suspended solids can lead to the formation of anaerobic conditions and sludge deposits when untreated wastewater was discharged into the aquatic environment. High levels of TSS result in increased water temperatures and decreased dissolved oxygen levels. This is because suspended particles absorb more heat from solar radiation than water molecules. This heat is then transferred to the surrounding water by conduction thereby increasing the temperature of the aquatic environment. High water temperature and low dissolved oxygen can lead to the mortality of aquatic life. Physical treatment technology was applied to wastewater whereby physical forces are applied to remove contaminants.

3.11. Reduction of Spent Waste in the Environment

Methods of reducing spent grain waste involve application in animal feed production, composting, biogas generation and anaerobic fermentation. The features, as well as its low cost and availability, make spent grain appropriate for many applications, including animal feed production and human nutrition, charcoal production adsorbent material in chemical treatments, cultivation of micro-organisms and support for cell immobilization. Dietary fibres have useful effects in the prevention of different diseases, like constipation, cardiovascular diseases, and diabetes.

3.12. Reduction of Hot Trub Waste in the Environment

Hot trub has the antibacterial potential of being a safe alternative to control bacteria in ethanol fermentations and able to efficiently replace antibiotics in ethanol production [27]. Trub mixed with the brewer's spent grains or other ingredients, can be used for the preparation of animal feed. Also, its rich composition has significant potential for application in bioprocesses, aiming particularly toward the exploitation of its protein concentration. Several compounds that can be recovered from trub waste are generated in the boiling and clarification process, such as organic acids, saccharides, and flavours that can be obtained after oxidation or hydrolysis of waste.

3.13. Reduction of Spent Yeast Waste in the Environment

Spent yeast has high nutritional value when mixed with spent grain and can be employed in animal feed and human nutrition. Recently, a new area of applications has been explored such as in the pharmaceutical industry and the human diet as dietary supplements due to their rich composition [28]. Spent yeast can be sold to farmers, as a low-cost animal feed additive, thus reducing the waste in the environment.

4. Conclusion

Investigating the effect of the production process of effluence on the environment, a case study of Guinness Nigeria Plc was carried out. The brewery process generates a large amount of waste identified as spent grain, hot trub, spent yeast and wastewater containing different chemical compositions and nature. The result of the proximate analysis revealed moisture, protein, carbohydrate, fibre, fat, ash and energy contents in the spent grain, hot trub and spent yeast waste. Therefore, the wastes are susceptible to microbial growth and rapid deterioration, resulting in environmental pollution including odour, acidification, and pollution of air and water bodies. The waste carried considerable nutrients and energy. Therefore, they can be applied in animal feed production and biogas generation. From the physicochemical analysis, the wastewater contains high levels of COD, BOD, TSD and TSS. Disposal of the waste to the environment can result in odour, acidification, respiration problem and mortality of aquatic life. Physical and chemical processes can be utilized for the treatment of wastewater.

Wastewater discharge to the environment can be reduced through treatment, which involves the removal of pollutants from the waste using physical, chemical and biological methods. In the physical method, physical forces are employed to the wastewater to remove contaminants. The physical method removes coarse solid matter, instead of dissolved pollutants. It can either be a passive process (e.g., sedimentation to allow suspended pollutants to settle out) or float to the top naturally. Chemical treatment technology was used for the removal of TDS from brewery wastewater. The process removes dissolved contaminants through chemical reactions which occur as a result of the addition of chemicals to the wastewater. The added chemicals contribute to pH adjustments, coagulating and flocculating dissolved contaminants in the wastewater. Coagulation and flocculation are physicochemical processes used for the removal of colloidal materials or colours from the wastewater. The biological process can be used for the effective treatment of wastewater BOD. Biological treatment includes the reduction of organic and inorganic compounds and the treatment depends on the activities of different microorganisms acting on the wastewater. These different microorganisms operate in different conditions. In the presence of air or oxygen, the process is referred to as aerobic while without oxygen, it is referred to as anaerobic. Anaerobic wastewater treatment unlike aerobic treatment occurs in the absence of oxygen, whereby inorganic microorganisms convert organic compounds into biogas. Wastewater temperature impacts can be mitigated through the use of industrial chiller systems to reduce and maintain temperatures.

Conflict of Interests

The author declares that there is no conflict of interests regarding the publication of this paper.

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