Environmental Impact Assessment of Chemical Industry in an Industrial Set-Up

A case Study of Guinness Nigeria PLC
Oba Akran Avenue, Ikeja

Submitted by

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CERTIFICATION

This is to certify that this project Environmental Impact Assessment of Chemical Industry in an Industrial Set Up was carried out by Samuel O. J. , Department of Chemical Engineering, Federal University of Technology, Minna.

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DEDICATION

This book is strictly dedicated to my late mum, Mrs. Agunbiade Aina Samuel and my brother Mr. Femi Agunbiade.

ABSTRACT

As the industrial output rises, improvements became necessary in effluent treatment of the land/water and atmospheric environment if the quality of the environment is to be maintained since man's survival is a function of this.

In the course of this study, the environmental impact of brewing industry which is a chemical processing industry with reference to the wastes generated was assessed.

The wastes(effluent) from Guinness Nigeria PLC,Oba Akran Avenue, Ikeja were sampled and analysed using titrimetric, quantitative and direct equipment reading method. The result was tabulated and the impact of this parameters on the aquatic ecosystem was assessed.

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NOMENCLATURE

C_p - Specific heat capacity

CO_2 - Carbon (iv) oxide

BOD - Biochimical Oxygen Demand

BOD_5 - 5 days biochemical oxygen demand

COD - Chemical oxygen demand

M - Mass

DO - Dissolved oxygen

EIA - Environmental impact assessment

EIS - Environmental Impact Statement

FEPA - Federal Environmental Protection Agency

SO_2 - Sulphur (iv) oxide

IA - Impact Assessment

O_2 - Oxygen

NO - Nitrogen (ii) oxide

TS - Total Solid

TA - Total Alkalinity

CO - Carbon monoxide

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CHAPTER ONE

1.0 INTRODUCTION

Environmental impact assessment is defined as an activity designed to identify, predict, interpreted and communicate information about the impact of an 'action' on man's health and well being including the well being of ecosystems in which man's survival depends.

This 'action' is mainly cause by the activities of chemical processing industries in any location or set-up.

The production activities of chemical industries yield the product, by product and effluents. Most often the by - products and effluents constitute certain hazardous effect when discharged to the surroundings causing enviornmental degradation and destruction.

Almost all chemical industries dispose of toxic and non-toxic waste and are therefore all guilty of environmental pollution which needeed to be assessed if the survival of man race is any thing to go by.

The list of sources of pollution include batterys manufacturing, paints, steel, plastics, chemical, breweries, fertilizer and textile industries . Their pollutant include highly toxic waste like hydrogen sulphide, ammonia salts, phenols, chromium, copper and acids. Others are heavy metal such as lead, arsenic, mercury, zinc, cyanide phosphates and textile dyes.

Industrial sources generated a range of pollutant specific to the process involved. These pollutant from industrial source is gradually changing the country's landscape, destroying sources of livelihood.

Many towns and villages in the country have suffered adversely from all forms of pollution resulting from industrial toxic waste. Toxic waste affect the environment in a number of ways, one of which is through direct contamination resulting in diseases. For instance the inhalation of asbestos dust causes asbetosis, a form of cancer water polution can result in a variety of water borne diseases such as cholera typhoid fever. Solid pollution affects crops which can either destroy cultivated crops or cause disease in human being when the crop is eaten.

Therefore the waste (effluent) coming out of chemical process has to be properly treated before discharging them into the environment if life is to be adequately protected.

In making an environmental impact assessment of an already existing industrial establishment three methodological approach are open for use viz.

1. Matrix Approach:- These are particularly useful for environmental impact assessment as they reflects the fact that impact result from interaction of development activities and the environment. Leopold et al [1971] were the first to suggest the use of the matrix method. This method is very complex. The 8800 cells result from ranging 88 environment parameters along one axis and 100 development characteristics along the other.

This matrix format is ideally suited for impact identification, although the ability to identify idirect impact has been questioned.

2. Carrying out the actual monitoring of the health of workers within the establishment, monitoring health of people around the set up over a period of time, the soil water and vegetation close to the factory and comparing the result with the outside vicinity of the factory.

3. Making projection of the impact on the environment based on measurement within and around the factory coupled with established fact from the literature.

This particular approach is being adopted. Among the varying factors associated with manufacturing industries are:

(i) Gaseous effluent discharge with varying characteristics

(ii) Solid waste discharge

(iii) Liquid effluent discharge with varying characteristics

(iv) Operational noise

In brewery industries which is a case study of this project, the problem posed as a result of their operation is high PH, high Temperature, high chemical oxygen demand and high biological oxygen demand.

The effluent generated by this company are mainly liquid effluent with minimal gas and solid waste.

1.1 TYPES OF EFFLUENT

The three major types of effluent that is generated by Guinness Nigeria Plc which is a case study of this project are solid, liquid and gaseous waste.

1.1.1 GASEOUS WASTE

The gaseous waste that is generated by the brewery is mainly from the burning of fossil fuel for the generation of energy. This contamines the atmosphere.

Gaseous waste of brewery industries consist of five principal classes of air pollutant, these are carbon-monoxide, particulate matters sulphur oxide, gaseous hydrocarbon and Nitrogen oxide. But there gaseous effluents are produced in negligible amount and their effect is not noticeable. Another important gaseous effluent of the brewery is carbon(iv) oxide which is produced during ferntation. Although this effluent is non-toxic but a high percentage of it is the atmosphere can lead to an increase in atmospheric temperature, and if inhaled at a concentration of 10% for a short time when it is produce during fermentation can cause unconsciousness, asphyxia and evntual death.

Gassing can also occur during caustic steaming which may lead to evaporation of toxic organic material. All these gaseous wastes are detrimental to the health of the workers and the public as well.

1.1.2 LIQUID WASTE

Most of the effluent generated in the brewery are liquid wastes. This waste is generated mainly by three department; Packaging, Production and Engineering and the nature of the effluent ranges between acidic to alkaline medium.

The highest percentage of effluent is produced during the cleaning and sterilizing of vessels and the connecting pipes.

During the daily scrubbing of floors by the use of chemicals a lot of effluent is generated within the industry which goes to the underground network discharge system.

In Engineering department, system is generated and discharged by boilers during the servicing of boilers in order to descale its deposits by the use of chemicals.

The brewery generates 259,800 litres of waste water per day. This waste have a high BOD and high PH.

1.1.3 SOLID WASTE

The solid effluents from the brewery industry are mainly spent grain which are obtained during filteration process. Another important solid effluent from the brewery are broken bottles and crates. Most of the solid effluents or wastes of brewery industries can be used for several purposes.

The spert grain can be used in feeding poultry producing fertilizer and also in manufacturing single cell protein.

The broken bottle is remulted and used in producing bottles and other types of glass materials likewise, the plastic crates is remelted and used in the production of various plastic materials.

CHAPTER TWO

LITERATURE REVIEW

2.1 OVER VIEW OF POLLUTION

Marked increase in national population and in the gross national product in our environement have been accompanied by a rapid increase in metal production.

Each new process or compound used in scientific research or industries can generate a different type of waste and such wastes is usually discharged into our environment where it can distrupt natural processes and endangers human health. Also large quantities of metal enriched waste like wise arise from the ever increasing production and manufacture of goods and services for human comfort and from the large quantities of fossil fuel that are burnt to generate the energy needed to sustain industrial activities.

Environmental problems, especially of air and water pollution, mainly from industrial effluent, are ~~the~~ the result of unintended consequences of production activities of industries. Few people hold the opimion that Nigeria as of now need not worry so much about environmental problems of industrial pollution because the country is not yet as industrialized as such advanced countries as the U.S.A, Britain, Germany and Japan.

As observed by Akinkuotu (1984), environmental pollution i Nigeria seems to be limited to disgust for the many slums and discrept quarters spread all over the country, the garbage heaps and over flowing gutters, the rotting carcasses and lawns and bushes that have become public lavatories. Very few also see noise as a form of environmental pollution.

According to Abimbola Odumosu an industrial chemistry lecturer with the University of Lagos, industrial toxic waste could effect the environment in a number of ways, one of which is direct contamination resulting in diseases. For instance, the inhalation of asbestos dust earses asbestosis, a form of cancer, water pollution also result in diseases such as typhoid fever and cholera.

The discharge of metallic effluents into the environment also constitute a health hazard to many people. It has been estimated that world - wide about 250,000 - 500,000 persons may have renal disfunction because of cadnium poisoning while 40,000 - 80,000 persons (mostly in fishing villages) may suffer from mercury poisoning as a result of eating mercury contaminated sea foods . About 250,000 persons are believed to be suffering first skin cancers resulting from arsenic poisoning. Furthermore, exposure to pollutant trace metals is being implicated in the etiology of large number od ailments, including carchrascula diseases, reproductive failure, dermatities, allergies and some cancers.

Human beings are no means the only organism at risk. For example, a large number of cats and dosg living in cities are known to have lead poisoning. High level of lead has been detected in pigeons living in London, where also the most contaminated birds shown signs of acute lead poisoning.

Pollution control are usually treated in three natural categories Air (atmospheric), Water and Land Pollution, although other forms of pollution such as thermal and noise polluiton also exist.

2.1.1 AIR POLLUTION

Air pollution, the contamination of the air with unwanted gases, smoke particles and other substance is generally considered a recently discovered phenomenon. However, pollution of the air especially with smoke has plagued many communities since the down of industrial revolution.

The total costs of air pollution in the Unted State arre incalculatable but they are believed to amount to many billions of dollars per year. The cost of painting steel structures damaged by air pollution is estimated at $100 million a year, while the cost of commercial laundering, cleaning and dyeing of fabrics spoiled and discoloured by air pollution is about ¢s40 million a year. Damage to agricultural crops and livestock is believed to be about $500 million a year, and adverse effects of air pollution on air travel delay caused by lowered visibility have been estimated to cost from $40 million to $80 million per year (Encyclopedia Americana, 386). There are five principal classes of air pollution: carbon monooxide, particulate matter, sulphur oxide, gaseous hydrocarbons and nitrogen oxides.

Air pollution in lagos is becoming stageering solid waste which include household and garden refuse, human and industrial waste litter almost every side walk in Lagos. There is no treatment of any kind and the stech escapes into the air .

Far more difficult to assess are the cost of replacing and protecting precision instruments and maintaining sanitary condition in the production of foods, beverages and other consumer goods.

It is also difficult to assess the cost of damage and soiling of homes and furnishing, the reduction in property values caused by air pollution, the amount of fuel waste in incomplete combustion, and the loss of valuable potentially recoverable resources such as sulphur that are ejected into the air as waste product.

Probably, the most difficult effects of air pollution to assess are those on health. It is practically impossible to determins the value of medical costs and time lost from work of those health is impaired by air pollution.

It is even more difficult to measure the resulting reduction in productivity in business and industry. This is why the Federal Environmental Protection Agency [FEPA] was created by degree no. 58 of 1998, with the responsibility to control and oversee the state of Nigeria environment.

2.1.2 WATER POLLUTION

Water, one of man's most precious resources is generally taken for granted until its use is threatened by reduced availability or quality . Water pollution is produced primarily by the activities of man, specifically his management of water resources. The pollutants are any chemical, physical or biological substances that affects the natural condition of water or its intended use. Because water pollution threatens the availability, quality and usefulness of water, it is world wide critical concern.

Water may be considered polluted because of an excess or burden of any gaseous, liquid or solid constituent. The list of substance that may pollute water is almost unlimited.

The problem of water pollution in Nigeria has recieved international indictment. As reported by Sunday Concord (19/1/92) 'Nigeria is one of the four African Countries that has been indicted by 23 environmental organisations. Others are Ghana, Tanzania and South Africa. Seventeen countries including the four African States were indicated world wide by report, prepared by various non governmental organization' (NGO's).

2.1.3 OIL POLLUTION

Among the worst type of poluutant is oil. This is true of both mineral and vegetable oils. Pollution due to oil spills and discharge of oily mixture from tankers, tugboats, passenger ships and cargo boat is becoming a permanent feature of the Nigerian coastal water.

Oil pollution has been known to destroy large numbers of marine birds plant and animal communities.

It is estimated that 1.5 million tons of oil are spilled into the ocean each year (Encyclopedia Americana iii).

Since Nigeria is a major oil producing Nation, experts says the oil refineries are among the biggest polluter in the country. An investigation by the Nigerian Environmental Society in 1985 revealed that between 1970 - 1983, offshore and onshore oil spillage amount to 1,711,354.6 barrels (Newswatch 1988).

2.1.4 THERMAL POLLUTION.

Thermal pollution is a form of environmental pollution caused by the release of waste heat into water. Heat introduced into water can make the water so hot that no living thing can survive in it. Several engineering solutions are available to minimise thermal pollution from major industrial sources. One is a cooling pond into which heated waste water is released before it enters a natural water way. Another possible solution is the cooling tower either wet or dry which also transfer heat to the air.

The direct entrance of waste heat into the environment may have serious consequences (Encyclopedia Americana 643).

2.2 ENVIRONMENTAL IMPACT ASSESSMENT OF BREWING INDUSTRY.

The major purpose of setting up FEPA is to ensure that environmental quality is fully considered in the decision making process of various chemical industry. The tools used in achieving this aim is the environmental impact statement whose main onjective is to provide a mean for giving environmental quality careful and priority attention in the planning and decision making process of chemical processing industries in which brewing industry is a subset. Rau (1980) stressed that water quality impact are changes in the values of water quality indicators resulting from a proposed action/project. It is then of great concern that the impact of a proposed action/project on the quality of the physical environment be objectively weighed putting into consideration the social, aesthetic and economic effect over short and long run.

The environmental impact statement is a document with sufficient information to allow the responsible officials to make a decision with full knowledge and consideration of the environmental impact expected.

Hence the key to providing this information in support of the decision making process is the impact assessment which is an objective analysis conducted to identify and measure the likely social, economic, aesthetic and environmental effects of the brewing industries and the various reasonable approach to check this effects.

CHAPTER THREE

RAW MATERIAL/POLLUTION SOURCES

3.0 GENERAL RAW MATERIAL.

Guinness Nigeria Plc uses sorghum (malted) and maize for the production of beer, stout and malt as a result of the ban on importation of wheat.

In the brewing process different types of chemical/enzymes are used for specific process.

These chemical/enzyme are listed below with their functions defined.;

(i) $CaCl_2$:- This chemical is used to protect enzymes during mashing.

(ii) Hops:- This acts on alpha and beta amylase and provides bitter taste and aroma in beer.

(iii) KOH:- This is a PH adjuster which helps to correct low PH in order to provide a suitable environment for alpha amylase to act

(iv) Bats: They act on the beta particles of carbohydrate hence they are used as liquefaction enzyme.

(v) Fungamyl (Beta amylase): - This as a proteolytic enzyme which converts protein into amino acid.

(vi) Protease:- This is an anti-oxidant which reduces viscosity in the mash. It acts at temperature range of 50 - 52°C.

(vii) Phosphoric Acid:- This is used as PH adjuster when correcting high PH.

(viii) Brewers Diase:- This is added to Guinness malta to increase the sugar content thereby improving the taste.

(ix) Thermanyl (& Amylase):- This enzyme gelatinalize and solubilize the mash.

(x) Caramel:- This is a colouring agent used for colouring beer.

(xi) Guinness Foreign Extra (GFE):- This is a black viscous acidic liquid of unknown composition and it is believed to be the secret of Guinness family. It is used for stout production and it is responsible for the darkness and the sweet aroma of stout.

3.1 PROCESS TECHNOLOGY.

The basic technology of brewing process can be expressed as follows:

- The maize and sorghum is degermed to reduce the oil content.
- 70% sorghum and 30% maize are fed into two different silos and milled. (first in first out basis)
- Mashing takes place which is the process of mixing warm water with grist (milled maize and sorghum) at 62°C.
- $CaCl_2$ is added to protect the incoming enzyme and PH is adjusted by adding KOH.
- Alpha amylase is added to gelatinalize and solubilize the mash and the mash is cooled.
- The wort is separated from the spent grain by mash filter.
- Hops is added to the wort and beta amylase is as well added. The beta amylase is a proteolytic enzyme which converts protein into amino acid useful for yeast growth while the hops add aroma and bitter taste to the beer. The mixture is then boiled.
- [MPA II A] Maltase is added for the final conversion of starch into fermentable sugar known as wort.
- Yeast is added to pitch the wort.
- Oxygen is injected and chilling (cooling down) takes place simultaneously to enable the yeast to act. For larger 9°C is desirable because yeast act at 13°C while for stout 18 - 20°C

suitable (yeast act at 26°C)

- After fermentation, the yeast is filtered from the beer by centrifugal method.
- finnings is dosed in which act as coagulant and the bottom sediment is purged.
- CO_2 is injected (Carbonation) and the beer is then transferred to packaging department by pipeing.
- The beer is bottled, pasteurized and packed.

3.2 POLUTION SOURCES

The effluents generated by Guinness Nigeria PLC which is a typical brewering industryare mainly liquid effluents. Although solid effluents are generated, they are reused by the company or sold to other company for various purposes. For example the spent grain that is generated during separation process is sold to company producing livestock feeds and fertilizers while the broken bottles and damaged crates are sold to glass and plastic manufacturing companies respectively.

The gaseous effluents are minimal. They are mostly the CO_2 generated during fermentation process and the gases released during theburning of fossil fuel for energy production. These comprises carbon monoxide, smoke particles, sulphur oxide, gaseous hydrocarbon and the oxide of nitrogen.

The liquid effluents are generated in three main department. These are (1) The production department (2) The packaging department (3) The engineering department.

3.2.1 PRODUCTION DEPARTMENT.

i. The use of highly concentrated NaOH solution for the caustic cleaning of vessels before production with the exception of vessels of the Bright Beer Tank(BBT) area because of the reaction of NaOH with CO_2.

ii. Ozonia (peracetic acid) is used in sterilizing vessels before being used. It is later flushed out.

iii. The use of acid detergents[phosphoric/nitric with low foam wetting and dispensing agent] in cleaning vessels in the BBT area to remove solid materials from it.

iv. The scrubbing of floor by the use of chemicals and the flushing out of beer from vessels before re-using all add to the liquid effluent generated.

3.2.2 PACKAGING DEPARTMENT

i. The use of 3% NaOH solution in washers for washing bottles and crater before being discharged to the effluent discharge system which is an underground channel.

ii. The use of acid detergent in the scrubbing of packaging floor.

iii. The wasting of beer during packaging due to breakage and leakages, beer has a PH of 3.8 while that of stout is 3.6.

The packaging department produces the highest volume of effluent.

3.2.3 ENGINEERING DEPARTMENT

i. The effluent generated in this department are mainly thermal pollution. Steam is generated by boilers and discharged to the underground discharge network system after use.

ii. The use of steam and caustic to descale boilers deposits in order to improve the boilers efficiency. This effluent is later discharged into the system.

The condensat tank also discharge condensed water as effluent.

All the effluent (liquid) generated and discharged within the company has an underground network channel system which they all pass.

CHAPTER FOUR

4.0 METHODOLOGICAL ANALYSIS OF WASTE.

The combined waste effluent was collected at a point before pumping into the river. Water samples from the river was also collected and analysed before and after the discharge of the effluent into the river.

Soil sample from the solid effluent dumping site was also collected and analysed. This was then compared with the analysis of soil sample from a bare site around thesame area.

The parameters looked into during effluent/water sample analysis are Total soild, chemical oxygen demand [COD] 5days Biochemical Oxygen demand (BOD_5) , PH, Temperature, the visually observed colour, flow rate and total alkalinity [as $CaCO_3$].

The parameters looked into during soil analysis are magnessium concentration, calcium concentration, PH and sulphate ion concentration.

4.1 LIQUID EFFLUENT/WATER SAMPLE ANALYSIS

4.1.1 MATERIAL/METHOD

In the course of carrying out the experiment, quantitative and titrimetric methods were mostly used. This is complemented by the use of sophisticated equipment.

For soil analysis, sample A_s is the soil from solid effluent dumping site while sample B_s is the soil from a bare site nearly.

For effluent/water analysis, sample A is the liquid effluent collected at a point before pumping into the river, sample B is the water from the river before pumping the effluents while sample C is the water from the disposal river after the discharge of the effluent.

PH DETERMINATION.

APPARATUS: (i) PH water

(ii) Conical flask containg sample A

(iii) Conical flask containing sample B

(iv) Conical flask containing sample C.

PROCEDURE: buffer the sample solution in the conical flasks and take direct readings from the water after dipping the PH water electrode in the samples.

DETERMINATION OF TOTAL ALKALINITY AS $CaCo_3$

The alkalinity of the samples can be determined by determining the amount of carbonate present in the sample.

Reagent/chemicals

0.1mhydrochloric acid

1% phenolpthalene

1% methyl orange

PROCEDURE

- Pipette 100ml of each sample into a 250ml conical flask.
- Add two drops of phenolpthalene
- Titrate the red solution to colourless with 0.1m hydrochloric acid

$$\text{Total Alkalinity} = \frac{A \times 100}{\text{sample used(ml)}} = \text{Mg/l}$$

A = Volume of acid used.

DETERMINATION OF COLOUR

Colour refers to the age of waste water which is determined qualitatively by the visually observed color and odour. Fresh water is usually colourless, however as organic compounds are broken down by bacteria, the dissolved oxygen in waste water reduces to zero and the color changes to black in this condition the water is said to be septic.

DETERMINATION OF TOTAL SOLID

APPARATUS: (i) Two small dishes

(ii) Water bath

(iii) Oven

(iv) Electronic weighingbalance

PROCEDURE: - 25cm^3 of sample A & B is put in each dish after the dish has been weighed.

- The dishes containing both sample is placed in a water both for 4 hours.
- The dishes and their contents are then returned to the oven for more drying after total drying the dishes are removed and placed in a dessicator to cool.
- After the cooling, the dishes were reweighed and the results were recorded.

DETERMINATION OF CHEMICAL OXYGEN DEMAND [COD].

APPARATUS/Reagent (i) Titration reagent

(ii) Conical flasks

(iii) Small beakers

(iv) Ice bath

(v) Burette and pipette

(vi) digital balance.

PROCEDURE: - Weigh 1g of $HgSO_4$ each in to four different small beakers and transfer into different conical flasks.

- 5ml of conc. H_2SO_4 is added to each conical flask and the mixture is placed in ice bath.
- 70ml of [H_2SO_4 + $AgSO_4$] mixture is also added to the mixture in the conical flask.
- 50ml of sample A,B and C is added to the content each conical flask respectively while the fourth flask content is used as the blank sample. These are then allowed to remain Ø in the ice bath for another five minutes.

- The mixture in each conical flask containg each sample is then reluexed for an hour. The resultant yellowish color solution is put in a measuring cylinder and distilled water is added to make up 300ml.
- 0.26N NH_3FESO_4 is prepared.
- Ferroir indicator (phenanthroline ferrous sulphate) is prepared and degessed.
- The reflux mixture in each conical flask is then titrated with 0.26N NH_3 $FeSO_4$ and the volume of NH_3FeSO_4 used is recorded.

DETERMINATION OF BIOCHEMICAL OXYGEN DEMAND [BOD]

The biochemical oxygen demand (BOD) is the amount of oxygen needed by micro organism for complete oxidation of micro biologically degradable materials in water, such as sewage or contaminated water measured by direct oxygen consumption.

The dilution method in determining [BOD_5] is themost commonly used. The dissolved oxygen content of the effluent is determined before and after incubation for 5 days at 20°C . The difference gives the BOD_5 of the sample after allowance has been made for the dilution

Apparatus/reagent. - incubation bottle:- narrow - mouthed glass stoppered bottle of 250ml capacity.
- incubator of adjusted temperature 20 $\pm$ 0.5°C
- Deionized water.

- ferronic chloride solution: 0.125g $FeCl_3.6H_2O$ dissolved in a litre of water
- Calcium chloride solution: 27.5g of anhydrrous $CaCl_2$ dissolved in a litre of water
- Magnessium sulphste solution: 25g $MgSO_4$ $7H_2O$ dissolved in a litre of water
- Phosphate buffer stock solution: 42.5g of potassium di hydrogen phosphate KH_2PO_4 dissolved in 700ml of water.

- add 8.8g of NaOH which gives a solution of PH 7.2.
- add 2g of $(NH_4)_2SO_4$ into a litre of water.

Dilution water : Add 1ml of each reagent to each litre of fresh deionized water. Bring the water to incubation temperature of 20 ± 1°C and saturate with oxygen by shaking the partially filled bottled and use as soon as possible.

Procedure: Pretreat the dilution water by seeding

- Pretreatment of sample was needed as the sample was super-saturated with oxygen or contain residal chlorine or the PH of the sample was not between 6.5 - 8.5.
- Sample stored in the water-cooled incubator were allowed to reach room temperature before dilution were made.
- The samples were vigorously shaken immediately before dilutions were made.

N.B Some samples may contain algae which if incubated in the light would give off oxygen by photosynthetic action and thus interfere with the BOD determination.

Determination of Flow Rate.

Apparatus: Flow meter

Procedure: The flowrate of the effluent water from the brewery was taken using a flow meter.

Determination of Temperature.

Apparatus: Thermometer

Procedure: The temperature was determined directly by dipping a thermometer into the samples.

4.2 SOIL ANALYSIS

The soil sample was collected from the dumping site of the solid waste product of Guinness Nigeria PLC.

Before taking the soil sample, the container was washed with distilled water and allow to dry.

The soil sample was preserved by storing in a refrigerator.

4.2.1 MATERIA/METHOD

The following soil sample analysis were determined PH, Sulphate, calcium and magnessium concentration.

Determination of PH

- 10.0g of air dried sample was weighed accurately in duplicate into a 50ml beaker.
- 25ml of distilled water was added to samples.
- There were stirred intermittently for about 15 minutes and allowed to settle
- The PH measurement is then taken using PH meter

The PH meter must be calibrated using buffer solution

Determination of Magnessium/Calcium

Prepare 1m ammonium acetate solution. Measure 29ml of glacial acetic acid into about 300ml of distilled water in a 500ml volume flask. Add 35ml of conc. NH_4OH Solution. Finally wake up to mark with distilled water.

Measure 5.0g each of soil samples. Add 100ml of prepared ammonium acetate solution into each sample. Shake for an hour. Filter off the sample into 100ml flask and make up to mark with prepared ammonium acetate solution.

For Magnessium:-

Reagent/Chemical:

Enochrome Black T[E B T]

0.02m Na_2EDTA (Sodium ethylene dimethyl tetra-cetic acid).

Ammonium hydroxide buffer.

Procedure:

- Add 50ml of distilled water into a 250ml conical flask.
- add 20ml of the soil extract and 25ml of ammonium buffer solution.
- add 5 drops of EBT indicator and titrate to a bright blue point using 0.02m Na_2EDTA.

Calculation:

$$[mg/100g \text{ soil}] = N \times v_2 \times 100/20 \times 100/s$$

v_2 = Volume of sample used - Volume of blank titre.
N = Molarity of Na_2EDTA
S = Original weight of soil sample.

Note: The blank titration was carried out when all other material was added except the soil sample.

For Calcium:-

Reagent/Chemical:

0.02m Na_2EDTA
20% KOH

Murexide indicator

Procedure:

- 50ml of distilled water was added into a 250ml conical flask.
- 20ml of 20% KOH and 20ml of the soil extract was all added.
- Then add 0.05g of murexide indicator powder.

Calculation

$$[Ca/100g \text{ soil}] = N \times v_2 \times 100/20 \times 100/5$$

Where v_2 = Volume of sample used - Volume of blank titre
N = Molarity of Na_2EDTA

Determination of Sulphate (so_4^{2-}) Concentration.

1.0ml of HCl in excess of that required to nentralize the alkalinity is added to the sample of the extraction from the soil. A measured volume of 0.01m $BaCl_2$ is added. After two hours of reaction, the sample hardness determination and the hardness and excess barium are titrated with EDTA. The titration should be carried out rapidly and the time taken should not exceed 5 minutes from the time the buffer was added.

Calculation;

$$\text{Concentration of } so_4^{2-} \text{ (mg/L)} = \frac{961(v_2 + v_3 - v_4)}{v_1}$$

Where v_1 = Volume of sample used

v_2 = Volume of 0.01m EDTA used

v_3 = Volume of 0.01m $BaCl_2$ used

v_4 = Volume of 0.01m EDTA and excess barium in titration.

CHAPTER FIVE

5.0 DESIGN OF A FERMENTER (Cylindroconical Vessel)

5.1 INTRODUCTION

Design is the synthesis, the putting together of ideas to achieve a desired purpose in the course of creativity hence it is a creative activity and one of the most rewarding and satisfying activities under taken by an engineer.

The main function of a fermenter is to provide a controlled environment for the growth of a micro-organism or a defined mixture of micro-organism to obtain a desired product.

In designing and constructing a fermenter a number of points must be considered.

1. The vessel should be capable of being operated aseptically for a number of days and should be reliable in long term operation .
2. Adequate generation and agitation should be provided to meet the metabolic requirements of the micro-organism. However the mixing should not cause damage to the organism.
3. Power consumption should be as low as possible.
4. Temperature control system should be provided.
5. PH control system should be provided.
6. Sampling facilities should be provided.
7. Evaporation losses from the fermenter should not be excessive.
8. The vessel should be designed to require the minimal use of labour in operation, harvesting, cleaning and maintenance.
9. The vessel should be constructed to ensure smooth internal

surface, using welds instead of flange joint whenever possible.

10 The cheapest material which enable satisfactory results to be achieved should be used.

5.2 DESIGN SPECIFICATION

- The fermenter should be designed that it may be steam sterilized under pressure and can withstand repeated steam sterilization cycle for strict aseptic requirement.
- High corrosion resistant material with good mechanical properties and good heat transfer coefficient should be used.
- All pipes should be constructed as simply as possible and slope towards drainage points to make sure steam reaches all part of the equipment and is not excluded by siphonst or pockets of condesate or mash.
- Each drainage point in the pipework should be fitted with a condensate outlet.

5.3 CONSTRUCTION MATERIAL, PROPERTIES & COMPOSITION

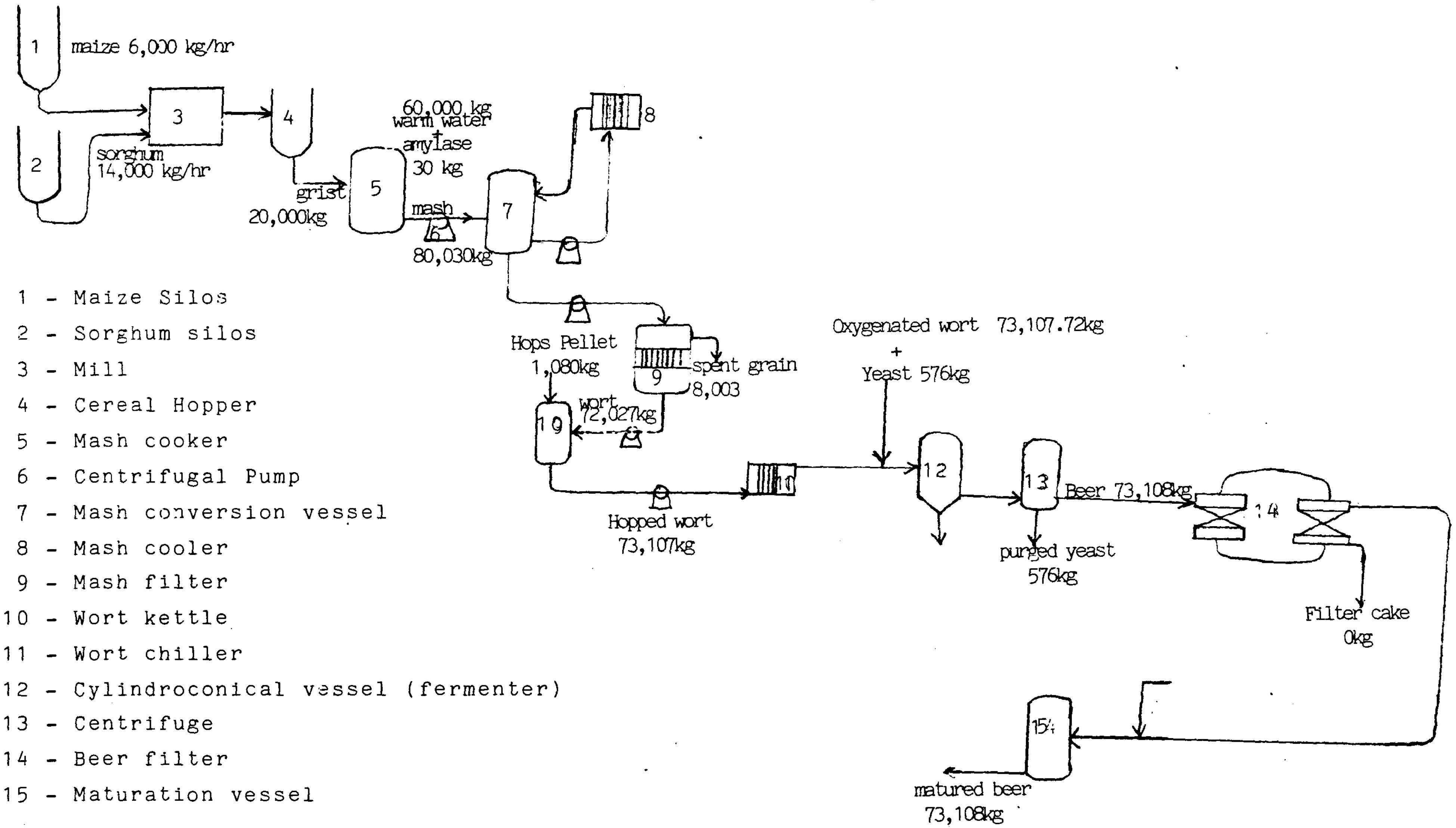
To construct an efficient cylindroconical vessel for brewing the stainless steels are the most frequently used corrosion resistant materials.

To impact adequate corrosion resistant, the chromium content must be about 12%, hence the more the chromium content the more resistance is the alloy to corrosion in oxidizing condition Nickel is added to improve the corrosion resistance in non-oxidizing environment.

The martensitic type of stainless steel is the most suitable in constructing a cylindro-conical vessel (fermenter).

This contains 12% chromium, 0.2 - 0.4% Carbon, up to 2% Nickel.

5.4



1 - Maize Silos
2 - Sorghum silos
3 - Mill
4 - Cereal Hopper
5 - Mash cooker
6 - Centrifugal Pump
7 - Mash conversion vessel
8 - Mash cooler
9 - Mash filter
10 - Wort kettle
11 - Wort chiller
12 - Cylindroconical vessel (fermenter)
13 - Centrifuge
14 - Beer filter
15 - Maturation vessel

5.5.1 MATERIAL BALANCE

30% maize	MILLING	6.00kg of milled maize
70% sorghum (malted)		14.00kg of milled sorghum

Basis 20,000kg/hr of feed.

Material	feed	Outlet
Maize	6,000	
Malted sorghum	14,000	
Milled maize		6,000
Milled sorghum		14,000

Material Balance Around the Cereal Hopper

Milled maize 6,000	Grist 20,000
Milled sorghum 14,000	

Material	Feed	Outlet
Milled maize	6,000	
Milled sorghum	14,000	
Grist		20,000

For the material balance around the mash cooker, the following informations are vital.

1. Ratio of liquor (water) to grist (milled cereal) is 3litre : 1kg
2. 0.075% of amylase (α and β) is needed for 1kg of cereal.
3. 0.075% of protease (Nitrase) is needed for 1kg of cereal.

water
grist
amylase
protease

mash

Materials	Feed	Outlet
Water	60,000	
Grist	20,000	
Amylase	15	
Protease	15	
Mash		80,030.

Material Balance around the Mash Filter

10% spent gran retaining 0.2% of water is filterted.

Mash
80,030kg

grain
90% worts

10% spent grain.

Material	Feed	Outlet
Mash	80,030	
Wort		72,027
Spent grain		8,003

Material Balance Around thee Wort Kettle.

Material	Feed	Outleet
Wort	72,027	
Hops Pellet	1,080	
Hopped Wort		73107

0.015kg of hops pellet is added to a litre of wort.

Material Balance Around the Fermenter.

In the fermenter 10mg of oxygen is needed for 1 litre of wort and 0.008 litres of 60% consistency yeast is needed for 1 litre of wort.

Material	Feed	Outlet
Hopped Wort	73107	
Oxygen	0.72	
CO_2	-	recycled to recuperation plant
Yeast	576	
Unrefined beer		73684

Material Balance Around the Centrifuge

refined beer

Unrefined
beer

Yeast

Material	Feed	Outlet
Unrefined beer	73684	
refined beer		73108
yeast	576	576

Material Balance Around the Maturation Vessel

73108

refined beer

Maturation
Vessel

Larger beer
73108.

Mateerial	Feed	Outlet
refined beer	73108	
large beer		73108

5.5.2 ENERGY BALANCE

Energy balance around the mash cooker. The quantity of heat required to heat the mash from 30°C to 60°C in an hour is given by

$q = M_T C_{Pm} \Delta T$

Where M_T = Total mass of water and grist

C_{Pm} = specific heat capacity of grist and water mixture

ΔT = Temperature change = 60 - 30 = 30°C

$M_T = M_w + M_g$

where M_w = mass of water = 60,000

M_g = mass pf grist = 20,000

C_p of cereal at 8% moisture content = 1760 J/Kg°C

Cp of water = 4216 J/Kg°C

$$C_{pm} = \frac{M_w C_{pw} + M_g C_{pc}}{M_w + M_g}$$

$$Cpm = \frac{60,000 \times 4216 + 20,000 \times 1760}{60,000 + 20,000}$$

Cpm = 3602J/kg °C

q = 80,000 x 3602 x 30

= 8.6448×10^{9} J

Energy balance around the Jacketed mash conversion vessel.

The quantity of heat removed to cool the mash from 60°C to 13°C in an hour is given by :

$q = M_T C_{pm} \Delta T$

ΔT = 60 -13 = 47°C

q = 80,000 x 3602 x 47

q = 1.35×10^{10} J

Energy balance around the wort Kettle.

Quantity of heat required to heat the wort from 13°C to 95°C in 1 hr is given by:

$q = MC_p \Delta T$

Where M = Mass of hopped wort

C_p = Specific heat capacity of wort.

ΔT = Temperature change

NB. The specific heat capacity of water is assumed for wort.

$q = 73107 \times 4216 \times 82$

$= 2.5274 \times 10^{10} J$

5..6 DESTAILED DESIGN OF FERMENTER

Energy balance around the fermenter.

Mass of hopped wort entering the fermenter = M_{hw} = 73107

quantity of yeast required = 576 litre

Total volume to enter the fermentation vessel = 73107 + 576

V_T = 73683 litres

The capacity of the jacketed cylindro-conical vessel (fermenter) (with 30% safety factor) is given by

$$73683 \times \frac{130}{100} = 95{,}785 \text{ litres}$$

Select a 95,785 litres cylindro-conical vessel, stainless steel construction.

For optimum fermentation the temperature of the content (oxygenated wort and yeast) of the Jacketed fermenter is held constant at 15°C by using a temperature indicator and controller.

This is then cooled to 0°C within 2 days (48hrs) .

The heat removed from beer by cooling from 15°C to 0°C within 48 hours is given by

$q = MC_p\Delta T$

C_p of beer = 4190 J/kg°C

$$q = \frac{95{,}785}{48} \times 4190 \times 15$$

$q = 1.254 \times 10^8$ J/hr.

To calculate the mass flow rate of the cooling 20% alcohol - water.

$$Cpmix = 0.2 \times Cpa + 0.8 \times Cpw$$

Cpa = specific heat capacity of alcohol

Cpw = specific heat capacity of water

$$Cpmix = 0.2 \times 1617 + 0.8 \times 4216$$

$$Cpmix = 3696.2 J/kg^{o}C$$

Mass flow rate of alcohol - water required with a temperature rise of $5^{o}c$ i.e inlet temperature of 20% alcohol - water = $0^{o}c$ and outlet temperature of alcohol - water = $5^{o}c$ is given by

$$q = MaCpm\Delta T$$

$$Ma = \frac{q}{Cpmix \times \Delta T}$$

$$= 1.254 \times 10^{8}/3696.2 \times 5$$

$$Ma = 6785.3 \text{ kg/hr}$$

mass flow of alcohol - water = 6763.7 kg/hr

The cooling area required is gotten from :

$$q = MaCpm\Delta T = UA\Delta T$$

U = average coefficient of heat transfer for Jacketed vessel = 600 $w/m^{2} {}^{o}c$ = 2160000 $J/hr\ m^{2} {}^{o}c$.

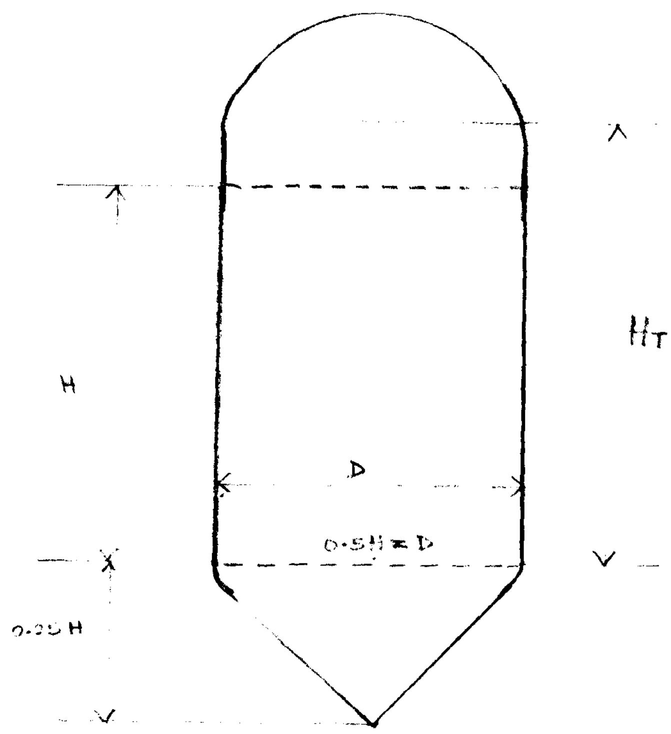
ΔT = inlet temperature - outlet temperature of cooling 20% alcohol water.

$$A = \frac{q}{U\Delta T}$$

$$A = \frac{1.254 \times 10^{8}}{2160000 \times 5}$$

$$A = 11.6 m^{2}$$

5.6.1 SIZING



$$\text{Volume of cylindrical part} = \pi \left(\frac{0.5H}{2}\right)^2 H$$

$$= \frac{0.25\pi}{4} H^3$$

$$= 0.0625\pi H^3$$

$$\text{Volume of conical part} = 1/3\, \pi \left(\frac{0.5}{2} H\right)^2 \times 0.25H$$

$$= 0.005\pi H^3$$

Total volume occupied by the liquid

$$V = 0.0625\pi H^3 + 0.005H^3$$

$$= 0.0675\pi H^3$$

Liquid Volume $= 73683$ litres $= 73.683m^3$

$$73.683 = 0.0675\,\Pi H^3$$

$$H^3 = \frac{73.683}{0.0675\,\Pi}$$

$$H = \sqrt[3]{347.47}$$

$$= 7.03m.$$

$$D = 0.5 \times H$$

$$D = 0.5 \times 7.03$$

$$= 3.515m$$

for 30% safety factor

$$H_T = \frac{130}{100} \times H$$

$$= 1.3 \times H$$

$$= 9.139$$

$$= 9.14m$$

5.3.2 COSTING

Size range = 10 - 100m^3, cost = £1500, n = 0.6

S = volume

Cost estimation = CS^n

Total volume of cylindro-conical vessel

$$= \Pi\left(\frac{D}{2}\right)^2 H_T + 1/3\,\Pi\left(\frac{D}{2}\right)^2\ 0.25H$$

$$= \Pi\left(\frac{3.515}{2}\right)^2 \times 9.14 + 1/3\Pi\left(\frac{3.515}{2}\right)^2 \times 0.25 \times 7.03$$

$$= 88.69 + 5.68$$

$$= 94.37m^3$$

$94.4M^3$.

[cost estimation] $C_e = 1500 \times 94.4^{0.6}$

C_e = £22965 (as mid 1992)

Cost escalation

$$\text{Cost in 1998} = \text{cost 1992} \times \frac{\text{cost index 1998}}{\text{cost index 1992}}$$

Cost index in 1998 = 170

Cost index in 1992 = 122

$$\text{Cost in 1998} = 22965 \times \frac{170}{122}$$

$$= £32000$$

$$= 32000 \times 130 = \#4160000$$

5.7 SAFETY/LOSS PREVENTION

The organisation has a moral obligation to safeguard the health and welfare of its employee and the general public.

The good management practices needed to ensure safe operation will also ensure efficient operation.

The term loss prevention is an insurance term, the loss being the financial loss caused by an accident. This loss will not only be the cost of replacing damaged plant and third party claim, but also the loss of earmings from lost production and lost sales opportunity.

The possible hazards and their prevention can be sectioned as follows: (1) Machinery (2) Electricity (3) Health hazard (4) Noise.

(1) MACHINERY:- Where malt is stored in silos, the opening should be protected and strict rules enforced regarding entry of personnel. Conveyors are much used in bottling plant; traps between belts and drums in the gearing can be avoided by efficient machinery guarding . Where there are walkways across or above conveyors automatic stop sensor should also be provided. In filling process, very serious

lesions can be caused by bursting bottles; stout guards on the machinery and face guards, rubber gloves, rubberised aprons and non - slip boots for the workers can prevent injury.

(2) ELECTRICITY:- Owing to the prevailing damp conditions, electrical installations and equipment need special protection.

(3) HEALTH HAZARDS:- Handling of grain can produce barley, itch caused by amite infesting the grain Mill-works' asthma, sometimes called malt fever, has been recorded in grain handlers and has been shown to be an allegic response to the grain weevil (sitophilus granarius).
Manual handling of hops can produce a dermatitis due to the absorption of the resinous essences through broken or chapped skin. Preventive measures include good washing and sanitary facilities, efficient ventilation of the work room and medical supervision of the workers.

The inhalation of CO_2 that is produced during fermentation for a short time can produce unconsciousness, asphyxia and eventual death. Carbon dioxide is heavier than air hence efficient ventilation with extraction at low level is essential in all fermentation chamber where open vats are used.
Gassing can also occur during relining of vats protective coatings containing toxic substances such as trichloroethylene.
Similar precaution should be taken as that of CO_2.

(4) NOISE:- When metal barrels replaced wooden casks breweries were faced with severe noise problem. Wooden casks made little or no noise during loading, handling or rolling but metal casks when empty create high noise level. Modern automated bottling plants generate considerable volume of noise. The noise produced in handling metals casks can

be reduced by the introduction of mechanical handling on pallets.

In the bottling plants the substitution of nylon or neoprene for metal rollers and guides can substantially reduce the noise

CHAPTER SIX

6.0 RESULTS

SOIL ANALYSIS RESULT

Sample As - soil from solid effluent dumping site
Sample Bs - soil from a bare site nearby.

SAMPLE	PH	Ca^{+2} (mg/100g)	Mg^{+2} (Mg/100g)	SO_4^{+2} (mg/100g)
As	7.5	34.9	26.4	17.5
Bs	6.5	24.68	17.4	18.5

SAMPLE A

Result for effluent analysis at the point of discharge

Parameters	Value (mg/l)
Total solid	96
PH	8.1
COD	104.8
Total alkalinity (as $CaCO_3$)	980
Temperature	41°c
Colour	light black
BOD	850
Flow rate	11.2 (litre per second)

Result for water sample at disposal river before the discharge of effluent

SAMPLE B

Parameter	Value mg/l
Total solid	1000
COD	50.5
PH	7.2
Temp	30°c
BOD	60
Color	Colorless
Total alkalinity(as $CaCO_3$)	100

Result for water sample at disposal river after the discharge of effluent.

SAMPLE C

Parameter	Value (mg/l)
Total solid	1002
COD	52.5
PH	7.4
Temp	33°c
BOD	63.5
Color	Colorless
Total alkalinity (as $CaCO_3$)	110

TRADE EFFLUENT TO BE DISCHARGE INTO RIVERS OR STREAMS

Parameter	Maximum Limit
PH	6.8
Suspended and dissoved metal	30 mg/l
Alkalinity as $CaCo_3$	50 mg/l
Free chlorine	1.0 mg/l
Sulphide as H_2S	1.0
Cyanide as HCN	0.2
Temperature	24 - 26
BOD_5 at 20°C	20
Phenol	1.0
Arsenic	< 1.0
Lead	< 1.0
Selenium	-
Chromium	-
Silver	-
Radioactive substances	not at all

SOURCE: Flentje M.E, quality specification

6.1 DISCUSSION OF RESULT

The experimental analysis result shows that the natural quality of the waste water disposal river has changed considerable due to the effluent discharge.

The PH, COD, BOD and temperature showed an increase and a deviation from that of fresh natural river.

This deviation is undoubtedly caused by the liquid effluent that is discharged into the river.

The high BOD and COD show that the type of pollutants discharged in this river are highly oxygen demanding. This will lead to dissolved oxygen depletion in the river.

Dissolved oxygen is essential for sustaining plant and animal life in any aquatic system. For example warm water fish requires a minimum dissolved oxygen level of at least 5mg/l (5ppm). If dissolved oxygen level drops below the level necessary to sustain normal life, then the aquatic system is classified as polluted and this is harmful to the aquatic inhabitant.

BOD is a direct measurement of oxygen requirement and an indirect measurement of biodegradable organic matter.

The high temperature of the liquid effluent indicates a thermal pollution. This could result in increase in temperature of water bodies with deleterious consequences for aquatic inhabitant. An increase in water temperature decreases the oxygen saturation percentage and at the same time accelerate the lowering of dissolved oxygen (DO) levels. This is because the hot water tend to form a separate layer above the cool water due to density differences between the two.

The hot layer which itself holds less oxygen than the cooler below prevents the replacement of oxygen in the cooler layer as it is denied contact with the atmosphere. The DO level falls rapidly due to normal biological functions in the lower layer and may lead to anaerobic conditions.

Moreover, the metabolic activities of micro-organism increases with temperature at a rate which is approximately doubled for every 10°c increase in temperature .

Hence an increase in temperature produces simultaneously a decrease in the availability of oxygen and an increase in the rate at which it is consumed.

The life cycles and natural processes of many aquatic life forms are closely and delicately geared to water temperature. Some cold water fish like trout may die if the water temperature is above 25°c and their eggs will not hatch at temperature above 14.5°c . Most fresh water fauna population declins with rising temperature and above 40°c only a few species can exist.

An increase in temperature also increases the toxicity of some chemicals pollutants, poisons are therefore more toxic in summer months.

The high PH of water also affect the dissolution of certian poisionous compounds in water , for example ammonia exist in two forms in water, ionized NH_4^+ and non-ionized NH_3. The equilibrium between these two formss in water depends on the PH (acidity and alkalinity) and the temperature.

$$NH_4^+ + OH^- \rightleftharpoons NH_3 + H_2O$$

$\longrightarrow$
Increasing temperature

$\longrightarrow$
Increasing PH.

Thus an increase in PH from 7.0 to 7.3 will double the proportion of the non-ionzing form in water the proportion of the non - ionized form in water containing ammonia. Similarly an increase in temperature from 10°c to 20°c will have the same effect. This is very important because the non-ionized form is toxic to fish while the ionized form have a very much lower toxicity that can be disregarded for all practical purposes. The actual concentration of ionized and non-ionized ammonia cannot be measured separately by chemical analysis, only the total ammonia present in the water can be measured.

The proportion of the toxic non-ionized ammonia present is calculated by using equations that predicts the ratio of the two forms present for a range of PH value and temperatures.

Therefore even if the concentration of total ammonia remains constant in a natural water, variation in PH and temperature will change the amount of toxic non-ionized ammonia present.

CHAPTER SEVEN

7.0 CONCLUSIONS AND RECOMMENDATIONS

7.1 CONCLUSIONS

From this study so far the following conclusions can be drawn:

1. The pollution loads and characteristics of the brewery wastes are very much influenced by manufacturing processes and industrial house keeping practices.
2. The waste water from the brewery contained a high BOD, COD, PH and temperature with a low solid content.
3. The high oxygen demand of brewery waste water led to the depletion of dissolved oxygen (DO) in rivers when discharged into it thereby making the ecosystem harmful to the aquatic inhabitant that man's survival depends.
4. The solid effluents generated by the brewery have little or no negative effect on the quality of the soil, the spent grain rather add to the organic manure of the soil with ageing hence it is used for fertilizer manufacturing.
5. The gaseous waste from the brewery shows no noticeable effect on the environment but when generated at high concentration the effect may be fatal especially to the factory workers.

7.2 RECOMMENDATIONS

To check or minimize the negative impact of chemical industries on the environment in Nigerian, being a developing country, the following steps should be taken.:

(1) The laws of environmental protection should be enforced to the letter and stop being for paper decoration.

(2) The laws that all industrial waste should be properly treated before discharge should be taken seriously

(3) Industrial waste should be recycled. This will be a step forward in our 'waste to wealth programme'.

(4) Government should make law, making it compulsory for the industries to fund research on how to revitalize damaged environment.

(5) Heavy industrial complexes that produces toxic gaseous waste should be sited far away from residentail areas in order to avoid air pollution.

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