PHYSIO-CHEMICAL CHARACTERIZATION AND COMPARATIVE ANALYSIS OF WASTE FROM NIGERIAN BREWERIES.

(A CASE STUDY OF NIGERIAN BREWERY, IBADAN.)

BY

BABATUNDE FUNBI FOLAKE

2003/14966EH

A PROJECT SUBMITTED TO THE DEPARTMENT OF CHEMICAL ENGINEERING

SCHOOL OF ENGINEERING AND ENGINEERING TECHNOLOGY

FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA

NIGER STATE, NIGERIA

IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE AWARD OF

BACHELOR OF ENGINEERING (B.ENG) IN CHEMICAL ENGINEERING

DEPARTMENT

NOVEMBER, 2008.

DECLARATION

I hereby declare that this project work was conducted solemnly by me under the constant guidance of my supervisor, Engr L.I Onyeji . The work has never to my knowledge been submitted elsewhere.

Babatunde funbi folake

Date

CERTIFICATION

This is to certify that the project "Physio – chemical characterization and comparative analysis of Waste from Nigerian Breweries (A Case Study of Nigerian Brewery, Ibadan) was carried out by BABATUNDE FUNBI FOLAKE (2003/14966EH) meets the demand for the award of degree of Bachelor of Engineering (B. Eng) in Department of Chemical Engineering, Federal University of Technology, Minna, Niger State

08/11/08

Engr L. I. Onyeji — Date

Dr. M. O Edoga — Date

External Examiner — Date

DEDICATION

This work is dedicated to Almighty God for his guidance and protection throughout my stay in school. I also dedicate it to my father, late chief. J.A Babatunde .

ACKNOWLEDGEMENT

I wish to express my profound gratitude to almighty God who has shown me great love in no small measure throughout my academic career.

I will forever be indebted to my mum Mrs E.O Babatunde for her love and prayer.

I also appreciate my research project supervisor, Engr L.I Onyeji, for his advice, suggestions, corrections and painstaking effort to go through this work.

My acknowledgement also goes to my lecturers Professor Odigure (Dean of Engineering), Professor Aberuagba (my daddy),Engr. Galadima, Engr Mohammed Isah, Engr. Umar, Engr. Mrs. Aisha, Engr. Isah, Engr. Manase, Engr. Garba, Engr. Agbajelola, Engr. Olutoye, Engr. Mrs M. Yahaya, Engr. Mukthar, Engr. Alhassan, Engr. Habib, Engr Kudu Bagudu, and others.

I will not forget to acknowledge the department's backbone, the head of department, in the person of Dr. M.O. Edoga, for his support, and the entire lecturers and students in the department and my mentors, professor Osunde, Dr Yahaya (Mr white), Engr Musa

I will never forget to specially appreciate my brothers who stood financially,spiritually Mr E.O Babatunde and Alhaji R .A Yusuf ,Mr Segun , Alh Luqman,Mr and Mrs Oyedepo, and the Aboyeji's family, Bro Moshood, Mr and Mrs Amos Opoola,Bro Luqman, Mayowa, Dunke, Moyo, Tomiwa, Lanre, Tobi Boy,Wale, Qudus, Bisola, Ayomide, Rilwan, Precious, Praise, Peace, Blessing, Kamal, Ayisat, Ramat(Baby Of The House).

And to my love Tope Gold for is support ,care and for his advice, may God bless you.

My thanks also goes to my friends,Feyi, Afolabi(prof),Seun Ajayi, Esther,Ayisat, Lawumi, demola, Aminu,Bose, to my entire classmates and to all who contributed in one way or other to my success, I love you all.

10.0 Environment acceptability 237

ABSTRACT

The Nigerian brewery, Ibadan waste was characterized, analysis and compared with the Federal Environment Protection Agency (FEPA). The wastes comprises of liquid, solid and gaseous wastes. The liquid waste was analysis for biochemical oxygen demand ,chemical oxygen demand , turbidity, PH, temperature, colour the results obtained were within the FEPA range standard. However total hardness (570) and total suspended solid (45) was against the FEPA value of 500 and 30. The solid waste was also analysis to determine its nutritional value for poultry feed. The properties analysis were protein test , moisture content, lipid content, carbohydrate content and the PH value. However, the moisture content of 72% was considered high. Thus aiding microbial growth this effect can be reduced by proper drying.

TABLE OF CONTENT

CHAPTER ONE

1.0 INTRODUCTION

This century could well be called the age of chemistry because man-made chemical compounds have changed our lives and /or ways of life. Our homes, offices and factories are filled with aerosols, artificial sweeteners, pharmaceuticals, brewery beverages, the list is inexhaustible.

To satisfy the world's demand for these products, the annual global production of processed products according to the world Health Organization (WHO) amount to about $1.5trillion. WHO reports that some 100,000 processed products or chemical are now on the market and that from 1000 to 2000 new ones are added each year (AWAKE, 1998).

The industrial community in any nation produces processed products that are of great benefit to mankind. One of such industries is the brewery industry where brewed beverages are produced. Brewed product comes from the brewing process which is the process of producing alcoholic beverages from starchy raw materials by steeping in water, boiling, usually with hops; and fermenting. The production of the brewed beverages involves the use of some chemical processes which the raw materials into valuable products i.e the beverage to be consumed.

A direct result of these industrial activities is the production of waste, Waste are generally substances that are at a reference point in time, not needed and therefore constitute an environmental, economical and health hazard to the community. However, the production of waste is an integral part of industrial activities. The term "substances" in the definition of waste above infers to man- made chemicals and/ or mixtures that can contaminate the environment and thus constituting nuisance to the inhabitant. Clearly then, the production of brewed beverages involves the production of both the desired and the undesired products.

Waste can also be defined as any substances or object which the holder discards, intends to discards or is required to discard, (Waste framework Directive European Directive 2006/121EC). Waste management is the process of managing waste materials (normally those produced as a result of human activities). It involves the collection, transportation, processing, recycling and/or proper disposal of waste materials. On human health or local amenity over the last thirty year, however the focus of waste management (developed countries) has shifted to reducing the impact of waste on the environment. (Wikipedia: waste management).

The undesired products are separated using adequate separation processes and they constitute waste which if not properly treated will be debilitating and detrimental to human health and the environment in general.

In the brewery industrial, various production process like washing, wortcopling, fermentation etc. go on within the entire plant. Hence a large amount of wastes are discharged / emitted daily to the environment. Hence the need to evaluate the consequence of these waste on the environment cannot be over emphasized in brewery industry, some of the waste are spent grain from the brew house, waste water from different department and gaseous waste from the fermenting tanks.

The waste from the brewery is often treated to meet the required guideline set but Federal Environmental Protection Agency. Effluent implies the waste coming out of a production process; these wastes are impurities, which are harmful to man, animals and the environment. This waste exists in solids, liquids and gaseous state. Most manufacturing processes produce waste which if not are properly treated before discharging into the environment; may be to some extend hazardous to life. The Ibadan brewery a branch of the Nigerian Breweries that produces Gulder, star, maltina etc is the plant of interest in this study.

1.1 Scope of Work

During the course of the research, the following will be considered.

1. Investigation and detailed study of the processes involved in the production of beverages, the generation and disposal of waste in the Nigerian brewery plc.
2. The study of the Federal Government guideline and regulation on disposal of wastes in effluents from various industries particularly in the Nigeria Brewery industry (Ibadan).

3. Characterization of the various wastes from different processes of production of beverages
4. Comparison of the analysis of the characterization results with the Federal Environmental Protection Agency (FEPA) standard.

CHAPTER TWO

2.0 LITERATURE REVIEW

The making of fermented beverages was discovered by primitive humans and has been in practiced for thousands of years now. Alcoholic beverages are divided into three groups: malt liquors, fermented wines and distilled liquors. Beer required matted (germinated) grain to make the carbohydrates fermentable. Wine is produced by the action of yeast on the sugar of fruit and distilled liquors are fermented liquors which are distilled to increase the alcoholic content. Bear and allied products are beverages of low alcohol content (2 to 7%). It is made by brewing various cereals and hops are usually added to improve taste and control fermentation. The cereal employed is barley, malt to develop the necessary enzymes and the desired flavor. (Mc Graw-hill, 1999)

2.1 Brewing Process

Most commercial brewing include four stages

1. Malting
2. Mashing
3. Wort boiling
4. Fermentation

2.1.1 Malting

Cereal usually barley is converted into malt form which is an extract obtained for fermentation. Untreated barley produces inferior wort (extract): grain steeped in water and germinated under controlled condition develops a complex of enzymes, facilitating the production of satisfactory wort. Malting takes advantages of enzymes by the young plant, starch

CHAPTER TWO

LITERATURE REVIEW

The making of fermented beverages was discovered by primitive humans and has been in cticed for thousands of years now. Alcoholic beverages are divided into three groups: malt iors, fermented wines and distilled liquors. Beer required matted (germinated) grain to make carbohydrates fermentable. Wine is produced by the action of yeast on the sugar of fruit and illed liquors are fermented liquors which are distilled to increase the alcoholic content. Bear allied products are beverages of low alcohol content (2 to 7%). It is made by brewing various eals and hops are usually added to improve taste and control fermentation. The cereal ployed is barley, malt to develop the necessary enzymes and the desired flavor. (Mc Graw-l, 1999)

Brewing Process

ost commercial brewing include four stages

Malting

Mashing

Wort boiling

Fermentation

1.1 Malting

Cereal usually barley is converted into malt form which is an extract obtained for rmentation. Untreated barley produces inferior wort (extract): grain steeped in water and erminated under controlled condition develops a complex of enzymes, facilitating the roduction of satisfactory wort. Malting takes advantages of enzymes by the young plant, starch splitting enzymes, mainly α and β amylase, break down the residual starch of malt and of any unmalted grain mixed with it, to largely fermentable sugars (Mc Graw-hill, 1999)

2.1.2 Mashing

Mashing is the process involved in the production of wort i.e. extract. Mashing is largely a chemical process in which the malt enzymes act to convert the starch to a mixture of soluble carbohydrates. Ninety-seven percent or more of the starch is extracted. The wort for an average type of beer consists of perhaps a 10% solution of carbohydrate, about three-fourth of the carbohydrate material being fermentable sugar. It also contains about 0.08% of nitrogen which is important in managing both the fermentation and final beer quality. The waste involved in this operation is the "spent grain or brewer grains" and they are useful as a nitrogenous addiditive to cattle feed.

2.1.3 Wort Boiling

Wort is next boiled with hops for up to 2 ½ hours in large "kettles" or reactors operated by oil firing. The main role of the hops, however, is to import an agreeable bitterness. When hop cones are used, they are eventually removed traditionally on a "hop-back" in which the debis form its own fitter bed. Spent hops compounded with ferrous sulphate and other mineral salts, are by-product of brewing producing an artificial horticultural fertilizer.

2.1.4 Fermentation

Chemically, fermentation involves the conversion of glucose into ethyl alcohol, carbon dioxide and water. Average bears contain around 3.5 percent of ethanol, but some contain up to 12%. During fermentation the specify gravity falls (average figures being) from 1.045 to 1.012. It never falls to one or less as might theoretically seem possible, since unfermented carbohydrate always remains and nitrogen compound also make a contribution. The strength of a beer is however quoted with reference to the original gravity (Mc Graw-Hill, 1999).

Generally however, to make malt, the barley is steeped in cold water and spread out on floor or in special compartments and regularly turned for about 5 to 8 days, the layers being gradually thimed as the components proceeds. In modern operation, mechanical devices are used allowing for greater grain depths. Germination is achieved in compartment, such as the SALADIN BOX or in drum and is controlled by rotating the drums on an inclined axis while aerating the grain with streams of humidified air.

At the end of the time the spent hops are separated from the boiling wort very quickly in a whirlpool separator. The wort is then ready to be cooled. The cooling step is not only to reduce the temperature but also to allow the wort to absorb enough air to facilitate the start of fermentation. The wort is then cooled in a plate heat exchanger to 48^{0}C and then aerated. Slight concentration, due to the evaporation occurs. This operation is performed under controlled conditions to prevent contamination by wild yeasts. Frequently, sterilized air is used.

The temperature is kept high enough to initiate the second fermentation and then is cooled to 0 to 2^{0}C to larger the beer. Lagering consists of storing at 0 to 2^{0}C for 1 to 4month. During this time the taste and aroma are improved, and tanmns, protein and hops resins are removed by setting. Highly hoped been require move lagering time then been containing less hops. Near the end of the period, the beer is saturated with carbon dioxides (CO_2) at 50 to 70kpa. In the United States, the beer is filtered though a pulp filters under CO_2. (Mc Graw-hill, 1999)
After bottling, the beer is pasteurized at 60^{0}C. Beer contains about 90% water and can be concentrated (dehydrated) to about one-fourth original volume.

2.2 Historical Legislation on Pollution

In Nigeria, government policies up to the 1970's did not greatly help to control or reduce pollution because of the low priority given to legislation. Action only appeared to be taken as a result of public concern, Successive government has passed a number of statutory acts and several board and agencies were set up. this is shown by the inauguration of Federal Environmental protection Agencies (FEPA) some fourteen year age, which for the first time is one statue that covers the area of atmosphere, land and water pollution, effluent discharge etc Industrial firms now have to adopt a more responsible attitude to waste treatment and disposal as a result of new legislation and rising charges for waste disposal imposed by FEPA authority (FEPA guideline, standard and regulation on environmental pollution central in Nigeria).

2.2.1 Air Pollution

In any industrial setup pollution is virtually unavoidable. The pollutant identified in the CO_2 production that refreshes the beer after being corked, using the Barden affect the air due to the particulate matter being released to the atmosphere. From research it has a very high degree of concentration around it immediate environment (Perry,1997)

Generally air pollutant may be classified into two broad categories.

1. Natural
2. Human-Made

Natural sources of air pollutant include

- Wind blow dust
- Volcanoes ash and gases
- Ozone from lightening and the ozone layer
- Esters and terpenes from vegetation
- Smokes, gases and fly ash from forest fires
- Pollens and other allergers
- Gases and odoun from biological activities
- Natural radioactivity

Air pollutants may also be classified according origin and state of matter.

1. Origin

a. Primary: Emitted to the atmosphere from a process

b. Secondary: Formed in the atmosphere as a result of chemical reaction.

2. State of Matter

a. Gaseous: True gases such as sulphur dioxide, nitrogen oxide, ozone, carbon monoxide etc. vapours such as gasoline plant solvent, dry cleaning agent etc.

b. Particulate: finely divided solid and liquid, solid such as dust, tunes and smokes; and liquids such as droplet mists togs and aerosols.

2.2.2 Gaseous Pollutants

Gaseous pollutants may be classified as organic or inorganic.

Inorganic pollutant consists of

1. Sulphur gases: Sulphur dioxide, sulphur trioxide hydrogen sulphide.
2. Oxide of carbon: carbon monoxide, carbon dioxide
3. Nitrogen gases: Nitrogen oxide, nitric oxide, nitrogen dioxide, other nitrous oxide
4. Halogens, includes: Hydrogen fluoride, hydrogen chloride chlorine, fluorine, silicon tetrafloride,

Organic pollutants consist of;

1. Hydrocarbon

a. Paraffin: methane, ethane, octane

b. Acetylene

c. Olefins: Ethylene, Butadiene

d. Aromatics: Benzene, toluene, Xylene, styrene

2. Aromatics oxygenated compounds.

a. Aldehydes: formaldehyde.

b. Ketones: Acetone

c. Organic acids

d. Alcohols: methanol, Ethanol, Isopropanol

e. Organic halides: Cyanogen chloride

2.3 Industrial Waste Water Management

All industrial operations produce some wastewater which must be returned to the environment wastewaters can be classified as:

i. Domestic wastewaters

ii. Process wastewaters

iii. Cooling wastewaters

Domestic wastewaters are produced by plant worker, shower facilities and cafeterias. Process wastewaters results from spills, leaks and product washing. Cooling wastewaters are the result of various cooling processes and can be once pass, systems and multiple recycle cooling systems. Once pass cooling systems employ large volume of cooling waters that are used once and returned to the environment.

Multiple recycle cooling systems have various types of cooling tower to return excess heat to the environment. Domestic wastewaters are generally handled by the normal sanitary sewage system to prevent the spread of pathogenic micro-organism which might cause disease. Normally, process wastewater does not pose the potential for pathogenic micro-organisms but they do pose potential damage to the environment through either direct or indirect chemical reaction. Some process waste is readily biodegraded and creates an immediate oxygen demand. Other process wastes are toxic and represent a direct health hazard to biological life in the environment. Cooling wastewaters are the least dangerous, but they can obtain or contain process wastewaters as a result of leaks in the cooling systems recycle cooling systems tends to contains both inorganic and organic contaminant to a point at which damage can be created (Gurnham,1998)

2.3.1 Waste Water Characteristics

Waste water characteristics vary widely from industry to industry, obviously, the specific characteristics will affect the treatment technique.

Because of the large number of pollutant substances wastewater characteristics are not usually considered on a substance-by-substance basis. Rather, substance of similar pollutant effect is grouped together into classes of pollutants.

2.3.1.1 Organics

An important measure of the waste organic strength is the 5-day biochemical oxygen demand (BOD). As this test measures the demand for and munipaties, it has been the primary parameter in determining the oxygen demand of a waste exposed to biological organisms (controlled seed) for an incubation period of five days. Usually this demand is caused by degradation of organic waste according to the following simplified equation but reduced inorganic in some industries may also caused demand (i.e. Fe^{2+}, S^{2-}& $S0_3^{-2}$)

Organic waste $+O_2(D.O) \rightarrow CO_2 + H_2O$

A major advantage of the COD test is the complete time of less then 3 hours, verses 5days for the BODs value but approximately correlations can be made to allow competition of BOD from COD. A more rapid measure of the organic content of a waste is the instrumental test for total organic carbon (TOC), which takes a few minutes and may be correlated to both COD and BOD for specific wastes. Unfortunately, BOD results are subject to wide statistical variation and require close scrutiny and expenses. For municipal wastewaters, BOD5 is about 67% of the ultimate BOD and 40-45% of the continuing need to run BOD as well as COD and TOC (an example of BOD, COD and TOC relationships for chemical industry wastewater). The concentration of the wastewater varies be two orders of magnitude, and the BOD/COD, COD/TOC and BOD/TOC ratio vary less then twofold.

Another technique for organic measurements that overcome the long period required for the BOD test is the use of continuous respirometry. Here the waste (full strength rather than diluted as in the standard BOD test) is contacted with biomass in the apparatus that continuously measures the dissolved oxygen consumption. This test determines the ultimate BOD in a few hours if a high level of biomass is used.

The test can also yield information on toxicity, the need to develop an acclimated biomass and required rate of oxygen supply. In general, low molecular weight water-soluble organic are biodegraded easily and readily. As organic complexity increases, solubility and biodegradability decrease. Soluble organics are metabolized more easily than insoluble organics. Complex carbohydrates, proteins and fats and oils must be hydrolyzed to simple sugar amino and other organic acids prior to metabolism. Petrochemicals, pulp and paper, slaughter house, brewing and numerous other industrial wastes containing complex organics have been satisfactorily treated biologically, but proper testing and evaluation is necessary.

2.3.1.2 Inorganic

The inorganic in most industrial waste are the direct result of inorganic compounds in the carriage water. Soft- Water source will have lower inorganic then hard-water or salt water source. Many food processing wastewaters are high in sodium. While domestic wastewaters have a balance in organics and inorganic many process wastewater from industry are deficient in specific inorganic compounds. Biodegradation of organic compounds requires adequate nitrogen, phosphorus, iron and trace salts. Ammonia salts or nitrate salts can provide the provides the nitrogen while phosphates supply the phosphorus.(Perry,1998)

2.3.1.3 PH and Alkalinity

This is the degree of acidity or basicity of the effluent. It measures the hydrogen and hydroxyl ion concentration in an aqueous solution. Wastewaters should have PH values between 6 and 9 for minimum impact on the environment. Wastewaters with PH valves less than 6 will tend to be corrosive as a result of the excess hydrogen ions. On the other hand, increasing the PH above 9 will cause some of the metal ions to precipitate as carbonate or as hydroxides at higher PH level Alkalinity is important in keeping PH valves at the right levels. Bicarbonate alkalinity is the primary buffer in wastewater. It is important to have adequate alkalinity to neutralize the acid waste components as well as those formed by partial metabolism of organic. Precipitation of the calcium which forms part of the alkalinity to neutralize the acid waste component as well as those formed. In a few instance sodium bicarbonate may be the best source of alkalinity (Water,1998).

2.3.1.4 Temperature

Most industrial waste tends to be on the warm side. For the most part, temperature is not a critical issue below 37^0C of wastewater is to receive biological treatment. Low temperature operation is Northern climates can result in very low winter temperature and slow reaction rates for both biological treatment systems and chemical treatment systems. Increased viscosity of wastewater at low temperatures make solid separation more difficult, effort are generally made to keep operating temperatures between 10 and 30 ^{0}c if possible.

2.3.1.5 Dissolved Oxygen

Oxygen is a critical environment resource receiving stream and lakes. Aquatic life requires risk. Aquatic life requires reasonable dissolved oxygen (DO) levels. The minimum stream DO level is set at 5mgll during summer operation. When the rate of biological metabolism is at maximum it is important that wastewaters have maximum DO levels when they are discharge and have minimum of oxygen demanding components so that DO above 5mg/l. DO is poorly soluble gas in water, having a solubility of 9.1mglv AT 20^0C and 101.3KPa (1atm) air pressure. As the temperature increases and the pressure decrease with higher elevations above sea level, the solubility of oxygen decreases.

2.4 Solid Waste Management

Solid wastes are waste arising from human and animal activities that are normally solid and that are discharged as useless or unwanted. It encompasses the heterogeneous mass of throw always; the brewery industry is taken as a case study due to the level of pollution arising from solid waste. The activities associated with waste management, from the point of generation to the final disposal are grouped into functional separates elements. These include

The function elements are the activities associated with the management of solid waste from the point of generation to the final disposal having been grouped into the functional elements.

Waste Reduction: Processes can be redesigned to reduce the amount of waste generated.

Waste Generation: Waste generation encompasses those activities in which materials are identified as no longer being of value and are either thrown away or gathered together for disposal. The economical treatment of wastes demands that the best place to sort waste materials for recovery is at the source.

Reuse: Waste may be diverted to reuse for example from one process like filtration mashing and can be used as animals, poultry feed and fertilizer.

Handling storage and processing

This involves activities associated with the handling storage and processing of solid waste at or near point of generation. On site storage is important because of the aesthetic consideration, public safely and economy involved.

Collection: The functional element of collection includes gathering of solid waste and hauling of waste kept / dump for recycling.

Industrial and domestic process: Solid wastes are wastes arising from human, and animal activities that are normally solid and that are discarded as useless or unwanted, industrial wastes are solid wastes arising from manufacturing activities in industries while domestic wastes are waste originating from domestic homes.

Transfer and transport – The functional element of transfer and transport involves two step (1) The transfer of waste from the smaller collection vehicle to the larger transport equipment and (2) The subsequent transport of the wastes usually over long distance to the disposal site.

Processing and recovery: This includes all the technique, equipment and facilities used both to improve the efficiency of the other functional elements and to recover useable materials, conversion products or energy from solid wastes. Materials that can be recycled are exported to the facilities equipped to do so. The residue goes to disposal.

Disposal: This is the final treatment of all solid wastes. The waste may arise from industrial treatment plants and landfill site. Industrial treatment plant and air-pollution control device, or other substance from various solid waste processing plants that are of no further use.

SCHEMATIC DIAGRAM OF THE WASTE TREATMENT PROCESS

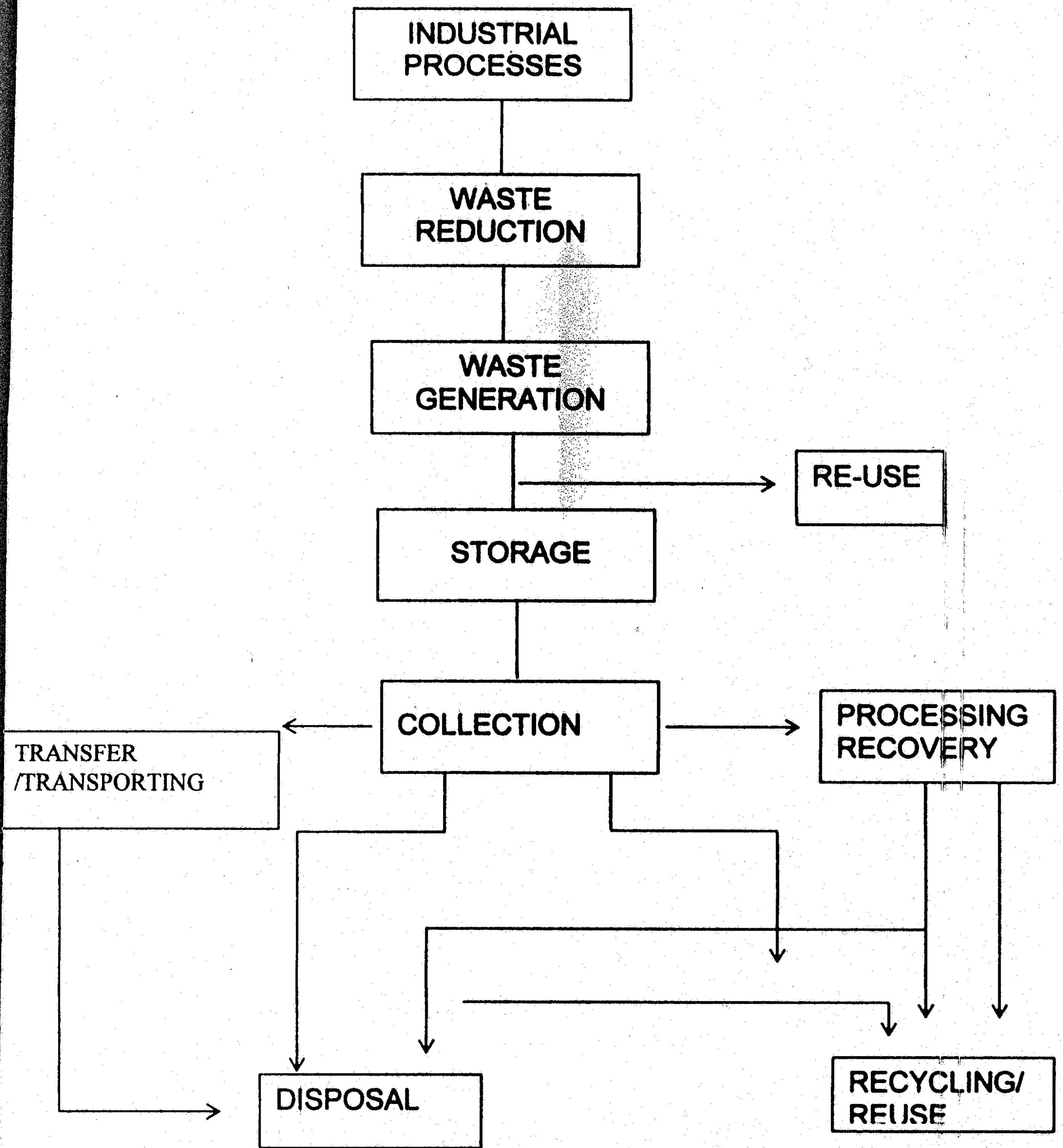

FIG 2.1 Functional elements in a solid waste management system

2.5 Federal Environmental Protection Agency Guidelines and Regulations on Discharge of Waste

Consequence upon the episode of koko toxic waste in old Bendel State of Nigeria and with the promulgation of the Federal Environmental Protection Agency (FEPA) decree 42 (1988). Nigeria is now aware of the rate at which the streams and rivers get polluted by industrial activities of the numerous manufacturing industries.

Though, Nigeria is witnessing a growing increase in technological awareness, little is being done in the area of waste treatment and this has adversely affected the health of the society.

Most antipollution legislation and regulatory action are at the federal level where the federal environmental protection agency (FEPA) coordinates the matter.

2.5.1 The Environmental Protection (Effluent Limitation) Regulation Of 1991.

The national environmental protection agency has been given specific instruction to interpret and give the following regulation to numerous industries, mainly to give meaning to the best practical technology available (BPTCA).

In doing its job, the federal environmental protection agency (FEPA) has to distinguish between the total costs of pollution control and balance it with the effluent reduction benefits. The activity might eliminate the application of technology which would be high cost compared to minimal reduction in pollution which might be achieved. This means that industries should install anti-pollution equipment and treat effluent to reduce contaminants to within the limits specified in the federal environmental protection agency (FEPA) standard. The regulation makes its mandatory for industries to cite the guideline and regulations and also defines the penalty due to the culprit.

2.5.2 Specific Effluent Limitation

All public owned treatment works must meet effluent limitation guidelines. In Nigeria for all categories of industries this is based on the information supplies by FEPA regarding chemical, physical and biological characteristic of pollutants. The effluent limitation must be met through the application of secondary treatment.

Industrial discharges must not be in any way detrimental to navigate water or fresh water around.

2.5.3 Scope of Fepa's Sanction Power

In discriminate waste disposal, be it from home, farmland or industries is an intraterritiorial waste dump, and it is as bad as waste dumped into Nigeria from extra-territorial sources.

FEPA will move quickly to other sectors of our economy, especially the old sector and provide guideline and standard for them, waste and spill management the agency has power, among other to:

1. Establish such environmental criteria guidelines, specification or standards for the protection of Nation's air and waste water as it may be necessary to protect the health and welfare of the population from environmental degradation

2. Establish such procedures for industrial or agricultural activities in order to minimize damage to the environmental from activities.

3. Maintain a program of technical assistance to bodies (public and private) concerning implementation of environmental criteria guidelines, regulations and standard and monitor, enforcement of the regulation and standard theory. The various guideline, criteria, specification and standard to be set up under the above stated power, should be by way of subsidiary legislation with the force of law.

2.6 Waste Generation

Waste Generated from Brewing could be classified into solid, liquid and gas.

Solid Waste

Solid waste in the brew house originated from the following:

The brewery generates large volumes of waste water derived from the various manufacturing operations. The effluent are polluted, being rich in dissolved and suspended substances, such as indigenous substances, sugars residues of beer, yeast, particles of refuse of malt after brewing and kieselghur (diatomaceous earth used for improving colour of beer). Inorganic chemical such as caustic soda, hypochlorite and peroxides, soap and detergents produced from washing and sterilizing of equipment and bottle are also present in the effluents.

The characteristic and qualities of a factory effluent depend on the source waste of the production activities and point of sample collection.

Liquid Waste

The brewery industry, water is used at virtual every steps of production. Stream water is generated for cleaning of vessels, production lines, bottles and floors. Liquid waste therefore originate in the cleaning and sterilizing of the brewery factory floors, cooling toughs, fermenting vessels, washing of bottles, wastes of whirlpool and fluidized solids.

The brewery generates large volumes of waste water derived from the various manufacturing process operations. The effluent are polluting, being rich in dissolved and suspended substances such as indigenous substances, sugar, residues of beer ,yeast, particles of chaff (refuse of malt after brewing) and kieselgur (diatomaceous earth used for improving colour of beer). Inorganic chemical such as caustic soda, hydrochloride and peroxide, soap and detergents produces from washing and sterilizing of equipment and bottles are also present in the effluents. The characteristic and qualities of a factory effluent depend on the source of the waste production activities and point of sample collection.

Gaseous Waste

The smoke generated from the open burning field is completely dispersed into the atmosphere. Volatile by-products like ketones, aromatics and esters are also released into the atmosphere.

Carbon dioxide gas is the only gaseous waste recovered in brewing. It is a volatile by-product. The gas is refined and used to carbonate beer during bottling. The excess CO_2 gas is bottled and sold to soft drinks bottling companies.

2.7 Waste Management

Solid Waste Management

The disposal of the process waste is handled by contractors in Nigerian brewery, Ibadan. The spent grain are stored in overhead storage silo and loaded at interval into the contractor's vehicle which dump the waste at some sites approved by the ministry of health.

To maintain good housekeeping, refuse bins are located around the factory for collection of solid wastes such as defective cartoons etc are collected and returned to metal box glass, for recycling in making new bottles.

Waste Water Management

The brewery has integrated drainage network which adequately take care of the effluent. The factory reduces the effect of waste generation by the following ways:

1. Washing and rinsing water can be made to undergo regeneration treatment after use. This allows more recirculation than is presently possible

2. Dilution in the emulsion and liquids preparation can be minimized that is more concentrated liquid chemical and emulsion can be used to shortened residence time

Also, reduction in concentration of the pollutant going into the waste water can be achieved:

3. Unnecessary liquid and beer spillage or overflow can be avoided by improving on the quality of operation and the effectiveness of the method

4. Collection troughs can be introduced to prevent the spillage and overflow liquid from discharging into the waste streams. The contents of such tough can be deccuted and returned to the tank from time to time.

CHAPTER THREE

3.0 MATERIAL AND METHODOLOGY

3.1 Material / Equipment Used

1. BOD apparatus
2. Turbidity meter
3. Pippette
4. Flask
5. Thermometer
6. Calorimeter Comparator
7. Glass Stopper
8. Glass tubes
9. PH Meter
10. Filter paper
11. Evaporating dish

3.2 Material Used

Sample of effluent were drawn from three points namely.

1. Before discharge (real effluent)
2. At the point of discharge of the effluent
3. Downstream after the point of discharge of effluent.
4. Ethylene Diamine Tetracetia acid (EDTA)
5. Mercury II sulphate (Mg_2SO_4)
6. Pottasium chromate ($K_2Cr_2O_7$)
7. Hydrogen Sulphate (H_2SO_4)
8. Anhydrous potassium sulphate K_2SO_4
9. Copper sulphate $CuSO_4$)
10. Anthrone / sulphuric reagent

11. Distilled water

12. Phenolphthalein

13. Methyl Orange

14. Hydrochloric Acid

3.3 Methodology

The following characteristics of waste water from NB plc Ibadan were analyzed: Temperature, PH value, colour and appearance, $COD, BOD, turbidity.

3.3.1 Determination Of Waste Water Temperature

The temperature was determined with a thermometer at the various point of collection.

3.3.2 Determination of PH Value

The electrode of the PH meter was rinsed with distilled water after which the PH meter was switched on and the electrode introduced directly into the sample. The PH value was measured and recorded.

3.3.3 Determination of Colour and Appearance Effluent.

A container with the sample was vigorously shaken and a portion of the waste water was poured into a clean separate transparent waste water sample were individual observed. The colour and the nature of the particle present were carefully observed and recorded.

3.3.4 Determination of Turbidity

This is the measure of the light transmitting properties of water. The turbidity of waste effluent was measured using a turbidity meter. The Nephelometric method was used in this case. This method was based on a comparison of the intensity of light scattered by the sample under definite condition with the intensity of light scattered by a standard reference suspension under the same condition.

3.3.5 Determination of Total Hardness

This is the sum of alkaline earth (calcium and magnesium ion) such as carbonate, sulphate, chloride and phosphate expressed in (mg/s).

Method:- 100ml of water was pipette into the canonical flask, 5ml of ammonia buffer solution was added with a very little quantity of black enrochrome was warmed to 50°c and titrated with 0.01ml of EDTA (Ethylene Diamine Tetracetia acid) until the colour change from red to blue which indicate that it was free of alkaline ions.

3.3.6. Determination of Chemical Oxygen Demand

Chemical Oxygen demand (COD) test indicate the quantity of oxidisable compound present in water. It determines the degree of Pollution in water. The principle used to determine COD was based on the amount of oxygen needed to oxidize all oxidisable compounds in water. This is directly proportional to the amount of potassium dichromate consumed.

Method: - 2ml of sample was pipette into a COD round bottom flask and the following were added, 0.1g of mercury II sulphate (Mg_2SO_4), 10ml of 0.25N $K_2Cr_2O_7$ solution and 15ml of H_2SO_4 in which Ag_2SO_4 has been dissolved.

A blank solution was prepared using distilled water for mixing the entire reagent above. Heat was apply to both sample under reflux for 2 hours and allow to ones then titrate with 0.1N $FeSO_4(NH_4)_2SO_4.6H_2O$ solution using ferrein solution as the indicator 2 drops was added until the end – point colour is reddish brown

Calculation

$$\text{COD mg/h} = \frac{y - x \ X\ 8000\ X\ T}{\text{Volume of sample used}}$$

Where y = Volume of $FeSO_4(NH_4)_2SO_4.6H_2O$ consumed by blank solution

x = Volume of consumed $FeSO_4(NH_4)_2SO_4.6H_2O$ by sample

T = Concentration of $FeSO_4(NH_4)_2SO_4.6H_2O$

3.3.7 Determination of Biochemical Oxygen Demand (BOD)

This is the amount of oxygen required by bacteria to reduce some of the organic matter in a waste under standard condition: The BOD serve as food for the bacteria, COD can be related empirical to BOD or organic carbon or even organic matter.

Method:

The process involve dilution i.e pre-treatment of dilution water by seeding and the PH of the sample was determined and shaken immediately before the dilution were made. A setting time of 30 minutes was applied.

3.3.8 Determination of alkalinity

The alkalinity of the sample can be determined by carrying out two test, which are literally alkalinity and determines the amount of carbonate present in the water why the other is literally complete which determine both carbonate and hydrogen carbonate.

Method;

Pipette 100ml of water sample into a conical flask. Add 2 drops of phenolphthalein if, the solutions red, titrate with 0.1m hydrochloric acid to colourless;

Add two drops of methyl orange to be used for titrable alkalinity. Titrate with 0.1m of hydrochloric acid from yellow to orange, orange to pink.

3.4 Analysis on Spent Grain (Solid Waste)

3.4.1. Determination of percentage moisture

The method adopted was that of air oven as outlined by food and agriculture organization (FAO) 1981. Three clean crucible with tight fittings lids were dried in an oven until constant weight was obtained and were cooled in the desiccators and weight of the crucibles were taken (w1). For each determination, 5g of the sample was weighted into each of the three crucibles and the crucible with lid and their contents were weighed (w2). They were then put into.. the oven and dried at 30°C for 24 hours after which they were allowed to cool in a desiccators and then weighed. The drying and the weighing process were repeated at intervals until a constant weight was obtained (w3)

Calculation: the percentage (%) moisture content weight was calculated using the formula:

%moisture content =

Weight of sample + crucible + lid (before drying) – weight of sample + lid (after drying) x 100

+Weight of sample taken

%moisture = w2 – w3/w2 –w1 x 100

Standard error of mean (SEM) = $\sqrt{S^2/n}$

Standard error of mean (SEM) = $\sqrt{S^2/n}$

3.4.2 Determinant of Percentage Protein

The protein content was determined by the micro-kjeldahl method, 0.25g of the sample was weighed into a clean dry 100ml kjeldahl flask. About one gram of mixed catalyst (160g anhydrous K_2SO_4 10g $CuSO_4$) $5H_2$ O, 3g selenium powder mixed well in a mortar was added followed by 6ml of concentrated sulphuric acid and few glass beds. It was then carefully digested over an electric heater in the hood (fume chamber) initially with low flame until frothing subside and then at higher temperature until content became clear greenish colour. Digestion was then continued for more 60mins. The heater was put off and the flask was allowed to cool. The content was transferred quantitatively to 100ml volumetric flask. The kjeldahl were rinsed off using distilled water. The content of the volumetric flask containing the digested sample was then made up to the marked volume with distilled water and mixed thoroughly.

10ml of the digest was then pipette into marked distiller and 10ml of 40% sodium hydroxide solution was added to digest. The steam distilled ammonia liberated was collected into 10ml boric acid solution containing 4 drops of mixed indicator (Bromocresol green 99mg, methyl red 66mg, and thymol blue 11mg) in the conical flask. After the indicator turned green the distillation was removed and titrated with standard hydrochloric acid, the end points being reached when the indicator changed from green through grey to definite pink. The amount of acid used (titre) was recorded V1ml.

A blank containing 6ml concentrated sulphuric acid, 1g of mixed catalyzed without any sample was prepared and the above procedure was carried out on it, the burette reading was recorded (V2ml).

Calculation: the percentage (%) nitrogen content is given by the formula:

%nitrogen = corrected titre volume (V1 – V2)ml x 14 x 5 x 100/1000x70xsamples weight(g)

= corrected titre(ml)/10x sample weight(g)

The percentage protein was calculated by multiplying percentage nitrogen by factor of 6.25

3.4.3 Determination of Percentage Lipid Content

Soxhlet Extraction

Soxhlet extraction was carried out to determine the percentage lipid contents. The methods were followed in order to calculate the percentage lipid extracted. The method used is that of TDRI (1984). 3g of sample were weighed into three whatman filter paper that has been folded and pinched at one end. The filter paper was previously dried to constant weight (w1). After the sample was added into the filter paper, the filter paper was folded and pinched at the other end and the weight was takenW2. This was placed in the extractor. Petroleum ether (40 – 60°C) was poured into the round bottom flask placed on a heating mantle set at 60°C until the petroleum ether just boiled. The extraction was continued for twelve hours after which the heating was stopped and apparatus was dismantled, the defatted sample and filter paper were then dried in the oven at 60Oc. This was cooled in the desiccators and the weight of the filter paper and the sample before and after extraction was weighed W3 and this is known as thimble method

Calculation: %lipid = w2 – w3/w2-w1 x 100

3.4.4 Carbohydrate Estimation

Weigh 0.2g of sample into 20ml of distilled water in conical flask (this may or may not be filter). Pipette 5mls of filtrate into 50mls volumetric flask and make up to the mark with distilled water.

Pipette 2mls of solution into duplicate test tube and add 10mls of anthrone/ sulphuric reagent. Prepare duplicate blank by mixing 2ml of distilled water and 10mls of anthrone/suphuric reagent. Duplicate standards with 2ml of standard carbohydrate and 10mls of anthrone / sulphuric acid reagents, stopped the tube slightly and shake, placed them in a water bath at 100oC for 20minutes (for proper development of the colour). Remove the tubes and cool in water. Then, measure the colour developed at 625nm. The blank is used to set the spectrophometer to zero.

Calculation: % Carbohydrate = Ra x20x500/Rs x 1000 = Ra x 10/Rs

Ra = sample absorbance

Rs = standard absorbance

3.4.5 Determination of PH

The method is a standard method. The spent grain was dissolved and mixed with distilled water, and was allowed to stay for 5 to 10mins for dissolution. The PH meter is used to take the reading.

CHAPTER FOUR

RESULTS/DISCUSSION

4.1 Results

The results were obtained from the experiment carried out on the liquid waste.

TABLE 1

Analysis Result of the Liquid Effluent

Test	Units	Before Discharge	Up-stream	Down-stream
A Appearance	----	Brown liquid with parti	Colourless	Colourless
Odour	----	Unpleasant, choking sm	Odourless	odourless
C PH at 29°C	----	11.3	9.7	7.4
Temperature	°c	40°C	30.2	28
T Alkalinity	Mg/l	36	30.4	27.6
T Total Suspended Solid	Mg/l	58	52	45
Biochemical oxygen dema	Mg/l	57	41	39
C Chemical oxygen demand	Mg/l	75	58	44
Foam	-----	Present in small amount	--	--
Turbidity	NTU	35	27.7	18.57
Total Hardness	Mg/l	790	667	570

Table 2

The FEPA standard for the below parameter

Parameter	FEPA Standard	Unit
Temperature	36 max	°C
PH	6-9	---
Turbidity	25 max	NTC
Conductivity	500 max	Ns/cm
Biochemical oxygen demand	50 max	Mg/l
Chemical oxygen demand	60 max	Mg/l
Phosphate	10 max	Mg/l
Alkalinity	28 max	Mg/l
Total dissolved solids	2000 max	Mg/l
Total suspended solids	30 max	Mg/l
Hardness	500 max	Mg/l

Table 3

Comparison of the FEPA standard with the result obtained (Down Stream)

Test	FEPA standard	Down-stream
Appearance	Colourless	Colourless
Odour	Odourless	odourless
PH at 29°C	6-9	7.4
Temperature	36max	28
Total solid dissolved	2000max	----
Total suspended solid	30max	45
Colour	20max	---
BOD	50max	39
COD	60max	44
Foam	---	–
Turbidity	25max	18.57
Hardness	500max	570
Alkalinty	28 max	25

Table 4

Result of solid waste (spent grain)

Protein	1.9%
Carbohydrate	1.32%
Lipid	8.5%
Moisture	72%
PH	3.27

4.2 Discussion

Result obtained for each parameter investigated was compared with the FEPA standard on effluent limitations and conclusion discussed as followed.

4.2.1 Temperature and PH

For temperature, the FEPA standard is 36^0C maximum and result from investigation gave 28°C, which falls within the standard for the effluents limitation. The result of the investigation gave 7.4, for PH of water. This also falls within the allowable limit.

4.2.2 Turbidity

Turbidity of the effluent sample after discharge gave 18.57 NTU and FEPA designated standards for this parameter is 25NTU maximum. This reflects the fact that turbidity met the FEPA standard for effluent limitation.

4.2.3 Biochemical Oxygen and Chemical Oxygen Demand

Result of investigation on biochemical oxygen demand gave 39mg/l as against FEPA standard which for this parameter, which is 50Mg/l maximum. This shows that this parameter falls within the allowable limits of the Federal Environmental Protection Agency (FEPA).

Chemical Oxygen demand tests were 49Mg/l from the investigation. The FEPA allowable limit for this parameter is 60Mg/l maximum and allowable limit.

4.2.4 Total Hardness and Alkalinity

Investigation on total hardness of the effluent sample gave an average result of 570Mg/l, which when compared with the FEPA standard of 500Mg/l maximum shows that hardness fall again the FEPA specification. And alkalinity result of 25 which also fall within the FEPA standard 28max

4.2.5 Spent Grain

The solid waste contains some nutrient which help the feedstock to grow but the moisture content is too high 72% i.e if not dry very well microbe can easily grow on it .

CHAPTER FIVE

5.1 Conclusion

Major emphasis was placed on the brewery's waste water discharge to the environment from the observation and analysis of results, it is clear that due to the effluents being free from any substances with high chemical oxygen demand and high suspended matter that may affect the livivg organism or life in the river were not affected.

Also there was no effect on the plant by the river side because the water from the brewery is free of chlorine and any other chemical element that may react with the soil forming an acidic salt.

Gaseous and solid waste emanating from the industry should also be reduced. Step taken to reduce the waste may not necessarily require major capital expenditure, good housekeeping and quality control methods are important and the benefit of waste reduction are immerse and they include

- Reduced production run: a stoppage in the line for even a short time creates an environment of waste and significantly decreases production.
- Reduced maintenance costs as there are fewer operational problems higher morale within the workplace and increase in saving in cost of production

5.2 Recommendation

After a careful study of the Nigeria Brewery Industry in Ibadan the following recommendation are made:

1. The Federal Environmental Protection Agency should review its standard with time and in accordance with the level of pollution, it should be aimed at reducing the level of pollution to the barest minimum, FEPA should also work with the company and monitor effort made in treating waste before discharge by carrying out environment audit assessment.
2. The Brewery should implement recommended FEPA suggestion they are:

   - Neutralizing the bottling hall effluent before joining the main waste stream

- Collection of whirlpool and filter press waste in a suitable holding tank to allow sedimentation to take place. The supernat can be discharged after neutralization and precipitate can be discharge as solid wastes.

- Neutralize and discharge brew house waste except when it is high in suspended matter in which case, it should be treated as mentioned above.

- CO_2 produced during fermentation which is green house gas should be used to chill, filter out carbonate bottled.

5.2.1 Operation Recommendation

The operating condition in the waste water treatment plant should be inspected continually and recorded in details as much as possible. This is also significant in the production of high quality and pollution free effluent in the sense that different chemical and reagent used in water treatment unit are added at particular pressure, temperature flow rate e. t.c.

5.2.2 Skilful Operation

The operator of waste water treatment unit should be operate with immersed knowledge, understand and should put the right attitude towards their various jobs. Manual should be made available for reference purposes if need be skilful operators will keep the unit in an excellent operating condition and the produce effluents that satisfies the laid down standard.

REFERENCES

1. **Austin, T.G. (1977)** Shreve's Chemical Process Industries, 5th edition (Mc Graw-Hill)
2. **Awake (1998)** Chemicals and Your Health, December 22, Watchtower Bible & tract Society, Brooklyn
3. **Federal Environmental and Protection Agency (FEPA) 1991,** guideline, Standard and Regulation on environmental pollution control in Nigeria..
4. **Gurnham, C.F. (1989)** ,industrial waste water control, second edition. Mc Graw hill series
5. **Perry, R. H and Green, D. W. (1997)** Chemical Engineers Handbook, 7th edition, pg McGraw-Hill Publishing companies New York
6. **Perry, R. H and Green, D. W. (1998)** Chemical Engineers Handbook, 7th edition, pg McGraw-Hill Publishing companies.New York
7. **Sinnott, R. K. (2005)** Coulson and Richardson's Chemical Engineering Volume 6, Chemical Engineering Design, 2nd edition
8. **The Encyclopedia Britanica**
9. **Walters, J.K and Wint, A. (1981)** Industries Effluent Treatment: Water and Solid wastes, Volume 1
10. **www.wikipedia**