ANALYSIS OF SURFACE AND GROUNDWATER POLLUTION OF ABATTOIR WASTE

A CASE STUDY OF MINNA ABATTOIR

BY

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DECLARATION

I hereby declare that this Project is a record of a research work that was undertaken and written by me. It has not been presented before for any degree or diploma or certificate at any University or Institution. Information derived from personal communications, published and unpublished works of others were duly referenced in the text.

.... 15/11/2006 ....

AbdulGafar, Hussaini Bello Date

2000/10879EA

DEDICATION

I dedicate this project work to Almighty Allah and to my Beloved Parent.

CERTIFICATION

This project entitled "Analysis of surface and groundwater pollution of abattoir waste, a case study of Minna abattoir" by **AbdulGafar, Hussaini Bello** meets the regulations governing the award of the degree of Bachelor of Engineering (B.ENG.) of the Federal University of Technology, Minna and it is approved for its contribution to scientific knowledge and literary presentation.

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ABSTRACT

This project evaluated the effect of abattoir waste on the surface and ground water, of the area the abattoir is located, Tayi, Minna, Niger State, Nigeria. Samples of water were taken from upstream, downstream of the receiving stream, point of discharge of the abattoir liquid waste into the water, a well in the area and a well in the abattoir. Analyses focused on the variability in the water quality along the stream and in the wells. The results presented clearly indicate that most of the elements/parameters were slightly above the acceptable limits by FEPA/WHO. Although some are within the range and some are below the limits. Hence, considering the analysis carried out on physical, chemical and organic parameters of the water samples, one safely draws the conclusion that, the abattoir waste/effluent has lowered the quality of receiving stream.

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CHAPTER ONE

INTRODUCTION

An abattoir or slaughterhouse refers to a building for butchering. An abattoir houses facilities to slaughter animals; dress, cut and inspect meats; and refrigerate, cure and manufacture by-products. The following are the main activities of a slaughterhouse:

i. receiving area for live animals prior to slaughtering

ii. retention area (12-24 hours) for live animals prior to slaughtering

iii. slaughtering/stunning/bleeding of the animals

iv. skinning of animal (removal of hide/skin)

v. splitting, washing and dressing of carcasses

vi. handling and transport of carcasses and meat

(Alonge, 1991) defined meat hygiene as a system of principles designed to ensure that meat and meat products are safe, wholesome and processed in a hygienic manner and are fit for human consumption. Meat quality control is a system that regulates the measure of extrinsic materials such as chemical residues, toxins, pathogenic microorganisms and putrefied tissues, which could be present in meat and are deleterious to human health (Olugasa *et al.,* 2000). Environmental pollution and other health hazards that may threaten animal and human communities can be monitored through food inspection and in live animals. The presence of residues of insecticides, antibiotics and aflatoxins, contamination by heavy metals (e.g. fluorine or lead) and radio nuclides, and biological hazards can be detected in meat, offal, milk, fish and honey and any abnormal conditions can be identified earlier at the abattoir. Veterinary Inspection has the additional relevant role of avoiding frauds to consumers.

At the Minna abattoir, ante-mortem examination is nil as animals are off loaded and conveyed straight to the slaughter halls. Animals are then slaughtered using the Muslim technique of decapitation on the bare floor with skinning or burning of the carcasses commencing outside the spot. Post-mortem examination is done perfunctorily and is restricted mainly to the examination of offal and incision of some lymph nodes. Evisceration and dressing are done right on the floor in the slaughter halls. With inadequate slaughtering and disposal facilities, the abattoir has also become a source of infection and pollution, attracting domestic and wild carnivores, rodents and flies, which are vectors of diseases. The area is rampant with filth and scattered rubbish, which is left uncollected, apart from the blood draining trenches through which the filth is scattered rather than eliminated.

Hygiene problems are not limited to slaughtering but are also associated with incorrect processing and marketing practices. Under tropical conditions, food of animal origin tends to deteriorate more rapidly and become an important vehicle for gastrointestinal infections, thereby endangering consumers' health. Transport facilities are often inadequate and unhygienic. Most vendors lack refrigerators and products are displayed without hygienic precautions. Urban food distribution chains in Nigeria are frequently long and involve different intermediaries, which render controls difficult.

In all countries, some form of on-the-spot slaughter either in the open or on the farm is inevitable. While the killing of animals is significant in meat supplies being a good source of protein and useful by-products such as leather, skin and bones; meat processing activities sometimes result in environmental pollution. The abattoir wastes just like any other waste can be detrimental to human and the environment if definite precautions are not taken.

There are several special environmental problems associated with abattoir that must be considered. Abattoir waste can have adverse environmental effects on both the land and the water quality especially if the waste (liquid) is directed toward a river/stream. In general, the major environmental problem associated with abattoir waste is the large amount of suspended solid and liquid waste as well as contamination of the environment (odour). These wastes are always of biological origin and can pollute waterway and soil if not properly handled. At present, little attention is given to abattoir waste management and most of these wastes are hazardous as many contain small quantities of components which are dangerous or potentially dangerous to the environment. It is not a pleasant statistic: A 100-cow dairy herd can produce as much waste as 2,400 people. But that's not the only unpleasant fact: In certain types of soil, this waste can seep through the ground and reach groundwater, contaminating it with nitrate and bacteria.

1.1 DEFINITION OF WASTE

Waste may be defined as unwanted matter or material of any type (Procter, 1996), or it is the failure to use something wisely, properly, fully, or to good effect. Thus, the definition of waste can be very subjective, what represents waste to one person may actually represent valuable resource to another. However, wastes could be hazardous or non hazardous. By definition, hazardous wastes are the wastes that pose a substantial present or potential hazard to human health or the environment when not properly treated, stored, transported or disposed off or otherwise managed while non hazardous wastes refer to the wastes that are converted into economical use either by analysis or treatment (Gilbert, 1998). The regulations covering waste use variety of terms to describe the different types of waste including controlled, household, industrial, commercial, special etc. in such case, strict definitions of waste have financial and legal implications for businesses, local authorities and the government.

In addition, for the requirement of a legal definition of waste, agreement on definitions and classification of waste are required for the local, regional and national waste management planning. In Nigeria, Federal Environmental Protection Agency (FEPA) now Federal Ministry of Environment (FME) is responsible for the collection of data on waste which is used by local authorities planning departments in the preparation of their waste local plans and for waste management planning.

1.1.1 WASTE CLASSIFICATION OF PARTICULAR CONCERN

Special Waste

Special waste is controlled waste of any kind that is or may be so dangerous or difficult to treat, keep or dispose off that special provision is required for dealing with it. Such waste is known to contain substances which are dangerous to life.

Industrial Waste

Waste from factory premises. Factors described within the factories Act of 1960, premises used for public transport services by land, water or air, premises used for the supply of gas, water, electricity or sewage services, postal or telecommunications services. Example include industrial waste producers from the manufacture of textiles, chemicals etc.

Household Waste

Household waste means waste from private domestic accommodation, caravans, residential homes, universities or schools or other educational establishments, hospital premise and nursing homes.

Commercial Waste

Waste from premises used wholly or mainly for the purpose of a trade or business, for the purpose of sport, recreation or entertainment. Excluded from the commercial waste category are household and industrial waste, mine and quarry waste, and waste from agricultural premises. Examples include waste from offices, hotels, shops, local authorities, markets and fairs.

Controlled Waste

Sewage sludge disposed off to landfill and by incineration is controlled waste, but disposal at sea and spreading on agricultural land is regulated separately (Paul, 2002). Information on waste technology, particularly on industrial and hazardous waste, is often difficult to assemble. The efficient data collection methods and some industrialist are reluctant to give information.

Abattoir Wastes (Meat Processing Wastes)

These are another form of agricultural waste. Slaughterhouse waste include intestinal content, rumen, scraps of tissues, horns, bones, blood, faecal waste, fatty waste, proteneous waste.

1.2 MINNA ABATTOIR

Minna town lies on latitude 9^o 30' N and longitude 6^o 3' E in Niger State of Nigeria. The abattoir is located in an area popularly known as Tayi village, along Bosso Road, Minna, Niger state. As of the time of this research there is no any known documentation about the abattoir. It is constructed in such a way on take to accommodate three to four slaughtering at a time.

The abattoir is sectioned into three namely; the slaughtering section, the processing section (skin and bone removal/skin burning) and the waste dumping site.

The slaughtering section: After the animal(s) have been checked by the vetinary Doctor for any infection(s) and certified free then the animal will be kept in a place called the waiting site after which it will be brought into the abattoir for slaughtering. The animals are slaughtered on the floor by religious personnel who are also a staff of the abattoir, the blood and other liquid that came out of the animal pass through a channel (central) which leads to a reservoir outside the building. As of the time of this research, the reservoir (constructed with concrete) had been destroyed thus, the wastes from the building are now channelled into a stream in the area.

Processing section: After the animals have been slaughtered, they are passed to this section where the skin, some bones and the internal parts of the animal will be removed and washed. On the other hand if the complete animal has been bought by those who prefer the skin to be processed by burning, immediately after slaughtering the animal will be taken to the burning site to remove the hair on the skin of the animal, the internal parts and some bones will now be removed and the animal will be cut into portion.

Dumping section: The blood and other liquid that comes out during the slaughtering as well as faecal waste from the animal intestines pass through the centralized channel which leads to a stream. These are liquid and suspended solid wastes. The bones which are solid waste are usually dumped into this section and burnt before it will be sold.

In summary, these are the processes involved in handling animals in any abatoir:

1. Animals are received by truck or rail from a ranch, farm, or feedlot.
2. Animals are herded into holding .

3. Animals receive a preslaughter inspection.
4. Animals are rendered insensible (unconscious) by stunning (method varies) like using a captive bolt pistol, breaking their necks or cutting their throats, this depends on belief of the community .
5. Animals are hung by hind legs on processing line.
6. A main artery is cut, the animal's blood drains out and it dies.
7. Animal's hide/skin/plumage is removed.
8. Carcass is inspected and graded by a government inspector for quality and safety.
9. Carcass is cut apart and the body parts separated.
10. Meat cuts are quickly chilled to prevent the growth of microorganisms and to reduce meat deterioration while the meat awaits distribution.
11. The remaining carcass may be further processed to extract any residual traces of meat, usually termed mechanically recovered meat, which may be used for human or animal consumption.
12. Waste materials are sent to a rendering plant if available.
13. The waste water generated by the slaughtering process and the cleaning of the slaughter house is treated in a waste water treatment plant if available.
14. The meat is transported to distribution centers that distribute to local retail markets.

1.3 STATEMENT OF THE PROBLEM

Slaughter activities, if not properly controlled, may pose dangers to the farmers, butchers, the environment as well as the consumers. Abattoir effluent reaching streams may contribute significant levels of nitrogen, phosphorus and biochemical oxygen demand and other nutrients, thereby resulting in stream pollution. In addition to reducing stream physical and chemical quality, Carolyn and Buckhouse (1985) observed that pathogen from cattle waste could be transmitted to human via water-based recreations. It's not a pleasant statistic that A 100-cow dairy herd can produce as much waste as 2,400 people. But that's not the only unpleasant fact, in certain types of soil, this waste can seep through the ground and reach groundwater, contaminating it with nitrate and bacteria.

These are some of the main reasons that led to the analysis of waste from Minna abattoir. Information obtained from the study will be used to design efficient end-use treatment and mitigation measures towards the impact of wastes on our environment.

1.4 JUSTIFICATION OF THE STUDY

In a developing country like Nigeria, the meat processing industries (abattoirs) are generally less developed when compared with the advanced countries. Because in these countries (developed) waste generation, analysis and treatment are being considered while constructing the abattoir.

The waste generated by abattoirs contributes to the increasing environmental pollution. Improper disposal constitute a nuisance (odours and flies) to the environment, most especially to the people living around the area and aquatic life the waste is directed toward. The scarcity of inorganic fertilizers could be minimized if it could be produced from the wastes generated by the abattoir.

1.5 OBJECTIVES OF THE STUDY

The objectives of the study are:

a. Identify the wastes generated by Minna abattoir.

b. Carry out the qualitative analysis of the wastes (suspended solid and liquid).

c. Identify the necessary treatments wastes generated by the abattoir can undergo.

d. Analyze the effect of the wastes on the receiving stream and ground water.

CHAPTER TWO

2.0 LITERATURE REVIEW

Feeding a growing population from a limited land area is a challenge and pro-livestock lobby maintains that livestock are essential to developing sustainable agricultural systems in Third World countries. However, livestock production, which is perceived by the public to be potential food for the world's needy people, is a major pollutant of the countryside (where they are raised) and cities, if processors do not manage slaughter wastes properly with dung and slurry washed into waterways. Other environmental problems include pollution of soil with dung and the atmosphere with methane (a green house gas). Manure also produces nitrous oxide, which is the most damaging of the green house gases being 320 times more effective than carbon dioxide at holding heat in the atmosphere (Barrett, 2001).

The most important issue in all meat-processing plants is maintenance of proper hygiene and adequate sanitary conditions. An abattoir has been defined as a premise approved and registered by the controlling authority for hygienic slaughtering and inspection of animals, processing and effective preservation and storage of meat products for human consumption (Alonge, 1991). While the slaughtering of animals result in meat supply and useful by-products like leather and skin, livestock waste spills can introduce enteric pathogens and excess nutrients into surface waters and can also contaminate ground waters (Meadows, 1995). Abattoir operations produce a characteristic highly organic waste with relatively high levels of suspended solid, liquid and fat. The solid waste includes condemned meat, undigested ingesta, bones, horns, hairs and aborted foetuses. The liquid waste is usually composed of dissolved solids, blood, gut contents, urine and water. Animal food is always microbiologically contaminated by organisms living in it naturally or entering it from the surrounding, such as those resulting from processing operations (Lewicki, 1993). On-going production quality control, washing and disinfection, are the main procedures of securing the hygiene of meat and meat products (Pezacki, 1970; Windyga *et al.,* 1996). In the production of animal for food, more attention should be focused on the interactions between animal production and the environment, realizing environmental conditions and structures in animal production, which not only seek to produce wholesome and safe animal food but should also avoid environmental pollution and the associated human health risks.

The abattoir industry processes both red (beef, mutton and pork) and white meat (Poultry). The annual water consumption of the red meat industry, as recorded in 1989, is Approximately 5-8 million cubic meters. Approximately 84 % of this water is discharged as wastewater containing high organic loads including suspended matter.

The wastewater quality from red meat abattoirs could be broadly summarized as follows: pH 5,7 to 8,4; COD 2380 to 8942 mg/l; suspended solids 189 to 3330 mg/l; TDS 595 to 2805mg/l; Total Nitrogen 0, 71 to 24 mg/l. Whereas abattoirs require high quality water due to the processing of a material destined for human consumption (especially abattoirs exporting), discharges from these facilities significantly contribute to the organic load of raw sewage treated at sewage treatment plants.

2.1 SLAUGHTERHOUSE DESIGN

In the later half of the 20th century, the layout and design of most US slaughterhouses has been significantly influenced by the work of Dr. Temple Grandin. Grandin is also well known for being autistic and it was a fascination with patterns and flow that first led her to redesign the layout of cattle holding pens. Grandin's primary objective was to reduce the stress and suffering of animals being led to slaughter. In particular she applied an intuitive understanding of animal psychology to design pens and corrals which funnel a herd of animals arriving at a slaughterhouse into a single file ready for slaughter. Her corrals employ long sweeping curves so that each animal is prevented from seeing what lies ahead and just concentrates on the hind quarters of the animal in front of it. Grandin now claims to have designed over 54% of the slaughterhouses in the United States as well as many other slaughterhouses around the world.

The largest slaughterhouse in the world is operated by the Smithfield Packing Company located in Tar Heel, North Carolina; it is capable of butchering over 30,000 pigs a day.

2.1.1 INTERNATIONAL VARIATIONS

The standards and regulations governing slaughterhouses vary considerably around the world. In many countries the slaughter of animals is virtually unregulated by law; often, however, it is strongly regulated by custom and tradition. In the non-Western world, including the Arab world, the Indian sub-continent, etc., both forms of meat are available: one which is produced hygienically in modern mechanized slaughterhouses, and the other of the animals slaughtered (conscious) in local butcher-shops.

In some communities animal slaughter may be controlled by religious laws, most notably halal for Muslims and kashrut for Jewish communities. These both require that the animals being slaughtered should be conscious at the point of death, as such animals cannot be stunned prior to killing. This can cause conflicts with individual national regulations when a slaughterhouse adhering to the rules of kosher preparation is located in some western countries.

In many societies, traditional cultural and religious aversion to slaughter led to prejudice against the people involved. In Japan, where the ban on slaughter of livestock for food was lifted only in the late 19th century, the newly found slaughter industry drew workers primarily from villages of former eta (out-castes), who traditionally worked in occupations relating to death (such as executioners and undertakers). In some parts of western Japan, prejudice faced by current and former residents of such areas (*burakumin* "hamlet people") is still a sensitive issue. Because of this, even the Japanese word for "slaughter" (tosatsu) is deemed politically incorrect by some pressure groups as its inclusion of the kanji (chinese symbol) for "kill" (殺) supposedly portrays those who practice it in a negative manner.

Some countries have laws that exclude specific animal species or grades of animal from being slaughtered for human consumption. The former Indian Prime Minister Atal Behari Vajpayee, suggested in 2004 introducing legislation banning the slaughter of cows throughout India, where the cow is a sacred animal to Hindus, for whom the slaughter of one is unthinkable and offensive (note that already in all the federal states of India except two, cow-slaughter is banned by law). The largest slaughterhouse in India and also in Asia is located at Deonar, a suburb of Bombay. The slaughter of cows and the importation of beef into the nation of Nepal are strictly forbidden under Nepalese law. Several U.S. states have banned the slaughter and consumption of dogs, which are frequently eaten in parts of Asia, especially Korea.

2.1.2 HISTORY OF ABATTOIR

Slaughterhouses are needed primarily to serve the large-scale demand for meat in urban areas where there is no livestock. Thus the slaughterhouse has developed as an adjunct of the city. Early maps of London show numerous stockyards in the periphery of the city, where slaughter occurred in the open air. A term for such open-air slaughterhouse is a "shambles." There are streets named "The Shambles" in some English towns (e.g. Worcester, York) which got their name from having been the site on which butchers killed and prepared animals for consumption.

Open-air slaughter inside cities produced very substantial concerns about public health, morals, and aesthetics. This antipathy towards slaughterhouses is mentioned at least as early as Thomas More's Utopia. In the 19th and 20th centuries, slaughterhouses were increasingly sited away from the public view, and took pains to portray themselves as clean, innocuous businesses. In this they have been responding not only to increasing regulation, but also to public sentiment. Most Westerners find the subject of animal slaughter to be very unpleasant and prefer not to know the details of what goes on inside a slaughterhouse. As such, in the West, the connection between packaged meat products in the supermarket and the live animals from which they are derived is obscured.

In recent years, animal rights groups and some vegetarians have accused slaughterhouses of secrecy, and have tried to highlight the practices inside a slaughterhouse. This tactics has been in part to expose and correct allegedly inhumane treatment of animals, or unhygienic standards. It has also been used to encourage people to inform themselves about meat production, which the activists hope will lead to more people choosing a meat-free or reduced-meat diet.

2.2 IMPACT OF URBANIZATION ON LIVESTOCK CONSUMPTION

In some years to come, there will be more than 6 billion people in the world and half of this figure will be residing in urban areas. Demographic changes have been very rapid since the Second World War and have occurred mainly in the developing countries and it is projected that, by the year 2025, two-thirds of humankind will be living in towns, United Nations Population Fund (UNFPA, 1995). Urban expansion is the result of high natural internal growth rates and of rural-urban and international migratory flows. Urbanization is associated with changes in food consumption patterns; together with human population and income growth, it is a major driving force influencing the global demand for livestock products. The diet of rural communities is higher in calories but less diversified, whereas city dwellers have a varied diet that is rich in animal proteins and fats and characterized by a higher consumption of meat, poultry, milk, dairy products and fish (Von Braun *et al.*, 1993). Large quantities of carcasses and offal are introduced into towns every day, as high numbers of livestock from ranches or nomadic herds are slaughtered to satisfy the increasing demand for meat. In developed countries, the role of the veterinary profession in addressing needs of urban communities has long been focused on public health and hygiene (Bellani, *et al.*, 1978; WHO, 1981).

2.3 RELEVANT LEGISLATION

Most countries have laws in regard to the treatment of animals at slaughterhouses. In the United States, there is the Humane Slaughter Act of 1958, an unenforceable declaration of policy requiring that animals be stunned before killing. This act, like those in many countries, exempts slaughter in accordance to religious law, such as kashrut. Most strict interpretations of kashrut require that the animal be fully sensible when its carotid artery is cut. The novel '*The Jungle*' detailed unsanitary conditions in slaughterhouses and the meatpacking industry, leading to the passage of the Meat Inspection Act and the Pure Food and Drug Act of 1906, which established the Food and Drug Administration.

Only the two main operative laws, (this discussion could be extended if required) normally used by DWAF, are briefly referred to.

2.3.1 Definition of waste in terms of the Environment Conservation Act, 1989 (Act 73 of 1989): "Waste" means any matter, whether gaseous, liquid or solid or any combination thereof, which is from time to time designated by the authority concerned by notice in the *Gazette* as any undesirable or superfluous by-product, emission, residue or remainder of any process or activity.

2.3.2 Definition of waste in terms of the National Water Act, 1998 (Act 36 of 1998):

"Waste" includes any solid material or material that is suspended, dissolved or transported in water (including sediment) and which is spilled or deposited on land or into a water resource in such volume, composition or manner as to cause, or to be reasonably likely to cause, the water source to be polluted.

2.3.3 Technical definition of Abattoir Waste:

Abattoir waste can be defined as waste or wastewater from an abattoir which could consist of the pollutants such as animal faeces, blood, fat, animal trimmings, paunch content and urine.

Abattoir waste could therefore be regulated through either the Environment Conservation Act, 1989 (protection of the total environment i.e. water, air, soil, humans, flora and Fauna), or the National Water Act, 1998 (predominantly protection of the water regime, most possibly excluding seawater quality).

Water quality protection in terms of the National Water Act could be achieved *via* water use licenses (section 21 (f) for discharges – excepting into sewage reticulation and 21 (g) for disposal on land), directives in terms of section 19 for preventing and remedying pollution and section 20 to control emergency incidence involving the spilling of a harmful substance that could detrimentally affect a water resource. Relevant procedural approaches for the preceding exist in documentation cited as "Water use authorization process" but needs to be developed for the implementation of sections 19 and 20.

The protection of water quality including the environment against the effects of abattoir waste disposed of onto land could also be achieved through section 20 (prescribing the need for a disposal site permit from the Minister of Water Affairs to establish and/or operate a disposal site) of the Environment Conservation Act. Standards and protocols for the deployment of Section 20 permitting exist in the form of the Minimum Requirement Trilogy (second edition 1998).

2.4 WASTE LEGISLATION IN NIGERIA

The disposal of wastes from a meat processing industry is an integral part of the total production system. To reduce the cost associated with conventional waste treatment, wastes should be utilized by product recovery and utilization should be studied as alternatives. These will serve as mechanisms for preventing intrusion of undesirable degradable materials into the environment (Carl *et al.,* 1988). Waste generation is the sole responsibility of any processing industry as well as its disposal but the latter has to be in line with the public sewers and environment. This has led to the enactment of environmental legislation and the law established a stringent regulatory system stating detailed pollution abatement requirements with heavy penalties for violations. Different countries have defined wastes policies on their respective national laws, but most abattoirs in Nigeria are owned by government, thus, stringent sanction is not affecting them so much.

Nigeria has been subject to a long history or legislative control. However, there has been no single Parliamentary Act dealing with the broad aspects of waste management. Consequently, waste treatment and disposal or waste is covered by a number of different controlling authorities. Local authorities had powers via various statute dating back to medieval times to control waste as a public health problem. The local authority powers of waste management became established through the Public Health Acts of 1917 and 1991, the Mineral Act 1984, and the Nigerian Urban and Regional Planning Acts of 1978 and 1992 (Osuntokun, 1998). The increasing concern for the environment and the toxic waste dumping incidents led to demands for tighter legislative controls on waste disposal.

Further legislation on waste treatment and disposal followed in 1974 with the control of Pollution Act, which controlled waste disposal on land (Paul, 2002). Waste disposal Authorities were required to prepare plans for the disposal of all households, commercial and industrial wastes likely to arise in their areas. The plans would be required to include information on the types, quantities and sources of wastes arising in the area; the methods of disposal, the sites and equipment being provided and the cost (Osuntokun, 1998).

The late 1980s and 1990s saw further development in waste management legislation and the increasing influence of the Federal Environmental Protection Agency (FEPA), established by Decree 58 of 1988 and amended by Decree 59 of 1992 (now Federal Ministry of Environment) has the mandate to protect, restore and preserve the ecosystem of Nigeria and ensure compliance with existing environmental laws. FEPA's approach to waste pollution control is the systematic and integrated abatement and control of waste pollution sources. In the exercise of its mandate as provided in section 16 of Decree 58 of 1988 and amended by Decree 59 of 1992, the National Effluent Limitation Regulations, S.1.8 of 1991 and the Pollution Abatement in the industries Facilities Generating Wastes Regulations, S.1.9 are already in force from 15th August, 1991. Furthermore, Section 15 of the FEPA Decree empowers the Agency to set water quality standards for inter state waters of Nigeria, to protect the public health or welfare and enhance the quality of water. In view of this mandate regarding the Nigerian aquatic environment, the Agency set National Water Quality Guidelines and Standards for various uses, (Aina and Adedipe, 1991).

2.4.1 GOVERNMENT INSTITUTIONAL RESPONSIBILITIES

Several Nigerian Ministries and Agencies, including FEPA, have issued a large number of laws, guidelines, rules and regulations for environmental pollution control in various fields, such as water quality, effluent limitations, air quality, noise control, hazardous substances and wastes. The Nigerian laws are derived from the pre-1990 English Status and have been adapted so that they address the specific problems of environmental degradation and resources depletion.

The main relevant Nigerian national laws which fully or partly concern the environment as contained in the current issues in Nigerian Environment (Osuntokun, 1998) are;

1) Federal Environmental Protection Agency Act Cap 131 Law of Federation of Nigeria 1990.
2) Standards Organizations Cap 412 Law of Federation of Nigeria 1990.
3) National Resources Conservation Agency Council Act Cap 286 Law of
. Federation of Nigeria 1990.

4) Harmful Waste Act Cap 165 Law of Federation of Nigeria 1990.

5) Factories Act Cap 126 Law of Federation of Nigeria 1990.

6) Land Use Act Cap 202 Law of Federation of Nigeria 1990.

7) Endangered Species Decree Cap 108 Law of Federation of Nigeria 1990.

2.4.2 ENFORCEMENT OF WASTE REGULATIONS

The legal apparatus seems to cover all the main environmental concerns in detail but still needs to be improved upon so as to provide a comprehensive legislation for the environment. This task would lie with the Federal Ministry of Justice and the Law Reform Commission in collaboration with the Federal Ministry of Environment. Moreover, the enforcement of these regulations is a difficult problem. The principal device used by the Ministry in order to induce industries to comply with the existing environmental legislations is of a coercive nature. Penalties ranging from fines, levies, pollution taxes up to arrest of offenders and seizure of equipment have been instituted. No incentives such as tax reduction, subventions or grants have yet been established.

An important component of the enforcement of the environmental regulations is the capacity to verify the compliance of industries through an adapted network of controls. Such a comprehensive mechanism has not yet been put in place, mainly owing to lack of equipment and lack of an efficient structure for control. Receiving the most attention are pathogenic organisms, the removal of organic and inorganic substances such as VOC, and total dissolved solids.

2.4.3 SOURCES OF WASTE (SOLID WASTE AND WASTE WATER) IN RED MEAT ABATTOIRS

The different sources of waste in red meat abattoirs could be categorized as:

Lairagus / animal pens;

Bleeding / stunning;

Carcass processing / cleaning;

Offal processing; and by-products processing.

2.5 TYPES OF WASTE

Every industry produces either Liquid, Solid or Gaseous wastes.

2.5.1 LIQUID WASTE

The meat processing industry generates large quantities of effluent rich in organic compounds and nutrients and plants require the best tools available to manage wastewater effectively. When taken a closer look at effective strategies for wastewater management by plant operators including the installation of cleaner technology during refits or green-field construction, minimizing wastewater generation, installing the most efficient and effective wastewater treatment processes, avoiding white elephants and good management practice. The liquid portion, wastewater is essentially the water supply of the industry after it has been fouled by a variety of uses. From the standpoint of sources of generation, wastewater may be defined as combination of the liquid or wastewater removed from residues, institutions and commercial and industrial establishments, together with such groundwater, surface water, and storm water as may be present (Metcalf and Eddy, 1991). If untreated wastewater is allowed to accumulate, the decomposition of the organic materials it contains can lead to the production of large quantities of mal-odorous gases. In addition, untreated wastewater usually contains numerous pathogenic, or disease-causing, micro organisms that dwell in the human intestinal tract or that may be present in certain abattoir waste. Wastewater also contains nutrients, which can stimulate the growth of aquatic plants, and it may contain toxic compounds. For these reasons, the immediate and nuisance free removal of wastewater from its sources of generation, followed by treatment and disposal, is not only desirable but also necessary in an industrialized society.

The food production and processing industries are concerned particularly with three broad aspects of water technology: Microbiological and Chemical purity and safety, impurities that affect suitability for processing use; and decontamination after use. Contamination affects the difficulty and cost of disposing of wastewater and ultimately affects the cost of manufacturing food (Norman and Joseph, 1995).There are strict environmental regulations regarding the discharge of polluted water from processing plants in Nigeria. Plants which contaminate water with food processing wastes must treat the water to return it to an uncontaminated state before discharging it into surface water.

To increase or preserve the amenity of the city and ensure public health standards are met by complying with all legislative requirements associated with the quality of storm water runoff.

2.5.2 SOLID WASTE

Meat processing accumulates waste materials such as manure and paunch material, sledges and NCV skins. Opportunities to dispose of these waste solids using traditional methods are disappearing and there are alternative processes for utilizing these materials. The processing of meat material is the beginning of solid waste generation. Waste can be any garbage, sludge, gaseous, and other discharged materials resulting from various abattoir activities. Solid waste is classified into garbage and rubbish. Garbage are putrefied waste food processing industries, while rubbish are non -perishable waste that are either combustible or non-combustible such as paper, carton, wood, polythene, iron, glasses and ceramics.

Organic wastes are finding ever-increasing markets for resale and companies are slowly switching to more biodegradable and recyclables products for packaging. Excessive packaging has been reduced and recyclable products such as foil, glass and high density polythene (HDPE) are being used where applicable. In most cases, treatment of solid waste in abattoir was confined to dumping and land applications.

2.5.3 GASEOUS WASTE

Greenhouse gas emission and pollution are two serious environmental side-effects of abattoirs. Abattoir effluent critically impacts human health, agriculture, potable water and the ecology of aquatic species and has become a significant problem for many urban communities in Nigeria. There are currently no waste treatment plants for abattoirs in Nigeria. Legislation for the protection of water sources is inadequate and there is no clearly established, coordinated policy framework to tackle water pollution and greenhouse gas emission.

Over the past decades, releases from process industries facilities and the technologies used to minimize them. Have come under increased scrutiny from regularly agencies and the public a variety of federal, state and local laws have been enacted to limit releases. While the pending Nigeria Clean Air Acts are expected to be a major driving force toward increased emission control. the law will likely mandate that the maximum achievable control technology (MACT) be installed for those industrial sources and source categories defined by FEPA as major emitters of toxic chemicals. It is clear that all affected facilities must commit to using proven control equipment to minimize toxic chemical releases. Toxic air pollutants (often called simply air toxics) and acid rain, which is caused by emission of sulphur oxides (SOx) and nitrogen oxides (NOx) are currently receiving a great deal of attention in processing industries.

Some gases exist in such small amounts that their volume fraction is measured in parts per million (ppm) , this is shown in Table 2.1. However, examination shows that clean air contains methane, nitrogen dioxide, carbon monoxide and sulphur dioxide, all of which are considered to be primary air pollutants. Such substances originate from natural sources such as forest fires and volcanic eruptions, which also add finely divided particulates such as dust to the atmosphere.

Table2.1: Typical composition of "clean" dry air

Constituent	Molecular formula	Volume
Nitrogen	N_2	78.09%
Oxygen	O_2	20.94%
Argon	Ar	0.93%
Carbon dioxide	CO_2	0.037%
Methane	CH_4	1.3ppm
Krypton	Kr	1.0ppm
Hydrogen	H_2	0.5ppm
Nitrous oxide	N_2O	0.25ppm
Carbon monoxide	CO	0.lppm
Ozone	O_3	0.02ppm
Sulphur dioxide	SO_2	0.00lppm
Nitrogen atmospheric air.	NO_2	0.00Ippm

Helium	He	5.2ppm

Source: Kannappa and David; 1989.

Since "clean air" is not found in nature, it is appropriate to define polluted air as air which contains polluting substances in such concentrations as to cause an unwanted effect.

EFFECTS OF GASEOUS EMISSION

All humans require breathe and therefore air pollutants enter the body through the lungs. Pollutants such as sulphur dioxide, nitrogen dioxide and ozone are pungent gases which can harm lung tissue, and are associated with bronchitis, asthma, emphysema and possibly lung cancer. Particulates can also enter the lungs and some, such as lead, fumes and asbestos fibres, are especially dangerous because of their toxic and cancer producing properties (Kannappa and David, I 989). Many air pollutants have adverse thus exposing the earth effects on vegetation and can damage fruits, vegetables, trees and flowers. Agricultural crops are damaged when leaves are bleached or discoloured. Leaf tissues can collapse causing growth alteration. Animals and livestock can be harmed when they consume forage contaminated by a pollutant.

2.6 HISTORY OF WASTE TREATMENT AND DISPOSAL

The main purpose of the livestock sector of the agriculture industry is to produce food for human consumption, whether as meat or dairy products. Accordingly, great efforts are made to maintain the health of farm animals while alive, and to protect public health interests by regulating the production of meat and offal destined for human consumption. But during their lives, and as carcasses, cattle produce a considerable quantity of material which does not serve the main purpose of human food production. Thus, one dairy cow produces about 40 litres of excreta a day with a 90 per cent moisture content, only about 45 per cent of a cattle carcass is used for human consumption as meat or offal and of the remainder about half is moisture. All of this material is waste, to the farmer or to the butchery process.

Nonetheless what is waste to the farmer or to the producer of meat for human consumption does not necessarily have any further use. Cattle excreta contain significant amounts of nitrogen, potassium and phosphorus and for this reason are valuable fertilizers as manure or slurry. Similarly, the material from the slaughter of cattle, which is not carcass meat or offal used for human consumption and is referred to as animal waste, can be processed and used as a feedstock for a host of products, including animal feeding stuffs and fertilizer. Some of this material can be used without further processing, such as bovine eyeballs used for teaching purposes, and the blood and gut contents which also have applications as fertilizer. Accordingly what is waste to one process may be a valuable source of raw material for another industry, process or undertaking. Its utility for the purpose is affected by the cost of the material to the user and the availability of substitutes. Hence the availability of soya protein affected the price and utility of meat and bone meal (MBM) as a source of protein in animal feeding stuffs in the late 1980s, with consequent effects on the quantity of MBM used for this purpose.

Although most parts of the cattle carcass were used for some beneficial purpose, some material was not so used or cannot be used. In the case of certain highly infectious diseases, such as anthrax or foot and mouth disease, the entire carcass was a potential source of infection and had to be destroyed as soon as possible. Similar considerations applied to animals that died on the farm, whether of some less serious disease, or naturally; their carcasses could not be used for human consumption and, depending on the cost of transport and their value, they might have to be disposed of on farm, by a local hunt kennel or at a knacker's yard. Turning to the industries which process cattle waste into its many products, there were produced – during or at the end of those processes–quantities of materials which required disposal because they had no beneficial use to industry. Furthermore, during the various processes other substances, principally water but also some chemicals were added to clean or cause or assist a reaction. These too had no purpose once they had done their job but had been contaminated or altered in the process and became waste to the industry. Waste was often the hidden or forgotten component of activities such as livestock farming and butchery and its by-products because it had little or no value to the producer. Thus the producer of the waste usually had no self-interest in ensuring that it was dealt with in an appropriate manner to do so might be a cost on the principal business with no return. Where waste was inert or harmless, the implications of this lack of value and consequent lack of producer self-interest might be of little wider importance unless the quantity was so great as to present a problem in itself. But where the waste was from live or dead animals, and hence was liable to contain pathogens or other organic material which could cause harm to human or animal health or the environment, it assumed a far greater significance because of its potential for pollution.

The historical development of waste treatment and disposal has been motivated by concern for public health. The industrial revolution between 1750 and 1850 led to any people moving from rural areas to the cities, a massive expansion of the population living in towns and cities, and a consequent increase in the volume of wastes produced. The production of domestic waste was matched by increases in industrial waste for developing new large scale manufacturing processes. The waste generated contained a range of materials such as pathogens and was dangerous to human health. In addition, it attracted flies, rats and other Vermin which in turn posed potential threats through the transfer of diseases (Paul, 2002). To deal with this potential threat to human health, legislation was introduced on a local and national basis in many countries. For example, in Nigeria, throughout the letter half of the nineteenth century, a series of Nuisance Removal and Diseases Prevention Acts were introduced which empowered local authorities. These Acts were reinforced by the Public Health Acts of 1917 and 1991 which covered a range of measures, some of which were associated with the management and disposal of waste. The 1917 Act placed a duty on local authorities to arrange for the removal and disposal of waste. The 1991 Act introduced regulation to control the disposal of waste into water, and defined the statutory nuisance associated with any trade business, manufacture or process which might lead to the degradation of health or of the neighborhood.

Following the Second World War, waste treatment and disposal was not seen as a priority environmental issue by the general public and legislature, and little was done to regulate the disposal of waste. However, a series of incidents in the late I 960s and 1970s highlighted waste as a potential major source of environmental pollution. A series of toxic chemical waste dumping incidents led to increasing awareness of the importance of waste management and the need for a more stringent legislative control of waste. Amongst the most notorious incidents were the discovery, in 1972 of drums of toxic cyanide waste dumped indiscriminately on a site used as children's playground near Numeaton in the UK. The dumping of 3000 tonnes of arsenic and cyanide waste into a lake in Germany in 187 I, and the leak of Polychlorinated biphenyls (PCBS) into rice oil in Japan in 1968, the "Yusho" incident. The industrialized countries have experienced very serious environmental disaster from waste pollution as a price of their industrial development. For example, the Japanese heavy metal poisoning caused by mercury (Manamata disease) and Cadmium (ltai-ltai disease) in 1960's cannot be easily forgotten. During the 1970's in the U.S.A., pesticide and polychlorinated biphenyl (PCBS) Contamination of fish in the upper great lakes brought a flourishing commercial fish industry to an abrupt halt. The Love Canal episode in Niagara falls, USA, in the 1970's and early 1980's also come readily to mind. Ground water contaminated by toxic chemicals and leachate resulted in high prevalence of spontaneous abortion in pregnant women. There were also, several birth defects and high incidence of cancer among the residents. The entire Love Canal community had to be evacuated and relocated. Since the 1960's many developed countries have established institutional framework and regulatory machinery for waste pollution control for different uses. The first United Nations Conference on Human Environment was held in Stockholm in Sweden, 1972 to address the need for international action to stern the catalogue of environmental woes arising from waste pollution and other forms of environmental pollution (Paul, 2002).

The history of waste pollution problems in Nigeria dates back to late 1970's and early 1980's when outbreak of cholera epidemics and other water-borne disease occurred as a result of gross organic pollution of river water with raw human wastes. Industrial and technological developments in the country further compounded the waste pollution problem. For example, the accidental discharge of waste containing high ammonia level into Okrika River from NAFCON ,a fertilizer company near Port-Harcourt in 1988 caused massive fish kill and socio-economic problem for the artisan fishery industries in the surrounding village. The villagers claimed about ₦3 million compensation from the company.

Petroleum product spillage from the Kaduna Refinery in 1987 into Romi and Rido River. Well waters in Rido village as well as the Rido and Romi River were grossly polluted.

Compensation of more ₦3million had been paid had to the villagers affected by the waste pollution problems caused.

In 1979, industrial effluent from Ikeja Industrial Estate through WEMABOD Treatment plant which had broken-down, spilled into Idimangoro area due to the blockage one of the main-holes on the effluent channel. Well water, in the area was grossly polluted. Surface and ground waters have been beset with waste pollution problems of toxic synthetic chemicals such as heavy metal and pesticides, nutrient enrichment and recently, acidification (Aina and Adedipe, 1991).

In the case of Minna abattoir, the wastes (liquid and suspended solids) are directed toward a stream, and if adequate measure is not taken, this posses future threat to the state.

2.7 WASTE TREATMENT OPERATIONS, PROCESSES AND CONCEPTS

These are methods of removing toxic and hazardous components. If these components are incorporated into gases, as is the case with stack emission, physical methods such as cyclone separation, electrical precipitation or filtration can be used, as chemical treatments such as liquid scrubbing or oxidation techniques. In the case of liquids filtration, electro lysis, eleetrodia lysis, reverse osmosis, chlorination, hydrolysis, oxidation, chemical precipitation, solidifications, biological and ion exchange techniques are all available. In all these cases the hazardous material is separated as a minor component from the bulk gas or liquid, usually as a solid or slurry requiring subsequent disposal. For solids, dewatering, chemical treatment, oxidation, incineration, pyrolysis and encapsulation can all be considered. Chemical methods such as oxidation and chlorination may also be used.

(a) Incineration

Abattoir wastes have a variety of physical forms and a large range of calorific values as well as liquid contents which makes virtually impossible the design of an incinerator capable of oxidizing both liquids and solids completely; this usually requires high temperatures and long residence times. Because of this, units have either been used outside their design limits, with resultant unsatisfactory performance, or several smaller, incinerators have had to be used for each individual purpose.

Incineration can efficiently decompose most organic substances and should be mandatory for pathogenic materials.

(b) Pyrolysis

When complete combustion of a substance to gaseous oxides is not attained, either intentionally as in the production of charcoal or unintentionally as a consequence of poor combustion in an incinerator, then the substance is said to have undergone pyrolysis. The method is not usually used to destroy dangerous waste materials, since the products are often more hazardous than their progenitor (Paul, 2002).

(c) Biological Treatment

Various biological methods are used for the treatment of sewage and for wastes with a high Biological Oxygen Demand (BOD), such as those from the food processing industry.

(d) Chemical Treatment

Because of the need to comply with limits when discharging an effluent, most industrial firms who need to do so treat their own waste before it leaves the premises. Very few treatment facilities exist in the disposal industry and those that do consist mainly of precipitation, neutralization, hydrolysis, and cyanide treatment plants.

(e) Physical Treatment

Filtration, distillation, separation, and centrifuge techniques are all used for removal of hazardous materials from quantities of inert bulk waste. They are in general not used for treatment of waste containing a high concentration of dangerous waste.

(f) Encapsulation

There are two types of encapsulation. One is where material is enclosed in a bunker, bottle, can drum or rock chamber made of an impervious inert material so that no reaction can take place. The other is where the waste intimately mixed with an inert matrix, usually based on complex silicates or aluminates, but inert plastics or bitumen may also be used, in which the waste is held by chemical and physical forces. A simple method is to encase a waste in concrete or bitumen within a steel drum, the whole may then be land filled with a high degree of integrity and the method is used for difficult materials such as beryllium, arsenic, antimony, cadmium, mercury, and other compounds.

(g) Dilution, delay and dispersion

Disposed requires the solid, liquid or gas to be diluted to such an extent that the concentration of the hazardous substance becomes so low that it is effectively non-hazardous. This can be achieved either by dispersing a small amount of the waste into a large volume of the waste so that only limited quantities can enter the environment.

(h) Landfill

Approximately 80% of noticeable waste is land filled and the amount is probably nearer 98% for all general waste and refuse. Since noticeable wastes account for only about 4 million tonnes, and industrial, commercial and household wastes for 43 million tonnes, if the wastes were dispersed evenly there would be a built-in dilution factor of 10:1 excluding any other attenuating mechanisms (Paul, 2002). Wastes containing calcium, selenium, antimony, thallium, beryllium, tellurium and mercury may be land filled.

Landfill is not an ideal disposal option for organic substances but, nonetheless, large quantities are dumped in spite of their potential as a source of heat. In many cases, especially with solids which are water insoluble and solvents which evaporate, the technique is generally adequate. There are problematic substances amongst these, namely many phenolic compounds which can migrate large distances through rock structure. Landfill therefore is a satisfactory disposal option for many wastes provided:

1. The site is geologically and hydrogeologicallys suitable;
2. The quantity and type of material introduced is controlled so that overloading or dangerous mixtures are avoided;
3. The liquid intake is controlled;
4. Sufficient inert material can, if necessary be introduced as diluents.

(i) Storage

For some materials it may be prudent to consider permanent storage. For example, a formulation containing an organic pesticide together with a mercury compound. Incineration cannot be used because of the mercury; landfill cannot be used because of the pesticide. Chemical treatment could be used but it would be expensive and, in practice, it is not always possible to persuade a commercial concern to undertake such a potentially dangerous programme of work (Paul, 2002).

2.8 REGULATION AND STANDARDS OF FOOD PROCESSING

The availability of sufficient and suitable water and means for disposal of plant (process) wastes always have been prime factors in determining food plant locations.

Enforcement of antipollution laws is now challenging the economic feasibility of many existing food production and processing operations. Today, materials that were formally considered wastes are converted to useful by-products in order to dispose of them more economically. In the past, the food engineer primarily was concerned with purity and chemical composition of water as it affects processing and food properties; problems of waste disposal were left mostly to the sanitary engineer. Now the food engineer and the sanitary engineer commonly plan and work together, since the increasing problems in handling food wastes are having direct effects on acceptable methods of food processing and disposition of the less desirable fractions of food raw materials (Norman and Joseph, 1995). Regulations in the food industry have to do with making a set of quality control standards specified by the regulatory body. In Nigeria, the Standard Organization of Nigeria (SON), established in 1970 and the National Agency for Food and Drug Administration and Control (NAFDAC) have joint responsibility to monitor the standards described for processed food and/or regulate the activities of the industry. As mentioned earlier most of the abattoirs in this country are owned by government thus, no much strict law is not exercise on these industries.

2.9 PROPERTIES AND REQUIREMENTS OF PROCESSING WATERS

Water entering a food processing plant must meet health standards for portable (drinking) water. The Federal Environmental Protection Agency has issued National Primary Drinking Water Regulations. Regulations covering radioactive contaminants and certain volatile synthetic organic chemicals have been added. These regulations are primarily concerned with health. Secondary regulations deal with colour, taste, and other aesthetic qualities. In addition to the chemical limits for safety of portable water, this water must be free from contamination with sewage, pathogenic organisms, and organisms of intestinal origin. Regulations call for such water to contain no more than one coliform organism (statistical value) per 100ml. Coliform organisms of the type assayed are not pathogenic in themselves but serve as a sensitive index of possible sewage contamination, which if present could harbour many kinds of human pathogens. Such water from municipal supplies or from private wells meeting these EPA recommendations for drinking purposes may not be suitable for certain food processing uses. On the other hand, this same water may be used as a heat exchange medium to condense vapours from an evaporator, to heat canned food in a retort, or to pre-chill range concentrate en-route to a freezer. It then may still be quite suitable for subsequent plant reuse without further purification, for cleaning or conveying fruits and vegetables, or for plant cleanup purposes. Some villages consume the water where these wastes are discharge and thus, standard have to be met.

2.1.10 WASTEWATER COMPOSITION

Water is essential for all forms of life on earth. The end result of water use *is,* of course, wastewater or polluted water. The concern for water pollution is necessary not only for human health but also to conserve natural beauty and resources. Wastewater is characterized in terms of its physical and biological composition. Before wastewater can be controlled it is of Course, necessary to measure water quality. This can be difficult since the pollutants are often at low concentrations and sometimes the substances responsible for the pollution are not known. The results of the analysis of wastewater samples are expressed in terms of physical and chemical units of measurements. Measurements of chemical parameters are usually expressed in the physical unit of milligrams per liter (mg/I) or grams per cubic metre (g/m^3). The most important physical characteristics of wastewater is its total solids content, which is composed of floating matter, setttieable matter, colloidal matter, and matter in solution. Other important physical characteristics include odours, temperature, density, colour and turbidity

BIOLOGICAL UNIT PROCESSES

It is obvious that abattoir waste contains mainly of organic components, thus, biological treatment(s) is appropriate. Treatment methods in which the removal of contaminants is brought about by biological activity are known as biological unit processes. Biological treatment is used primarily to remove the biodegradable organic substances (colloidal or dissolved) in wastewater. Basically, these substances are converted into gases that can escape to the atmosphere and into biological cell tissue that can be removed by settling.

Biological treatment is also used to remove nutrients (nitrogen and phosphorus) in wastewater. The objectives of the biological treatment of wastewater are to coagulate and remove the non settable colloidal solids and to stabilize the organic matter. For industrial wastewater, the major objective is to reduce the organic content and, in many cases, the nutrients such as nitrogen and phosphorus. In many locations, the removal of trace organic compounds that may be toxic is also an important treatment objective. For agricultural return wastewater, the objective is to remove the nutrients, specifically nitrogen and phosphorus, which are capable of stimulating the growth of aquatic plants.

Because many of these compounds are toxic to micro-organisms, pretreatment may be required. The major biological processes used for wastewater treatment are aerobic processes, anoxic processes, anaerobic processes, combined aerobic, anoxic, and anaerobic processes, and pond processes. The individual processes are further subdivided, depending on whether treatment is accomplished in suspended-growth systems, attached -growth systems, or combinations thereof. The principal applications of biological treatment processes are for (1) the removal of the carbonaceous organic matter in wastewaters, usually measured as BOD, total organic carbon (TOC), or chemical oxygen demand (COD); (2) nitrification; (3) denitrification; (4) phosphorus removal; and (5) waste stabilization.

TOTAL SOLIDS

Analytically, the total solids content of a wastewater is defined as all the matter that remains as residue upon evaporation at 103-105^0 C. Matter that has a significant vapour pressure at this temperature is lost during evaporation and is not defined as a solid. Total solids, or residue upon evaporation, can be further classified as non filterable suspended or filterable by passing a known volume of liquid through a filter. The filterable-solids fraction consists of colloidal and dissolved solids. The colloidal fraction consists of the particulate matter with an approximate size range of from 0.001 to 1μm. The dissolved solids consist of both organic and inorganic molecules and ions that are present in true solution in water. The colloidal fraction cannot be removed by settling. Generally, biological oxidation or coagulation, followed by sedimentation is required to remove these particles from suspension.

ODOURS

Odours in abattoir wastewater usually are caused by gases produced by the decomposition of organic matter or by substances added to the wastewater. Fresh wastewater has a distinctive, somewhat disagreeable odour, which is less objectionable than the odour of wastewater that has undergone anaerobic (devoid of oxygen) decomposition. The most characteristic odour of stale or septic wastewater is that of hydrogen sulphide, which is produced by anaerobic micro-organism that reduce sulphate to sulphide. Industrial wastewater may contain either odorous compounds or compounds that produce odours during the process of wastewater treatment.

TEMPERATURE

The temperature of wastewater is commonly higher than that of the water supply, because of the addition of warm water from abattoir activities. As the specific heat of water is much greater than that of air, the observed wastewater temperatures are higher than the local air temperatures during most of the year and are lower only during the hottest months. Depending on the geographic location and time of year, the effluent temperatures can either be higher or lower than the corresponding influent values. In addition, oxygen is less soluble in warm water than in cold water. The increase in the rate of biochemical reactions that accompany an increase in temperature, combined with the decrease in the quantity of oxygen present in surface waters, can often cause serious depletions in dissolved oxygen concentrations in the hotter months. When significantly large quantities of heated water are discharged to natural receiving water. These effects are magnified. It should also be realized that a sudden change in temperature can result in a high rate of mortality of aquatic life. Moreover, abnormally high temperatures can foster the growth of undesirable water plants and wastewater fungus. Optimum temperatures for bacterial activity are in the range from about 25-35^{0}C. Aerobic digestion and nitrification stop when the temperature rises to 50^{0}C. When the temperature drops to about 15^{0}C, methane-producing bacteria become quite inactive, and at about 5^{0}C, the autotrophic-nitrifying bacteria practically cease functioning. At 2^{0}C, even the chemoheterotrophic bacteria acting on carbonaceous material become essentially dormant (Metcalf and Eddy, 1991).

DENSITY

The density of wastewater (ρ_w) is defined as its mass per unit volume expressed as kg/m^3. Density is an important physical characteristic of wastewater because of the potential for the formation of density currents in sedimentation tanks and other treatment units. The density of domestic wastewater that does not contain significant amounts of industrial waste is essentially the same as that of water at the same temperature. In some cases, the relative density of the wastewater R_w, defined as $R_w = \rho_w/\rho_o$ where ρ_o is the density of water, is used in place of the density. Both the density and relative density of wastewater is temperature dependent and will vary with the concentration of total solids in the wastewater.

COLOUR

Historically, the term "condition" was used along with composition and concentration to describe wastewater. Condition refers to the age of the wastewater, which is determined qualitatively by its colour and odour. Fresh wastewater is usually a light brownish-grey colour. However, as the travel time in the collection system increases and more anaerobic conditions develop, the colour of the wastewater changes sequentially from grey to dark grey and ultimately to black. When the colour of the wastewater is black the wastewater is often described as septic. Some industrial wastewater may also add colour to domestic wastewater. In most cases, the grey, dark grey and black colour of the wastewater is due to the formation of metallic sulphide, which form as the sulphide produced under anaerobic conditions reacts with the metals in the wastewater.

TURBIDITY

Turbidity is measured by devices which determine the amount of light scatter electronically, and is another test used to indicate the quality of waste discharges and natural water with respect to colloidal and residual suspended matter. The measurement of turbidity is based on comparison of the intensity of light scattered by a sample as compared to the light scattered by a reference suspension under the same conditions. Colloidal matter will scatter or absorb light and thus prevent its transmission. In general,

there is no relationship between turbidity and the concentration of suspended solids in untreated wastewater. The most important chemical characteristics of wastewater is its organic matter, the measurement of organic content, inorganic matter and gases. The measurement of organic content is discussed also because of its importance.

ORGANIC MATTER

In a wastewater of medium strength, about 75 percent of the suspended solids and 40 percent of the filtrate-able solids are organic in nature (Metcalf and Eddy, 1991). These solids are derived from both the animal and plant kingdoms and these activities of man as related to the synthesis of organic compounds. Organic compounds are normally composed of a combination of carbon, hydrogen, and oxygen, together with nitrogen in some cases. Other important elements, such as sulphur, phosphorus, and iron, may also be present. The principal groups of organic substances found in wastewater are proteins (40 to 60 percent), carbohydrates (25 to 50 percent) and fats and oils (10 percent). Urea, the chief constituent of urine, is another important organic compound contributing to wastewater.

Along with the proteins, carbohydrates, fats and oils, and urea, wastewater contains small quantities of a large number of different synthetic organic molecules ranging from simple to extremely complex in structure. Typical examples include surfactants, organic priority pollutants, volatile organic compounds and agricultural pesticides (Metcalf and Eddy, 1991).

CARBOHYDRATES

Widely distributed in nature, carbohydrate includes sugars, starches, cellulose, and wood fibre. All are found in waste water. Carbohydrates contain carbon, hydrogen, and oxygen.

PROTEINS

Proteins are common to all organic substances, as well as hydrogen and oxygen. In addition, they contain, as their distinguishing characteristics, a fairly high and constant proportion of nitrogen, about 16 percent. In many cases sulphur, phosphorus and iron are also constituents. Urea and proteins are the chief sources of nitrogen in wastewater. When proteins are present in large quantities, extremely foul odours are produced by their decomposition.

FATS, OILS AND GREASE

Fats and oils are the third major component of foodstuffs. The term "grease" as commonly used includes the fats, oils, waxes, and other related constituents found in wastewater. Grease content is determined by extraction of the waste sample with trichlorotluorooethane. Other extractable substances include mineral oils, such as kerosene and lubricating and road oils. Fats and oils are compounds (esters) of alcohol or glycerol (glycerin) with fatty acids. The glycerides of fatty acids that are liquid at ordinary temperatures are called oils, and those that are solids are called fats. They are quite similar, chemically, being composed of carbon, hydrogen, and oxygen in varying proportions.

Lubricating oils are derived from petroleum and contain essentially carbon and hydrogen. These oils sometimes reach the sewers in considerable volume from the plant (slaughter house), they float on the wastewater, although a portion is carried into the sludge on settling solids.

SURFACTANTS

Surfactants or surface-active agents are large organic molecules that are slightly soluble in water and cause foaming in wastewater treatment plants and in the surface waters into which the waste effluent is discharged. Surfactants tend to collect at the air water interface. During aeration of wastewater, these compounds collect on the surface of the air bubbles and thus create very stable foam. The determination of surfactants is accomplished by measuring the colour change in a standard solution of methylene blue dye. Another name for surfactants is methylene blue active substance (MBAS).

VOLATILE ORGANIC COMPOUNDS (VOCs)

Organic compounds that have a boiling point $\leq 100^{O}C$ and/or vapour pressure > 1mm Hg at $25^{0}C$ are generally considered to be volatile organic compounds (VOCs). For example, vinyl chloride, which has a boiling point of $-13.9^{0}C$ and a vapour pressure of 2548mm Hg at $20^{0}C$, is an example of an extremely volatile organic compound. Volatile organic compounds are of great concern because (1) once such compounds are in the vapour state they are much more mobile, and therefore more likely to be released to the environment; (2) the presence of some of these compounds in the atmosphere may pose a significant public health and (3) they contribute to a general increase in reactive hydrocarbons in the atmosphere, which can lead to the formation of photochemical oxidants.

INORGANIC MATTER

Several inorganic components of wastewaters and natural waters are important in establishing and controlling water quality. The concentrations of inorganic substances in water are increased both by the geologic formation with which the water comes in contact and by the wastewaters, treated or untreated, that are discharged to it. The natural waters dissolve some of the rocks and minerals with which they come in contact. Wastewaters, with the exception of some industrial wastes, are seldom treated for removal of the inorganic constituents that are added in the use cycle. Concentrations of inorganic constituents also are increased by the natural evaporation process, which removes some of the surface water and leaves the inorganic substance in the water. Because concentrations of various inorganic constituents can greatly affect the beneficial uses made of the waters, it is well to examine the nature of some of the constituents, particularly those added to surface water via the use cycle.

pH

The hydrogen -Ion concentrations IS an important quality parameter of both natural water and wastewaters. The concentration range suitable for the existence of most biological life is quite narrow and critical wastewater with an adverse concentration of hydrogen ion is difficult to treat by biological means, and if the concentration is not altered before discharge, the wastewater effluent may alter the concentration in the natural waters.

CHLORIDES

Another quality parameter of significance is the chlorides concentration. Chlorides in natural water results from the leaching of chlorides - containing rocks and soils with which the water comes in contact, and in coastal areas, from salt water intrusion. In addition, agricultural, industrial, and domestic waste waters discharged to surface waters are a source of chlorides.

ALKALINITY

Alkalinity in wastewater results from the presence of the hydroxides, carbonate, and bicarbonates of elements such as calcium, magnesium, sodium, potassium, or ammonia. Of these, calcium and magnesium bicarbonates are most common. Borates, silicates, phosphates and similar compounds can also contribute to the alkalinity. The alkalinity in wastewater helps to resist changes in pH caused by the addition of acids. Wastewater is normally alkaline, receiving its alkalinity from the water supply, the groundwater and the materials added during domestic use.

PHOSPHORUS

Phosphorus is also essential to the growth of algae and other biological organisms. Because of noxious algal blooms that occur in surface waters, there is presently much interest in controlling the amount of phosphorus compounds that enter surface waters in industrial waste discharges and natural runoff. Industrial wastewaters, for example, may contain from 4 to 10mg/1 of phosphorus.

SULPHUR

The sulphate ion occurs naturally in most water supplies and is present in wastewaters as well. Sulphur is required in the synthesis of proteins and is released in their degradation.

Sulphate is reduced biologically under anaerobic conditions to sulphide, which in turn can combine with hydrogen to form hydrogen sulphide (H_2S).

HEAVY METALS

Trace quantities of many metals such as Nickel (Ni), Manganese (Mn), Lead (Pb), Chromium (Cr), Cadmium (Cd), Zinc (Zn), Copper (Cu), Iron (Fe), and Mercury (Hg), are important constituents of most water. Some of these metals are necessary for growth of biological life, and absence of sufficient quantities of them could limit growth of algae for example. The presence of any of these metals in excessive quantities will interfere with many beneficial uses of the water because of their toxicity; therefore, it is frequently desirable to measure and control the concentrations of these substances. Methods for determining the concentrations of these substances vary in complexity according to the interfering substance that may be present. In addition quantities of many of these metals can be determined at very low concentrations by such instrumental methods as polarography and atomic absorption spectroscopy (Metcalf and Eddy, 1991).

GASES

Gases commonly found in untreated wastewater include nitrogen (N_2), Oxygen (O_2), Carbon dioxide (CO_2), hydrogen sulphide (H_2S), ammonia (NH_3) and methane (CH_4).

The first three are common gases of the atmosphere and will be found in all water exposed to air. The latter three are derived from the decomposition of the organic matter present in wastewater. Although. not found in untreated wastewater, other gases include chlorine (Cl) and ozone (O_3) (disinfection and odour control), and the oxides of sulphur and nitrogen.

METHANE

The principal by product of the anaerobic decomposition of the organic matter in wastewater is methane gas. Methane is a colourless, odourless, combustible hydrocarbon of high fuel value. Normally, large quantities are not encountered in untreated wastewater because even small amounts of oxygen tend to be toxic to the organisms responsible for the production of methane. Occasionally, however as a result of anaerobic decay in accumulated bottom deposits methane is produced.

MICRO ORGANISMS

The principal groups of organisms found in wastewater are classified as eukaryotes, eubacteria, and archaebacteria. Most bacteria are classified as eubacteria. The category prostates, contained within the eukaryote classification, includes algae, fungi, and protozoa. Plants including seed plants, ferns and mosses are classified as multi-cellular eukaryotes. Invertebrates and vertebrates are classified as multi-cellular eukaryotic animals. Viruses, which are also found in wastewater, are classified according to the host infected (Ronald, 1997).

Bacteria

The simplest wholly contained life systems are bacteria or prokaryotes, which are the most diverse group of micro organisms. They are characterized by the lack of nuclear membrane and their machinery of metabolism is not contained in organelles. They reproduce by simple binary fission.

The bacteria cell is enclosed with a cell wall that is semi-rigid polymeric membrane on the order of 100nm thick. The cell wall maintains the integrity of the cell, holding it together against osmotic pressure gradients that occur because of concentrations differences between the cell contents and the surrounding liquid. The cytoplasmic membrane is immediately inside the cell wall and it controls passage of nutrients and other compounds into and out of the cell.

The cytoplasm is a solution that contains the bi-molecules essential for metabolism. The fundamental controlling bimolecular, deoxyribonucleic acid (DNA), and others are contained within the nuclear material (Ronald, 1997).

Fungi

Fungi are generally filamentous and have a true cell wall. Individual filaments are known as hyphae that may have no cross walls or be divided at irregular intervals by cross-walls. Yeasts are non filamentous fungi that are reproduced by a process known as budding. A small bubble is produced on the mother cell that grows to about the same size as the other cell, then a cross wall is formed and the new cell separates. Most fungi are aerobic. Fungi can tolerate a lower pH than bacteria and their nitrogen and phosphorus requirements are lower than those for bacteria. These characteristics make them valuable for treating some industrial wastewaters. However, filamentous forms are difficult to settle and significant growth of fungi in wastewater treatment plants can lead to poor effluent quality.

Algae

Algae are photosynthesizers that occur in all natural waters. They can be unicellular or multi-cellular. There are three large groups characterized by their colour: green, brown and red. The green colour of most algae is due to chlorophyll, which is essential for capture of light and photosynthesis. All algae contain chlorophyll but the green colour of chlorophyll can be masked by other pigmented chlorophylls that absorb light different in wavelengths.

Algae play a role in some wastewater treatment processes, particularly stabilization ponds. Many algae species are harmless, but in water treatment algae are nuisance. Large amounts of certain algae species can lead to taste and odour problems from by products of their metabolism or decay of the cells. Some species produce toxins.

Protozoa

Protozoa are single-celled organisms. Many of these are motile because of flagella or cilia they move by means of pseudopodia (i.e. amoeboid protozoa). Many protozoa feed on prokaryotes and other eukaryotes. There are also protozoan that are saprobes; however, bacteria degrade organic matter more efficiently than protozoan.

Viruses

Viruses are non cellular entities that contain protein and nucleic acids. A protein (capsid) surrounds the nucleic acid molecule (genome). The longest dimension of the largest virus particle (the small pox virus) is 200nm. Viruses are unable to reproduce or metabolize on their own. They are obligate parasites that invade a cell and direct the cell metabolism to manufacturing new viruses. The host cell ultimately dies. Viruses are host specific, which make the analysis of viruses difficult.

Rotifers

Rotifers are simple multi-cellular organisms at the first stage above single-celled organisms. They have cilia, used for locomotion and food currents, located around their mouth. These aerobic micro organisms are naturally found in marine and fresh waters in relatively high numbers.

Worms

Worms have an elongated body and move with undulating motion. These simple animals are sometimes found in sewage treatment processes but their greater significance is the diseases that a number of them cause. There are many worms classified into a number of different phyla. Roundworms or nematodes are estimated to be the second and numerous group of organism after insects. Flatworms are distinguished by a flat body.

2.1.12 WASTE MANAGEMENT

There are scientific bases for urgent wastes management in the country; otherwise the country could experience large scale disasters similar to Minimata in Japan or Rhine in Switzerland or Love Canal in U.S.A. It is cheaper to control wastes than to clean up polluted environment. For example, polluted ground water can remain unusable or hazardous for long periods of time. Rivers are generally used to convey wastes, provided they do not cause a pollution that affects natural flora and fauna extensively thereby preventing other legitimate Users. Water pollution control in wastewater does not mean keeping the water in the original state, rather certain important contaminants are been treated and to 10 minimize man's influence on Water bodies. The entire catchments is difficult to protect, however the area Upstream of the river is protected especially when used for drinking water. River specialization will ensure high standard and avoid contamination of drinking Water abstraction points. The discharge of non biogenic toxic substances to which the community cannot actively respond but can only passively succumb should not be permitted.

Best management practices which broadly apply in terms of pre-treatment include:

Solids separation by screening;

Fat / oil removal by flotation / skimming;

Primary settling;

Blood separation (protein recovery);

Waste effluent balancing;

pH correction (chemical correction);

Protein recovery

Ultra filtration;

Reverse osmosis.

2.1.13 WASTE AND DISEASES CONTROL

As much as 80% of all diseases are associated with waste pollution and poor sanitation. Disease such as Diarrhea, Cholera, Typhoid and Paratyphoid fever, Infectious Hepatitis. Amoebic and Basic dysentery, Impetigo and a host of other skin diseases are associated with waste water pollution. Some of them are due largely to inadequate supply of water. Therefore, even an increase in water quality status will not wipe such conditions especially diarrhea. Effort should be made not only in water quality improvement but also in adequate supply of the good quality Water. As a matter of policy, water requirement as a basis for 'planning and development, in order to improve user's health condition. (Oso B.A, 2000)

2.1.14 PROTECTION OF AQUATIC PROCESSES

In order to protect the tropic levels within our water resources and thereby preserving primary production. all necessary steps need to be taken now to protect aquatic life in our water. The destruction of primary producers could lead to diminishing consumer populations in water. The direct repercussion of this is diminishing fish yield with the resultant consequence that human diet suffers. Such conditions may arise through careless discharge of dangerous slowly biodegradable and non biodegradable wastes e.g. pesticides. The use of detergent that contains phosphorus may lead to eutrophication of inland lakes or dams. Anoxic conditions may arise, therefore that will make it difficult for aquatic life to flourish. On the other hand, aquatic life is one very important tool for water quality monitoring. The term for its biological indications of water quality, and uses aquatic life (e.g. Daphniamagna) which are very sensitive to changes in pressure, pH, dissolved oxygen, toxicity and other chemical changes in water to give a measure of the purity of such water. Benthic life forms such as worms have also been used as indicators for this and for bottom sediments. These organisms may become disfigured or their reproductive lives impaired or are killed outright by changes in the conditions enumerated above (Aina and Adedipe, 1991).

CHAPTER THREE

3.0 MATERIALS AND METHODS

The recent developments in the laboratory instrumentation have been of great benefit to the water and wastewater experts. The new instrument designs have incorporated automatic sample handling, sequential analysis and improved data presentation. The current change to digital output, in contrast to meter readings, has reduced error and increase the speed of the determination. In addition to the expanded variety in the types or laboratory analyses performed, there has been an associated increase in the number of individual samples to be analyzed. To meet the increased work load laboratory operations has been redesigned to take advantage of automatic instrumentation wherever possible. The elimination of manual analytical procedures, in favour of automated methods, permits a significant increase in the numbers of samples handled, without the necessity for additional laboratory personnel. The samples of water analyzed were obtained from Minna abattoir and its environs. The study is to reveal to what extent the abattoir waste affects the quality of its receiving stream. The data collected were from the analysis carried out on the samples collected from these area using the stated materials and reagents.

3.1 SAMPLES COLLECTED

Samples were taken at different points. Five plastic containers of equal capacity are used (50 cl) each with cap. Each container was plunged into different points specified and filled to the point of overflowing of the containers. After every sample was taken, the cap was immediately replaced, the samples were taken to the laboratory without any delay.

The five samples collected were designated and summarized as follows:

U_S - Sample collected 60-70 meters before the point where the abattoir waste meet with the stream (i.e. upstream).

P - Sample collected at the point where the abattoir waste meets with the stream.

D_S - Sample collected 60-70 meters away from the point where the abattoir waste meet with the stream (i.e. downstream).

C - Sample collected in an old well within the abattoir premises (10-12 meters) away from the slaughtered area.

D - Sample collected in a residence well (300-320 meters) away from the abattoir.

3.2 REAGENTS AND MATERIALS USED

1. The five water samples collected
2. Analar perchloric acid
3. Hydrochloric acid
4. Distilled water
5. BDH concentrated nitric acid
6. Platinum crucibles
7. Desiccators
8. Bibby hotplate bicasa product
9. Thermometer
10. Corning flame photometer 410 Bicasa product
11. Lovibond colour comparator Bicasa product
12. Biby merit W4000 distiller
13. Hach conductivity/TDS meter
14. DR/2000 direct reading spectrophotometer

15. Back-ups 600
16. HACH digital titrator
17. 60ml dissolved oxygen bottle
18. Masking tape
19. Wall clock
20. 25ml samples cell
21. Volumetric flasks
22. Conical flask
23. Pipettes
24. Dissolved oxygen 1 reagent
25. Dissolved oxygen 2 reagent
26. Dissolved oxygen 3 reagent
27. Universal P^H strips
28. Iron reagent powder pillow
29. Sulphover 4 reagent powder pillow
30. Calcium and magnesium indicator
31. Alkali solution
32. Ethylenediamine-Tetra-acetic acid (EGTA) solution
33. Ethylibis(oxyethylenenitrilo) Tetra-acetic acid (EGTA) solution
34. Chloride 2 indicator powder pillow
35. Silver nitrate ($AgNO_3$) Titration cartridge
36. Sulphuric acid titration cartridge
37. Phenolphthalein indicator powder pillow

38. Bromo cresol green-methyl red indicator powder
39. Flame photometer standard 1000ppm potassium
40. Flame photometer standard 1000ppm sodium
41. Corning air compressor
42. Phenol red indicator delivery tubes
43. Clean towel
44. COD vial indicator
45. Zincover 5 reagent powder pillow
46. Cyloexanone
47. Razor blade
48. Chromium 1 reagent powder pillow
49. COD reactor
50. Delivery tube

3.3 METHODS OF ANALYSIS

The methods and the procedures of the analysis carried out are shown in appendix 4.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSIONS

4.1 PRESENTATION OF RESULTS

The samples were analyzed using method developed by American Public Health Association (APHA), and comparing the results of the analysis with the standards given by World Health Organizations (WHO) and Federal Environmental Protection Agency (FEPA) Nigeria. (Appendices 1, 2 and 3). The results of the analysis are presented in the Tables 4.1, 4.2 and 4.3.

TABLE 4.1: PHYSICAL PARAMETERS OF THE SAMPLES

S/N	PARAMETERS	U_S	P	D_S	C	D
1	Electrical Conductivity(μs/cm)	100	180	150	260	250
2	Total Dissolved Solids(mg/l)	50	90	70	130	120
3	Temperature (^{O}C)	25.9	25.9	25.9	26.2	26.2
4	P^H	6.8	8.8	6.8	8.4	8.4
5	Odour	Free	Offensive	Little odour	Free	Free
6	Suspended Solids (mg/l)	0	15	12	83	0
7	Turbidity (FTU)	43	58	55	115	11
8	Colour (PtCo)					

PtCo = Platinum Cobolt

FTU = Formazin Turbidity Unit

TABLE 4.2: CHEMICAL PARAMETERS OF THE SAMPLES

S/N	PARAMETERS	U_S	P	D_S	C	D
1	Total Hardness (mg/l)	21	41	32	72	113
2	Alkalinity Total (mg/l)	64	104	90	128	171
3	Hardness (Ca) as $CaCO_3$ (mg/l)	8.4	16.4	12.8	28.8	45.3
4	Hardness (Mg) as $CaCO_3$ (mg/l)	12.6	24.6	19.2	43.2	67.7
5	Iron Content (mg/l)	0.41	0.52	0.52	0.44	0.51
6	Nitrate as Nitrogen (mg/l)	1.5	2.2	2.0	1.0	0.6
7	Nitrate (mg/l)	6.6	9.68	8.8	4.4	2.64
8	Sulphate (mg/l)	10	9	4	8	15
9	Phosphate (mg/l)	2.42	1.99	0.86	2.04	0.60
10	Calcium (mg/l)	3.36	6.56	5.12	11.52	18.12
11	Magnesium (mg/l)	3.06	5.98	4.67	10.50	16.45
12	Nitrite (mg/l)	0.073	0.205	0.152	0.512	0.050
13	Nitrite as Nitrogen (mg/l)	0.022	0.062	0.046	0.155	0.016
14	Nickel (mg/l)	0.00	0.030	0.00	0.010	0.020
15	Copper (mg/l)	0.00	0.01	0.00	0.00	0.00

TABLE 4.3: ORGANIC PARAMETERS OF THE SAMPLES

S/N	PARAMETERS	U_S	P	D_S	C	D
1	BOD (mg/l)	3.41	3.89	2.50	3.25	2.41
2	COD (mg/l)	2.20	2.73	1.98	2.11	1.92
3	DO (mg/l)	0.85	0.80	0.85	1.50	0.86

4.2 DISCUSSION OF RESULTS

4.2.1 ELECTRICAL CONDUCTIVITY

The electrical conductivity of the samples ranges from 100-260(μs/cm). The highest been that of the old well in the abattoir (C) and the lowest was that of the upstream water sample (U_S). This (higher number) can be attributed to increase in dissolved solids. Since a rapid method of obtaining an estimate of the dissolved solids in waste water sample is by measurement of its electrical conductivity. Besides it may be due to the influence of the metallic ions present.

4.2.2 TOTAL DISSOLVED SOLIDS AND TOTAL SUSPENDED SOLIDS

The total dissolved solids of the whole samples are less when compared to WHO (1983/2004) and FEPA standard thus the polluting power of the waste is low. And the total suspended solids in sample (C) exceed the FEPA limits of 30mg per litre. This was as a result of organic matter present in the sample. It was also observed that abattoir does not treat their waste at all. The values range from 50mg per litres to 130 mg per litre for Total Dissolved Solids (TDS), while Total Suspended Solids (TSS) ranges from 0mg per litre to 83mg per litre. The high value, obtained indicate the high potential of the leachate to cause gross organic pollution.

4.2.3 TEMPERATURE

The temperature of the samples ranged between 25.9^{O}C and 26.2^{O}C. However, the temperature levels of the samples are well within the FEPA range of 35^{O}C to 40^{O}C. And it has no effect on the environment except if the temperature exceeds 40^{O}C. It will have adverse effect on the receiving water body at the same time; it will increase the level of the dissolved Oxygen.

4.2.4 ODOUR

The samples P and D_S were associated with offensive and little odour respectively while other samples were free of odour. This may be due to the direct influence of the abattoir waste on the two (P and U_S) samples.

4.2.5 P^H

The P^H of the samples ranges between 6.8 and 8.8. The highest value of 8.8 was measured in sample P. The sample had P^H value of 8.8 which is slightly alkaline. The low P^H reading of 6.8 in sample D_S and U_S was attributed to the decay of organic matter in the samples. The P^H of the samples are within acceptable limit of FEPA range of 6 to 9 but with little deviation with WHO standard (which 6.5 to 8.5). In most situations the concentration of H^+ or OH^- is small or insignificant compared to the concentrations of other species but this does not mitigate the influence of these ions as controlling variables of the state or the water.

4.2.6 TURBIDITY

Turbidity is associated with suspended solids concentrations. It was observed that size and concentrations of particles influenced the measurement of turbidity. Turbidity of the samples range between 11PtCo to 115PtCo. The highest turbidity is from sample C and lowest from sample D, these can be due to distance of each well. The nature of the solids causing the turbidity may have other health ramifications. Turbidity in natural waters reduces light transmittance and affects the species that may survive in the waters.

4.2.7 DISSOLVED OXYGEN

Without free dissolved oxygen, there will he no survival of aquatic life forms in any water body. Streams and lakes therefore, simply become uninhabitable to most desirable aquatic life without free dissolved oxygen. At normal temperature water is said to be saturated with oxygen at 9mg/l. This saturation value decreases rapidly with increasing water temperature. DO of the samples ranged from 0.80mg/l to 1.50mg/l. The values are within the FEPA maximum level of 30mg/l and WHO of 5mg/l.

4.2.8 CHEMICAL OXYGEN DEMAND

Chemical oxygen demand is a measure of the oxygen that certain chemicals will take from the environment. The values range from 1.92mg/l to 2.73mg/l. However, the values obtained do not exceed the maximum limit of 80mg/l set by FEPA. The COD has major influence on the trade effluent charge: higher strength equal higher charge.

4.2.9 BIOCHEMICAL OXYGEN DEMAND

Biochemical oxygen demand (BOD) is simply the rate of oxygen use. The effluent samples, generally had low BOD content with the highest value of 3.89mg/l recorded in sample P compared to FEPA tolerance limit of 30mg/l. This may be as a result of dilution and distance traveled by the waste before meeting the stream.

4.2.10 IRON

The beneficial effects of iron include: Chlorophyll synthesis, oxidation-reduction in respiration, constituent of certain enzymes and proteins. The iron content of the effluents sample ranged from 0.41mg/l to 0.52mg/l. The samples had a low concentration of iron due to the low usage of metal in the abattoir. The iron concentration of the samples fall within the FEPA range of 20mg/l and slightly above that of WHO of 0.3mg/l.

4.2.11 SULPHATE

The sulphate concentrations of the samples ranged between 4mg/l to 15mg/l when the samples were analyzed. The values obtained are below FEPA maximum limit of 500mg/l, also the values are below WHO limit of 30mg/l. Sulphur is absorbed by plant roots exclusively as the sulphate ion SO_4^{2-}. It is also an essential constituent of volatile crops of such crops; an onion and garlic gives them their characteristic fragrance.

4.2.12 CALCIUM

The calcium content of the samples ranged from 3.36mg/l to 18.12mg/l. The values fall below the Federal Environmental Protection Agency maximum level of 200mg/l. Calcium appears to be essential for the growth of meristems and early for the proper growth and functioning of root tips.

4.2.13 MAGNESIUM

The magnesium content of the samples used in this study ranged from 3.06mg/l to 16.45mg/l. the obtained are well below the FEPA maximum desirable level of 200mg/l and also 30mg/l of WHO standard. High magnesium and calcium concentrations result to hardness of water and magnesium has been known to be essential for plant growth and development.

In summary, the frequent high colour change of the stream impart on the receiving stream water lowers the quality of the water making it unfit for drinking and bathing. The value DO for the samples ranged from 0.80mg/l to 1.50mg/l. these are lower than the minimum of 5ppm value required to sustain normal life in aquatic environment and the water is said to be polluted (Rao, 1993). Water samples with BOD higher than 5ppm are said to be fairly polluted (Welcher, 1975). Drinking water is expected to have a BOD less than 1ppm and water is considered fairly pure with BOD of 3ppm. The values obtained are above 1ppm and some are above 3ppm. The streams are considered fairly polluted. Chemical oxygen demand (COD) on the other hand was between the range 1.92mg/l to 2.73mg/l, when compared to the control, which falls between 0.97mg/l and 4.39mg/l. it can be seen that change in COD is a measure of the amount of carbon sources that was utilized as a food source by the micro-organisms. In addition, it can give an indication of the fraction of the waste which will remain.

CHAPTER FIVE

5.0 CONCLUTION AND RECOMMENDATIONS

5.1 CONCLUSION

After the analysis, the results presented clearly indicate that most of the elements/parameters were slightly above the acceptable limits by FEPA/WHO. Although some are within the range and some are below the limits. Hence, considering the analysis carried out on physical, chemical and organic parameters of the water samples, one safely draws the conclusion that, the abattoir waste/effluent has lowered the quality of receiving stream.

Tables 4.1, 4.2 and 4.3 respectively depict the water samples to be analyzed from Minna abattoir. When compared with FEPA guidelines and Standards as well as WHO standards of 1983/2004 contain several pollutants which are slightly above limits.

Finally, with growing environmental consciousness on the part of the populace, clamoring for better environmental responsibility from the government. The increasing agitation and resentment of industries for multiple taxes, levies governmental enforcement on the industries; it is certain that the nation will have long expected environmental friendly behavior and a sustainable and safe environment for all now and for future generations.

5.2 RECOMMENDATIONS

Environmentally sound management of waste/effluents is among the environmental issues of major concern in maintaining the quality of the earth natural trees and especially in achieving environmentally sound and sustainable development.

This however goes beyond mere safe disposal of effluents or recovery of things that arc generated and seek to address the root course of the problem by attempting to change unsuitable patterns of production and consumption. This implies application of the integrated life cycle management concept which provides the opportunity to reconcile development in all its ramifications with environmental friendliness..

Following are recommended from the conclusion reached:

1. Periodic assessment, data collation and analysis, and systematic reporting to appropriate agencies are highly recommended.
2. Mathematical models can be generated for predicting the level of pollutants at that portions of the abattoir. These models can be formulated after repeated surveying and analysis of effluents.
3. The most effective waste load reduction practice is keeping by-products out of the water stream. Alternatively, establishing a treatment plant will be most appropriate because of the volume of the waste.
4. Water pollution prevention and control is necessary by the application of the 'polluter pays' principle to the sources where appropriate. Also it involves strict compliance to the standards of effluent discharge for receiving streams; use of new technologies, product and process change, effluent reuse, recycling and recovering , treatment and environmentally safe disposal for pollution minimization. In addition, mandatory environmental impact assessment of major water resources development project is necessary.
5. For proper understanding of the abattoir waste, I would recommend that the analysis should be carried out in dry season again because from the results it was understood that the polluting power was low, which may be due to dilution of the waste by rain water.

6. Finally, the improvement on waste quality including associated resources is only achieved if the various regulatory measures put in place by FEPA/WHO are vigorously enforced. Ensuring compliance by polluters with FEPA/WHO regulations requires comprehensive monitoring programme of waste in the country.

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APPENDIX 1

Effluent Limitation Guidelines in Nigeria for all categories of industries

Parameters	FEPA
P^H	6-9
Turbidity	N/A
Temperature	$40^{O}C$
Conductivity	N/A
Dissolved Oxygen (DO)	30
Biochemical Oxygen Demand (BOO)5	30
Chemical Oxygen Demand (COD)	80
Total dissolved solids (TDS)	2000
Total Suspended Solid (TSS)	30
Total Solid (TS)	2030
Odour	N/A
Magnesium (Mg^{2+})	200
Phosphate (PO_4^{3-})	5
Calcium (Ca^{2+})	200
Sulphate (SO_4^{2-})	500
Chloride (Cl)	600
Iron (Fe)	<1

Note: Units in milligram per litre (mg/I) unless otherwise stated

Source: FEPA MONOGRAPH (1991)

APPENDIX 2

World Health Organization Standards for (1983)

Substances or Characteristics	Unit	Symbols	WHO
Nickel	mg/l	Ni	0.001
Nitrates	mg/l	NO_3	10 as N
Calcium	mg/l	Ca	N/A
Copper	mg/l	Cu	0.05
Iron	mg/l	Fe	0.30
Magnesium	mg/l	Mg	30
Nitrite	mg/l	NO_2	1
Potassium	mg/l	K	N/A
Sulphate	mg/l	SO_4	400
Total dissolve solids	mg/l	TDS	1000
Conductivity	μs/cm		N/A
Total hardness as $CaCO_3$	mg/l		500
Odour			Inoffensive
Suspended solids	mg/l	SS	N/A
Turbidity	FTU		5
p^H			8.5

FTU = Formazin Turbidity Unit

PtCo = Platinum Cobolt

N/A = Not Available

APPENDIX 3

World Health Organization Standards for (2004)

Substances or Characteristics	Unit	Symbols	WHO
Nickel	mg/l	Ni	N/A
Nitrates	mg/l	NO_3	10
Copper	mg/l	Cu	1.0
Iron	mg/l	Fe	0.30
Magnesium	mg/l	Mg	30
Nitrite	mg/l	NO_2	1
Sulphate	mg/l	SO_4	250
Total dissolve solids	mg/l	TDS	500
Conductivity	μs/cm		N/A
Total hardness as $CaCO_3$	mg/l		500
Odour			Inoffensive
Suspended solids	mg/l	SS	N/A
Turbidity	FTU		5
P^H			6.5-8.5
Biochemical Oxygen Demand	mg/l	BOD	0
Dissolved Oxygen	mg/l	DO	5
Chemical Oxygen Demand	mg/l	COD	N/A

FTU = Formazin Turbidity Unit

PtCo = Platinum Cobolt

N/A = Not Available

APPENDIX 4

DETERMINATION OF TEMPARATURE

1. Temperature/Conductivity/T.D.S meter was switched on by pressing the appropriate button.
2. The probe was immersed in the beaker containing the deiodized water to rinse.
3. The probe was immersed in the meter containing the sample, and moved up and down and taped on the beaker to free any bubbles from the electrode area. The probe was immersed beyond the vent holes.
4. The reading was recorded in degree Celsius (^{O}C).

DETERMINATION OF CONDUCTIVITY

1. Conductivity/T.D.S meter was switched on by pressing the appropriate button.
2. The probe was immersed in the beaker containing the deiodized water to rinse.
3. The probe was immersed in the meter containing the sample, and moved up and down and taped on the beaker to free any bubbles from the electrode area. The probe was immersed beyond the vent holes.
4. The reading was recorded microsiemens/cm (μS/cm) or millisiemen/cm (mS/cm)

DETERMINATION 0F TOTAL DISSOLVED SOLIDS (TDS)

1. The conductivity /TDS meter was switched on using the appropriate button.
2. The probe was immersed in the beaker containing the deionized water to rinse the probe.
3. The probe was immersed in the beaker containing the sample. The probe was moved up and down and taped it on the beaker to free any bubbles from the electrode area. The probe was immersed beyond the vent holes.

4. The reading was recorded in milligram per litre (mg/l) or gram per litre (g/l).

DETERMINATION OF SUSPENDED SOLIDS

1. The stored program number was entered for suspended solids. 630 READ/ENTER were pressed, the display showed: DIAL nm to 810
2. the wavelength dial was rotated until the small display Shows: 810nm
3. READ/ENTER was pressed, and the display shows: Mg/l suspended solids.
4. The sample cell with 25ml of tap or deionized water (the blank) was filled.
5. The blank was placed into the cell holder. The light was closed.
6. ZERO was pressed, the display shows: "WAIT" then: "0mg/l suspended solids"
7. The prepared sample cell was swirled to remove any gas bubbles and uniformly suspend any residue.
8. The prepared sample was placed into the cell holder. The light shield was closed.
9. READ/ENTER was pressed, the display showed: "WAIT" then the result in mg/l suspended solids was displayed

DETERMINATION OF P^H (POTENTIAL HYDROGEN)

The p^H was determined using universal p^H strips and lovibond color comparator with phenol red as an indicator.

1. 2 Clean 10ml cuvettes were used.
2. Distilled water was filled in one of the 10ml cuvette to the mark as blank.
3. The samples were filled in one of the 10ml cuvette and 1 to 2 drops of phenol red was added.
4. The phenol red disc was placed in the lovibond comparator. It was then rotated for colour matching. The reading was then recorded.

DETERMINATION OF TOTAL ALKALINITY

1. 100ml of the sample was selected and sulphuric acid (H_2S0_4). Titration cartridge corresponding to the expected alkalinity concentration in mg/l was chosen.
2. clean delivery tube was inserted into the titration cartridge. The cartridge was inserted into the titrator body.
3. Digital titrator was held with the cartridge tip pointing up and the delivery knob was turned to eject air few drops of titrant. The counter was reset to zero and the tip was wiped.
4. A graduated cylinder was used to measure the sample volume.
5. One phenolphthalein indicator power pillow was added and swirled to mix.
6. The content was then titrated to a colourless end point with the sulphuric acid. While titrating, the flask was swirled to mix. The digits were then recorded.
7. One bromo Green Methyl Red indicator powder pillow was added to the contents and swirled to mix
8. The titration was continued with sulphuric acid to a light greenish blue-grey, a light grey or light pink color, as required.
9. Total digits required x Digit Multiple = mg/l Total Alkalinity.

DETERMINATION OF TURBIDITY

1. The stored program number for turbidity was entered, 750 READ/ENTER was pressed, then display showed: "DIALnm TO 450"
2. The wavelength dial was rotated until the small display shows: 450nm.
3. READ/ENTER was pressed, then display showed: "FTU Turbidity"
4. 25ml of deionized water (the blank) was poured into a sample cell.

5. The plank was placed into a cell holder. The light shield was closed.

6. Zero was pressed, then display showed: "WAIT" then: "0 Formazin Turbidity Unit" (FTU)

7. 25ml of sample was poured into another cell. Immediately, the sample cell was placed into the cell holder. The light shield was closed.

8. READ/ENTER was pressed, then display showed: "WAIT" then results in Formazin Turbidity Units (FTU) were displayed. When the display stabilizes, the results were recorded.

DETERMINATION OF TOTAL HARDNESS, MAGNESIUM AND CALCIUM

1. 100ml of water sample was poured in a 100ml graduated mixing cylinder.

2. 1.0ml of calcium and magnesium indicator solution using a 1.0ml measuring dropper was added. It was inverted several times to mix.

3. 1.0ml of Alkali solution for Calcium and Magnesium test using a 1.0ml measuring dropper was added. It was inverted several times to mix.

4. 25ml of solution was poured into each of three sample cells.

5. One drop of IM EDTA solutions was added to one cell (the blank). It was swirled to mix.

6. one drop of solution was added to another cell (the prepared sample) and swirled to mix.

7. A stored program number for Magnesium was entered.

8. The wavelength dial was rotated until the small display shows: 522nm.

9. READ/ENTER was pressed, then display showed: "Mg/l $CaCO_3$ mg

10. The blank was placed into the cell holder. The light shield was closed.

11. Zero was pressed, then display showed: "WAIT" Then 0.oomg/l $CaCO_3$ mg

12. The prepared sample was placed into the cell holder and the light shield was closed.

13. READ/ENTER was pressed, then display showed: "WAIT" then the result in mg/l as $CaCO_3$ was recorded

14. CONFIG button was pressed two times.

15. A stored program number for Calcium was entered.

220 READ/ENTER for units of mg/l Ca as $CaCO_3$ was pressed, then display showed: "DIAL NM to 522"

16. READ/ENTER was pressed, then display shows: mg/l $CaCO_3$ Ca

17. Zero was pressed, then display showed: "WAIT" then: "0.00mg/l $CaCO_3$ Ca"

18. The third sample cell was placed into the cell holder.

19. READ/ENTER was pressed, the display showed: "WAIT" then the result in mg/l Ca as $CaCO_3$ was displayed.

DETERMINATION OF SULPHATE

1. The program for sulphate (SO_4^{2-}) was entered, 680 READ/ENTER was pressed The display showed: "DIALnm to 450"

2. The wavelength dial was rotated until the small display showed 450nm

3. READ/ENTER dial pressed, the display showed: Mg/l SO_4^{2-}

4. A clean sample cell was filled with 25ml of sample.

5. The contents of one sulfover 4 reagent powder pillow were added to the sample (the prepared sample). It was swirled to dissolve. A white turbidity developed signifying the presence of sulphate.

6. SHIFT TIMER was pressed A 5-minute reaction period began. The cell allowed standing undisturbed.

7. When the timer beeps, the display showed: Mg/l SO_4^{2-} A second sample cell was filled

with 25ml of sample (the blank)

8. The blank was placed into the cell holder. The light shield was closed.

9. Zero was pressed: "WAIT" was displayed. Then 0.Mg/l SO_4^{2-}

10. Within five minutes after the timer beeped the prepared sample was placed into the cell holder. The light shield was closed.

11. READ/ENTER was pressed. The display showed: "WAIT" Then the results in Mq/1 SO_4^{2-} were display.

DETERMINATION OF IRON CONTENT

1. The store program for iron (Fe), ferrover powder pillows was entered.

2. The wavelength dial was rotated until the displayed showed 510nm.

3. READ/ENTER was pressed and the display showed: "Mg/l Fefv"

4. A cell with 25ml of sample was filled.

5. The contents of one ferrover iron reagent powder pillow was added to the sample cell (the prepared sample) and swirled to mix. All orange color indicates the presence of iron.

6. SHIFT TIMER was pressed

A 3-minute reaction period began

7. When the timer beeps, the display showed: "Mg/Fe Fv"

Another sample cell (the blank) was filled with 25ml of sample.

8. The blank was placed into the cell holder. The light shield was closed.

9. Zero was pressed, the display showed: "WAIT" Then: "0.00Mg/lFeFv"

10. Within 30 minutes after the timer beeped, the prepared sample was placed into the cell holder. The light shield was closed.

11. READ/ENTER was pressed, the display showed: "WAIT" Then the result in Mg/l

boron was displayed.

NOTE: A sample containing visible rust was allowed to react at least five minutes.

DETERMINATION OF DISSOLVED OXYGEN (DO) USING 60-ML BOD BOTTLE

1. A water sample was collected in a clean 60ml glass-stopped BOD bottle. This ensures that there is no air bubbles trapped in the bottle
2. One content of Dissolved Oxygen 1 Reagent powder pillow and one Dissolved Oxygen 2 Reagent powder pillow were added to the sample.
3. Stopper was inserted immediately so that no air is trapped in the bottle and inverted several times to mix. Flocculent precipitate formed was brownish-orange signifying the presence of dissolved oxygen.
4. The sample was allowed to stand until the floc has settled, leaving the top half of the solution clear. Again, it was inverted several times to mix and allowed to stand until the upper half of the solution was clear
5. The stopper was removed and one content of one dissolved oxygen 3 powder pillow was added. The stopper was replaced with care not, to allow air bubbles into the bottle and it was inverted several times to mix.
6. 20ml of the prepared solution was measured accurately and transferred into a titration flask.
7. A straight-stem delivery tube was attached to a 0.2000N sodium thiosulphate titration cartridge. The cartridge was twisted onto the titrator body.
8. The delivery tubes were flushed by turning the delivery knob to eject few drops of titrant. The counter was reset to zero and the tip wiped.
9. The prepared solution was titrated with 0.2000 Sodium thiosulpate until the sample

changes from yellow to colourless.

10. The number of digits was read from the digital counter window.

The reading was multiplied by 0.1 to determine the concentration of dissolved oxygen in mg/l.

DETERMINATION OF BIOCHEMICAL OXYGEN DEMAND (BOD)

Two 60ml BOD bottles were filled with the sample to overflow.

The contents of one of the bottles were used for the determination of dissolved oxygen as described above, while the other bottle was incubated for five days at a temperature of 20 ± 1^0C. At the end of the fifth day, the dissolved oxygen at the end of the day five of incubation and the BOD was calculated by subtracting the final D.O from the initial D.O

DETERMINATION OF CHEMICAL OXYGEN DEMAND (COD) USING REATOR DIGESTION METHOD

1. The sample was shaken beginning with second step.
2. COD Reactor was turned on. It was preheated to about 150^0 C
3. The cap of a COD Digestion Reagent vial was removed.
4. The vial was held at a 45-degree angle. 2.00ml of the sample was measured into the vial.
5. The vial cap was replaced tightly. The COD vial was rinsed with deionized water and wiped with clean towel.
6. The vial was held by the cap and over a sink. It was inverted several times to mix the contents. The vial was placed in the preheated rector.
7. The blank was prepared by repeating step 3 to 6 substituting 2.00ml with deionized water for the sample.

8. The vial was heated for 1-2hours

9. The reactor was turned off. The reactor was allowed to stay for about 20minutes to cool to 120^{0}C or less.

10. The vial was inverted several times while still warm. The vials were placed into a rack. The vial was allowed to cool to room temperature.

Colorimetric determination techniques were used to determine the sample concentration and process are as follows:

1. The program number for chemical oxygen demand (COD) 430 READ/ENTER was pressed, then display showed "DIALnm to 420"
2. The wavelength dial was rotated until the small display showed 420nm.
3. READ/ENTER was pressed, then display showed "mg/l COD"
4. The COD vial adapter was placed into cell holder with the marker to the right.
5. The outside of the cell containing the blank was wiped with a clean towel.
6. The blank was placed into the adapter
7. Zero was pressed, then display showed: "WAIT" then: "0mg/l COD"
8. The outside of the sample vial was wiped with a clean towel.
9. The sample vial was placed into the adapter.
10. READ/ENTER was pressed, then display showed "WAIT" Then the result in mg/l COD was displayed.

DETERMINATION OF ALKALINITY

1. Pipette was used to measure 25ml of a sample into the 250ml Erlenmeyer flask.
2. Phenolphthalein indicator powder pillow was added to the content in the flask, it was then swirl and mix.

3. The 25ml burette was filled to the zero mark with 0.020 N sulphuric acid standard solution.

4. The sample was titrated with the acid solution until the solution changes from pink to colourless.

5. The mg/L phenolphthalein alkalinity as $CaCO_3$ is now calculated.

DETERMINATION OF HARDNESS

1. Pipette was used to measure 25ml of a sample into the 250ml Erlenmeyer flask.

2. Phenolphthalein indicator powder pillow was added to the content in the flask, it was then swirl and mix.

3. 1ml of hardness 1 buffer solution was added using 1ml calibrated dropper and swirl to mix.

4. The 25ml burette was filled to the zero mark with titraver hardness titrant.

5. The sample was titrated until the solution changes from red to pure blue.

6. The mg/L total hardness as $CaCO_3$ is now calculated.

DETERMINATION OF NICKEL

1. The stored program number for Nickel (Ni) was entered (i.e. 335 and press enter).

2. The display show "Dial nm to 430"

3. The wavelength was rotated until the display show 430nm.

4. Then press READ/ENTER and display show "mg/L Ni".

5. 300ml of a sample was measured into a graduated measuring cylinder.

6. Nickel reagent powder pillow was added into the cylinder and shaked.

7. Press SHIFT TIMER and 5 minutes reaction period occur.

8. After the timer beeps the content of Nickel 2 reagent powder pillow was added into the

cylinder and shake.

9. Press SHIFT TIMER and 5 minutes reaction occur.

10. After the TIMER beeps the display showed WAIT then mg/L Ni.

11. A second cell was filled (i.e. blank) with 25ml of the sample, it was placed into the cell holder and the light shield was closed.

12. Zero was pressed and the display showed "WAIT then 0.00 mg/L".

13. The prepared sample was placed into the cell holder and the light shield was closed.

14. READ/ENTER was pressed and the display showed "WAIT and then 'X'mg/L Nickel" was displayed.