ASSESSMENT OF THE IMPACT OF ABATTOIUR WASTE ON GROUNDWATER QUALITY IN OPEN WELLS (A CASE OF STUDY TAYI COMMUNITY, MINNA)

BY

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MATRIC.No.2005/21648EA

DEPARTMENT OF AGRICULTURAL AND BIORESOURCES ENGINEERING.

FEDERAL UNIVERSITY OF TECHNOLOGY MINNA, NIGER STATE.

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BEING A FINAL YEAR PROJECT REPORT SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF BACHELOR OF ENGINEERING (B.ENG.) DEGREE IN AGRICULTURAL AND BIORESOURCES ENGINEERING. FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA, NIGER STATE

JANUARY, 2011.

DECLARATION

I hereby declared that this project work is 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 Information derived from personal communication, published and unpublished work were duly reference in the text.

25/01/11

Okeke Uchechukwu

Date

CERTIFICATION

This is to certify that project entitled "Assessment of the Impact of Abattoir Waste on Groundwater Quality in Open Wells" by Okeke, Uchechukwu Samuel, 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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Supervisor

19.01.2011
Date

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25/01/11
Date

External Examiner

13/01/2011
Date

DEDICATION

This project is dedicated to Almighty God and to my Parents Mr and Mrs D. O. Okeke for all their love and support throughout my education.

ACKNOWLEDGMENTS

My profound gratitude goes to Almighty God, the creator of the heavens and earth for his protection, guidance, wisdom and blessings. My gratitude also goes to my supervisor, Mr.M.A. Sadeeq who brought his valuable pieces of professional advice and Engr. Dr. (Mrs.) Z.D. Osunde, Engr. Dr. O. Chukwu, Engr. Dr. Alabadan, Mr. Adamu, Mrs. Mustapha, Mrs Bose and all the laboratory technicians for their relentless effort to make my stay in the department worthwhile. May God grant you long live and be with you all, and may he bless and assist you in performing all tasks you wish to carry out Amen.

Special mention must be made of my beloved parents, Mr. and Mrs. D.O. Okeke, and my wonderful siblings, Thanks for believing in me. To my aunts, uncles and cousins, I love you all.

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ABSTRACT

A research was conducted in Tayi village along Bosso Road in Niger State. Water samples were collected from three (3) different water sources. The collected water samples were analysed in the laboratory. The analysis was on different range of properties, which include physical, chemical, and micro-bacteriological qualities. The result which show, the specific conductance of the three samples range from (535-689 μS/cm), the pH (5.70-5.88), the Turbidity (0.69-1.84 NTU), the TDS (534.33-688.33 mg/l), the Dissolved oxygen (0.47-0.50 mg/l).All parameters tested fall within WHO (2006) and NIS (2007) standards. However, the water from the three samples should be boiled, to eliminate any bacterial risks, and should be properly covered, to disallow any insect or foreign material getting in contact. The degree of contamination is dependent on the distance of the bore hole from the site. Sustainable solid waste management system and engineered landfill were suggested as an acceptable option.

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1. INTRODUCTION

1.1 Background to the Study

An abattoir or slaughter house 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 slaughter house:

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 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 hygiene manner and are fit for human consumption. Meat quality control is a system that regulates the measures of extrinsic materials such as chemical residues, toxins, pathogenic microorganims and putrefied tissues, which could be 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 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-morten 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-morten 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 renders 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 hazards as many contain small quantities of compounds which are dangerous or potentially dangerous to the enviroment. It is not a pleasant static: 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 be seep through the ground and reach groundwater, contaminating it with nitrate and bacteria.

1.2 Definition of Waste

Waste is unwanted or unusable materials. Thus, definition, wastes is sometimes a subjective concept, because items that some people discard may have value to others (Baker, 2004). However, waste could be hazardous or non hazardous. By definition, hazardous wastes are the waste that pose a substantial present or potential hazard to human health or the environment when not properly treated, stored, transport or disposed off or otherwise managed while non hazardous wastes refers to the wastes that are converted into economical use either by analyses 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 definition 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 legal, 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 waste management planning.

1.3 Waste Classification of Particular Concern

1.3.1 Special Waste

Special waste is controlled 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 known to certain substances which are dangerous to life.

1.3.2 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.

1.3.3 Household waste

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

1.3.4 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, market and fairs.

1.3.5 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.

1.3.6 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, proteinious waste.

1.4 Statement of the Problem

Indiscrimatinate disposal of waste naturally proliferate the tendency of attracting flies, rodents, cats, dogs, mosquitoes, unpleaseant smell, as well as creation of unsanitary condition and other aesthetic problems resulting from open dumpsites. Agricultural soil exposed to incessant deposition of solid waste are liable to become contaminated due influx of heavy metal, which subsequently through intrusion intercept and affect the ground water quality.

1.5 Objective of the Study

In addition to groundwater depletion, scientists worry about groundwater contamination, which arises from leaking underground landfill, storage tanks, poorly designed industrial wastes into underground geologic formations. By some estimates, on average, 25 percent of usable groundwater is contaminated, and in some areas as much as 75 percent is contaminated (Microsoft Encarta, 2007). The objectives of this study therefore include:

- to analyze the adverse impact of abattoir waste on groundwater quality at Tayi Community in Bosso-Minna Niger state.
- to have a clear idea about the quality of water for human consumption.
- to examine the current solid waste practice in abattoir.
- Development of comprehensive database on the impact of dumpsite on underground water quality.
- to awaken self- consciousness on ecological apathy.

1.6 Significance of the Study

The survival of man and indeed of any nation depends on his ability to manage its wastes in an environmentally sound manner (Mackenzie, 1996). This can be achieved by evolving strategies to evaluate and manage wastes in an environmentally friendly manner.

Minimizing of wastes using safe and proper technological strategies will enhance minimization of adverse environmental impact from waste generation.

1.7 Scope of the Study

This study is to investigate the impact of abattoir waste on underground water quality via physio-chemical and bacteriological analyses.

CHAPTER TWO

2. LITERATURE REVIEW

Industrialisation has afforded man a high standard of living, solves technology problems and in the process, enhances the quality of life (Olishifski, 1999).

Industrialisation is also a significant index of assessing the level of development of a country.

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 dioxide at holding heat in the atmosphere (Barrett, 2001).

The most important issue in all meat-processing plants in maintenance of proper hygiene and adequate sanitary conditions. An abattoir has been defined as a premise approved and registered by 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 results 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 level of suspended solid, liquid and fat. The solid waste includes condemned meat, undigested ingests, bones, horns, hairs and aborted foetus. 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 (Lewieki, 1993). On – going production quality control, washing and disinfection, are the man 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 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 waste water 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 8942mg/l; suspended solids 189 to 3330mg/l; TDS 595 to 280mg/l; total nitrogen 0, 71 to 24mg/l. whereas abattoirs require high quality water due to 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 Slaughter House Design

In the later half of the 20th century, the layout and design of most US slaughtering houses has been significantly influenced by the work of Dr. Temple Gradin. Gradin is also well known for being autistic and it was a fascination with patterns and flows that first lead her to redesign the layout of cattle holding pens. Gradin'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 slaughtering house into a single file ready for slaughter. Her corrals employ long seeping curves so that each animal is prevented fro seeing what lies ahead and just concentrates on the hind quarters of the animal in front of it. Gradin now claims to give designed over 54% of the slaughter houses in the United States as well as many other slaughter houses around the world.

The largest slaughter house 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.

2.2 History of Abattoir

Slaughter houses are needed primarily to serve the large scale demand for meat in urban areas where there is no livestock. Thus the slaughter house has developed as an adjunct of the city. Early maps of London show numerous stock yards in the periphery of the city, where slaughter occurred in the open air. A term for such open air slaughter houses is a shamble. There are streets named the shambles in some English towns e.g. Worcester, York which got their names from been the site on which butchers killed and prepared animals for consumption.

Open air slaughter inside cities produced by very substantial concerns about public health, morals, and aesthetics. This antipathy towards slaughter house is mentioned at least as early as Thomas More's Utopia. In the 19th and 20th centuries, slaughter houses were increasingly sited away from the public view, and took pains tom portray themselves as clean, innocuous business. 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 slaughter house. As such, in the west, the connection between packaged meat products in the supermarkets and the live animals from which they are derived is obscured.

In recent years, animal rights groups and some vegetarians have accused slaughter houses of secrecy, and have tried to highlight the practices inside a slaughter house. This tactics has been in part to expose and correct allegedly inhuman treatment of animals, or unhygienic standards. It has been used to encourage people to in form themselves about meat production, which Activists hope will lad to move people choosing a meal-free or reduced-meat diet.

2.3 The Environment

The term environment refers to the natural conditions in which we live. It is composed of living and non-living components. The living components constitute the biological environment consisting of plants, animals and micro-organisms. The non-living components constitute the physical environment consisting of the earth, the water and atmosphere. (Mason, 1973). The biological environment and the physical environment are interrelated. Man's relationship to this environment is dynamic because the environment has profound influence on man; likewise, man's Activities have extensive on the environment (Reyment, 1995).

2.4 Environmental Pollution

Environmental pollution can be defined as the addition to the environment of substances that cannot be rendered harmless by normal biological process, (Allan, 1981), that is, substances which are not biodegradable. It can also be viewed as on undesirable change in the physical chemical or biological characteristics of the air, land and water that may or will harmfully affect human life or that of other species, industrial processes, living conditions and culture al assets, at that may or will waste or deteriorate the raw materials sources. (Claus, 1992).

2.4.1 Pollutants

Energy and matter causing pollution are referred to as pollutants, (Scott, 1979). Pollutants can be solid, liquid or gaseous; they can also appear as energy or noise in the environment. Pollutants, which retain their original composition after introduction into the environment, are known as primary pollutants, while those that are formed as a result of some reactions in environment are known as secondary pollutants. Carbon monoxide and sulphur dioxide are primary pollutants. Examples of secondary pollutants in cloud ozone formed by ultra violet radiation, catalyses nitrogen oxides reactions in the atmosphere and methyl mercury from macro and micro environmental concerns (or pollutants) and their sources (Schield, 1998).

2.5 Water Pollution

Water pollution occurs when a body of water is adversely affected due to the addition of large amounts of materials to the water (Todd, 1990). When it is unfit for its intended use, water is considered polluted. Substance which result to pollution in water include oxygen demanding waste, pathogens, nutrients, salts, excessive heat discharge, heavy metals from industries, sediments, oil, pesticides and effluent from industries. Two types of water pollutants exist; point source and non-point sources

(FEPA, 1991). Point sources of pollution occur when harmful substances are emitted directly into a body of water. an oil spill best illustrates point source water pollution. A non-point source delivers pollutants indirectly through environmental changes. An example of this type of water pollution is when fertilizer from a field is carried into a stream by rain, in the from of run-off which in turn affect aquatic life. The technology exist fro point sources of pollution to be monitored and regulated, although political factors may complicate matters. Non-point sources are much more difficult to control. Pollution arising from non-point sources accounts for a majority of the contaminants in streams and lakes.

2.5.1 Causes of Water Pollution

Many causes of pollution including sewage and fertilizers contain nutrients such as nitrates and phosphates (Murat, 2000). In excess levels, nutrients over stimulate the growth of aquatic plants and algae. Excessive growth of these types of organisms consequently clogs our waterways, use up dissolved oxygen as they decompose, and block light to deeper waters. This in turn proves very harmful to aquatic organisms as it affects the respiration ability of fish and other invertebrates that resides in water (Iioeje, 1980).

Pollution is also caused when silt and other suspended solids, such as soil, wash off plowed fields, construction and logging sites, urban areas, and eroded river banks when it rains. Under natural conditions, lakes, rivers, and other water bodies undergo eutrophication, an aging process that slowly fills in the water body with sediments and organic matter. When these sediments enter various bodies of water, fish respiration becomes impaired, plant productivity and water depth become reduced, and aquatic organisms and their environments be come suffocated. Pollution in the form of organic materials enters waterways in many different forms as sewage, as leaves and grass clippings, or as runoff from livestock feedlots and pastures.

When natural bacterial and protozoan in the water break down this organic material, they begin to use up the oxygen dissolved in the water (Poppe, 1997). Many types of fish and bottom dwelling animals cannot survive when levels of dissolved oxygen drop low two or five parts per million. When this occurs, it kills aquatic organisms in large numbers which leads to disruptions in the food chain. The pollution of rivers and streams with chemical contaminants has become one of the most crucial environmental problems within the 20th century. Waterborne chemical pollution entering rivers and streams cause tremendous amounts of destruction.

Pathogens are another type of pollution that proves very harmful. They can cause many illness that range from typhoid and dysentery to minor respiratory and skin diseases. Pathogens include such organisms as bacteria, viruses, and protozoan (sanda, 1985). These pollutants enter waterways through untreated sewage, storm drains, septic tanks, runoff from farms and particularly boats that dump sewage. Though microscopic, these pollutants have tremendous effect evidence by their ability to cause sickness.

Three last forms of water pollution exist in the forms of petroleum, radioactive substances, and heat (DPR, 1991). Petroleum often pollutes water bodies in the form of oil, resulting from oil spills, these large scale accidental discharges of petroleum are an important cause of pollution along shore lines. Besides the super tankers, off-shore drilling operations contribute a large share of pollution. One estimate is that one ton of oil is spilled for every million tons of oil transported. This is equal to about 0.0001 percent.

Radioactive substances are produced in the form of waste from nuclear power plants, and from the industrial, medical, and scientific use of radioactive materials (Jonah, 1987). Specific forms of waste are uranium and thorium mining and refining. The last form of water pollution is heat. Heat is a pollutant because increased temperatures result in the deaths of many aquatic organisms. These decreases in temperatures are caused when a discharge of cooling water factories and power plants occurs.

The use of land for agriculture and the practices followed in cultivation greatly affect the quality of groundwater. Intensive cultivation of crops cause's chemicals from fertilizers (e.g. nitrate) and pesticides to seep into the groundwater, a process commonly known as leaching (Stuckey, 1982). Routine applications of fertilizers and pesticides for agriculture and indiscriminate disposal of industrial and domestic wastes are increasingly being recognized as significant sources of water pollution. The high nitrate content in ground water is mainly from irrigation run-off from agricultural fields where chemical fertilizers have been used indiscriminately.

Waste water from manufacturing or chemical processes in industries contributes to water pollution. Industrial waste water usually contains specific readily identifiable chemical compounds. During the last fifty years, the number of industries in India has grown rapidly. But water pollution is concentrated within a few sub-sectors mainly in the form of toxic waste and organic pollutants. Out of this a large portion can be traced to the processing of industrial chemicals and to the food products industry. In fact, a number of large and medium sized industries in the region covered by the Ganga Action plan do not have adequate effluent treatment facilities (Dessel, 1994). Most of these defaulting industries are sugar mills, distilleries, leather processing industries and thermal power stations. Most major industries have treatment facilities for industrial effluents. But this is not the case with small-scale industries, which cannot afford enormous investments in pollution control equipment as their profit margin is very slender.

2.5.2 Types of Water Pollution

Although some kinds of water pollution can occur through natural processes, it is mostly a result of human Activities. We use water daily in our homes and industries, about 150 gallons per day per person in the United States. The water we use is taken from lakes and rivers, and from underground (groundwater); and after we have used it and contaminated it most of its returns to these locations (Cercla, 1980).

The used water of a community is called wastewater, or sewage. If it is not treated before being discharged into waterways, serious pollution in the result. Historically, it has taken humanity quite a bit of time to come to grips with this problem. Water pollution also occurs when rain water runoff from urban and industrial areas and from agricultural land and mining operations makes its way back to receiving waters (river, lakes or ocean) and into the ground (Gray, 1980). Some different types of water pollution include the following:

2.5.2.1 Microbiological: - Disease causing (pathogenic) microorganisms, like bacteria, viruses and protozoan can cause swimmers to get sick. Fish and shellfish can become contaminated and people who eat them can become ill. Some serious disease like polio and cholera are waterborne.

2.5.2.2 Chemical: - A whole variety of chemicals from industry, such as metals an solvents and even chemical which are formed from the breakdown of natural wastes (ammonia, for instance) are poisonous to fish and other aquatic life. Pesticides used in agricultural and around the home insecticides for controlling insects and herbicides for controlling weeds are another type of toxic chemical. Some of these can accumulate in fish and shellfish and poison people, animals, and birds that eat them. Materials like detergents and oils floats and spoils the appearance of a water body, as well as being toxic; and many chemical pollutants have unpleasant odours (Ayanruoh, 2001). The Niagara River, between the US and Canada, even caught fire at one time because of flammable chemical wastes discharged into the water.

2.5.2.3 Oxygen-depleting substances: - Many wastes are biodegradable, that is, they can be broken down and used as food by microorganisms like bacteria. We tend to think of biodegradable wastes as being preferable to non-biodegradable ones, because they will be broken down and not remain in the environment for very long times. Too much biodegradable material though can cause the serious problem of oxygen depletion in receiving waters.

Like fish, aerobic bacteria that live in water use oxygen gas which is dissolved in the water when they consume their food. (The oxygen in the compound H_2O, water, is chemically bund, and is not available for respiration (breathing). But, oxygen is not very soluble in water. even when the water is saturated with dissolved oxygen, it contains only about 1/25 the concentration that is present in air. So if there is too much food in the water, the bacteria that are consuming it can easily use up all of the dissolved oxygen leaving none for the fish, which will die or suffocate (Desnoo, 1996).

Once the oxygen is gone depleted, other bacteria that do not need dissolved oxygen take over. But while aerobic microorganisms those which use dissolved oxygen convert the nitrogen, sulphur and carbon compounds that are present in the waste water into odourless and relatively harmless oxygenated forms like nitrates, sulphate and carbonates, these anaerobic microorganisms produce toxic and smelly ammonia, amines and sulphides and flammable methane (Swamp gas) add in the dead fish and you see why we don't want large amount of biodegradable material entering lakes and streams (Fleming, 2000).

2.5.2.4 Nutrients: - The elements phosphorous and nitrogen are necessary for plant growth and are plentiful in untreated wastewater. Added to lakes and streams, they cause nuisance growth of aquatic weeds, as well as blooms of algae, which are microscopic plants. This can cause several problems. Weeds can make a lake unsuitable for swimming and boating. Algae and weeds die and become biodegradable material, which can cause the problems mentioned above (and below). If the water is used as a drinking water source, algae can clog filters and impart unpleasant tastes and odours to the finished water (Safferman, 1991).

2.5.2.5 **Suspended matter:** - Some pollutants are dissolved in wastewater, meaning that the individual molecules or ions (electrically charged atoms or molecules) of the substance are mixed directly in between the molecules of water. Other pollutants, referred to as particulate matter, consist of much larger but still very small particles which are just suspended in the water. Although they may be kept in suspension by turbulence, once in the receiving water, they will eventually settle out and from silt or mud at the bottom (Veil, 2001). These sediments can decrease the depth of the body of water. if there is a lot of biodegradable organic material in the sediments, it will become anaerobic and contribute to problems mentioned above. Toxic materials can also accumulate in the sediment and affect the organisms which live there and can build up in fish that feed on them, and so be passed up the food chain, causing problems all along the way. Also, some of the particulate matter may be grease or coated with grease, which is lighter than water, and float to the top, creating an aesthetic nuisance (Yo-cum, 1997).

2.6 Ground water

The amount of waste produced by human society is increasing. Commercial and domestic solid waste is a great practical problem for many local governments. Industrial wastes are usually much smaller in volume but are more likely to contain hazardous materials, such as toxic chemicals, flammable liquids and asbestos. Although the total amount is les, the disposal of hazardous industrial waste has been a greater concern than of domestic waste because of the perceived hazard to health and the risk of environmental contamination (Pettijohn, 1995).

The generation of hazardous waste has become a major problem worldwide. The root cause of the problem is industrial production and distribution. Land pollution occurs when hazardous wastes contaminate soil and groundwater due to inadequate or irresponsible disposal measures. Abandoned or neglected waste disposal sites are a particularly difficult and expensive problem for society. Sometimes, hazardous waste is disposed of illegally and in an even more dangerous number because the owner cannot find a cheap way to get rid of it. One of the major unresolved issues in managing hazardous waste is to find methods of disposal that are both safe and inexpensive. Public concern over hazardous waste focuses on the potential health effects of exposure to toxic chemicals, and particularly the risk of cancer (Casagrande, 1998).

The Basel convention passed in 1989 is an international agreement to control the trans-boundary movement of hazardous waste and to prevent dangerous wastes from being shipped for disposal to countries that do not have the facilities to process them safely. The Basel convention requires that the generation of hazardous wastes and trans-boundary movement of the wastes be kept to a minimum. Traffic in hazardous waste is subject to the informed permission and laws of the receiving country. Trans-boundary movement of hazardous waste is subject to good environmental practices and assurance that the receiving country is able to handle them safely (Bouwer, 1988). All other traffic in hazardous waste is considered illegal and therefore criminal in intent, subject to national laws and penalties. This international convention provides an essential framework for controlling the problem at an international level (Redmond, 2007).

Ninety-five percent of all fresh water on earth is ground water. Ground water is found in natural rock formations. These formations, called aquifers, are vital natural resources with many uses. Nationally, 53% of the population relies on ground water as a source of drinking water. In rural areas this figure is even higher. Eighty one percent community water is dependent on ground water. Many areas in Nigeria have experienced significant ground water contamination. Some examples are leaking underground storage tanks and municipal landfills (Arthur, 1983).

In well-designed hazardous waste disposal (contaminants) facilities, there is an effectively impermeable seal to prevent hazardous chemicals from migrating out of the site and into the underlying soil. Such a site also has facilities to treat those goes into the site; those chemicals that cannot be so treated are contained in impermeable containers (Eckenfelder, 1990).

Chemicals may escape by leaking if the container is compromised, leaching if water gets in or spilling during handling or after the site is disturbed. Once they permeate the liner of a site, or if the liner is broken or if there is no liner, they enter the ground and migrate downward due to gravity. This migration is much more rapid through porous soil and is slow through clay and bedrock. Even underground, water flows downhill and will take the path of least resistance, and so the groundwater level will fall slightly in the direction of flow and the flow will be much faster through sand or gravel.

If there is a water table under the ground, the chemicals will eventually reach it (Tebutt, 1992). Lighter chemicals tend to float on the groundwater and form an upper layer. Heavier chemicals and water soluble compounds tends to dissolve or be carried along by the groundwater as it flows slowly underground through porous rock or gravel. The region of contamination, called the plume, can be mapped by drilling test wells, or bore holes. The plume slowly expands and moves in the direction of groundwater movement.

Surface water contamination may occur by runoff from the site, if the top layer of soil is contaminated, or by groundwater (Sundstrom, 1979). When the groundwater feeds into a local body of water, such as a river or lake, the contamination is carried into this body of water. some chemicals tend to deposit in the bottom sediment and other are carried along by the flow. Groundwater contamination may take centuries to clear by itself. If shallow wells are used as a water source by local residents, there is a possibility of exposure by ingestion and by skin contact.

2.7 Water Quality

Water quality is closely linked to water used and to the state of economic development. In industrialized countries, bacterial contamination of surface water caused.

1. Harmful waste act cap 165 law of Federation of Nigeria 1990.
2. Factories Act cap 126 law of Federation of Nigeria 1990.
3. Land use Act cap 202 law of Federation of Nigeria 1990.
4. Endangered species decree cap 108 law of Federation of Nigeria 1990.

2.8 Enforcement of Waste Regulations

The legal apparatus seems to cover all the main environmental concerns in details 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 legislation 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 volatile organic compound, and total dissolved solids.

2.9 Sources of Waste (Solid Waste and Waste Water) in Red Meat Abattoirs

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

1. Lairagus / animal pens
2. bleeding / stunning

3. carcass processing / cleaning

4. Offal processing and by-products processing.

2.9.1 Types of Waste

Every industry produces either, Liquid, Solid or Gaseous wastes.

2.9.2 Liquid Waste

Water pollution occurs when a body of water is adversely affected due to the addition of large amounts of materials to the water (Todd, 1990). When it is unfit for its intended use, water is considered polluted. Substance which result to pollution in water include oxygen demanding waste, pathogens, nutrients, salts, excessive heat discharge, heavy metals from industries, sediments, oil, pesticides and effluent from industries.

The meat processing generates large quantities of effluent rich in organic compounds and nutrients and plants require the best tools 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 process, 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 e, 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 of 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 industrialization 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 the stabilities 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.

2.9.3 Solid Waste

Solid wastes are all the wastes arising from human and animal Activities that are normally solid and that are discarded as useless or unwanted. The term is all inclusive and it encompasses the heterogeneous mass throw ways from the urban community as well as the more homogenous accumulation of agricultural, industrial and nine wastes.

Meat processing accumulates waste materials such as manure and paunch materials, sledges and NCV skins. Opportunities to dispose of these waste solids using traditional methods are disappearing and there are alternative process for utilizing these materials.

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 materials 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 (HDP) are being used where applicable. In most cases, treatment of solid waste in abattoir was confirmed to dumping and land application.

2.9.4 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 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 become under increased scrutiny from regularly agencies and public a variety of federal, state and local laws have been enacted to limited releases. While the pending Nigeria cleans air Acts are expected to be a major driving force towards 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 gasses 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 fire and volcanic eruptions, which also add finely divided particulates such as dust to the atmosphere.

Table 2.1: 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_2	1.3ppm
Krypton	Kr	1.0ppm
Hydrogen	H_2	0.5ppm
Nitrous oxide	N_2O	0.25ppm
Carbon monoxide	CO	0.1ppm
Ozone	O_3	0.02ppm
Sulphur dioxide	SO_2	0.001ppm
Nitrogen atmospheric air	NO_2	0.001ppm
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 which contain polluting substances in such concentrations as to cause an unwanted effect.

2.9.5 Effect 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, 1989). 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.

2.10 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 90 percent moisture content, only about 45 percent 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.

Nevertheless 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 phosphorous 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 fore teaching purposes, and the blood and gut content 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 1980s, with consequently 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 food 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 carcass could not be used for human consumption and, depending on the cost of transport and their value, they might have to dispose of on farm, by a local hunt kennel or at a knacker's yard. Turning to the industries which process cattle waste into it many products, there were produced – during or at the end of those process – quantities of materials which required disposal because they had no beneficial used 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 has 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 materials which could cause harm to human or animal health or the environment, it assumed a far greater significance because of its potential for pollutant.

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 management and disposal of waste. The 1991 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 neighbourhood.

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 incident in the late 1960s 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 more stringent legislative control of waste. Amongst the most notorious incidents was the discovery, in 1972 of drums of toxic cyanide waste dumped indiscriminately on a site used as children's playground near numeration in the UK. The dumping of 3, 000 tones of arsenic and cyanide waste into a lake in Germany in 1871, and the lake of polychlorinated biphenyls (PCBS) into rice oil in Japan in 1968, the Yusho Incident. The industrialised 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 diseases) and cadmium (Itai-Itai disease) in 1960's cannot be easily forgotten. During the 1790'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 contaminated by toxic chemicals and leachate resulted in high prevalence of spontaneous abortion in pregnant women. 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 factory 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 portharcourt in 1988 caused massive fish kill and socio-economic problem for the artisan fishery industries in the surrounding villages, the villagers claimed about N3 million compensation from the company.

Petroleum product spillage from the Kaduna refinery in 1987 into Romi and Rido River. Well water in Rido village as well as the Rido and Romi River were grossly polluted. Compensation of more than N3million had been paid to the villagers affected by the waste polluted 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 has been desert with waste polluted 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 towards a stream and if adequate measure is not taken, this posses future threat to the state.

2.11 Waste Treatment Operations, Processes and Concepts

These are methods of removing toxic and hazardous components, if these components are incorporated into gasses, 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, electrolysis, electro dialysis, reverse osmosis, chlorinated, hydrolysis, oxidation, chemical precipitation, solidifications, biological and ion exchange techniques are all available. In all these cases the hazardous materials 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 the considered. Chemical methods such as oxidation and chlorination may also be used.

2.11.1 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 incineration 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.

2.11.2 Pyrolysis

When complete combustion of a substance to gaseous oxides is not attained, wither 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).

2.11.3 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.

2.11.4 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.

2.11.5 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.

2.11.6 Encapsulation

There are two types of encapsulation. One is where materials is enclosed in a bunker, bottle can drum or rock chamber made of an impervious inert material so that no reaction can take place.

CHAPTER THREE

3. MATERIALS AND METHODS

The research process typically began with an initial scoping of the study. This element is critical in determining the objectives, needs and concerns of the research and defined the overall content and depth of the study. Both the initial scoping and later study stages generally involved on interaction with affected people who live by the abattoir and who use water from the boreholes for their consumption use. This was followed by site visits.

The site (abattoir) is located at tayi village in Minna, the receiving environment and sanitary conditions of the areas were inspected. The data collected were from the analysis carried out on the samples collected from these area using the stated materials and reagents.

3.1 Location of the Study

3.1.1 Minna Abattoir

Minna town lies on latitude $9^{0}30'$N and longitude $6^{0}3'$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.

3.2 The Slaughtering Section: after the animals 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 a staff of the abattoir, the blood and other liquid that came out of the animals 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.

3.2.1 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 of 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.

3.2.2 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 wastes 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 abattoir.

1. Animals are received by truck or rail from a ranch, farm, or feedlot.
2. Animals are herded into holding.
3. Animals receive a pre-slaughter 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 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 centres that distribute to local retails markets.

3.3 Samples Collected

Samples were taken at different points. Three plastic containers of equal capacity are used (150cl) each with cap. Each container was plunged into different point specified and filled to the point of overflowing of the containers replaced; the samples were taken to the laboratory without any delay. The three samples collected were designated and summarized as follows:

A – Sample collected 20 – 30 meters within the abattoir premises but away from the abattoir wastes.

B – Sample collected in a residence well 90 – 100 meters away from the abattoir.

C – Sample collected in a residence well 300 – 330 meters away from the abattoir.

The procedures and reagents used in this study are present in appendix 1 and 2.

CHAPTER FOUR

4. 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 organization (WHO) and Nigeria industrial standard (NIS). 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

Parameter	Units	A	B	C	NIS 554:2007 MAX. PERMITTED LEVEL	WHO GUIDE STANDARD 2006
Conductivity	µs/cm	670	689	535	1000	10 – 1000
Temperature	^0C	27.0	27.2	27.1	ambient	-
pH	-	5.72	5.88	5.70	6.5 – 8.5	6.5 – 8.5
Turbidity	NTU	1.21	1.84	0.69	5	5
Total dissolved Solid	mg/L	669.33	688.33	534.33	500	1000
Suspended solid	mg/L	6	0	6	-	-
Colour	TCU	colourless	colourless	colourless	15	15
Odour	-	odourless	odourless	odourless	-	-

Table 4.2: Chemical parameters of the samples

Parameters	units	A	B	C	NIS STANDARD	WHO STANDARD
Total hardness	mg/L	146.13	165.14	106.09	150	150
Alkalinity	mg/L	74	19	48	-	-
Iron	mg/L	0	0	0	0.3	0.3
Nitrate	mg/L	1.59	0.53	3.72	50	50
Calcium	mg/L	58.16	56.96	41.32	-	-
Magnesium	mg/L	1.0	23.01	3.0	-	-
Sulphate	mg/L	5	5	5	100	500
Phosphate	mg/L	0.11	0.03	0.03	-	-
Nitrate	mg/L	0.0045	0.01	0.0075	0.2	3
Sodium	mg/L	17	19	16.5	200	200
Manganese	mg/L	0.039	0.00	0.50	0.2	0.5
Potassium	mg/L	5.36	1.34	2.01	-	-

Table 4.3: Organic parameters of the samples

Parameters	units	A	B	C	NIS STANDARD	WHO STANDARD
COD	mg/L	145.13	142.13	103.09	-	-
DO	mg/L	0.47	0.48	0.50	-	-

4.2 Discussion of Results

4.2.1 Electrical Conductivity

The electrical conductivity of the samples ranges from 535-689(μs/cm),

A. The highest been that of residence well away from the abattoir waste

B. The lowest was from well before the abattoir waste. The higher number can be attributed to increase in dissolved solids since rapid method of obtaining an estimate of the dissolved solid 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 Temperature

The temperature of the samples ranges between 27.0^0C and 27.1^0C. However, the temperature levels of the samples are well within the NIS range, and if has no effect on the environment, it will have adverse effect on the receiving water body at the same time; it will increase the level of the dissolved oxygen.

4.2.3 pH

The pH of the samples ranges between 5.7 and 5.8. The highest volume of 5.8 was measured in sample 3. The sample had pH value of 5.8 which is acidic the low pH reading of 5.70 and 5.72 in sample C and A was attributed to the decay of organic matters in the samples. The pH of the samples are within acceptable limits of NIS range 6.5 to 8.5 and WHO standard which is also 65. to 8.5. In most situations the concentration of H^+ or H^- is small or insignificant compared to the concentration of other spices but the does not mitigate the influence of these ions are controlling variables of the state or the water.

4.2.4 Turbidity

Turbidity is associated with suspended solids concentrations. It was observed that size and concentration of particles influenced the measurement of turbidity. Turbidity of the samples ranges between 0.69NTU and 1.84NTU. The highest turbidity is from B and lowest from sample C, these can be due to the distance of each well. The nature of the solids causing the turbidity may have other health ramifications. Turbidity in natured waters reduces light transmittance and affects the species that may survive in the waters.

4.2.5 Total Dissolved Solids and Total Suspended Solids

The total dissolved solids of the samples are less when compared to WHO (2006) and slightly high in NIS standard thus the polluting power of the waste is low. It was observed that abattoir does not treat their waste of all. The values range from 534.33mg per litres to 688.33mg per litre for total dissolved solids (TDS), while total suspended solids (TSS) ranges from 0mg pel litre to 6mg per litre. The values, obtained indicate a slight high potential of the leachatic to cause grass organic pollution.

4.2.6 Dissolved Oxygen

Like solids and liquids, gases can dissolve in water and like solids and liquids; different gasses vary greatly in their solubilities, i.e. how much can dissolve inn water (Safferman, 1991). A solution containing the maximum concentration that the water can holds is said to be saturated. Oxygen gas, the element which exists in the form of O_2 molecules, is not very soluble. A saturated solution at room temperature and normal pressure contains only about 9 parts per million of D.O. by weight (9mh/L). Lower temperature or higher pressure increase the solubility, and vise versa. Dissolved oxygen is essential for fish to breathe. Many microbial forms require if as well. DO of the samples ranged from 0.47mg/L to 0.5mg/L. The values are within the NIS maximum level of 7.5mg/L.

4.2.7 Chemical Oxygen Demand

Chemical oxygen demand is a measure of the oxygen that certain chemicals will take from the environment. The value ranges from 103.09mg/L to 145.13mg/L. The COD has major influence on the trade effluent charge: higher strength equal higher charge.

4.2.8 Iron

The beneficial of iron include: chlorophyll synthesis, oxidation reduction in respiration, constituent of certain enzymes and proteins. The iron content of the effluent samples is 0mg/L. The samples had a low concentration of iron due to the low usage of metal in the abattoir. The iron concentration of the fall within the NIS range of 0.3mg/L and WHO range of 0.3mg/L.

4.2.9 Sulphate

The sulphate is an abundant ion in the earth's crust and its concentration in water can range from milligrams to several thousands milligrams per litre. The sulphate concentration of the samples is 5mg/L each when the samples were analyzed. The values obtained are below NIS maximum level of 100mg/L and also the values are below WHO level of 500mg/L. sulphur is absorbed by plants roots exclusively as the sulphate SO_4^{2-}. It is also an essential constituent of volatile crops of such crops; garlic and an onion gives them their characteristic fragrance.

4.2.10 Phosphate

Ground waters rarely contain more than 0.1mg/L phosphorous unless they have passed through soil containing phosphate or have been polluted by organic matter. Phosphorus compounds are present in fertilizers and in many detergents. Consequently, they are carried into both ground and surface waters with sewage, industrial wastes and storm run-off. High concentrations of phosphorus compounds may produce a secondary problem in water bodies where alga growth is normally limited by phosphorus. In such situations the presence of additional phosphorus compounds can stimulate algal productivity and enhance eutrophication process.

CHAPTER FIVE

5. CONCLUSION 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 of NIS/WHO. Although some are within the range and some are below the limits. Hence considering the analysis carried out on physical, chemical and organic parameter of the water samples, one safely draws the conclusion that, the abattoir waste/effluent has lowered the quality of receiving streams.

Table 4.1, 4.2 and 4.3 respectively depict the water samples to be analyzed from tayi village abattoir in Minna. When compared with NIS guidelines and standards as well as WHO standards of 2006 contain several pollutants which are slightly above limits.

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

5.2 Recommendations

The followings recommendations based on the study are:

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 portion 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 NIS / WHO are vigorously enforced. Ensuring compliance by polluters with NIS / WHO regulations requires comprehensive monitoring programme of waste in the country.

REFERENCE

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APPENDIX 1

Reagents and Materials Used

1. The three water samples collected
2. Hydrochloric acid
3. Distilled water
4. Desiccators
5. Thermometer
6. Biby merit W400distiller
7. Conductivity meter
8. Dissolved oxygen/temperature meter
9. Masking tape
10. Wall clock
11. 25ml sample cell
12. Volumetric flask
13. Conical flask
14. Pipettes
15. pH meter
16. Hack conductivity/TDS meter
17. DR/890 Wash calorimeter
18. Organoleptic
19. Titrimetric method
20. Iron reagent powder pillow
21. Calcium and magnesium indicator
22. Corning flame photometer 410 bicass product
23. Alkali solution
24. Calorimeter (sherword calorimeter)

25. DR/890 colorimeter direct reading
26. Sherwood calorimeter with optical filter
27. Phenolphthalein indicator powder pillows
28. Flame photometer standard 1000ppm potassium
29. Flame photometer standard 1000ppm sodium
30. Corning air compressor
31. Phenol red indicator delivery tubes
32. Clean towel
33. COD vial indicator
34. Razor blade
35. Hach COD Reactor
36. Delivery tube

APPENDIX 2

Determination of Temperature

1. Temperature / conductivity / TDS meter was switched on by pressing the appropriate button.
2. The probe was immersed in the beaker containing the de-iodized 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 de-iodized 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 micro siemens / cm (μs/cm) or milli-siemens / cm (ms/cm)

Determination of pH (Potential Hydrogen)

The PH was determined using universal PH strips and love bond colour compare for 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 blink
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 love bond comparator. It was then rotated for colour matching. The reading was then recorded.

Determination of Turbidity

1. The stored program number for turbidity was entered, 750READ/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: "NTU Turbidity"
4. 25ml of de-ionized 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: "O Nephelometric Turbidity Unit" (NTU)
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 Nephelometric Turbidity Units (NTU) were displayed, when the display stabilizes, the results were recorded.

Determination of 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 de-ionized 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 milligrams 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: DIALnm 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 de-ionized 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 Alkalinity

1. 100ml of the sample was measured and sulphuric acid (H_2SO_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 titration body.

3. Digital titrate was held with the cartridge tip pointing up and the delivery knob was turned to eject out 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 swirled 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 colour, as required.

9. Total digits required x digits multiple = mg/l total alkalinity

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 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 1M EDTA solution 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, and then display showed: "WAIT" then 0.00mg/la$CaCO_3$ 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 showed: mg/l $CaCO_3$ Ca

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

18. Then 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-minutes 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 Mg/l SO_4^{2-} were displayed.

Determination of Iron Content

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

2. The wavelength dial was rotated until display showed: 510nm.

3. READ/ENTER was pressed and the display showed: "Mg/ 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 colours indicate the presence of iron.

6. SHIFT TIMER was pressed. A 3 minutes reaction period began

7. When the timer beeps, the display showed: "Mg/Fefv". 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/ENRER was pressed, the display showed: "WAIT" then the result in Mg/l boron was displayed.

Determination of Chemical Oxygen Demand (COD) Using Reactor 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 vial
5. The vial cap was replaced tightly. The COD vial was rinsed with de-ionized 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 reactor.
7. The blank was prepared by repeating step 3 to 6 substituting 2.00ml with de-ionized water for the sample.
8. The vial was heated for 1-2 hours
9. The reactor was turned on. 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 vial were placed into a rack. The vial allowed cooling 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 0.02N 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 was added to the content in the flask, it was then swirl and mix.
3. 1 ml 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 shakes

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

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 0.00mg/L"

13. The prepare 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.

Plate 4.1 Minna Abattoir Cattle Waste (bones, horns, hooves), 2010.

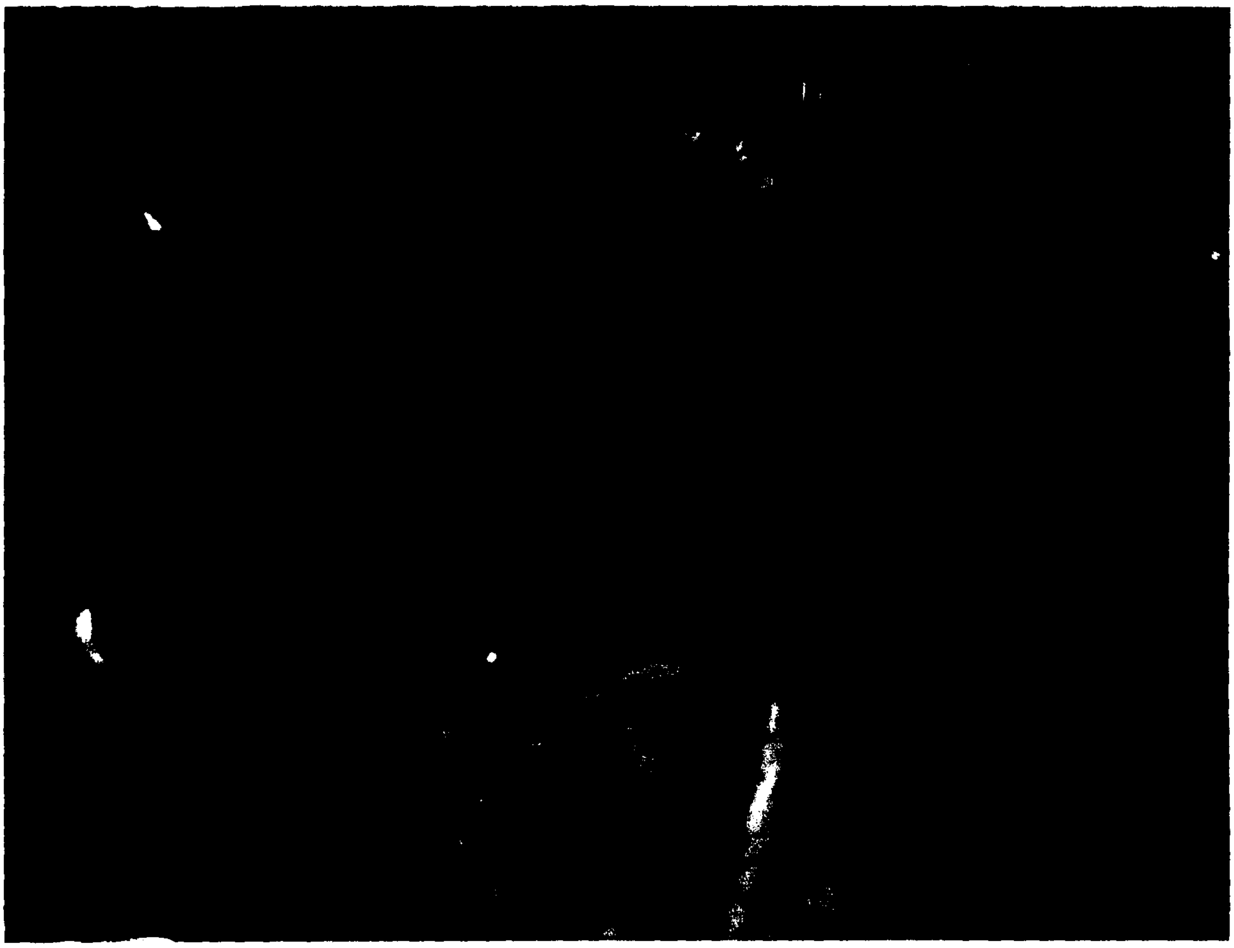

Plate 4.2 Minna Abattoir Cattle Waste (effluent), 2010.

FEDERAL MINISTRY OF WATER RESOURCES

REGIONAL WATER QUALITY LABORATORY, MINNA

OFFICE
Km5, Zungeru Road
River Basin Estate
P. M. B. 137, Minna
Niger State.

☎ 066:224178
Fax: 066:224178
Our Ref:.........................
Your Ref:.........................

RESULT OF PHYSICO-CHEMICAL ANALYSIS

Date Sample Collected: 24/06/2010
Date/ Time Sample Delivered To the Laboratory: 24/06/2010
Client: Student Project
Sample Analyzed by: Laboratory Analysts
I hereby certify that we have analyzed the above described samples in the condition submitted to us and stated hereunder our findings.

Parameter	Units	B	C	A	NIS 554:2007 Maximum Permitted Level	WHO Guide Level 2006 Maximum Permitted Level
Conductivity	Ms/cm	689	535	670	1000	10-1000
Temperature	°C	27.2	27.1	27.0	Ambient	-
pH	-	5.88	5.70	5.72	6.5-8.5	6.5-8.5
Turbidity	NTU	1.84	0.69	1.21	5	5
TDS	Mg/L	688.33	534.33	669.33	500	1000
Suspended Solid	Mg/L	0	6	6	-	-
Colour	TCU	0	0	0	15	15
Total Hardness	Mg/L	165.14	106.09	146.13	150	150
Alkalinity	Mg/L	19	48	74	-	-
Iron	Mg/L	0.00	0.00	0.00	0.3	0.3
Nitrate	Mg/L	0.53	3.72	1.59	50	50
Calcium	Mg/L	56.96	41.32	58.16	-	-
Magnesium	Mg/L	23.01	3.0	1.0	-	-
Sulphate	Mg/L	5	5	5	100	500
Phosphate	Mg/L	0.03	0.03	0.11	-	-
Nitrite	Mg/L	0.01	0.0075	0.0045	0.2	3
Sodium	Mg/L	19	16.5	17	200	200
Manganese	Mg/L	0.00	0.50	0.039	0.2	0.5
Potassium	Mg/L	1.34	2.01	5.36	-	-
Dissolved Oxygen	Mg/L	0.48	0.50	0.47	7.5	
COD	Mg/L	142.13	103.09	145.13		-

Jamilu Habu
Laboratory Manage

REGIONAL WATER QUALITY
LAB MINNA.
LABORATORY MANAGER
SIGN
DATE 13/7/2010