# EVALUATION OF DRAINAGE WASTEWATER FOR IRRIGATION FARMS: a case study F.U.T. Minna, Bosso campus main drainage.

BY

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2003/14902EA

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NOVEMBER, 2008.

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A PROJCT SUBMITTED TO THE DEPARTMENT OF AGRICULTURAL AND BIORESOURCES ENGINEERING, FEDERAL UNIVERSITY OF TECHNOLOGY MINNA, IN PARTIAL FUFILMENT OF THE REQUIREMENT FOR THE AWARD OF BARCHALOR OF ENGINEERING (B.ENG.) IN AGRICULTURAL AND BIORESOURCES ENGINEERING.

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## DECLARATION

I sincerely declare that this project work is solely and wholly undertaken and written by me under the strict supervision of Engr. John M. Jiya. Information hereby obtained from published and unpublished work of others have been duly referenced and acknowledged.

18 - 11 - 2008

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## CERTIFICATIONS

I testify that this work has been supervised, read and has meant part of requirement for the award of Bachelor of Engineering (B. ENG) Degree in the department of Agricultural and Bioresources Engineering, Federal University of Technology, Minna Niger State, Nigeria.

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External Examiner DATE

# DEDICATION

This project work is dedicated to my paternal grandparents LATE PA IORLAHA AKWAYA and MAMA HANNAH MNGOUNDU IORLAHA, and maternal grandparents LATE PA IYORKEGH WANGUN and LATE MAMA MARY IYORKEGH WANGUN.

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# ABSTRACT

The project was based on evaluation of drainage wastewater for irrigation farms. the wastewater was found to be highly polluted in almost all its constituents which shows that the wastewater is not good for direct use for irrigation purpose as it will affect the crops irrigated with the water adversely, hence there is need for treatment of the wastewater before use to reduce the constituents of the wastewater to the set standards for irrigation farms.

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# CHAPTER ONE

## 1.0 GENERAL INTRODUCTION

Nigeria and Africa as a continent is presently facing a major food crisis as being reported by the print and electronic media in our daily news, a situation if not properly handled will escalate into farmine. Majority of our farmers depend solely on rain water for cultivation of their crops, because water is an essential criteria for optimum crop growth. Agriculture consumes about 83% of water used from all source including precipitation, farmers hardly engage in dry-season farming as they is hardly adequate water for consumption and other domestic duties talk more of using it for farming during the dry-season.

Every community produces both liquid and solid waste. The liquid portion waste is essentially the water supply of the community after it has been fouled by a variety of uses. It is the liquid waste portion that is known as wastewatèr. Wastewater may be defined as the combination of liquid water carrying waste produce from residence, institutions, commercial and industrial establishment together with such ground, surface water and storm water as may be present (Ayotamuno and Akor, 1994).

Untreated water usually contains numerous pathogenic and toxic compounds, which constitute the following environmental risks:

i. Health hazards; in which diseases are caused by pathogenic organisms in the wastewater.
ii. Nuisance; in which physical characteristics like scum, odors cause a psychological stress in human.

iii. Ecological risk; in which the discharge of effluent in surface water may exceed the surface purification of the recipient water. This is particularly dangerous to the aquatic life.

iv. Agricultural risk; in which toxic compounds in the polluted water can adversely affect the plant irrigated with the water from the recipient streams or water bodies (Arthur, 1993).

In view of this, the immediate and nuisance free removal of wastewater from its source of generation followed by treatment and disposal is not only desirable but also a necessity.

Most developing countries lack effective collection system for domestic and agro industrial waste. This problem will persist in so far as their government refuses to afford environmental sanitation and public health the desired attentions (Agumwamba, 2001).

There is need for effective collection system for drainage wastewater and its ultimate disposal in a receiving water cost in order to:

a. Prevent the pollution of surface and ground water.
b. Reduce the spread of disease caused by pathogenic organisms in the drainage wastewater channel and sewage.

These two reasons are interdependent to the extent that the polluted body of water is a potential and frequently an actual source of infection, particularly in a hot climate (Nigeria inclusive). There is now an increasing awareness of pollution, contamination of the environment is most undesirable in itself and that measures to abate pollution should be viewed from an ecological point rather than merely the improvement they make to the human condition (Mara, 1986).

The treatment of wastewater therefore is to improve its quality, and good quality water for house hold and other agricultural purposes must be free of harmful bacteria, sediments, objectionable minerals, taste, odor etc. (Adeoye, 2006).

These treatment are done for

i. Excessive mineral content, hardness in particular.
ii. Acidity
iii. Objectionable odors
iv. Sediments removal
v. Contamination.

Wastewater management is therefore defined as the control of wastewater generation, collection, transfer and transportation, processing and disposal activities based on engineering principles at minimum environmental impacts and cost. The ultimate goal of wastewater management is the protection of the environment in a manner to commensurate with public health, economic and social concerns.

## 1.1 DRY-SEASON FARMING (IRRIGATION)

Irrigation may be defined as the application of water to soil for the purpose of supplying the moisture essential for plant growth. Irrigation plays a vital role in increasing crop yields and stabilizing production. In arid and semi-arid regions, irrigation is essential economically viable agriculture, while in semi-humid and humid areas. It is often on a supplementary basis.

### 1.1.1 IRRIGATION METHODS.

Many different methods are used by farmers to crops. They range from watering individual plants from a can of water to highly automated irrigation by a centre pivot system. However, from the point of wetting the soil, these methods can be grouped under five headings, namely:

i. Flood irrigation; water is applied over the entire field to infiltrate into the soil (e.g wild flooding, contour flooding, borders, basins e.t.c)

ii. Furrow irrigation; water is applied between ridges (e.g level and graded furrows, contour furrows, corrugation, e.t.c ) water reaches the ridges, where the plant roots are concentrated, by capillary action.

iii. Sprinkler irrigation; water is applied in the form of a spray and reaches the soil very much like rain(e.g portable and solid set sprinklers, travelling sprinkler, spray guns, centre- pivot system, e.t.c). The rate of application is adjusted so that it does not create ponding of water on the surface.

iv. Subsurface irrigation; water is applied beneath the root zone in such a manner that it wets the root zone by capillary rise (e.g subsurface irrigation canals or buried pipe, e.t.c). Deep surface canal or buried pipes are used for this purpose.

v. Localized irrigation; water is applied around each plants so as to wet locally and the root zone only (e.g. drip irrigation, bubblers, micro-sprinkler e.t.c). The application rate is adjusted to meet evapo-traspiration needs so that percolation losses are minimized.

## 1.2 WASTEWATER TREATMENT AND MANAGEMENT STATUS IN NIGERIAN UNIVERSITIES.

Wastewater collected from municipalities and communities must ultimately be returned to its source or to the land. It is however unfortunate that Nigeria has not clearly established effluent standards to ensure that the streams and water courses do not become unsuitable for their present uses. In recent times, industrial development and the growth of cities in the country has led to increased rate of pollutant discharges into our water courses (Ojukwu, 1996). The uses of the water courses (river and stream) include fishing, irrigation, cattle grazing, laundry and recreation. Most towns, communities or industries in Nigeria and developing countries consider treating their wastewater as a wasteful venture. Hence it is very convenient to dispose its wastewater from communal premises without paying attention to its toxic effect on our agriculture land or level of pollution. However, some higher institutions in Nigeria have over the years being involved in establishing or constructing wastewater treatment plants which are being improved upon. Some of these higher institutions are: Ahmadu Bello University (A.B.U) Zaria, Kaduna state. University of Nigeria Nsukka, Enugu state. Obafemi Awolowo University Ile- Ife, Osun state. (Agumwanba, 2001)

## 1.3 STATEMENT OF PROBLEM

The use of wastewater for irrigation was first practice in Ancient Athens in mid 19$^{th}$ century without regards to unpleasant condition produced at the farmland (Horan 1990). This was the only way to its disposal. In most developing countries (Nigeria inclusive), farming system depend solely on rainfall, which restrict production of food only during the rainy season, where as the population and the demand of this food is on the increase, a typical example of which most of the Africans countries including Nigeria is experiencing food crisis as reported by This day newspaper dated June 8 2008.

The need for waste stabilization pond for Bosso campus of Federal University of Technology Minna is a challenge that should be face with all seriousness. The method of allowing wastewater to flow in open drains and to be discharged into the environment pose a risk to the resident of the community.

Untreated wastewater discharged into the environment are stagnant and provide a favorable breeding place for mosquitoes, which are agent for transmitting diseases such as malaria, dysentery, diarrhea and related aliment.

The problems associated with the use of domestic wastewater which are mostly in open drains for dry season farming (irrigation) include:

1. Assessment of its pollution potential in order to establish the likely effects of discharge on receiving farmland.

2. The type and degree of treatment, which would be required in order to render the wastewater harmless.

3. Assessment of strength and flow rate in order to levy the discharge with an appropriate treatment charge.

4. Design of storage reservoirs to assure necessary treated domestic wastewater effluent.

Therefore, there is the urgent need to address some of the problems for the successful implementation of the project. The treatment method should produce an effluent with a quality that meet established guidelines, but with the minimum operational and maintenance requirements. In this respect, waste stabilization ponds are superior to conventional processes (Mara 1986).

As simpler a wastewater treatment process is, the greater the likelihood that the re-use scheme will be successful provided the system is properly managed.

## 1.4 AIM AND OBJECTIVES

This project is aimed at proffering water supply problem to the university community for dry season farming. It is also aimed at seeing the best treatment method of wastewater from the major drainage that passes through the Bosso campus that will be collected at a point (pond).

The objectives of the project work include:

1. To evaluate the constituent composition of drainage wastewater within the area of study.
2. To determine the bacteriological pathogenic parameters in the influent domestic wastewater.
3. To determine the best treatment method for the wastewater to make it suitable for dry season farming.
4. To make recommendation on the types of crops that can produce optimally with the quality of effluent.

## 1.5 PROJECT SCOPE

In this project, a waste stabilization pond will be designed for the treatment of drainage Waste water and supply for dry-season farming so as to boost food production for the host community. For the purpose of this work, the wastewater to be use is from the main drainage that passes through the school (Federal University of Technology Minna, Bosso campus.)

# CHAPTER TWO

## 2.0 LITERATURE REVIEW

### 2.1 INTRODUCTION

Wastewater collected from municipalities and communities must ultimately be returned to their receiving waters or to the land. Although the collection of storm water from drainages dates back from ancient times, the collection of wastewater can only be traced to the early 18$^{th}$ century. The systematic treatment of wastewater followed in the late 80's and early 90's. The development of Germ theory by Koch and Pastuer in the latter half of the 19$^{th}$ century marks the beginning of the new era in sanitation (Metcalf and Eddy, 1979). Before that time, the relationship of pollution to disease had only been faintly understood, and the signs of bacteria, than in its infancy, had not been applied to the subject of wastewater treatment.

In the United States, the treatment and dispose of waste water did not receive much attention in the late 80's because the extent of the nuisance caused by the discharge of untreated waste water into the relatively large bodies of water (compared to those in Europe) was not severe, and because large areas of land suitable for disposal were available. By the early 90's however, nuisance and health conditions brought about an increasing demand for more effective means of wastewater management (Agumwanba, 2001). The impracticability of procuring sufficient areas for disposal of untreated wastewater on land, particularly for large cities, led to adoption of more intensive methods of treatment.

With the new approach to treatment and disposal of wastewater, there exit a marked difference in wastewater disposal between communities in developed countries and those of the developing once. In the developed countries, wastewater effluents such as domestic, industrial and agricultural are discharged through sewers, but in developing countries like Nigeria, wastewater effluents is discharged untreated with disease carrying organisms and toxic chemicals through open drainage with acute health effects. Untreated municipal wastewater can be harmful to the environment in several ways as micro-organisms can spread diseases. Decomposition of organic materials can cause oxygen depletion in lakes or sea resulting into releasing of foul smelling gases and the nutrients in the wastewater also contribute to eutrophication (W.H.O. 1999).

In the developed countries, there are centralized wastewater system and sewers are connected to common treated plants were they are treated to meet international quality standards before being disposed into the environment as a secondary effluent. Ayotemuno and Akor. (1994) acknowledged this fact using Rio De Genero city, which is up to eleven million people, the second largest metropolitan city in Brazil as an example. Also waste management in developed countries is undertaken by implementing sound environmental strategies and technical expertise such as environmental and wastewater management at national, regional and local levels along the local initiatives (Hambraeeus, 2002).

In contrast to the wastewater management in the developed countries, the wastewater management in several countries is determined by other prevailing factors of governance, bad regulatory and economic policies, inappropriate technologies, insufficient knowledge and information. Poor governance (i.e. exercise and the sharing of power) is a major constraint to effective municipal wastewater management. In most undeveloped country cities, municipal government lack institution capacity to carry out effective municipal planning and waste management and to routinely provide effective sewage and drainage services (Agumwanba, 2000). Poor co-ordination of public infrastructure at different levels of government causes the failure of most government to provide insufficient education or to include community and private sector participation in the design, planning and or implementation of sewage and drainage services (Masor, 2003).

An obvious problem facing the developing countries in promoting better sanitation is to identify and to provide appropriate technology for wastewater management (Ogunrobi and Onuona, 1986). In the poorer countries of the world, especially in the humid tropical regions, Nigeria inclusive, with the exception of some countries in the South East Asia, improvement in wastewater management have been quite slow.

## 2.2 WASTE WATER AND ITS COMPOSITION

Wastewater is defined as any water that has been adversely affected in quality by anthropogenic influence which comprises of liquid waste discharge by domestic residences, commercial properties, industries and agriculture. It encompasses a wide range of potential contaminants and concentrations. In the most common usage, it refers to the municipal wastewater that contains broad spectrum of contaminants resulting from the mixture of wastewater from different sources (Bratty, 1993).

Fresh wastewater is a gray turbid liquid which has an earthly but offensive odor. It contains largely floating or suspended solids (such as rags, plastics containers, maize cods e.t.c) smaller suspended solids such as (paper, vegetable peels e.t.c) and small solids in colloidal i.e. non settleable suspension, as well as pollutants in true solution is objectionable in appearance and extremely hazardous in content, mainly because of the number of diseases-causing (pathogenic) organisms it contains (Mara, 1986). In the hot climate areas wastewater can soon lose its content of dissolved oxygen and so become stale or septic. Septic wastewater has the most offensive odor usually of hydrogen sulphide.

According to Metcalf and Eddy (1979), composition refers to the actual amount of physical, chemical and biological constituents in wastewater.

## 2.3 PHYSICAL COMPOSITION OF WASTEWATE

The most important physical characteristics of wastewater are its total solid content, which compose of floating matter, settle able matter, and colloidal matter in solution. Other important physical characteristics include: odor, temperature, colour.

### A. TOTAL SOLIDS

Analytically, the total solid content of a wastewater is defined as all the matter that remain as residue upon evaporation between103$^{0c}$ to 105$^{0c}$, matter that has a significant vapor pressure at this temperature is lost during evaporation and is not defined as solid (Meltcalf and Eddy, 1979). Settleable solids are those solids that will settle at the bottom of a cone shaped container (called an inholf cone) in a 60 minute period, settleable solids are an approximate measure of the quantity to sludge that will be removed by primary sedimentation.

### B. ODOR

Odor in domestic wastewater is usually caused by gases produced by the decomposition of organic matter or by substances added to the wastewater. Fresh wastewater has a distinctive, somewhat disagreeable odor, which is less objectionable than the odor of wastewater that has undergone anaerobic (devoid of oxygen) decomposition (Meltcalf and Eddy, 1979). The most

## 2.4 CHEMICAL COMPOSITION OF WASTEWATER.

The chemical constituents that make up the chemical composition of wastewater include: organic matter, inorganic matter and gases.

**Organic Matter.**

In a wastewater of strength, about 75% of the suspended solids and 40% of the filterable solid are organic in nature. These solid are derived from both the animals and plant kingdoms and the activities of man as related to the synthesis of organic compounds. Organic compound are normally composed of a combination of carbon, hydrogen and oxygen together with nitrogen in some cases. Other important elements such as sulphur, phosphorous and iron may also be present. The principal groups of organic substances found in wastewater are proteins, carbohydrates and fats. Urea, the chief constituent of urine, is another important organic compound contributing to wastewater. Because it decomposes so rapidly, un-decomposed urea is seldom found in other than very fresh wastewater (FAO, 1992).

Along with the proteins, carbohydrate, fats and urea, wastewater contains small quantities of a large number of different synthetic organic molecules ranging from simple to extremely complex structures. Typical example includes surfactants, organic priority pollutants, volatile compounds, and agriculture pesticides.

**Inorganic Matter.**

The inorganic constituent of wastewater is composed of chlorides, heavy metals, nitrogen, PH, phosphorus, sulphur, alkalinity and priority pollutant. 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 geological formation with which the water comes in contact and by the wastewater, treated or untreated that are discharge to it (FAO, 1992). Wastewaters with the exception of some industrial waste are seldom treated for removal of the inorganic constituents that are added to the circle, concentration of inorganic constituents are also increased by the natural evaporation process, which removes some of the substances in the water and leaves the inorganic substances in the water. Because the concentration of various organic constituents can greatly affect the beneficial uses of the waters, it is well to examine the nature of some of the constituents, particularly those added to the surface water.

**Gases**

Gases are mostly found in untreated wastewater. The gases commonly found in untreated wastewater include; nitrogen ($N_2$), oxygen ($O_2$), carbondioxide ($CO_3$), hydrogensulphide($NH_3$) and methane($CH_4$) (Metcalf and Eddy, 1979). The first three are common gases of the atmosphere and will be found in all waters exposed to air. The latter two are derived from the decomposition of the organic matter present in wastewater.

Although the constituents that make up chemical composition of wastewater are stated above, the category that are of primary importance in both the design and operations of wastewater treatment plants and the management of water quality is the organic content. The concentration of organic matter is expressed in terms of the amount of oxygen required for its oxidation (BOD and COD).

According to UN Department 1990, wastewater are usually treated by supply them with oxygen so that bacteria can utilize the waste as food. Basically, there are three ways of expressing the oxygen demand of wastes:

**Theoretical Oxygen Demand (ThoD).**

This is the stoichiometric amount of oxygen required to oxidize the organic fraction of a sample (Agunwamba, 2001). It is the theoretical amount of oxygen required to oxidize the organic fraction completely to carbondioxide and water (UN Department 1990). Wastewater is usually so complex in nature that the ThoD cannot be calculated in practice, it is approximated by the chemical oxygen demand (COD).

**Chemical Oxygen Demand (COD)**

The chemical oxygen demand of the wastewater is a measure of the oxygen equivalent of the organic matter susceptible to oxidation of a strong chemical oxidation. (Agunwamba, 2001). This is obtained by oxidizing wastewater with a boiling acid Dichromate solution. This process oxidizes almost all organic compounds to carbondioxide and water, the reaction usually process to more than 95% completion (Mara, 1986).

**Biological Oxygen Demand (BOD)**

According to Agunwamba, (2001), Biological Oxygen Demand is the measure of the Oxygen required to break down organic matter by micro organism for a period of five days at $20^0$c. It is also a measure of the concentration of biodegradable organic matter in a wastewater usually expressed on a five day, $20^0$c basis for convenience, because $BOD_5$ is easier to measure than ultimate BOD (BODu) (Mara, 1986).

## 2.5 BIOLOGICAL COMPOSITION OF WASTEWATER

The biological constituents of wastewater composed of bacteria, viruses, algae and protozoan. The biological wastewater treatments depend on the activities of micro-organism.

## Bacteria

Bacteria are single celled prokaryotic eubacteria. Most bacterial can be grouped into four general categories: Rod, Spheroid, Curved Rod or Spiral and Filamentous (Metcalf and Eddy, 1979).

According to Mara (1986), bacteria are usually classified in one of the following tributes according to the range in which their optimum temperature occurs: psychrophilis < 20°c, Mesophilis 20-45 °c, thermophilis >45 °c.

The bacterial of importance in the aerobic treatment of sewage are the rod shaped and for facultative are mesophilic. It is important to know that they are excellent oxidizers of dead organic matters (Saprophytes) that grow extremely well in sewage. They are all capable of exuding a slummy fluculent layer which in some treatment unit (eg. activated sludge) is an important mechanism in the treatment process (Mara 1986). Coliforms and intestinal bacterial do not play any significant role in the sewage treatment processes: they are merely passengers in the system.

## Virus

Viruses are obligate parasitic particles consisting of a strand of genetic material deoxyribonucleic acid (DNA) or ribonucleic acid (RNA) with protein coat (Metcalf and Eddy, 1979).

Viruses are peculiar micros in that they do not directly use organic or inorganic compounds i.e. they do not have the ability to synthesis new compounds) during growth: they reproduce by invading a host cell whose reproductive processes they redirect to manufacture more virus particles (Mara, 1986). They are extremely small (about 0.02-0.2 um long) and when they behave as stable chemicals molecules and thus can remain inactive for many years.

## Algae

Algae are mostly multicellular photosynthetic organisms, which are extremely varied in their shapes and sizes (Mara, 1986). Carbondioxide is used as the source for the synthesis of new cell and oxygen evolved from the water by the classic mechanism of plant photosynthesis.

$$6CO_2 + 12H_2O \xrightarrow{light} C_6H_{12}O_6 + 6H_2O + 6O \text{---------} (1)$$

Algae can be a great nuisance in surface waters because, when condition are right, they will rapidly reproduce and cover streams, lake and reservoirs in large floating colonies called blooms. Algae blooms are usually characteristically of what is called a eutrophic lake, or a lake with high content of the compounds needed for biological growth. Because effluent from wastewater treatment plants are usually high in biological nutrients, discharge of effluents to lakes cause enrichment and increases the rate of eutrophication (Athur, 1998).

## Protozoa

Protozoa are single celled eucaryotic micro-organism with cell walls. The majority of protozoa are aerobic or facultative anaerobic chemotrophs. The protozoa of importance in wastewater engineering include amoebas, flagellates, and free-swimming and stalked alliates. Protozoa feed on bacteria treatment processes and in the purification of streams because they maintain normal balance among the different groups of micro-organism (FAO, 2002)

## 2.6 WASTEWATER MANAGEMENT

Wastewater management is defined as the control of wastewater generation, storage, collection, transfer and transportation, processing and disposal activities based on engineering principal at minimum environmental impacts and cost. The ultimate goal of wastewater management is the protection of the environment in a manner to commensurate with public heath, economic and social concern.

There are three constituents and inter-related aspects of wastewater management. These include: wastewater collection, wastewater treatment and wastewater re-use.

### 2.6.1 WASTEWATER COLLECTION.

It is necessary that wastewater be initially collected at a point before treatment commences. The collection of the domestic wastewater is best achieved by full sewerage (water-carriage) system.

Wastewater conveyed in pipes known as sewers from its place of production to its place of treatment and disposal. Except when sewage is treated, septic tank which is situated close to the house or houses where the sewage emanates, the pipe network, which comprises the retention and trunk sewers, is usually considerable during hot climates by having separate or dual sewage system or sanitary sewers, which carry only storm water (Agumwanba, 2001).

### 2.6.2 WASTEWATER TREATMENT.

Treatment is the required principal to destroy pathogenic agents in the sewage and ensure it is suitable whatever re-use process is selected for it. Wastewater may contain pathogenic organism, organic and nutrients. Hence wastewater must be treated before discharge in order to prevent pollution of the surface and underground water sources. Wastewater exerts biological oxygen demand in rivers, which depletes oxygen thereby starving aquatic organism of oxygen. Besides being rich in nutrients (mainly nitrogen and phosphorous) wastewater is generally treated by supplying it with oxygen so that bacteria may utilize the waste as food (Agunwamba, 2001).

Wastewater treatment is a combination of physical and biological processes which, occasionally chemical processes are additionally employed. The common physical process is screening and the removal of grit and organic suspended soils by sedimentation. Biological process involves the agency of bacteria and algae and constitutes, by far the most important methods of wastewater treatment particularly in hot climates. Chemical processes are not now in common use, although considerable interest is being shown in physiochemical reclamation of drinking water from sewage effluent (Vladimir, 2000).

Agunwamba, 2001 summarized the objectives of wastewater treatment as

(i). Reduction of biochemical oxygen demand

(ii). Reduction of suspended solids.

(iii). Destruction of pathogens.

(iv). Removal of nutrients .

(v). Removal of non-biodegradable compounds

(vi). Removal of toxic compounds.

(vii). Removal of dissolved solids.

**2.6.3 WASTEWATER RE-USE**

The responsible re-use of sewage effluent in agriculture and crop irrigation can make a significant contribution to community food supply and hence its general social development. Industrialized countries may afford to waste the nutrients in sewage effluent, but tropical developing countries generally cannot.

Domestic sewage is usually considered an actual or potential pollutant, but in many societies, it is in fact a scarce resource (Mara, 1986). In order to prevent the pollution of surface waters, treated wastewater is used to produce some tangible and beneficial end product. The principal rule for economic re-use of sewage effluents is in protein production either as irrigation water or by stimulating the growth of algae and fish

Effluent from sewage treatment plants are often used in irrigation especially in advanced countries (Barton and Ariosonoff, 1987; Agunwamba, 2001). The advantages of such re-use include water conservation; by re-use, portable water can be conserved for alternative uses; lower income generated farmers who cannot afford organic fertilizers for their farm for more than one season, thereby increasing production of a variety of food and reduce environmental pollution. However, such effluents re-use may be associated with the risk of transmission of communicable diseases, accumulation of toxic chemicals in foodstuffs and salt in soil; and pollution of surface and underground water sources.

### 2.6.3.1 EFFLUENT RE-USE

It is generally impossible to re-use waste-water completely or indefinitely. The need to conserve valuable water resources by effluent re-use arises from the general scarcity of water in the tropics and the high costs of developing new water supplies.

Effluents re-use may be classified according to use as

1. Municipal
2. Industrial
3. Agricultural
4. Re-use in aquaculture
5. Recreational
6. Ground water recharge

**Municipal**

Direct re-use of treated water as drinking water, after dilution in natural waters to the maximum possible extent and after coagulation, filtration, and heavy chlorination for disinfections is practicable on an emergency basis (Metcalf and Eddy, 1979).

An effluent which has received tertiary treatment is suitable for watering municipal parks and golf courses. It is often cheaper to use effluent for these purposes than fully treated water meant for drinking.

Effluents can also be used in municipal fish ponds to replace evaporation loses and provide nutrients (Mara, 1986).

**Effluents re-use in Industries**

The use of wastewater in industry is often practiced as a means of minimizing cost of water, the most common example being the serial re-use of the wastewater of one process as cooling water to another. For example, in the brewery, water used for cooling is in most cases recycled and water from washing operations in the cold rooms may find its application as first wash water for other processes. Some effluents of fairly clean character have been used as cooling water, but this practice is not widespread in cooling towers (Mara, 1986).

**Effluents re-use in Agriculture**

This is mostly restricted to crop irrigation. Stock watering is not recommended because of health risks to animals. Two major considerations, which govern the suitability of an effluents for irrigation are the chemical quality and the potential risk to public can best be protected by restricting irrigation with wastewater to certain crops, so that wastewater will not come in contact with any part of a plant used as food for man, particularly if eat uncooked. Broad irrigation of fruit bearing tree is usually safe, where as spray irrigation is not. It is therefore ésirable to restrict wastewater to crop used for folder and industrial purposes. If folder crops or ıasture are so irrigated, there is risk that cattle will be infected with larvae of the beef tapeworm. eania saginata (WHO, Geneva, 1978).

Irrigation areas should be farmed in one unit to which only trained workers have access. Jnder no circumstance should such area be in the hands of small holders, where dual system of water supply pipe would be necessary. Sooner or later cross connections would occur, or children would drink from the wrong tap (Watson, 1992). Raw wastewater should not be used for irrigation because of health risks associate with those working on such irrigation schemes and the general public that may consume the produce. Using treated effluent rather than raw wastewater will best protect the health of farm workers. And risk of public is best minimized by restricting the use of treated effluent to the irrigation of industrial hand folder crops. Raw Effluent should never be used to irrigate crops that are eaten raw.

**Effluent re-use in Aquaculture.**

Aquaculture means the growing of plants and animals in water for their eventual harvesting as food, either for man or domestic animals. The dense algal blooms in waste stabilization ponds do not only provide oxygen for the bacteria oxidation of the effluent wastewater, they are also available food source being approximately 50 percent protein (Mara, 1986). The growth of algae in ponds is a highly efficient process with protein yields far in excess of those commonly found in conventional agriculture. The algae may be harvested from maturation pond effluent and then used as an animal food supplement. Sewage-grown algae have been successfully fed to chicken, pig, cattle and sheep (McGarry, 1978), which is harvested by one several tertiary treatment processes.

n the developing countries where tertiary treatment process are expensive, algae protein in :e stabilization pond is most conveniently exploited by growing algae eating fish in the .ıration pond (Hey,1983 and Knapp, 1977). The tilapia is particularly tolerant of high sities, grows extremely well in maturation pond. Other fish which have been grown in uration ponds include carp (cattla cattla), laboe loluta (frontispiece), channel catfish alurus punctatus) and mosquito fish (gambusia spp). Fish yield particularly of tilapia ·otherodem mossambia) may be increased by the introduction of sterile hybrids, but this uires the expert attention of an experienced farmer (Hicking, 1978).

**:creational re-use**

Golf course and park watering, establishment of ponds for booting, recreation and intenance of fish or wild life pond are methods for the recreational re-use of treated water. e use of treated effluent for park watering has been practiced for many years in developed .intries. The dam tee project in San Diego is an example of recreational re-use of wastewater in ming some series of lakes, suitable for boating, fishing, and other recreational purposes !errel, 1967).

**·ound Water Recharge**

Ground water recharge is one of the most common method of combining water re-use and iluent disposal recharge has been use to replenish ground water supplies in many areas. The fluent from the Witter narrowly operated by the Los Angeles county sanitation district is use r replenishment of the ground water table in Rio Hando river basin. In New York, California ıd other coastal areas, rapid development of industry and increase in population has caused the ›wering of the ground water, resulting in salt water intrusion into the fresh water aquifers.

Treated effluent is used to replenish the ground water to stop this intrusion. Another possible effluent used in the recharging of oil-bearing strata (Meltcalf and Eddy, 1976)

From one process of pond to the next and the soil should preferable be impermeable.

## 2.7. WASTE STABILIZATION POND

A waste stabilization pond is a complex biological ecological system in which the wastewater is treated by natural processes based on combined activities and cooperation of both bacteria and algae (Ogunrombi, 1986). They are large shallow basin dug on the earth for the organic and pathogenic bacteria and intestinal parasite than the conventional treatment plant (Mara, 1983), it is more economical (Arthur, 1983). It is both simple to construct, operate and maintain and does not require any input of external energy. It also requires large land area because of its long detention time, which is attributed to its complete dependence on natural processes and its efficiency depend on the availability of sunlight and high ambient temperature (Agumwamba, 2001).

Waste stabilization ponds are one of the most appropriate extensive wastewater treatments methods to reduce pathogens. Low operation and maintenance cost coupled effective pathogen removal has made waste stabilization pond widely employed all over the world, particularly in developing countries were sufficient land is normally available and climate is more favorable for their operation (Mara and Pearson, 1998)

In addition to being useful in the treatment of wastewater, waste stabilization ponds are applied in the treatment of industrial and agricultural waste. Its long detention time: and its physiochemical condition such as neutrality to alkaline, pH make it attractive in treating industrial wastewater.

Waste stabilization pond have considerable advantages (particularly as regarding it being most effective and least expensive method of wastewater treatment) in the hot climate over all other methods (Mara, 1986). These advantages include;

1. They can achieve any required degree of purification at the lowest cost with the minimum of maintenance by unskilled operation.
2. The removal of pathogen is considerable greater than that in other method of sewage treatment.
3. They are as well able to withstand both organic and hydraulic shock load.
4. They can effectively treat a wide variety of industrial and agricultural waste.
5. They can easily be design so that the degree of the treatment is readily altered.
6. The method of construction is such that should at some future date the land may be required for some other purpose, it is easily reclaimed.
7. The algae produced in the pond are a potential source of high protein food which can be conveniently exploited by fish farmers.
8. Pond requires no power use.
9. They are constructed in earthen basins.
10. They generate very slight sludge.

In general, waste stabilization ponds are the cheapest method of wastewater treatment in developing countries were land is not a problem.

The major disadvantage of waste stabilization pond is that they require much larger areas of land than other form of sewage treatment.

### 2.7.1 TYPES OF WASTE STABILLIZATION POND

Waste stabilization ponds are usually classified according to the nature of the biological activities taking place. Other criteria of classification include the type of effluent (untreated, screened, settled or activated sludge influent); pond overflow condition and methods of oxygenation (Agunwamba, 2001). In terms of biological activities, pond are classified as aerobic, facultative, and maturation pond.

### A. ANAEROBIC POND

Anaerobic ponds (2-5m deep), devoid of dissolved oxygen and age certain little or no algae. They are usually suitable for the treatment of strong wastewater (BOD5 >300 mg/l) and those containing high concentrations of suspended solids (SS>300mg/l). (Mara, 1983). Anaerobic ponds remain anaerobic throughout their depths except for an extremely shallow surface zone.

Anaerobic ponds receive wastewater with high organic loads (i.e. usually greater than 3000kg/ha.day for a depth of 3m). The BOD removal is achieved by sedimentation of solids and subsequently anaerobic digestion in the resulting sludge (Kayombo, 1998). The anaerobic bacteria are usually sensitive to a PH < 6.2 thus, acidic wastewater must be neutralized prior to its treatment, an aerobic pond function essentially as open septic tanks. The settle able solids in wastewater settle to form a sludge layer, where acidiogenic and methangenic bacteria are the temperature above 15% digest them anaerobically. An aerobic pond can achieve over 60% BOD removal (Agunwumba, 2001).

Maintenance of anaerobic ponds involves scum removal and spraying with clean water or biodegradable insecticides for control of fly breeding.

## B. FACULTATIVE PONDS

Facultative ponds are ponds that are designed principally for BOD removal of 60-80% with dept of 1-2m. Facultative pond can receive more waste as influent in which case it is called a primary facultative pond. If the influent is from an anaerobic pond or an inhoff tank, it is called secondary facultative pond. BOD removal in both types of facultative ponds is through aerobic bacterial oxidation of non settleable organic compounds, together with the solublelize product of anaerobic digestion (Aguwumba, 2001). Its been estimated that 30% of the influent BOD leaves the primary facultative pond in the form of methane (Marais, 1970). A high proportion of the BOD that does not leave the pond as methane ends up in Algae. This process requires more time, more land and possibly 2-3 weeks water retention time other than 2-3 days in the anaerobic ponds. In the secondary facultative ponds (and the upper layers of the primary facultative ponds) sewage BOD into "algae" BOD, and has implication for effluent quality requirement (Kayombo 1998). About 70-90% of the BOD of the final effluent from the series of well design waste stabilization pond is related to the algae they contain.

## C. MATURATION PONDS

The maturation pond usually follows the facultative ponds in series. It is used as a second stage to facultative pond, with a depth ranging from 1.1m to 2m. It is principally design for removal or destruction of pathogens (Aguwamba 2001). It is usually less stratified biologically and physiochemical and as well oxygenated throughout the day.

Although maturation pond achieve only a small degree of BOD removal, their contribution to the nutrient removal can be significant. The algae population in maturation pond is much more diverse than that of the facultative pond, with non-motile genera tending to be more common (Mara, 1986).

Maturation ponds are primarily for the treatment of soluble organic waste and effluent for wastewater treatment plant. They also determine quality of the final effluent.

## 2.8. FACTORS AFFECTING THE OPERATION OF WASTE STABILIZATION PONDS

The processes occurring in waste stabilization pond are entirely natural processes involving both algae and bacterial actions. Since this processes are unaided by man (who merely allocate a place for their occurrence), there is need to know the favorable factors which keep in the effective operations of the ponds. The factors affecting the operation of waste stabilization pond are as follows:

### 2.8.1 MIXING

The degree of mixing occurring within a pond is influenced by two factors: wind and heat. the vital function that mixing fulfils in stabilization ponds are:

1. To minimize hydraulic short circulating and the formation of stagnant regions.
2. To ensure a reasonable uniform vertical distribution of BOD, algae and oxygen.
3. It serves as the only means by which the large number of non-motile algae can be carried up to the zero of effective light penetration, known as the "photic" zone: the phonic comprises only the top 150 -300mm off the pond.
4. It is also responsible for the transportation of the oxygen produced for the photic zone to the bottom layer of the pond and increases the safe BOD load that can be applied to a pond. The distance the wind comes in contact with the water determines the depth to which wind induced mixing is felt. About 100m unobstructed contact length is required for maximum mixing by the wind action.

### 2.8.2 OXYGEN

Re-aeration through the surface supplies some of the oxygen required to keep the upper layers aerobic. Most of this oxygen is supplied by the photosynthetic activities of the algae. They grow naturally in the pond were considerable quantities of both nutrients and incident light energy are available, the pond bacterial utilize this algae oxygen to utilize the organic wastewater.

### 2.8.3 SLUDGE LAYER

As the wastewater enters the pond, most of the solid settle at the bottom to form a sludge layer. Intense anaerobic digestion of the sludge solids occur at a temperature greater 150°c. as a result, the thickness of the sludge is rarely more than 250mm. De-sludging is required rarely about once in 10-15 year. Evolution of methane gas at temperature over 22°c is sufficiently rapid to buoy sludge particles to the surface were drifting sludge particles must be removed with the floating scum, to ensure steady penetration of light into the photic zone. The soluble product of fermentation diffuses into the buck liquid of where they are further oxidized.

### 2.8.4 DEPTH

Depth below 1m must be avoided as otherwise a pond becomes a breeding ground for mosquitoes and midges and do not prevent the emergence of vegetation. For depth greater than 1.5m, the pond is predominantly anaerobic and this is undesirable as unacceptably low factor of safety in normal operation are to be less able to cope with a fluctuating sludge or a sudden sludge of heavy pollution.

### 3.3 SAMPLE IDETIFICATION.

To identify and locate samples easily, all samples carried self adhesive labels. These were affixed on the sample bottles instead of the cover to prevent lost or misplacing, causing sample mix-up. The information carried on the sample label includes; location, date and time.

### 3.4 EXPERIMENTAL PROCEDURE

#### 3.4.1 DETERMINATION OF PHYSICAL PARAMETERS OF WASTEWATER.

##### 3.4.1.1 pH DETERMINATION.

The pH of the effluent sample was determined using the HACH MODEL EC10 portable pH/mv/temp Meter.

The model EC10 features a custom digital LCD display the pH measurement. This meter has all the features of a simple pH meter plus multivolt mode, sealed keypad, electrode holder, tilt strand, ergonomic design and battery/ line power.

The required MODE was selected using the keypad. The meter electrodes were rinsed with distilled water and the pH electrode probe was immersed into the sample contained in the beaker. The display was allowed to settle and the result was read.

##### 3.4.1.2 ELECTRICAL CONDUCTIVITY DETERMINATION.

The electrical conductivity of the effluent sample was determined with a HACH MODEL CO150 conductivity meter. This meter features a micro processor design which automates complicated and time-consuming calibration and measurement procedures for a wide variety of applications. Water quality, salinity, acids, bases and other samples can be easily analyzed or conductivity with the available conductivity probes.

The conductivity meter was pressed to conductivity mode. The probe was rinsed with distilled water and inserted into the sample contained in a beaker, while the display was allowed to stabilize before recording measurements.

### 3.4.1.3 TURBIDITY DETERMINATION.

Turbidity was determined by Nepheleiometric method. Turbidimeter consist of a Nephelometric with a light source for illuminating the sample and one photoelectric detector, a read out device to indicate intensity of light scattered at 900 to the path of incident light.

The sample was thoroughly shaken to allow air bubbles disappear. The shaken sample was poured into turbidimeter tube and immersed into an ultrasonic bath for two seconds, causing complete bubbles release. Turbidity was read directly from the instrument scale as Nepheiometric Turbidity Units (NTU).

### 3.4.1.4 TOTAL DISSOLVED SOLID DETERMINATION.

A well mixed sample was filtered through a standard glass fibre and the filtrate was evaporated to dryness in an already weighed dish and dried to constant weight at 180c. The increase in dish weight represents the total dissolved solids.

The sample was stirred with a stirrer and pipette, 60ml was measured into a glass fibre. Then, wash with three successive 10ml volumes of reagent-grade water allowing complete drainage between washings and continue suction for about three minute after filtration was completed.

Total filtrate (with washings) was transferred into a weighed evaporating dish and evaporated to dryness on a steam bath. Dry for about 1 hour in an oven at 180$^{oc}$, cool in a desicator to balanced temperature and constant weight.

$$\text{Total dissolved solids} = \frac{(Y-Z) \times 100}{\text{25ml of sample volume}} = \text{mg/l}$$

Where Y = weight of dried residue + dish

Z = weight of dish.

### 3.4.1.5 TOTAL SUSPENDED SOLID

A well mixed sample was filtered through an already weighed standard glass fibre filter and the residue retained on the filter was dried to a constant weight at 105$^{oc}$. The increase in weight of the filter represents the total suspended solids. The sample was stirred with a stirrer and while stirring 25ml of the sample was pipette into a glass-fibre filter. Wash with three successive 10ml volumes of reagent-grade water and allow complete drainage between washings, and continued suction for about three minute after filtration was completed. The filter was carefully removed from filtration apparatus and transferred into stainless steel. Dry for about 1 hour at 105$^{oc}$ in an oven, cool in a desicator to a balanced temperature and constant weight.

Total suspended solids = $\frac{(Y-Z) \times 100}{25ml \text{ of sample volume}}$ = mg/l

Where Y = weight of filter + dried residue

Z = weight of filter.

### 3.4.1.6 TOTAL HARDNESS.

The plastic measuring tube was filled with the wastewater sample to be tested and the contents were then poured into a mixing bottle. Three drops of buffer solution were added into the mixing bottle and was swirled followed by a drop of Maver hardness indicator solution. EDTA (ethylene-diamine-tetra-acetic acid) titrant was then added to the solution in the mixing bottle drop by drop. The bottle was swirled at each drop and each drop of the EDTA titrant added into the mixing bottle was counted. The addition continued until a color change from pink to blue was seen or noticed. The hardness in mg/l as calcium carbonate ($CaCO_3$) is equal to the number of drops EDTA titrant required to bring about color change multiplied by 20.

### 3.4.1.7 CALCIUM HARDNESS

The plastic measuring tube was filled with the wastewater sample to be tested and contents of the tube were then poured into mixing bottle followed by addition of 8N potassium hydroxide. A clipper was used to open calver calcium indicator powder pillow which was added into the solution in a mixing bottle. EDTA (ethylene-diamine-tetra-acetic acid) titrant was then added to the solution in mixing bottle drop by drop. The bottle was swirled at each drop and each drop of EDTA titrant added into the mixing bottle was counted. The addition continued until a color change from pink to blue was seen or noticed. The hardness in mg/l as calcium carbonate

($CaCO_3$) is equal to the number of drops of EDTA titrant required to bring about color change multiplied by 20.

It should be noted that magnesium-hardness can be gotten as magnesium hardness = total hardness – calcium hardness.

### 3.4.1.8 TOTAL ALKALINITY

A measure of 40ml of 0.025M $Na_2CO_3$ solution sample of the wastewater sample in a conical flask was added to 60ml and 3 drops of methyl orange indicator was use. 0.05M of $H_2SO_4$ was use to titrate until a color change from yellow to orange was noticed.

## 3.4.2 DETERMINATION OF INORGANIC MATTER COMPOSITION OF WASTEWATER.

### 3.4.2.1 CHLORIDE ION DETERMINATION.

It was determined by titration with silver nitrate:

Procedure/Reagent

1. The following three reagents were prepared.

a. 48g of silver nitrate was dissolved in 1 litre of distilled water and 1ml was equivalent to 1mg chloride.

b. 1.6g of sodium chloride standard and 1ml contains 1ml chloride

c. Potassium chromate indicator, 5g per 100ml was added to the silver nitrate solution to produce a slight red precipitate and was filtered.

2. 100ml of wastewater sample was measured into a flask and 1ml of potassium chromate solution was added and titrated with silver nitrate with constant stirring until a slight red colour persists.

$$\text{Chloride} = \frac{\text{volume of silver nitrate for sample-blank}}{\text{Volume of wastewater sample (ml)}} \times 100 = \text{mg/l}$$

### 3.4.2.2 PHOSHATE ION DETERMINAION.

Phoshate was determined by the turbidimeter method. Colloidal Barium sulphate was formed by the reaction of sulphate with barium ion, a barium chloride hydrochloric acid solution in the presence of glycerol and ethyl alcohol. The colour intensity was measured using DR 2000 spectrophotometer at 42mm wavelength.

### 3.4.2.3 SULPHATE ION DETERMINATION

Sulphate is a minor ion occurring in natural waters and wastewaters. Direct anthropogenic sources of sulphate include industrial and municipal waste.

To determine sulphate, an excess of barium chloride $BaCl_2$ was added to the wastewater sample. The barium ion reacted with the sulphate to precipitate barium sulphate crystals, the colloidal suspension was measured using a spectrophotometer and the sulphate concentration was determined by comparing with standards.

### 3.4.2.4 NITRATE

This is one of the four inorganic forms of nitrogen compounds that is of sanitary significance. This is measured using the spectrophotometer. The stored programme number for nitrate was entered and a wavelength dial was rotated. By pressing the enter bottom on the device. mg/l $NO_3^-$ H was displayed. A sample cell was filled with 25ml of the sample to be tested followed by the addition of the contents of one nitraver 5 nitrate reagent powder pillows to the cell (prepared sample). The shift timer bottom on the device was pressed and the cell was vigorously until the timer beeped in one minute. The content of the sample was allowed to stand for 5 minutes. Another sample cell filled with 25ml of distill water was placed into the cell holder and closed until the timer beeped, 0.00mg/l $NO_3^-$ H was displayed. By removing the black and placing the prepared sample in the cell holder the value of the nitrate was displayed and removed.

### 3.4.2.5 TRACE METALS DETERMINATION.

Prior to metal analyses, each sample of 100ml was acidified with concentrated $HNO_3$ (0.5ml). 25ml of each sample was poured into a beaker and diluted with 1.25ml HCl. The mixtures were heated for 15 minute on a steam bath and the final volume was adjusted to 25ml. Graded concentrations of the standard metal solutions were similarly prepared (0.2, 0.4, 0.6, 0.8, 1.0 and 1.2ppm) and aspirated into the flame and the absorbance read in the atomic absorption spectrometer. The absorbance of the standard calibration curve from which the concentrations of the metals present in the sample extrapolated. Metals detected were iron, calcium, magnesium and lead.

### 3.4.3 DETERMINATION OF ORGANIC MATTER COMPOSITION OF LIQUID WASTES.

Over the years a number of different tests have been developed to determine the number of organic content of wastewater. In general, the test may be divided into those used to measure gross concentration of organic matter greater than 1ml and those used to measure trace concentration in the range of 10-13mg/l. The laboratory methods commonly used today to measure gross amounts of organic matter (greater than 1mg/l) in wastewater include:

1. Biological Oxygen Demand (BOD)
2. Chemical Oxygen Demand (COD)
3. Total organic carbon.
4. Theoretical Oxygen Demand (ThoD)

Trace organic matter in the range of 10-13mg/l are determined using instrumental methods including gas chromatography and mass spectroscopy. Within the past 10 years, the trace organic compound has improved significantly and detection of concentration in the range of 10-13mg/l is now almost a routine matter (Metcalf and Eddy, 1991).

### 3.4.3.1 DISSOLVED OXYGEN DETERMINATION.

The Dissolve Oxygen (DO) was determined in the field with JEN WAY MODEL 9071. Dissolved Oxygen Meter. The measurement system consists of a "clark" type polorgraphic oxygen electrode and an oxygen metre. The units give the user readout of dissolved oxygen in mg/l or % and have a temperature measurement range of -30 to150c. The required mode was selected. The dissolved oxygen probe was immersed in the beaker containing the sample to be measured. The model 9071 dissolved oxygen metre simultaneously display dissolved oxygen and measurement results. It is possible to fix dissolved oxygen by Winkers method and subsequent analysis in the laboratory.

### 3.4.4 BACTERIOLOGICAL ANALYSIS

This is the determination of the indicator of organism in a sample of wastewater or water. This is also referred to as coliform count. The test was carried out using the Most Probable Number (MPN).

An indicator, bromoresol purple indicator was added into a series of sterilized culture bottles. A change of colour from pink to yellow after 48 hours indicated the presence of coliform. The number of coliform available was estimated by the use of MPN table. The culture media was prepared by dissolving approximately 1g of beef boullion and 4g of powdered milk in 250ml of distilled water. 15ml of media was then introduced into each 15 screw capped sterilized bottle followed by the addition of the drops of bromoresol purple indicator solution.

10ml of wastewater sample was introduced in the first group of culture sterilized bottle which contain the media and indicator solution. The second group of the five sterilized bottles was introduced with 1ml of wastewater sample. And the third group of five sterilized bottles was introduced with 0.1ml of wastewater sample by means of a sterilized syringe. The bottles were then incubated at about $35^{oC}$ for two days.

After two days, the bottles were observed for colour'change. positive test bottles that have colour change to pink were obtained. A MPN table was used to estimate the number of coliform present in the wastewater.

MPN values per 100ml of sample and % confidence limits for various combinations of positive and negative result when (five 10ml, five 1ml and five 0.1ml) test partition are used.

# CHAPTER FOUR

## 4.0 PRESENTATION AND DISCUSSION OF RESULT

### 4.1 RESULTS

The results of laboratory analysis of the domestic wastewater collected from the main drainage that passes through F.U.T Minna Bosso campus are shown in Tables 4.2, 4.3 and 4.4, while World Health Organization (W.H.O) and Food and Agriculture Organization (F.AO) standards for irrigation waters in Table 4.1.

**TABLE: 4.1: FOOD AND AGRICULTURE ORGANIZATION (FAO) AND WOLRD HEALTH ORGANIZATION (W.H.O.) STANDARDS**

| S/No. | Parameters | World international bodies | |
|---|---|---|---|
| | | WHO | FAO |
| 1. | PH | 6.85 -8.5 | 7.0 – 7.5 |
| 2. | Electrical conductivity (:mh) | 30 | 15 |
| 3. | Total hardness – EDTA (mg $caco_3$) | 100 | 28 |
| 4. | Dissolved oxygen (mg/l) | 1.3 | 4 |
| 5. | Chloride $Cl^-$ (mg/l) | 200 | 220 |
| 6. | Sulphide $So_3^-$ (mg/l) | 200 | 200 |
| 7. | Total Hardness (mg/l) | 500 | |
| 8. | Iron $Fe^{2+}$ (mg/l) | 0.3 | 0.3 |
| 9. | Total Alkalanity (mg/l) | 150 | 100 |
| 10. | Potassium $k^+$ (mg/l) | 0.001 -100 | 200 |
| 11. | Manganese $Mn^+$ (mg/l) | 0.3 | 0.3 |
| 12. | Total solids Ts (mg/l) | | 100 |

| | | | |
|---|---|---|---|
| 13. | Total dissolved Solids (mg/l) | - | 100 |
| 14. | Suspended solid ss (mg/l) | - | 100 |
| 15. | Nitrate | 45 | 40 |
| 16. | Sodium $Na^+$ | 200 | - |
| 17. | Lead | 0.14 | - |
| 18. | Total alkalinity ($caco_3$) (mg/l) | 150 | 200 |
| 19. | Turbidity | 10 | 15 |
| 20. | Total calcium hardness | 200 | 150 |
| 21. | Total magnesium hardness | 200 | 150 |
| 22. | Phosphate (mg/l) | 50 | 50 |
| 23. | Free $Co_2$ (mg/l) | - | - |
| 24. | Total bacterial count (CFU/Ml) | 0 | 100 |

**Source: W.H.O 2003 and FAO 2004.**

## 4.2 DISCUSSION

Table 4.2 **Results of Physical Parameters of The Waste Water.**

| Parameters | Sample 1 | Sample 2 | Sample 3 | Means |
|---|---|---|---|---|
| PH | 8.5 | 8.5 | 8.9 | 8.6 |
| Conductivity (:ohms/cm) | 967 | 981 | 1321 | 1090 |
| Turbidity (NTU) | 49 | 47 | 38 | 45 |
| Total Suspended solids | 38 | 28 | 27 | 31 |
| Total dissolved solids | 1009 | 1240 | 1006 | 1085 |
| Total Solids | 1047 | 1268 | 1033 | 1116 |
| Appearance | Not clear | Unobjectionable | Clear | - |
| Colour | 230 | 230 | 89 | 183 |
| Odour | Objectionable | Odorless | Odorless | - |
| Taste | Sipid | Insipid | Insipid | - |

### 4.2.1 pH:

The pH Value indicates the degree of acidity or alkalinity any water, the pH value also represents the Hydrogen ion ($H^+$) concentrations in water and is also the logarithm of the reciprocal of the Hydrogen ion concentrations. The pH value below 5 indicates acidic concentration while pH Value above 8 indicates the alkaline concentration of the water. From the result of wastewater analysis, the mean pH value of sample shows that the wastewater is slightly above the WHO and FAO limit of 8.5, therefore it will be wise to treat the water to reduce the pH value before using it for dry season farming.

### 4.2.2. ELECTRICAL CONDUCTIVITY

The electrical conductivity is used to measure salt concentration in any water, it measures the ability of any water to conduct electricity and this is expressed in Mhos/cm.

When the electrical conductivity and salt concentration of water samples where compared with standards obtained from World Health Organization (W.H.O) and Food and Agriculture Organization (FAO) of the 2006; it was discovered that the electrical conductivity of the samples ranged between 961 and 1321 ohms/cm fell under the group four of the standards. This clearly shows that the water cannot be used for any form of irrigation practice since the soil of the area is the sandy clay soil that will not allow the easy movement of the water through.

**Group 1**: 0-200 mhos/cm

a) Water samples can be use for irrigation with most crops as the samples hav Electrical conductivity with low salinity hazard.
b) Little likelihood of soil salinity hazard.
c) Leaching due to irrigation can handle pressure of salts (except in soils with extremely low permeability)

**Group 2**: 200-400

a) Water samples can be used with moderate amount
b) Leaching salinity control required

**Group 3**: 400-800

a) Water sample cannot be used on soil with restricted drainage.

b) Management of salinity control required.

**Group 4**: 800-1600

a) Water sample not suitable for irrigation under ordinary conditions.

b) Soil must be permeable, have good drainage.

c) Irrigation water must be applied in excess to provide considerable leaching.

d) Only tolerant crops yield satisfactorily.

It can be seem that the electrical conductivity of the wastewater sample falls within group four which means that at present state, it is not suitable for dry season farming.

Source: FAO 2002

### 4.2.3 TURBIDITY

The suspended solid concentration influences the level of Turbidity. The Turbidity of the effluent had a mean measurement of 45NTU. Turbidity in natural waters reduce light transmittance and affects the species that may survive in the waters, the nature of the solids causing the turbidity may have other health ramification which may affect the crops if use directly for dry season farming (irrigation). To do away or reduce the turbidity of the effluent, screens of different diameters should be used along the flow channel before the collection point.

## 4.2.4 TOTAL DISSOLVED SOLID.

The acceptability and suitability of water resources for irrigation purpose is guided by the amount of total dissolved solid (TDS) present in the water. The osmotic pressure of the soil solute increase when the total dissolved solid is present in large quantities thereby, causing high soil moisture stress in the root zone which in turn hinder plant growth and subsequently affect crops yield.

The acceptable limit of TDS and pH value for suitability indicates that water containing TDS up to 400mg/l or less and pH value of below 8 (eight) are generally quite suitable for irrigations purpose.(FAO 2002)

However, the wastewater sample result shows a high mean level (1085mg/l) of TDS, hence the wastewater is unsuitable for irrigation purpose.

## 4.2.5 APPEARANCE AND COLOUR

The appearance of water is closely related to colour of water. The colour of portable water is colourless and the appearance of portable water has to be clear and attractive according to W.H.O standard for domestic water. This was due by close observant of the samples collected at different sampling point.

The sample collected at $S_1$ and $S_2$ did not show clear appearance but sample $s_3$ was observed to be clear and attractive. The appearance of this sample conformed to the recommended standards by W.H.O.

### 4.2.7 TASTE AND ODOUR

Taste and odour depends on the actual contact of the stimulating substance with the appropriate human reception cell, it is normally correct to suggest that most taste in water is really a sensation of smell. The wastewater had an offensive odour and is tasty too, hence there is need to treat the wastewater before using it for irrigation farming.

Table 4.3 Results of Inorganic Matter Composition.

| Parameters | Sample 1 | Sample 2 | Sample 3 | Means |
|---|---|---|---|---|
| Total iron | 0.72 | 0.77 | 0.70 | 0.73 |
| Sulphate ($So_3$) | 544 | 703 | 190 | 479 |
| Chloride ($Cl_2$) | 512 | 338 | 412 | 420 |
| Lead mg/l | 0.15 | 0.18 | 0.14 | 0.16 |
| Sodium | 315 | 325 | 209 | 283 |
| Manganese | 0.71 | 0.63 | 0.33 | 0.56 |
| Phosphate | 65 | 79 | 88 | 77 |
| Nitrate | 25 | 33 | 65 | 41 |
| Potassium | 654 | 502 | 234 | 463 |

### 4.2.8 TOTAL IRON

Iron concentration of 0.5mg/l may be severed and may need to be corrected. This may be achieved by applying appropriate measure. The highest desirable level of iron is 0.1 mg/l while the maximum permissible level is 1.0 mg/l but not all crops will survive.

Iron has a chemical effect that could become a problem at the concentration of 1.0mg/l. It has the ability to cause rusting must especially in some sprinklers or overhead irrigation system.

From the result of the analysis, iron was found to have a mean value of 0.7mg/l, which appear to be severe and there is the need for treatment so as not to affect crops irrigated with the wastewater.

### 4.2.9 SULPHATE

The same limit of 200mg/l is also desirable for sulphate. From result available, the mean value of sulphate is 479mg/l which far exceed the limit, for the wastewater to be suitable for irrigation purpose it must be treated to reduce the sulphate content to its permissible limit.

### 4.2.10 CHLORIDE

This is considered to be an important element in water because its concentration determines the susceptibility of water to pathogens that causes some water borne diseases in the system of man and lower animal that consume it. The permissible limit of chloride according to WHO and FAO for irrigation purpose is 200mg/l, hence the mean value of the samples (420mg/l) shows that there is need for chloride to be treated before use for dry season farming (irrigation).

### 4.2.11 SODIUM

Sodium has the ability to destroy soil structure and it is capable of building up salts in the soil. Therefore, it is an undesirable element in the irrigation of crops particularly in large quantities.

The mean sodium content in the wastewater sample is 283mg/l, which exceed the 200mg/l which is the WHO limit, for this reason the wastewater cannot be used for irrigation purpose unless treated to reduce the concentration of sodium.

### 4.2.12 MAGNESSIUM

Magnesium is a common water pollutant too, which results to temporary hardness of water. The WHO permissible limit is 30 -150mg/l. The mean value of the wastewater is 92mg/l which shows that the wastewater on the aspect of magnesium content is good for dry season farming.

### 4.2.13 PHOSPHATE

This is the chemical form of phosphorous when in solute. Phosphorous is one of the 3 primary nutrients largely required by plants for growth. The wastewater analysis shows a very high rate of phosphorous content of 77mg/l mean value and this has exceeded the permissible limit of 50mg/l of the WHO and FAO standards.

### 4.2.14 NITRATE

This is the Chemical form in which Nitrogen is absorbed or taking in by plants from the soil. From the result analysis, the mean value of the wastewater sample was 41mg/l and this has fallen within the WHO standard of 45mg/l for irrigation purpose. Hence the wastewater can be use without treatment for nitrate as it will even act as a source of fertilizer.

### 4.2.15 POTASSIUM

This is one of the primary nutrient elements required by plant for morphological performance in the field. Although, some time, it is considered to be toxic simply because, in the elemental state, it reacts violently with moisture to librates Hydrogen and form Potassium Hydroxide which is extremely caustic in nature. It affect public water and too much of its element affect agricultural crops at the root zone.

From result of wastewater, the mean value of 463mg/l shows that it far exceed WHO and FAO standards value of 0.0001-100mg/l and 150mg/l respectively which is the permissible limit

Table 4.4 Results of Chemical Parameters.

| **Parameters** | **Sample 1** | **Sample 2** | **Sample 3** | **Means** |
|---|---|---|---|---|
| Total alkalinity | 1020 | 941 | 843 | 934 |
| Total Hardness | 350 | 418 | 602 | 456 |
| Calcium hardness | 223 | 109 | 66 | 132 |
| Free $Co_2$ | 80 | 85 | 143 | 102 |
| Total bacterial count (CFU/ml) | 564 | 551 | 502 | 539 |
| Pathogenic organism | Detected | Detected | Neutral | - |

### 4.2.16 TOTAL ALKALINITY

The permissible limit of alkalinity in water is between 100-150mg/l, but from the wastewater analysis mean value of 934mg/l, it shows that the wastewater must be treated to meet the standards before use it will be use for irrigation purpose.

### 4.2.17 TOTAL HARDNESS

The permissible level of total hardness in any water is 500mg/l, which in most cases comprises of calcium carbonate ($CaCo_3$) or magnesium carbonate ($MgCo_3$), the mean total hardness of the wastewater is 456mg/l which is close to the 500mg/l limit, to be on save side, the wastewater should be treated to reduce the value so as make the wastewater suitable for dry season farming.

### 4.2.18 CALCIUM

Calcium is a very common environmental pollutant. It causes calcium hardness in water, the WHO standard is 75 -200 mg/l which is the permissible limit. The calcium content of the wastewater falls within the limit with 132mg/l which is good for dry season farming.

### 4.2.19 TOTAL BACTERIAL COUNT

The standard for bacterial count is 100 bacterial in 100ml of water, but from the wastewater analysis, it shows that the mean bacteria count per 100ml was 539 which far exceed the limit specified by WHO and FAO for irrigation purposes, hence there is need to treat the wastewater before it use to irrigate crops especially crops that are to be eaten uncooked.

# CHAPTER FIVE

# 5.0 CONCLUSION AND RECOMMENDATION

## 5.1 CONCLUSIONS

Table 4.2, 4.3 and 4.4 shows the level of the wastewater constituent, the water analysis shows a high level of pollution. When compared with the World Health Organization (WHO) and Food and Agriculture Organization (FAO) guidelines and standards, it was observed that, the effluents contain several pollutants far exceeding the WHO and FAO limits.

The effluents is therefore not fit or good for use for dry season farming (irrigation) because the crops will be adversely affected due to the high concentration of most of the elements found in the wastewater, except necessary precaution of treatment are carried out.

The drainage wastewater flows from the outside of the university community into the school drainage, refuse and other forms of waste are dumped along the flow channel, this shows the reason while the wastewater is highly polluted. For the drainage wastewater to be fit for dry season farming, the wastewater must be treated to meet the World Health Organization (WHO) and Food and Agricultural Organization (FAO) standards for irrigation, and after considering the various methods of wastewater or water treatment, the most appropriate method for treating wastewater from the drainage is the use of a wastewater stabilization pond system. It has least a cost of construction and maintenance compared to other treatment methods.

Only a few crops can grow when irrigated with the wastewater without treatment, if the wastewater is treated, crops like spinach, pumpkin, tomatoes, pepper and other vegetable can be cultivated during dry season effectively.

## 5.2. RECOMMENDATIONS

After a careful study and consideration of the project, the following recommendations are made:

1. That a wastewater stabilization pond system that cost less and is more efficient than most conventional treatment works be constructed to provide quality water for dry season farming to enhance food supply to the university community.
2. That the university should consider the proposed project as it will serve as a source of revenue, a practical site and will create employment for our teeming youths.
3. The wastewater from the drainage should not be used for dry season farming unless it is treated, as it is not good health wise for both human and livestock.
4. That further research work should be carried out in evaluating the cost and design/ construction of the pond

## EFERENCES

dejemulua, F (1988). "Ways with water" African Review of Business and Technology. Vol 5 Pp88.

Adeoye, A. (2006). "Lecture Note on Water Supply and Sanitation" Federal University of Technology Minna (Unpublished).

Agunwamba, J.C (2000). "Water Engineering Systems" Immaculate publications Ltd, Enugu. Pp40-42, 96-100, 203-206.

Agunwamba, J.C (2001). "Waste engineering and management tools" Immaculate publication Ltd, Enugu. Pp37-60, 117-145.

Arthur, J.P. (1993). "Notes on the Design and Operation of Waste Stabilization Pond in Warm Climates of Developing Countries." Technical paper no.7, World Bank, Washington D.C

Ayotamuno, M.J and Akor, A.J (1994) "The Pollution Potentials of Open Drains in Port Harcourt, Nigeria". An International Journal on environment management and Health. Vol 5(3) Pp28-32, MCB University Press Australia.

Bratty, S.J.(1989). "Sewage Sludge Disposal to Agricultural Land" European Commission Directive. The institution Of Civil Engineers proceedings Vol 86.

F.A.O. (2002). "Quality of irrigation waters" Irrigation and Drainage, Paper 20 Rome, Italy

Knapp, C.E (1971). "Environmental Science and Technology" McGraw Hill Co. New York. Vol. 5 Pp70-73

Mara, D.D and Pearson, H. (1998) "Waste Design Stabilization Ponds: Design manual for Mediterranean Europe. World Health Organization, Pp6-9

Marais, G.V.R (1970). "Proceeding of the Second international Symposium for Waste Treatment Lagoons" Kansas City.

Merrel, J.E (1961) "The Santee Recreation Project, Santee California" Final Report US Department of Federal Water Pollution and Control Administration Cincinnati.

Metcalf, L and Eddy, H.P (1991) "Wastewater Engineering: Treatment, Disposal and Re-Use" McGraw-Hill Book Co., New York. Pp 50-100

Ogunrombi, J.A and Onuoha, N. (1996) "Performance Study on Waste Stabilization pond system" A.B.U. Zaria, NJE Vol 4.

Ojukwu, D. (2006). "Lecture Note on Water Resources and Environment" University of Nigeria Nsukka (Unpublished).

U. N Department of Technical Cooperation for Development (1985) "The use of non Conventional Water resources in Developing Countries." Natural Water Resources Series, No. 14. United Nations DTCA, New York.

W.H.O (1968). "Water Pollution Control in Developing Countries" (Technical Report Series, No. 404).

W.H.O (1973). "Re-Use of Effluents" Method of waste Water Treatment and Health Safeguards.