# PERFORMANCE EVALUATION OF A SEWAGE TREATMENT PLANT: A CASE STUDY OF WUYE WASTE WATER TREATMENT PLANT

BY

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## DECLARATION

I, OGOINA NANAYE (97/6102EH), declare that this project: Performance Evaluation of a Sewage Treatment Plant: A Case study of Wuye Wastewater Treatment Plant, presented for the award of Bachelor Degree in Chemical Engineering, has not been presented for any other degree elsewhere.

____________________ ____________________

Signature Date

## CERTIFICATION

his is to certify that this project was supervised, moderated and approved by the following nder listed persons on behalf of the Chemical Engineering Department, School of ngineering and Engineering Technology, Federal University of Technology, Minna.

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External Examiner Date

# DEDICATION

This project is dedicated to my father Col. S. B. Ogoina and my late Mom, Mrs Oupoebi Ogoina. Even though I never got to know you, I'm still missing you.

## ACKNOWLEDGEMENT

I'd like to use this opportunity to acknowledge a few persons who in their own little way contributed to the completion and success of this research project. To my parents, Col and Mrs. S. B. Ogoina, for their support and patience. My brothers and sisters: Mr. Ebiowei, Timi, Tolumoye, Capt. Ebibomo, Mrs. Ipigansi, Dr. Dimie, Tonbara, Iteimo, Olaowei, Tarilado, Powei and Nimi, thanks for the encouragement.

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## ABSTRACT

The performance evaluation of the Wuye Wastewater Treatment Plant is carried out to determine the effect of treatment on the sewage parameters and the effluent on Wuye River.

Temperature, pH, COD, BOD, TSS, $NO_3^-$, $NO_2^-$, $Cl^-$, $Mg^{2+}$, $Ca^{2+}$ and total coliform were measured over a six (6) weeks period (July 10 – August 24, 2003). From results obtained it was observed that the TSS, Nitrate, Nitrite, BOD, COD, PH and temperature of the effluents are beyond FEPA standards while total Coliform, $Mg^{2+}$, $Ca^{2+}$ and total Coliform are within FEPA standards which is an indication of overloading in Wuye Wastewater Treatment Plant.

Therefore, additional treatment plants should be established to cope with growing population.

# CHAPTER ONE

## 1.0. INTRODUCTION

Water is one of the commonest substances on Earth. It falls as rain and makes up Rivers, Lakes, and Oceans. It is essential for life –plants and animals soon die if they get no water. Water is of paramount importance to the survival of man. Growing populations demand more of it for domestic use, irrigation, and industrial activities e.t.c. To scientist, water is just another chemical compound that is colorless and tasteless. Chemically, it is an oxide of hydrogen and has the formula H2O. (World Ency, 1978).

In cities where water is available and cheap, people tend to abuse it, using much more than really need. It is used of several domestic and industrial purposes, after which it thrown down a toilet, a waste pipe or some convenient drain. This used water called Wastewater is disposed in water resources violating existing environmental laws. (World Book, 1990 ).The volume of water supply required by a community is closely related to the volume of wastewater discharged by it. (World Bk, 1990). Rivers, Streams and Oceans would be in an unhygienic state if all that wastewater were allowed to reach them. Therefore, it became necessary for the population's wastewater to be cleaned up or treated before its disposal into watercourses.

When waste matter enters water, the resulting product is called Sewage. ( World Ency, 1978 ).Sewage is used water supply of a community, it contains waste matter produced by human beings. ( Sc & Invention Ency, 2001 ).It originates mainly from domestic, industrial, groundwater, meteorological sources, and these forms of sewage are commonly referred to as domestic sewage, industrial waste, infiltration and storm water drainage respectively. Domestic sewage results from activities people such as bathing, body elimination, house keeping, cooking and recreation. It is also comes from water used in restaurants and office build-dings. The quantity and character of industrial waste depends more on the nature and condition of the sewer system than on the activities of man. The amount of storm water drainage depends on the intensity and duration of rainfall. ( World Bk, 1990 )

Raw untreated sewage has a foul odor and an unpleasing appearance. It is a grey turbid (soapy) liquid. Several physical, chemical and biological measurements characterise the composition of sewage. Fresh sewage contains about a tenth of 1 percent solid matter. ( Schroeder, 1985 ). This solid matter includes dissolved and suspended solids. Most sewage also includes harmful chemicals and disease producing organisms.

Disposal of sewage presents quite a problem. The need for something to be done to tackle this problem gave rise to sewage treatment. A sewage treatment plant is process plant designed for the sole aim of treating wastewater. In a plant, sewage is treated to destroy disease organisms and to remove substances that can cause harm to the life that get water from such source. This treated water is discharged into nearby streams, lakes or coastal waters. The disposal of untreated sewage directly into a stream or body of water can result in serious water pollution. Disease organisms endanger water supplies and swimming areas. Various poisonous chemicals may pollute the water, killing fish and other wildlife, while certain nutrient may cause an excessive growth of aquatic plants. (World Bk, 1990 ). Untreated wastewater also contains numerous pathogenic organisms. Sewerage systems are designed for the effective collection, treatment and disposal of sewage. In highly populated and industrial areas where water demand and supply is high, it becomes imperative to establish an effective sewage treatment plant to prevent the spread of diseases and environmental pollution.

Abuja sewage treatment plant is one of such systems. Abuja is an industrialized and highly populated city. The plant was established in 1993 and is designed to treat domestic sewage from 50,000- population equivalent before discharge into the Wuye River. ( Abdulrahman, 2000 ).

## 1.1. AIMS AND OBJECTIVE

This research project aims at evaluating the performance of Abuja sewage treatment plant. The aim of this research work will be achieved via realization of the following objectives:

(1). Check the effectiveness and efficiency in collecting, treating and disposal of wastewater.

(2). Identify any treatment problems and possibly suggest possible solution to these problems.

(3). To highlight the implication of inadequate treatment before discharge into Wuye River.

These objectives are achieved by carrying out analysis on the samples of effluent collected at the plant for treatment and sample of treated effluent which was discharged into Wuye River, to see if the value of parameters conform with FEPA (Federal Environmental Protection Agency) water quality standards.

## 1.2. SCOPE OF WORK

The scope of this work covers the determination of the physical, chemical and biological characteristics of effluent received at the plant and waste discharged into the Wuye River, the upstream and downstream of the river for the purpose of determining the quality of water. The physical characteristics include temperature, settle-able solids, suspended solids and dissolved solids. Along with this, visual observation is used to check the colour and presence of organisms like fish, reptiles, and plants such as spirogyra. The chemical characteristics include: chloride ion, pH, BOD, COD, Ca2+, Mg2+, NO3-, Cl- and total hardness. The biological characteristics include microorganisms e.g. protozoa, algae.

## 1.3. JUSTIFICATION

There is no doubt that man's basic need apart from food and clothing is a neat, healthy and sanitized environment. It is therefore necessary to take a critical look at the issues of sewage treatment as it affects the environment. This study , perhaps in a little way will help evaluate a more a more efficient system that will enhance environmental stabilization.

# CHAPTER TWO

## 2.0. LITERATURE REVIEW

### 2.1. HISTORY

In ancient cities, covered channels or pipes were often used for removing human wastes from dwellings. Rome, for example, had a system of sewers for disposing of wastes and rainwater (Schroeder, 1985). Most ancient sewers fell into disrepair during the Middle Ages (Barker.H.K,1999). Refuse and human wastes were commonly thrown into the streets. By the late 1700's, many large cities had sewers for removing storm water, but cesspools were usually used for sewage disposal (Barker.H.K, 1999) Both cesspools and privies were widely used in cities and towns. Modern sewage disposal systems were introduced in $19^{th}$ century(Schroeder, 98)

Existing storm sewers were usually enlarged to carry both rainwater and wastes. In the $19^{th}$ century, either combined sewers or sanitary sewers were for disposing of sewage and industrial wastes. The wastes, untreated, were usually discharged into nearby bodies of water.

Municipal sewage treatment was introduced in the early $20^{th}$ century, but many cities and industrial plants were slow to adapt to this method. (Coates,J.F,1991). As the population increased, some existing sewage plants became inadequate. In cities with combined sewers, heavy rains periodically overloaded otherwise adequate disposal facilities. By the 1970's, water pollution caused by the discharge of untreated or inadequately treated sewage had become a major problem. (Goetz.P.W,1989). In the United States, legislation was passed in the 1970's to help control and prevent water pollution. The legislation set standards for the quality of water discharged into streams and lakes and provides funds to assist in the improvement and construction of sewage treatment facilities.

## 2.2. WASTEWATER CHARACTERISTICS

Every community produces both liquid and solid wastes. Waste is any superfluous or rejected material. When waste matter enters water, the resulting product is called sewage or wastewater. (Goetz.J.T, 1991) Wastewater is liquid waste, which originates mainly from domestic, industrial, ground water, and meteorological sources. (Sasse.H, 1998). An understanding of the nature of wastewater is essential in design and operation of treatment and disposal facilities and in engineering management of environmental quality. Wastewater is characterized in terms of its physical, chemical and biological composition. (Goetz.P.W, 1989 ).

### 2.2.1 PHYSICAL CHARACTERISTICS

The physical characteristic of wastewater are those properties which appeal to the natural senses, they include odour, colour, turbidity, temperature and total solids which is the most important physical characteristic of sewage.

**Odour:** Fresh sewage is odourless. The objectionable odour in water may be of either biological or industrial origin. (Horan.N.J,1990). Odour is rated the first social concern of the public relative to the implementation of wastewater treatment facilities. The importance of odour in human terms is related primarily to the harm that they do to the body.(Metcalf,Eddy,1991). Industrial wastewater may contain compounds like $CH_4$, $H_2$, S, $NH_3$ or compound that produces odour during the processes of water treatment.

**Colour:** Fresh sewage has an earthy or grey colour. In 3 to 4 hours, it becomes stale with all the oxygen present in the sewage being practically exhausted. Even though colour is not necessarily harmful; it is obviously undesirable in drinking water and for certain industrial uses.(Hulshoft,Lettinga,1986). Industrial effluents do vary in their colour but the degree to which they are coloured is a measure of the extent of pollution. (Hulshoft,Lettinga,1986). Chemical coagulation proved to be the most effective way used to remove colour from both raw and biologically treated water in the world water $86^0$ conference.(Metcalf,Eddy,1991). Colour vis a vis odour can be used to determine qualitatively the age of sewage.(Goetz.P.W,1989).

**Turgidity:** Sewage is normally turbid resembling dirty dishwater from bath having other floating matters. Turbidity increases as sewage becomes stronger. (Aina. E. O. A,1991). Suspended solid are the primary cause of turgidity.

**Temperature:** The normal temperature of sewage is higher than that of water supply because of heat added during the utilization of water.(Duggal,1993). Temperature is a very important parameter because of its effects on the aquatic life, chemical reaction, dissolved oxygen, reaction rate and suitability of the water for beneficial uses.

(Aina.E.O.A,1990).

**Solids**: Sewage contains 99.9% water and only 0.1% (Kamala, K.Rao.1988) of solids. The total solids are composed of matter, which are settle-able, suspended or dissolved solids. Settleable solids are those solids which will settle within one hour under the influence of gravity.(Coates.J.F,1991). Suspended solids, both organic and volatile matters will determine the sludge handling requirements for treatment and may also affect the necessary degree of treatment. Suspended are removed by filtration through a 0.45-1.00 micro- membrane.(Hulsholft,Lettinga,1986).

### 2.2.2. CHEMICAL CHARACTERISTICS OF WATER

These characteristics indicate the state of sewage decomposition, its strength and type of treatment required.( Duggal,1993).The presence of these parameters can adversely affect the well being of the community. Wastewater contains both inorganic and organic chemicals.( Mc.Ghee,1991) Chemical characteristics are divided into organic, inorganic and gases.

**Organic Compounds:** are normally composed of a combination of carbon, hydrogen, and oxygen together with nitrogen, phosphorus, sulphur or iron in some cases. Impairment of taste and odour, lowering of dissolved oxygen and direct toxicity and carcinogenicity are some of the effects of organic matter on water.( Mc.Ghee,1991). The principal groups of organic substance found in wastewater are proteins, carbonhydrates and lipids. Synthetic organic molecules like surfactants, agricultural pesticides and volatile organic compounds (VOCs) are also found in industrial wastewater.(Schroeder,1985)

Proteins are complex in chemical structure, unstable, fairly soluble in water and produces extremely foul odour when present in large quantities. Lipids are the common organic compounds found in domestic wastewater.

Surfactants (Surface Active Agents) are large organic molecules that are slightly soluble in water and cause foaming in wastewater treatment plant and in the surface water into which the waste effluent is discharged. It tends to collect at the air- water interface. Organic compounds that have a boiling point $100^0$c and/or a vapour pressure < 1mm Hg at $25^0$c are generally considered to be volatile organic compounds (VOCs). They are of great concern because their presence in the environment may pose a significant risk and could lead to formation of photochemical oxidants. Agricultural pesticide which are trace organic compound are toxic to most life forms and therefore can be significant contaminants of surface water.(Burton,G.T,1991)

**Inorganic matter:** This accounts for about 30% of dissolved solids and consists of minerals and salts. The concentrations of the inorganic substance in water are increased both by the geological formations with which the water comes in contact and by influent.(Gambo,1992).

**Nitrogen**: The nitrogen present in wastewater may be in both organic and inorganic forms and in both reduced and oxidized states. It is primarily combined in proteinacious matter and urea. This decomposes to give ammonia, whose relative amount is used to qualitatively determine the age of wastewater.(Burton,G.T,1991).In aerobic condition, ammonia is oxidized to nitrite and nitrates.

Although, nitrite as nitrogen compound is unstable, its presence is undesirable as it reacts with oxygen-carrying pigment (haemoglobin) in the blood to produce a compound, which is an oxygen transporter and hence, may produce serious physiological effects when present in high concentration (World Ency,1978). Nitrate may produce in man a condition known as methemaglibinemia (blue babies), which generally affects infants under six months of age.(Batstone,Smith,1989). Nitrogen concentration is determined by digestion–distillation process followed by colorimetric, titrimetric, or electrophoretic analysis.

**Chlorides:** chlorides in natural water result from the leaching of Chloride containing rocks and soil with which the water comes in contact. From the standard methods of examination of water and wastewater, chloride in addition to salty taste it impaired onto water may damage metallic pipes and structures as well as growing plants.(Batstone,Smith,1989) Chloride has a demonstrable physiological effect, it has been used in the past as an indicator of pollution.(Hulshoft,Lettinga,1986).

**Acidity:** acidity of water is its quantitative capacity to react with strong bases to a designed pH. Its measurement also reflects a change in the quality of the source of water. In wastewater treatment, the presence of low pH with high acidity generally indicates the discharge of acidic industrial wastes. Acid contributes to corrosiveness, influences chemical reaction rates, chemical speciation and biological process.(Handa.B.K,1990)

**Alkalinity:** This is a primary function of hydroxides, carbonate and bicarbonates of element such as calcium, magnesium, sodium and a host of others. Alkalinity is quantitatively used to express the acid neutralizing capacity and thus measures the sum of all titrable bases in the water sample.(Marias.G.V,1994). Alkalinity value is used to determine the type of Coagulant to be used, type of treatment method to be employed and measures the hardness of water. Alkaline in waste water or water even at low concentration causes irritation to the eyes, mucous membrane and upper respiratory tract.(Horan.N.J,1990).

**pH:** pH is the measure of hydrogen ions concentration and most bacterium are favored by pH level between 6.5 to 8.5(Goetz.P.W,1989). In wastewater pH is an important parameter which must be considered in disinfecting biological activities, coagulation, corrosion control, water softening and others.(Hulshoft, Lettinga, 1986). pH is not only a limiting factor to marine life, also it may increase the effectiveness of a toxicant as the departure from the normal seasonal value becomes more pronounced.(Burton, G.T, 1991).

**Toxic Compounds and Heavy Metals:** Because of their toxicity, certain cautions are of great importance in the treatment and disposal of wastewater.(Amund, Odubela, 1987) Copper, lead, Silver, arsenic and boron are toxic to varying degree and therefore must be taken into account in the design of a biological treatment plant. Trace quantities of heavy metals such as Ni, Mn, Pd, Cr, Cd, Zn, Cu, Fe, and Hg are important constituents of most water. Some of the metals are necessary for growth of biological life, and absence of sufficient quantities of them could limit the growth of algae for example.(Melcalf, Eddy, 1991). Some toxic compounds most commonly produce in wastewater treatment are hydrogen sulphide ($H_2S$), Carbon monoxide (CO) and methane ($CH_4$). These are associated to air pollution, though CO and $H_2S$ in aqueous solution form carbonic and sculpture acid respectively and contribute to water pollution density.

### 2.2.3. BIOLOGICAL CHARACTERISTICS OF WASTEWATER.

Biological test are used to determine the pathogenic and indicator/coliform organisms and also for obtaining the population of micro-organisms responsible for treatment, and determination of method to be adopted in evaluating the toxicity of the waste. The effect of a contaminant on an individual organism should be quantifiable and related to the concentration of the contaminants in the sediment, water or animal tissue. Sewage contains living organisms such as bacteria, algae, fungi and protozoa. (Duggal, 1993).

**Micro-organisms:** Protozoa is the most important group of micro-organisms as far as wastewater treatment is concerns because of the role they play in decomposition and stabilization of organic matters. Their characteristics, functions, metabolism and synthesis must be understood. The class includes:

**Algae:** They have the ability to carry out photosynthesis and thus interfere with the nitrogen and phosphorus content of the wastewater.(Melcalf, Eddy,1991). Algae thrive in water polluted by excess nutrients from agriculture, soil erosion and sewage treatment. When algae die they release a highly toxic peptide called micro-cystic.(Coates.J.F, 1991). Small amounts of micro-cystic can cause liver damage and may promote cancer.

**Bacteria:** they are the simplest form of plant life. They are single cell micro-organisms that multiply rapidly in the presence of excess food. Aerobic bacteria need dissolved oxygen (DO) to oxidize organic matter whereas anaerobic bacteria don't need dissolved oxygen.(Gambo, 1992). Bacteria are found in water, soil and air under a wide range of temperature, salinity, oxygen concentration and acidity.(Amund, Odubela, 1987). Recent research on bacteria shows that it can be used to determine the short- term dispensation of sewage sludge over a period of days.(Bridguster.R, Mumford.P, 1979).

**Protozoa:** they maintain a natural balance among the different groups of micro-organisms, for this reason they are essential in the operation of biological treatment processes.

**Fungi:** because of their ability to exist and function under extreme conditions they are important in wastewater treatment. They are non-photosynthetic and can growth in low solutions where bacteria could not survive. (Bridguster.R, Mumford.P, 1979).

**Viruses:** These are small, non-cellular particles that multiply only within the living cells and are inert outside of living cells. Viruses that are excreted by human beings may cause health hazard to the public.

**Pathogenic Organisms:** bacterial pathogenic organisms that can be excreted by man causes a disease of the gesto intestinal tract such as typhoid and Para-typhoid fever, dysentery, diarrhea and cholera.(O.Ravera, 1978).

## 2.3. ENVIROMENTAL POLLUTION

Environmental pollution is a term that refers to all the ways that human activity harms the natural environment. (Hulshoft,Lettinga,1986). Pollution can be visible, invisible, odourless and tasteless. Some kinds of pollution do not actually dirty the land, air or water, but they reduce the quality of life for people and other livings things. Environmental pollution is one of most serious problems facing humanity and other forms of life today. In the prehistoric times, populations were smaller and were spread out over large areas. As a result, pollution was less concentrated caused few problems.

The growth of pollution started during ancient times when large numbers of people began living together in cities. As cities grew, environmental pollution increased became even more serious and widespread in the 1700's and early 1800's, during a period called Industrial Revolution. (Melcalf,Eddy,1991). This period was characterized by the development of factories and the overcrowding cities with factory workers.

### 2.3.1. SOURCES OF ENVIRONMENTTAL POLLUTION

The sources of environmental pollution are varied. When pollution comes from one specific source or location, such as sewage pipe spilling dirty water into a river , it is called Point Source Pollution on the other hand, when pollution comes from large areas i.e. water from farmlands carrying pesticides and fertilizer that run into river: rainwater can wash gasoline, oil and salt from highways and parking lots into the wells that supply drinking water, it is called Non Point Source Pollution. (Gambo,1992).

### 2.3.2. TYPES OF ENVIRONMENTAL POLLUTION

The major types of environmental pollution include: air, water, soil, solid waste and noise.(Horan.N.J,1990).

**Air Pollution:** This is the contamination of the air by such substances as fuel, exhaust and smoke. It can harm the health of plants, animals and damage buildings and other structures. According to World Health Organization, about one fifth of the world's people are exposed to hazardous levels of air pollutants. (Horan.N.J,1990). There are two (2) main types of air pollution, they include:

(1) Outdoor Air Pollution

(2) Indoor Air Pollution

Soil Pollution: this is the destruction of the earth's thin layer of healthy, productive soil, where much of our food is grown. Without fertile soil, farmers could not grow enough food to support the world's people.

**Solid Waste Pollution:** this is probably the most visible form of pollution. Every year, people dispose of billions of tons of solid garbage. Industrial wastes account for the majority of the discarded material. Solid waste from homes, offices and stores is called Municipal solid waste, leftover materials from agricultural processes, mining waste junked automobiles, scrap metals are known as spoil. (Gambo,1992).

**Hazardous Waste Pollution:** this is composed of discarded substances that can threaten human health and the environment. A waste is hazardous if it corrodes (wear away) other materials; ignites easily; reacts strongly with water; or is poisonous. Sources of hazardous waste include industries , hospitals and laboratories. Some hazardous waste seriously the health of people, wildlife and plants, they include radiation, pesticides and heavy metals.

**Noise pollution:** this comes from such machines as airplanes, motor vehicles, construction machinery, and industrial equipment. Noise does not dirty the air, water, or land, but it can cause discomfort and hearing loss in human beings and other animals.

**WATER POLLUTION:** This is one of the most serious environmental problems. It is the contamination of water by sewage, toxic chemicals, metals, oils or other substances that can affect water bodies such as rivers, lakes and oceans as well as water beneath the earth's surface called Groundwater. Polluted water may look clean or dirty, but it all contains bacteria, viruses, chemicals or other material that can cause illness or death to plants and animals. According to World Health Organization, about

5 million die every year from drinking polluted water.(Goetz.P.W, 1989).There are three (3) major sources of water pollution.

The sources include:(1) Industrial Waste

(2) Agricultural Chemicals and Waste

(3) Sewage Waste

**Industrial Waste:** Industries discharge chemical waste directly into natural bodies of water. In addition, the burning of Coal, Oil and other fuels by power plants, factories and motor vehicles release Sulfur and Nitrogen Oxides into the air. These pollutants caused "acid rain", which enters streams and lakes.(Burton, G.T, 1991). Some industries use large quantities of water to cool certain equipment and heat from the equipment makes the water hot. The industries then discharge the hot water into Rivers, Lakes and Oceans, heating up these bodies of water. Such heating that harms plants and animals is known as Thermal Pollution.(                    )

**Agricultural Chemical and Waste:** Water from rain or melted snow flows from farmland into Streams, carrying Chemical Fertilizers and Pesticides that farmers have used on the land. Animal waste can also cause water pollution, particularly from feedlots with many animals. Salt, agricultural pesticides and toxic chemicals may also pollute water used for irrigation.

**Sewage:** This water contains waste matter produced by human beings. It consists of human waste, garbage and water that have been used for laundering or bathing. It is also called Wastewater and contains about a tenth of 1% solid matter.(C.John, 1984). Most sewage includes harmful chemicals and disease-producing bacteria and eventually flows into lakes, oceans, rivers or streams.

## 2.4. EFFECTS OF WATER POLLUTION

**Disruption of Natural Processes:** Various processes that occur in water turn waste into useful or harmless substances. These processes use oxygen that is dissolved in the water. Water pollution upsets these processes, mainly by robbing the water of oxygen. (Gambo, 1992). In addition, pollution prevents people from enjoying some bodies of water for recreation. For example, odors and floating debris make boating and swimming unpleasant, and the risk of disease makes polluted water unsafe. More troubling is the fact that water polluted with human and animal waste can spread typhoid fever, cholera, dysentery and other diseases. For out of every five common diseases in developing countries are caused either by dirty water or lack of sanitation. Water-borne diseases alone cause an average of about 25,000 deaths a day in the Third World.(T.J.McChfe, 1991)

## 2.5. WATER POLLUTION CONTROL

There are three (3) main types of measures employed to control water pollution.

I. The protection of water resources from direct fecal contamination and any form of secondary pollution caused by leaching from pit latrines, septic tanks, cesspool e.t.c.

II. The treatment of source of water prior to supply is an obvious fallback position where protection measures have failed.

III. Health Education is a mandatory companion to any technology-based control measure, if only to guarantee proper use and maintenance of the facilities.

IV. Preventive control-measure can be adopted.

## 2.6. SEWAGE TREATMENT

In countries where water is available and cheap, people often tend to abuse it, using much more than they really need. It is used for drinking, bathing, washing clothes and cars, for a thousand and one different purposes in industry, and finally, after it has been used, it is thrown away down a toilet, a waste pipe or some convenient drain. In industrialized countries, each person on average uses about 50 gallons (227 liters) of water per day. Rivers and streams would be in an appalling state if all that water were allowed to reach them in a dirty condition, bringing with it a load of filth and waste materials. (Micheal.E, 1993). The need for something to be done about cleaning up of the population's wastewater or sewage as it is generally called became apparent about the time of the Industrial Revolution. Initially, the ability of organisms, normally present in soil, to remove or stabilize polluting matter was used extensively. For example, organic matter of animal origin contains nitrogen, often tied up in a complex form, but the soil organisms are able to breakdown the complexes and incorporate the nitrogen into the soil itself. So, by irrigating sewage on to land, a certain amount of purification of water was effected.(Micheal.E, 1983)

When sewage is discharged into water, decomposition takes place, the oxygen in the water going into combination with the organic content.(Micheal.E, 1983). If the dilution is not high, the water becomes depleted of oxygen with loss of fish life and development of offensive conditions. In some parts of the U.S.A., rivers are large enough for it to be possible to discharge sewage without treatment (Goetz.P.W, 1989) but this is not the case in Nigeria.

### 2.6.1. TREATMENT METHODS

Of the various methods of sewage treatment that have been tried, those that have survived consist in the main, of the removal of the most of the suspended solids by sedimentation and the oxidation of dissolved and remaining suspended solids with the aid of micro-organisms. The aim is to transform almost completely the organic content by oxidation to harmless substances so that when the effluent is discharged to a watercourse, no environmental hazard is caused. The methods of sewage treatment are the same throughout the world, the differences being mainly in detail and the degree to which treatment is perfected according to local need. The individual methods usually are classified as Physical Unit Operations, Chemical Unit Operations and Biological Unit Operations or processes.

Wastewater treatment processes are classified as Primary, Secondary and Tertiary treatment.

(I). Pre and Primary treatment involve Physical Unit Operations.

(II).Secondary treatment involves physical, chemical and biological unit operations.

(III).Tertiary treatment includes physical, chemical and biological unit operations.

**2.6.1.1. PRIMARY TREATMENT**

This is a treatment that applies physical forces. It consists of the removal of suspended matter, which settles out under placid conditions. The process of sedimentation removes sand, grit and other light particles to the extent of 35% to 40%.(Melcalf, Eddy, 1991). Primary treatment removes the heaviest solid material from sewage. At a treatment plant, sewage first passes through a screen that traps the largest pieces of matter. It then flows through a Grit Chamber where heavy inorganic matter such as sand, settles. The liquid then flows into a large Primary Sedimentation Tank. Many of the suspended solids sink to the bottom of this tank and form a muddy material called Sludge. Grease floats to the surface where it can be removed by a process called Skimming. The effluent is then released into waterways. Primary treatment removes about half the suspended solids and bacteria in sewage. (Schroeder, 1985). Sometimes, a gas called chlorine is added after primary and secondary treatment to kill most of the bacteria. Primary treatment removes about 30% (Coates.J.F,1991) of the organic wastes. When the remaining organic wastes are discharged into waterways, bacteria break them down and thus continue the process of purifying the water. The breakdown process uses up oxygen in the water. Some Physical Unit Operations include the following:

**Screening:** sewage admitted to sewage treatment plant should be effectively screen to protect the machinery in the plant and to avoid difficulties in subsequent stages of treatment. Screening is used to remove solid found in wastewater with the aid of devices having a uniform opening called Screen. The screened objects are flushed to an incinerator where they are shredded into small pieces and then returned to the sewage flow downstream of the screens to go through the screening process again. There are two (2) types of screens, the Traveling Band and Rotating Cup or Down Screen.

**Flocculation:** its objective is to convert the polluting substances into a form that can be easily separated. Flocculation is a process where metal ions are employed for elimination of very fine suspended particles as well as undesirable dissolved solids. Flocculation takes place in three (3) steps that merge into each other without any worked boundaries; these are destabilization, coagulation and agglomeration.(Handa,B.K,1990).

**Sedimentation:** The Objective of Primary sedimentation is to take load off biological units by removing most of the settle-able and floating solids, but the degree of treatment must be considered in relation to subsequent treatment stage for an overall least cost result.(Williams.T, 1993). The Objective of Secondary Sedimentation is to control the effluent suspended solids to prescribe regulatory limits..

An example of Primary Sedimentation tank is **Lamella Solids Separators.** . **Fig 2.1**

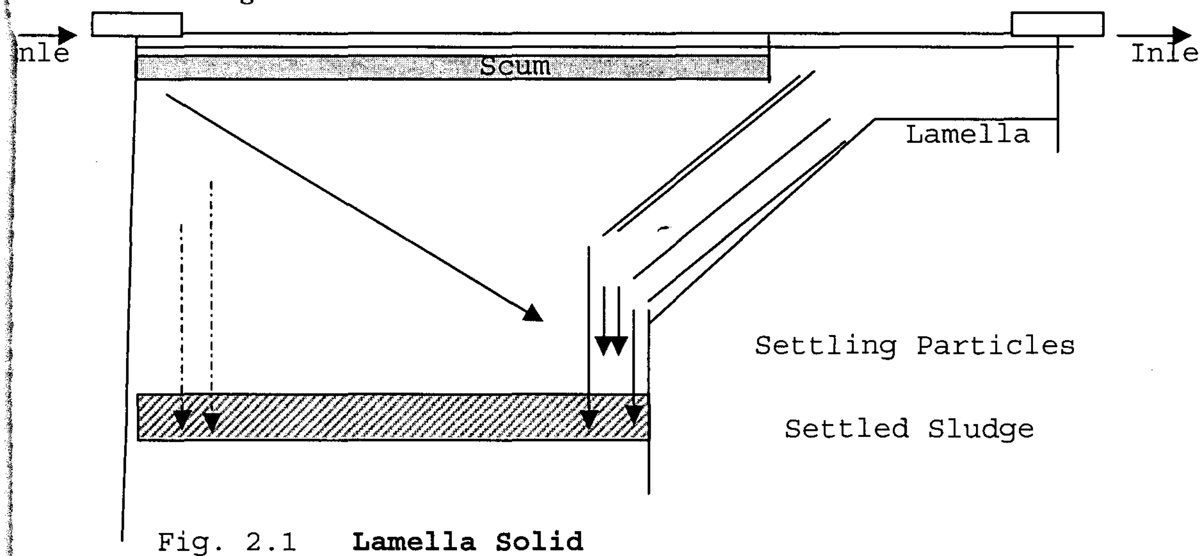



Fig. 2.1 **Lamella Solid**

**Floatation:** This is a Physical Unit Operation used to separate solid or liquid particles from a liquid phase. Introducing fine gas (usually air) bubbles into the liquid phase brings about the separation.(Williams.T, 1973).

**Filtration:** This is a process of removing suspended and colloidal particles from water by passing the stream through porous media. The main objective of filtration methods such as reverse osmosis is to stop pollution and to find a remedy for the lack of water in many countries throughout the world. The new system of filtration consists of two filters arranged in series. The filtering action of the first filler, which takes at least 70% of the turbidity load, is aided by injection of both sodium hypo-chlorides to oxidize ion, any organic matter, and a coagulant to remove colloids. The second filter retains the remaining 30% of the total turbidity load and buffers any leakage from the first filter.

**2.6.1.2 SECONDARY TREATMENT**

Having removed 40 to 60% of the suspended solids and 20 to 40% of the BOD in primary treatment by physical means, the secondary treatment biologically reduces the organic material remaining in the liquid stream. Usually the microbial processes employed are aerobic, that is, the organisms function in the presence of dissolved oxygen. Secondary treatment actually involves harnessing and accelerating nature's process of waste disposal. (Hansenne.M, 1990). Secondary treatment involves Chemical Unit Processes in which the removal or conversion of contaminants is brought by the addition of chemical or by other chemical reactions. Some of the operations involved are briefly described below.

**CHEMICAL UNIT PROCESSES**

**Precipitation and Coagulation:** In precipitation treatment, a precipitate is produced which then settles. Coagulation is a process whereby a minor input of energy affects the accumulation of the neutralized particles to form the so-called "micro flocs". Chemical Coagulation is the most effective way to remove colour with both raw and biologically treated wastewater.

**Gas Transfer:** It is a process by which gas is transferred from one phase to another usually from the gaseous to liquid phase. It is applied in the transfer of oxygen in the biological treatment of wastewater and in one of the processes of removing nitrogen compounds from wastewater. (Hansenne.M, 1990 )

**Adsorption:** It is the removal of specific compounds from wastewater in the solid surfaces using the forces of attraction between bodies.

**Disinfection:** This refers to the selective destruction of disease causing organism. The mechanism for detection depends on the nature of the disinfectant used and the micro-organism. (Micheal.E, 1983). The common disinfectants used are chlorine , its compounds and ozone.

### 2.6.1.3 BIOLOGICAL UNIT PROCESSES

Secondary treatment also involves some Biological unit processes by which contaminant is removed. These treatment methods are used primarily to remove the biodegradable organic substance (colloidal or dissolved) in wastewater. (O.Ravera, 1978). Two (2) biological processes, Mass transfer and Aerations is briefly discussed below.

**Mass Transfer:** in order to carry biological reactions, it is necessary to transfer substances into or out of the wastewater as well as to move them adequately within the water to control concentration differences. The rate at which these substances are transferred is the important consideration and is the primary concern of the field of mass transfer.

**Aeration:** the process of oxidation happens aerobically with free dissolved oxygen (DO) present in water, or an aerobically, without oxygen from outside the degrading molecules. Aeration involves the use of mechanical aerators to supply abundant oxygen to the wastewater for effective aerobic operations.

Secondary treatment involves the removal of dangerous bacterial material and organic material, which could seriously deplete oxygen level. There are two (2) systems that are used. (Abdul, 2000)

(i) Trickle System (Bio-filtration)

(ii) Activated Sludge System

The two systems utilize the action of bacterial as tiny automatic chemical reaction. They have the advantage of being cheap, self-adjusting and self-sustaining. Biological oxidation is the bacterial conversion of elements from organic form to their most highly oxidized inorganic forms, a process known as mineralization (Abdul, 2000). For example

Organic – C + O2 => Bacterial + Co2

Organic – H + O2 => Bacterial + H2O

Organic – N + O2 => Bacterial + N2O

Organic – S + O2 => Bacterial + So4

Bacteria oxidize waste to provide themselves with sufficient energy to enable them to synthesize the complete molecules such as protein and polysaccharides, which are needed to build new cells. The bacterial metabolism has two component parts; Catabolism (literally "breaking down") for synthesis. Waste Oxidation is described as "aerobic" when molecular oxygen is used as the terminal-oxidizing agent. The verbal equation: (Abdul, 2000)

Waste + O2 => Bacteria + Oxidized Waste + New Bacteria

The following reaction describes the principal anabolic reactions: (Abdul, 2000).

1. $CxHyO_2N + O_2 => Bacteria + CO_2 + H_2O + NH_3O$ + Organic Matter

2. CxHyN + Organic Matter => $C_3 + H_2NO_2O$ + Bacterial Cells

As a general guide, one third of BOD available is used in catabolic reaction and two-thirds in anabolic reactions (Abdul, 2000). Domestic sewage contains approximately the correct balance of nutrients required for bacterial growth but some industrial sewage has insufficient nitrogen and phosphates (Abdul, 2000).

Biological Sludge treatment is commonly an "anaerobic process" (absence of O2) although aerobic digesters are sometimes used. Sewage solids are degraded in two stages by two groups of anaerobic bacteria; first the organic compounds are oxidized to fatty, acetic acid, which are then converted to methane (Abdul, 2000).

For example, Amino acid Cysteine is converted as follows

$4C_3H_7NS + 8H_2O => 4CH_3COO + HCL_2 + 4NH_3$ acid (acetic) + $4H_2S$

Nitrification is the bio-oxidation of ammonia to nitrate. This conversion is a two-stage process, which is accomplished by two groups of bacteria. The bacteria oxidize nitrite to nitrate. The formal equations are: (Abdul, 2000)

Nitrosomonous as

$55NH_4 + 76O_2 => 5CO_2 => C_5HNO_2 + 54NO_2 + 52H_20$ Cells + 109H

Nitrobacters as

$400NO_2 + 195O_2 + 5CO_2 => NH_3 + 2H_2O => C_5H_7NO_2 + 400NO_3$

## 2.7. BIOLOGICAL TREATMENT SYSTEMS

### 2.7.1 STABILIZATION PONDS SYSTEM

Waste Stabilization ponds are the most economical method of sewage treatment in tropical developing countries where sufficient land is available except when marine discharge is cheaper. In their simplest form, they are large earthen basins that are used for the treatment of wastewater by natural processes involving the use of both algae and bacteria.(Gambo, 1992) Depending on the use of oxygen and micro-organism different types of pond are:

**Aerobic Ponds:** As the name suggest, biodegradable processes occur in the presence of oxygen. Organic matter is removed from wastewater by concentrating the natural aerobic biodegradable process into an engineered system under controlled condition. (Hansenne.M, 1990)

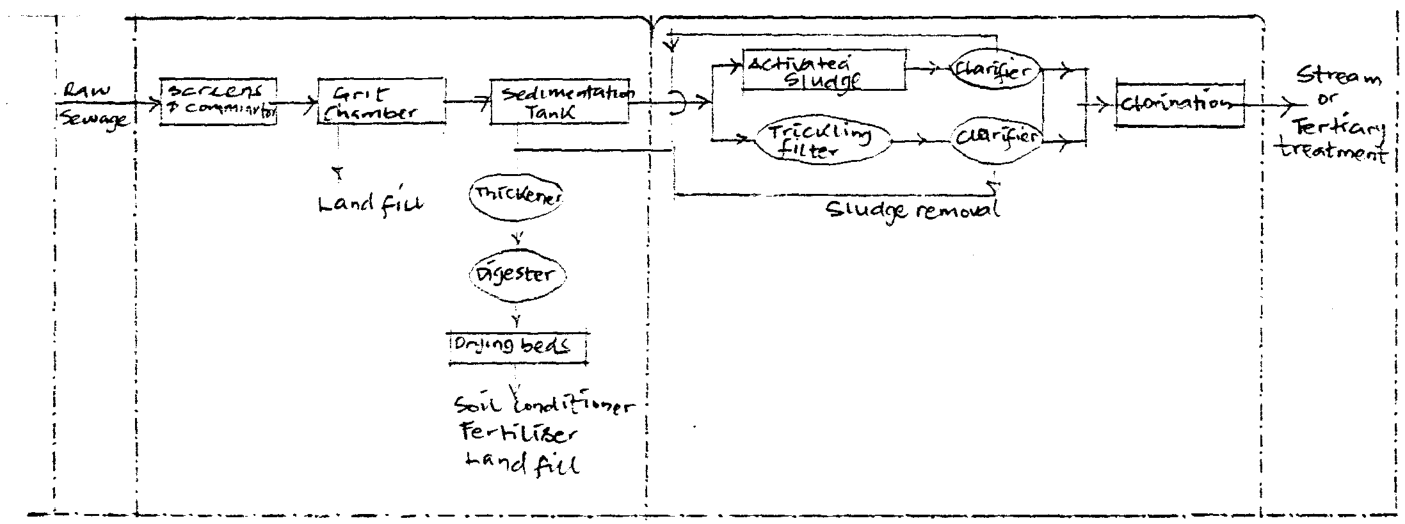
**Anaerobic Ponds:** here, the concentration of organic matter is very high, it often becomes either physically difficult or economically impracticable to transfer sufficient oxygen into the wastewater in order to sustain aerobic action, therefore anaerobic process is more economical.(Hansenne.M, 1990).

**2.7.2 TRICKLING FILTER:** In this process, waste stream is distributed intermittently over a bed or column of some type of porous media. A gelatinous film of micro-organisms coats the media and functions as removal agent. Air penetrates the pore spaces in the media and provides adequate oxygen to the organisms in the film. As the organic matter in waste stream is exposed to the microbial film. The film accumulates until hydraulic flushing action of the waste stream flows down through the bed causes bits and pieces of the film to detach from the media bits and pieces being removed prior to discharge of the liquid stream. The trickling-filter process when preceded by sedimentation can remove about 85% of the BOD entering the plant.

(Horan.N.J, 1990).

**2.7.3. ACTIVATED SLUDGE**: this is an aerobic process in which organic pollutants are contacted with suspended gelatinous sludge particles. The particles are simultaneously suspended in aeration supply tank, and supplied with oxygen by means of pressurized gas or mechanical aeration. The activated sludge process derives its name from the nature of the sludge particles, which are commonly referred to as Floc. The floc are composed of millions of actively growing bacteria and a gelatinous slime bonds the organisms together yielding a floc particle several millimeters in diameter. Organic matter is absorbed by floc and converted to aerobic products, including new cells. Activated-Sludge tanks are usually rectangular, but sometimes circular, the dimension varying with the size of the city served. The reduction of BOD fluctuates between 60 and 80% (Horan.N.J, 1990).

An important unit in any plant employing activated sludge or trickling filter is the secondary clarifier which separates the biological growth from the liquid stream before discharge; the efficiency of treatment drops sharply otherwise (Marais.G.V, 1994).




FLOW DIAGRAM OF A TYPICAL SEWAGE TREATMENT PLANT.

**Table 2.1 A Summary of comparison is shown below (A.A.Chika, 2000)**

| | Stabilization Pond | Tricking Filter | Activated Sludge |
|---|---|---|---|
| Land | Large land area required | Average | Small |
| Capital for construction | Fair | Very high | Very high |
| Operation of maintenance cost labour | Cheap Unskilled | Fair fairly Skilled | High highly skilled |
| Resistance to shock load | Can withstand | Fair withstand | Cannot with stand remarkable change in Outflow is noticed |
| Environmental nuisance | Produces Odour, breed flies and Mosquitoes | A lot of odour and some flies are eminent | Little odour |
| Economic importance | Used to breed fish | | |

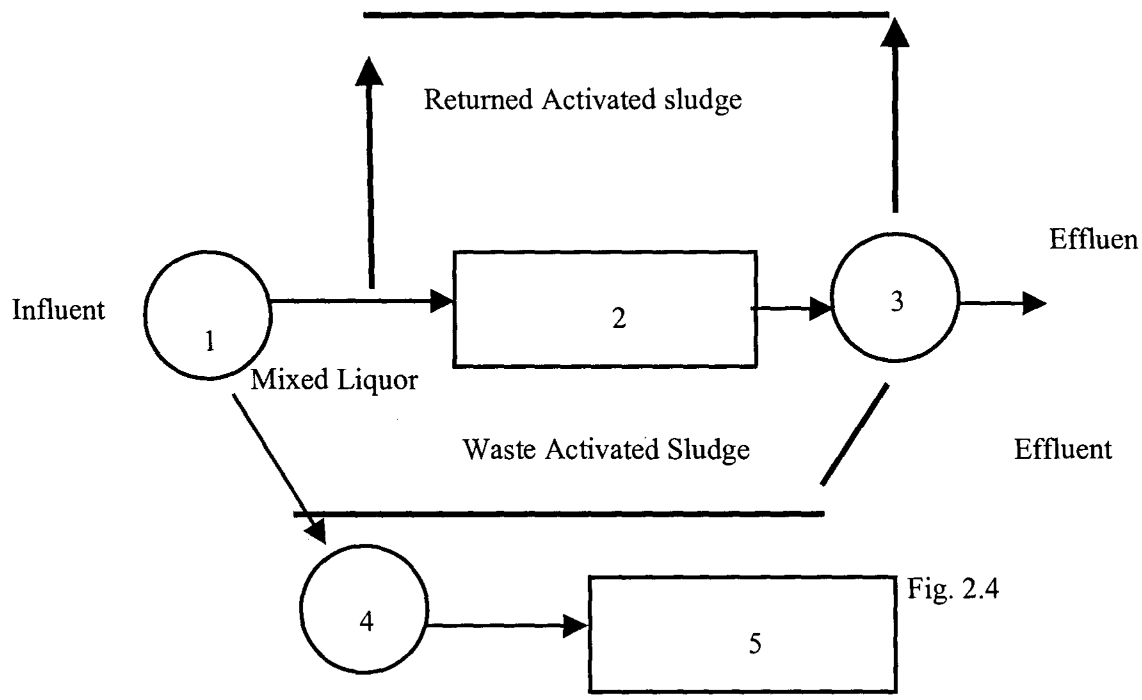



Fig. 2.4

1. Primary Sedimentation
2. Aeration tank
3. Secondary Sedimentation
4. Sludge Digestion tank
5. Sludge drying Beds

**Fig. 2.4 Activated Sludge Flow Diagram** ( A.A.Chika, 2000)

## 2.8. EFFLUENT DISPOSAL

There are four (4) methods of disposing sewage. It can be dumped at sea, dumped in land fill as solids or liquid, recycled to land for beneficial use or it can be in incinerated.

**Lake Disposal:** The ultimate disposal of the treated liquid stream is accomplished in several ways. Direct discharge into a receiving stream or lake is the most commonly practiced. Type of receiving water and effluent standards are used as a regulatory to quantity and quality of the effluent to be disposed in water.

**Land Application**: Land application of wastes provides relatively low cost but very high treatment thus allowing a fixed amount of resources to achieve a greater level of public health and environmental protection. (Burton, G.T, 1991) Land application is agriculturally based, hence is more amenable to a broader variety of sites. There is limitation, however, to use of wastewater for agricultural purposes.

The type of crops to be irrigated with reclaimed wastewater depends on the quality of the effluent, the amount of effluent used, and the heath regulation concerning the use of treated and untreated wastewater on crops. The use of untreated water is generally discouraged.

## 2.8. EFFLUENT RE-USE

**Recycling and Recovery:** Some form of treatment is always required to reduce the health risks caused by pathogens in water coming from a biological plant. Biogas production is used but of the digested sludge from the biogas generator is to be reused on the land, additional treatment is necessary (Micheal.E, 1983). The renovated water can be used directly for municipal, industrial, agricultural, recreational and groundwater recharge. The sludge, after dewatering and drying can be used as manure for landfill or incinerated.

**Table 2.2 Guidelines for wastewater use in agriculture (Abdul, 2000)**

| Category | Reuse Condition | Treatment Required |
|---|---|---|
| A | Irrigation of crops to be eaten uncooked sports fields, public packs | Series of stabilization ponds |
| B | Irrigation of cereal – and folder crops, pasture and trees | At least Primary sedimentation. |
| C | Localized Irrigation of crops category B, no contact by workers or public | At least Primary sedimentation. |

**Sludge disposal:** This is necessary because in the course of primary and secondary treatment a large amount of solid matter is removed from the wastes. It occurs as a liquid sludge containing about 5% to 8% solid matter. Depending on its original source, the solid in the sludge contains both organic matter (45% to 5%) and inorganic matter (55% to 35%) If not treated further, this organic decomposes and creates a nuisance and health hazard. Solids may be treated by anaerobic digestion (controlled decomposition by bacteria in the absence of air) or by chemical treatment followed by filtering, drying or incineration. Digested sewage sludge is black, has a tarry odour, and contains a considerable amount of humus and about 2% of nitrogen (M.G.Royston, 1979). It has been used as a soil conditioner for lawns. Sludge from the activated sludge process contains about 6% Nitrogen and more organic humus than digested sludge. When dried, it makes an excellent soil and lawn conditioner. A number of cities market dried sludge from their water pollution control plants. Other plants burn the sludge and use the inorganic ash as fill. The economics of the process often determines treatment and disposal. (M.G.Royston, 1979).

**WUYE WASTEWATER TREATMENT PLANT**

The activated sludge system is used to treat Domestic sewage in the Wuye Sewage Treatment Plant. In this system sewage from sewer is channeled to Treatment plant through sewer pipes by gravity. Four (4) pumps pump sewage to a screener; the screener screens the sewage and sends it to a classifier, which classifies the sewage into grease and grit. The sewage is then aerated using blowers to keep bacteria alive which grows to form sludge. The intermediate treatment is carried out using secondary segregation pumps along side other equipments. Sewage (Treated sewage) is left for 6 hours before discharge in River. The Abuja Sewage Treatment Plant has a treatment capacity of about $340m^3/hr$

**Table 2.3 DESIGN DATA FOR WUYE LAGOON**

| S/N | DESCRIPTION OF PARAMETER | UNIT | DESIGN DATA |
|---|---|---|---|
| 1 | Population equivalent | P.E. | 50,000 |
| 2 | Specific waste Water Quantity | I/E.d | 210 |
| 3 | Extraneous water | % | 30 |
| 4 | Total Specific Sewage inflow | $m^3/d$ | 14,000 |
| 5 | Expected Hourly Inflow (1/10) | $m^3/hr$ | 1,200 |
| 6 | Specific Load $BOD_5$ @ $20^oC$ | g/E.d | 70 |
| 7 | Total $BOD_5$ @ $20^oC$ Load | kg/d | 1,500 |
| 8 | Specific Load $NH_4^-N$ | g/E.d | 12 |
| 9 | Total Load $NH_4^-N$ | kg/d | 600 |
| 10 | Specific Load $PO_4^-P$ | g/E.d | 3 |
| 11 | Total Load $PO_4^-P$ | kg/d | 150 |
| 12 | Aeration rate | $K_gO_2/KWh$ | 0.15kg |

# CHAPTER THREE

# EXPERIMENTALS

## 3.1 MATERIALS AND EQUIPMENTS

### 3.1.1 MATERIALS

The following is the list of reagents. Chemicals and materials used in the analysis: Sodium Hydrogen, Sodium Iodide, Sodium Nitrate, Distilled water, Dichloromethane, Sulfuric Acid, Potassium Dichromate, Potassium Iodide, Starch solution, Potassium Hydroxide, Potassium Hepta- oxochromate, EDTA solution, ferrochrome Black T indicator, Iron Sulphate Heptehydrate, ferrion indicator, Sulphuric Acid, Zinc Dust, NANA indicator, Blank Solution of $Mg^{2t}$, $NO_3^-$ and $NO_2$ Absorbent, Hydrochloric Acid and Nutrient agar.

### 3.1.2 EQUIPMENTS

The following are the list of equipment used in the analysis: BOD Machine, MPM 300 photometer, Thermometer, Test-tube, Pipette, Burette, Desiccators, Glass Fiber, Filter Disc, Filter Holder, Suction Flask, Dry oven, Analytical balance, Evaporating Dishes, Muffle Furnace, Auto claves: 14 Liter Aluminum autoclave dims: Int Dia x Depth 280x230mm, SC57.

Microscope: MODEL Swift M35050F, Refrigerator.

Tape face Shield: Shakers, Magnetic Stirrers, Timers, Colony counter model suntex 560 Tissue Culture, Washers.

## 3.2. SAMPLING

The data from the analysis of the sample ultimately serve as a basic for designing treatment facilities. Representative sample is to be ensured when sampling techniques are carried out. There are no universal procedures for sampling. However, the velocity of flow at sample point should at all time be sufficient to prevent deposition of solids. Care had been taken to avoid creation of excessive turbulence that might liberate dissolved gases and yield unrepresentative sample.

The sampling methods used are of two main types. They are Spot and Composite samplings. The Spot sampling includes method for determining parameters at a fixed point. More so, Composite sampling involves the mixing of samples taken at regular internal for analysis. This being is done because of the strength and flows at the time of sampling.

The samples were collected at the point of discharge from the plant; 200m backward from the point of discharge and 200m away from the point discharge.

Storing in a refrigerator at $\pm 4^0C$ preserved the samples. The containers used for sampling were rinsed with concentrated HCL and then with distilled water several times and allowed to dry before the samples were taken. The sample container were washed with the sample trace at the collecting point and then filled with the sample and corked.

The samples collected were identified by label on each container showing.

(a) Location of sample

(b) Time and data of sample collection

(c) pH and temperature at the time of collection

(d) Nature of sample

However, samples were collected twice, very early in the morning and in the late afternoon. Samples were taken over a six (6) weeks period (July 10- August 24, 2003).

## 3.3. EXPERIMENTAL PROCEDURE

### 3.3.1 DETERMINATION OF BOD

The BOD was determined by the use of Warburg apparatus, which consist of a constant temperature, water bath, an agitator mechanism and a set of special flask equipped with manometers.

The flask was filed with a measured quantity of wastewater sample 432ml and was agitated in the water with the aid of stirring magnet. After the contents were thoroughly mixed, the manometer was connected, the temperature of the machine was regulated to 20°C and the reading was taken periodically. Oxygen was used up while $CO_2$ was produced by the biological respiration within the sample. The KOH absorbs the $CO_2$ depletion of the oxygen causes oxygen in the air space over the liquid to enter. The quantity of oxygen consumed can then be calculated from the pressure drop as measured with the manometer at the end of the fifth day.

### 3.3.2 DETERMINATION OF TEMPERATURE

The temperature was measured at both the site and laboratory by using thermometer. The thermometer was dropped into the sample and allowed for some minutes and the value that coincides with the risen mercury level was observed and recorded.

### 3.3.3 DETERMINATION OF TOTAL SETTLE ABLE SOLIDS

100ml of the sample was measured into an ion hoff cone and allowed to settle for one hour with the help of a glass rod. This was to facilitate the settling of those solids that stick to the wall of the cone. After fifteen minutes, the amount of settleable solids was read and recorded.

### 3.3.4 DETERMINATION OF PH

The PH was determined by the use of PH Meter. The electrode of this meter was placed in a solution of PH 7 and temperature of the buffer was measured with a thermometer. The temperature control dial was set at the temperature of the buffer and electrode from the buffer solution, rinsed with distilled water and blot dry using cotton. The electrode was then inserted in the second solution and the slope is adjusted until PH Meter indicates the PH of the buffer. The electrode was removed again, rinsed and blot dried before inserting in the sample. The reading on the meter after inserting the electrode in the sample gives PH of the sample.

### 3.3.5 DETERMINATION OF TOTAL HARDNESS

25ml of sample was diluted to 50ml with distilled water and 2ml buffer solution added. 2 drops of eriochrome black T indicator was added and the mixture titrated slowly with EDTA titrant until the last reddish tinge disappears. The last few drops were added 3 to 5 seconds intervals. At the end point, the solution is usually green. The amount of EDTA used for titration was recorded and the hardness of the sample computed from the formulae.

$$\text{Hardness (EDTA)mg } CaCO_3/L = \frac{A \times B \times 100}{\text{ML Sample}}$$

Where: A = ml titration for sample

B = mg CaCO3 equivalent to 1.00ml of EDTA titrant.

### 3.3.6 DETERMINATION OF COD

5ml of sample diluted to 25ml were placed in 500ml refluxing flask and 0.5g of 5ml of AgSO4 added. 5ml of Sulphuric acid reagent were slowly added to dissolve $AgSO_4$. 12.5ml of 0.0417Mo. Solution was also added and mixed while swirling the flask and cooling it under tap water, 35ml of $H_2SO_4$ reagent was slowly added simultaneously through the open end of the condenser. The flask was then refluxed for 2 hours after which the condenser was washed down with distilled water and allowed to cool to room temperature before titrating the excess $K_2Cr_2O_7$ with Ferrion Ammonium Sulphate (FAS) solution, using 3 drops of Ferrion indicator, until the colour changes from blue green to brown green and finally reddish brown. The procedure was repeated with the same volume of distilled water. The COD was calculated from the equation:

$$(COD)\ mg\ O_2/L = \frac{A \times B \times M \times 100}{ML\ of\ Sample}$$

Where: A = ml of FAS used for blank

B = ml of FAS used for sample

C = Morality of FAS

### 3.3.7 DETERMINATION OF CALCIUM IONS.

100ml of the sample was measured into a 300ml beaker and 4ml of Potassium Hydroxide solution added. The mixture was well shaken and then allowed to settle. 0.3ml of Hydroxylamine hydrochloride solution was then added and titration was carried out with 2.5ml of EDTA solution until the colour of the mixture changed from purple to blue using NANA indicator.

$$Ca^{2+} mg/L = A \times C/V \times 1000$$

Where: A= Volume of EDTA Solution

V= Volume of Sample

C= Volume of Concentration of EDTA Solution

### 3.3.8 DETERMINATION OF MAGNESIUM ION.

The $Mg^{2+}$ was determined using MPM 3000 photometer. A sample solution was prepared using 100ml of sample to every 10ml of reagent 7 for $Mg^{2+}$. The Solution was mixed and allowed to stay for 20 minutes at a temperature 30°C. The position of the photometer was adjusted to position 17 for $Mg^{2+}$ by using blank solution. The prepared sample was then inserted into the photometer for $Mg^{2+}$ ion reading.

### 3.3.9 DETERMINATION OF CHLORIDE (CL) ION

50ml of sample filtered was measured into 250ml conical flask. 2 drops of phenolphthalein solution was added until a red colour was produced. 0.1M nitric acid was then added until the solution turned colourless. Two drops of Potassium dichromate solution were added and the mixture titrated with 0.1M Silver nitrate until a reddish brown colour appeared.

$$\text{Chloride (Mg/L)} = \frac{(V1-V2) \times 1000}{V1}$$

Where: V1 = Volume of Silver in Sample

V2 = Volume of Silver Nitrate

C = Concentration of Silver Nitrate

### 3.3.9 DETERMINATION OF NITRATE AND NITRITE

A MPM 3000 Photometer was used in the determinations of nitrate and nitrite values. A sample solution was prepared by mixing 5ml of sample each with 0.5ml of reagent 1 and 2 for nitrates and nitrites. The solution was then mixed and allowed to stay for 10 minutes at a temperature of 30°C. The position of the photometer was adjusted to position 3 and 5 for nitrate ion blanks solution. The sample prepared was then inserted after each blank. The readings from the photometer were recorded as the value of nitrate ion and nitrite ion present in the sample.

### 3.3.11 DETERMINATION OF TOTAL COLIFORM

A method of multitude for detection and enumeration of organisms in wastewater was used. In this method, 100ml of sample was diluted with distilled water in series of 10 tubes. The diluted solution was inoculated into series of petit-dishes containing nutrient agar. The content was then incubated for 24hrs at 35°C. The content from these petit-dishes was placed in the colony counter to get direct reading of Coliform Organisms. The reading was then taken and recorded.

CHAPTER FOUR

# 4.0. EXPERIMENTAL RESULTS

Physio-chemical analysis was carried out on samples of raw sewage (R.S), final Effluent (F.E), raw sewage Upstream (U.S) and final effluent downstream (D.S) over a six (6) weeks period. The results are shown in the tables below.

**Table 4.1: PHYSIO-CHEMICAL ANALYSIS OF PARAMETERS FOR INFLUENT, EFFLUENT, UPSTREAM AND DOWNSTREAM. (WEEK 1).**

| Parameter | (R.S) | (F.E) | (U.S) | (D.S) |
|---|---|---|---|---|
| Temp$^0$c | 32.9 | 32.0 | 31.3 | 32.0 |
| PH ($^{mg}/_L$) | 6.1 | 7.0 | 6.0 | 6.6 |
| $NO_3^-$ ($^{mg}/_L$) | 1.7 | 21.3 | 11.8 | 16.7 |
| $NO_2$ ($^{mg}/_L$) | 0.8 | 10.5 | 17.0 | 18.2 |
| Cl- ($^{mg}/_L$) | 119.1 | 98.2 | 20.6 | 32.4 |
| $Ca^{2+}$($^{mg}/_L$) | 80.6 | 40.2 | 31.6 | 33.1 |
| $Mg^{2+}$ ($^{mg}/_L$) | 85.3 | 31.2 | 14.6 | 17.0 |
| T SS ($^{mg}/_L$) | 225 | 110.0 | 206 | 206 |
| COD ($^{mg}/_L$) | 800 | 72 | 215 | 196 |
| BOD($^{mg}/_L$) | 485 | 33.1 | 98 | 92 |

Raw Sewage is untreated wastewater coming into the Wuye sewage treatment plant.

Final Effluent is treated sewage that is discharged into the Wuye River.

Table 4.2 : PHYSIO-CHEMICAL ANALYSIS OF PARAMETERS FOR INFLUENT, EFFLUENT, UPSTREAM AND DOWNSTREAM. (WEEK 2 )

| Parameter | (R.S) | (F.E) | (U.S) | (D.S) |
|---|---|---|---|---|
| Temp $^0$c | 33.7 | 34.2 | 33.6 | 33.8 |
| PH ($^{mg}/_L$) | 6.2 | 7.2 | 5.9 | 6.7 |
| $NO_3^-$ ($^{mg}/_L$) | 1.3 | 20.0 | 14.0 | 15.6 |
| $NO_2^-$($^{mg}/_L$) | 0.8 | 11.6 | 16.8 | 17.8 |
| Cl ($^{mg}/_L$) | 118.6 | 97.5 | 21.4 | 32.7 |
| $Ca^{2+}$ ($^{mg}/_L$) | 80.4 | 44.3 | 30.0 | 31.9 |
| $Mg^{2+}$($^{mg}/_L$) | 83.7 | 27.2 | 15.5 | 16.2 |
| TSS($^{mg}/_L$) | 230 | 116.0 | 217 | 215 |
| COD($^{mg}/_L$) | 856 | 74.0 | 218 | 201 |
| BOD($^{mg}/_L$) | 493 | 33.9 | 111 | 101 |

**Table 4.3 : PHYSIO-CHEMICAL ANALYSIS OF PARAMETERS FOR INFLUENT, EFFLUENT, UPSTREAM AND DOWNSTREAM. (WEEK 3)**

| Parameter | (R.S) | (F.E) | (U.S) | (D.S) |
|---|---|---|---|---|
| Temp$^0$c | 34.3 | 39.5 | 33.0 | 33.2 |
| pH ($^{mg}/_L$) | 6.1 | 6.9 | 6.1 | 6.5 |
| $NO_3^-$ ($^{mg}/_L$) | 1.5 | 21.2 | 12.3 | 16.1 |
| $NO_2^-$($^{mg}/_L$) | 1.2 | 11.4 | 16.5 | 18.3 |
| Cl- ($^{mg}/_L$) | 120.4 | 99.4 | 20.7 | 33.1 |
| $Ca^{2+}$($^{mg}/_L$) | 78.3 | 40.9 | 31.5 | 32.1 |
| $Mg^{2+}$ ($^{mg}/_L$) | 90.1 | 24.7 | 14.3 | 16.7 |
| T SS ($^{mg}/_L$) | 235 | 113.0 | 207 | 206 |
| COD ($^{mg}/_L$) | 880 | 75 | 213 | 201 |
| BOD ($^{mg}/_L$) | 512 | 33.7 | 100 | 99 |

**Table 4.4: PHYSIO-CHEMICAL ANALYSIS OF PARAMETERS FOR INFLUENT, EFFLUENT, UPSTREAM AND DOWNSTREAM. (WEEK 4)**

| Parameter | (R.S) | (F.E) | (U.S) | (D.S) |
|---|---|---|---|---|
| Temp $^0$c | 31.6 | 27.0 | 31.2 | 32.0 |
| pH ($^{mg}/_L$) | 8.2 | 6.8 | 6.3 | 6.4 |
| $NO_3^-$ ($^{mg}/_L$) | 1.6 | 17.9 | 12.0 | 16.9 |
| $NO_2^-$($^{mg}/_L$) | 1.0 | 10.9 | 17.2 | 18.0 |
| Cl- ($^{mg}/_L$) | 120.6 | 97.8 | 22.6 | 33.0 |
| $Ca^{2+}$($^{mg}/_L$) | 76.1 | 41.2 | 30.7 | 32.8 |
| $Mg^{2+}$ ($^{mg}/_L$) | 93.2 | 22.6 | 16.0 | 16.7 |
| T SS ($^{mg}/_L$) | 229 | 114.0 | 209 | 210 |
| COD ($^{mg}/_L$) | 866 | 63 | 207 | 197 |
| BOD ($^{mg}/_L$) | 497 | 30.4 | 99 | 96 |

**Table 4.5 : PHYSIO-CHEMICAL ANALYSIS OF PARAMETERS FOR INFLUENT, EFFLUENT, UPSTREAM AND DOWNSTREAM. (WEEK 5 )**

| Parameter | (R.S) | (F.E) | (U.S) | (D.S) |
|---|---|---|---|---|
| Temp $^{0}$c | 31.1 | 29.1 | 30.0 | 30.7 |
| pH ($^{mg}/_{L}$) | 8.4 | 6.8 | 6.0 | 6.4 |
| $NO_3^-$ ($^{mg}/_{L}$) | 1.8 | 17.6 | 13.4 | 16.3 |
| $NO_2^-$($^{mg}/_{L}$) | 1.2 | 11.5 | 17.7 | 17.9 |
| Cl- ($^{mg}/_{L}$) | 122.3 | 97.6 | 21.6 | 33.3 |
| $Ca^{2+}$($^{mg}/_{L}$) | 76.5 | 43.7 | 30.1 | 32.1 |
| $Mg^{2+}$ ($^{mg}/_{L}$) | 90.1 | 22.2 | 16.3 | 17.5 |
| T SS ($^{mg}/_{L}$) | 225 | 110.0 | 205 | 207 |
| COD ($^{mg}/_{L}$) | 840 | 57.0 | 203 | 199 |
| BOD ($^{mg}/_{L}$) | 486 | 25.6 | 98 | 99 |

**Table 4.6: PHYSIO-CHEMICAL ANALYSIS OF PARAMETERS FOR INFLUENT, EFFLUENT, UPSTREAM AND DOWNSTREAM. (WEEK 6 )**

| Parameter | (R.S) | (F.E) | (U.S) | (D.S) |
|---|---|---|---|---|
| Temp $^{0}$c | 31.6 | 28.7 | 30.6 | 31.6 |
| pH ($^{mg}/_{L}$) | 6.3 | 6.9 | 6.1 | 6.5 |
| $NO_3^-$ ($^{mg}/_{L}$) | 1.5 | 18.5 | 12.7 | 16.8 |
| $NO_2^-$ ($^{mg}/_{L}$) | 1.1 | 10.7 | 16.8 | 18.0 |
| Cl- ($^{mg}/_{L}$) | 120.6 | 99.3 | 22.1 | 32.6 |
| $Ca^{2+}$ ($^{mg}/_{L}$) | 77.7 | 41.2 | 30.7 | 32.7 |
| $Mg^{2+}$ ($^{mg}/_{L}$) | 85.0 | 30.1 | 15.3 | 16.9 |
| T SS ($^{mg}/_{L}$) | 235 | 115.0 | 205 | 206 |
| COD ($^{mg}/_{L}$) | 893 | 63 | 206 | 198 |
| BOD ($^{mg}/_{L}$) | 472 | 30.1 | 97 | 95 |

Table 4 .7: RESULTS OF MICROBIAL ANALYSIS OF TOTAL COLIFORM IN THE INFLUENT, EFFLUENT, UPSTREAM AND DOWNSTREAM.

| No | ITC x $10^3$ | ETC x $10^3$ | UTC x $10^4$ | DTC x $10^4$ |
|---|---|---|---|---|
| Test I | 3.5 | 0.7 | 0.9 | 1.2 |
| Test II | 3.5 | 1.0 | 1.1 | 1.2 |
| Test III | 4.1 | 0.9 | 1.3 | 1.4 |
| Test IV | 4.3 | 1.0 | 1.3 | 1.4 |
| Test V | 3.8 | 1.0 | 1.1 | 1.2 |
| Test VI | 3.7 | 0.9 | 1.1 | 1.1 |

Table 4.8: FEPA STANDARDS FOR PHYSIO-CHEMICAL CHARACTERISTICS OF DOMESTIC SEWAGE.

| Contaminants | Weak ($^{mg}/_L$) | Medium ($^{mg}/_L$) | Strong ($^{mg}/_L$) |
|---|---|---|---|
| Total sold | 350 | $x10^3$ | $x10^4$ |
| BOD | 110 | 0.7 | 0.9 |
| COD | 250 | 1.0 | 1.1 |
| $NO_2^+$ | 0 | 0.9 | 1.3 |
| $NO_3^-$ | 0 | | |
| $PO_4^-$ | 4 | 1.0 | 1.3 |
| $CL^-$ | 30 | 1.0 | 1.1 |
| $Ca^{2+}$ | 50 | 0.9 | 1.1 |
| $Mg^{2+}$ | 50 | 100 | 200 |
| $T^0C$ | 29 | 30 | 30 |
| Total coliform | $10^6$ -$10^7$ | $10^7$-$10^8$ | $10^7$ -$10^9$ |
| S | 20 | 30 | 50 |
| T.S. S | 50 | 100 | 200 |

Table 4.9: FEPA GUIDELINE FOR EFFLUENT STANDARD

| Contaminants | Concentrations |
|---|---|
| PH | 6.5 |
| Total Hardness | 62 $^{mg}/_{L}$ |
| BOD | 10 – 20 $^{mg}/_{L}$ |
| COD | 20 – 40 $^{mg}/_{L}$ |
| $NO_2^+$ | 20 $^{mg}/_{L}$ |
| $NO_3^-$ | 25 $^{mg}/_{L}$ |
| $CL^-$ | 115 $^{mg}/_{L}$ |
| $Ca^{2+}$ | 35 $^{mg}/_{L}$ |
| Temp | $30^0C$ |
| Total coliform | $10^3$/100mg $H_2{}^0$ |
| T S S | 2 – 5 $^{mg}/_{L}$ |

# CHAPTER FIVE

## 5.0 DISCUSSION OF RESULTS

Tables 4.1 to 4.6 contains results of physio-chemical analysis carried out on samples of; raw sewage, effluent, upstream influent and downstream effluent. From the tables it was observed that the results obtained for various parameters deferred from time to time.

For the effluent (raw sewage) analysis shows that the temperature ranges from 31.1$^0$C to 34.3$^0$C, pH ranges from 6.1 to 8.4, total settleable solid (TSS) ranges between 225mg/l and 235mg/l, $mg^{2+}$ ranges between 83.4mg/l and 93.2mg/l, $Ca^{2+}$ ranges between 76.1mg/l and 80.6mg/l, $NO_3^-$ ranges between 1.3mg/l and 1.8mg/l, $NO_2^-$ ranges between 0.8mg/l and 1.2mg/l, $Cl^-$ ranges between 118mg/l to 122.3mg/l, COD ranges between 472mg/l and 512mg/l.

For the effluent, temperature ranges between 28.7$^0$C and 37$^0$C, pH ranges between 6.8 and 7.2, TSS ranges between 110mg/l and 116mg/l, $mg^{2+}$ ranges between 22.2mg/l and 31.2mg/l , $Ca^{2+}$ ranges between 40.2mg/l and 44.3mg/l, $NO_3^-$ ranges between 17.1mg/l and 21.3mg/l, $NO_2^-$ ranges between 10.5mg/l and 11.6mg/l, $Cl^-$ ranges between 97.5mg/l and 99.4mg/l, COD ranges between 57mg/l to 75.0mg/l and BOD ranges between 25.6mg/l and 33.9mg/l.

Temperature difference was observed between the raw sewage and final effluent (treated sewage). Temperature decreased from 31.1$^0$C to 28.7$^0$C, 31.1$^0$C to 21$^0$C, 32.9$^0$C to 32$^0$C, 311$^0$Co 29$^0$C and increases from 33.7$^0$C to 34.2$^0$C and 34.3$^0$C o 39.5$^0$C in test V, VI, I, IV, II and III respectively.

The raw sewage and final effluent samples were found to have an average temperature of 32.5$^0$C and 32.08$^0$C respectively. Therefore, temperature is relatively stable or constant before and after treatment.

The results show that the treated sewage (final effluent) is mostly basic. Fresh sewage is alkaline. (Duggal, 1993)

Also, in the final effluent, there is an increment of $NO_3^-$ and $NO_2^-$ but a decrease in the $Cl^-$, $Cu^{2+}$, $mg^{2+}$, TSS, COD and BOD values which is highly desirable.

From test I, II, III, IV, V and VI the COD and BOD values drop tremendously from 800mg/l to 72mg/l and 485mg/l to 33.1mg/l, 856mg/l to 74mg/l and 493mg/l to 33.9mg/l, 880mg/l to 75mg/l and 512mg/l to 33.7mg/l, 866mg/l to 63mg/l and 497mg/l to 30mg/l, 840mg/l to 57mg/l and 486mg/l to 25.6mg/l, 893mg/l to 63mg/l and 472mg/l to 30.1mg/l respectively.

The average COD value of raw sewage and final effluent samples was found to be equal to 855.83mg/l and 67.33mg/l respectively.

The average BOD value of raw sewage and final effluent samples is equal to 490.83mg/l and 31.13mg/l.

From the obtained result as presented in the tables, the COD readings in all the analyzed samples were greater than their corresponding BOD readings.

For the raw sewage samples analyzed and from the results table the following can be deduced.

Average $NO_3^-$ value = 1.567mg/l

Average $NO_2^-$ value = 1.012mg/l

Average $Cl^-$ value = 120mg/l

Average $Ca^{2+}$ value = 78.27mg/l

Average $mg^{2+}$ value = 87.9mg/l

Average TSS value = 229.83mg/l

Also, from the final effluent samples analysis result we get;

Average $NO_3^-$ value = 19.4mg/l

Average $NO_2^-$ value = 11.1mg/l

Average $Cl^-$ value = 94.9mg/l

Average $Ca^{2+}$ value = 41.9mg/l

Average $mg^{2+}$ value = 26.33mg/l

Average TSS value = 113mg/l

From analysis results, raw sewage and final effluent were found to have an average temperature of $32.5^0C$ and $32.08^0C$ respectively, which are slightly higher than acceptable standard limit value of $30^0C$. These higher temperatures may be as a result of organic decomposition and other reactions that are exothermic.

The pH value for raw sewage and final effluent samples was found to have an average value of 6.88 and 6.93 respectively. These pH values compare favourably with acceptable limit value of 6.5 – 7.2. The pH of the effluent discharge does not pose any environmental or health hazards to the Wuye River.

The effluent TSS average value is 113mg/l, which is higher than acceptable limit value of 50mg/l, therefore, the Wuye is being polluted.

The average flow rate of the wastewater coming into the plant is $m^3$/hr, this value is low when compared with the expected amount of waste water generated by Abuja and its environs.

$Mg^{2+}$ and $Ca^{2+}$ ions found to have average values of 87.9mg/l, 8.27mg/l and 26.33mg/l, 41.9mg/l for the influent and effluent respectively. The influent values are higher than 50mg/l, which is the acceptable limit for week sewage influent.

For $NO^-_2$ ions, the amount in the effluent discharged into the river is higher than the acceptable limit value.

The average values of COD and BOD for the influent and effluent are within the acceptable limit values of 1000mg/l and 500mg/l respectively for domestic sewage.

The result of microbial analysis (total coliform) shown in table 4.7 gives average values of $3.8 \times 10^3$and $0.92 \times 10^3$ for the influent and effluent respectively. The number of total coliform for the influent and effluent ranges from $3.5 \times 10^3$ to $4.3 \times 10^3$ and $0.7 \times 10^3$ to $1.0 \times 10^3$.

The effluent total coliform average value agrees with the acceptable limit value of $1.0 \times 10^3$/100ml.

## 5.1 CONCLUSION

On completion of this research study, which focused on the Wuye sewage treatment plant and based on results from analysis carried out on sewage samples, the following conclusions can be drawn.

At the Wuye sewage treatment plant, domestic sewage is treated to reduce the adverse effect of the final effluent on the Wuye River. However, results obtained from physio-chemical parameters (TSS, BOD, COD, pH, $NO_2^-$, and $NO_3^-$) shows that values are beyond FEPA standards for raw sewage and final effluent. This could be due in part to the increase in population in Abuja urban area which has led to overloading of the treatment plant originally designed for a population equivalent of 50, 000.

Other sewage treatment plants should be established in Abuja to handle the waste water from the constantly growing population.

## 5.2 RECOMMENDATION

i. Government and the private sector should begin to participate in pollution control in terms of proper funding.

ii. Future research should be directed towards the design of more effective sewage treatment facilities.

iii. Effluent standard laws should be enforced to prevent the pollution of water resources.

iv. More sewage treatment plants should be constructed to meet the growing population in Abuja.

v. FEPA should ensure that effluent standards are adhered to.

# APPENDIX

Average Temperature of Raw sewage $\Rightarrow \frac{32.9+337+734.3+31.6+31.1+31.6}{6} = 32.5^0{}_c$

Average Temperature of final Effluent $\Rightarrow \frac{32+34.2+39.5+29+29.1+287}{6} = 32.08^0{}_c$

Average COD value of raw sewage $\Rightarrow \frac{880+856+800+893+840}{6} = 85583mg/_l$

Average COD value of final effluent $\Rightarrow \frac{75+74+72+63+63+57}{6} = 67.33mg/_L$

Average BOD value of raw sewage $\Rightarrow \frac{512+493+485+497+486+472}{6} = 490.83mg/_L$

Average BOD value of final effluent $\Rightarrow \frac{33.7+33.9+33.1+30.4+25.6+30.1}{6} = 31.13mg/_L$

Average Raw sewage sample parameter value

Average $N0_3^- = \frac{1.7+1.3+1.5+1.6+1.8+1.5}{6} = 1.567mg/_l$

Average $N0_3^- = \frac{0.8+0.8+1.24+1.0+1.2+1.1}{6} = 1.012mg/_l$

Average $Cl^- = \frac{119.1+118.6+120.6+122.3+120.6}{6} = 120mg/_l$

Average $Ca^{2+} = \frac{80.6+80.4+78.3+76.1+76.5+77.7}{6} = 75.27mg/_l$

Average $Mg^{2+}$ = 85.3+83.7+90.1+93.2+90.1+85 = 87.9mg/l

6

Average T S S = 225+230+235+229+225+235 = 229.83mg/l

6

Average Final effluent sample parameter values

Average $NO_3^-$ = 21.3+20+21.2+17.9+17.6+18.9 = 19.4mg/l

6

Average $NO_2^-$ = 10.5+11.6+11.4+10.9+11.5+10.9 = 11.1mg/l

6

Average $Cl^-$ = 78.2+97.5+99.4+97.8+97.6+99.3= 94.9mg/l

6

Average $Ca^{2+}$ = 40.2+44.3+40.9+41.2+43.7+41.2 = 41.9mg/l

6

Average $Mg^{2+}$ = 31.2+27.2+24.7+22.6+22.2+30.1 = 26.33mg/l

6

Average T S S = 110+116+113+114+110+115 = 113mg/l

6

Average pH value for Raw sewage => 6.1+6.2+6.1+8.2+8.4+6.3 = 6.88

6

Average Total coliform value for Raw sewage => 3.5+3.5+4.1+4.3+3+3.8+3.7 =

$3.8x10^3$/100mg/l

6

Average Total coliform values => 0.7+1.0+0.9+1.0+1.0+0.9 = $0.92x10^3$/100mg/l

6

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