EFFECT OF DOMESTIC WASTEWATER DISCHARGE ON WELL WATER USE QUALITY IN IKOLE-EKITI, EKITI STATE NIGERIA.

BY

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CERTIFICATION

This is to certify that this is an original and independent research project carried out by IBIDEJI, A. R. (WMA/12/0490) in the Department of Water Resources Management and Agro-meteorology, in partial fulfillment for the award of Bachelor of Agriculture (B.Sc.) in Water Resources Management and Agro-meteorology, Federal University Oye-Ekiti.

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DEDICATION

This dissertation is dedicated to my father, Mr. A.G Ibideji and my mother, Mrs. Celina Ibideji.

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ABSTRACT

The aim of the present study is to know the effect of wastewater (sewage) discharge on the quality water in Ikole-Ekiti, Ekiti State Nigeria.

The community discharges wastewater which affect the water quality with most of the wastewater coming from domestic wastewater. Associated with the development of the area, the increase of pollutants into the surface water has been majorly from domestic activities.

The study involved sampling of well water from four communities in Ikole LGA of Ekiti State, i.e, Ilotin-Ekiti, Asin-Ekiti, Usin-Ekiti, Ikoyi-Titun Ekiti. Samples were is collected from wells in three different locations in each community.

Four sampling stations were selected .The first was Ilotin Ekiti denoted as A, the second station is Asin Ekiti denoted as B, the third station is Usin Ekiti denoted as C, the fourth station is Ikoyi- Titun Ekiti denoted as D.

The results obtained showed that the values of Turbidity, Electrical conductivity, Salinity, Total dissolved solid, total suspended solid, dissolved oxygen, biological oxygen demand, total Hardness, chlorides, sulphate, nitrate, phosphate, total bacterial count, total coliform bacteria, Faecal coliform were found to be higher at station 1 and station 4 but easily within the permissible limit of (WHO) at station 2 and station 3. The electrical conductivity values vary from 164- 399pscm$^{-1,}$ the total dissolve solid values varied from 41.968-112.285mg/l. Total suspended solid values ranged from 18.653-49.905mg/l with turbidity value range from 6.995-18.714 NTU. It was found that the well water has values which ranged between 5.9-7.5. The biological oxygen demand values were found to be higher at stations 1 and 4 BOD values ranged from 20.984-56.143. The total hardness ranged between 85.450-228.60mg/l. The chloride value varied from 4.663- 12.476mg/l, the sulphate value ranged between 11.658-31.190 mg/l. Nitrate values ranged from 2.073-5.54 mg/l and the phosphate values ranged between 0.234-0625 mg/L.

The study result also showed that heavy metals concentration (Zinc and Copper) were 0.397-1.062 mg/l and 0.099-0.265 mg/l respectively. This study has shown that the highest total

bacterial count was recorded at the third station which was 6 CFU/125ml, whereas the lowest value was found at station 2 and 4 which was 2 CFU/125ml. Total coliform bacterial counts ranged from 0 CFU/125ml-3 CFU/125ml, Fecal coliform ranged from 0 CFU/125ml-7 CFU/125ml. these values were above the WHO permissible limit for drinking water, only a well from station 2 and 3 was within the permissible limit from WHO drinking water standard of 0 CFU/125ml.

The significance of the study is to access the current status of well water quality in Ikole-Ekiti and it is hoped that the result of this study will assist the relevant and appropriate preventive measures to ensure that the water is improved.

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LIST AND DEFINITIONS OF SYMBOLS

AOAC: Association of Official Analytical Chemists

BOD: Biochemical Oxygen Demand

COD: Chemical Oxygen Demand

DO: Dissolved Oxygen

EC: Electrical Conductivity

FC: Faecal Coliforms

NTU: Nephelometric Turbidity Units

pH: Potential of Hydrogen

TBC: Total Bacterial Count

TC: Total Coliform

TDS: Total Dissolved Solids

TH: Total Hardness

TSS: Total Suspended Solids

WHO: World Health Organization

UNEP: United Nations Environment Programme

USEPA: United State Environmental Protection Agency

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CHAPTER ONE

1.0 INTRODUCTION

1.1 Background of the study

Water is the most important natural resource and essential for life, as it provides habitat for diverse types of aquatic life in rivers, lakes and oceans, and it covered about 70% of the earth surface. It constitutes more than 2.5 times that of the earth main land. Also it is known the water constitutes about 70% of the human body. Availability of water resources in countries is a principal factor for the development. Therefore, it is necessary to protect it from the pollution problems and manage it uses. (Cheepi, 2012; Ahmed and Kheder, 2009)

Approximately, 20% of the world's population lacks safe drinking water and nearly half the world population lacks adequate sanitation. This problem is acute in many developing countries, which discharge an estimated 95% of their untreated urban sewage directly into surface waters.

Surface water bodies are affected because they received water from wastewater (point source), irrigated drainage and runoff (non-point source). Impacts depend on the extent that wastewater has been in contact with soil, on that type of water body, and their use, as well as the hydraulic retention time and the part played within the ecosystems.

The availability and quality of water always have played an important role in determining the quality of life. Water quality is closely linked to water use and to the state of economic development (Chennakrishnan et al., 2008). Ground and surface waters can be contaminated by several sources. In urban areas, the careless disposal of industrial effluents and other wastes may contribute greatly to the poor quality of water (Mathuthu et al., 1997). Most of the water bodies in the areas of the developing world are the end points of effluents discharged from industries.

The unscientific disposal of the wastewater (sewage) has caused immense environmental problems not only to the aquatic environment but also to human beings worldwide. This problem started long back but intensified during the last few decades, and now the situation has become alarming (Mohammed et al., 2012). During the past three decades, the effects of municipal sewage and effluents, the point source pollution, on the water quality of canals, streams and rivers have received some attention but very little has been reported about the temporal effects of the sewage on the water quality of the receiving water bodies (Kumar and Reddy, 2009).

The changes in the nutrient concentrations of water may lead to harmful effects to humans and aquatic life. Most heavy metals in streams of water are commonly associated with industrial discharges but less in domestic discharges (Mdamo, 2001) and heavy metals have cumulative toxins to aquatic life. The physical-chemical parameters of an aquatic body not only reflect the type and diversity of aquatic biota but also the water quality and pollution (Birley and Lock, 1999). The term "sewage" means gray water that is generated by man activities in the process of meeting his various living requirements. The sewage can be described as wastewater from a community. Wastewater refers to spent or used water containing dissolved or suspended matter. Wastewater from residential areas is referred to as domestic sewage (Porteous, 2000; EPA, 2012; Kamusoko and Musasa, 2012).

In Ikole Ekiti, Ikole LGA, there are less industrial discharges due to little or no industries in the community. The major form of wastewater discharge is domestic wastewater discharge and it comes from domestic use like clothe washing, toilet water, bathing, dish washing and kitchen use. Domestic wastewater consists of pollutants such as human wastes (faeces and urine) and sludge. The term sludge refers to wastes arising from food preparation and cleaning of kitchen utensils, laundry and floor drain wastes. Sewage from various homes and institutions (private and public) in a community constitute municipal sewage (Girija et al.

2007; Uwidia and Ademoroti, 2011).

1.2 Problem statement

Domestic effluents are discharged in Ikole Ekiti almost exclusively without proper disposal and adequate treatment which results in deterioration of water quality and nutrient enrichment, the accumulation of toxic compounds in biomass and sediments, and other nuisances.

Streams and wells. Water are highly colored, and there is high turbidity. Water is used for cleaning, bathing, toilet use, kitchen use, food cooking and some farmers use it for irrigation of vegetables. Wetlands are known to act as natural filters for nutrients and contaminants that originate from the catchment area, thereby protecting the water quality (Kansiime and Nalubega, 2000). Regrettably, wetland that is expected to filter contaminants has been degraded and reduced in size due to increased human activities causing a reduction in its cleaning potential thus allowing wastewater to move downward to the water table level.

Ikole Ekiti community do not practice any form of wastewater treatment or proper disposal of wastewater. This leads to reduced quality of water in the community due to too much loading of wastewater without proper disposal and treatment. This creates an urgent need to assess the impact of wastewater from domestic use in Ikole Ekiti on water quality of receiving streams.

1.3 General objective

To assess the impact of domestic wastewater discharge on water quality of Ikole, Ekiti State.

1.3.1 Specific objectives

To determine the physico-chemical characteristics (COD, BOD, pH, E.C, turbidity, TDS, TSS, Total Hardness,) elemental characteristics (Ca^2+, Cl", SO_4, NO_3 and PO_4) and metals (Fe, $Cu^2+$and Zn) in wells in Ikole-Ekiti.

1.4 Significance of the study

The study assessed the current status of well water quality in Ikole-Ekiti and it is hoped that the results of this study will assist the relevant and appropriate preventive measures to ensure that the water quality is improved.

1.5 Aims of the study.

The current study was designed to achieve the following objectives:

1. Determining the effect of wastewater discharge on physical, chemical and biological characteristics of water in Ikole-Ekiti.
2. Determination of some bacteria numbers included Total Bacterial Count, Total Coliforms, and Fecal Coliform as indicators for water pollution of well water in Ikole-Ekiti.
3. Determination of some heavy metals levels (zinc and copper) as indicators for water pollution of well water in Ikole-Ekiti.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Water pollution

Water pollution due to discharge of untreated effluents and improper disposal of waste into water bodies and lands is a major problem in the global context (Mathuthu et al., 1997). The problem of water pollution is being experienced by both developing and developed countries. Human activities give rise to water pollution by introducing various categories of substances or waste into a water body. The more common types of polluting substances include pathogenic organisms, oxygen demanding organic substances, plant nutrients that stimulate algal blooms, inorganic and organic toxic substances.

Wastewater from domestic uses and sewage spillages from burst pipes in urban centres are being released to water bodies and improper disposal of waste on lands. With the prevailing hard economic situation in the country, most of the waste effluents are released into the environment untreated or partially treated. Industrialists have adopted the use of substandard treatment methods that partially treat and in some instances, forego the effluent treatment process. Industrialization is expanding rapidly and domestic use of water is inevitable, this leads to increase demand of water and increased waste water disposal.

However, there has been little regard to the effects of most domestic wastes to the environment and to whether it would leave the environment as it were or would have some adverse impact. Today, the most affected part of the environment is the water resources, and it is one of the most essential resources available for human use. Most communities have little or no knowledge on the effect of waste disposal on water and the environment and they do not have treatment plants, sanitary landfills and incinerators. Solid waste, which is indiscriminately dumped in wetlands in the suburbs are one of the sources of chemicals that end up in drinking water. These results indicated directly the high possibility of pollution to municipal waters.

Furthermore, this can be the major cause of pollution to water resources in the community and makes humans vulnerable to toxic substances through drinking water. Chemical waste producing industries are not sited in Ikole-Ekiti, the industries available are saw mill industries which pose little chemical impact on the environment.

The major causes of pollution in Ikole-Ekiti communities has been subsequently identified as: improper waste disposal, poor drainage systems, dumping of refuse on bear soil , waste water discharge from homes, works, hospitals, schools, abattoir effluent and garbage collection.

The environment is exposed to various types of pollutants such as heavy metals, pesticides, detergents, petroleum products, and other materials, in additional to industrial, agricultural and medical wastes may lead to a negative impact on public health and biodiversity (Maitera et al., 2010; Osibanjo et al., 2011).

The danger of industrial waste substances being toxic to humans and other organisms, and many studies have been made to identify these toxic residues using methods used in Environmental toxicology, which deals with the study of harmful effects of pollutants and knowledge effects of chemicals in environmental regulations and the reasons and magnitude of these affects to take preventive and remedial measures possible (Kanu and Achi, 2011; Kenneth and William, 2012). World health organization (WHO), has reported that 2.3 billion people in 2025 would suffer from an acute shortage of potable water unless significant steps have to be considered at least to reduce water pollution (WHO, 1996a; WHO, 2004).

2.2 Wastewater discharge characteristics and water quality

Water pollution is commonly defined as any physical, chemical or biological change in water quality which adversely impacts on living organisms in the environment or which makes a water resource unsuitable for one or more of its beneficial uses. Some of the major categories of beneficial uses of water resources include public water supply, irrigation, recreation, industrial production and nature conservation.

Occasionally, pollution may derive from natural processes such as weathering and soil erosion. In the vast majority of cases, however, impairment of water quality is either directly or indirectly the result of human activities (Dix, 1981). Virtually all categories of water use contribute to pollution. Every time water is used, it acquires one or more contaminants and its quality declines. Whenever any resource is processed or consumed, some of it becomes waste and is disposed of in the environment. In a large number of cases the waste materials are or become water borne and contribute to water pollution.

Both the nature of a pollutant and the quantity of it are important considerations in determining its environmental significance. Generally, readily degradable substances are quickly broken down in the environment and are of great concern only when they are disposed of in sufficiently large quantities that a significant burden is placed on the natural purification processes. On the other hand, industries produce and use a multitude of synthetic substances, a great many of which are non-biodegradable or degrade extremely slowly. Such recalcitrant substances persist in the environment for prolonged periods of time and may therefore become progressively more concentrated. Many of these substances are toxic or carcinogenic and may accumulate in the tissues of organisms. Such pollutants are particularly worrisome, as they tend to build up in successive trophic levels of a food web. When characterizing pollution and for formulating control and management strategies, it is useful to distinguish between "point" and "non-point" sources. Point sources are discrete and readily identifiable and, as a result, they are relatively easy to monitor and regulate (Stumm and Mogarn, 1981). Most sewage (wastewater of mainly domestic origin, containing among others, human excreta) from urban areas and industrial wastewaters are discharged from point sources.

Non-point sources, on the other hand, are distributed in a diffused manner. The location and origin of non-point sources are sometimes difficult to establish and they are therefore less amenable to control. Runoff from large urban or agricultural catchments carrying loads of sediments and nutrients, are examples of non-point sources of water pollution.

2.3 Types of water pollutants.

2.3.1 Domestic sewage wastes.

This type of wastewater originates from residential locations and other municipal activities such as water are heavily contaminated with various organic and inorganic pollutants (Reddy et al., 2011; Geetu and Surinderjit, 2012).

2.3.2 Industrial wastes.

This type of wastewater include different types of pollutants which are:

- Physical contaminants, such as some remnants of paper mills, dyes, tanning and textiles which cause change in color of water (ICIMOD, 2007; Kenneth & William, 2012).
- Chemical contaminants, such as solid waste, hydrocarbons, oil products and inorganic chemicals such as heavy metals and dissolved gases which affect on values of hydrogen ion (pH) and biochemical oxygen demand (BOD_5) in water (Jay and Keely, 2005; Sultana et al.,2013).

2.3.3 Agricultural wastes.

This type of wastewater including nutrients, chemical fertilizers and organic pesticides which reach into rivers and lakes through irrigation and drainage water in soils adjacent to water bodies (Bradl , 2005; Sada, 2010).

2.3.4 Other pollutants.

There are other types of pollutants as radioactive pollutants and thermal pollutants and acid and alkaline pollutants and gases pollutants as chlorine and ammonia and negative ion as fluorides and sulfate (EEA, 2012).

2.4 Organic pollution in the water.

The term "Organic pollution" refers to the pollution that is happening to the water and resulting from organic materials biodegradable naturally by microorganisms, and which can pose serious environmental health problems (Al-sarwi, 2008; Uwidia and Ademoroti, 2011).

Natural organic matter found in all the surface water such as aromatic and large allophatic compounds. These materials differ due to weather changes, water system and a number of other environmental factors (Young and Ulrich, 2008; Matilainen and Sillanpaa, 2010).

The most important source of organic matter in the water is municipal sewage due to human biological activity and other organic household wastes such as detergents and wash liquids releasing various nutrients (Goel, 2008).

High nutrients concentration leads to eutrophication, a condition characterized by significant diurnal variation in dissolved oxygen concentration and excessive algal growth (Sengupta, 2006; Wang et al., 2013).

Studies indicate that most of the World Rivers are contaminated, but to varying degrees. For example the Rhine River becomes polluted even called the longest stream of dirty water in the world (Cited in AlHaidarey, 2003).

Many millions more suffer from frequent and debilitating water borne diseases. About half of the inhabitants of developing countries do not have access to safe drinking water and 73% have no sanitation. Some of their wastes eventually contaminate their drinking water supply leading to a high level of risks (Maitera et al., 2010; Charity et al., 2012).

2.4.1 Domestic Sewage.

The impact of sewage disposed on the environment has become a threat to the existence of plant, animals and ultimately human life. Pollution is causing widespread concern and has become an important area of interest in the field of modern research.

Discharge of untreated sewage water into water body is a common practice in many countries. This is the common cause for pollution of surface and groundwater due to lack of proper wastewater plants in Nigeria.

In general, the municipal wastewater is a combination of the water and carried wastes removed from residential, institutional and commercial establishments together with infiltration of water, surface water and runoff water (Gautam et al., 2012; APEGBC, 2013).

The domestic sewage contains a large variety of inorganic and organic impurities and pathogens bacteria and viruses resulting in waterborne diseases. Water is organically polluted by high molecular weight compounds such as sugars, fats, oils, proteins released from domestic and industrial wastes and causing unpleasant odor, color, taste and algal growth (Chavan and Dhulap, 2012 ; Puerari et al., 2012).

Sewage effluents are often the main factors responsible for deterioration of water quality as they have a major impact on the chemical loads received by surface water bodies (Drolc et al., 2007; Picot et al., 2009). High levels of nitrogen and phosphorus are generally found in sewage effluents, and contribute to high eutrophication levels and reduce water functionalities

(David et al., 2012). Discharge points of industrial and municipal wastewater are continuous sources of pollution for surface water, where making the river not always able to absorb them and, compromising their quality. Since flow discharges vary with the hydrological conditions, the dilution may or may not occur. This is important because the dry season can last several months in arid and semi-arid areas and intermittent rivers and sewage effluents can contribute up to 100 % of the inflow during dry periods (David et al., 2011; Garcia et al., 2012).

2.4.2 Chemical structure of raw sewage.

Water previously used or resulting from population centers and industrially, are not suitable for consumption and classified according to their source: wastewater, domestic, industrial and agricultural Kumar et al., 2012).

Agricultural wastewater is chemical fertilizers and organic used in agriculture such as pesticide spraying and fertilizer application, which arrive to surface and ground water body through drainage. Also, detergents consist of different chemical components such as surfactants, soaps, bleaches and enzymes that reach surface and groundwater through sewage (Geetu and Surinderjit, 2012; Zelenakova et al., 2013).

Industrial processes are causing the production of large amounts of toxic and stable pollutants, which are all collected into the water out coming from the plant. The disposal of these contaminated effluents into receiving waters can cause environmental damages, directly influencing the aquatic ecosystem and even human being (Spina et al., 2012; Sultana et al., 2013). Also, textile and pharmaceutical effluents are usually recalcitrant to the standard biological treatments, due to the complex aromatic compounds, the extreme chemico-physical parameters and the presence of an autochthonous bacterial microflora (Hai et al., 2008; Rosales et al., 2011). The domestic and municipal wastewater are composed of 99.9 % water and remaining 0.1 % suspended, colloidal and dissolved solids (EPA, 2005; Gautam et al., 2012).

These contaminants consist of solids is 30% inorganic materials and 70% of organic materials include 65% proteins and 25% carbohydrate and 10% fat.

These components vary depending on the purpose of the water uses, as in Table 2.1 (Al-Saadi, 2006):

Table 2.1: The percentage of the household water uses.

No.	Use type	Percentage
1.	Drinking	. 1%
2.	Food cooking	. 3%
3.	Clothes wash	13%
4.	Dishes wash	13%
5.	Toilet	30%
6.	Bathes	40%

Source: Al-Saadi (2006)

Domestic sewage contains on a number of pollutants causing bacterial diseases such as cholera, salmonella, shigellas; viral diseases such as hepatitis, enteroviruses, poliovirus, and other parasites diseases such as protozoan's, helminthes. All these diseases lead to physiological and even psychological problems that may lead to death in some cases (Kahun and Yardley, 2007; Adingra et al., 2012).

Also domestic sewage may contain phosphorus and nitrogen which allows the growth of some undesirable algae species particularly in locations where water static terms lead to the formation of a layer of the algae on the surface of the water emit unpleasant odors and change the taste of water, as well as lead its growth to increased demand for oxygen and therefore reduce its concentration in the water (EPA 2012a; Loe et al. 2012).

However, sewage may contain heavy metals at considerable levels which gives rise to toxic concentrations in the body. Some of these metals such as arsenic, cadmium and chromium may act as carcinogens while such as mercury and lead are associated with developmental abnormalities in children (Adekunle et al., 2012; Preeti and Fazal, 2013).

2.4.3 Biodegradable Organic Substances

Human and animal wastes as well as effluents from industries processing plant or animal products contain a mixture of complex organic substances such as carbohydrates, proteins and fats as their major pollution load (DANIDA, 1998). These substances are readily biodegradable and when introduced into the environments are quickly decomposed through the action of natural microbial populations.

Some of the organic matter is oxidized to carbon dioxide and water while the rest is assimilated and used for the synthesis of new microbial cells. In due course, these organisms will also die and become food for other decomposers. Eventually virtually all of the organic carbon will be oxidized. When a biodegradable organic waste is discharged into an aquatic ecosystem such as a stream, estuary or lake, oxygen dissolved in the water is consumed due to the respiration of microorganisms that oxidise the organic matter (Davies and Walker, 1986). The more biodegradable a waste is, the more rapid is the rate of its oxidation and the corresponding consumption of oxygen. Because of this relationship and its significance to water quality (dissolved oxygen levels in the water), the organic content of waste waters is usually measured in terms of the amount of oxygen consumed during its oxidation.

Biological Oxygen Demand (BOD).

In an aquatic ecosystem, a greater number of species of organisms are supported when the dissolved oxygen (DO) concentration is high. Oxygen depletion due to waste discharge has the effect of increasing the numbers of decomposer organisms at the expense of others.

When oxygen demand of a waste is so high as to eliminate all or most of the dissolved oxygen from a stretch of a water body, organic matter degradation occurs through the activities of anaerobic organisms, which do not require oxygen (Meertens et al., 1995).

Not only does the water then become devoid of aerobic organisms, but anaerobic decomposition also results in the formation of a variety of foul smelling volatile organic acids and gases such as hydrogen sulphide, methane and mercaptans (certain organic sulphur compounds). The stench from these can be quite unpleasant and is frequently the main cause of complaints from residents in the vicinity.

Chemical Oxygen Demand (COD)

COD is the measure of the total quantity of oxygen required to oxidize all organic material into carbon dioxide and water. It does not differentiate between biologically available and inert organic matter. COD values are always greater than BOD values, but COD measurements can be made in a few hours while BOD measurements usually take five days (BOD5).

2.4.4 Plant Nutrients

The availability of plant nutrients, particularly nitrogen and phosphorus are important determinants of the biological productivity of aquatic ecosystems. Nutrient deficient aquatic environments are called "oligotrophic" and those rich in nutrients, "eutrophic".

Sewage, animal wastes and many industrial effluents contain high levels of nitrogen and phosphorus. Another major source is fertilizer run off from urban and agricultural catchments. While in the long term, cultural eutrophication accelerates the natural successional progress of aquatic ecosystems towards a terrestrial system; in the short term problems arise due to cyclic occurrences of algal blooms and decay. In warm weather, nutrients stimulate rapid growth of algae and floating aquatic weeds. The water often becomes opaque and has unpleasant tastes and odours. When these organisms die they become food for decomposer bacteria. Depletion of dissolved oxygen leads to anaerobic conditions and a general decline in the ecological and aesthetic qualities of the water body.

According to Perry et al, (2007), nitrogen, phosphorus, or both may cause aquatic biological productivity to increase, resulting in low dissolved oxygen and eutrophication of lakes, rivers, estuaries, and marine waters. Besides adding to nutrient-content of the water, addition of some forms of nitrogen and phosphorus will increase BOD and COD (Mahdieh and Amirhossein, 2009). Increased nitrogen levels adversely affect cold-water fish more than they do warm water fish.

In the natural world phosphorus is never encountered in its pure form, but only as phosphate. Phosphorous is one the key elements necessary for growth of plants and animals. Phosphorus in its pure form has a white colour. White phosphorus is the most dangerous form of phosphorus that is known to us (Mosley et al., 2004). When white phosphorus occurs in nature, this can be a serious danger to our health because it is extremely poisonous. White phosphorus enters the environment when industries use it to make other chemicals and when the military uses it as ammunition. Through discharge of wastewater, white phosphorus ends up in surface waters near the factories that use it. Phosphorus is generally the limiting nutrient in fresh water systems and any increase in phosphorus usually results in more aquatic vegetation. Phosphates can also be found commonly in plants. Concentrated phosphoric acids are used in fertilizers for agriculture and farm production. Phosphates are used for special glasses, sodium lumps, in steel production, in military applications (incendiary bombs and smoke screening), and in other applications such as pyrotechnics, pesticides, toothpaste and detergents.

In oceans, the concentration of phosphates is very low, particularly at the surface. The reason lies partly within the solubility of aluminium and calcium phosphates, but in any case in the oceans phosphate is quickly used up and falls into the deep Sea as organic debris. There can be more phosphate in rivers and lakes, resulting in excessive algae growth (USEPA, 1986). Phosphates enter waterways from human and animal waste, laundry cleaning, industrial effluents, and fertilizer runoff. These phosphates become detrimental when they over fertilize aquatic plants and cause stepped up eutrophication.

If too much phosphate is present in the water, the algae and weeds will grow rapidly, may choke the waterway, and use up large amounts of precious oxygen (in the absence of photosynthesis and as the algae and plants die and are consumed by aerobic bacteria).

The result may the death of many aquatic organisms (USEPA, 1986) such as the zooplankton and fish.

The net result of the eutrophic condition and excess growth in water is the depletion of oxygen in the water due to the heavy oxygen demand by microorganisms as they decompose the organic material. Little attention has been given to management strategies to minimize the nonpoint point movement of phosphorus in the landscape because of the easier identification and control of point source inputs of phosphorus to surface waters and lack of direct human health risks associated with eutrophication.

Phosphates exist in three forms: orthophosphate, metaphosphate (polyphosphate) and organically bound phosphate. Each compound contains phosphorus in a different chemical formula. Ortho forms are produced by natural processes and found in sewage. Poly forms are used for treating water boilers and in detergents. In water, they change into the ortho form. Organic phosphates are important in nature; their occurrence may result from the breakdown of organic pesticides which contain phosphates.

Phosphates are not toxic to people or animals unless they are present in very high levels.

2.4.5 Heavy Metals.

The term "heavy metals" refers to any metallic element that has a relatively high density and is toxic or poisonous even at low concentration (Duruibe et al., 2007) also “Heavy metals” are defined as all metals of atomic weight greater than sodium with specific gravity of more than 5.0 g/cm3 (Beasley & Kneale, 2007; Rahimi et al., 2013).

The presence of heavy metals in the aquatic environment has been of great concern because of their toxicity at lower concentrations (Uba et al., 2009; Nasrabadi et al., 2010).

According to Richardson & Niebaer (1980), these metals can be divided into three main groups (Raikwar et al., 2008):

- Macro elements, which includes a group of elements that are needed by living organisms for catalyzing their biological systems and represent as important factors for metabolism, such as calcium (Ca), sodium (Na), potassium (K), magnesium (Mg), chloride (Cl), and phosphor (P).
- Essential elements, which includes a group of elements that are needed by living organisms in trace amounts and play significant roles in the biological systems but have toxic effects if they one present in concentrations more than organisms needing, such as chromium (Cr), zinc (Zn)‘ iron (Fe), manganese (Mn), copper (Cu), cobalt (Co), and selenium (Se).
- Non-essential elements, which includes a group of elements haven’t exact roles in biological systems and consider as toxic agents, such as arsenic (Ar), barium (Ba), cadmium (Cd), lead (Pb), lithium (Li), mercury (Hg), and nickel (Ni).

In case of toxicity, these metals can be classified into three groups according to Neis (1999):

- Low toxic elements, which include molybdenum (Mo), iron (Fe), and manganese (Mn).
- Middle toxic elements, which include zinc (Zn), nickel (Ni), chromium (Cr), copper (Cu), cobalt (Co), vanadium (V), as well as tungsten (W).
- High toxic elements, which include mercury (Hg), lead (Pb), cadmium (Cd), arsenic (As), silver (Ag), antimony (Sb), and uranium (U).

Zinc (Zn).

Zinc (Zn) is the metallic element bluish-white in color ,subject to form when heated,, its atomic number (30), atomic weight 65.409, density 7.14, melting point 419.53°C, boiling point 907°C, a white or blue in color (Trunk et al, 2011).

It is one of the most elements prevalent on soil, air and water. Also it may necessary in food being an essential element and small amount would be required for human beings to organize biological physiology.

Also, it is used in the process of making protein a catalyst for many of the enzymes that regulate cell growth and the level of hormones, and also contributes to the regulation of gene expression (Dimirkou, 2007).

Health and environmental impacts of zinc toxicity are very common such as nausea, vomiting and damaging of the pancreas. However, toxicity of zinc becomes more severe when present with other heavy metals, such as cadmium, in water because it has synergistic effect with these metals (Hussoun, 2006; EPA, 2012).

The main sources of zinc are mining operations, secondary metal production, plastics, coal combustion, ceramic, batteries, rubber tire wear and phosphate fertilizers, also enters in some alloys such as bronze , pesticides and cosmetics protection against sunburn and inhibitors sweating and some types of medicines (Salim et al., 2003; Solberg, 2009).

2.4.6 Pathogenic Organisms

Many serious human diseases such as cholera, typhoid, bacterial and amoebic dysentery, enteritis, polio and infectious hepatitis are caused by water-borne pathogens. In addition, malaria, yellow fever and filariasis are transmitted by insects that have aquatic larvae.

Faecal pollution of water resources by untreated or improperly treated sewage is a major cause for the spread of water-borne diseases (Mott Mac Donald and M & E Associates, 2001). To a lesser extent, disease-causing organisms may also be derived from animal rearing operations and food processing factories with inadequate wastewater treatment facilities.

In most developed nations, the spread of water-borne infectious diseases has been largely arrested through the introduction of water and sewage treatment facilities and through improved hygiene. But in many developing countries, such diseases are still a major cause of death, especially among the young (Lamb, 1985). A strong correlation exists between the infant mortality rates of various countries and the percentage of the population with access to clean water and sewage disposal facilities.

Bacteriological Indicators of Fecal Contamination.

Fecal indicator bacteria are used to assess the microbiological quality of water. Although these bacteria are not typically disease causing, they are associated with fecal contamination and the possible presence of waterborne pathogens. The density of indicator bacteria1 is a measure of water safety for body-contact recreation or for consumption. Fecal material from warm-blooded animals may contain a variety of intestinal microorganisms such as bacteria, viruses, and protozoa that are pathogenic to humans resulting in several types of diseases including gastroenteritis, typhoid fever, cholera, hepatitis and dysentery (Myers et al., 2007; WHO, 2010).

Bacteriological tests for specific indicator bacteria are used to assess the sanitary quality of water and sediments and the potential public health risk from gastrointestinal pathogens carried by water. The suitability of indicator organisms for fecal contamination in water is ranked according to a specific set of criteria, described below (Bitton, 2005; Zheng et al., 2013):

1. It should be a member of the intestinal microflora of warm-blooded animals.
2. It should be present only when pathogens are present, and absent in uncontaminated samples.
3. It should be present in greater numbers than the pathogen, and densities correlated with fecal contamination.
4. It should be at least equally resistant as the pathogen to environmental factors and to disinfection in water and wastewater treatment plants.
5. It should survive as long as, or longer than, pathogens.

Total Bacterial Count (TBC).

The total bacterial count represent the content of the bacteria generally in the waters, but does not clarify the presence of all species of bacteria in the waters except the able to growth, and producing the clear colonies in the culture media under suitable examining circumstances included time and temperature (WHO, 2004).

Usually account the number of colonies after the incubation period at temperature 22 °C and 37 ° C for 24 hours to assess the numbers of the bacteria presence naturally in water and that is not related to fecal contamination. The bacteria derived from human and warm-blooded animals (Olutiola et al., 2010), therefore account for the numbers of bacteria at temperature 22 °C and have little health importance but useful in evaluating the efficiency of water treatment. The numbers of bacteria growing at temperature 37 C° represents an early indicator of pollution, because the organisms growing in this degree to the external source (WHO, 1996; Al-Fatlawy, 2007).

Total Coliform (TC).

The term “coliform bacteria” refers to the bacterial species in the family Enterobacteriaceae genera such as Escherichia, Klebsiella, Enterobacter and Citrobacter that live in the intestines of warmblooded vertebrates (mammals and birds), (WHO,2008).

They are including the aerobic and facultative anaerobic, gramnegative, non-spore forming, rodshaped bacteria that ferment lactose with gas production within 48 hours at 35 °C (Oliver et al., 2012; Nzung’a et al., 2013).

Therefore, total coliform counts are not necessarily a measure of fecal pollution but useful for determining the quality of potable water, shellfish harvesting waters, and recreational waters (WHO, 2008; Christensen, et al., 2013)

Faecal coliforms (FC).

Faecal coliform is a subgroup of total coliforms that include all coliforms that ferment lactose and produce gas at 44.5 °C within 24 hours. This group comprises thermotolerant strains such as Escherichia, Klebsiella and Citrobacter (Gilpin and Devan, 2003).

Faecal coliforms are usually associated only with human or animal waste.The enteric bacterium Escherichia coli, is the member of this subgroup most commonly cited as an exclusive indicator of faecal contamination (Gilpin and Devan, 2003).

The presence of faecal coliforms indicates the presence of fecal material from warm-blooded animals. Outside of a warm-blooded host, faecal coliforms are short-lived compared to the coliform bacteria that are free-living and not associated with the digestive tract of man or animals (Bitton, 2005).

A high faecal coliform counts have been positively related to urban development, agriculture, and the amount of erodible soils (Mehaffey et al., 2005). Faecal coliforms is considered as an index of fecal contamination and therefore contaminated with pathogenic organisms (Sankararamakrishnan and Guo, 2005; Bastholm et al., 2008).

Faecal coliform concentrations are not evenly distributed in surface waters. Their densities vary in relation to season, climate, tidal cycles, and other environmental factors such as temperature, pH, salinity, turbidity, nutrients, and solar radiation intensity. Faecal coliforms in surface waters are peaked after a rain event. Subsequently, they decrease or disappear from the water column with time, through death and sedimentation processes, but may concentrate in sediments at high densities. Coliform bacteria in sediments can be resuspended in shallow waters by tidal movements and winds, dredging, storm surge, increased stream flow, and recreational activities such as boating(Nollet,2007; Jolley et al., 2008).

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Study Area

This research was carried out in Ikole, Ekiti state. Ikole is a local government area of Ekiti state, Nigeria. It is located between latitude 7^{o} 47’ 29 N and longitude 5^{o} 30’ 31 E. it has an estimated area of 321km^2 and a population of 168,436 at the 2006 census. Ikole is about 65km from Ado, the capital of Ekiti state.

3.2. Study stations

The study involved sampling of well water from four communities in Ikole LGA Ekiti, i.e, Ilotin- Ekiti, Asin-Ekiti, Usin-Ekiti, and Ikoyi-Titun Ekiti. A sample is collected from wells in three different locations in each community. Sample area are between the north latitude (7° 78’ 97N- 7° 80’ 05N) and east longitude (5° 49; 03E - 5° 50’ 94E). The positions of stations were determined by the Global Positioning System (GPS).

3.3 Sampling

Samples were collected from wells in each community to analyze the impact of domestic wastewater discharge on the quality and use of the water. Samples were taken in transparent bottles in July 2017. The GPS co-ordinates were recorded for each sampling site. Station 1 was Ilotin, station 2 was Asin, station 3 was Usin, while station 4 was Ikoyi Titun. This was taken as reference point with relatively clean water.

First station

The first station is Ilotin Ekiti. Samples are taken from three different wells in Ilotin

Table 3.1

ILOTIN EKITI (A)	LATITUDE	LONGITUDE
A1	7° 79’ 42N	5° 50’ 89N
A2	7° 80’ 05N	5° 50’ 94N
A3	7° 79’ 64N	5° 50’ 87N

Second station

The second station is Asin Ekiti, samples from three wells were taken

Table 3.2

ASIN EKITI (B)	LATITUDE	LONGITUDE
B1	7° 79’ 18N	5° 49’ 17E
B2	7° 78’ 97N	5° 49’ 08E
B3	7° 79’ 21N	5° 49’ 03E

Third station

The third station is Usin

Ekiti Table 3.3

USIN EKITI (C)	LATITUDE	LONGITUDE
C1	7° 79’ 33N	5° 50’ 13E
C2	7° 79’ 33N	5° 49’ 93E
C3	7° 79’ 33N	5° 49’ 85E

Fourth station

The fourth station is Ikoyi-Titun Ekiti

Table 3.4

IKOYI-TITUN (D)	LATITUDE	LONGITUDE
D1	7° 79’ 27N	5° 50’ 65E
D2	7° 79’ 30N	5° 50’ 41E
D3	7° 79’ 28N	5° 50’ 34E

3.4 Sample analysis

The samples were analysed for Ca^2+, Mg, K+, Na^2+, Mn, Fe, Zn, Cu^2+, BOD, COD, TDS, TSS, $Cl^{-\ 1}$, p H, Turbidity, E.C, Total bacteria count, Total coliform, Fecal coliform, Ca-Hardness (CaCO3), Mg-Hardness (CaCO3), and Total-Hardness (CaCO3).

pH

pH (potential of hydrogen) is a numeric scale used to specify the acidity or basicity of an aqueous solution. It’s a scale of acidity and alkalinity from 0 to 14.

The pH is a measure of the acid balance of a solution and is defined as the negative of the logarithm to the base 10 of the hydrogen ion concentration (WHO 1996). The pH of water affects the solubility of many toxic and nutritive chemicals. It is a good indicator whether the water is hard or soft, In general water with a pH lower than 7 is considered acidic, and with a pH greater than 7 is considered basic. The normal pH range of surface water systems is 6.5 to 8.5 and for groundwater systems 6 to 8.5. Water with a pH <6.5 is considered soft while water >8.5 is considered hard.

The pH of pure water is 7, but when exposed to the carbon dioxide in the atmosphere this equilibrium results in a pH of approximately 5.2 because of the association of pH with atmospheric gases and temperature.

The pH was measured using a pH meter (Mettler Toledo 320 model) according to APHA (1998).

Electrical conductivity (EC)

Electrical Conductivity is a measure of the ability of water to carry electric current and it is sensitive to variations in dissolved solids, mostly mineral salts. It is a measure of how much total salt is present in the water. The more the ions, the higher the conductivity. The determination of electrical conductivity helps in estimating the concentration of electrolytes. Its ability is dependent upon the presence of ions in solution and its measurement is an excellent indicator of the total dissolved solid in a matter (Adejuwon and Adelakun, 2012).

This ability depends on the presence of ions, their total concentration and temperature. EC was measured stream using a Mettler Toledo MC 226 conductivity meter. The EC meter was switched on and its probe dipped into the sample contained in a beaker. The electrical conductivity was read directly and recorded in pScm"^{1}.

Turbidity

Water turbidity is the measure of fine suspended matter in water, mostly caused by colloidal particles such as clay, silt, non-living organic particulates, plankton and other microscopic organisms, in addition to suspended organic and inorganic matter. Turbidity is the measure of relative clarity of a fluid. The turbidity degree of stream water is an approximate measure of pollution intensity (Siliem, 1995; Lako, et al. 2012).

Turbidity in water has public health implications due to the possibilities of pathogenic bacteria encased in the particles and thus escaping disinfection processes. Turbidity interferes with water treatment (filtration).

Turbidity levels were measured in Nephelometric turbidity units (NTUs) using the HACH 2100A turbidity meter.

Chemical Oxygen Demand (COD)

Chemical oxygen demand (COD) is the amount of oxygen required to completely oxidize the organic matter in waste water by use of a strong oxidant and to convert it to carbondioxide and water. Potassium dichromate was used in this test because of its superior oxidizing ability. A known quantity of water sample was mixed with a known quantity of standard solution of potassium dichromate (K2&2O7) and the mixture heated. The organic matter was oxidized by the potassium chromate in the presence of sulphuric acid (H2SO4) and the oxygen used in oxidizing the water was determined.

Biochemical Oxygen Demand (BOD)

Biochemical oxygen demand (BOD5) was determined by conventional methods according to Association of Official Analytical Chemists (AOAC), 2002. A sample of the solution (50 ml) was placed in a 500 ml BOD bottle and filled to the mark with previously prepared dilution water. A blank solution of the dilution water was similarly prepared and placed in two BOD bottles.

A control solution without dilution water was also prepared and placed in a BOD bottle.

The bottles were stoppered, sealed and incubated for five days at room temperature. BOD was calculated from the relation: BOD= (D1-D2)/P, where D1= dissolved oxygen 15 minutes after preparation, D2= dissolved oxygen in diluted sample after incubation and P= amount of sample used.

Chloride

Chloride exists in all natural waters, the concentrations varying very widely and reaching a maximum in sea water (up to 35,000 mg/l). In fresh waters the sources include soil and rock formations, sea spray and waste discharges. Sewage contains large amounts of chloride, as do some industrial effluents (Ezeribe et al., 2012).

In natural water chloride occurs in widely varying concentration. Abnormal chloride concentration may result due to pollution of sewerage waste and leaching of saline residues in the soil. Its desirable limit is 200-250 mg/L beyond this limit, taste, corrosion and palatability are affected; and deficiency of chloride also an influence of the productivity of the agriculture. Excess presence of chloride in water leads to gastrointestinal, diarrhea , and skin allergies (Cheepi, 2012).

This anion was determined by titration of the sample with silver nitrate. To 100ml sample was added potassium chromate (5%, 1ml) and titrated with 0.1 M silver nitrate solution to the first appearance of a buff color (AOAC, 2002). The sample titrated against silver nitrate solution of 0.041normal until convert the color from yellow to orange, results expressed as mg /l, then calculate the concentration of chloride ion from formula as follows:

Cl^- mg/l = (A-B) (N) ^{x} 35450 / ml of

sample Where A = first reading of the

sample B = first reading of the Blanck N

= normality of silver nitrate.

Nitrate (NO3)

Nitrate is the most highly oxidized form of nitrogen compounds commonly present in natural waters. Significant sources of nitrate are chemical fertilizers, decayed vegetable and animal matter, domestic effluents, sewage sludge disposal to land, industrial discharge, leachates from refuse dumps and atmospheric washout. Depending on the situation, these sources can contaminate streams, rivers, lakes and ground water. Unpolluted natural water contains minute amounts of nitrate (Foglar, 2013).

High nitrate levels in waters to be used for drinking will render them hazardous to infants as they induce the "blue baby" syndrome (methaemoglobinaemia).The nitrate itself is not a direct toxicant but is a health hazard because of its conversion to nitrite which reacts with blood haemoglobin to cause methaemoglobinaemia (Robert, 2006; EPA, 2013).

Nitrate ions was measured according to APHA (1999) by using 2ml HCl (1N) added to the diluted sample (5ml of sample to 50ml deionized water), then measured by UV spectrophotometer at wave length 220nm. Results were recorded in unit mg/L.

Sulphates (SO4)

Sulphates exist in nearly all natural waters, the concentrations varying according to the nature of the terrain through which they flow. They are often derived from the sulphides of heavy metals (iron, nickel, copper and lead). Iron sulphides are present in sedimentary rocks from which they can be oxidised to sulphate in humid climates; the latter may then leach into watercourses so that ground waters are often excessively high in sulphates. As magnesium and sodium are present in many waters their combination with sulphate will have an enhanced laxative effect of greater or lesser magnitude depending on concentration (EPA, 2001).

The method described by APHA (1985), where 5 ml of the sample diluted to 100 ml of distilled water, 5 ml of Conditioning Reagent (HCl, NaCl, Glycerol, alcohol, Distil water) was added to the sample, ,and 0.15 mg of powder of barium chloride BaCh is added, then the absorption is determined by using UV-spectrophotometer at wave length 420nm, then the absorption is read on the above mentioned wavelength which makes the barium sulphate minutes stuck, the amount of sulphates is calculated from the difference between the two readings after making a trend of calibration from standard sulphuric acid solution (H2SO4) .The results are expressed in units of mg /l.

Phosphate ($PO4^{-3}$).

Phosphorus is the principal growth-limiting nutrient for macroplankton and phytoplankton growth in freshwater rivers and lakes and is the main cause of eutrophication in rivers and lakes. Additional phosphorus encourages algal growth beyond the natural levels. This growth depletes the dissolved oxygen in the water, causes algal blooms in lakes and fish kills in rivers (EPA, 2013). Phosphorus is present in natural waters primarily as phosphates. Phosphates can enter aquatic environments from the natural weathering of minerals in the drainage basin, from biological decomposition, and as runoff from human activities in urban and agricultural areas (UNEPA, 2008; Flores and Zafaralla, 2012).

Reactive phosphate is measured by using ascorbic acid method by adding 8ml of combined reagents (H2SO4 5N + Potassium antimony tartrate + ammonium molybdate + ascorbic acid) was added then shacked and stand for 30min then measured after blue color developed by a spectrophotometer at wave length 860nm. Blank is zero (APHA, 1999).

Total Dissolved Solids (TDS)

TDS is the term used to describe the inorganic salts and small amounts of organic matter present in solution in water. The principal constituents are usually calcium, magnesium, sodium, and potassium cations and carbonate, hydrogen carbonate, chloride, sulfate, and nitrate anions (WHO, 1996). The concentration and composition of TDS in natural waters are determined by the geology of the drainage, atmospheric precipitation and the water balance (evaporation, precipitation) (Phyllis and Lawrence, 2007).

Total Dissolved Solids were measured according to EPA (2001) by the following equation, depending on E.C. value: TDS mg/l= E.C. pScm^{-1} X (2/3)

Total Suspended Solids (TSS)

The term "total suspended solids" (TSS) applies to the dry weight of the material that is removed from a measured volume of water sample by filtration through a standard filter (UNEP&WHO, 1996). The total suspended solids may be organic and inorganic, that are suspended in the water. These would include silt, plankton and wastes. Source of total suspended solids include erosion from urban runoff and agricultural land, industrial wastes, bank erosion, bottom feeders, algae growth or wastewater discharges (Bamakanta et al., 2013). APHA (1998) method was used to determine the suspended particulate matter by washing millipore filter paper 0.45pm then oven dried at 105oc for one hour, then cooled and weight. Filter 100ml of sample and returned again to the oven and cooled then weight and used the following equation: TSS mg/l= (A - B) x 1000 / mL of sample A: weight of filter paper with residue mg B: weight of filter paper

Total Hardness (TH)

Hardness is one of the important chemical characteristics to determine the suitability of water for domestic drinking and industrial purposes. Hardness is caused principally due to the dissolved contents of carbonates and sulphates of calcium and magnesium; at times to a lesser degree, presence of chlorides, nitrates and sometimes iron and aluminum is effective in causing hardness. It is expressed as ppm in terms of calcium carbonate (Cheepi, 2012; Anhwange et al. 2012).

The calcium occurs in water due to presence of lime stone, gypsum, dolomite and gypsiferrous matters. Calcium and magnesium are the major scale forming constituents in raw water. Calcium is an essential element for Human and for plant growth. Magnesium is an essential element for human beings, but higher levels of magnesium are harmful as they act as cathartics and diuretics in man (Bamakanta et al., 2013).

The method described by Lind (1979), was used for the purpose of measuring the values of total hardness, by taking 10 ml of the sample and diluted to 50 ml with distilled water, then added one ml of ammonia regulator solution where the pH is10. After the addition of a few of dry indicator (Erichrom black T) use as reagents and titrated against EDTA solution Normaly 0.05, and calculated values often by the following equation: Total hardness as CaCO3 = A x B x 1000/ml of sample, Where: A = number of titration moles

B = number of grams of calcium carbonate equivalent 100 ml of EDTA titrated.

Heavy metals test

The sample preparation was done according to Abbawi and Hassan (1990), was used by taking 100 ml of water sample in a clean Beaker glass with distilled water and water sample, and added 5 ml of nitric acid, then it was evaporated by using a hot plate without boil at 85° C until the volume had been reduced to approximately 10 mL. The sample allowed to cool and transferred to a 50-mL volumetric flack, diluted to volume with de-ionized water and let settle overnight to remove insoluble materials. The solutions were kept in a clean polyethylene flasks, and stored in a refrigerator until later analysis for the measurement by using Atomic absorption spectrophotometer , and then the following equation was applied: Concentration (mg / L) = reading of device x the volume of the sample after Concentration / volume of the sample. Calcium, zinc, and copper were determined using Atomic Absorption Spectrometer (model AA6800- SHIMADZU) according to APHA, 1998.

Microbial Tests

Total Bacterial Count (TBC)

The total bacterial includes all of the bacterial species that are capable of growing in or on a nutrient rich solid agar medium. The incubation temperature and time used were 37°C for 24 hours to encourage the growth of bacteria derived from humans and warm- blooded animals (APHA, 1998; WHO, 2004).

The pour plate count method used as described by APHA (2005) and Adam & Allaahmed (2012), by means of Nutrient agar as cultivated medium. Plates were incubated at 37ºC for 24 hrs. Results expressed as CFU/100ml.

Total Coliform count (TC)

Coliform bacteria had been used historically to assess the microbial quality of drinking water. Also no consider as indicators of fecal contamination, but their presence indicates that your water supply may be vulnerable to contamination by more harmful microorganisms. Some coliform bacteria may be part of the natural bacterial flora in the water and intestines of human and warm-blooded animals. Coliforms are also considered useful for monitoring

treatment processes and assessing the disinfection of new or repaired mains (WHO, 2003).
Most Probable Number (MPN) procedure used as described by APHA (2005) and Ell-Amin et al (2012) using MacConkey broth as cultivated medium. Tubes incubated at 37±0.5^{o}C for 24 hrs. The results expressed as CFU /100ml.

Faecal Coliform (FC)

The presence of faecal coliform bacteria in aquatic environments indicates that the water has been contaminated with the fecal material of man or other animals. At the time this occurred, the source water may have been contaminated by pathogens or disease producing bacteria or viruses, which can also exist in fecal material. The presence of fecal contamination is an indicator that a potential health risk exists for individuals exposed to this water. Fecal coliform bacteria may occur in ambient water as a result of the overflow of domestic sewage or nonpoint sources of human and animal waste (Shivayogimath et al., 2012).
MPN procedure used as described by APHA (2005) and Ell-Amin et al (2012), using EC media broth as cultivated medium. Tubes incubated at 44.5±0.25oC for 24 hrs. The results expressed as cell/100ml.

Data analysis

All obtained data were subjected and properly analyzed using MS Excel. The mean of parameters and the standard deviation was calculated and determine

CHAPTER FOUR

4.0. RESULTS AND DISCUSSION

This section presents the results of physio-chemical parameters as determined in samples collected from well in the various stations, station 1, Ilotin Ekiti (A), station 2, Asin Ekiti (B), station 3, Usin Ekiti (C) and station 4, Ikoyi-Titun Ekiti (D). The results of analysis obtained are summarized in Table 4.1.

Table 4.1: Mean and standard deviation for parameters at selected sample stations

Parameters	Station 1 (A)	Station 2 (B)	Station 3 (C)	Station 4 (D)
pH	7.27 ± 0.32	6.40 ± 0.47	7.20 ±0.31	6.90 ± 0.26
E.C. pS/cm	284.96 ± 13.90	157.78 ±13.90	227.40 ± 8.91	382.98 ±14.30
TDS mg/L	86.15 ± 3.91	44.38 ± 2.18	63.95 ± 2.50	107.72 ± 4.02
Turbidity NTU	13.36 ± 7.96	90.35 ± 4.45	130.22 ± 5.10	219.32 ± 8.18
TSS mg/L	35.62 ± 1.74	19.72 ± 0.97	28.43 ± 1.11	47.87 ± 1.79
BOD mg/L	40.07 ± 1.95	22.19 ± 1.09	31.98 ± 1.25	53.86 ± 2.01
T.H. mg/L	163.18 ± 7.96	90.35 ± 4.45	130.22 ± 5.10	219.32 ± 8.18
Cl^- mg/L	8.91 ± 0.43	4.93 ± 0.24	7.11 ± 0.27	11.97 ± 0.45
SO4 mg/L	22.26 ± 1.08	12.33 ± 0.61	17.77 ± 0.69	29.92 ± 1.12
NO3 mg/L	3.96 ± 0.19	2.19 ± 0.11	3.16 ± 0.12	5.32 ± 0.19
PO4 mg/L	0.45 ± 0.02	0.25 ± 0.01	0.36 ± 0.01	0.60 ± 0.02

4.1 pH

pH ranged from 6.90 to 7.50 at station 1 Ilotin Ekiti (A), value of 7.40 at A1, 6.90 at A2, 7.50 at A3. pH ranged from 5.90 to 6.80 at station 2 Asin Ekiti (B), value of 5.90 at B1, 6.80 at B2, 6.60 at B3. pH ranged from 6.90 to 7.50 at station 3 Usin Ekiti (C), value of 7.50 at C1, 7.30 at C2, 6.90 at C3. pH ranged from 6.70 to 7.20 at station 4 Ikoyi-Titun Ekiti (D), value of 6.80 at D1, 7.20 at D2 and 6.70 at D3.

The lowest value of pH was measured in station 2, Asin Ekiti (B1) with a value of 5.90, the highest value of pH was measured in station 3, Usin Ekiti (C1) with a value of 7.50.

The pH values were within the permissible level set by WHO (1993) standard for water quality (Tebbutt, 1998), which were between 6.5-8.5. Only station 2 Asin Ekiti (B1) has a very low value of pH with a value 5.90, this is considered acidic and it is below the standard set by WHO (1993) which was 6.5.

The reduction in pH levels observed at station 2 Asin Ekiti (B1) is probably due to organic waste which is disposed to the point near the well. The pH can be decreased by the carbondioxide released by the bacteria breaking down the organic wastes (Matovu, 2010). Carbondioxide dissolves in water to form carbonic acid. Although this is a weak acid, large amounts of it will lower the pH and when waters with low pH values come into contact with certain chemicals and metals, this often makes them more poisonous than normal.

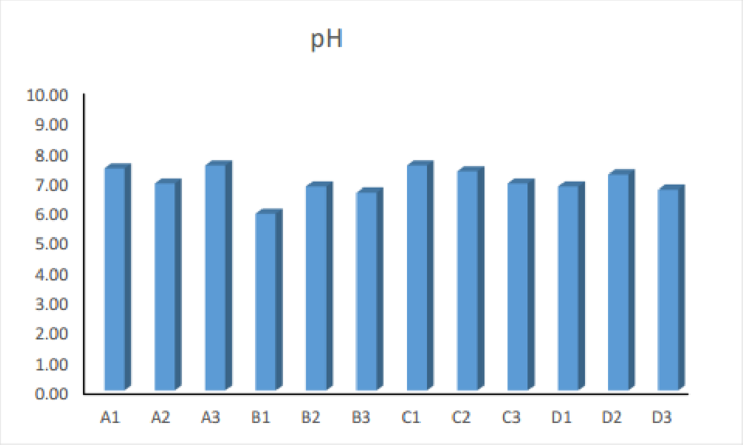

Figure 4.1: pH trend of well waters in Ikole

4.2 Electrical Conductivity (E.C)

Electrical Conductivity is a measure of the ability of water to carry electric current.

EC ranged from 271 pScm"$^{*\ 1}$ to 299 pScm"^{1} at station 1, Ilotin Ekiti, 149 pScm"^{1} to 164 pScm"^{1} at station 2, Asin Ekiti, 221 pScm'^{1} to 237 pScm'^{1} at station 3, Usin Ekiti, 372 pScm'^{1} to 399 pScm^{-1} at station 4, Ikoyi Titun.

The highest value of EC was measured at station 4, Ikoyi-Titun Ikole (D2) with a value of 399 pScm^{-1}. No EC values exceed EC guidelines of 400 pScm^{-1} for drinking water. EC was generally within permissible limits and this is attributed to the dilution effect and other natural processes in the surface water.

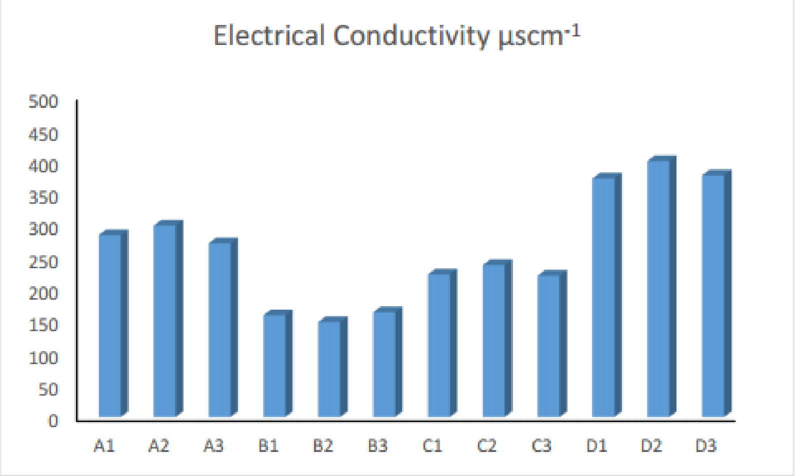

Figure 4.2: Electrical Conductivity of well waters in Ikole

4.3 Turbidity

In this study the highest value of turbidity recorded is at station 4, Ikoyi-Titun Ikole (D2) which was 18.714 NTU while the lowest value of turbidity was recorded at station 2, Asin Ekiti (B2) which was 6.995 NTU.

Increased turbidity is attributed to soil erosion in the nearby catchment during rainy seasons and massive contribution of suspended solids from sewage. Surface runoffs and domestic wastes mainly contribute to the increased turbidity (Gangwara et al., 2012).

Turbidity in natural waters is commonly caused by the presence of clay, silt, organic matter, algae and other microorganisms.

High turbidity can decrease the amount of available sunlight, limiting the production of algae and macrophytes. Turbid waters may also damage fish directly by irritating or scouring their gills, also harm some benthic macroinvertebrates (Owens et al., 2005)

Generally, turbidity is widely concerned as an important parameter for drinking water. However, the observed value were higher than the permissible level recommended by the WHO of 5 NTU and should ideally be below 1 NTU. European standard of turbidity state that it must not be more than 4 NTU.

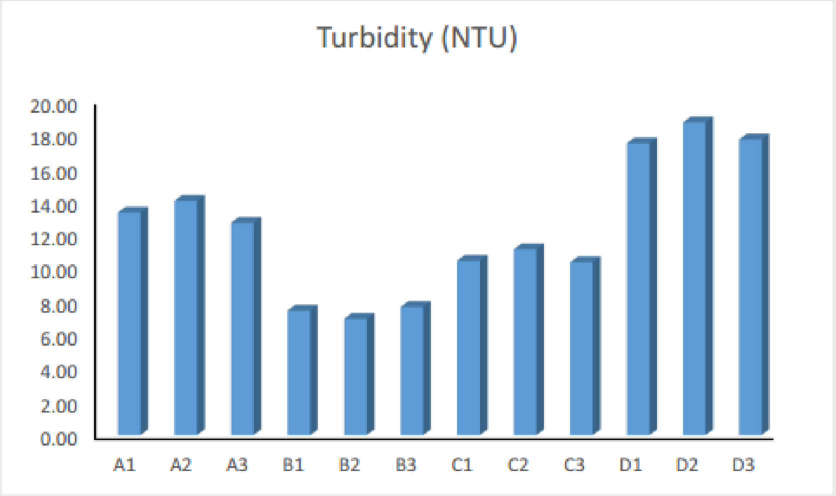

Figure 4.3: Turbidity of well waters in Ikole

4.4 Total Dissolved Solids (TDS)

The present study results showed that the maximum value of TDS 112.285 mg/L was found at station 4, Ikoyi-Titun Ekiti (D2), while the minimum value 41.968 mg/L was found at station 2, Asin Ikole (B2).

High value of TDS could be related to increase in the load of soluble salts, mud, increase in the urban and fertilizer runoff, wastewater, septic effluent, decaying plants, animals and erosion of river banks. Lower value of TDS might be due to dilution factor and sedimentation of suspended solids and slow decomposition rate (Imnatoshi and Sharif, 2012).

The results of TDS values in this study is within the range of Iraqi standards for drinking water in 1998 and WHO water quality standards in 2003 that maximum value was 1500 mg/L.

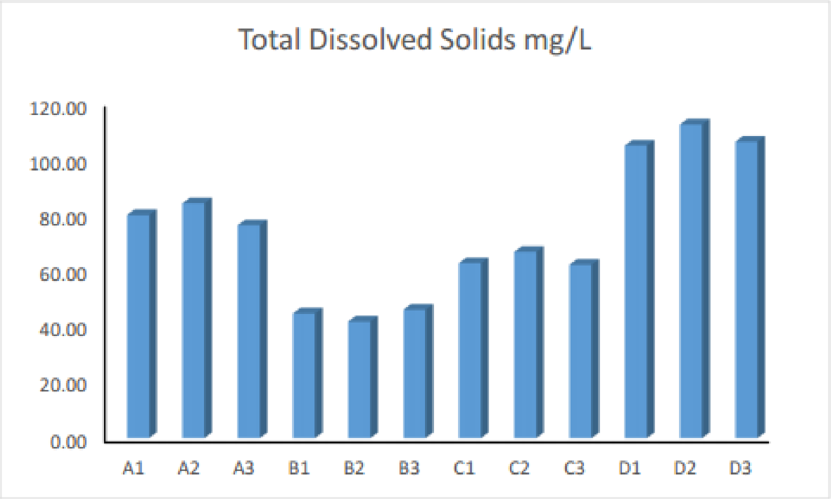

Figure 4.4: TDS of well waters in Ikole

4.5 Total Suspended Solids (TSS).

Present study findings showed that maximum value of TSS recorded was at station 4, Ikoyi-Titun (D2) which was 49.905 mg/L while the minimum value was recorded in spring season at station 2, Asin Ikole (B2) which was 18.653 mg/L.

High concentrations of suspended solids may alter water quality by absorbing light. Waters then become warmer and lessen the ability of the water to hold oxygen necessary for aquatic life. Because aquatic plants also receive less light, photosynthesis decreases and less oxygen is produced. (Lawson, 2011). Also high TSS in a water body can often mean higher concentrations of bacteria, nutrients, pesticides, and metals in the water because suspended particles provide attachment places for these other pollutants (Health Canada, 2012).

Also, these results showed clear increase in TSS values may be due to increase in water level, soil erosion and rainfall, as well as, other matters such as algae and organic matter

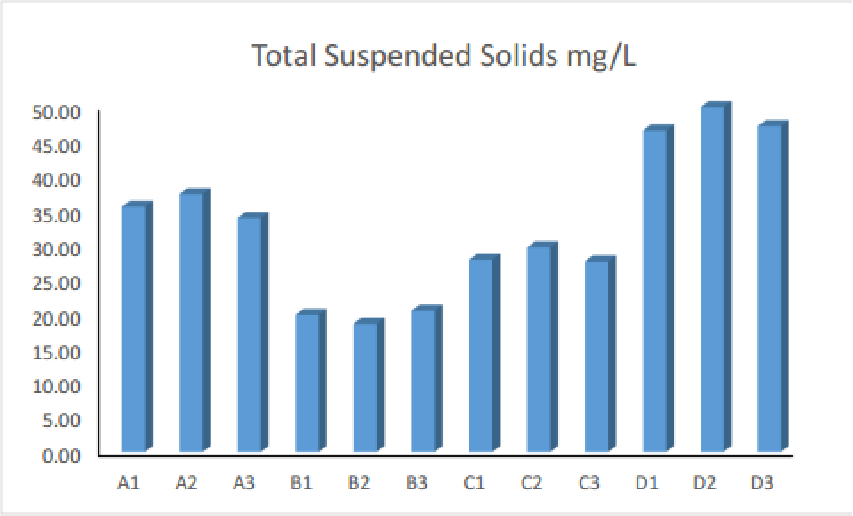

Figure 4.5: TSS of well waters in Ikole

4.6 Biological Oxygen Demand (BOD5).

The BOD5 is a measure of the oxygen in the water that is required by the aerobic organisms (Chapman, 1996). The biodegradation of organic materials exerts oxygen tension in the water and increases the biochemical oxygen demand (Shivayogimath et al., 2012). BOD5 tests measures only biodegradable fraction of the total potential DO consumption of a water sample. High BOD5 levels indicates decline in DO, because the oxygen that is available in the water is being consumed by the bacteria leading to the inability of fish and other aquatic organisms to survive in the river (Vaishali and Punita 2013).

The obtained BOD5 data showed that the maximum value was recorded at station 4, Ikoyi-Titun (D2) which was 56.143 mg/L while the minimum value was recorded at station 2, Asin Ekiti (B2) which was 20.984 mg/L.

The increase in BOD5 value in station 4, may be due to the wastewater enriched with organic matter. The concentration of BOD5 for station 4 exceed the permissible limit for WHO standards of 50 mg/L.

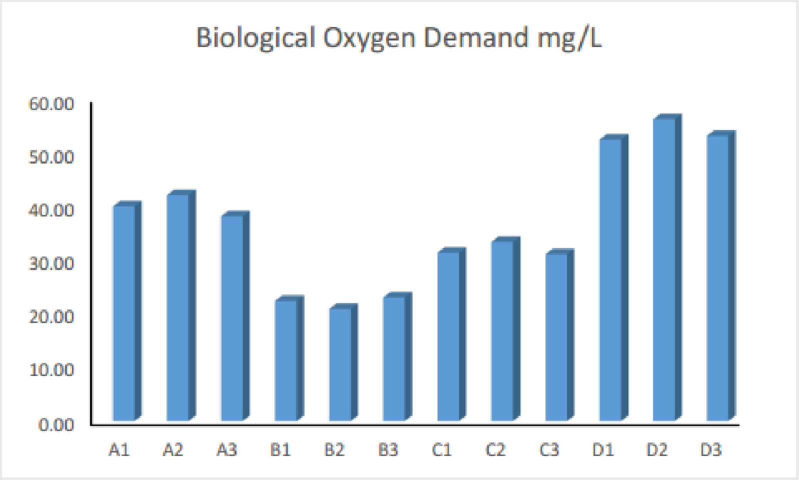

Figure 4.6: BOD of well waters in Ikole

4.7 Chemical Oxygen Demand (COD)

COD is a measure of the capacity of water to consume oxygen during the decomposition of organic matter and the oxidation of inorganic chemicals such as ammonia and nitrite. COD measurements are commonly made on samples of waste waters or of natural waters contaminated by domestic or industrial wastes.

The maximum COD value was recorded at station 4, Ikoyi-Titun (D2) which was 112.285 mg/L while the minimum value was recorded at station 2, Asin Ekiti (B2) which was 41.968 mg/L. Station 4 had COD concentrations above WHO standards of 100 mg/L indicating a heavy load of organic and inorganic pollution that require more oxygen to oxidise under increased thermal conditions.

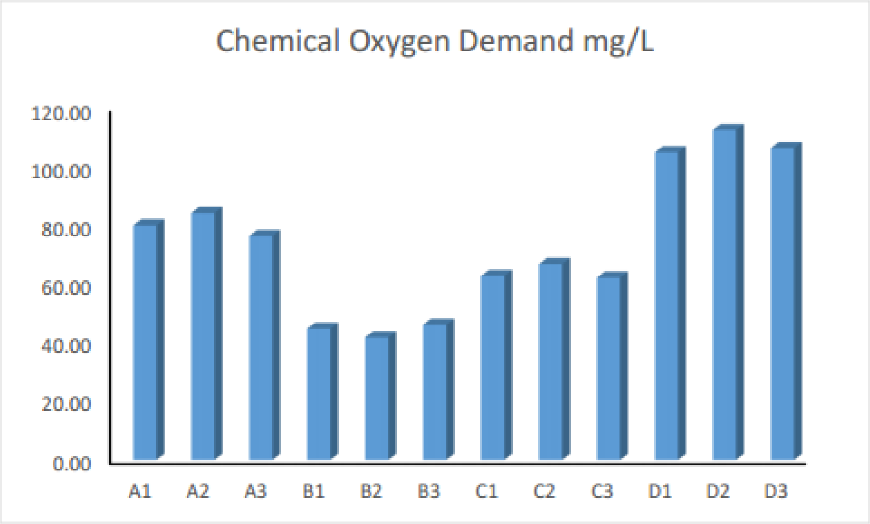

Figure 4.7: COD of well waters in Ikole

4.8 Total hardness (TH)

The lowest value was 85.450 mg/L recorded at station 2, Asin Ekiti (B2), whereas the highest value was 228.621mg/L recorded at station 4, Ikoyi-Titun Ekiti (D2).

Kevin (1999) had divided water sample into four types depending on total hardness as: Total hardness concentration less than 50mg/L calcium carbonate as non-hard water, the water with values ranged from 50 to 100 mg/L is considered moderate-hard water, values from 100 to 200 mg/L is hard water, and more than 200 mg/L calcium carbonate as a very hard water, according to present study finding, Samples from station 1 and station 3 can be considered as hard water, samples from station 2 can be considered as moderate-hard water, station 4 can be considered as very hard water but all are within the permissible limit of WHO water quality standards in 2003 that maximum value was 500 mg/L.

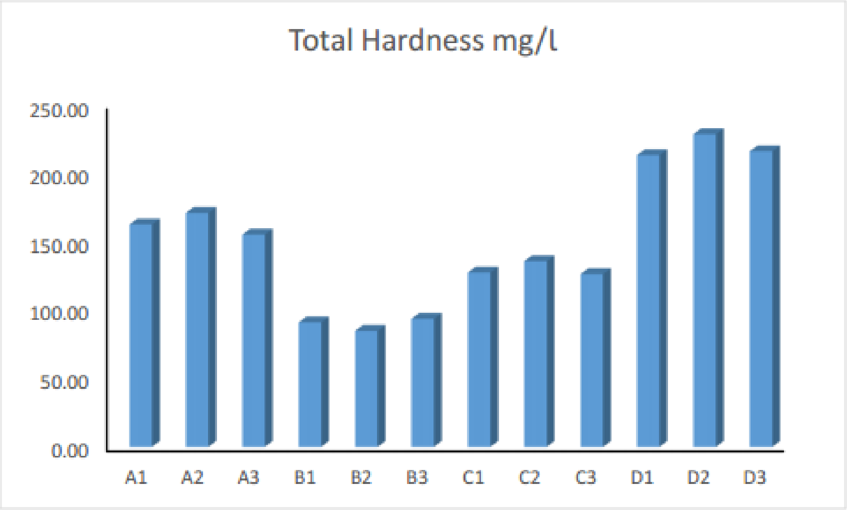

Figure 4.8: Total Hardness of well waters in Ikole

4.9 Chlorides (Cl^-)

The range of chloride ions values was 4.663 mg/L to 12.476 mg/L. The minimum value of Chloride (4.663 mg/L) was recorded at station 2, Asin Ekiti (B2), while the maximum value (12.476 mg/L) was found in station 4.

The minimum concentration and the mean concentration of Cl^- were within the permissible limit for WHO standards (1993), which was 250 mg/L

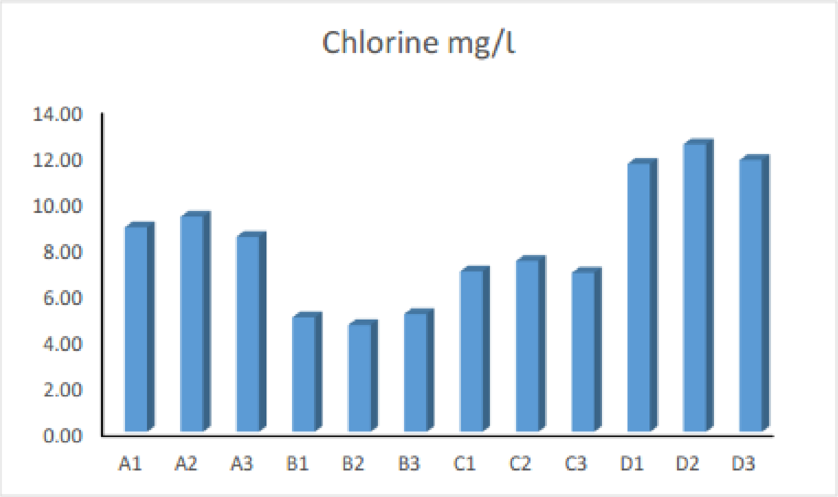

Figure 4.9: Chlorine of well waters in Ikole

4.10 Sulphate (SO_4^{-2}).

The minimum value was 11.658 mg/L in station 2 (B2), and the maximum value of 31.190 mg/L in station 4 (D2).

The sulphate ions $(SO4)^{-2}$ occur naturally in most water supplies and hence are also present in well waters (Ezeribe et al., 2012). The values obtained for each of the locations do not exceed the permissible limit for WHO standards for drinking water (2004), which was 250 mg/L

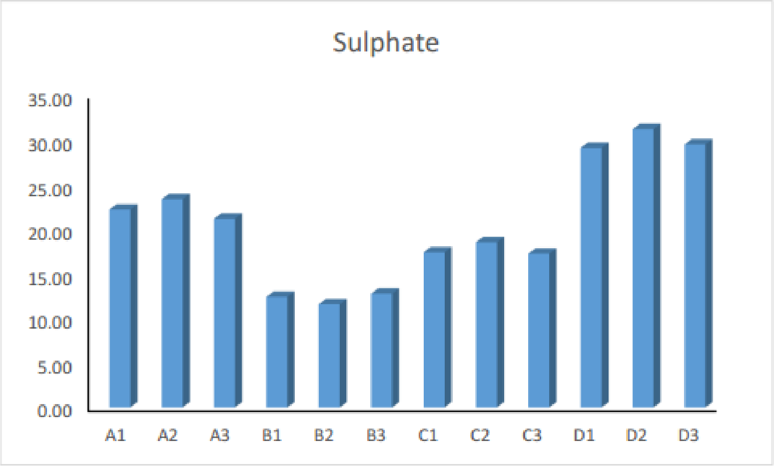

Figure 4.10: Sulphate of well waters in Ikole

4.11 Nitrate (NO_3^{-2})

The highest concentration of NO_3 ions was recorded at station 4 which was 5.54 mg/L, while the lowest value was recorded at station 2 which was 2.073 mg/L.

High nitrate level is due to the rainfall and fertilizer runoff as well as bacterial activity which convert nitrite to nitrate and the decomposition of organic compounds, but the decreasing of nitrate may be due to the dilution factor and consumption of nitrate by phytoplankton growth and reduction of nitrate to nitrite in the bottom (Allen, 2011; Salman and Hussain, 2012).

The values of NO3 for all water samples from selected sites are within the permissible limit for WHO standards drinking water (2004), which was 50 mg/L

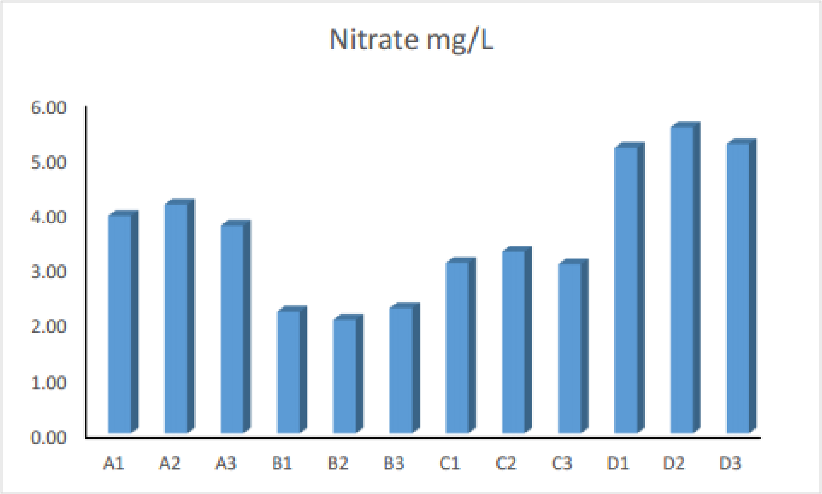

Figure 4.11: Nitrates of well waters in Ikole

4.12 Phosphate (PO_4^{-3}).

The phosphate concentration ranged from 0.234-0.625 mg/L. The minimum value was 0.234 mg/L in station 2 (B2), and the maximum value was 0.625 mg/L in station 4 (D2).

The values of phosphate for most selected sites exceed the permissible limit for WHO standards drinking water (2004), which was 0.1 mg/L.

Hassan (2001) reported that increase in phosphate concentration may be related to rainfall and death of aquatic plants and lesser consumed phosphate by phytoplankton, while the decline may be due to phosphate consumed by plants and phytoplankton in photosynthesis and increase soil particles adsorption (L ind, 1979).

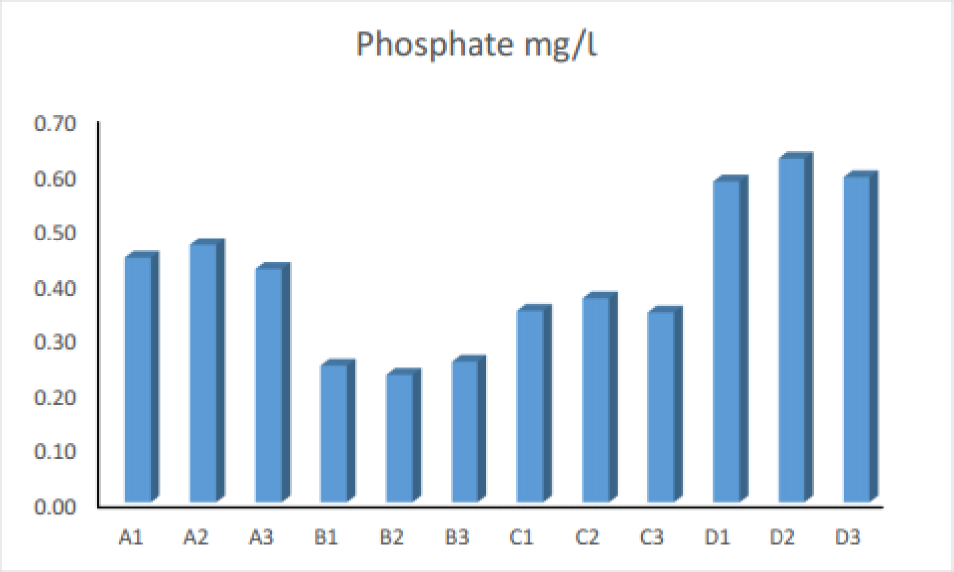

Figure 4.12: Showing TDS of well waters in Ikole

4.13 Heavy metals

4.14 Zinc (Zn).

Zinc, in small concentrations, is an essential element for living organisms. It is essential for the enzymes required for forming red blood cells in living organisms. It is also essential for plants because it takes part in the biosynthesis of nucleus acids and polypeptides required for plants. On the other hand, when concentration of zinc increases above certain a limit, it becomes toxic to man, animals and plant life (Dojlido and Best, 1993; EPA, 2001).

Toxicity of zinc becomes more severe when present with other heavy metals, such as cadmium, in water because it has synergistic effect with these metals. The main sources of zinc to the environment are mining operations, secondary metal production, coal combustion, rubber tire wear and phosphate fertilizers (Salim et al., 2003).

The highest concentration of Zn was recorded at station 4 (D2) which was 1.062 mg/1, while the lowest value of Zn was recorded at station 2 (B2) which was 0.397 mg/1.

The increase of the concentration of Zn might be resulted from the increase of discharge of domestic sewage especially at station 4 as well as the different population densities as suggested by (Alloway & Ayres, 1997; WHO, 2006), whereas lowest values may be due to the dilution factor followed rainfall (Al-Taee, 1999).

The concentration of Zn for all selected sites were in the permissible range of values reported by WHO standards of drinking water (2006), which was 3 mg/1.

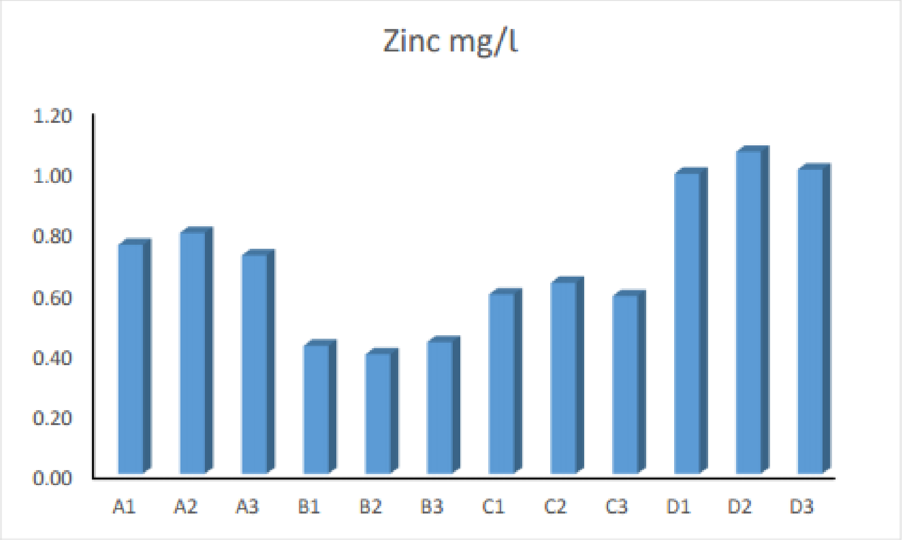

Figure 4.14: Zinc of well waters in Ikole

4.15 Copper

Copper is essential for all plant and animal nutrition. Increased quantities of copper make water distasteful to drink. Very large prolonged doses may result in liver damage. Copper is acutely toxic to most forms of aquatic life at relatively low concentrations.

Copper was below maximum permissible limits (MPL) for WHO (2003) standards at most sampling sites. Copper ranged from 0.099 mg/L at upstream to 0.265 mg/L The maximum value of copper was recorded at station 4 (D2) which was 0.265 mg/L and the minimum value was recorded at station 2 (B2) which was 0.099 mg/L.

High level of copper could be due to the wastewater discharge containing copper metal chips from metal fabricating operations involving Cu scrap. Although copper toxicity in humans is rare, aquatic organisms are potentially at risk from Cu exposures (Adriano, 2001).

A remedy must be sought for Cu levels in the effluent of industry where the metal is high in effluent. Low levels of copper observed are attributed to the natural purification processes within the water and this is in agreement with the findings of Muwanga and Barifaijo (2006).

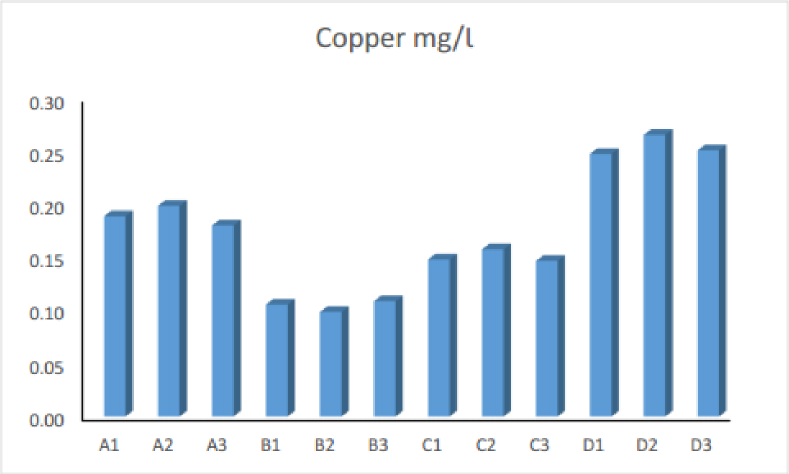

Figure 4.15: Copper of well waters in Ikole

4.16 Bacteriological Characteristics

Bacteria are ideal sensors for microbial pollution of surface water because of their fast response to environmental (Kavka and Poetsch, 2002). The use of bacteria as water quality indicators can be viewed in two ways, which were suggested by Baghed et al. (2005) as the presence of such bacteria can be taken as an indication of fecal contamination of water and an indication of potential danger of health risks.

4.17 Total Bacterial Count (T.B.C)

The highest number of total bacterial count was recorded at station 3 (C1) which was 6 CFU/125ml, while the lowest number of total bacterial count was recorded at station 2 (B1), (B2) and station 4 (D1) which was 2 CFU/125ml. These results exceeded local and international guidelines ranges.

High number of TBC might be due to the consequence of the high level of suspended solid and nutrients in the drainage water and high numbers of bacterial level of the well water due to the well receiving large amounts of sewage/ wastewater (Adams and Kolo, 2006).

On the other hand, low number of bacteria may be due to flood period which dilutes the organic matter which used as food for the bacteria, as well as high temperature that caused killing of large number from the bacteria (Davies et al., 1999; Abdo, et. al. 2010). This results agree with the results of Mashcor (1986) and Sabae & Rabeh (2006).

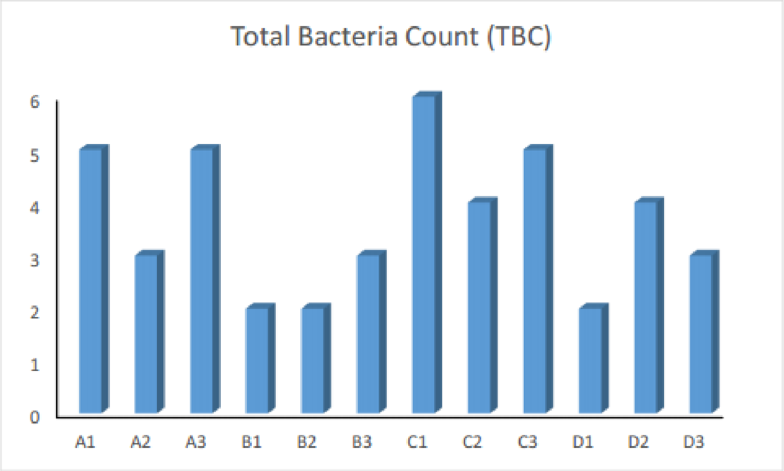

Figure 4.17: TBC of well waters in Ikole

4.18 Total Coliform (TC)

The minimum value of T.C was recorded at station 2, (B3) and station 4 (D1), (D3) which was 0 CFU/125 ml, while the maximum value of T.C was found at station 1 (A1) and station 3 (C1), (C2) which was 3 CFU/125ml.

The increase in numbers of T.C in station 1 and 3 may be due to the wastewater discharge enriched with organic matter from the domestic sewage.

On the other hand, the number of total coliforms for all the study stations exceed the WHO

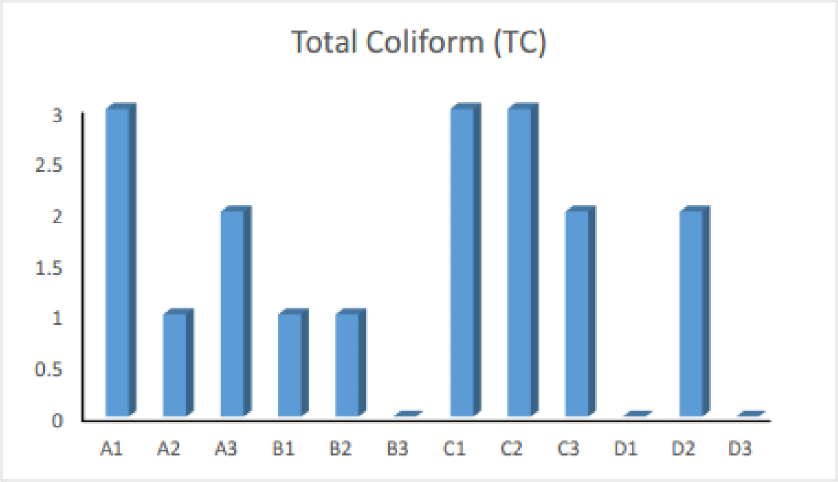

Figure 4.18: Total coliform of well waters in Ikole

4.19 Fecal Coliform (FC)

The presence of fecal coliform bacteria in aquatic environments indicates that the water has been contaminated with the fecal material of man or other animals. At the time this occurred, the source water may have been contaminated by pathogens or disease producing bacteria or viruses, which can also exist in fecal material. The presence of fecal contamination is an indicator that a potential health risk exists for individuals exposed to this water. Fecal coliform bacteria may occur in ambient water as a result of the overflow of domestic sewage or nonpoint sources of human and animal waste (Shivayogimath et al., 2012).

Current results revealed maximum value of FC recorded at station 4 (D2) which was 7 CFU/125ml, while the lowest value of F.C was recorded at station 2 (B1) and station 3 (C3) which was 0 CFU/125ml.

The increase in numbers of FC in station 1 and 4 may be due to the wastewater discharged enriched with organic matter from domestic wastes leading to increase in BOD5 value.

The values of FC for all selected sites exceed the permissible limit for US-EPA (2011) which established FC concentration limit of (0 CFU/125mL) for drinking water, only B1 and C3 recorded 0 CFU/125ml.

Byamukama et al. (2005) attributed a gradual increase of fecal coliform bacteria in water during winter season to higher survival and growth at suitable temperature. Fecal coliforms are the best indicators for the assessment of recent fecal pollution, mainly caused by raw and treated sewage, and diffuse impacts from the farmland and pasture (Kavka and Poetsch, 2002).

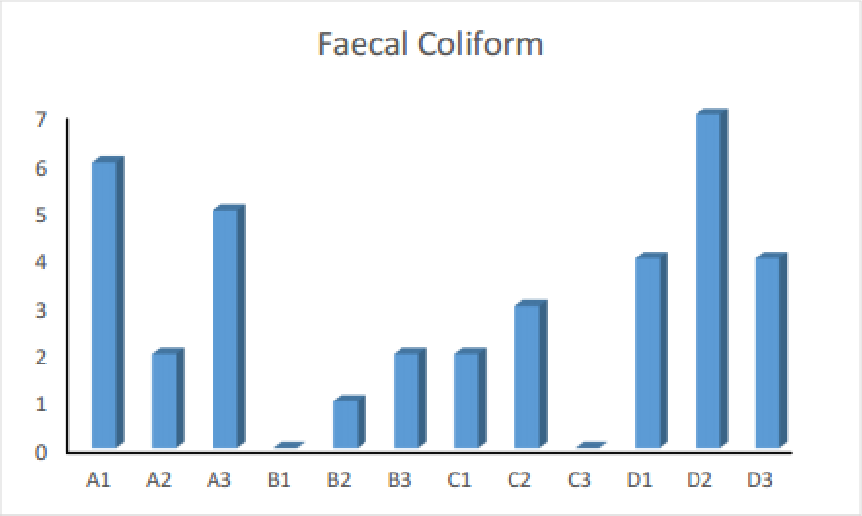

Figure 4.19: Fecal Coliform of well waters in Ikole

CHAPTER FIVE

5.0 Conclusion and Recommendation

5.1 Conclusion

The study has shown that well water in Ikole was contaminated by domestic sewage and have a big impact on the water quality. This is depicted by the fact that there is a general increase in concentration of the parameters analyzed in the well water. Although the values in some cases were lower than the maximum permissible limits by WHO (1993), ' the continued improper discharge of wastewater may result in severe accumulation of contaminants in the well water and this will impact on the quality of the well water.

5.2. Recommendation

The results suggest that the wastewater being discharged have considerable negative effects on the water quality of the well waters. With increased improper waste disposal the load of nutrients and pollutants will continue to increase and further diminish the quality of water.

It is therefore recommended that careless disposal of the wastes should be discouraged.

There is urgent need for drainage and for sewage water not to be discharged to surface waters or carelessly on land surface.

Units to address impact of wastewater should be created to help inform people on the threat it poses on water quality.

Continued monitoring of surface waters in terms of bacterial contamination and other potential contaminants such as hydrocarbon compounds, pesticides and examine their residuals to clarify its health effects on humans and animals is necessary.

Government agency should determine the important hotbeds pollution sources that cause higher pollution for the purpose of monitoring and find appropriate solutions.

Government should support of the laboratories activities and the assurance of the application of the laws and regulations for the assessment of waste water and obliging all institutions relationship that to apply before being discharged into rivers and cooperation to support their application.

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