

ASSESSING THE QUALITY OF SURFACE WATER FOR IRRIGATION PURPOSE

BY

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CERTIFICATION

This is to certify that this is an original and independent research project carried out by Omojofodunmi, A. O (WMA/12/0495) 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 of Oye, Oye-Ekiti Nigeria.

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Contents

| | |
|--|-----|
| TITLE PAGE | i |
| CERTIFICATION | II |
| ABSTRACT | IV |
| ACKNOWLEDGEMENT | V |
| LIST OF FIGURES | vi |
| LIST OF TABLES | vii |
| CHAPTER ONE | 1 |
| 1.1 INTRODUCTION | 1 |
| 1.2 Scope of Work | 2 |
| 1.3 Justification | 2 |
| CHAPTER TWO | 3 |
| LITERATURE REVIEW | 3 |
| 2.1 RIVERS | 3 |
| 2.2 WATER POLLUTION | 4 |
| 2.2.1 SOURCES OF WATER POLLUTION | 4 |
| 2.2.2 Natural factors affecting water pollution..... | 6 |
| 2.2.2.1 Water pollution due to natural causes..... | 6 |
| 2.2.2.2 Water pollution due to anthropogenic causes..... | 7 |
| 2.3 Nutrients in surface water..... | 11 |
| 2.4 Bacteria in Surface Water | 14 |
| CHAPTER THREE | 17 |
| MATERIALS AND METHOD | 17 |
| 3.1 Sampling Procedures | 17 |
| 3.2 Determination of Nitrate | 20 |
| 3.3 Chloride Determination..... | 21 |
| CHAPTER FOUR | 29 |
| RESULT AND DISCUSSION | 29 |
| CHAPTER FIVE | 39 |
| 5.1 Conclusion..... | 39 |
| 5.2 Recommendation | 41 |
| 5.3 References..... | 42 |

ABSTRACT

The study areas (Water works, Ureje and Kurundu) are situated in Ado Local Government Area of Ekiti State, and lies within latitude $7^{\circ}45'N$ and $7^{\circ}25'N$ and longitude $5^{\circ}60'E$ and $6^{\circ}00'E$ respectively. The study area also falls within the basement complex of south western Nigeria. The dominant lithologies include migmatites, granite gneisses, quartzites, charnockites and granites. Physical, chemical and bacteriological evaluation of surface water in the study areas were carried out to ascertain its suitability for irrigation uses. Water samples were collected at different localities in the study areas. Three different surface water were sampled for their physical, chemical and bacteriological properties and were compared with FAO (2006) standards. The physical parameter shows that PH ranges from 7.4 to 7.7 which is slightly alkaline, the chemical parameter revealed that turbidity value ranges from 5.5 to 6.0NTU, total dissolved solids (80 to 117ppm), total alkalinity (98.40 to 101.67 mg/l), EC (124 to 179us/cm), total hardness (99 to 149 mg/l), chloride (16.30 to 34.40 mg/l), nitrate (0.91 to 1.47 mg/l), sulphate (34.10 to 69.04 mg/l), BOD (1.7 to 1.9 mg/l), total coliform count (09 to 14 cfu/mi), E.coli is (negative to positive) facial streptococci and S.aerues are positive, pb (0.030 to 0.107 ppm), Zn (0.174 to 0.245 ppm), Fe (0.741 to 1.92 ppm), Cu (0.083 to 0.187ppm) and Mn (0.047 to 0.113ppm). Some fall in the standard given by FAO (2006) while other are above and below. The PH and TSS for all samples fall within the given standard.

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LIST OF FIGURES

| | |
|--|----|
| FIG.3.1. ADO LOCAL GOVERNMENT MAP..... | 18 |
| FIG.4.1. GRAPH SHOWING VARIATION IN PH..... | 29 |
| FIG.4.2. GRAPH SHOWING VARIATION IN DISSOLVE SOLIDS..... | 30 |
| FIG.4.3. GRAPH SHOWING VARIATION IN ELECTRICAL CONDUCTIVITY..... | 30 |
| FIG.4.4. GRAPH SHOWING VARIATION IN TOTAL SOLUBLE SOLIDS..... | 31 |
| FIG.4.5. GRAPH SHOWING VARIATION IN TURBIDITY..... | 31 |
| FIG.4.6. GRAPH SHOWING VARIATION IN ALKALINITY..... | 32 |
| FIG.4.7. GRAPH SHOWING VARIATION IN TOTAL HARDNESS..... | 32 |
| FIG.4.8. GRAPH SHOWING VARIATIO IN TOTAL CHLORINE..... | 33 |
| FIG.4.9. GRAPH SHOWING VARIATION IN NITRATE..... | 33 |
| FIG4.10. GRAPH SHOWING VARIATION IN SULPHATE..... | 34 |
| FIG.4.11. GRAPH SHOWING VARIATION IN BOD..... | 34 |

LIST OF TABLES

| | |
|--|----|
| TABLE.3.1. ANALYTICAL METHOD..... | 25 |
| TABLE.3.2. CONDITION OF ANALYSIS..... | 25 |
| TABLE3.3. CALIBRATION SUMMARY OF ANALYSIS..... | 26 |
| TABLE4.1. PHYSIOCHEMICAL TEST ANALYSIS..... | 34 |
| TABLE4.2. MICROBIAL ANALYSIS..... | 33 |
| TABLE.4.3. METAL ANALYSIS..... | 34 |
| TABLE.4.3. PHYSIOCHEMICAL PARAMETER AVERAGE..... | 34 |
| TABLE.4.4. DESCRIPTIVE STATISTICS..... | 35 |

CHAPTER ONE

1.1 INTRODUCTION

Surface waters could be regarded as including all inland waters permanently or intermittently occurring on the Earth surface in either liquid (rivers, temporary streams, lakes, reservoirs, bogs) or solid (glaciers, snow cover) condition but this article does not attempt to cover the latter.

Irrigation can be defined as the science of artificial application of water to the land in accordance with 'crop requirements' throughout the 'crop period'.

Water is essential to maintain and sustain human life, animals and plant (patil and patil,2010). The availability of good quality water is an indispensable feature for preventing diseases and improving quality of life (Oluduro and Aderiye, 2007).

All types of liquid surface waters are considered—rivers, reservoirs, lakes, bogs. The basic terms used to describe these water bodies are defined. Their types and classifications are given, and data are presented on the largest rivers, lakes and reservoirs. Surface waters play a very important role in economics and the functioning of ecosystems. According to their topographic and morphological peculiarities, and hydrological regime, lakes can be subdivided in three different ways:

- into lowland, foothill and mountain rivers, depending on relief;
- into large, medium and small, depending on river size;
- into snow-fed, rain-fed, glacier-fed and groundwater-fed, depending on sources of supply.

Lakes can be also divided according to their size, the origin of their depressions, their water regime, degree of river channel stability, water exchange character, water balance structure, temperature regime, dissolved load, etc. Data on the largest rivers and reservoirs are cited.

About 3.5 million km² of the Earth are covered with wetlands and mires, or peatlands. The article provides a general classification of peatland landscapes and micro landscapes, based on ecological characteristics and vegetation.

1.2 SCOPE OF WORK

The study area Ado Ekiti happens to be the capital of Ekiti state. Ekiti state is located in the south western part of Nigeria and having a total land area of 293km². Three rivers where selected for studies which include,

1. Waterworks raw water
2. Ureje river
3. Kurundu river

Three major rivers make up the raw water at waterwork at Ado. Ureje, Omisanjana and Ayanya are the three major river making up waterwork at Ado. The study areas, Ureje River lies at longitudes 005°18'25.87" E and latitudes 07°36' 23.82" N (Afe 2014) along federal poly road Ado Ekiti. Kurundu river is located at Adebayo street, Ado Ekiti. The river is the narrowest and shallowest among the three rivers.

1.3 JUSTIFICATION

This project is carry out to be able to monitor surface water against all forms of pollution reducing it, to the minimum level so that irrigation can be well planned. To make it good enough for irrigation uses and also reducing its purification cost, energy and time. The monitoring processes will cover all forms of surface water (streams, lakes, rivers, bogs and so on). The monitoring process reduces the chemical effects on water because there is no industrial waste, fertilizers from agriculture, waste from metallurgical industries therefore the surface water colour, odour, taste, movement is maintained at a stable level.

1.4 AIM

Assessing the quality of surface water at Ado-Ekiti, Ekiti State for irrigation purposes.

1.5 OBJECTIVES

1. To reduce surface water pollution to the minimum rate so that cropping can be successful.
2. To improve the quality of surface water in Ado, Ekiti State.

CHAPTER TWO

LITERATURE REVIEW

2.1 RIVERS

Natural water flows moving under the force of gravity along their channels and fed by surface and underground runoff are called rivers. Rivers can be divided into mountain, which have rapid flows and narrow valleys, or lowland rivers, which have slower flows and wider, often terraced, valleys. The rivers of polar regions and high mountain areas can be mainly supplied by glacier melting. A network of tributaries usually supplies the main river, which can flow into the ocean, an interior (partially enclosed) sea, an endorheic (drain less) lake, or it can disappear into an arid desert. A main (trunk) river and all its tributaries constitute a river system. A lake (or lakes) may be present within a main (or tributary) river. Rivers are classified according to their topographic/morphological features and their hydrological regime. These in turn are influenced by climate, soils, relief, and vegetation.

Topographic/morphological types of rivers:

1. Mountain rivers with large channel gradients and rapid flow.
2. Rivers of glaciated areas, the channels of which have been considerably transformed by glaciers, at least in former times.
3. Lowland rivers with small slopes and slow flow in meandering channels.

The hydrological types of rivers are fairly diverse. The main criterion for their evaluation is the dependence of runoff variation on seasonal variation in rainfall and air temperature.

Classification of rivers, especially large ones, according to their hydrological features, is rather difficult. The variety of geographical and climatic conditions is very wide. Water regime is therefore taken as a basis for river classification. River types are determined according to various criteria, such as river size, flow conditions, sources of feeding, water regime, degree of channel stability, ice regime, etc. According to their size, rivers are divided into large, medium, and small. Large rivers are characterized by a basin area of more than 50 000 km²; medium rivers, by basin area of 2000 - 50 000 km², and small rivers, by basin area less than 2000 km². The lower boundary

of the basin area (50 km²) separating small rivers from creeks is ambiguous. Large river basins are usually located in several geographical zones. The hydrological regime of a large river is not typical of any specific zone and is therefore poly zonal. The basin of a medium size river is usually situated within the limits of one geographical zone. The hydrological regime of rivers of this group is zonal since it is typical of the majority of rivers in each specific zone.

2.2 WATER POLLUTION

Water pollution can be defined as the contamination of water making it unfit for its purposes. Water pollution occurs through many processes.

2.2.1 SOURCES OF WATER POLLUTION

(1) Rural run-off loads:

- agricultural lands, including pastures and grasslands;
- forest watersheds • barnyards and feedlots;
- wasteland and storage facilities in form of seepages or discharges; and
- construction sites.

(2) Atmospheric deposition (wet/dry deposition).

(3) Common sources of water quality impairment:

- channelization;
- animal husbandry;
- industrial wastewater;
- increased flows due to harvesting of trees;
- seepages from municipal solid waste disposal sites;
- seepages/leachates from landfill sites;
- domestic wastewater/sewage;
- flow from pasture land;
- silviculture and pasture management;

- stream bank modification;
- stream bank and shore line erosion; and
- oil and gas production.

Water can also contain substances that may be harmful to human health, e.g. metals such as mercury, lead and cadmium; organics such as pesticides and toxins; and even certain radioactive materials. Water that comes from natural sources generally contains organisms that are a part of the biogeochemical cycles of aquatic systems. However, certain bacteria, protists, parasitic worms, fungi and viruses may be harmful to human life if contained in drinking water. The availability of water and its physical, chemical and biological properties have an impact on the health of ecosystems, as well as on adequate supply of clean, usable water, which is a basic human requirement. Uses for water include, but are not limited to:

- human consumption and domestic water supply;
- irrigation and aquaculture;
- industrial use;
- electricity generation; and
- recreational use.

The required water quality varies with the use, and the criteria used to assess water quality also vary. Water quality is a function of natural background conditions and is necessary for maintaining the health of ecosystems; however, some aquatic ecosystems can tolerate vast changes in water quality without the composition and function of the ecosystem being affected. In contrast many ecosystems are sensitive to small changes in the physical and chemical composition of the water body, resulting in degradation of the ecosystem including loss of biodiversity. The degradation in physical and chemical water quality due to anthropogenic reasons is mostly slow and gradual. Furthermore, subtle adaptations by the aquatic ecosystems to such degradation are not readily detected unless a notable shift takes place in the ecosystem. For example, in many shallow European lakes, the gradual enrichment of surface water with plant nutrients has resulted in shifts from systems that once were dominated by aquatic plants to systems that are now dominated by algae suspended in the water column. Direct relationships exist among water, sanitation, nutrition

and health. Lack of availability of good quality drinking water, use of contaminated water, lack of personal hygiene, consumption of contaminated food and incorrect disposal of solid and liquid waste have been major causes of diseases in most nations. Many governmental programs such as “Health for All” and total sanitation programs have focused on personal hygiene. Good personal hygiene can reduce water pollution. Better coordination between ministries of health and rural development may solve problems related to drinking-water hygiene and health.

2.2.2 Natural factors affecting water quality in rural and urban areas.

The quality of both surface water is affected by natural and anthropogenic factors. The natural factors that affect water quality in rural and urban areas are similar. The composition of surface water is dependent on e.g. geological, topographical, meteorological, hydrological and biological factors. It varies with seasonal differences in weather conditions, run-off volumes and water levels. Geological factors are due to the contribution of the geosphere to surface water composition, mainly through the effect of chemical water–rock interactions in aquifers. Geological factors are due to the contribution of the geosphere to groundwater composition, mainly through the effect of chemical water–rock interactions in aquifers (Pönkka 1981; Rönkä 1983).

When there are no human influences, changes in water quality occur due to factors such as weathering of bedrock evapotranspiration and the deposition of dust and salt by wind. Furthermore, natural processes such as leaching of organic matter and nutrients from soil, hydrological factors leading to run-off and biological processes within the aquatic environment bring about changes in physical and chemical composition of water. Thus due to these natural processes, water in the natural environment may contain dissolved as well as undissolved solids. Dissolved salts and minerals are necessary components of good quality water as they help maintain the health and vitality of organisms that rely on this ecosystem service. Dissolved salts and minerals are necessary components of good quality water as they help maintain the health and vitality of organisms that rely on this ecosystem service (Stark et al. 2000). Natural water bodies such as lakes, rivers, streams and groundwater need to contain water of good quality.

2.2.2.1 ASPECTS OF WATER POLLUTION DUE TO NATURAL CAUSES.

Rural as well as urban areas

1 Water–rock interaction is the primary source of Ca^+ , Mg^+ , HCO_3 in groundwater

2 Atmospheric deposition of nitrate (minor source)

3 Sodium (Na) in surface water from plagioclase in granite rocks. Sodium toxicity is not as easily diagnosed as chlorides toxicity.

4 Potassium (K⁺) from orthoclase and muscovite minerals present in granite

5 Chloride from natural sources such as rainfall, dissolution of fluid inclusions and chloride-bearing minerals. The most common toxicity is from chloride in the irrigation water. Chloride is not absorbed or held back by soils. Chloride limit for fruit crops is given by Ayers and Westcott (1985).

6 Disturbance of riparian vegetation results in increased sedimentation of rivers.

7 Fluoride occurs naturally as a result of run-off from weathering of fluoride-containing rocks and soils and leaching from soils into groundwater

2.2.2.2 ASPECTS OF WATER POLLUTION DUE TO ANTHROPOGENIC CAUSES.

RURAL AREA

Nitrate and sulphate as a result of fertilizers used in agriculture and sewage effluents. Sodium (Na⁺) and potassium (K⁺) in groundwater from chemical fertilizers. Chloride from fertilizers and septic tanks

Application of fertilizers, waste water discharges and concrete from constructions, etc., are the contributing factors for high calcium.

Most contaminants affecting water quality in rural areas comprise simple inorganic ions, more complex organic molecules or particulates. These can derive from various sources, including soils and decomposing vegetation, but also from animal manure. Agricultural run-off is one of the nonpoint sources of pollution that affect water quality. Agricultural activities that can cause pollution include poor animal husbandry practices; overgrazed grasslands; over and excessive use including untimely application of pesticides, ploughing over irrigated fields and application of

fertilizers. There is considerable agreement in recent studies that amounts of nitrogen and phosphorus in surface waters are significantly influenced by anthropogenic inputs associated with land cover, land use and point sources. Pollutants that result from farming and cattle breeding are comprised of nutrients, sediments, pathogens, pesticides, metals and salts.

Sedimentation

The most common agricultural water pollution is loss of top soil that is washed from fields. Rainwater carries soil particles or sediments and deposits them in lakes or streams nearby, thus affecting water quality. Other pollutants such as fertilizers, pesticides, and heavy metals that stick to the soil particles are also washed into the water bodies. These pollutants cause algal blooms and deplete oxygen, threatening aquatic life. Turbidity, a measure of the light scattering effects of suspended particulate material (SPM) in water, increases with suspended sediment concentrations and loading rates. It also depends upon characteristics such as particle size distribution and refractive index and colour of water. The suspended solid concentration in streams is often higher in the spring and autumn than in the summer.

Nutrients

Nutrient (nitrogen and phosphorus) loading in waters through point and nonpoint sources is an ecological concern and affects water quality in surface water bodies. Nutrients are essential to the survival of aquatic organisms, but excess nutrient loading to water bodies can impact the designated uses of water. Nitrates can be leached or transported in run-off. Nitrates are strongly associated with agricultural land and grasslands, and concentrations are highest in spring and in conjunction with high run-off events. The antecedent conditions – topography, soil type, farming practice and crop type – influence the movement of water as well as pesticide dispersal. All such factors are more significant than the physicochemical parameters of the ingredients in determining the run-off potential of the compound. Ammonium and phosphate sorption onto sediments, sedimentation of nitrogen and phosphorus in particulate forms and phosphate co-precipitation with calcite enhance sediment storage. Conversely, sediments can become a nutrient source through the release of dissolved species under well-defined pH and redox conditions. Phosphorus is given special attention, because it is often the limiting nutrient for algal growth in freshwaters.

Livestock grazing

Overgrazing by livestock leads to exposure of soil and increased erosion. This can result in ecosystem regression, encouraging invasion of unwanted species, destruction of stream banks, flood plain vegetation and fish habitats. It thus not only affects water quality filtration but also the habitat of flora and fauna.

Irrigation

The objective of irrigation is to supplement the natural precipitation and to protect crops against freezing or wilting, depending upon the location of the farm. Inappropriate irrigation can cause water quality problems. In arid/dry areas, for example, rainwater does not carry the minerals deep into the soil, leading to evaporation of irrigation water and overconcentration of salts in soils. Over-irrigating a field may lead to soil erosion, and transportation of nutrients, pesticides and heavy metals. It may reduce the natural surface flow in streams and rivers.

Pesticides

Insecticides, herbicides and fungicides are used to kill agricultural pests. They may enter water due to run-off from the fields or atmospheric deposition, or even due to direct application. Water may become polluted with a range of contaminants due to the use of land for agriculture. Of these pollutants, dissolved organic carbon, nutrients (nitrogen and phosphorus) and pesticides are the most important issues for some land-owning UK water utilities due to the need to remove them from raw water to meet regulatory standards. Pesticide occurrence in water supplies is a concern for water-quality assessment, since a huge number of pesticides are widely used in agriculture. Pesticides are a group of hazardous materials with potential risk to human health. Herbicides are the most widely used pesticides, constituting more than 40% of total use, while insecticides account for approximately 30% and fungicides for some 20%. Pesticides play an important role in harvest quality and food protection, providing enormous benefits in increasing production, as pests and diseases damage up to a third of crops. As a result of massive global consumption, pesticides as well as their degraded products spread through the environment and can contaminate water

resources. Pesticide residues from agricultural fields contaminate water sources through nonpoint and point pollution sources, e.g. due to leaching or run-off directly from fields, or by dumping or washing of used containers. The extent of pollution of surface water and groundwater by pesticides depends on the physicochemical characteristics of the compounds. These characteristics include water solubility, retention by soil components, degradation rate, the properties of the medium in which they are applied, their abiotic and biotic degradation and factors external to them, such as locally occurring precipitation and patterns of wind or the topology of the area. Surface water contamination may have Eco toxicological effects on aquatic flora and fauna, and on human health if used for public consumption

Surface water is an interface where dynamic reactions take place. For example, precipitation influences the presence of surface water, while that presence in turn affects local temperature and humidity.

The periodic absence of surface water in wetland areas fosters the release of carbon to the atmosphere. Precipitation is the greatest factor controlling stream flow. Evaporation is another dynamic process that takes place with surface water. Water from rainfall returned to the atmosphere largely through evaporation. This is dependent on temperature, solar radiation, wind, atmospheric pressure and many other factors. All these factors influence the hydrology of watersheds. Data on the extent and duration of surface water informs watershed hydrology and wetland ecosystem science. Better information on the extent of past and current flood water aids hazard mitigation and recovery.

URBAN AREA.

Chemical pollution

Waste gas, waste water and waste residues cause increases in pollutants such as nitrogen, phosphate, chloride, sulphate, organic solvents and heavy metals. Sodium (Na^+) in groundwater from plagioclase in granite rocks, chemical fertilizers, domestic effluents, etc.

Disposal of solid waste into rivers and other water bodies. Potassium from pollution sources such as chemical fertilizers and domestic effluents.

Chloride from industrial effluent and domestic fertilizers and septic tanks. Sulphate sources include rainfall run-off, fertilizers, sewage effluents, and dissolution of sulphide minerals present in granite.

Nitrate and sulphate enter groundwater from effluents from septic systems and livestock waste in residential areas. High sulphate content can be found in river water in areas where soil is formed from limestone, marble and gypsum. In snowy regions, de-icing agents such as rock salts, primarily consisting of sodium chloride (NaCl), can leach into water courses. Other agents used include Ferro cyanide, used as an anti-clumping agent, and impurities consisting of trace elements (phosphorous, Sulphur, nitrogen, copper and zinc).

Chlorofluorocarbons (CFCs) Point sources of dissolved CFC contamination in groundwater include sewage effluent discharge, localized septic system, landfills and manufacturing leachate.

Nonpoint sources of CFC include agricultural practices and urban run-off sewage effluent. Volatile organic compounds and CFCs Landfill and manufacturing plants have been identified as anthropogenic point sources of CFCs and other VOCs associated with disposal of aerosols, paint removers, dry cleaning agents, foam blowing agents and refrigerants. Heavy metal pollution Run-off from industrial and residential areas has been shown to contain Pb, Cu, Zn, and Ni.

Miscellaneous

Wastewater is one of the major sources of nutrients in coastal areas and geomorphic aspects of aquatic systems. Land use and land cover changes are major anthropogenic activities that influence water flow and quality of rivers in particular. Industrial, agricultural and other anthropogenic activities often lead to increased inputs of metals in soils and water.

2.3 Nutrients in Surface Water

Changes in water quality can be caused by pollution from both point sources (such as industrial and treated sewage discharges) and diffuse sources (such as storm-water runoff from agricultural and urban areas). Nutrients are an important indicator of surface water quality because inorganic nitrogen (nitrate and ammonia) and phosphorus control the growth of aquatic plant. Excessive growth of aquatic plants can cause dissolved oxygen concentrations in streams to decrease during the night to levels that may not sustain certain species of fish. Inorganic nitrogen enters surface waters directly in runoff from agricultural fields treated with fertilizer or indirectly via ground

water. Phosphorous binds to soil particles and enters surface waters as a result of erosion. Other nutrients like chlorine and iron may enter surface waters from waste water and feedlots, contributing to high levels of nutrients in the water. These nutrients affect the color, appearance and smell of the water and can be a nuisance to Nitrate represents the most completely oxidized state of nitrogen, and is commonly found in water. Sources include: nitrate-forming bacteria that convert nitrites into nitrates under aerobic conditions, lightning converting large amounts of atmospheric nitrogen directly to nitrates, and commercial use of fertilizers containing nitrogen in the form of nitrates. Nitrate in water is undetectable without testing because it is colourless, odourless, and tasteless; however, the negative impacts of high levels of nitrates in water demand EPA standards be adhered to.

Nitrates are essential plant nutrients since it necessary for growth and reproduction and it is a basic constituent of proteins. A deficiency in nitrates may cause stunted growth, yellowing of leaves due to reduced chlorophyll content and dormant lateral buds. The use of fertilizers prevents these detrimental results, but can lead to a greater problem: excess nitrates. Together with phosphorus, nitrates in excess amounts can accelerate eutrophication, causing dramatic increases in aquatic plant growth and changes in the type of plants and animals that live in the stream. This then affects other parameters such as dissolved oxygen and temperature, and lowers the water quality of that area. Furthermore, the effects of excess nitrates are severe. Hypoxia, (low levels of dissolved oxygen) can occur as a result, and become toxic to warm-blooded animals at higher concentration and under certain conditions. Drinking water with high levels of nitrates can also cause infant methemoglobinemia (blue babies) and increase mortality near the point of pollution. Two methods of analysis are used in the high range tests: The NitraVer™5, using gentisic acid, or the Chromotropic Acid. The low range nitrate test is a modification of the Cadmium Reduction Method and uses very sensitive chromotropic acid indicators. According to EPA standards, low-range standard should be <0.10 mg/L and high-range should be > 1.0 mg/L.

Phosphorus

Phosphorus is a common constituent of agricultural fertilizers, manure and organic wastes in sewage and industrial effluent. Although it does not threaten human health, high levels speed up the process of eutrophication. This is a reduction in dissolved oxygen in water bodies caused by an increase of mineral and organic nutrients. This can also have an effect on the growth of microbes

in the water. One study conducted in Finland showed that microbial growth was regulated both by organic carbon and the availability of phosphorus. A significant increase in the growth of microbes was recorded due to high levels of phosphorus present in the water. Regulating the concentration of phosphorus in water can regulate the microbial growth in drinking water.

Total phosphate content in water should not exceed a range of 0.05 mg/L to 0.1 mg/L, depending upon whether the water sources discharge directly into a lake or reservoir. Phosphorus is also a concern because phosphate levels greater than 1.0 mg/l may interfere with coagulation in drinking water treatment plants. The EPA water quality criteria state that phosphates should not exceed .05 mg/l if streams discharge into lakes or reservoirs, .025 mg/l within a lake or reservoir, and .1 mg/l in streams or flowing waters not discharging into lakes or reservoirs to control algal growth. Surface waters that are maintained at .01 to .03 mg/l of total phosphorus tend to remain uncontaminated by algal blooms.

Chlorine

Chloride (Cl⁻) is a naturally occurring major anion found in all natural waters. Chloride behaves as a conservative ion in most aqueous environments, meaning its movement is not retarded by the interaction of water with soils, sediments, and rocks. High levels of chloride are not primary indicators of pollution, but act as secondary indicators of other types of contamination. Chloride is non-toxic to humans, but elevated levels make water unpotable due to the salty taste. It is also corrosive to steel, and thus may corrode pipes in water treatment and industrial plants. For these reasons, the U.S. EPA standard for Chlorine is 250mg/L and studies have shown that other governments have proposed a lower maximum Cl⁻ concentration to protect freshwater life, since high levels has been linked to damage of terrestrial and aquatic animals at concentrations as low as 210 mg/L. (Environment Canada, 2001; Hart et al., 1991; Kaushal et al., 2005; Wilcox, 1986).

Iron

Iron makes up about five percent of the earth's crust and can be found in a soluble or insoluble form in water. Soluble iron oxidizes when exposed to oxygen, and becomes relatively insoluble iron, which gives water the reddish brown discoloration. Primary sources include geological sources, corroding systems and house hold pipes. Studies have shown that ingesting iron from

drinking water is not directly associated with adverse health effects, although trace impurities and microorganisms that are absorbed by iron solids may pose health concerns (Symeonidis & Marangos, 2012). The average lethal dose of iron is 200–250 mg/kg of body weight, but death has occurred following the ingestion of doses as low as 40 mg/kg of body weight.

Iron (as Fe²⁺) concentrations of 40 µg/litre can be detected by taste in distilled water. Studies show that in mineralized spring water with a total dissolved solid content of 500 mg/litre, the taste threshold value was 0.12 mg/litre. In well-water, iron concentrations below 0.3 mg/litre were characterized as unnoticeable, whereas levels of 0.3–3 mg/litre were found acceptable (WHO, 1996). Iron also promotes bacterial growth within water distribution systems, which results in slimy coating of piping and other structures. Based on aesthetic issues like taste, odour and colour, EPA has issued a secondary maximum contaminant level of 0.3 mg/L for source water iron.

2.4 Bacteria in Surface Water

The most serious public health risk associated with drinking-water supplies is microbial contamination. Pathogens such as bacteria, viruses and parasites, can cause a wide range of health problems when ingested in drinking water, but the primary concern is infections diarrheal disease transmitted by the faecal-oral route (UNICEF Handbook on Water Quality, 2008). Studies have shown that each year in several countries people are exposed to waterborne disease whose effects vary in severity from an upset stomach to death. In 1990 a serious waterborne disease, cholera, caused death and major suffering in South America. Diseases such as cholera are known to be very common in developing countries, and are the cause of death to approximately 2.2 million people yearly. Research shows that much of the ill health, which affects the humanity in developing countries, can be traced to lack of safe and wholesome water supply.

Lactose Fermenting Bacteria

Lactose fermenting bacteria can also be called total coliform bacteria. They include a wide range of aerobic and facultative anaerobic, Gram-negative, non-spore-forming bacilli capable of growing in the presence of relatively high concentrations of bile salts with the fermentation of lactose and production of acid or aldehyde within 24 h at 35-37 °c (Washington State Department of Health, 2008). There are three groups of coliform bacteria, and each is an indicator of drinking water

quality, carrying a different level of risk. Total coliform is a large collection of bacteria. Fecal coliform are types of total coliforms that exist in faeces, and *E. coli* is a subgroup of fecal coliform. Total coliform bacteria are common in the environment and are generally harmless. Presence of this type of bacteria indicates the source is probably environmental. Coliform bacteria are unlikely to cause illness, however their presence in drinking water may indicate disease-causing organisms.

I. *E. coli*

The fecal indicator bacteria (*Escherichia coli*, fecal coliforms, and fecal streptococci) are typically used to measure the sanitary quality of water for recreational, industrial, agricultural and water supply purposes. *E. coli* can cause serious diseases like urinary tract infections, bacteremia and meningitis. Some strains are even known to cause acute diarrhea. These strains like *E. coli* O157:H7 cause diarrhea that ranges from mild and non-bloody to highly bloody, which is indistinguishable from haemorrhagic colitis. This has the potential to lead to acute renal failure and haemolytic anaemia. Waterborne transmission of pathogenic *E. coli* has been well documented and research has shown that an outbreak took place in Canada in 2007. This outbreak caused 7 deaths and 2300 illnesses due to contamination by rainwater runoff containing cattle excreta (O'Connor, 2002). The presence of *E. coli* in a drinking water sample usually indicates recent fecal contamination. That means there is a greater risk that pathogens are present.

ii. *Klebsiella*

Klebsiella spp. are also Gram-negative, non-motile bacilli that belong to the family Enterobacteriaceae. Their outermost layer has a large polysaccharide capsule that distinguishes the organisms from other members of the family. Species like *K. pneumonia* and *K. oxytoca* may cause serious infections like pneumonia in humans, but these are rare occurrences. *Klebsiella* spp. naturally inhabits many water environments and multiplies to high numbers in water rich in nutrients. *Klebsiella* is not known to represent a source of gastrointestinal illness in the general population through ingestion of drinking-water and are unlikely to pose health risks.

Non-lactose Fermenting Bacteria

Non-lactose fermenting bacteria cannot utilize lactose and uses peptose instead. This forms ammonia which raises the pH of agar and leads to the formation of white/colorless colonies when cultured.

Shigella

Shigella spp. are Gram-negative non-spore-forming, non-motile, rod-like members of the family Enterobacteriaceae, which grow in the presence or absence of oxygen. This disease usually affects children under 10 years of age and can be transmitted by contaminated food and water, and even flies. Research has shown a number of large waterborne outbreaks of shigellosis over the past years. Their presence in drinking water indicates recent human faecal pollution, since organisms are not exactly stable in water environments.

CHAPTER THREE

MATERIALS AND METHOD

STUDY SITE

The study areas (Water works, Ureje and Kurundu) are situated in Ado Local Government Area of Ekiti State, and lies within latitude $7^{\circ}45'N$ and $7^{\circ}25'N$ and longitude $5^{\circ}60'E$ and $6^{\circ}00'E$ respectively. The Kurundu is located along Adebayo. Adebayo is situated at the upper part of figure 3.1 while Waterworks and Ureje is located at the base part of figure 3.1 below.

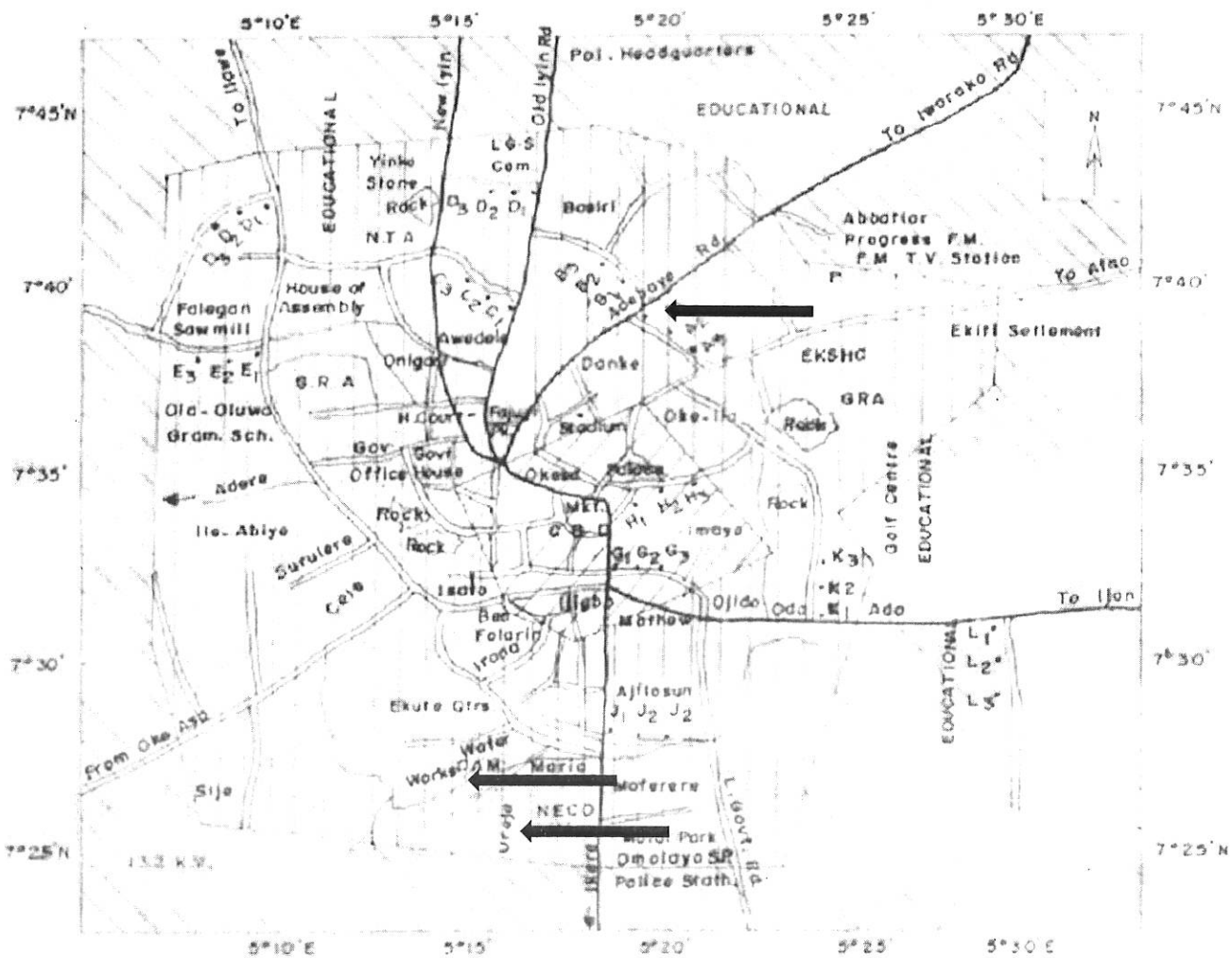


FIG.3.1. SHOWING THE ENTIRE ADO LOCAL GOVERNMENT AND THE THREE SAMPLE LOCATION.

3.1 Sampling procedures

Water samples were collected on July 2017, which covered the water work raw water at Fajuyi, Kurundu stream at Adebayo and Ureje stream at poly road, Ado-Ekiti. The physical and chemical parameters of the river sample were obtained. The surface water quality changes from season to season and is easily polluted. For this purpose, Samples were collected during the first week at two different point in the rivers, between 9.00am to 12.00 pm in clean plastic bottles, labeled properly and brought to the laboratory for analysis.

Test that were carried out on the sample:

❖ **PH**

The pH of the sample was electrometrically measured using a well calibrated HANNA Hi208 pH meter.

❖ **Electrical Conductivity**

The Electrical Conductivity was measured using DDS-307 Conductivity meter.

❖ **Turbidity**

Turbidity of the sample was determined after vigorously shaken using Labtech AVI-654 Turbidity meter.

❖ **Total Dissolved Solid (TDS)**

The total dissolved solid was measured using HM TDS-3 TDS Meter.

❖ **Total hardness**

Determination of total hardness was achieved thorough shaking of sample and measuring 25mL into a cylinder which was top to 50mL with distilled water and then poured into a conical flask. 2mL of a buffer solution with a drop of Eriochrome black indicator were added to it. The sample was gently shaken and was titrated with a solution of 0.02EDTA as a titrant to a blue coloration as end point. The actual concentration of total hardness in mg/L as CaCO_3 was gotten using the formula given below

$$\text{Total hardness (mgL}^{-1} \text{ as CaCO}_3) = \frac{A \times B}{Z} \times 1000(3.2)$$

(Source: APHA, 1985)

Where:

A = mL of titrant used to reach end point

B = 2.5252

Z = mL of sample used for analysis (25mL).

3.2 DETERMINATION OF NITRATE

Preparation of solutions

- 0.7218g anhydrous potassium nitrate (KNO_3) was weighed and dissolved in 100ml of distilled water.
- 1g of sodium salicylate was weighed and dissolved in 1ml of distilled water (this solution can be suitable for only one month).
- 30ml of conc. H_2SO_4 was measured.
- 4% NaOH was weighed and dissolved in 100ml of distilled water.
- 2g of sodium hydroxide potassium tartrate was weighed and dissolved in 100ml of distilled water.

Procedure

- 0.7218g of KNO_3 was weighed and dissolved in 100ml of distilled water (stock nitrate solution)
- From the stock nitrate solution, 0,5,10,15,20,25 were diluted in 50ml of distilled water, 2ml was taken from each and 2ml of sodium salicylate was added into each and was evaporate into dryness (standard).
- 2ml was taken from each standard and 2ml of sodium salicylate was added into each and also evaporate into dryness on hot plate.
- 2ml of conc. H_2SO_4 was added into both sample and standard.

- E. It was allowed to stand for 10minutes.
- F. 15ml of distilled water was added into both sample and standard
- G. 2ml of sodium hydroxide-potassium tartrate solution was added into both sample and standard.
- H. Yellow colour was observed
- I. The absorbance was read on u.v spectrophotometer with 420nanometer.

3.3 CHLORIDE DETERMINATION

The sample was well agitated, followed by measuring 100ml into a conical flask. 1mL of standard potassium chromate (an indicator) was added and the solution was titrated with standard silver nitrate solution to a reddish-brown colouration as end point. Concentration of chloride in mg per liter of the sample was obtained by applying the formula below;

$$\text{Chloride concentration (mgL}^{-1}\text{)} = \frac{A \times N}{Z} \times 35450(3.4)$$

(Source: APHA, 1985)

Where:

A = mL of titrant used to reach end point

N = Normality of silver nitrate solution = 0.0141

Z = mL of sample used for analysis (100mL).

3.4 Enumeration and isolation of total and faecal coliform count

Total coliforms were estimated using the most probable number (MPN) method. MacConkey's lactose bile salt broth with bromocresol purple as indicator was used for the presumptive tests. With a sterile pipette, 50 ml of each of the water sample was aseptically dispensed into 50ml double strength broth, another 10 ml of the sample into each of the five tubes containing 10 ml double strength broth and another one ml of the sample was then inoculated into each of the second five culture tubes containing 5ml single strength MacConkey broth with Durham's tubes. Inoculated tubes of MacConkey broth were incubated at 37° C for 24 to 48 hours.

After 24-48 hours of incubation, the cultures were observed for the presence of acid production and gas formation

A sterile pipette was used to transfer 1ml of the culture from the positive presumptive fermentation tubes into tubes containing 5ml brilliant green lactose bile broth aseptically and incubated for 24-48 hours at 37°C. Following incubation, culture positive tubes were inoculated into MacConkey agar for total Coliform and Eosin Methylene Blue agar for faecal coliform and incubated at 37 ° C and 44 ° C respectively.

Determination of heterotrophic plate count/ total viable count

Heterotrophic plate count of all water samples were determined using dilution plate method technique and standard plate count agar medium. Serial dilutions were prepared (using peptone water) and 1 ml of the sample or dilution was transferred to a sterile, empty Petri dish. Plate count agar was melted by heating in boiling water and then allowed to cool in a water bath to 44 - 46° C. Approximately 15 ml of the agar medium was poured into the Petri dish containing the sample. The sample and agar was mixed thoroughly by rotating the plate several times. When the media has solidified, the plates were inverted and incubated at 35 °C for 48 to 72 hours. Following the appropriate length of incubation, suitable plates from different dilutions were selected and the visible colonies were counted using a colony counter. Then the average colonies were counted and expressed as colony forming unit per ml of water.

Identification of isolates

Representative isolates from total coliforms and total viable counts were identified. Standard isolation techniques were employed. Pure isolated colonies were Gram differentiated and then biochemically identified using Indole, Catalase, Citrate, Oxidase, Coagulase and Urease tests. E. coli should not be present in irrigation water.

3.5 Determination of Heavy Metals in irrigation water.

20 ml of the water sample was measured and transferred into 250 ml conical flask. The water sample was digested by the addition of 20 ml of aqua regia (mixture of HCl and HNO₃, ratio 3:1). The beaker was covered with an inverted funnel, and heated over a heating mantle at 90°C for

about two hours until the volume reduced to about 5ml. The conical flask and funnel were washed with distilled water. The solution was cooled, filtered through Whatman No. 1 filter paper and transferred quantitatively to a 50 mL volumetric flask and made up to the mark with distilled water. The filtrate was transferred into plastic sample bottle and kept. The digested sample was analyzed for metals using Buck Scientific 210VGP atomic absorption spectrophotometer (AAS).

Analytical techniques

Tables showing analytical method used to the surface water.

TABLE 3.1.

| Quality parameter | Symbol | Method used |
|-------------------------------------|---|------------------------------------|
| Turbidity | Turbidity | Turbidity meter |
| Chemical oxygen demand | COD | Potassium dichromate method |
| PH | PH | PH meter |
| Potassium/calcium/sodium/magnesium | K ⁺ /Ca ²⁺ /Na ⁺ /Mg ²⁺ | Inductively coupled plasma optical |
| Spectroscopy(ICP-OES) | | |
| Ammonium | NH ₄ ⁺ | Nessler's reagent photometry |
| Fluorine/Nitrate nitrogen electrode | F ⁻ /NO ₃ ⁻ | Fluorine ion electrode |
| Chloride | CL ⁻ | AgNO ₃ titration |
| Bicarbonate | HCO ₃ ⁻ | Acid-base titration |
| Electrical conductivity | EC | Electrical conductivity meter |

3.6 ELEMENTAL ANALYSIS.

EDUIPMENT NAME: ATOMIC ABSORPTION SPECTROMETER

MANUFACTURER: BULK SCIENTIFIC

MODEL: 210VGP

TABLE 3.2 CONDITION OF ANALYSIS

| | Cd | Cr | Cu | Mn | Ni | Pb | Zn |
|----------------------|-------|-------|-------|-------|-------|-------|-------|
| Wavelength (Nm) | 228.9 | 357.9 | 324.8 | 279.5 | 232.0 | 217.0 | 213.9 |
| Slit (Nm) | 0.7 | 0.7 | 0.7 | 0.7 | 0.2 | 0.7 | 0.7 |
| Detection limit(ppm) | 0.01 | 0.04 | 0.005 | 0.03 | 0.05 | 0.08 | 0.005 |

TABLE 3.3 CALIBRATION SUMMARY FOR THE ANALYSIS

CADMIUM

| Concentration (ppm) | Absorption |
|---------------------|------------|
| 0.125 | 0.013789 |
| 0.25 | 0.025717 |
| 0.5 | 0.044014 |
| 1.0 | 0.089156 |

Correlation coefficient: 0.996 (2nd Order Calibration Curve)

LEAD

| Concentration (ppm) | Absorption |
|---------------------|------------|
| 10.0 | 0.316371 |
| 8.0 | 0.279329 |
| 6.0 | 0.213179 |

| | |
|-----|----------|
| 4.0 | 0.146448 |
| 2.0 | 0.079898 |
| 0.0 | 0.0 |

Correlation Coefficient: 0.991 (Linear Curve).

ZINC

| Concentration (ppm) | Absorption |
|---------------------|------------|
| 2.0 | 0.309334 |
| 1.0 | 0.179958 |
| 0.5 | 0.097686 |
| 0.25 | 0.047734 |
| 0.0 | 0.0 |

Correlation Coefficient: 0.997 (Linear Curve).

The water quality parameters monitoring each water sample includes, turbidity, COD, pH, calcium, potassium, sodium, magnesium, ammonia, nitrate, fluoride, EC, etc. Along with the on-site measurement of the pH and conductivity was done due to expected change in the measurement during the process transport and storage.

Dissolved Oxygen

The amount of dissolved oxygen in streams is dependent on the water temperature, the quantity of sediment in the stream, the amount of oxygen taken out of the system by respiring and decaying organisms, and the amount of oxygen put back into the system by photosynthesizing plants, stream flow, and aeration. Dissolved oxygen is measured in milligrams per liter (mg/l) or parts per million (ppm). The temperature of stream water influences the amount of dissolved oxygen present; less oxygen dissolves in warm water than cold water. For this reason, there is cause for concern for streams with warm water. Trout need DO levels in excess of 8 mg/liter, striped bass prefer DO levels above 5 mg/l, and most warm water fish need DO in excess of 2 mg/l.

Biochemical Oxygen Demand (BOD)/Chemical Oxygen Demand (COD)

Natural organic detritus and organic waste from waste water treatment plants, failing septic systems, and agricultural and urban runoff, acts as a food source for water-borne bacteria. Bacteria

decompose these organic materials using dissolved oxygen, thus reducing the DO present in water. Biochemical oxygen demand (BOD) is a measure of the amount of oxygen that bacteria will consume while decomposing organic matter under aerobic conditions. Biochemical oxygen demand is determined by incubating a sealed sample of water for five days and measuring the loss of oxygen from the beginning to the end of the test. Samples often must be

diluted prior to incubation or the bacteria will deplete all of the oxygen in the bottle before the test is complete.

The main focus of wastewater treatment plants is to reduce the BOD in the effluent discharged to natural waters. Wastewater treatment plants are designed to function as bacteria farms, where bacteria are fed oxygen and organic waste. The excess bacteria grown in the system are removed as sludge, and this "solid" waste is then disposed of on land.

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

If effluent with high BOD levels is discharged into a stream or river, it will accelerate bacterial growth in the river and consume the oxygen levels in the river. The oxygen will diminish and reduce oxygen availability for plant. As the river re-aerates due to atmospheric mixing and as algal photosynthesis adds oxygen to the water, the oxygen levels will slowly increase downstream. The drop and rise in DO levels downstream from a source of BOD is called the DO sag curve.

pH/Acidity/Alkalinity

pH is a measure of the amount of free hydrogen ions in water. Specifically, pH is the negative logarithm of the molar concentration of hydrogen ions.

$$\text{pH} = -\log[\text{H}^+]$$

for example, at pH 2, $[\text{H}^+] = 10^{-2}$ or .01

at pH 10 $[\text{H}^+] = 10^{-10}$ or .0000000001

at pH 4 $[\text{H}^+] = 10^{-4}$ or .0001

Because pH is measured on a logarithmic scale, an increase of one unit indicates an increase of ten times the amount of hydrogen ions. A pH of 7 is considered to be neutral. Acidity increases as pH values decrease, and alkalinity increases as pH values increase. Most natural waters are buffered by a carbon-dioxide-bicarbonate system, since the carbon dioxide in the atmosphere serves as a source of carbonic acid.



This reaction tends to keep pH of most waters around 7 - 7.5, unless large amounts of acid or base are added to the water. The acceptable pH for irrigation water ranges between 6.5-8.4. The pH of water affects the solubility of many toxic and nutritive chemicals; therefore, the availability of these substances for irrigation is affected. As acidity increases, most metals become more water soluble and more toxic. Toxicity of heavy metals also increases with a decrease in pH (increase in acidity). Ammonia, however, becomes more toxic with only a slight increase in pH. Alkalinity is the capacity to neutralize acids, and the alkalinity of natural water is derived principally from the salts of weak acids. Hydroxide, carbonates, and bicarbonates are the dominant source of natural alkalinity. Reactions of carbon dioxide with calcium or magnesium carbonate in the soil create considerable amounts of bicarbonates in the soil. Organic acids such as humic acid also form salts that increase alkalinity. Alkalinity itself has little public health significance, although highly alkaline waters are unpalatable and can cause irrigation discomfort.

The quality of water is also influenced by the type of rock and soil, environment and catchment area, as well as the anthropogenic activities within the sighted wells. The surface water quality is affected by the combined effects of physical, chemical and biological processes as the water moves along hydrologic pathways over, under and through the land. The physical and chemical changes that alter the hydrologic pathways that change the water quality include the removal of soil surfaces, vegetation through road construction, farming, urbanization, land drainage as well as addition of unwanted wastes to the landscape. Natural water quality has no universal reference due to high variability in the chemical quality of the water. Most rivers in Ado-Ekiti were studied and found to be polluted by various human activities. Such as; washing, defecating and refuse dumps. These are often found close to areas where rivers are located and during rains they move into the river body and changing hydrologic water regime. Water is a carrier of undesirable physical,

chemical and bacteriological matters that constitute contaminants and to higher degrees' pollutants.

CHAPTER FOUR

RESULTS AND DISCUSSION.

TABLE 4.1 Results of the physiochemical tests to Jordanian Standard for irrigation.

| | UREJE | KURUNDU | WATER CO- OPERATION | JORDANIAN STANDARD(2002) |
|---|--------|---------|------------------------|-----------------------------|
| PH POINT1 | 7.4 | 7.5 | 7.5 | 6.0-9.0 |
| POINT 2 | 7.5 | 7.7 | 7.5 | 7.2-7.6 |
| TDS (ppm) | 117.00 | 71.00 | 80.00 | 30 |
| POINT 1 | | | | |
| POINT 2 | 119 | 74 | 83 | 30 |
| Electrical conductivity (us/cm) POINT 1 | 179.00 | 113.00 | 124.00 | 250-750 |
| POINT 2 | 181 | 115 | 125 | 250-750 |
| TSS (mg/l)POINT 1 | 72.13 | 68.47 | 76.33 | 50-150 |
| POINT 2 | 73.02 | 67.54 | 75.32 | 50-150 |
| Turbidity (mg/l) POINT 1 | 5.50 | 5.50 | 6.00 | 10 |
| POINT 2 | 5.6 | 5.7 | 5.9 | 10 |
| Alkalinity (mg/l)POINT 1 | 101.67 | 137.33 | 98.40 | 200 |
| POINT 2 | 102.02 | 138.34 | 99 | 200 |
| Total Hardness (mg/l) POINT 1 | 121.50 | 149.00 | 109.30 | 200 |
| POINT 2 | 123.02 | 138.34 | 99 | 200 |
| Chloride (mg/l) POINT 1 | 21.40 | 16.30 | 34.40 | 400 |
| POINT 2 | 23 | 16.5 | 34.4 | 400 |

| | | | | |
|----------------------------|-------|-------|-------|--------|
| Nitrate (mg/l)POINT1 | 1.28 | 1.47 | 0.91 | |
| POINT 2 | 1.34 | 1.5 | 1 | |
| Sulphate (mg/l) POINT 1 | 53.04 | 68.60 | 34.10 | 51-240 |
| POINT 2 | 53.4 | 69.04 | 34.5 | 51-240 |
| BOD (mg/l)POINT 1 | 1.90 | 1.80 | 1.90 | 5 |
| POINT 2 | 1.8 | 1.7 | 1.8 | 5 |

From the table 4.1. EC and TDS from the three samples are generally not in conformity with Jordanian standard. Sulphate for water co-operation sample is below the Jordanian standard. While the rest still fall within Jordanian standard.

TABLE 4.2 MICROBIOLOGICAL ANALYSIS

| | UREJE | KURUNDU | WATER CO- OPERATION |
|--|----------|----------|------------------------|
| TOTAL COLIFORM COUNT (CFU/MI)POINT 1 | 14 | 12 | 09 |
| POINT 2 | 13 | 13 | 10 |
| E.coli | Positive | Positive | Negative |
| Facial streptococci | Positive | Positive | Positive |

S.aaeurus Positive Positive Positive

TEST REQUIRED: METAL ANALYSIS

METHOD OF ANALYSIS: SPECTROMETRY

EQUIPMENT USED: AAS BUCK SCIENTIFIC 210 VGP

TABLE.4.3. METAL ANALYSIS COMPARISM WITH FAO IRRIGATION STANDARD.

| SAMPLE CODES | Pb (ppm) | Zn (ppm) | Fe (ppm) | Cu (ppm) | Mn (ppm) |
|-----------------|----------|----------|----------|----------|----------|
| UREJE POINT 1 | 0.030 | 0.175 | 1.343 | 0.083 | 0.047 |
| POINT 2 | 0.032 | 0.174 | 1.354 | 0.095 | 0.05 |
| WATER | ND | 0.271 | 0.741 | 0.187 | 0.069 |
| COOPERATION | | | | | |
| POINT 1 | | | | | |
| POINT 2 | ND | 0.245 | 0.75 | 0.184 | 0.073 |
| KURUNDU | 0.107 | 0.213 | 1.920 | 0.159 | 0.113 |
| POINT 1 | | | | | |
| POINT 2 | 0.107 | 0.213 | 1.92 | 0.159 | 0.113 |
| FAO | 5.000 | 2.000 | 5.00 | 0.200 | 0.200 |
| STANDARD | | | | | |

From Table.4.3. all the samples are still in conformity with the FAO given standard, since they are not above.

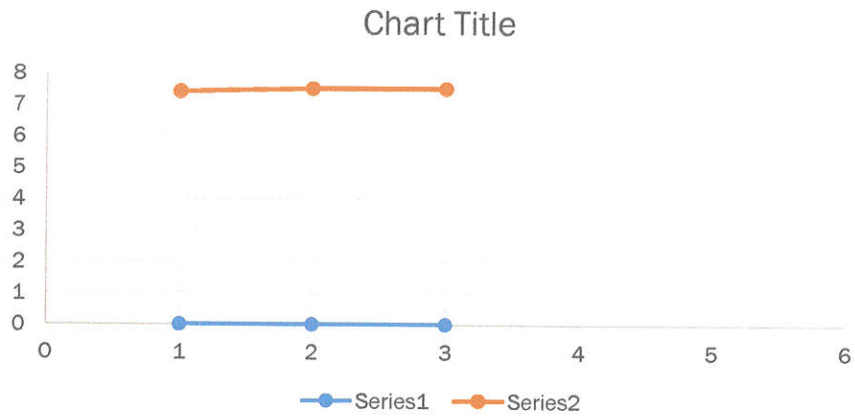


FIG.4.1.

VARIATION IN PH ACCORDING THE TABLE

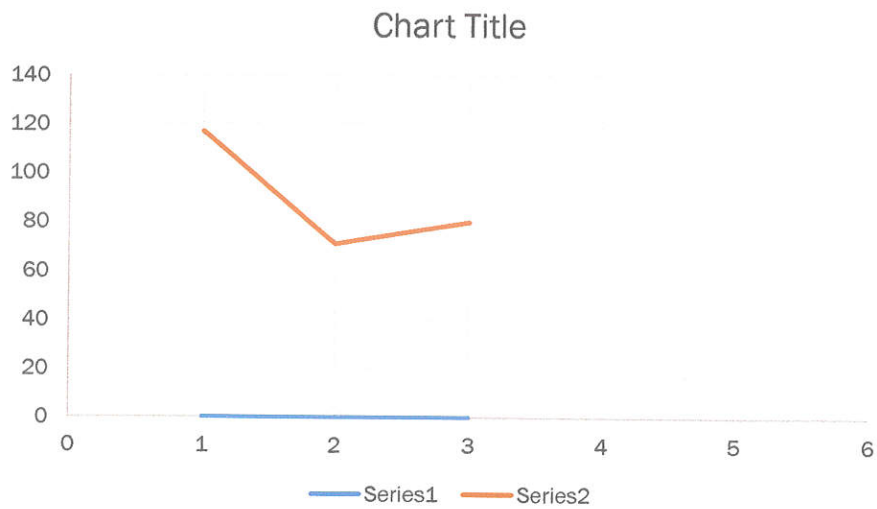


FIG 4.2 VARIATION IN TOTAL DISSOLVE SOLIDS (TDS).

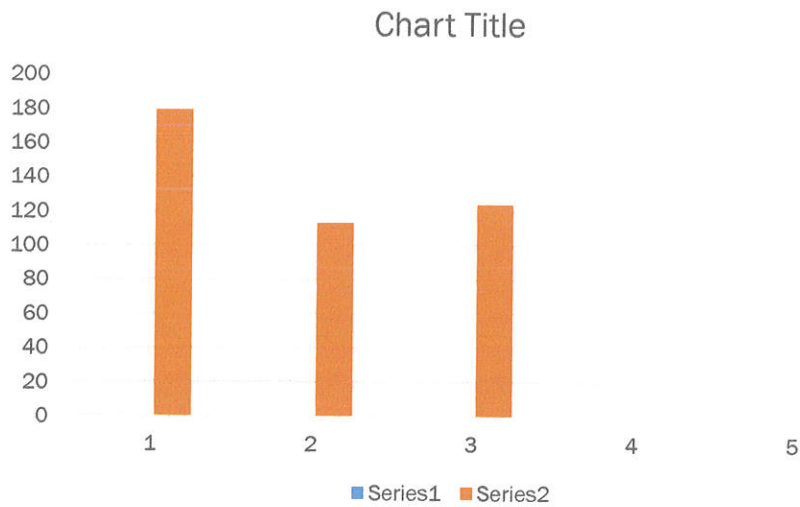


FIG 4.3 VARIATION IN ELECTRICAL CONDUCTIVITY.

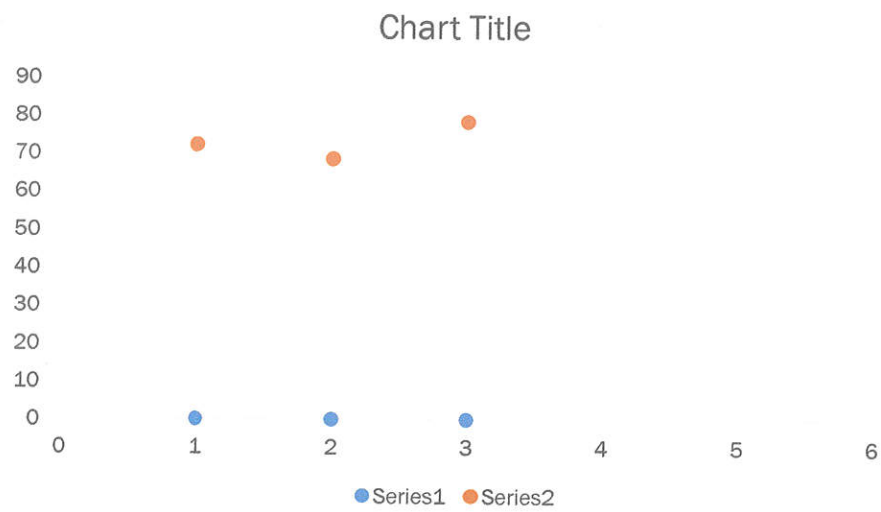


FIG 4.4 VARIATION IN TOTAL SOLUBLE SOLID.

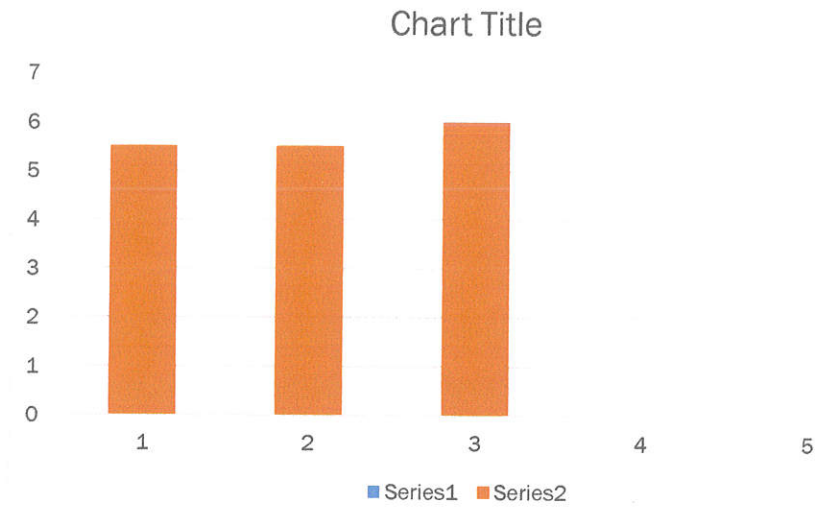


FIG 4.5 VARIATION IN TURBIDITY.

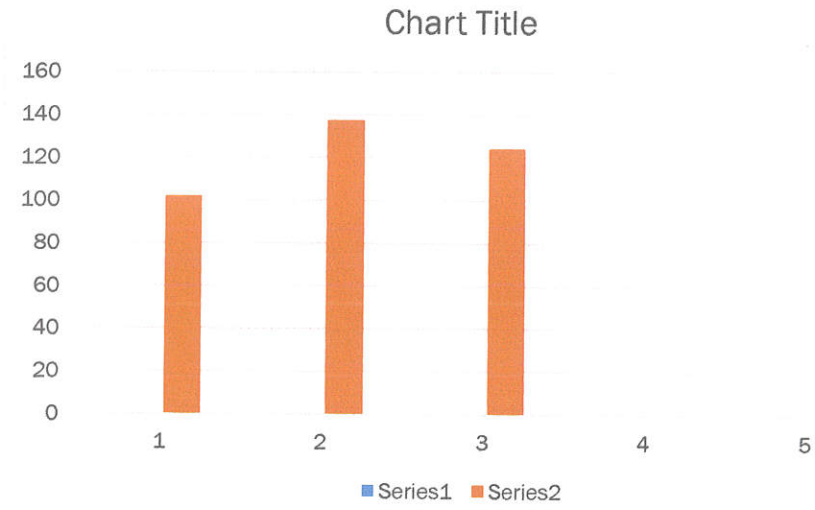


FIG 4.6 VARIATION IN ALKALINITY.

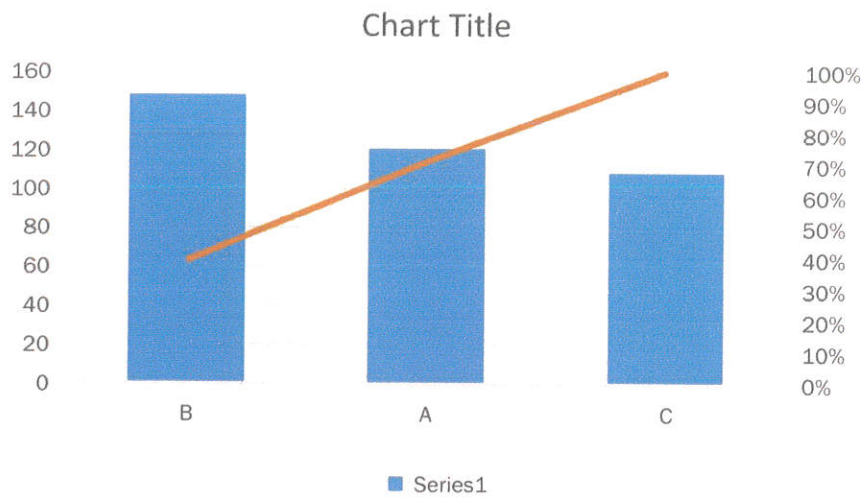


FIG 4.7 VARIATION IN TOTAL HARDNESS.

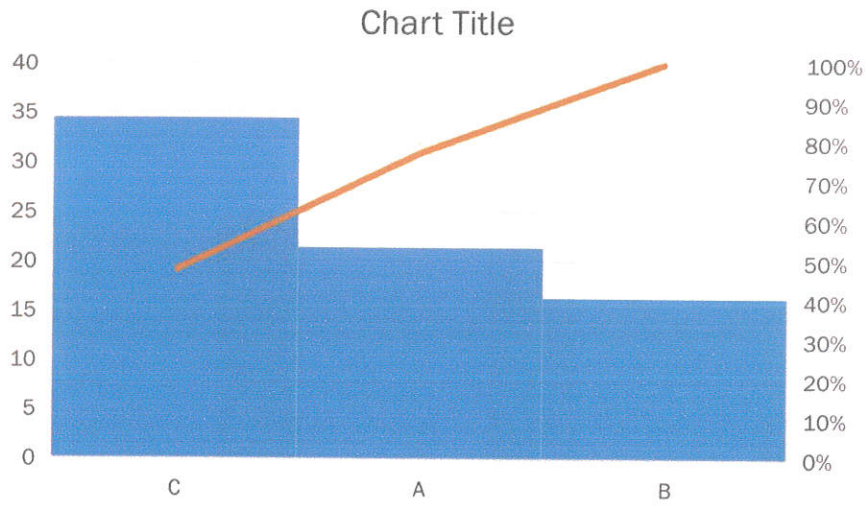


FIG 4.8 VARIATION IN TOTAL CHLORINE.

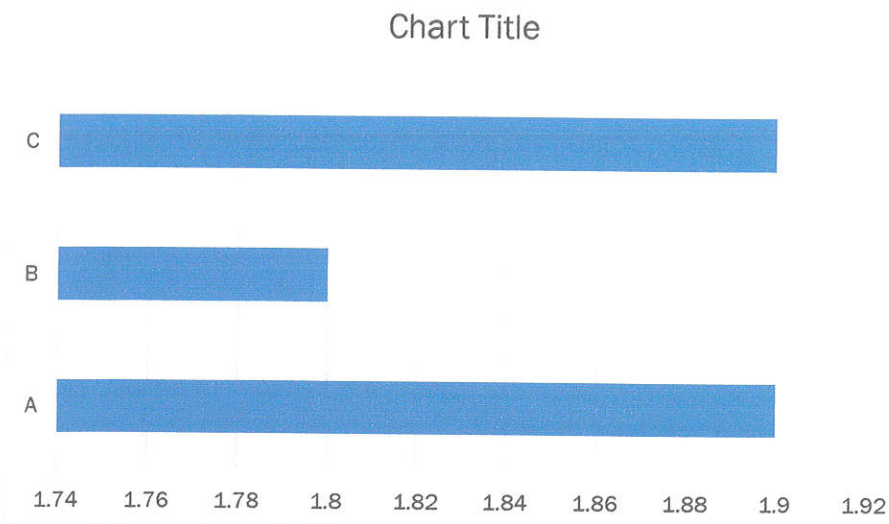


FIG 4.11 VARIATION IN BOD.

| Parameters | UREJE | KURUNDU | WATER CO-OPERATION |
|------------|--------------|--------------|--------------------|
| PH | 7.45±0.05 | 7.60 ±0.10 | 7.55±0.05 |
| TDS | 118±1.00 | 72.50±1.50 | 81.5±1.50 |
| EC | 149±32 | 114±1 | 125±0.5 |
| TSS | 72.575±0.445 | 68.005±0.465 | 75.825±0.505 |
| TURBIDITY | 5.55±0.05 | 5.6±0.1 | 5.95±0.05 |
| ALKALINITY | 102±0.175 | 138±0.505 | 98.7±0.3 |
| T.HARDNESS | 122±0.76 | 150±1 | 110±0.46 |
| CHLORIDE | 22.2±0.8 | 16.4±0.1 | 34.65±0.25 |
| NITRATE | 1.31±0.03 | 1.485±0.015 | 0.955±0.045 |
| SULPHATE | 53.22±0.18 | 68.82±0.22 | 34.3±0.2 |
| BOD | 1.31±0.04 | 1.485±0.015 | 0.955±0.045 |

**TABLE.4.4. SHOWING AVERAGE AND DIFFERENTS IN THE PHYSIOCHEMICAL
PARAMETER.**