**Sudan university of science and technology**

**Collage of graduate studies**

**Environmental engineering program**


# Assessment of groundwater quality for Umbada, District,Omdurman, Sudan.

**تقييم نوعية المياه الجوفية في محلية أمبدة - أمدرمان - السودان**

**A thesis submitted in partial fulfillment for the requirements of the degree of science in environmental engineering**


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DEDICATION

This research is lovingly dedicated to my father, mother, siblings who have been my constant source of inspiration; they have given me the drive and discipline to tackle and task with enthusiast and determination. Without their love and support this project would not been made possible.

To whom it my concern …

To me …

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I would like to express my deep gratitude to my master thesis advisor, Dr. Abdellatif Mukhtar Ahmed

For his able guidance and support in completing this research.

I would also like to extend my gratitude to the general directorate of groundwater and wades

For providing me with all the facility that was required.

## Abstract:

This study was dealing with assessment of groundwater quality and its fitness for agriculturaland domestic uses for Umbada district in western Omdurman, Sudan.

The objectives of the study were to determine the groundwater quality through chemical and microbiological analyses for the samples taken from the studied boreholes in the area under investigation.

Water samples for five groundwaterwells were collected in poly ethylene bottles and analyzed physically, chemically and bacteriologically, the analyses had been shown in tables illustrating some physical and chemical parameterssuch as pH, EC,TDS, $NO_3$, $HCO_3$, Na, Mg, Ca, Cl, F,$SO_4$.

The study showed that the groundwater is fit for irrigation and also domestic purposes according to Sudanese and WHO standards.

The microbiological analyses had shown that samples (BH1, BH2, BH5) contaminated with total coliform and fecal coliform.

**المستخلص :**

تناولت هذه الدراسة تقييم جودة المياه الجوفية وملائمتها للإستخدامات الزراعية والمنزلية لمنطقة أمبدة في غرب أم درمان ، السودان.
كانت أهداف الدراسة هي تحديد نوعية المياه الجوفية من خلال التحاليل الكيميائية والميكروبيولوجية للعينات المأخوذة من الآبار المدروسة في المنطقة قيد البحث.

تم جمع عينات المياه لخمس آبار للمياه الجوفية في زجاجات بولي إيثيلين وتحليلها فيزيائيًاوكيميائيًا وبكتريولوجيًا ، وقد تم عرض التحاليل في الجداول التي توضح بعض الخصائص الفيزيائية والكيميائية مثل pH، EC، TDS، $NO_2$، $HCO_3$، Na، Mg، Ca، CL، $SO_4$ F.
أظهرت الدراسة أن المياه الجوفية صالحة للري وكذلك للأغراض المنزلية وفقًا للمعايير السودانية ومنظمة الصحة العالمية.

وقد أظهرت التحاليل الميكروبيولوجية أن العينات ( BH1، BH2، BH5) ملوثة بالبكتريا القولونية الكلية.

Content index


| No | Subject | Page No |
|---|---|---|
| | Dedication | |
| | Acknowledgment | |
| | المستخلص | |
| | Abstract | |
| | Content index | |
| | Figures index | |
| | Tables index | |
| **1** | **Chapter one : introduction** | **1** |
| 1.1 | Introduction | **1** |
| 1.2 | Study area | **1** |
| 1.3 | Problem statement | **2** |
| 1.4 | Objective of the study | **2** |
| 1.5 | Justification of choosing the topic & area of the study | **2** |
| 1.6 | Methodology | **3** |
| **2** | **Chapter two :literature review** | |
| 2.1 | Background | **4** |
| 2.2 | Groundwater in Sudan | **5** |
| 2.3 | Ground water quality | **6** |
| 2.4 | Groundwater contamination | **10** |
| 2.5 | Water-related Disease | **16** |
| **3** | **Chapter three: Materials and Methods** | |
| 3.1 | Study area | **19** |
| 3.2 | data collection | **19** |
| 3.3 | Sampling methods for physical and chemical analysis: | **20** |
| 3.4 | Sampling methods for bacteriological analysis | **20** |
| 3.5 | Methods of analysis: | **21** |
| **4** | **Chapter four : results and discussion** | |
| 4.1 | Results of the experiments | **24** |
| 4.2 | Discussions of the experiments | **26** |
| **5** | **Chapter five** | |
| 5.1 | Conclusion | **40** |
| 5.2 | Recommendations | **41** |
| 5.3 | References | **42** |
| **6** | **Appendix** | |

Figures index V


| No | Figure name | Page No |
|---|---|---|
| 1 | The hydrological (water) cycle | **4** |
| 2 | common sources of ground water contamination | **11** |
| 3 | The study area , Umbada district | **19** |
| 4 | the result of TDSof water samples in the study area of Umbada district | **26** |
| 5 | the result of PHof water samples in the study area of Umbada district | **27** |
| 6 | the result of T.Hof water samples in the study area of Umbada district | **28** |
| 7 | the result of HCO3 and CO3 of water samples in the study area of Umbada district | **29** |
| 8 | the result of Caof water samples in the study area of Umbada district | **30** |
| 9 | the result of Mg of water samples in the study area of Umbada district | **31** |
| 10 | the result of Clof water samples in the study area of Umbada district | **32** |
| 11 | the result of F of water samples in the study area of Umbada district | **33** |
| 12 | the result of Na of water samples in the study area of Umbada district | **34** |
| 13 | the result of SO4of water samples in the study area of Umbada district | **35** |
| 14 | the result of NO3 of water samples in the study area of Umbada district | **36** |
| 15 | the result of NO2 of water samples in the study area of Umbada district | **37** |
| 16 | the result of E.Cof water samples in the study area of Umbada district | **38** |

Tables index


| No | Table name | Page No |
|---|---|---|
| 1 | Classification of water related disease | **18** |
| 2 | wells coordinates and groundwater levels | **19** |
| 3 | Chemical analysis of water in umbada district | **24** |
| 4 | Physical analysis of water in umbada district | **24** |
| 5 | Microbiological analysis of water in umbada | **25** |
| 6 | the result of TDS of water samples in the study area | **26** |
| 7 | the result of PHof water samples in the study area of Umbada district | **27** |
| 8 | the result of T.H of water samples in the study area of Umbada distric | **28** |
| 9 | the result of HCO3 and CO3of water samples in the study area of Umbada distric | **29** |
| 10 | the result of Ca of water samples in the study area of Umbada distric | **30** |
| 11 | the result of Mg of water samples in the study area of Umbadadistric | **31** |
| 12 | the result of Clof water samples in the study area of Umbada distric | **32** |
| 13 | the result of Fof water samples in the study area of Umbadadistric | **33** |
| 14 | the result of Na of water samples in the study area of Umbada distric | **34** |
| 15 | the result of SO4of water samples in the study area of Umbada distric | **35** |
| 16 | the result of NO3 of water samples in the study area of Umbada distric | **36** |
| 17 | the result of NO2 of water samples in the study area | **37** |
| 18 | the result of E.Cof water samples in the study area | **38** |
| 19 | the results of microbiological testsof water samples in the study area | **39** |

# CHAPTER ONE

# INTRODUCTION

## 1.1 Introduction

Groundwater refers to all the water occupying the voids, pores and fissures within geological formations, which originated from atmospheric precipitation either directly by rainfall infiltration or indirectly from rivers, lakes or canals.

Only a small fraction (about 2.5%) of earth's water is fresh and suitable for human consumption. Approximately 13% of this fraction is groundwater; an important source of drinking water for many people worldwide (Bachmat, 1994). For example, more than 50% of the world's population depends on groundwater for drinking water. For many rural and small communities, groundwater is the only source of drinking water (Canter, 1987).

Sands, gravel, sandstones, and lime stone for motions are the usual sources of ground water some may be drawn from impervious rocks such as granite when they have an over burden of sand or gravel. Groundwater is a valued fresh water resource and constitutes about two-third of the fresh water reserves of the world .

now a days one of the most important environmental issues is ground water contamination , in areas where population density is high and human use of the land is intensive , groundwater is especially vulnarable , virtually any activity where chemicals or waste may be released to the environment either intentionally or accidentally has potential to pollute groundwater.

## 1.2 Study Area

### 1.2.1 Location

The study area is located in the west of the omdurman between latitude 15.6859° N, and longitude 32.3108° E cover an area of about 20695$Km^2$.

### 1.2.2 Climate

Its average annual high temperature is 37.1 °C (99 °F), with six months of the year seeing an average monthly high temperature of at least 38 °C (100 °F). Furthermore, throughout the year, none of its monthly average high temperatures falls below 30 °C (86 °F). During the months of January and February, while daytime temperatures are generally very warm, nights are relatively cool, with average low temperatures just above 15 °C (59 °F).

## 1.3 Problem Statement

Sudan dependent upon ground water aquifers for it is supply for both human consumption and irrigation.

Ground water contamination is increasing concern in Sudan because most of drinking water in the study area comes from well water therefore More attention should be focused on ground water to meet the requirements for present an future development ,

This study aim to evaluate the quality of groundwater in umbada .

Water scarcity is the single most important natural constraint to Umbada growth and development, rapid increases in population and industrial development have placed unprecedented demands on water resources

## 1.4. Objectives of the Study

### Main Objective

To determine the quality of ground water in umbada district for different uses (agricultural, industrial and domestic purposes ).

### Special Objective

- The chemical parameters of groundwater
- The physical parameters of groundwater
- The bacteriological parameters of groundwater

## 1.5 Justification of Choosing the Topic & Area of the Study

There is no data available for the district
Suitability of groundwater for drinking

## 1.6 Methodology

- Field work : take water samples for analysis .
- Laboratory work : analysis of water samples collected in the field . the water samples are analyzed in a water quality lab .
- Office work :

# CHAPTER TWO

# LITERATURE REVIEW

## 2.1 Background

Groundwater is water located under the ground surface in soil pore spaces and inthe fractures of rock formations.
Groundwater recharge can be made due to natural rainfallhowever natural discharge often occurs at springs and seeps, and can form oases orwetlands.
Ground water is often withdrawn for agricultural, municipal and industrial use by means of constructions and operations of extraction wells.
The study of distribution and movement of groundwater in hydrogeology is called groundwater hydrology. The water cycle, also known as the hydrologic cycle describes the continuous movement of water on, above and below the surface of the Earth.
The hydrologic cycle is used to model the storage and movement of water between the biosphere, atmosphere and hydrosphere.
Water is stored in the reservoirs such as atmosphere, oceans, lakes, rivers, glaciers, soils,snowfields, and groundwater.

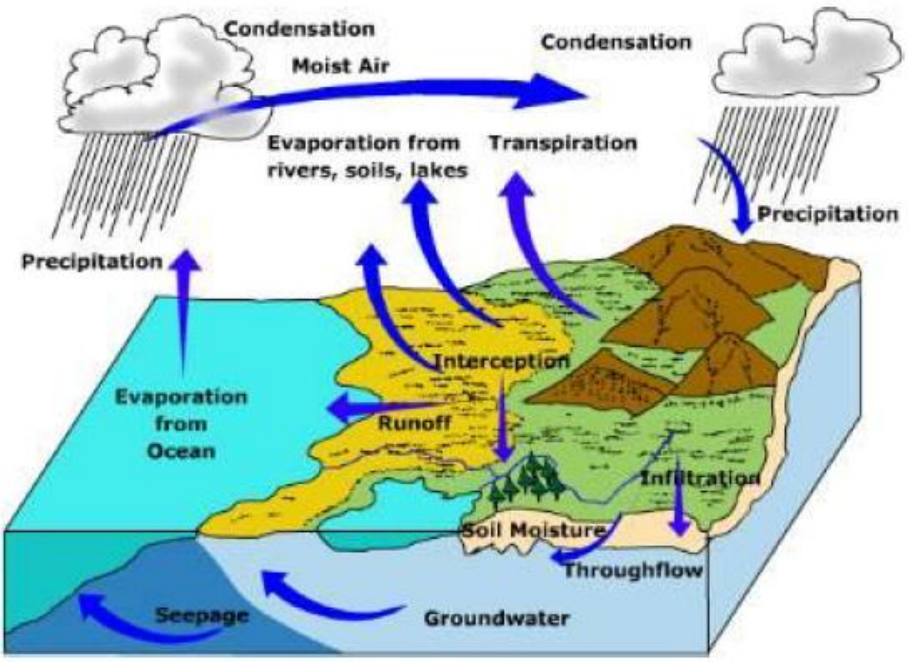


Figure (1): The hydrological (water) cycle.

## 2.2 Groundwater in Sudan

Groundwater is potentially available in large areas away from Nile. Major water aquifers cover about 50% of the surface of the country and occur either in shallow aquifer along the major seasonal steams or in deep aquifer of Nubian sand stone formation.

- **The main aquifers exist under three categories:**
  - I. The Nubian sand stone aquifers.
  - II. The detrital quaternary, tertiary. Aquifers.
  - III. The recent alluvial wade-fill aquifers.(SSMO, 2002)

### 2.3 Groundwater quality

The chemical, physical and bacterial characteristics of groundwater determine its usefulness for various purposes.

Chemical analysis of groundwater includes the determination of the concentrations of inorganic constituent.

The analysis also includes measurement of pH and specific electrical conductance Temperature, colour, turbidity, odour and taste are evaluated in a physical analysis

Bacteria analysis generally consists of tests to detect the presence of coli form organisms.

Lloyd and Helmer (1991) observed that the water quality problem may be associated with and traceable to, any or all of the following:

1. Poor quality source of water.
2. Poor site selection or protection such as apron and lining.
3. Construction difficulties.
4. Structural deterioration with age.

## 2.3.1 Microbial Quality

Safe guarding the microbial quality of drinking water is said by the experts to be the most important objective even ahead of its physical and chemical quality, since water represents an obvious mode of transmission of enteric diseases (Bland, 1980; Skinner and Shecon (1997).

According to the WHO (1971), the greatest danger associated with drinking water is contamination by sewage, human and animal excreta.

Microbial qualify is determined using various methods of bacterial examination.

The indication organism's method as invented by Percy Frankland in London in 1981 is basically the concept of using organisms usually abundant in human and animal excrement, as evidence of contamination and possible presence of other potentially dangerous microorganisms (WHO, 1984).

The use of indicator organisms for determination of the microbial quality of water saves the time, laboure and expenses involved in attempting to test for all pathogens that a water sample might possible contain.

For an organism to be ideal for use as an indicator, it must meet the following criteria:

1. The method of isolation, identification and enumeration should be simple and unambiguous.
2. It should be resistant to chlorine and have a higher survival rate in water than pathogens.
3. It should be more neutral than all pathogens in the environment.

The significant that can be attached to the presence or absence of a particular fecal indicator varies with each organism and with the degree to which that organism canbe specifically associated with faeces (WHO, 1984).

The WHO (1984) recommended standards for testing contamination during transportation or storage is an MPN count of less than 10 per 100 ml for total coli forms and 2.5 per 100 ml for E. coli.

The body also recommends that the wide spread of faecal contamination in developing countries, the nation surveillance agency should set medium term targets for the progressive improvement of water supplies

## 2.3.2 Physicochemical quality

The term physicochemical quality is used in reference to the characteristics of water which may affect its acceptability due to aesthetic considerations such as colour and taste; produce toxicity reactions, unexpected physiological responses of laxative effect, and objectionable effects during normal use such as curdyprecipitates (WHO, 1995).

**Taste and Odour**

Taste and odour depend on the stimulation of the human receptor cells, which are located in the taste-buds for taste and nasal cavity for odour(WHO, 1984).

Taste and odour are complimentary, for example when tasting water; both the olfactory and gustatory nerves are active.

In all taste it is actually flavour that is being measured flavour refers to the combination of taste, odour, temperature and feel.

The close association between taste and odourmay be illustrated by the lack of flavour of many food substances, when the sense of smell is lost during a head cold (Emslie-smith, 1988).

Taste and odour problems account for the largest single class of consumer complaints in drinking water supplies, due to the water source, the treatment method, distribution system or a combination of all three (WHO, 1984).

Taste in drinking water is measured by taste tests such as the threshold test or taste rating tests.

The odour tests are carried out for odour in drinking water

The sense of smell is more sensitive than the best analytical method, for example the guideline for cyanide in drinking water would be 1/100th of the present limit if based on the odour threshold of 0.001 mg/l (WHO, 1984).

**Temperature:** The growth rate of microorganisms, some of which produce bad tasting metabolites is positively associated with temperature. The odour of substance is also temperature influenced because of relationship between odour and vapour pressure, therefore odour measurement usually specify temperature.

**pH:** pH influences the taste and odour of a substance significantly, especially when it controls the equilibrium concentration of the neutral and ionized forms of a substance in solution.

The average threshold increases from 0.075 to 0.450 mg/l as the pH increases from 5.0 to9.0 (WHO, 1984).

**Residual chlorine**: A balance is sought such that the level of residual chlorine is high enough for microbial safety without leaving an objectionable taste in drinking water.

**Total dissolved solids (TDS):** Total Dissolved solids comprise of organic matter and inorganic salts, which may originate from sources such as sewage, effluent discharge, urban run-off or from natural bicarbonates,

Chlorides, sulphate, nitrate, sodium, potassium, calcium and magnesium. The major determinant of the TDS level in water is the geochemical characteristics of the ground it comes in contact with, for example granite and silicon sands, and well leached soils have TDS less than 360 mg/l, the WHO (1984) gave the palatability of drinking water according to its TDS level with rating given by Bruvold as less than 500 mg/l s excellent level and greater than 1700 mg/l as unacceptable .

TDS is related to other water quality parameters like hardness, which may occur if the high TDS content is due to the presence of carbonates.

**Turbidity:** Turbidity is an expression of certain light scattering and light absorbing properties of the water sample caused by the presence of clay, silt, suspended matter, colloidal particles, plankton and other microorganisms (WHO, 1984). Turbidity can be measured by turbidity and nephelometry.

Turbidity of water affects other water quality parameters such as colour, when it is imparted by colloidal particles. It also promotes the microbial proliferation, thus affecting negatively the microbiological quality of water.

It also affects the chemical quality of drinking water through the formation of complexes between the turbidity causing humic matter and heavy metals (WHO, 1984).

**Colour:** Colour in drinking water is caused by the presences of coloured organic substances, usually humic, which originate from the decay of vegetation in surface water.

**Dissolve oxygen**: The level of dissolved oxygen in water is used as an indication of pollution and its portability.

This thus forms a key test in water pollution control activities and waste treatment process control activities and waste treatment process control. The recommended guideline value for drinking water is a level not below 8 mg/l (WHO,1984).

Lower levels indicate microbial contamination or corrosion.

**Hardness:** This is simply the resistance of water informing lather with soap. Hard water thus requires a considerable amount of soap to produce lather.

Groundwater is often harder than surface water and may have levels up to several thousand mg/l because of it high solubilizing potentials, particularly for rocks containing gypsum, calcite and dolomite.

Source of hardness include sewage and run-off from soils particularly limestone formations, building materials containing calcium oxide and textile and paper materials containing magnesium.

**Alkalinity:** Alkalinity is an index of the buffering capacity of water produced anions of weak acids, like hydroxides, bicarbonates and carbonates.

An increase in alkalinity causes a loss of colour, which is directly proportional to the alkalinity of the water sample and is usually close to its hardness value.

**Chloride:** Chloride occurs in groundwater as a result of saline in frusion, brine in oil well operations, sewage discharge, irrigation water being drained, and contamination from refuse leachate. The WHO (1984) recommends a guideline value of 250 mg/l any higher value than 1000 mg/l is an indication of polluted water with chloride.

### 2.3.3 Toxic Chemicals

Chemical contaminations of drinking water supplies occur along with contaminants of other inorganic and organic constituents.

**Nitrates and nitrites**: They are considered together because conversion from one form to the other occurs in the environment and the health effects of nitrates are generally as a consequence of its ready conversion to nitrites in the body. The WHO (1984) guideline for nitrates in drinking water are typically below 50 mg of nitrate-N per liter, levels exceeding these are indicative of pollution. Nitrite levels can be reduced doing water treatment by the oxidizing effects of chlorine.

**Lead:** Lead is a natural constituent of the earth crust at an average concentration of about 16 mg/kg. Lead levels in drinking water are relatively low, because convectional water treatment procedures remove a significant amount of lead. Low pH and softness increases lead content of water by promotion corrosion. The maximum intake of lead from food, air and water is 3 mg/week (0.05 mg/kg of body weight) for adults (WHO, 1984).

**Iron:** Iron is the most abundant element by weight in the crust, it occurs in water in its ferric and ferrous states, particularly in well-aerated conditions. Rock and mineral dissolution acid mine drainage, land fill leachates ,sewage and iron related industries are causes of high iron levels in groundwater, lakes and reservoirs, particularly where reducing conditions are present (Okun,1983).

**Others:** Other toxic chemicals include Ammonia in no ionized form ($NH_3$) and ionized form ($NH_4^+$); arsenic, asbestos, barium, boron, cadmium, chromium, copper and aluminum. Others include fluoride, mercury and organic contaminants.

## 2.4 Groundwater Contamination

Groundwater contamination occurs when contaminants are discharged directly or indirectly into water bodies without adequate treatment to remove harmful compounds.

The widespread use of chemical products, coupled with the disposal of large volumes of waste materials, poses the potential for widely distributed groundwater contamination.

Hazardous chemicals such as pesticides, herbicides, and solvents, are used everywhere in everyday life.

These and a host of other chemicals are in widespread use in urban, industrial, and agricultural areas. The largest potential source of groundwater contamination is the disposal of solid and liquid wastes. Waste disposal is not only the source of groundwater contamination but some additional sources like septic tank systems, agriculture, accidental leaks and spills, mining, artificial recharge, underground injection, and saltwater encroachment etc. are causes for groundwater contamination.(Gordon, W. (1984))

### 2.4.1 Sources of groundwater contamination

Ground water can become contaminated from natural sources or numerous types of humanactivitiesResidential, municipal, commercial, industrial, and agricultural activities can all affect groundwater quality.

Contaminants may reach ground water from activities on the land surface, such as releases or spills from stored industrial wastes; from sources below the land surface but above thewater table, such as septic systems or leaking underground petroleum storage systems; from structures beneath the water table, such as wells or from contaminated recharge water.(Patrick, & Quarles, J. (1983))

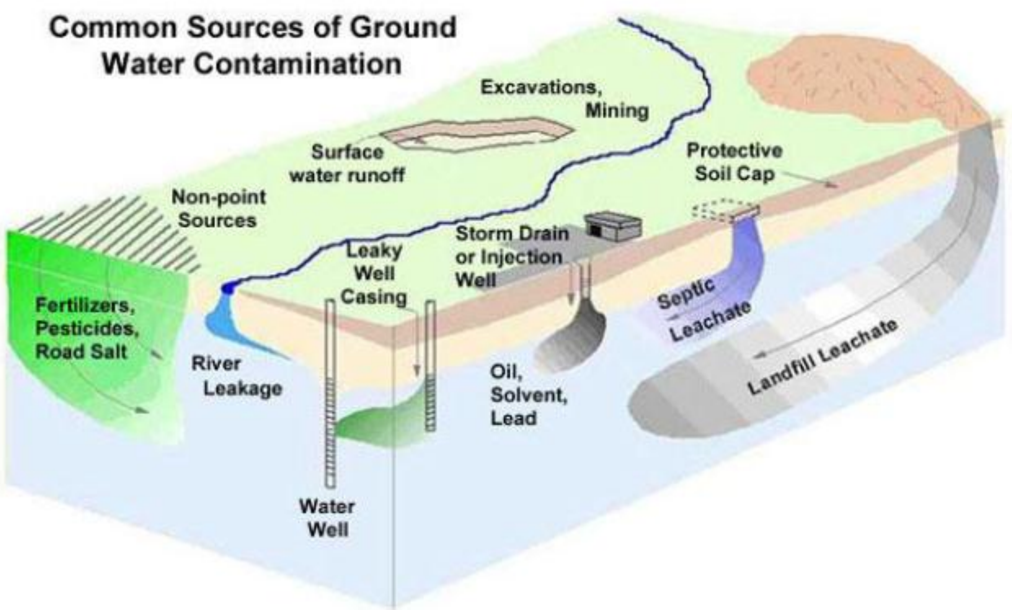


Figure (2): common sources of ground water contamination

**Natural Sources**

Some substances found naturally in rocks or soils, such as iron, manganese, arsenic, chlorides, fluorides, sulfates, or radionuclides, can become dissolvedin ground water.

Other naturally occurring substances, such as decaying organic matter, canmove in ground water as particles. Whether any of these substances appears in ground water depends on local conditions. Some substances may pose a health threat if consumed in excessive quantities; others may produce an undesirable odor, taste, or color. Ground water that contains unacceptable concentrations of these substances is not used for drinking water or other domestic water uses unless it is treated to remove these contaminants.(Freeze, Cherry 1979)

**Septic Systems**

One of the main causes of ground water contamination is the effluent (outflow) from septic tanks, cesspools, and privies.

Although each individual system releases a relatively small amount of waste into the ground, the large number and widespread use of these systems makes them a serious contamination source.

Septic systems that are improperly sited, designed, constructed, or maintained can contaminate ground water with bacteria, viruses, nitrates, detergents, oils, and chemicals. Along with these contaminants are the commercially available septic system cleaners containing synthetic organic chemicals (such as 1,1,1- trichloroethane or methylene chloride). These cleaners can contaminate water supply wells and interfere with natural decomposition processes inseptic systems.

Most, if not all, state and local regulations require specific separation distances between septic systems and drinking water wells. In addition, computer models have been developed to calculate suitable distances and densities.(Bachmat 1994 )

**Improper Disposal of Hazardous Waste**

Hazardous waste should always be disposed of properly, that is to say, by a licensed hazardous waste handler or through municipal hazardous waste collection days. Many chemicals should not be disposed of in household septic systems, including oils (e.g., cooking, motor), lawn and garden chemicals, paints and paint thinners, disinfectants, medicines, photographic chemicals, and swimming pool chemicals. Similarly, many substances used in industrial processes should not be disposed of in drains at the workplace because they could contaminate a drinking water source.

Companies should train employees in the proper use and disposal of all chemicals used on site.
The many different types and the large quantities of chemicals used at industrial locations make proper disposal of wastes especially important for groundwater protection.(Bachmat,1994 ).

**Releases and Spills from Stored**
Chemicals and Petroleum Products Underground and aboveground storage tanks are commonly used to store petroleum products and other chemical substances. For example, many homes have underground heating oil tanks.
Many businesses and municipal highway departments also store gasoline, diesel fuel, fuel oil, or chemicals in on-site tanks. Industries use storage tanks to hold chemicals used in industrial processes or to store hazardous wastes for pickup by a licensedhauler.
Approximately 4 million underground storage tanks exist in the United States and, overthe years, the contents of many of these tanks have leaked and spilled into the environment.
If an underground storage tank develops a leak, which commonly occurs as the tank ages and corrodes, its contents can migrate through the soil and reach the ground water. Tanks that meet federal/ state standards for new and upgraded systems are less likely to fail, but they are not foolproof.
Abandoned underground tanks pose another problem because their location is often unknown.
Aboveground storage tanks can also pose a threat to ground water if a spill or leak occurs and adequate barriers are not in place .

Improper chemical storage, sloppy materials handling, and poor-quality containers can be major threats to ground water. Tanker trucks and train cars pose another chemical storage hazard.
Each year, approximately 16,000 chemical spills occur from trucks, trains, and storage tanks, often when materials are being transferred. At the site of an accidental spill, the chemicals are often diluted with water and then washed into the soil, increasing the possibility of ground water contamination ( Bachmat, 1994).

**Landfills**
Solid waste is disposed of in thousands of municipal and industrial landfills throughout the country.
Chemicals that should be disposed of in hazardous waste landfills sometimes end up in municipal landfills.
In addition, the disposal of many household wastes is not regulated.
Once in the landfill, chemicals can leach into the ground water by means of precipitation and surface Runoff New landfills are required to have

clay or synthetic liners and leachate (liquid from alandfill containing contaminants) collection systems to protect ground water. Most older landfills, however, do not have these safeguards.
Older landfills were often sited over aquifers or close to surface waters and in permeable soils with shallow water tables, enhancing the potential for leachate to contaminate ground water.
Closed landfills can continue to pose a ground water contamination threat if they are not capped with an impermeable material (such as clay) before closureto prevent the leaching of contaminants by precipitation.( Bachmat, 1994).

**Sewers and Other Pipelines**
Sewer pipes carrying wastes sometimes leak fluids into the surrounding soil and ground water.
Sewage consists of organic matter, inorganic salts, heavy metals, bacteria, viruses, and nitrogen.
Other pipelines carrying industrial chemicals and oil brine have also been known to leak, especially when the materials transported through the pipes are corrosive.

**Pesticide and Fertilizer Use**
Millions of tons of fertilizers and pesticides (e.g., herbicides, insecticides, rodenticides, fungicides) are used for crop production.
In addition to farmers, homeowners, businesses (e.g., golf courses), utilities, and municipalities use these chemicals.
A number of these pesticides and fertilizers (some highly toxic) have entered and contaminated ground water following normal, registered use.
Some pesticides main in soil and water for many months to many years.
Another potential source of ground water contamination is animal wastes that percolate into the ground from farm feedlots.
Feedlots should be properly sited and wastes should be removed at regular intervals.(Freeze and Cherry, 1979).

**Drainage Wells**
Drainage wells are used in wet areas to help drain water and transport it to deeper soils.
These wells may contain agricultural chemicals and bacteria..(Freeze, Cherry 1979)

**Injection Wells/Floor Drains**

Injection wells are used to collect storm water runoff, collect spilled liquids, dispose of wastewater, and dispose of industrial, commercial, and utility wastes. .(Freeze, Cherry 1979)

**Improperly Constructed Wells**

Problems associated with improperly constructed wells can result in ground water contamination when contaminated surface or ground water is introduced into the well.( Freeze, Cherry 1979)

**Improperly Abandoned Wells**

These wells can act as a conduit through which contaminants can reach an aquifer if the well casing has been removed, as is often done, or if thecasing is corroded.

In addition, some people use abandoned wells to dispose of wastes such as used motor oil.

These wells may reach into an aquifer that serves drinking supply wells. Abandoned exploratory wells (e.g., for gas, oil, or coal) or test hole wells are usually uncovered and are also a potential conduit for contaminants.( Freeze and Cherry,1979).

**Active Drinking Water Supply Wells**

Poorly constructed wells can result in ground water contamination. Construction problems, such as faulty casings, inadequate covers, or lack of concrete pads, allow outside water and any accompanying contaminants to flow into the well.

Sources of such contaminants can be surface runoff or wastes from farm animals or septic systems.

Contaminated fill packed around a well can also degrade well water quality. Well construction problems are more likely to occur in older wells that were in place prior to the establishment of well construction standards and in domestic and livestock wells.(Gordon, W. (1984)

**Mining Activities**

Active and abandoned mines can contribute toground water contamination.

Precipitation can leach soluble minerals from the mine wastes(known as spoils or tailings) into the ground water below.

These wastes often contain metals, acid, minerals, and sulfides.

Abandoned mines are often used as wells and waste pits, sometimes Simultaneously. (Gordon, W. 1984)

In addition, mines are sometimes pumped to keep them dry; the pumping can cause an upward migration of contaminated ground water, which may be intercepted by a well.(Patrick, R., and Quarles, J. (1983))

## 2.5 Water-related Disease

Water-related disease is defined as any significant or widespread adverse effects on human health, such as death, disability, illness or disorders, caused directly or indirectly by the condition, or changes in the quantity or quality of any waters.( R Stanwell-Smith ,2009).
The causes of water related disease include micro-organisms, parasites, toxins and chemical contamination of water. Other terms include 'waterborne disease', which implies direct spread and is used mainly to refer to disease caused by microbiological pathogens or chemical contaminants in water.
'Water associated disease' covers the wide range of diseases in which water plays apart, such as legionnaires' disease, as well as diseases related to lack of water for washing and hygiene.

The advantage of the term water related disease is that it includes both water borne and water associated ill health, although diseases with an indirect association and another major mode of spread are usually excluded from specific surveillance systems.
An example of an indirectly related disease is trachoma: the predominant mode of spread is via poor hygiene and flies thriving in conditions of poor sanitation: clean water for hygiene is an important element in prevention, but the disease is not otherwise water-related.
Such diseases used to be known as 'water-washed', referring to the role of clean water in removing the agents, but the term is no longer widely used: McJunkin suggested the alternative of 'water-hygiene diseases'..(R Stanwell-Smith ,2009).

### 2.5.1 Categories of Water-related Disease

Seven categories of water-related disease can thus be identified (Table () water borne microbiological disease; waterborne chemical disease; water hygiene disease; water contact disease; water vector habitat disease; excretal disposal disease and water aerosol Disease.
In addition to the subcategories in Table (), other subcategories could be included such as those related to duration of exposure (acute/ prolonged).(Hunter P.1997) .

### 2.5.2 Type of water exposure

The commonest distinction regarding water exposure is between drinking water and recreational water.

For some surveillance systems, disease is also classified according to Whether the water supply involved is a public water system, usually regulated by national legislature and local by-laws, or other types of supply, such as private wells or untreated water sources.

A more detailed classification requires specification of the type of water source, such as groundwater or surface water. For water-contact diseases, the classification sub-categories include fresh water and marine waters(R Stanwell-Smith ,2009 ).

## Table (1) :Classification of water related disease

| Category | Description of category | Type of water exposure | Subcategories | Example(s) |
|---|---|---|---|---|
| Waterborne microbiological disease | Diseases related to consumption of pathogens consumed in water; most due to human or animal faecal contamination of water | Drinking Water | i) Treated or untreated water (ii) Public (municipal) supplies or private supplies | Cholera, Typhoid fever, viral gastroenteritis e.g. due to Norovirus |
| Waterborne chemical disease | Disease related to ingestion of toxic substances in water | Drinking Water | i) Treated or oruntreated water (ii) Public (municipal) supplies or private supplies | Arsenicosis |
| Water hygiene Diseases | Diseases whose incidence, prevalence or severity can be reduced by using safe (clean) water to improve personal and domestic hygiene | Any water used for washing/ personal hygiene | (i)Disease related to variations in water quality (ii) Disease related to watershortage | Scabies, shigellosis; trachoma |
| **Water contact Diseases** | Caused by skin contact with pathogeninfested water or with chemicalcontaminated water | Recreational Water | (i)fresh water sources (ii) marine waters | Schistosomiasis (bilharzia); cyanobacteria |
| **Water vector habitat diseases** | Diseases where vector lives all or part of its life in or adjacent to a water habitat | Untreated freshwater sources | (i) rivers, streams (ii) small collections of stagnant water e.g. water butts | Malaria (mosquitoes); filiariasis (mosquitoes); onchocerciasis (aquatic flies); schistosomiasis (snails); trypanosomiasis (tsetse flies) |
| **Water aerosol Diseases** | Diseases related to respiratory transmission, where a water aerosol containing suspended pathogens enters airway | Drinking or raw water sources | (i) water used in industrial/ residential buildings (ii) raw water sources | Legionellosis (legionnaires' disease; humidifier fever); Norwalk-like viral gastroenteritis |
| **Excreta disposal Diseases** | Diseases related to unsanitary disposal of human waste (faeces and urine | Drinking water and untreated water sources | (i) diseases related to human/animal waste in drinking water (ii) diseases related to direct/ indirect contact with faeces | Ascariasis; faecal-oral infections e.g. shigellosis; schistosomiais; trachoma |

# CHAPTER THREE

# MATERIALS AND METHODS

### 3.1 The study Area

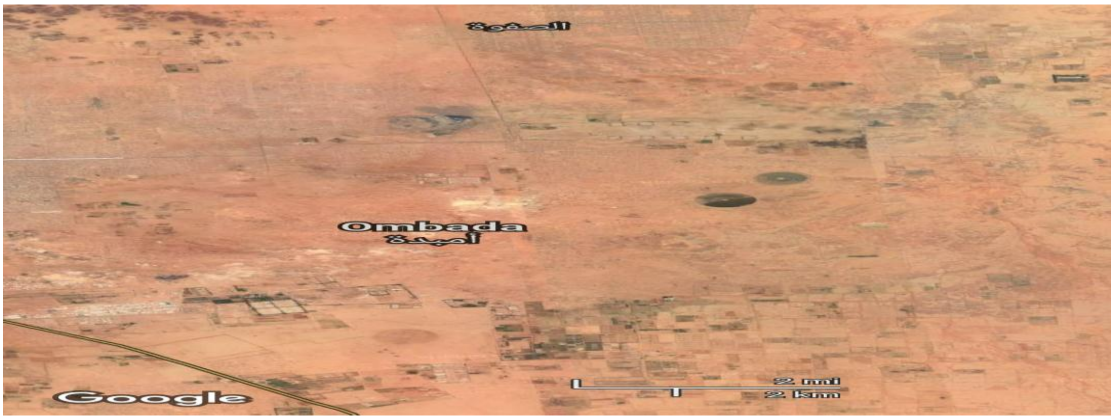


Figure (3) Umbada district

Table (2) wells coordinates and groundwater levels

| Well No | X | Y | Z | Depth to water level (ft) |
|---|---|---|---|---|
| BH1(N) | 2035520 | 243021 | 256 | 195.82 |
| BH2(S) | 2031598 | 243521 | 257 | 190.82 |
| BH3(E) | 2033653 | 243380 | 256 | 195.82 |
| BH4(W) | 2030655 | 243860 | 253 | 195.82 |
| BH5(C) | 2034140 | 244980 | 251 | 195.82 |

## 3.2 data collection

Collection of water samples

five samples for this study were collected from five wells.

The five samples for this study were collected in poly ethylene bottles for chemical analysis in 250ml sterile-glass bottle, for bacteriological analysis in 250 ml sterile-glass bottle, They were taken to the laboratory (at ambient 25C°).Then the samples were immediately analyzed.

## 3.3 Sampling Methods for Physical and Chemical Analysis

All precautions were considered to collect samples which are representative as far as possible of the water to be examined in accordance with methods of laboratory test of water.

The water samples collected for chemical and physical analysis were used to determine PH, color, temperature, turbidity, odor, total hardness, total alkalinity, chlorides, nitrates, ammonia, sulfate and fluoride as the followings:

- The containers (new, clean, plastic bottles with screw cap, 2.5 liter) were used.
- The container was gently washed by distilled water firstly, then filled with water samples.
- The water samples of groundwater were taken from the source directly via nozzle or tap near the source, before it flows through the network distribution system of reservoirs.

## 3.4 Sampling Methods for Bacteriological Analysis

Water sample collected from bacteriological were used to analyze the total account of bacteria, total coli form, and E-coil that carried as follows:

A glass bottles (250 ml) were sterilized in the laboratory by using hot air sterilization method, putting the bottle in an autoclave, 1800 C° for half an hour).

The samples from groundwater were taken from tab located near well. The tab is firstly heated by a gas torch, and then the water allowed to flow for several minutes to ensure it is a true sample from the groundwater.

The bottles (250 ml) were filled to the level just above the rim.

After filling, the bottles removed quickly and immediately the samples were packed into ice till to deliver to the laboratory.

## 3.5 Methods of Analysis

### 3.5.1 Physico-Chemical Parameters

**pH**

pH of water is measured by a pH meter

**T.D.S. (Total Dissolved Solids)**

Choose a sample of volume that will yield a residue between 2.5 mg and 200 mg.

A volume of 50-100 ml is usually suitable.

- The sample should first be filtered through 0.45 um membrane filter before TDS determination. Use the water that has been filtered in the TSS procedure.
- Transfer 50 ml of the membrane filtered (0.45um) sample to pre-weighed dish and evaporate to dryness on the hotplate.
- After most of the water has evaporated, put the dish inside an oven with fixed temperature of 180℃ for 24 hours.
- remove the dish from the oven, and let it cool down in the desiccator.
- weight and calculate the ppm of dissolved solids.

**Calculation for TDS:**

**Mg total solids/L = (A-B) * 1000 / sample volume (ml)**

**Where:**

**A= weight of dried residue + dish mg**

**B= weight of dish, mg.**

**Sodium (Na)** & **Potassium ions ($K^{+}$)** were obtained by 543 nm flame photometer.

**Calcium ions ($Ca^{2+}$)** and **Magnesium ions ($Mg^{2+}$)** were determined by titration with EDTA – disodium salt solution (0.01 M).

**Fluoride (F)** was determined by Alizarin visual method (reaction between fluoride and zirconium Dye Lake). Fluoride reacts with dye lake, dissociating apportion of it into colorless complex anion ($ZrF_6$). As the amount of fluoride increases, the color produced becomes progressively lighter or of different hue.

Fluoride increases, the color produced becomes progressively lighter or of different hue.

**Chloride (Cl)** was determined by filtration using standard siver nitrate solution (0.014) and potassium chromate (5%) solution as an indicator.

**Sulfate ($SO^{-2}_4$)** was determined gravimetrically by ignition. Sulfate is precipitated in HCL solution as barium sulfate, thus by addition of Barium Chloride, the precipitation was carried out near boiling temperature. Then after digestion the precipitate was filtered. Washed with water unit be free of CL, ignited and weighed as $BaSO_4$.

**Bicarbonate ($HCO_3$)** was determined by titration against HXL (0.012 N) to PH 4.5 using methyl orange as an indicator.

**Total Hardness (TH)** was obtained by calculation from $Ca^{2+}$& $Mg^{2+}$ determined concentrations

**Nitrate ($NO_3$)** was determined by Cadmium reduction method. $NO_3$ is reduced almost quantitively to nitrite ($NO_2$) in the presence Cadmium. The ($NO_2$) produced thus determined calorimetricall

A correction may be made for any $NO_2$ present in each sample by analyzing excluding the reduction step. Total alkalinity was obtained by EDTA titration method.

## 3.5.2 Biological Analysis

According to WHO, total coli from number was determined by membrane filtration method (MF).

The following basic steps are necessary for a membrane filtration test:

1. Non-potable water samples are diluted.
2. The sample or dilution is filtered through a membrane filter that retains the bacteria.
3. The filter is put in a petri dish on an absorbent pad that contains a nutritional broth or agar that
is selective for the growth of a specific organism.
4. The petri dish containing the filter and pad is incubated for 24 hours at a specific temperature.
5. After incubation, the colonies that have grown are identified and counted.

**Method of Membrane Filtration**

100 ml water samples were filtered through the membranes using sterile forceps. The membrane filters were placed in the Petri Dishes and the pads which were saturated with membrane laurel broth medium. The dishes were placed in the incubator at 37C° for 24 hour

Thermo tolerant (fecal) coli-forms were determined by membrane filtration method. But incubation was done at 44C°.

It can be calculated as follows thermo tolerant coli-form per 100 ml equal number of thermo tolerant, coli-form calories counted divided by number of ml of sample filtered.

# CHAPTER FOUR

# RESULTS AND DISCUSSION

### 4.1 Chemical Characteristics

The ground water of Umbada sandstone aquifer generally fresh water with chemicals composition that varies over wide range table (3)

**Table (3) chemical analysis of water samples in the study area of Umbada district**

| No | Loc. | Na | Ca | Mg | $SO_4$ | Cl | $HCO_3$ | $CO_3$ | $NO_3$ | $NO_2$ | $NH_3$ | F |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | **BH1** | **115.89** | **36.6** | **26.25** | **44** | **76.5** | **366** | **0** | **2.64** | **0.0396** | **0.0122** | **1.08** |
| 2 | **BH2** | **96.67** | **33.6** | **11.19** | **38** | **35.9** | **305** | **0** | **3.96** | **0.0294** | **0** | **0.66** |
| 3 | **BH3** | **72.99** | **47.6** | **10.69** | **35** | **49.7** | **231.8** | **0** | **6.6** | **0.0264** | **0** | **0.42** |
| 4 | **BH4** | **45.89** | **37.6** | **21.89** | **39** | **51.7** | **207.4** | **0** | **5.6** | **0.0033** | **0** | **0.35** |
| 5 | **BH5** | **55.56** | **57.6** | **20.42** | **33** | **59.7** | **280.6** | **6** | **5.7** | **0.0231** | **0** | **0.67** |

**Table (4) physical analysis of water samples in the study area of Umbada district**

| No | Loc. | E.C | pH | TDS | TH |
|---|---|---|---|---|---|
| 1 | **BH1** | **764** | **8** | **534.8** | **202** |
| 2 | **BH2** | **566** | **7.8** | **396.2** | **130** |
| 3 | **BH3** | **482** | **7.4** | **337.4** | **138** |
| 4 | **BH4** | **511** | **7.3** | **357.7** | **184** |
| 5 | **BH5** | **701** | **7.9** | **490.7** | **288** |

**Table (5) Microbiology analysis of water samples in the study area of Umbada district**

| NO | LOC. | TOTAL COLIFORM | FAECAL COLIFORM |
|---|---|---|---|
| 1 | BH1 | 8 | 3 |
| 2 | BH2 | 7 | 4 |
| 3 | BH3 | 0 | 0 |
| 4 | BH4 | 0 | 0 |
| 5 | BH5 | 5 | 2 |

# CHAPTER FIVE

# CONCLUSION

# AND

# RECOMMENDATION

## 4.2 Discussion

### 4.2.1 Total Dissolved Solids

Table (6) illustrates the results of TDS testing in lab work, from the table it found that the concentration of TDS in the area of study ranges between (534.8 – 337.4) mg/l .

Table (6) shows the result of TDS of water samples in the study area

| No of sample | Name of sample | TDS mg/l |
|---|---|---|
| 1 | BH1 | 534.8 |
| 2 | BH2 | 396.2 |
| 3 | BH3 | 337.4 |
| 4 | BH4 | 357.7 |
| 5 | BH5 | 490.7 |

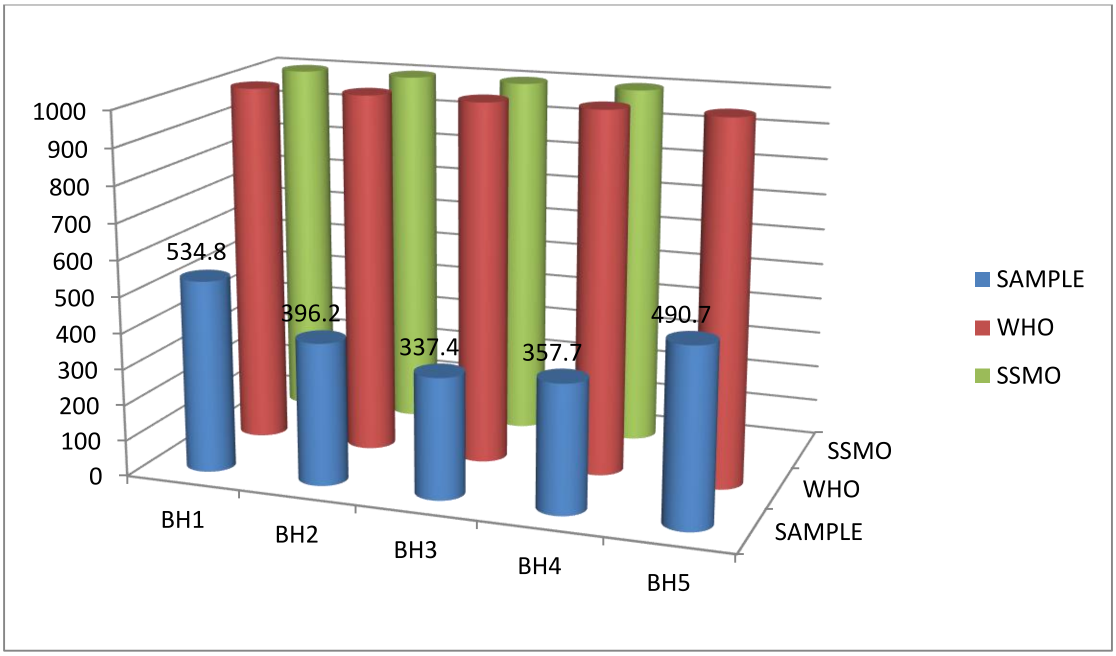


Figure (4) illustrates the chart of TDS results of water samples in the study area Which fit WHO and SSMO limits .

## 4.2.2.pH

Table (7) illustrates the results of pH testing in lab work, from the table it found that the concentration of PH in the area of study ranges between (8 – 7.3) mg/l

table (7): shows the result of pH of water samples in the study area

| No of sample | Name of sample | pH mg/l |
|---|---|---|
| 1 | BH1 | 8 |
| 2 | BH2 | 7.8 |
| 3 | BH3 | 7.4 |
| 4 | BH4 | 7.3 |
| 5 | BH5 | 7.9 |

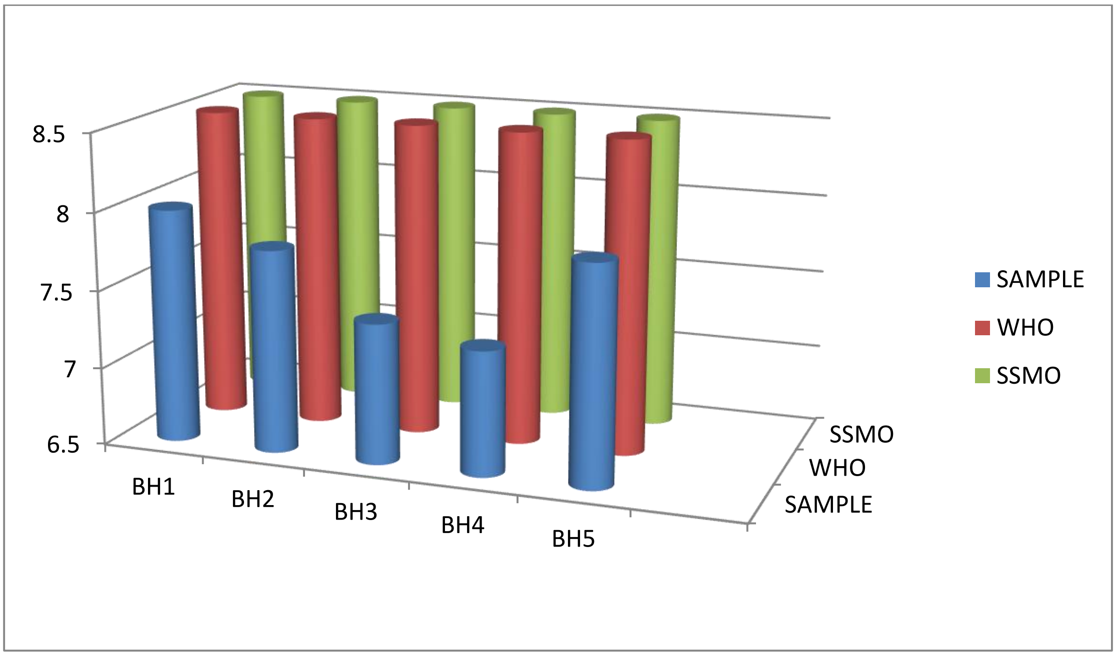


Figure (5) illustrates the chart of PH results of water samples in the study area Which fit WHO and SSMO limits .

## 4.2.3 Total hardness (T.H)

Table (8) illustrates the results of T.H testing in lab work , from the table it found that the concentration of T.H in the area of study ranges between (288 -130 ) mg/l .

**Table (8) shows the result of T.H of water samples in the study area**

| No of sample | Name of sample | T.H mg/l |
|---|---|---|
| 1 | BH1 | 202 |
| 2 | BH2 | 130 |
| 3 | BH3 | 138 |
| 4 | BH4 | 184 |
| 5 | BH5 | 288 |

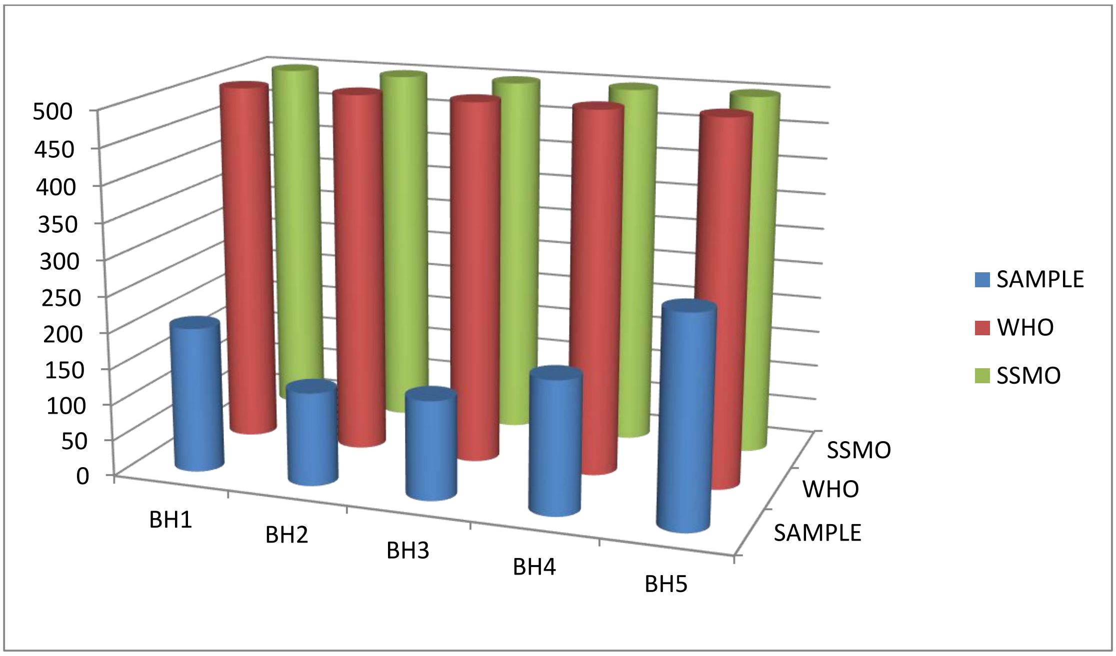


Figure (6) illustrates the chart of T.H results of water samples in the study area which fit WHO and SSMO limits

### 4.2.4 bicarbonates (HCO3) and carbonate (CO3) alkalinity

Table (9) shows the results of testing of bicarbonates and carbonate ALKAlinity

**Table (9) shows the result of HCO3 and CO3 of water samples in the study area**

| No of sample | Name of sample | HCO3 | CO3 | T alkalinity Mg/l |
|---|---|---|---|---|
| 1 | BH1 | 366 | 0 | 366 |
| 2 | BH2 | 305 | 0 | 305 |
| 3 | BH3 | 231.8 | 0 | 231.8 |
| 4 | BH4 | 207.4 | 0 | 207.4 |
| 5 | BH5 | 280.6 | 6 | 286.6 |

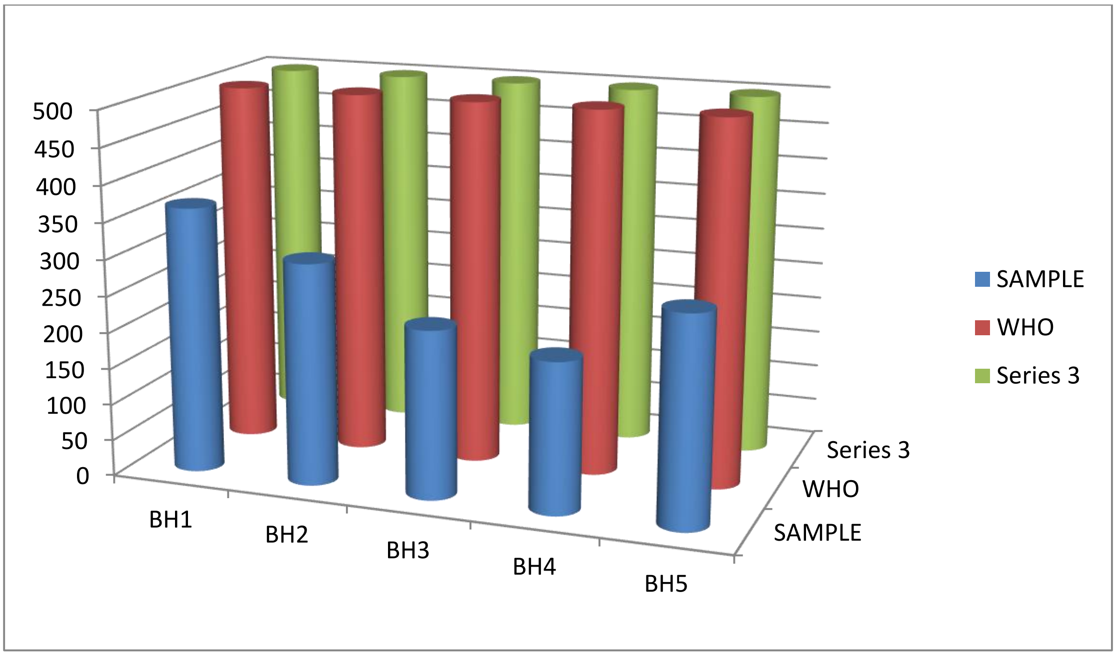


Figure (7) illustrates the chart of T ALKAlinity results of water samples in the study area Which fit WHO and SSMO limits .

### 4.2.5 Calcium ($Ca^{+2}$ )

Table (10) illustrates the results of $Ca^{+2}$ testing in lab work , from the table it found that the concentration of Ca in the area of study ranges between ( 57.6 - 33.6) mg/l .

**Table (10) shows the result of Ca of water samples in the study area**

| No of sample | Name of sample | $Ca^{+2}$ mg/l |
|---|---|---|
| 1 | BH1 | 36.6 |
| 2 | BH2 | 33.6 |
| 3 | BH3 | 47.6 |
| 4 | BH4 | 37.6 |
| 5 | BH5 | 57.6 |

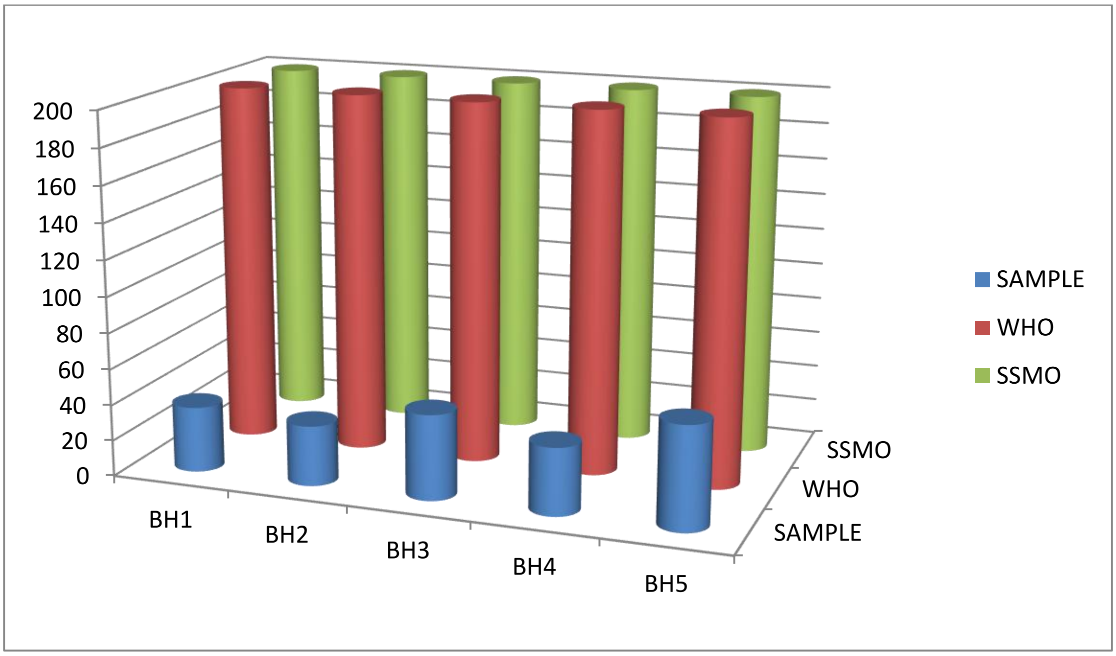


Figure (8) illustrates the chart of Ca results of water samples in the study area ,Which fit WHO and SSMO limits .

### 4.2.6 Magnesium ($Mg^{+2}$)

Table (11) illustrates the results of $Mg^{+2}$ testing in lab work, from the table it found that the concentration of Mg in the area of study ranges of (26.25 – 10.69) mg/l .

**Table (11): shows the result of $Mg^{+2}$ of water samples in the study area**

| No of sample | Name of sample | $Mg^{+2}$ mg/l |
|---|---|---|
| 1 | BH1 | 26.25 |
| 2 | BH2 | 11.19 |
| 3 | BH3 | 10.69 |
| 4 | BH4 | 21.89 |
| 5 | BH5 | 20.42 |

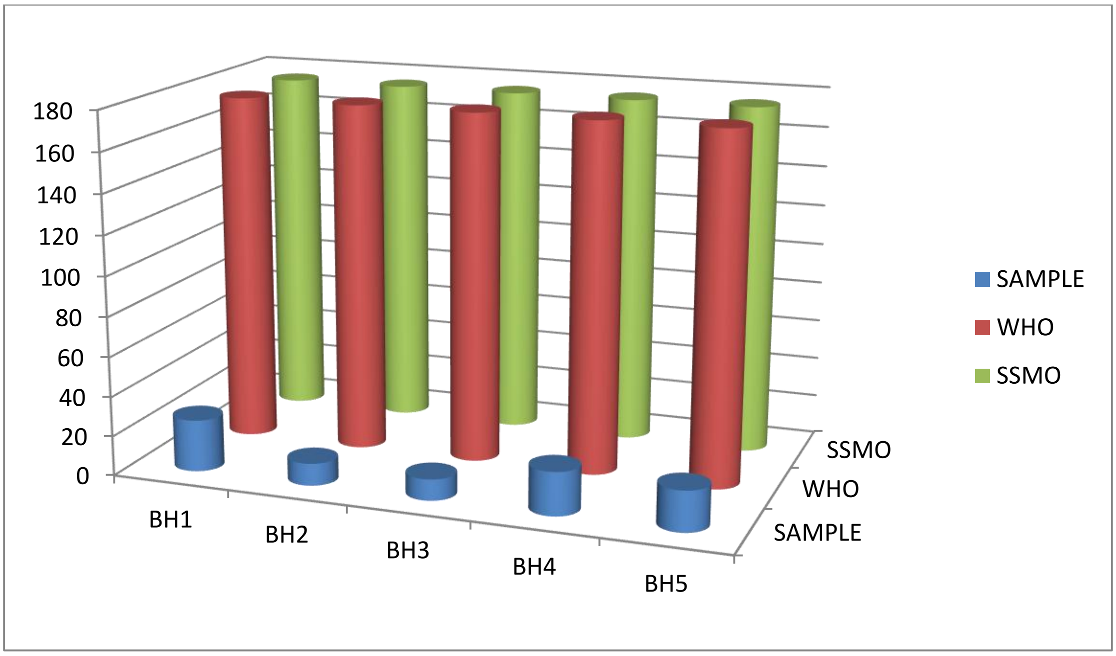


figure (9) illustrates the chart of $Mg^{+2}$ results of water samples in the study area which fit the WHO and SSMO limits .

### 4.2.7 Chloride Ion ($Cl^-$)

Table (12) illustrates the results of $Cl^-$ testing in lab work, from the table it found that the concentration of Cl in the area of study ranges between (76.5 – 35.9) mg/l .

**Table (12) shows the results of $Cl^-$ of water samples in the study area**

| No of sample | Name of sample | $Cl^-$ mg/l |
|---|---|---|
| 1 | BH1 | 76.5 |
| 2 | BH2 | 35.9 |
| 3 | BH3 | 49.7 |
| 4 | BH4 | 51.7 |
| 5 | BH5 | 59.7 |

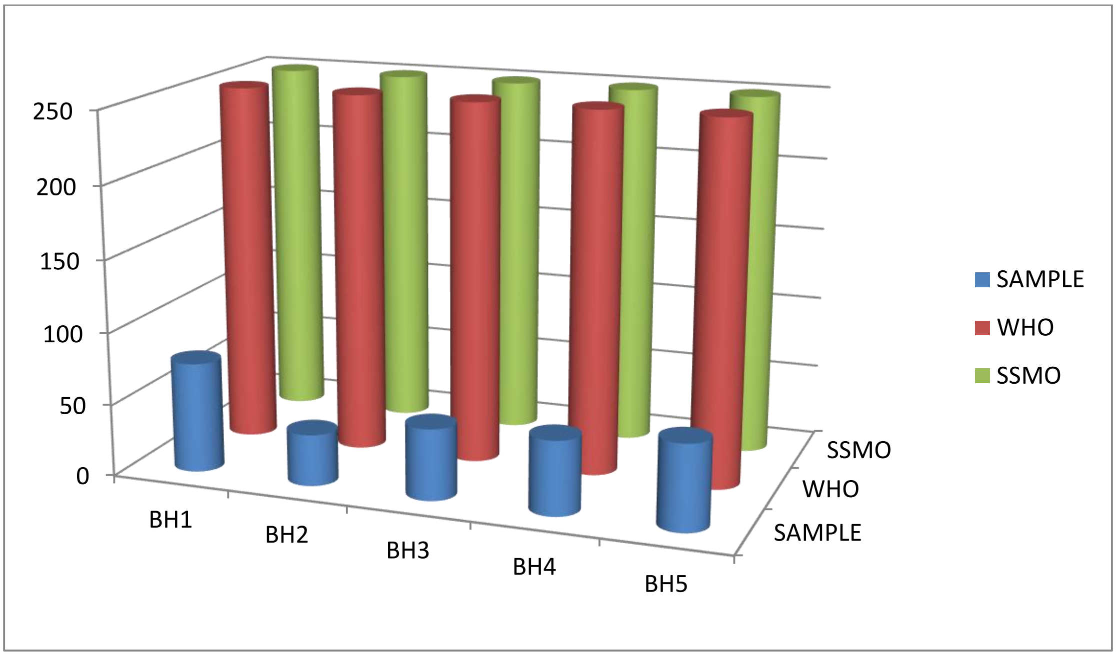


Figure (10) illustrates the chart of $Cl^-$ results of water samples in the study area ,which fit the WHO and SSMO limits .

### 4.2.8 Fluoride ($F^-$ )

Table (13) illustrates the results of $F^-$ testing in lab work from the table it found that the concentration of F in the area of study ranges between (1.08 – 0.35 ) mg/l .

**Table (13): shows the result of F of water samples in the study area**

| No of sample | Name of sample | $F^-$ mg/l |
|---|---|---|
| 1 | BH1 | 1.08 |
| 2 | BH2 | 0.66 |
| 3 | BH3 | 0.42 |
| 4 | BH4 | 0.35 |
| 5 | BH5 | 0.67 |

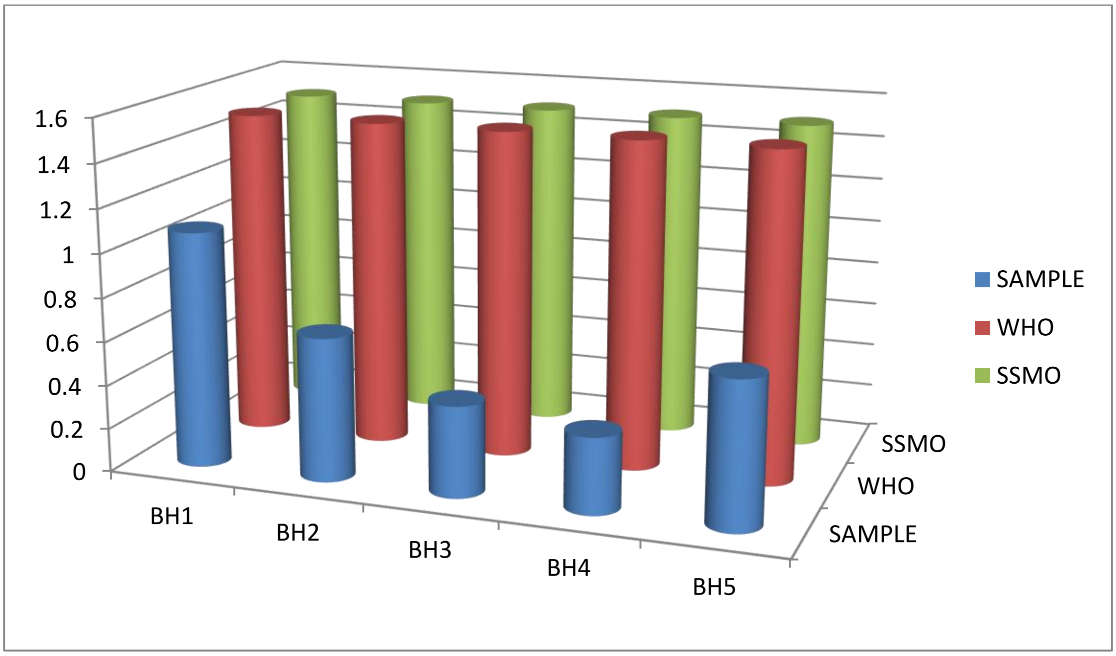


Figure (11) illustrates the chart of $F^-$ results of water samples in the study area , which fit the WHO and SSMO limits .

### 4.2.9 Sodium (Na )

Table (14) illustrates the results of Na testing in lab work , from the table it found that the concentration of Na in the area of study ranges between (115.89 – 45.89 ) mg/l .

**Table (14)shows the result of Na of water samples in the study area**

| No of sample | Name of sample | Na mg/l |
|---|---|---|
| 1 | BH1 | 115.89 |
| 2 | BH2 | 96.67 |
| 3 | BH3 | 72.99 |
| 4 | BH4 | 45.89 |
| 5 | BH5 | 55.56 |

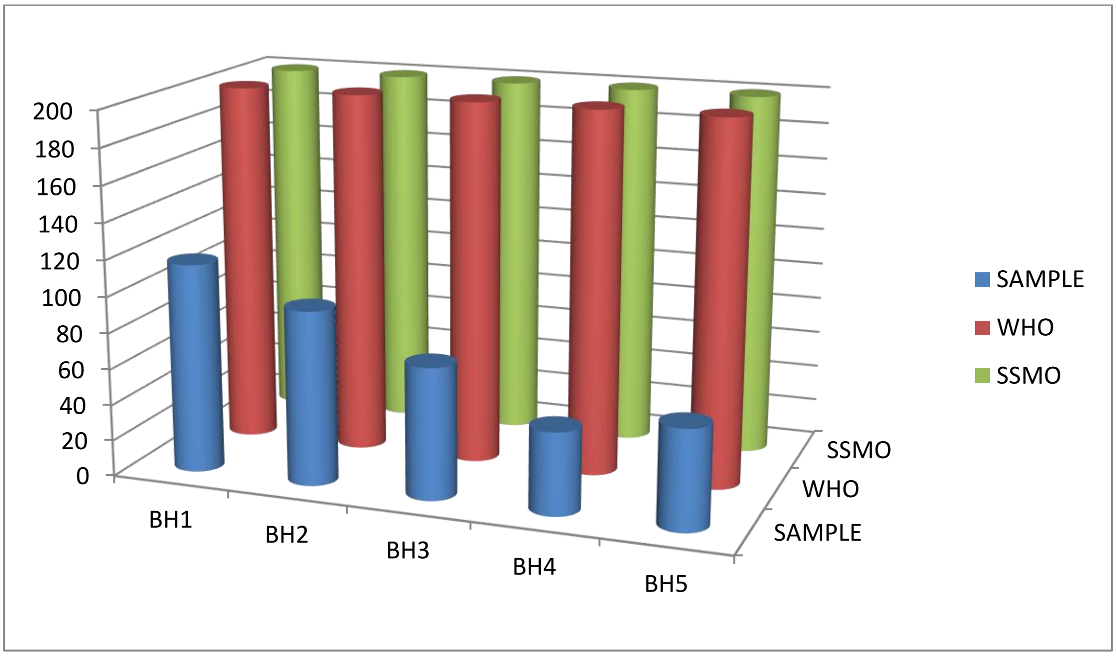


Figure (12) illustrates the chart of Na results of water samples in the study area , which fit the WHO and SSMO limits .

### 4.2.10 Sulfate concentration ( $SO_4^{-2}$)

Table (15) illustrates the results of $SO_4^{-2}$ testing in lab work, from the table it found that the concentration of SO4 in the area of study ranges between (44 - 33 ) mg/l .

**Table (15) shows the result of $SO_4^{-2}$ of water samples in the study area**

| No of sample | Name of sample | $SO_4^{-2}$ mg/l |
|---|---|---|
| 1 | BH1 | 44 |
| 2 | BH2 | 38 |
| 3 | BH3 | 35 |
| 4 | BH4 | 39 |
| 5 | BH5 | 33 |

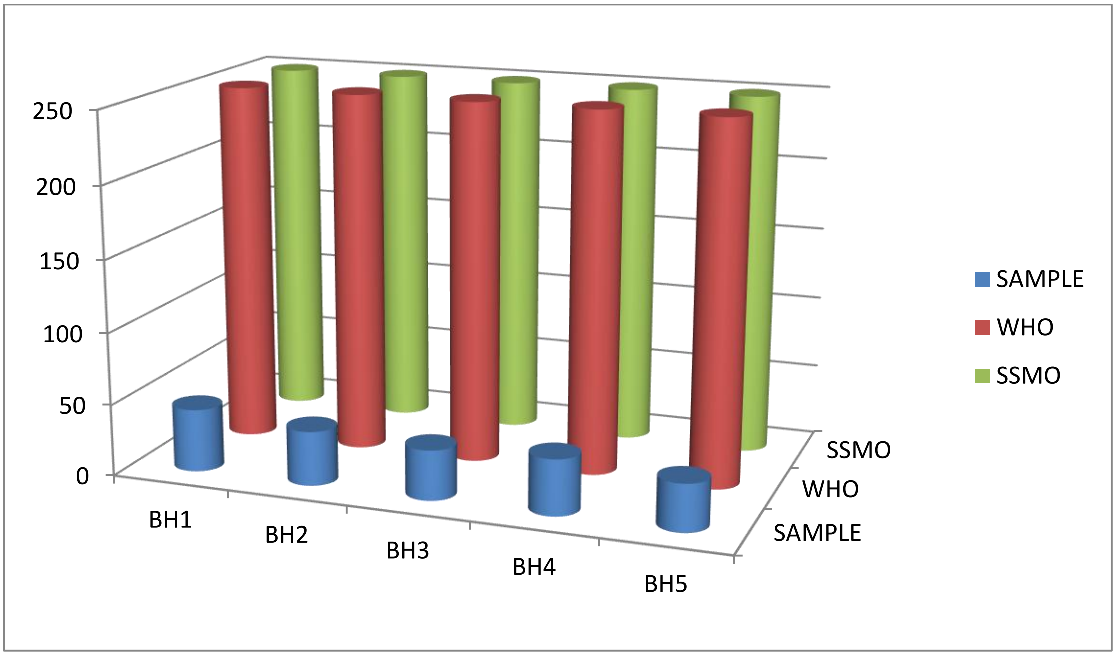


Figure (13) illustrates the chart of results of water samples in the study area , which fit the WHO and SSMO limits .

#### 4.2.11 Nitrate ($NO_3^-$ )

Table (16) illustrates the results of $NO_3^-$ testing in lab work , from the table it found that the concentration of NO3 in the area of study ranges between (6.6 – 2.64 ) mg/l .

**Table (16): shows the result of $NO_3^-$ of water samples in the study area**

| No of sample | Name of sample | $NO_3^-$ mg/l |
|---|---|---|
| 1 | BH1 | 2.64 |
| 2 | BH2 | 3.96 |
| 3 | BH3 | 6.6 |
| 4 | BH4 | 5.6 |
| 5 | BH5 | 5.7 |

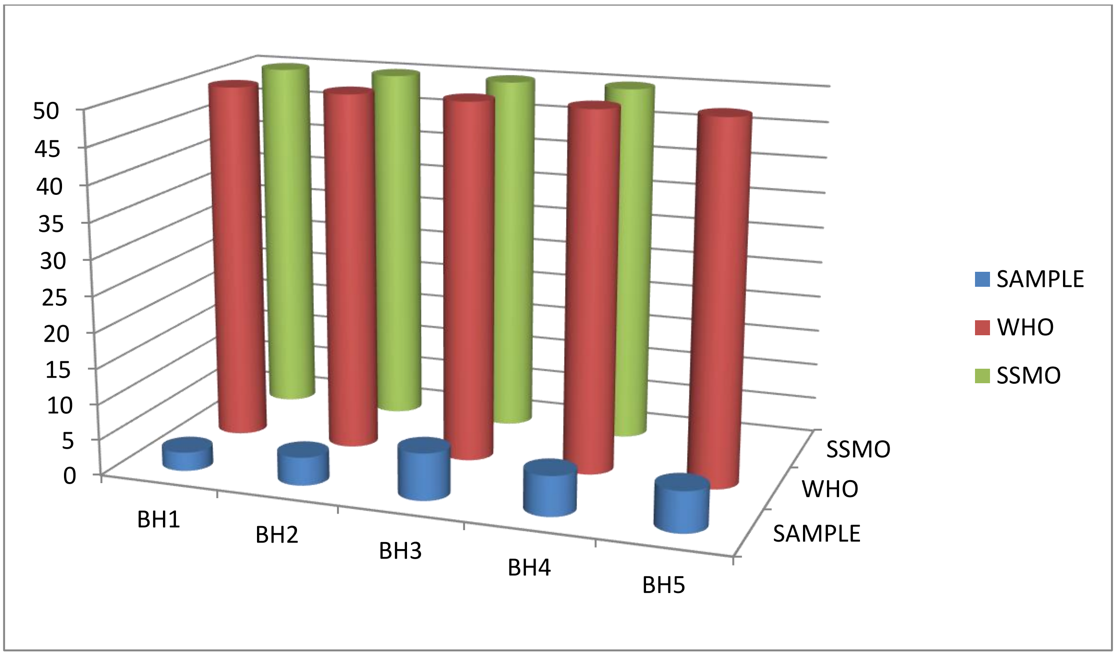


Figure (14) illustrates the chart of $NO_3^-$ results of water samples in the study area , which fit the WHO and SSMO limits .

### 4.2.12 Nitrite ( $NO_2^-$ )

Table (17) illustrates the results of $NO_2^-$ testing in lab work , from the table it found that the concentration of $NO_2^-$ in the area of study ranges between (0.231 – 0.0033) mg/l .

**Table (17) shows the result of $NO_2^-$ of water samples in the study area**

| No of sample | Name of sample | $NO_2^-$ mg/l |
|---|---|---|
| 1 | BH1 | 0.0396 |
| 2 | BH2 | 0.0294 |
| 3 | BH3 | 0.0264 |
| 4 | BH4 | 0.0033 |
| 5 | BH5 | 0.0231 |

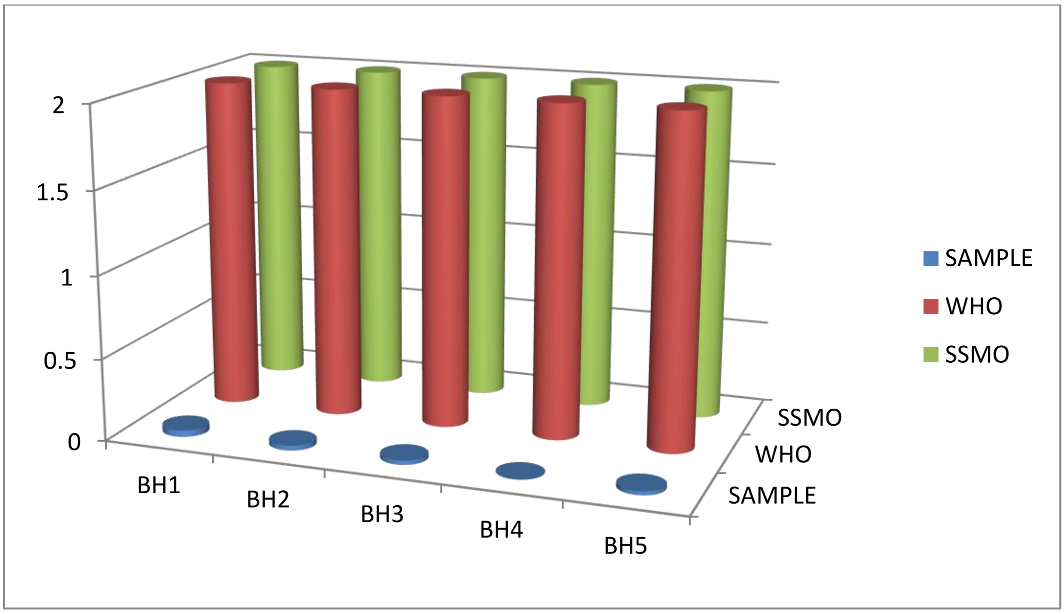


Figure (15) illustrates the chart of $NO_2^-$ results of water samples in the study area , which fit the WHO and SSMO limits .

### 4.2.13 electrical conductivity ( E.C )

Table (18) illustrates the results of E.C testing in lab work , from the table it found that the concentration of E.C in the area of study ranges between (764 – 482 )micrs/ cm

**Table (18) shows the result of E.C of water samples in the study area**

| No of sample | Name of sample | E.C micrs/ cm |
|---|---|---|
| 1 | BH1 | 764 |
| 2 | BH2 | 566 |
| 3 | BH3 | 482 |
| 4 | BH4 | 511 |
| 5 | BH5 | 701 |

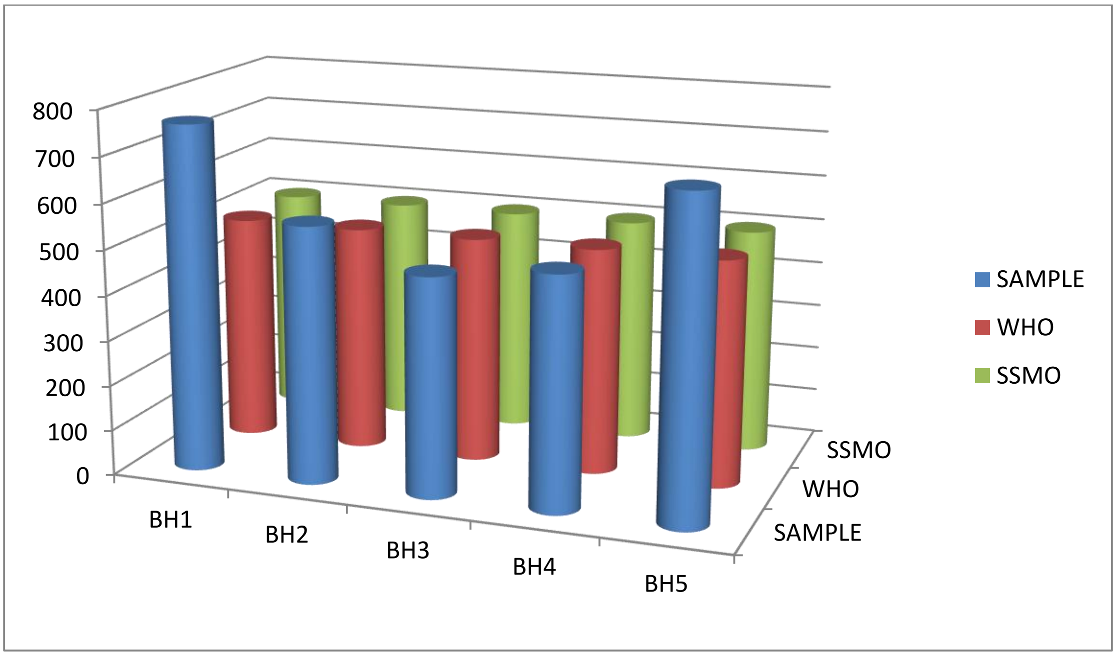


Figure (16) illustrates the chart of E.C results of water samples in the study area , all samples have E.C exceeding WHO and SSMO limits except one sample ( BH3 )

## 4.2.14 microbiological analysis

Table (18) illustrates the results of microbiological testing in lab work , from the table it found that the total coliform the area of study ranges between (8 – 0 ) and faecal coliform ranges of ( 3 – 0 )

**Table (18) shows the results of microbiological test of water samples in the study area**

| NO | LOC. | TOTAL COLIFORM | FAECAL COLIFORM |
|---|---|---|---|
| 1 | BH1 | 8 | 3 |
| 2 | BH2 | 7 | 4 |
| 3 | BH3 | 0 | 0 |
| 4 | BH4 | 0 | 0 |
| 5 | BH5 | 5 | 2 |

Which found contaminated with faecal coliform and total coliform in ( BH1 ,BH2, BH5 ) .

## 5.1 conclusion

ground water sampled and analyzed for their **physical, chemicals** and **microbiological** characteristics and evaluation of the water quality for drinking and irrigation purposes.

**Physical and chemicals** characteristics of the samples taken from are falling the permissible limits recommended by the national, regional and international standards and guidelines .however the E.C exceeded the permissible limits for ( BH1 ,BH2 ,BH4,BH5 ) .Bacteriological contamination is evident in the belonging samples of ( BH1 ,BH2 ,BH5 ) and should be cleaned and monitor .

### 5.2 Recommendations

* It is highly recommended to carry out bacteriological and chemical examination frequently and regularly for the groundwater for monitoring of the groundwater quality and for further decision making.

* For pipe supplies it is necessary to maintain it continuously for sufficiently high pressure throughout the whole distribution system to prevent contamination getting into the system .

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# APPENDIX

**Appendix (1) standards specification of water according to Sudanese and WHO specification**

| Physical Parameter | Levels likely to give rise to consumer complain |
|---|---|
| Color<br>Taste &Odor<br>Temperature<br>Turbidity<br>PH | 15 TCU<br>Acceptable<br>Acceptable<br>5 NTU<br>6.5 - 8.5 |

| Chemical parameter | Levels likely to give rise to consumer complain |
|---|---|
| Fluoride<br>Manganese<br>Nitrate as NO3<br>Nitrite as NO2 | 1.5 mg/l<br>0.27 mg/l<br>50 mg/l<br>2 mg/l |

| Organisms | Guidelinevalue |
|---|---|
| W.coil or thermo tolerant coli form bactrtia | Must not be detectable any 100ml sample |