2021-08

Physiochemical analyses on assessment to ground water quality parameters and ground water management options

Esubalew, Wubie Adal

BAHIR DAR UNIVERSTY

BAHIR DAR INSTITUTE OF TECHNOLOGY

SCHOOL OF GRADUATE STUDIES

FACULTY OF CHEMICAL AND FOOD ENGINEERING

ENVIRONMENTAL ENGINEERING PROGRAM

Master Thesis on:

Physiochemical analyses on assessment to ground water quality parameters and ground water management options

By

Esubalew Wubie Adal

August, 2021

Bahir Dar, Ethiopia

BAHIR DAR UNIVERSTY

BAHIR DAR INSTITUTE OF TECHNOLOGY

FACULTY OF CHEMICAL AND FOOD ENGINEERING

Physiochemical analyses on assessment to ground water quality parameters and ground water management options

By

Esubalew Wubie Adal

A Thesis submitted to the school of graduate studies of Bahir Dar Institute of Technology, Bahir Dar University in partial fulfillment of the requirements for the degree of Masters of Science in Environmental engineering

Supervisor Dr Temesgen A.

August, 2021

Bahir Dar, Ethiopia

BAHIR DAR UNIVERSITY

BAHIR DAR INSTITUTE OF TECHNOLOGY

SCHOOL OF RESEARCH AND GRADUATE STUDIES

FACULTY OF CHEMICAL AND FOOD ENGINEERING

Approval of thesis for defense result

I hereby confirm that the changes required by the examiners have been carried out and incorporated in the final thesis.

Name of student Esubalew Wubie Signature______ Date 04/09/2022

As a member of the board of examiners, we examined this thesis entitled "**Physiochemical analysis on assessment to ground water quality parameters and ground water management options**"

By **Esubalew Wubie**. We here by certify that the thesis is accepted for fulfilling the requirements for the award of the degree of Master of Science in "**Environmental Engineering**"

Approved by:

Temesgen Atnafu (PhD) Advisor Name	signature	04/09/2022 Date
Dr. Mulugeta External Examiner Name	signature	04/09/2022 Date
Belay Tefera (PhD) Internal Examiner Name	signature	29/8/2022 Date
Alemayehu Keflu (PhD) Chair Person Name	for signature	04/09/2022 Date
Belay Tefera (PhD) Chair Holder Name	signature	29/8/2022 Date
Metadel Kassahun Abera (PhD) Faculty dean Name	signature	04/9/2022 Date

Declaration

I, undersigned, to state that the thesis encompasses my work, in compliance with universally accepted performs. I have dually acknowledged and referred to all materials used in this work. I comprehend the non-adherence to the code of academic integrity and honesty, misrepresentation/fabrication of idea/data/fact will constitute an adequate ground for disciplinary action by the university and can also evoke penal action from the source which have not been properly cited or acknowledged. I am working physicochemical analyses on assessment of ground water quality parameters. The guidance of this research is Assistant Professor Dr. Temesgen Atnafu.

I certify that my work is original and compiled according to the thesis writing guidelines used by the faculty of chemical and food engineering.

Name of the Student	Signature	Date
Esubalew Wubie Adal	____________________	_________________

Approved by:

Advisor Name: Temesgen Atnafu (PhD)

Signature:________________________.

Acknowledgements

First of all, thanks to the Almighty God who gave me this opportunity. I would like to express my deepest gratitude to my advisor Dr. Temesgen Atnafu, for his constant guidance and support for the successful completion of this work. Also I would like to thank Dr. Belay Tefera and Dr. Alemayehu Kifilu for their suggestions and comments throughout my progress presentation. I would like to give special acknowledgement to Mr.Alemie Haile, and Mr. Getahun Mekuria Addis Zemen Municipality, urban planner, willingness and patience in replying to the interviews and accessing secondary data. Also my thanks go to Mr. Miseganaw Moges and Mr. Habetamu kindu for their GIS officers" assistant. And finally I want to thank you for my family for financial as well as ideal supports to enhance my efforts for wards.

Abstract

Water (surface water and ground water) is an important parameter for a sustainability and ecological balance of biodiversity. Ground water samples were collected from selected locations of Addis Zemen city and the physicochemical factors were characterized by employing standard research methods. The groundwater quality and its appropriateness for drinking and irrigation purposes was investigated. The average physicochemical properties of groundwater were about a conductivity of 1137 µs/cm, a total hardness of 439 mg/l, a magnesium of 179.5 mg/l, a calcium of 309.5 mg/l, a total dissolved solid of 887 mg/l, a pH of 8.40, a total alkalinity of 691 mg/l, a sodium of 109 mg/l, a phosphate of 0.28 mg/l, a chloride of 56mg/l, a potassium of 5 mg/l, a sulphate of 64 mg/l, a nitrate of 19 mg/l. bicarbonates alkalinity value of 565 mg/L. Moreover, calculated parameters such as exchangeable sodium percentage, percentage sodium, residual sodium carbonate, sodium adsorption ratio, langelier saturation index and aggressive index were used to check the suitability of ground water for drinking, domestic, irrigation and industrial purpose. The research showed that the majority of the groundwater samples were inappropriate for irrigation and for drinking. Finally, ground water pollution management options were recommended.

Keywords: Groundwater, Physico-chemical, Characterization, Pollution Management, Addis Zemen City.

List of Acronyms

BOD	Biological Oxygen Demand
COD	Chemical Oxygen Demand
TDS	Total Dissolved Solids
TSS	Total suspended Solids
USEPA	United States Environmental Protection Agency
WHO	World Health Organization
DO	Dissolved Oxygen
SAR	Sodium Adsorption Ratio
AI	Aggressive Index
LSI	Langelier Saturation Index
RSC	Residual Sodium Carbonate
ESP	Exchangeable Sodium Percentage
SWM	Solid Waste Managements

Table of Contents

List of Table

List of Figure

1. Introduction

1.1 Background

Water (surface water and ground water) is an important parameter for a sustainability and ecological balance of biodiversity. The quantity and quality of water determine the variation of Earth‟s ecosystems, animals, plants, algae bacteria and crustaceans, etc. together with their physical and chemical environments. Surface water comprises rivers, streams, lakes, wetlands and reservoirs. Surface waters and its ecosystems offer habitat to many animal and plant species such as aquatic life and fishes in lakes for instance use insects and plants as food or habitat. The food chain in surface water is complicated and, interlinked and the life of an aquatic life relies on others to withstand. Moreover, surface waters developed for use and henceforth visible to stresses which effect from such human activities since surface waters are on the surface of land.

Water which is composed of one atom oxygen and two atoms hydrogen is an abundant transparent liquid and physical substance on earth and it is the foundation of all form of life and an essential natural resource for life of plants, animals and human beings on water planet. Sufficient and safe drinking water supply is a vital problem in urban and many rural areas in developing countries [1]. Groundwater is a finite and reliable source of water in rural areas. Surface water and groundwater are the most common sources of water for various purposes such as irrigation and drinking. The groundwater existing underneath the surface of the earth‟s in porous rocks and soils while the surface water is existing in the form of rivers, oceans, lakes, streams and ponds on the surface of the earth.

Groundwater is a vital source of water throughout the world. Groundwater which is extracted by a well or a bore is a vital constituent of the resources of water for drinking, industries and domestic, purpose. It is contaminated from, animal waste, waste disposal sites, industrial chemical waste, leaking underground storage tanks, fertilizers and pesticides that have been employed in agricultural lands. And this contaminated groundwater may be inappropriate for different applications. And remediation of the ground water is expensive, time-consuming and difficult since they can be harmful for Environmental and human health [35] hence, it is significant to study the actions that influence the quantity and quality of groundwater since it is broadly employed for the purpose of drinking in rural area [2].

It is a vital natural resource of drinking water in which the biological and chemical property of ground water is tolerable for most applications however the ground water quality is changed because of man‟s activities [3,4]. Groundwater comprises utmost dissolved mineral substances like potassium, sodium, calcium, magnesium, bicarbonate, sulfate and chloride [5]. Many factors like organic substances and dissolved minerals existing in ground water in diverse concentrations[86] determine the appropriateness of groundwater for numerous since some constituents are harmful, others are harmless and a few can be highly toxic [6,7]. One of the major parameters accountable for enlarged solid waste is the growth of population. Industrialization and urbanization has wide impact on quality of groundwater. Agriculture have noteworthy influence on groundwater quality. Atmospheric situations as well change the groundwater quality in many parts of earth. If the dissolved minerals quantity exceeds from permissible limit groundwater is not considered desirable for drinking [8, 9]. Dissolved minerals may be hazardous to plants and animals in large concentrations and groundwater that comprises a lot of calcium and magnesium is known as hard water in which the water hardness is signified in terms of the calcium carbonate amount [10, 11]. The growth of technology, population and industries has increased the stress upon water resources in recent years and its quality has been degraded [12].

Water it is vital for the existence of all form of life and it is rich on our planet. However, the fresh part of water is a limited and finite resource [13,14] in which the available fresh water to human is barely 0.3 to 0.5 % of the collective water available on the earth and its rational use is necessary [15]. Water is vital for various domestic purposes, power generation, sanitation, industries and irrigation. Hence, to safeguard nontoxic groundwater for drinking in rural and urban areas a comprehensive method is essential with the cooperation of industrial management, the people, government, and health staff to preserve water quality for drinking. The water quality may be determined by numerous pollutants like, biological, physical and chemical. Infections, microorganisms, substantial metals, salt and nitrate have determined their way into supplies of water [16]. The contamination of water occurs when a waterway is affected as a result of the expansion of materials to the water [17]. Ground water crisis is a result of human activity as well as natural factors.

Ground water comprises numerous salts and ions in high concentration, hence employing such water for drinking water leads to different water- borne diseases and various health problems such as the one billion or more existences of diarrhea that occur yearly [18].

Chloride occurs in a wide range of waters naturally. The chloride in the groundwater may found from minerals like apatite, mica, and hornblende [19, 20, 21] and human excreta, like urine [22]. High chloride leads salty water in taste, which is not acceptable for consumption by human [23, 24, 25]. Water quality calculation index is a significant method for separating quality of groundwater and its appropriateness for the purposes of drinking [26, 27].

The use of water has encouraged its over misuse joined with the emerging population along with improved means of life as a technological innovations outcome [28]. Groundwater quality is deteriorating at a quicker step because of pollution spreading from land fill leachates, septic tanks, domestic sewage, agricultural fields, industrial wastes and agricultural runoff. Reddy et al have showed that the high iron concentration in groundwater because of disposal of scrap iron in open areas, contamination due to industrial activities rusting of casing pipes, non-usage of bore wells for a long time, etc [29-36]. Also it has been reported that the relative quantities of carbonates, calcium, and bicarbonates determine the pH value of the water [37]. Zafar etal also reported that the dependence of the pH value of the water on the relative quantities of carbonates, calcium, and bicarbonates [38].The absence of carbonate alkalinity indicating that the total alkalinity documented was because of buildup of bicarbonate and when it possesses carbonates the water tends to be more alkaline [39,40]. Saralakumari[164] D. et al. have observed that from drinking water a significant part of the fluoride entering the human body [41]. In drinking water fluoride causes mild type of dental fluorosis [42].

The pollution of ground water by the heavy metals has turned into a remarkable matter for most current two decades due to the increasing use of agrochemicals (pesticides and fertilizers), release of industrial effluent, untreated domestic waste [43-44].

Various research workers have carried out broad studies in the related field such as Patil et al [45] investigated the physicochemical analysis of groundwater samples in selected areas and Karunakaran et al. [46] have studied statistical investigation on physicochemical features of groundwater.

Even though literature reviews show many researchers have been practiced in this area the problem is still not solved. Moreover, no specific work has been investigated to evaluate the qualitative aspect of groundwater of Addis Zemen city for drinking, domestic, industrial purpose and irrigation. Therefore, this study will investigate the physicochemical characteristics of groundwater of Addis Zemen city and propose the main pollution prevention.mechanisms.

1.2. Statement of the Problems

Quality of groundwater deteriorated because of contamination of agrochemicals, heavy metals, microbiological growth and organic pollutants from, industrial effluents, storm water and filtering from solid disposal sites and agricultural runoff. Many major cities in Africa use groundwater for different purpose. the lack of services in such informal settlements poses serious threats to groundwater through sewerage and effluent leakages, the dumping of domestic waste, and uncontrolled and un-scientific dumping of municipal wastes has brought about a rising number of incidents of hazards to human health, contamination of ground water which is in turn a serious human health risk.

From the increasing human population, uncontrolled urbanization and inadequate sanitation infrastructure cause serious quality degradation of ground waters.

Similar to other African city, Addis Zemen city also used groundwater for a source of water for domestic, drinking, agriculture, and recreational. However, dumping site can cause pollution to groundwater through contaminant transportation by flooding, wind and ground water movement from the open dump sites.

Ground water flows downstream across the town and all sides of the ground water. Addis Zemen open dump site among the proper and locate in a place where a number of people are living around. The communities who are living near the disposal area (in a position of downstream and upstream) are using polluted ground water for their daily activities. (From Addis zemen municipality and Molla Nega his study on SWM). As a result of this it becomes a great deal or threat for the city communities regarding the water quality aspect since contamination of groundwater is the most serious problems affecting the health of the population and irrigation purposes.

Therefore, this research aimed on the assessment of physicochemical properties of groundwater quality of Addis Zemen city for drinking and irrigation purposes and suggestions of the possible ground water pollution control methods.

1.3 Objectives

1.3.1 General Objective

The general objective of the study is to characterize the physicochemical parameters of ground water quality parameters of Addis Zemen city in Amhara region, Ethiopia for drinking and irrigation purposes and used to suggest a groundwater quality management option.

1.3.2 Specific Objectives

- To investigate qualitative and quantitative characterization of physico-chemical parameters of groundwater resources
- Assessing the physicochemical values of the groundwater resources with international standards such as WHO and APHA of drinking water.
- To suggest a possible groundwater physicochemical parameters management option.

1.4. Scope of the Study

The scope of this study focuses in physicochemical analysis of Addis-Zemen city and suggestion of the possible groundwater physico-chemical parameters management options. The study has characterised the current condition of the ground water and assessed and compared the physicochemical values of the groundwater resources with WHO and APHA international standards of drinking water followed by recommendations of a possible groundwater management options to sustainably manage the waste management system.

2. Literature Review

Water plays an essential role in living things on the worlds. About 97% water is exists in surface water, ground water, lake, river, springs, oceans that is not suitable for drinking and irrigations only 3% is fresh water where in 2.97% is comprised by glaciers and ice caps and remaining little portion of 0.3% is available as a surface and ground water for human use [47]. Water is needed in all aspects of living things. Water obtained from rivers, lakes, springs and wells has been used for drinking, washing, agriculture and manufacturing. Most of the Earth‟s liquid fresh water is found, not in lakes and rivers, but is stored underground in aquifers; where surface water is absent, the supply of good quality ground water is essential for the health and development of nations. The quality of water is a vital concern for mankind since it is directly linked with human welfare.

Table 2.1 Global water distribution.

Water Source	Volume in 1000 Km^3	Total Water in %	Fresh Water in %
Groundwater	23,400	1.7	-
Fresh	10,530	0.76	30.1
Saline	12,870	0.94	-
Oceans, Sea and Bays	1,338,000	96.5	-
Ice caps, Glaciers and permanent Snow	24,064	1.74	68.7
Soil Moisture	16.5	0.001	0.05
Swamp water	11.47	0.0008	0.03
Rivers	2.12	0.0002	0.006
Biological water	1.12	0.0001	0.003
Saline	85.4	0.006	-
Fresh	91.0	0.007	0.26
Atmosphere	12.9	0.001	0.04
Ground Ice and Permafrost	300	0.022	0.86
Lakes	176.4	0.013	-
Total	1,385,984	100.0	100.0

Source USGS (2005)

Groundwater is the main source of drinking water as well as agricultural and industrial usage about 40% of the drinking water comes from groundwater, about 97% of the rural population drinks groundwater, and about 30-40% of the water used for irrigation comes from groundwater [48]. Ground water quality comprise the physical, chemical quality of ground water temperature, turbidity, Colour, taste, odor, make up the list of physical water quality parameters since most ground water is colorless, odorless and without specific tastes, we are typically most concerned with its chemical and physical quality .although spring water or ground water products are often sold as pure their water quality is different from that of pure water. So groundwater is one of earth"s most vital renewable and widely distributed resources as well as an important source of water supply throughout the world [49]. At least two billion people around the world rely on groundwater as their only source of drinking water. The issues of groundwater use and quality have until recently received far less consideration than surface water, and data on groundwater stocks and flow sareevenless reliable. The world health organization has repeatedly in sited that the single major factor adversely influencing the general health and life expectancy of a population in many countries of the developing world is the access of clean drinking water. Water quality problems can often be as severe as those of water availability but less attention has been paid to them, particularly in developing regions [50].Ground water pollution is a global issue. It is vulnerable to a variety of threats, including overuse and contamination. Water obtains from rivers lakes, springs and well has been used for drinking, washing, agriculture, and manufacturing most often Earth"s liquid fresh water is found, not in lakes and rivers, but is store underground in aquifers. So groundwater is one of earths most vital renewable and widely distribute resources as well as an important source of water supply throughout the world. A least two billion people around the world rely on ground water as their only source of drinking water [50].Groundwater is the main source of drinking water and also in dispensable source for living beings. The ground water quality problem has become acute now a day [51]. In urban area of the country, uncontrolled growth of population has left several cities deficient in infrastructural services. Water supply sewerage and solid waste management. Ground water is the most important source of domestic, industrial and agricultural water supply in the world, and assessment of its quality status is important for socio-economic growth and development [52]. Many communities in the developing world depend heavily on ground water due to increasing pollution with the concomitant rise in the cost of surface water treatment [53].Ground water quality reflects inputs from the atmosphere, soil and water rock reactions as well as pollutant sources such as mining, land clearance, agriculture, acid Precipitation and domestic and industrial wastes [54] and the quality assessment of ground water is essential to ensure sustainable safe use of the resource for drinking, agricultural, and industrial purposes [55].

Ground Water composition may concentrate salts in soils or water to such an extent that crop yield disaffects [56].The salt concentration, which may be the result of aquifer properties, determines to a large extent the quality status of ground water for agricultural purpose which needs to be assessed with the calculation of environmental factors and indices. Groundwater contaminations due to municipal solid waste and heavy metals poses threat for health like, miscarriage, infertility and have a long term effect on environment [57-58].It is accountable for deteriorating the groundwater quality and can lead to harmful effect. A system for assessing the suitability of available water for irrigation is also related to the requirements of the different crops under cultivation. Groundwater is also an important source for industry and agriculture uses as well as sustaining rivers experiencing low flows. Groundwater is not only abstracted for supply or river regulated purposes, it also naturally feeds ground waters through springs and passages in to rivers and it is often important in supporting wetlands and their ecosystems. Removal or diversion of groundwater can affect total flow. A reduction in either quality of quantity of the discharging ground water can significantly influence water quality and the attainment of water quality standards. Ground waters are therefore intimately linked in the water cycle, with many common issues. The protection of groundwater quality is of paramount importance. If groundwater becomes polluted, it is difficult, if not impossible, to rehabilitate [59].

Recently, GIS and remote sensing technology is developed to assess the water characteristics. In water resource management and evaluation remote sensing data are well employed [79]. Scientists have investigated so many modeling and techniques for water quality interpretation of in terms of suitability for drinking, domestic, irrigation and industrial purpose. The most popular characterization techniques for checking the suitability of water for drinking, domestic, irrigation and industrial purpose these are Langelier Saturation Index and Aggressive Index. Also, Residual Sodium Carbonate, Sodium Adsorption Ratio, Exchangeable Sodium Percentage and Percentage Sodium, data of water quality show the suitability of water for irrigation purpose [80].

2.1 Characteristics of Water

The water characteristics make it appropriate for human to continue in varying conditions of weather and it is the universal solvent due to its polar nature that dissolves a large number of various chemical substances. Its characteristics are physical, chemical and biological.

2.1.1 Chemical properties of Water

It is the chemical substance with bent shape and chemical formula of H_2O. It is a liquid because of hydrogen bonding at room temperature. Both the oxygen atom creates a negative charge and hydrogen atoms create a positive electrical charge which makes polar in nature for water molecules. It is thermally stable however it dissociates into oxygen and hydrogen gases at higher temperatures [60]. Water reduces chlorine gas to hydrogen chloride acting as a reducing agent while it oxidizes carbon to carbon monoxide behaving as an oxidizing agent.

2.1.2 Physical properties of Water

Water (having many distinctive physical properties) exists in all three physical states of matter comprising of liquid, solid, and gas at atmospheric pressures & temperatures. Water contains a very a high heat of vaporization and high specific heat capacity because of hydrogen bonding between molecules of water. It has high density that depends on the temperature and dissolved solids of the water. It is physically distinctive since it is less dense as ice (solid) than as a liquid having a maximum density of at 4ºC. Water can dissolve most of gases like CO_2, O_2, N_2, H_2, NH_3 andSO_2. It also has high heat of vaporization and a high surface tension due to strong cohesion between molecules as compared to other liquids [61].

2.1.3 Biological properties of Water

Water dissolves extensive range of substances than other common solvents and it is the universal solvent [62]. It works as transporting bio minerals, biotic molecule, vitamins and hormones to diverse parts of plant and animal bodies.

2.2 Major Water Sections

The major water sections include glaciers, ice and snow oceans and seas, oceans and seas, oceans and seas, rivers, groundwater, ponds and lakes, wetlands, springs and atmosphere.

2.2.1 Glaciers, Ice and Snow

Glaciers stock 75% of the world's total freshwater. Glaciers which appear blue when it becomes very dense are slow moving rivers of ice and it takes a long time to from a glacier. Glacier‟s affect weather patterns, climate, and sea levels. Glacial ice is the largest reservoir of freshwater on Earth.

2.2.2 Oceans and seas

The oceans comprise 97% of the Earth's liquid water and it is a main section of saline water that covers 70% of the Earth's surface and covers over the 4 billion Tons.

2.2.3 Rivers

Rivers make up 0.2 percent of all the fresh water on earth and are essential not only to humans, but to all form of life on the earth. Rivers and streams carry important gases. Organisms and water to many areas and they aid to rainwater drain and deliver homes for many species of animals and plants. They deposit water in the ocean and rivers are delivering the power for hydroelectric plants.

2.2.4 Ground water

They are the unseen reserves which are linked to the surface water. A hydrologic way in which water transfers from surface water to groundwater downward is called percolation. It is the subsurface water which r cracks in soils or saturates pores. A geologic creation which comprises adequate permeable saturated material to give significant amounts of water is known as aquifer. It has been vital for irrigating crops, and as a source of municipal water livestock [63]. One of the valleys in the water table is cone of depression as shown in **Figure 2.1**. Contaminated water movement and dispersion within the aquifer spreads the pollutant over a larger area and contamination of surface water seepage of pollutants through wells and in recharge zones has polluted many aquifers creating aquifers unfit for uses.

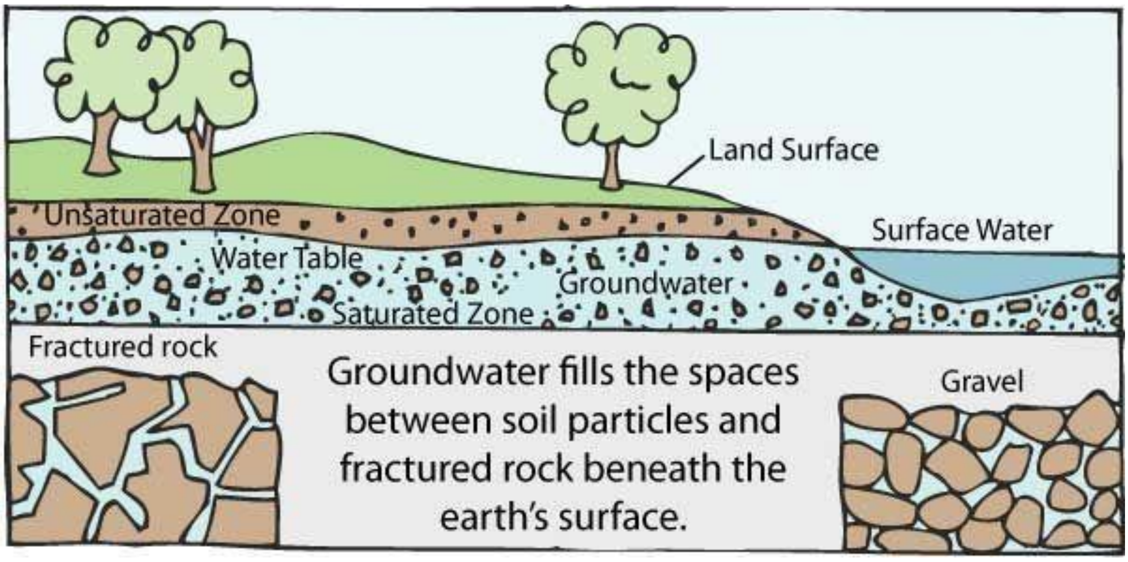

Figure. 2.1. Groundwater Source: The area below the water table is zone of saturation in an aquifer.

Source; ground water foundation (1985, 1996 US. Geological survey)

2.2.5 Ponds and Lakes

Lakes are inland bodies of slowly moving water while a pond is a small area of fresh water. Lakes get water from rivers, from precipitation, and streams and from underground water while pond is different from a river since it does not have moving water.

2.2.6 Wetlands

Wetlands are water bodies where water covers the soil or a place where the land is covered by salty or fresh water. They are brackish or saline, freshwater, inland or seasonal, coastal, or natural, permanent, or man-made (such as farm ponds, fish ponds, agricultural land, canals, and reservoirs).

2.2.7 Atmosphere

It is the smallest water (located in the troposphere of the atmosphere) reservoir of the earth which is the layer of gases that surrounds the Earth

2.2.8 Springs

It is a natural condition in which groundwater naturally arises from the subsurface of the Earth's in a distinct flow and they are the most clear and exciting indication of groundwater.

2.3 Sources of Water Pollution

The groundwater quality is threatened by numerous causes of pollution which occur by both natural and human activity [64].

- ✓ Agriculture Discharges
- ✓ Industrial Effluents
- ✓ Sewage and Domestic wastes
- ✓ Organic Chemicals
- ✓ Inorganic Pollutants Runoff from Urban Areas
- ✓ Toxic Metals

2.3.1 Agriculture Discharges

They occur as non-point sources pollution over a large area, consequently its treatment and management is more difficult. Agricultural discharges contribute to degrade both surface and ground water [65]. Chemicals from pesticides, fertilizers, insecticides, farm waste, animal and plants, debris, manure and inorganic material slurry are investigated to cause surface and groundwater pollution. Pollution Fertilizer is difficult to reduce and regulate since it comprises high levels of phosphorous and nitrogen with smaller amounts of potassium. Groundwater can easily contaminate nitrogen fertilizers containing nitrates since nitrates are very soluble in water in which a rainwater runoff carries fertilizers into streams, rivers, oceans and lakes [66-67].

2.3.2 Industrial Effluents

They contain numerous materials, based on the industry like metal processers, chemical manufacturers, textile manufacturers and steel plant. Industrial effluent consists of both organic substances (e.g. organic dye, pharmaceutical, cosmetics, soaps, glue, synthetic detergents, pesticide, herbicide, paper textiles, plants, metal processing, fermentation industries, and oil refining. and inorganic substances (are produced mainly in electroplating plants, the iron picking, steel and coal industries [68]. Industrial effluents without treatment caused the serious pollution problem to an environmental threat, human‟s life and ground water resources [69].

2.3.3 Fertilizers

A fertilizer is synthetic or natural materials which supply nutrients to plant vital to the plants growth. They are employed in agricultural fields as they comprise great levels of phosphorus and nitrogen and resulted in ecological problems when much use of fertilizer at the wrong time simply wash off into storm and drains and then flow untreated into lakes or streams. The extra fertilizer practice runs off into waterways cause‟s algae blooms [70].

2.3.4 Sewage and Domestic wastes

Sewage (contains soap, human waste, detergent, metals, glass, garden waste and sewage sludge) is discharged after home or industrial use and has a significant water pollution source. Domestic sewage carries used water from houses while industrial sewage is used water from chemical processes. Sewage released into the lakes, rivers and oceans cause a threat to human health since untreated sewage might comprise phosphorus, nitrogen, organic matter, viruses, bacteria, protozoa, oils, mercury, greases, cadmium, lead, copper many toxic chemicals, and chromium.

2.3.5 Inorganic Pollutants

Inorganic pollutants (as trace elements, mineral acids, metals, inorganic salts, cyanides sulphates, and metal compounds,) are non-biodegradable and persevere in the environment and they affect aquatic ecosystem and biological communities and contaminate groundwater [71].

2.3.6 Organic Chemicals

A very small amount of the chemicals (e.g. synthetic pesticides, food additives, synthetic detergents, pharmaceuticals, insecticides, synthetic fibers, plastics, solvents and volatile organic compounds) that can spread to drinking-water from numerous bases are vital bases of toxic organic chemicals in water and are a thoughtful risk to human health [72].

2.3.7 Runoff from Urban Areas

Water is incapable to infiltrate into the soil resulting urban landscapes and urban runoff flows across roadways in urban areas. The urban runoff pollutants include household chemicals waste, pesticides, fertilizers, and plant material.

2.3.7 Toxic Metals

Water resources contamination by toxic metals ((e.g. arsenic, aluminum, barium, chromium, cadmium, lead, selenium, silver, and mercury,) occurs largely due to human activity and they can be harmful to human health like abnormalities, cardiovascular diseases, neurologic and diabetes, hearing loss, neurobehavioral disorders, hematologic, cancer, and immunologic disorders. Toxic Metals in water sources can happen naturally (i.e. dissolved in water when comes in contact with soil or rock) or can be the result of contamination (corrosion of pipes and leakage from waste disposal sites) and are widely distributed in the drinking water, air, and food [73].

2.4. Ethiopian Environmental Regulation, policy, and Standards

Though efforts of communal and individual are very vital to stop pollution of rivers lakes, and ponds, a regulation and policy in the form of legislation is necessary for implementing the activities to have a legal power for regulating the failure for protecting the water resources and controlling the implementations. The Federal Democratic Republic of Ethiopia (FDRE), Environmental Protection Agency and ministry of water resources have a detail document on how to protect and utilize resources of water. The accountability of livestock, industrial, water supply, individual users and agriculture sectors have been documented in the ministry in its water policy document (FDRE Ministry of Water Resources, 2011). Moreover, the Constitution of FDRE guarantees the fundamental right to live in a healthy and clean environment, the right to sustainable development and the right to livelihood such as article 44 (1) states that „all persons have the right to a healthy and clean environment‟. Article 44 (2) also guaranty the right to livelihood to every person of Ethiopia and virtue of article 43 (3) and/or also established, concluded, or conducted international agreements relations and must protect the right to sustainable development.
Also, it has stated that all Ethiopians live in a clean and healthy environment in Article 92.

It also enforces a constitutional „duty‟ on the Regional and the Federal Governments to safeguard the environment‟ along with citizens.

The public health proclamation no. 200/2000, the environmental protection organs establishment proclamation no. 295/2002, the environmental impact assessment proclamation no. 299/2002, the environmental pollution control proclamation no. 300/2002, the forest development, conservation and utilization proclamation no. 542/2007 and the development conservation and utilization of wildlife proclamation no. 541/2007 are among the legal institutes for the protection of the environment.

The Environmental Protection Authority to prepare environmental protection policies and laws have been established in The Ethiopian Environmental Protection Authority Establishment Proclamation No. 9/1995 and its aims were improving good governance of environmental through removing the constraints faced by individuals, public agents, civil the private sector to know and society, as well as explore fully their own potentials to enlarge their choices for understanding their respective functions in an environmentally sound manner and gives mandating at federal and regional levels. The Environmental Organs Establishment Proclamation No. 295/2002 re-established as a federal EPA as an autonomous organization and gave with extended mandates. The environmental proclamation 295/2002 allows to designate an existing agency instead for the same environmental management and protection function and establish regional environmental agencies and it decentralize also goes to every sector to establish their own environmental units the management environmental. The Authority has specified for fertilizers, pesticides and other chemicals formulations, importation, management and usage. Article 55 sub article (1) under proclamation number 674.2010 also proclaims control of pesticides and the registration.

Environmental impact „defined according to the EIA Proclamation as any change to the environment that can influence safety human or health, fauna, water, flora, air, climate or soil, and these impact must be evaluated on the basis of the location, nature size, or cumulative effect in comparison with other concurrent impacts. EIA puts a provision that it is not possible to render any development activity without getting an authorization to do so from environmental protection agency and it also defines a set of environmental crimes.

EIA is a legal requirement devised to implement the rights granted by the constitution and protects against the violation of these by any person or development project. Therefore, the Ethiopian floriculture industries as one of the devilment activities are in charge of implementing the Ethiopian EIA ahead, during and after implementation of their projects.

As part of management and policy of water resources the government FDRE under the ministry of water resources has found policies including aquatic resources. Moreover, Ministry of Environment, Forestry and Climate change (former Ethiopian EPA) has set limit values for pesticides discharges to water and the standard for discharges of pesticides to water is tabulated in **Table 2.2**.

Table 2.2 Ethiopian Standard for discharges of pesticides to water [74]

Factors	Ethiopian EPA standard
Total phosphorus as P (mg/l)	50
Total nitrogen as N (mg/l)	30
Suspended solids (mg/l) Oils (mg/l)	30 15
Fats (mg/l)	15
pH	6-9
temperature (oC)	40
Greases (mg/l)	15
Organochlorines (mg/l)	0.1
AOX (mg/l)	2
Phenoxy compounds (mg/l)	0.1
Pyrethroids (mg/l)	0.1
Arsenic (mg/l)	0.2
Active ingredients (mg/l)	0.05
Chromium as total Chromium (mg/l)	0.1
Copper (mg/l)	2
Chromium as Chromium four (mg/l)	0.1
COD (mg/l O2)	250
Mercury (mg/l)	0.01
Phenols (mg/l)	250

2.5. International Environmental Regulation, policy, and Standards

Water used for food production, drinking, and domestic utility and irrigation purposes has an important impact on health as defined by the world health organization (WHO) and hence to maintain the quality of surface water setting standards are very vital. Ethiopian standard, US EPA Standards, world health organization and international organizations have been employed to analyse the physical and chemical parameters of water as guide such as drinking purpose. Some selected physicochemical parameters and their maximum limit of Ethiopian US EPA and WHO are shown in **Table 2.3**[75,82].A national standard for drinking-water, ES 261:2001 Drinking-water-specifications were established in 2001 by the Quality and Standards Authority of Ethiopia, the organization responsible for setting standards in Ethiopia. The 2001 standard supersedes the first edition of 1990 (ES 261:1990), which was limited to piped drinking-water supplies and supplies that served more than 10000 people [82]. ES 261:2001 was developed by a national technical committee of members from FMOH, FMOWR, EHNRI and the Ethiopian Environmental Protection Agency, as well as from other governmental and nongovernmental organizations. The national standards were largely based on the second edition of the WHO Guidelines for drinking-water quality (the latest guidelines at the time. The maximum permissible levels for the parameters used in the RADWQ project were consistent with the WHO guideline value [82]. Also, some other extreme impairment and high integrity thephysico-chemical standards for water quality is shown in **Table 2.4** [75-78].

Table 2.3. Ethiopian and international standards of quality of drinking water [75, 82].

Factors	Ethiopian standards	US EPA Standards	WHO Standards
Colour	Non objectionable	-	15 TCU
Electrical Conductivity	1500µS/cm	2500 µs/cm	1000 µs/cm
PH	6.5-8.5	6-8.5	6-8.5
Turbidity	5NTU	0.5-1 NTU	5 NTU
TDS	1000 ppm	500 mg/l	500 mg/l
Ammonia	1.5-35 mg/l	-	1.5-35 mg/l
Nitrate	50 mg/l	50 mg/l	10 mg/l
Phosphate	0.3 mg/l	1.5 mg/l	0.3 mg/l
Calcium	75 mg/l	-	75 mg/l

Fluoride	1.5 mg/l	2-4 mg/l	1.5 mg/l
Arsenic	0.7 mg/l	10microg/l	0.7 mg/l
Chloride	250 mg/l	250 mg/l	250 mg/l
Sulphate	400 mg/l	250mg/l	400 mg/l
Iron	0.3 mg/l	1 mg/l	1 mg/l
Total hardness	300 mg/l CaCO3	300 mg/l CaCO3	300 mg/l CaCO3
Sodium	200 mg/l	-	200 mg/l
Magnesium	150 mg/l	-	150 mg/l
Manganese	0.5 mg/l	50 micro g/l	0.1 mg/l
Potassium	-	-	-
Alkalinity	200 mg/l CaCO3	-	200 mg/l CaCO3
DO	4- 6 mg/l	-	4- 6 mg/l
Bicarbonate	150 -350 mg/l	-	150 -350 mg/l
BOD	2 mg/l	-	2 mg/l
COD	10 mg/l	-	10 mg/l

Table 2.4. Physicochemical standards for water quality [75-78]

Factors	Extreme Impairment	High Integrity
BOD5 (mg/l)	>10	-
Dissolved Oxygen Saturation (%)	< 30 or > 150	80 – 120
Total Phosphorus (µg/l)	>125 or >190	< 10 or < 20
Total Nitrogen (µg/l)	<2500 or > 2500	< 500 or < 700
pH	500 mg/l	500 mg/l
Chlorophyll a (µg/l)	> 165 or > 125	3.0 or < 5.0
Temperature	Large deviations from the thermal tolerance range for characteristic species	No deviation optimum temperature ranges of relevant species
pH	< 5	6.5-9.0
Un-ionized Ammonia (µg NH_3/l)	100	15
Arsenic (µg/l)	150	10
Aluminium (µg/l)	5-10	100
Chromium (µg/l)	40-75	1-10
Cadmium (µg/l)	1	0.08
Copper (µg/l)	1	2.5

Mercury (µg/l)	1	0.05
Lead (µg/l)	2	5
Zink (µg/l)	50	8
Nickel (µg/l)	50	20

The Industrial Standard, WHO and APHA for drinking water are given in **Table 2.4** which shows various physiochemical parameters and the standard which were published and prepared jointly by the water pollution control federation (WPCF), American water works association (AWWA) and American public health Association (APHA), 17th edition, 1989 [83,84].

Table 2.4. International Standards of Drinking Water [83, 84]

No.	Factors	W.H.O. standards (1971)		APHA 1993, (International Standards)		APHA1993, (International Standards)	
		Acceptable concentration(Maximum)	Acceptable concentration(Maximum)	Acceptable concentration(Maximum)	Allowable concentration (Maximum)	Acceptable concentration (Maximum)	Allowable concentration (Maximum)
1	Odor	Unobjectionable	Unobjectionable	Unobjectionable	~	Unobjectionable	~
2	Color	5 Units	5 Units	5 Units	25 Units	5 Units	25 Units
3	Turbidity	2.5 NTU	2.5 NTU	2.5 NTU	10 NTU	5 NTU	10 NTU
4	Taste	Agreeable	Agreeable	Agreeable	~	Agreeable	~
5	TDS	500	500	500	1500	500	2000
6	Total Alkalinity					200	600
7	pH	7.0 to 8.0	7.0 to 8.5	7.0 to 8.5	6.5 to 9.2	6.5 to 8.5	~
8	Total Hardness	100	100	100	500	300	600
9	Magnesium	80	30	30	150	30	150
10	Calcium	75	75	75	200	75	200

3. Materials and Methods

This chapter discusses the approaches of sample collection and analytical methods employed for analysis of groundwater samples of Addis Zemen city employing various analytical techniques.

The study area, Addis Zemen town, is locates at Amhara National Regional State, south Gondar zone. Addis Zemen town is the capital of the libo-kemkem district and is found 645km from Addis Ababa and 82 km from the regional capital, Bahir Dar in northern part of Ethiopia. The town is dividing into four kebele and the bounders include 7 rural Keble‟s from center of it.

To investigate the influence of contaminates on the groundwater of Addis zemen city, water samples were collected from six various selected sites in season (i.e. the winter and spring periods) throughout the one year (from February, 2021 to March 2021). The samples were collected as composite samples, at each selected site, samples were collected from three different points of each selected site, and then mixed together i.e. from six selected sites samples were collected from eighteen (18) points. Samples of ground water were collected from various sampling sites of six Addis zemen city as composite samples for assessment and characterization of their physiochemical characteristics.

3.1 Sampling methods

To sampling of ground water is done from site selects located in agricultural and residential areas as per the standard procedures to assess the level of groundwater contamination. Very good quality narrow mouth screw-capped polypropylene bottles of two litter capacity were used to collect the sample. Bottles first washed with dilute nitric acid followed by demineralized water three times. Before sample collection bottles were rinsed three times with water to be sampled and then samples were collected.

Figure 3.1GIS satellite images of the sampling sites at Addis Zemen city. S1A, S1B, S1C means sample 1 taken at three different points i.e. point A, point B, point C.S2A, S3B, S2C means sample 2 taken at three different points i.e. point A, point B, point C.S3A, S3B, S3C means sample 3 taken at three different points i.e. point A, point B, point C.S4A, S4B, S4C means sample 4 taken at three different points i.e. point A, point B, point C.S5A, S5B, S5C means sample 5 taken at three different points i.e. point A, point B, point C.S6A, S6B, S6C means sample 6 taken at three different points i.e. point A, point B, point C. For each sample the distance among A to C ranges from 1.5 to 2 m while the distance among S1 to S6 ranges from 150 m to 200m.

3.2 Sites for the sampling

Six sampling sites in Addis zemen city and minimum three locations in the selected sites, so that drawn sample represent the real ground water quality of the study area**(Figure**

3.1).For each sample the distance among A to C ranges from 1.5 to 2 meter while the distance among S1 to S6 ranges from 150 m to 200 meter.

3.3 Samples Labeling

Each sample was labeled sufficiently and mark label on sampling bottles by permanent marker, recorded all the information including sample location, source and date of collection in field book to avoid any error and confusion.

3.4 Collection of samples

Before collection of sample the bore wells were flushed for a sufficient period of time, so that actual sample can be collected which represents the actual quality of ground water for the city. The samples were collected from three spot and then mixed together. Sample bottles were rinsed three times with the water to be collected and then filled completely to avoid infringement of air bubble. Sample bottles screw-caped tightly and brought to the laboratory. The samples were preserved in refrigerator at $4^{o}C$. The analysis of pH was made in field with portable pH meter.

3.5 Samples examination

Samples of the groundwater of different locations were analyzed for determination of degree of pollution with respect to the various physiochemical variables and heavy metals selected for study. The physiochemical parameters and heavy metals selected for the examination include: Electrical conductivity (EC), pH, Total dissolved solids (TDS), total hardness (TH), Calcium hardness, Magnesium hardness, Sodium, Potassium, Total alkalinity, bio-carbonates, carbonates, dissolved oxygen (DO), Chemical oxygen demand (COD), biological oxygen demand (BOD), fluoride, Nitrate, chloride, sulphate, and heavy metals including iron, cadmium, zinc, copper, manganese and lead.

3.6 Standard methods employed for analysis

To determine the degree of pollution samples of the groundwater collected were collected from the various selected sites (selected points or locations) to analyzed the physicochemical variables. For the determination of the various physiochemical parameters the standard approaches given in standard approaches for the examination of waste water and water published and prepared jointly by the water pollution control federation (WPCF), American water works association (AWWA) and American public health Association (APHA), 17^{th} edition, 1989, were employed.

Electrical conductivity (EC), pH, Total dissolved solids (TDS), total hardnes (TH), Calcium hardness, Magnesium hardness, Sodium, Potassium, Total alkalinity, bio-carbonates, carbonates, dissolved oxygen (DO), Chemical oxygen demand (COD), biological oxygen demand (BOD), fluoride, Nitrate, chloride, sulphate, and heavy metals including iron, cadmium, zinc, copper, manganese and lead.

The determination of Heavy metals (cadmium, iron, zinc, manganese lead and copper etc.) concentrations in water sample can be done by various methods including, gravimetric, titrimetric, atomic absorption spectrophotometer (AAS), flame photometric method, colorimrtic, ion chromatographic, etc. For the determination of heavy metals available even at very low concentrations in water samples Atomic absorption spectro photo metric which can be used to determine sixty-eight elements from ppm to ppb over a wide range of concentrations, is widely employed since the method is relatively accurate, versatile, free from major interferences and simple. The atomic absorption spectrophotometer is first calibrated with the standard metal solutions, to be analyzed, with employing corresponding hollow cathode lamp of that metal.

For analysis of trace heavy metals i.e. iron, copper, cadmium, zinc, lead and manganese by atomic absorption spectrophotometer the standard approach for the examination of wastewater and water, prepared and published jointly by the water pollution Federation and American public health Association water works Association 17^{th} edition, 1989 were used.

3.7. Methods for computation of Some Important Variables

3.7.1 Aggressive Index

Aggressive index (AI) is given by AI= pH+log (TA. TH) where pH is the actual pH, TH is total hardness in mg/l of the water and TA is $CaCO_3$ (TA) of the water. AI values greater than 12 indicate non-aggressive water, value between 10 and 12 indicate moderately aggressive water and values less than 10 indicate highly aggressive water.

3.7.2 Langelier Saturation Index

It is often used as an indicator of the corrosivity of water is a degree of a solution‟s ability to deposit or dissolve calcium carbonate. It deals only with the thermodynamic driving force for calcium carbonate scale growth and formation and is purely an equilibrium index. It simply indicates growth in terms of pH as a master variable and the driving force for scale formation. It provides no indication of how much calcium carbonate or scale will actually precipitate to bring water to equilibrium.

In order to calculate the (Langelier Saturation Index) LSI, it is necessary to know the total hardness (mg/L as $CaCO_3$), total alkalinity (mg/L as $CaCO_3$), the actual pH, the total dissolved solids (mg/L TDS), and the temperature of the water (^oC).

The use of the equation developed by Langelier made it possible to predict the of natural or conditioned water to deposit calcium carbonate or to dissolve calcium carbonate.

Langelier Saturation Index (LSI) is defined as:

$$LSI = pH - pHs \quad (1) \qquad (1)$$

where pH is the measured water pH and pHs is the pH at saturation in calcite or calcium carbonate. pHs is defined as

$$pHs = (9.3 + A + B) - (C + D) \qquad (2)$$

where:-

$$A = (\log_{10} [TDS] - 1)/10 \qquad (3)$$

$$B = -13.12 \times \log_{10} (^0C + 273) + 34.55 \qquad (4)$$

$$C = \log_{10} [TH \text{ as } CaCO_3] - 0.4 \qquad (5)$$

$$D = \log_{10} [\text{total alkalinityasCaCO}_3] \text{---} (6)$$

This is useful in predicting the corrosive or scaling tendencies of the water. If the water deposits calcium carbonate; it has a scaling tendency and a positive value, if the water dissolves calcium carbonate, the water is corrosive and has a negative value.

If Langelier Saturation Index (LSI) is positive the scale can form and $CaCO_3$ precipitation may occur. If LSI is close to zero, then the Borderline scale potential may occur. If the LSI is negative, then there will be no potential to scale and the water will dissolve $CaCO_3$.

3.7.3 Sodium Adsorption Ratio (SAR)

The inorganic constituents (soluble) of irrigation water react with soils as ions. The principle cat ions are calcium, sodium, and magnesium with minor amount of potassium. The principle anions are sulphate, bicarbonate, carbonate, and chloride with nitrate and fluoride in low concentration. The absolute and relative concentrations of cat ions determine the alkali hazard involved in the use of water for irrigational purpose. If calcium and magnesium predominate the hazard is low conversely and if the proportion of sodium is high, the alkali hazard is high. The criteria given by westcot and Ayers and Wilcox will be used to study the suitability of water for irrigational purpose. To illustrate the irrigational suitability of groundwater the following calculations were used i.e. a ratio of irrigation water and soil extract used to express the relative activity of sodium ions in exchange reaction with soil. Sodium adsorption ratio (SAR) is calculated with the help of the following equation-

$SAR=Na^+ / \quad +Mg^{2+})/2$ ....(7)

Where, Mg^{2+}, Na^+ and Ca^{2+} ions are expressed in meq/L.

3.7.4 Percent Sodium

The proportion of sodium or sodium percent (% Na), also called as soluble sodium percentage (SSP), among all the cat ions present in water is usually expressed in terms of percent sodium. It will be estimated with following equation-

$\%Na = Na^+/[Ca^{2+} + Mg^{2+} + K^+ + Na^+]*100$ --- (8)

where Na^+ Mg^{2+}, K^+ and Ca^{2+} ions are expressed in meq/L.

3.7.5 Exchangeable Sodium Percentage (ESP)

Exchangeable sodium percentage (ESP) is a degree of saturation of the soil exchange complex with sodium. ESP is estimated with the following equation:

ESP = 100 (-0.0126 + 0.01475 SAR / 1+ (-0.0126 + 0.01475 SAR) ---------------- (9)

3.7.6 Residual Sodium Carbonate (RSC)

Residual sodium carbonate (RSC) is also an index for evaluation of water for irrigational purpose and estimated as:

RSC = (CO_3^{2-} + HCO_3^{-}) - (Ca^{2+} + Mg^{2+}) --- (10)

Classification of irrigational water given by Wilcox based on electrical conductance and calculated sodium adsorption ratio will be employed. .

4. Results and Discussion

In this chapter the results and discussion on results have been presented. The physicochemical parameters of groundwater of Addis Zemen town and the calculated indices such as aggressive index Langelier, saturation index percentage, sodium adsorption ratio, residual sodium carbonate, exchangeable sodium percentage were calculated and presented**.** A good quality drinking water is a vision for most the population in the world since water is life.

Therefore, assessing the quality of water for recreational purpose and human consumption is of utmost importance. The high fluoride water consumption causes skeleton disorder and floristic and high quantity of nitrate results methaemoglobinaemia disease. Nitrate and fluoride values are most important due to more hazardous impact on human health; conversely all the quality parameters have equal importance.

One fourth of the world production represents amount of iron washed due to corrosion and corrosiveness of water may damage purification systems as well as water distribution systems. Corrosivity indices namely aggressive index and Langelier saturation index will be determined to determine corrosion potential of ground water of study area. To evaluate irrigational suitability of ground water of study area residual sodium carbonate and exchangeable sodium percentages are determined to know the water quality since it has major impact on soil quality and crop yield. The water quality suitability for irrigational determination would be presented. .

4.1. Ground-Water Quality Parameters

Various locations groundwater samples of were examined and investigated for evaluation of pollution degree with the physicochemical factors such as (total dissolved solids Mg hardness, electrical conductivity, pH, Ca hardness, total hardness, potassium, sodium, total alkalinity, biological oxygen demand carbonates, bicarbonates, dissolved oxygen),) chemical oxygen demand), heavy metals, fluoride, chloride, sulphate, nitrate, and as well as heavy metals (e.g. copper, zinc, iron, manganese, cadmium and lead).

Table 4.1summarizes the results found for the physicochemical parameters of groundwater of Addis Zemen town.

Table 4.1. Physicochemical parameters of groundwater of Addis Zemen town

Nameof sample	EC	pH	TA (mg/L)	TDS (mg/L)	HCO_3^- (mg/L)	TH (mg/L)	Mg^{2+} (mg/L)	Ca^{2+} (mg/L)
Sample-1	1129	8.3	569	906	569	419	176	259
Sample-2	1246	8.5	829	959	615	485	201	286
Sample-3	1226	8.4	612	923	620	453	186	266
Sample-4	1029	8.4	627	815	510	393	158	233
Sample-5	1177	8.5	588	884	587	463	187	276
Sample-6	1112	8.3	553	858	549	401	162	238

4.1.1 Conductance

Conductance varies with the season and conductance is not harmful but water with higher conductance is not suitable for irrigational and drinking purpose. The values of conductance of groundwater samples are ranged from 1029 to 1246 µS with an average value of 1153.16 µS, lower conductance could be due to dilution from rainwater (**Table 4.1** and **Figure 4.1**). The values found (**Table 4.1 and Figure 4.1**) are compared with the literature values (**Table 4.2**). The water can be classified for irrigation purpose based classification of water for irrigation according to Wilcox presented in 1948 **Table 4.2.** Based on our result the classification of water is unsuitable for irrigation purpose. It appears that the values for the EC exceeds WHO standard limit for drinkable water. This could be due to Water evaporates during the concentration of ions increases hence electrical conductivity increases (the increase in electrical conductivity was due to evaporation of water in underground water channels which increased the concentrations of dissolved salts or the dilution of the ions due to rainwater increasing underground water volumes resulting in a decrease in electrical conductivity (Hassan 2008).

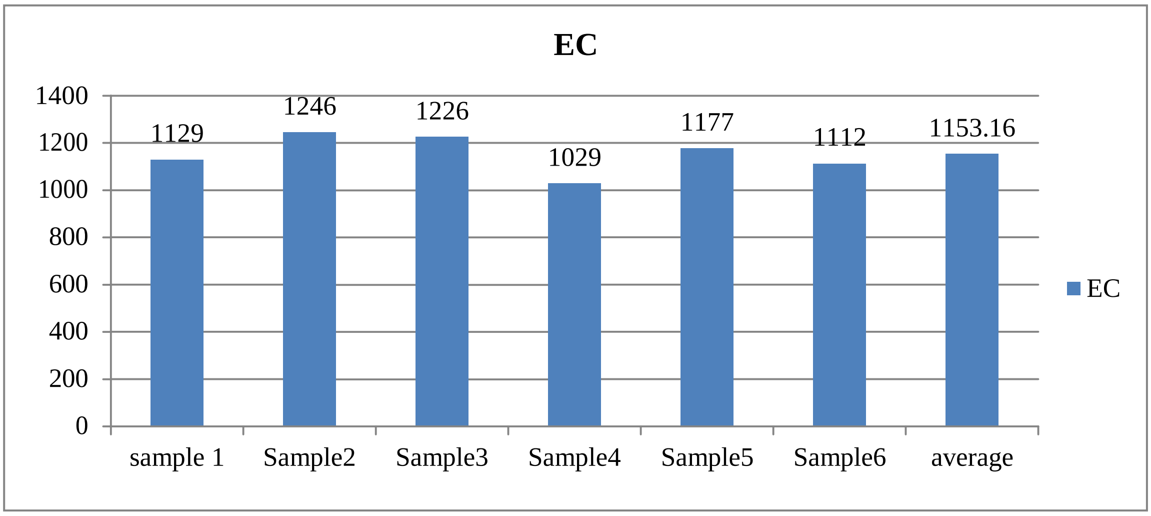

Figure 4.1. Measured conductance values

Table 4.2 Classification of water for irrigation according to Wilcox presented in 1948

Factors	Class	Limit
Conductance (µS/cm)	Good	20-40
	Doubtful	60-80
	Excellent	< 20
	Unsuitable	> 80
	Permissible	40-60

4.1.2 PH Values

The increase or decrease of human and biological activities may result the variations in pH values. The pH values of groundwater samples were ranged from 8.3 to 8.5 with an average value 8.40, and all the six samples have value as per IS 10500 permissible limit of pH values for drinking water which is specified as 6.5 to 8.5 (**Table 4.1** and **Figure 4.2**)

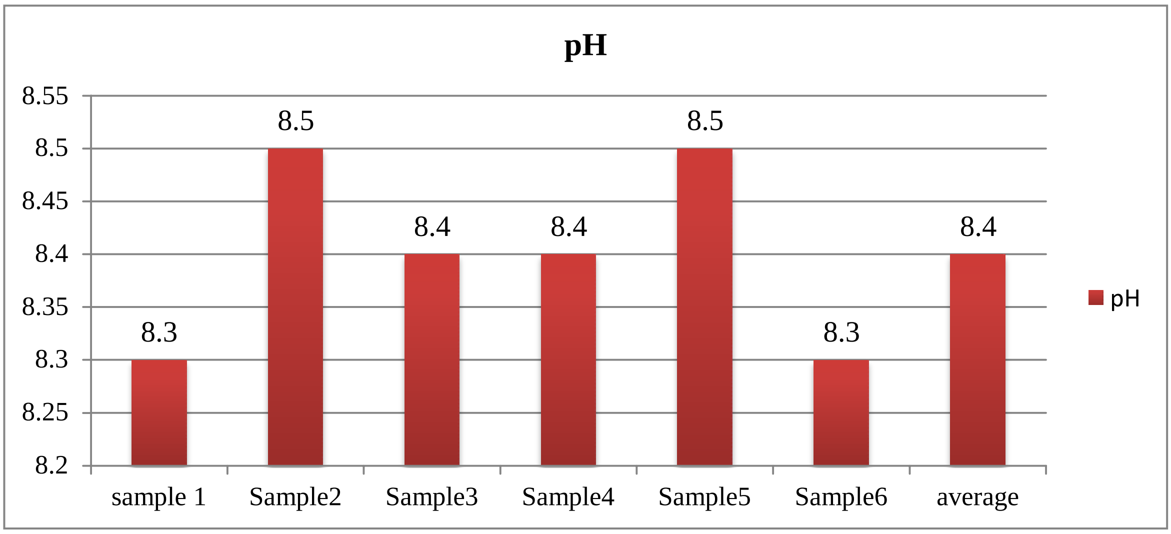

Figure 4.2 Measured pH values

4.1.3 Total Alkalinity

The capacity of water to neutralize a strong acid is called alkalinity of water. For drinking water, the maximum allowable concentration of total alkalinity is 600 mg/L according to IS 10500. The hydrolysis of salts and free hydroxyl ions formed by strong bases and weak acids such carbonates and bicarbonates results in alkalinity in natural water. Total alkalinity of groundwater samples varies from 553 mg/L to 829 mg/L with an average value of 629.66 mg/L>600 mg/L .it is not good for drinking. (**Table 4.1** and **Figure 4.3**).

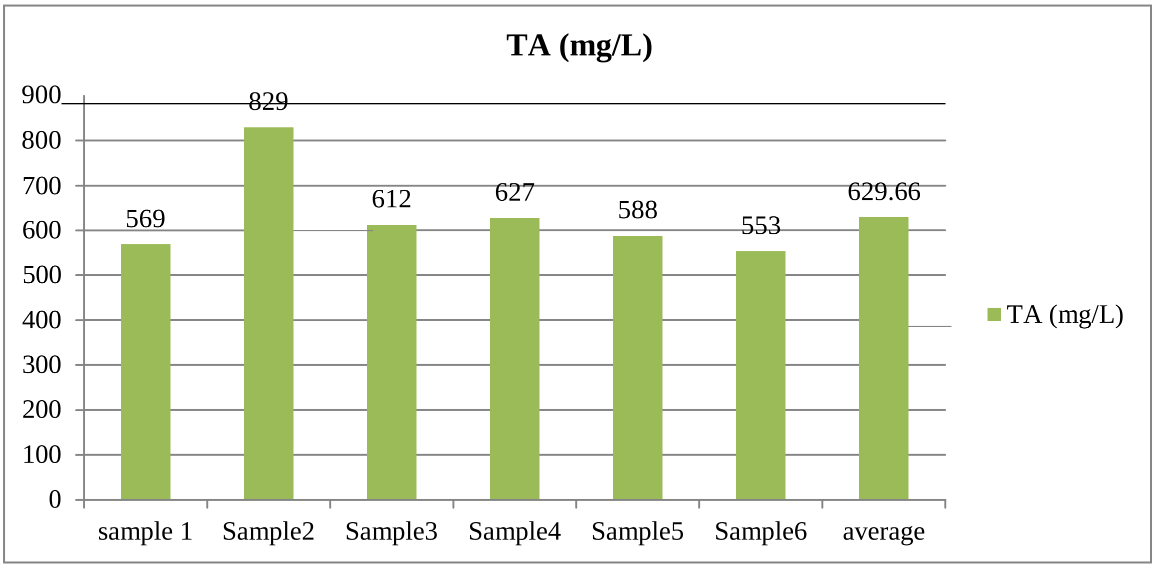

Figure 4.3 Measured TA values

4.1.4 Total Dissolved Solids

Water of high total dissolved solids (TDS) restricted industrial use since it is not suitable for use in boilers. Ground water has a higher TDS load compared to surface water. The TDS of groundwater samples ranged from 815 to 959 mg/L with an average value of 890.83 mg/L. (**Table 4.1** and **Figure 4.4**). The lower values could be due to the dilution of water with rainwater while the higher TDS values could be because of the concentrated water due to evaporation. The water can be classified for irrigation purpose based on Westcot and Ayers presented in 1984 **Table 4.3**. Comparing it the result with **Table 4.3** the classification of water under moderate for irrigation purpose.

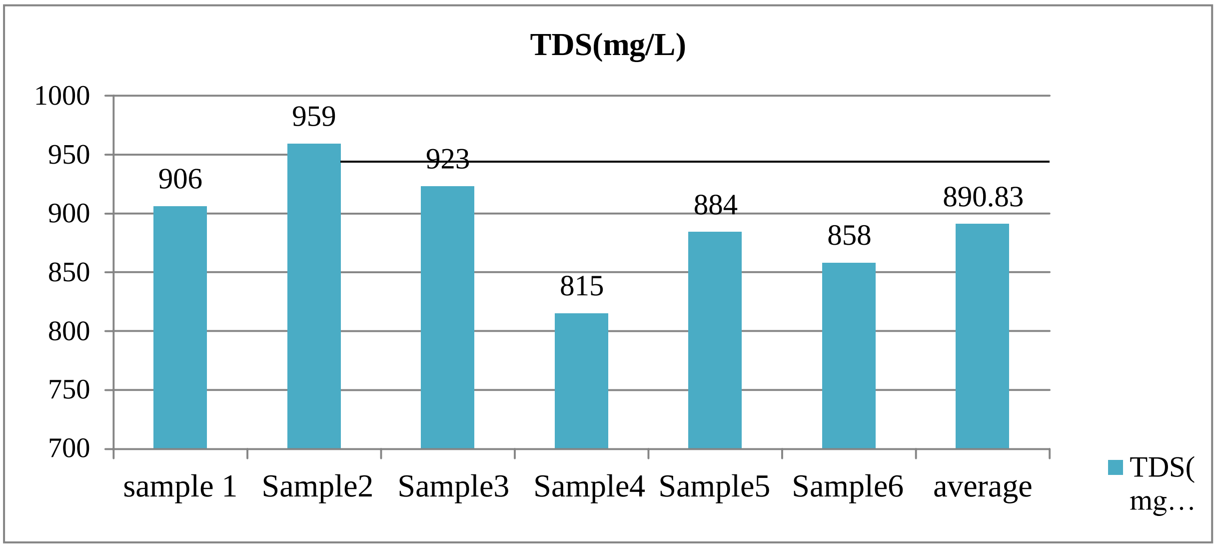

Figure 4.4. Measured total dissolved solids

Table 4.3 Classification of water for irrigation based on total dissolved solids (mg/l) according to Westcot and Ayers presented in 1984

Factors	**Problem**	**Class**	**Limit**
Total Dissolved Solids	Salinity (Affect the availability of crop water)	Slight to Moderate	0.70-3.0 / 450 -2000
		None	< 0.70 < 450
		Severe	> 3.0 / > 2000

4.1.5 Carbonate Alkalinity and Bicarbonates Alkalinity

In all samples carbonates alkalinity were non-detectable **as** shown in **Table 4.1**. The bicarbonates alkalinity ranged from 510 to 620 mg/L with an average value of 575 mg/L<600 mg/L. For drinking water, the maximum allowable concentration of bicarbonate alkalinity is 600 mg/L. it an average value of the six samples have value as per IS 10500 permissible limit. (**Table 4.1**and **Figure 4.5**)

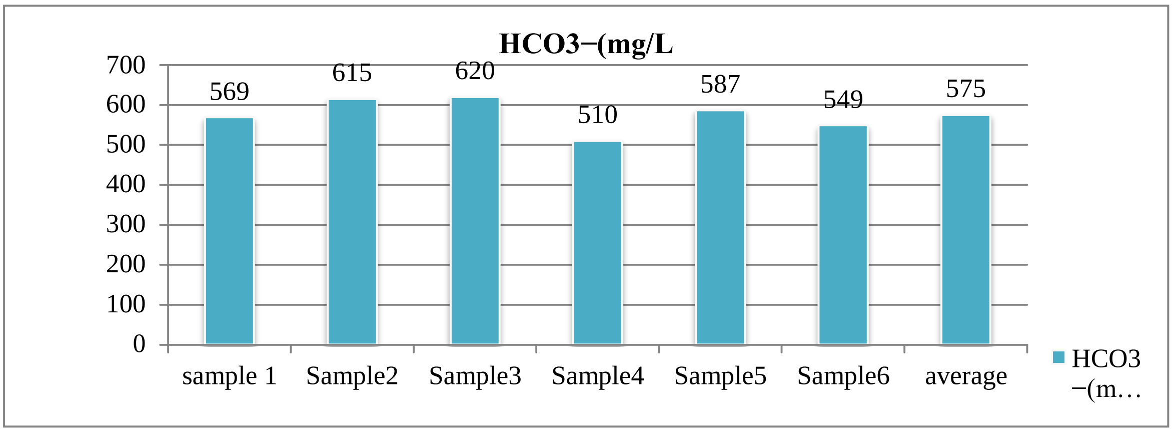

Figure 4.5. Measured total bicarbonate alkalinity

4.1.6 Total hardness

Hardness which was the property of water that avoids the lather creation with soap and enhance the boiling point of water. Calcium and magnesium are the major cat ions imparting hardness of water. The total hardness of groundwater samples ranged from 393 to 485 mg/L with an average value of 435.66 mg/L<500 mg/L. For drinking water, the maximum allowable concentration of total hardness is 500 mg/L. it all the six samples have value as per IS 10500 permissible limit. (**Table 4.1** and **Figure 4.6**). Bicarbonates, carbonates, chloride and sulphate are the anions accountable for hardness. Hardness is permanents if with chloride and sulphate and temporary if it is associated mainly with bicarbonates and carbonates.

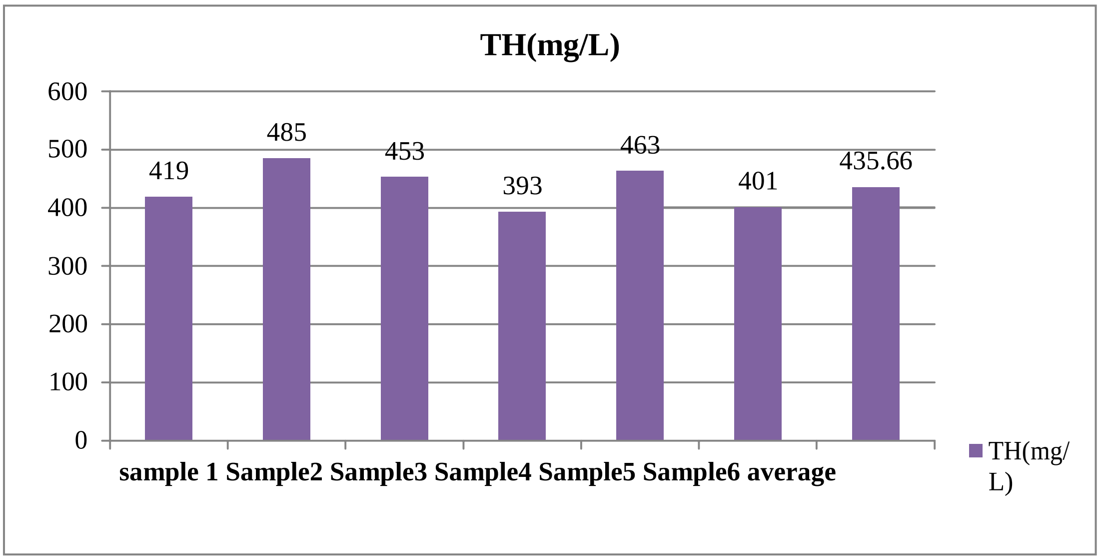

Figure 4.6. Measured total hardness values

4.1.6.1 Magnesium Hardness

Magnesium presents in all sort of natural waters; however, its concentration remains lower than the calcium hardness. The variation between the total hardness and calcium hardness results in magnesium hardness. The magnesium hardness values ranged from 158 to 201 mg/L with an average of 178.33 mg/L (**Table 4.1** and **Figure 4.7**). In most case water systems using groundwater as a source are concerned with water hardness, since as water moves through soil and rock it dissolves small amounts of naturally occurring minerals and carries them into the groundwater supply.

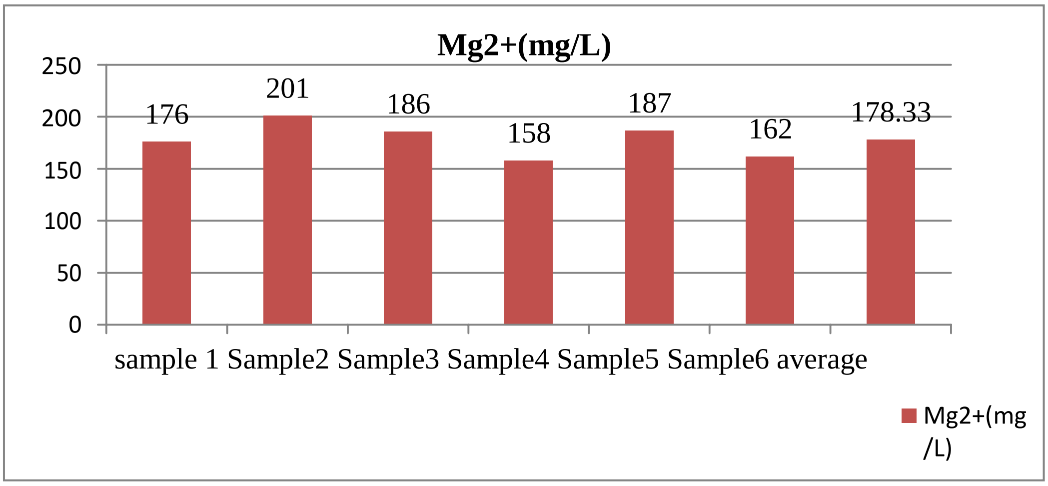

Figure 4.7. Measured magnesium hardness values

4.1.6.2 Calcium Hardness

Calcium also presents in all sort of natural waters; ion imparting the hardness to the waters and is one of the most abundant elements found in natural water. The calcium hardness of groundwater samples ranged from 233 to 386 mg/L with an average of 259.66 mg/L and at high pH value much of its quantities may be precipitated as calcium carbonate (**Table 4.1** and **Figure 4.8**). An increase in total hardness, seepage and runoff from waste disposal sites along the sampling points could be explained by high levels of calcium dissolved from chemical fertilizers.

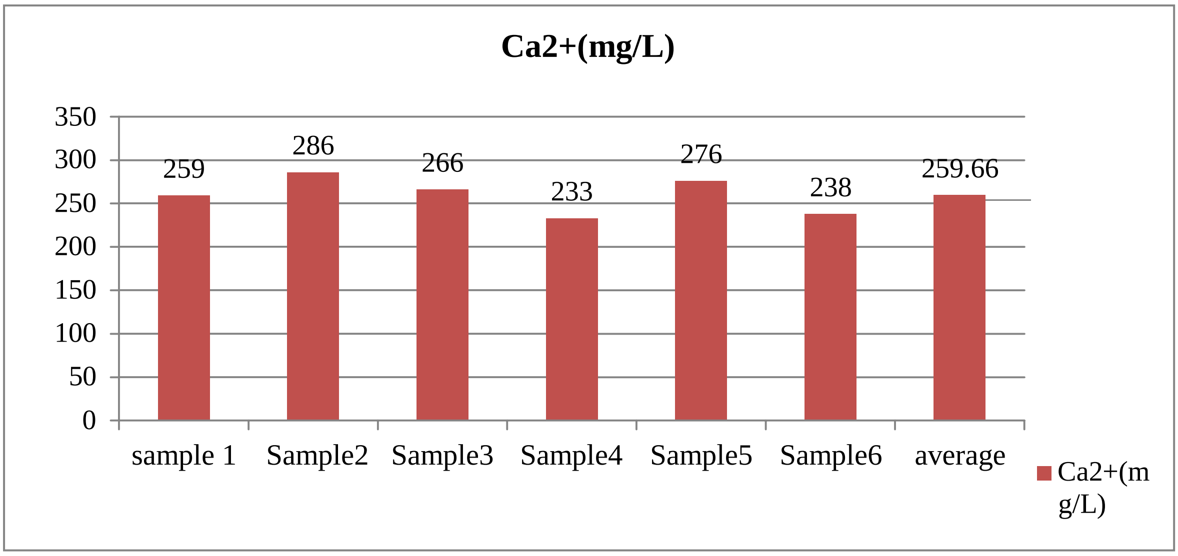

Figure 4.8. Measured magnesium hardness values

4.1.7 Dissolved oxygen

Moreover, some other physicochemical analyses such as dissolved oxygen, biochemical oxygen demand and chemical oxygen demand have been investigated. The results have shown in **Table 4.4**.**Table 4.5** physicochemical analyses (dissolved oxygen (DO), biochemical oxygen demand (BOD) and chemical oxygen demand (COD) of Addis Zemen city.

Name of Sample	Factors		
	COD	DO	BOD
Sample 1	3.3	6.7	0.4
Sample 2	3.1	6.3	0.5
Sample 3	3.4	6.5	0.6
Sample 4	3.7	6.4	0.3
Sample 5	3.5	6.2	0.5
Sample 6	3.6	6.9	0.7

The dissolved oxygen values were ranged from 6.2 to 6.9 mg/L for the ground water samples (**Table 4.4** and **Figure 4.9**). The result shows that there are no major differences found in these results. The minimum value of DO was observed in sample 4 and maximum value in sample 6.

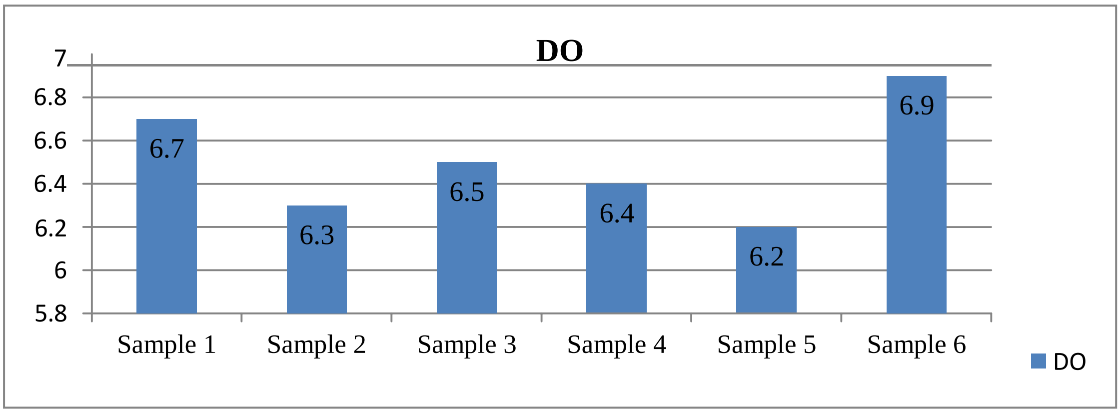

Figure 4.9 Measured total dissolved oxygen values.

4.1.8 Biological Oxygen Demand

The Biological oxygen demand values of BOD ranged from 0.3 to 0.6 mg/L with an average value of 0.45 mg/L (**Table 4.4** and **Figure 4.10**). Whereas the minimum values were obtained at sampling point. The water is considered somewhat polluted because there is usually organic matter present and bacteria are decomposing this waste.

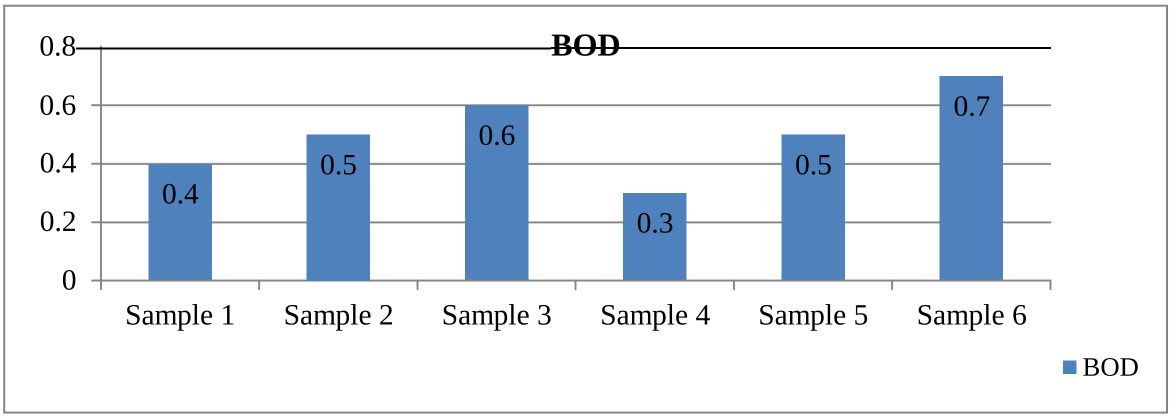

Figure 4.10 Measured biological oxygen demand values

4.1.9 Chemical Oxygen Demand

A maximum value of chemical oxygen demand of 4.1 mg/L was found in sample 4. The values of chemical oxygen demand were varied from 3.1 to 4.1 mg/L in the all the six ground water samples (**Table 4.4** and **Figure 4.11**). an indicator of organic pollution, which is caused by the inflow of domestic waste, live stocks and waste that contains elevated level of organic pollutants (Maitera, Ogugbuaja et al. 2010).

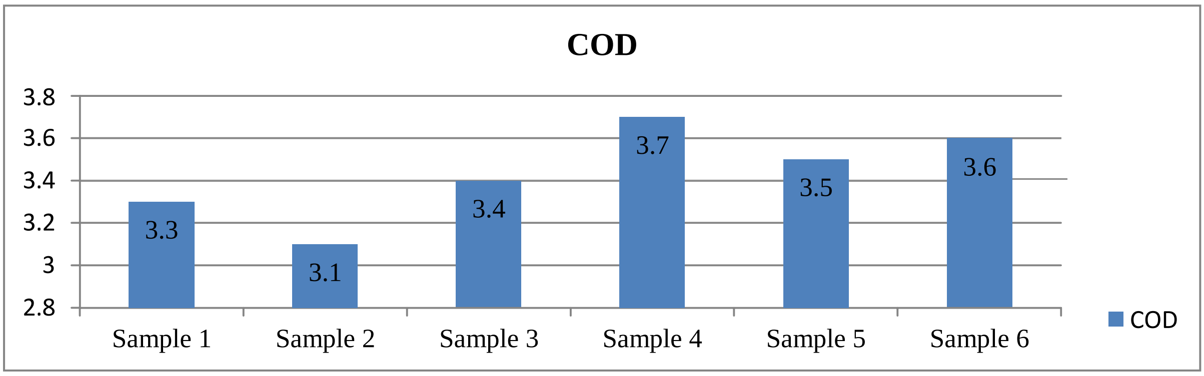

Figure 4.11. Measured chemical oxygen demand values

4.1.10 Potassium

A maximum value of potassium of 8.7 mg/L and a minimum value of 4.2 mg/L were found in the all the six ground water samples (**Table 4.5**).Moreover, the other most important ground water physicochemical parameters such as potassium, chloride, sodium, nitrate, sulphate and chloride have been investigated. **Table 4.5** Physicochemical parameters of groundwater (potassium, chloride, sodium, nitrate, sulphate and chloride) of Addis Zemen town.

Name of sample	K^+ mg/L	F^- mg/L	Na^+ mg/L	Cl^- mg/L	NO_3^- mg/L	SO_4^{2-} mg/L
Sample-1	8.5	0.8	141	56	32	70
Sample-2	8.7	1.1	149	65	33	73
Sample-3	7.5	0.7	149	53	36	61
Sample-4	5.6	1.2	126	59	29	69
Sample-5	7.8	1.1	139	63	35	71
Sample-6	4.2	0.9	130	41	30	52

4.1.11 Fluoride

The concentration of fluoride ions in this research work ranged from 0.7 to 1.2 mg/L and all these values were within the specified limit (**Table 4.5**). The maximum concentration of fluoride in drinking water is 0.1- 1.50 mg/L based on IS 10500. The water for drinking and its health effect due to fluoride concentration values are presented in **Table 4.6**. Based on our result (**Table 4.5**) the ground water may damage and promotes dental health, prevents tooth decay [81] as you observed in **Table 4.5**.

Table 4.6 Water for drinking and its health effect due to fluoride concentration [81]

Effect	Fluoride Concentration (mg/L)
Dental fluorosis	1.5- 4.0
Dental caries	< 0.5
Crippling fluorosis	> 10.0
Promotes dental health, prevents tooth decay	0.5-1.5
Adverse effect on pregnancy power and can be damage a fetus	Nil
Dental fluorosis, skeletal fluorosis severe pain in joints, back bones and other disorders.	4.0-10.0

4.1.12 Sodium

The concentration of sodium in the six groundwater samples differs from 126 to 149 mg/L as presented in (**Table 4.5**). In Addis zemen the ground water sodium ion concentration is below 200 mg/l mg/L and in the whole study area is less than WHO and Ethiopian standard

4.1.13 Chloride

High concentrations of Chloride can make water unpalatable and therefore, unfit for drinking or livestock watering (UNICEF, 2008).The minimum and maximum value of Chloride observed were 41 and 65 mg/l in sample in all of the investigate investigated samples as presented in (**Table 4.5**) in Addis zemen the ground water chloride ion concentration is below 250 mg/L and in the whole study area is less than WHO and Ethiopian standard.

4.1.14 Nitrate

It also originates from sewage effluents, septic tanks and natural drains carrying municipal wastes. NH_{4+} from organic sources is converted to NO_3^- by oxidation. The maximum and minimum value of nitrate was 29 and 36 mg/l respectively (**Table 4.5)**. Because of this and its anionic form NO_3^- is very mobile in groundwater (Balakrishnan et al, 2011). The concentration of nitrate in natural water is less than 10 mg/L in WHO Standards. Water containing more than 32.5 mg/L is bitter to taste and causes physiological distress.

4.1.15 Sulphate

Sulphates are generated from the dissolution of minerals, such as gypsum and anhydrite. The maximum value and minimum of sulphate found were 52 and 73 mg/l in all six samples as presented in (**Table 4.5**) High concentrations greater than 400 mg/L may make water unpleasant to drink (UNICEF, 2008).and all the values found are which is less than 400 mg/L.

4.1.16 Heavy Metals

Heavy metals (Zn, Fe, Cu, Mn, Pb, and Cd) were measured and analyzed as shown **Table 4.7**

Table 4.7 Heavy Metals Concentration and Some Physicochemical Analysis of Addis Zemen city.

Name of Sample	Trace Heavy Metal					
	Cu	Pb	Cd	Zn	Fe	Mn
Sample 1	0.12	0.02	ND	0.14	0.15	0.31
Sample 2	0.17	0.01	ND	0.13	0.13	0.22
Sample 3	0.21	0.04	ND	0.11	0.16	0.23
Sample 4	0.16	0.01	ND	0.16	0.19	0.17
Sample 5	0.14	0.03	ND	0.15	0.14	0.15
Sample 6	0.18	0.05	ND	0.12	0.17	0.16

- Cupper (Cu) Copper forms strong solution complexes with humic acids .and Solution and soil chemistry strongly influence the speciation of copper in ground-water systems. Values ranged from 0.12 to 0.21 mg/L.The affinity of Cu for humates increases as pH increases and ionic strength decreases. Were under permissible limits of IS 10500 and WHO recommended standards.

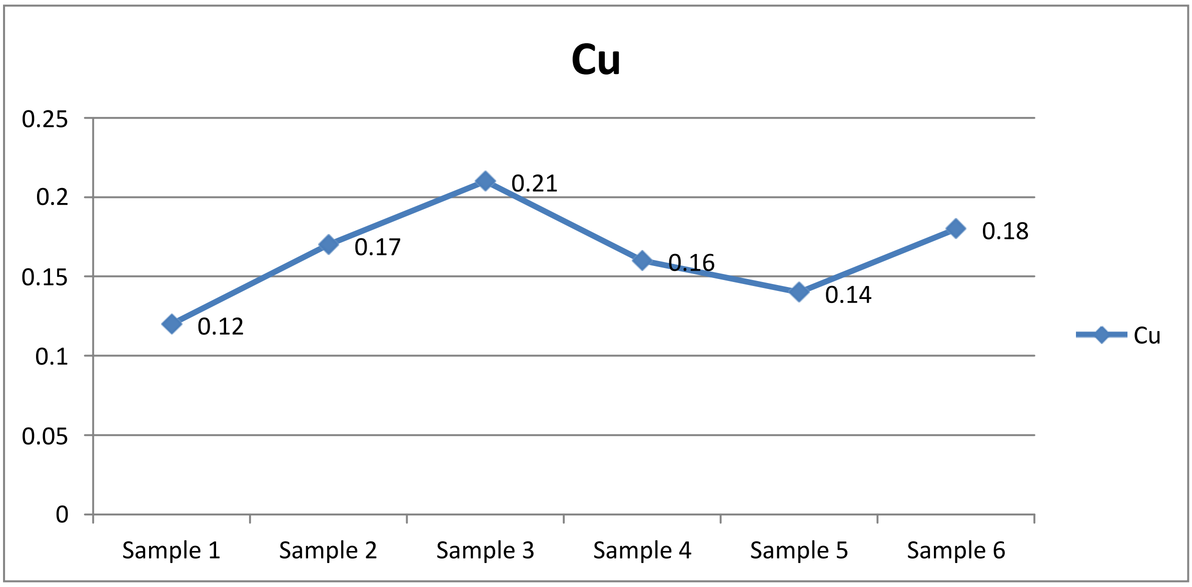

Figure 4.12. Measured Cu values

- Lead (Pb) values ranged from 0.01 to 0.05 mg/L. Exposure to high lead levels can severely damage the brain, kidneys and ultimately cause death. In pregnant women, high levels of exposure to lead may cause miscarriage. High level exposure in men can damage the organs responsible for sperm production [31]. Were under permissible limits of IS 10500 and WHO recommended standards.

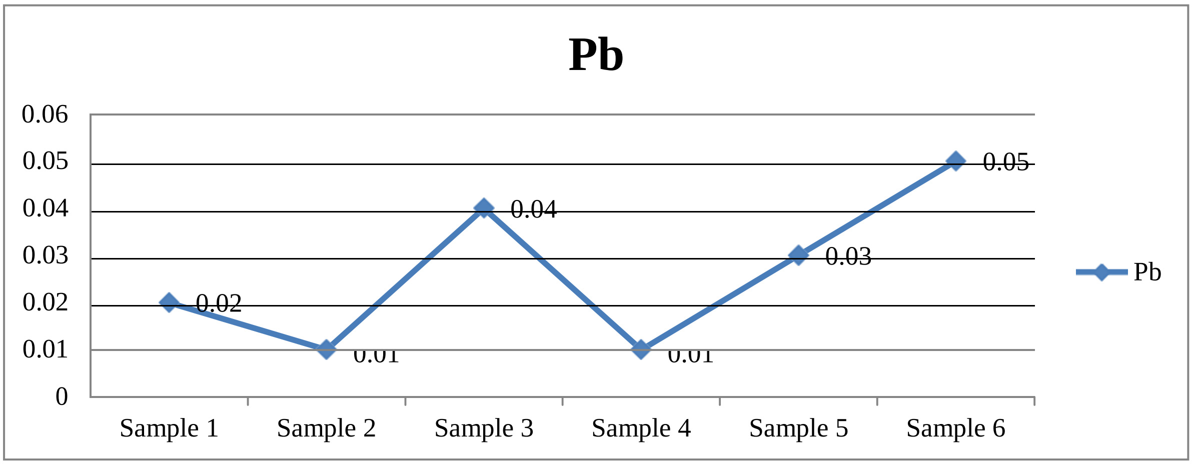

Figure 4.13. Measured Pb values

- Zinc (Zn) it is an essential element in human diet and values ranged from 0.11 to 0.16 mg/L. Without enough zinc in the diet people may be experience loss of appetite, decrease sense of taste and smell. Shortage of Zn can cause birth defects and were under permissible limits of IS 10500 and WHO recommended standards.

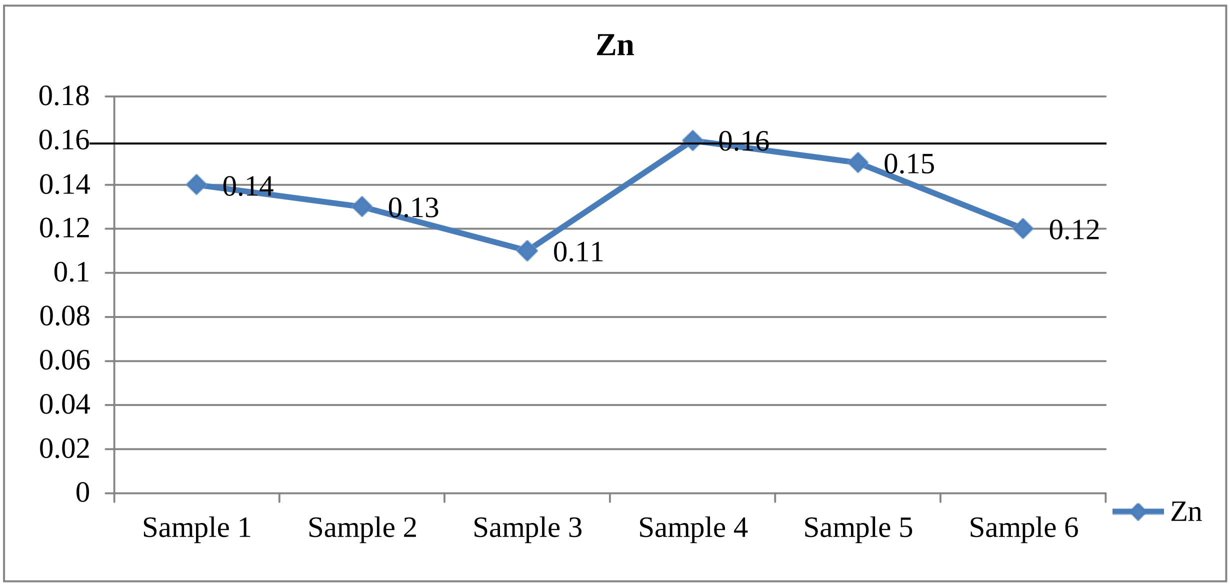

Figure 4.14. Measured Zn values

- Iron (Fe) values ranged from 0.13 to 0.19 mg/L were under permissible limits of IS 10500 and WHO recommended standards.

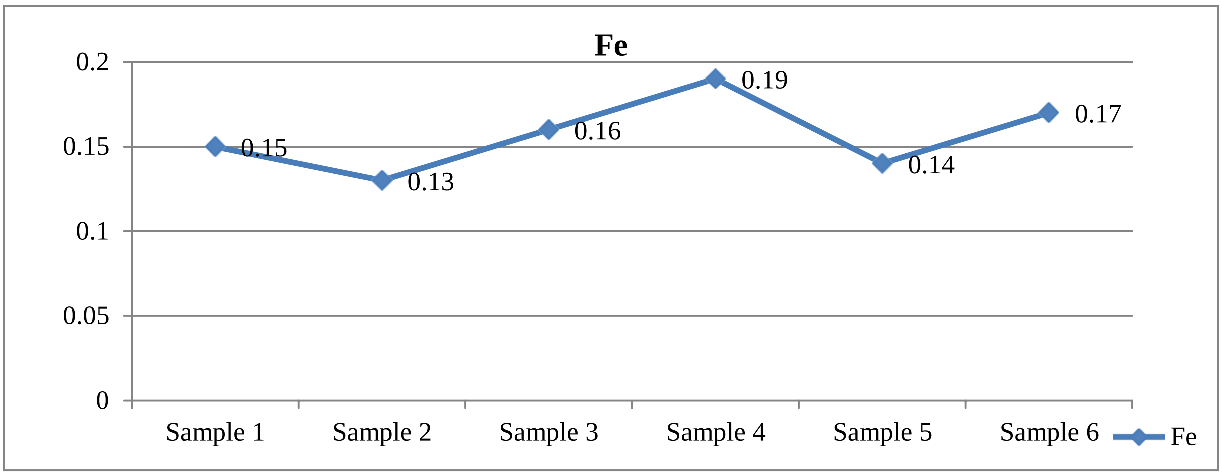

Figure 4.15. Measured Fe values

Manganese (Mn) values ranged from 0.15 to 0.31 mg/L. manganese at all ground water samples were much less than the WHO permissible limits of 0.5mg/L.

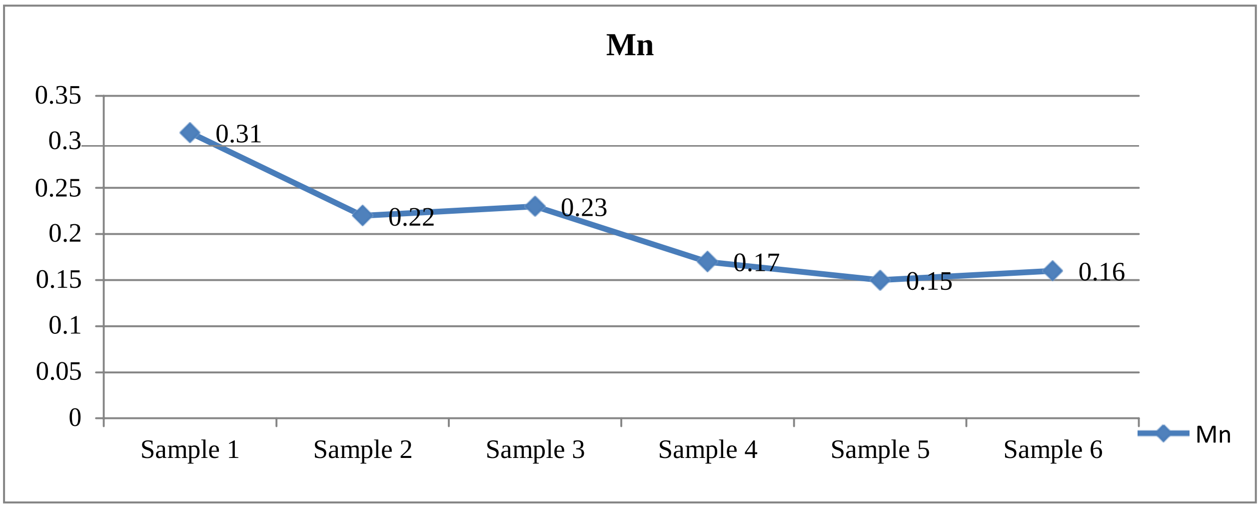

Figure 4.16. Measured Mn values

4.1.17 Aggressive Index

Moreover, the calculated factors such as exchangeable sodium percentage, percentage sodium, residual sodium carbonate, sodium adsorption ratio, and Langelier saturation index were evaluated and presented in **Table 4.8** and were compared with the World Health Organization and other standards.

Table 4.8 Some important calculated or computed factors

Name of Sample	Data Interpretation					
	LSI	%Na	SAR	ESP	RSC	AI
Sample 1	0.76	41.31	2.97	2.95	2.55	13.51
Sample 2	1.05	41.97	2.93	2.73	2.37	13.29
Sample 3	1.14	43.81	3.07	2.64	2.04	13.41
Sample 4	1.32	42.67	3.12	3.21	2.81	13.89
Sample 5	0.95	44.12	2.88	2.97	2.72	13.76
Sample 6	1.12	41.08	3.02	3.03	2.91	13.36

For all the samples analyzed the values of calculated aggressive index was ranged from 13.27 to 14.05 with an average of value of 13.67 and that maximum values display nature of corrosivity (non-aggressive) as presented in (**Table 4.8** and **Figure 4.17**).

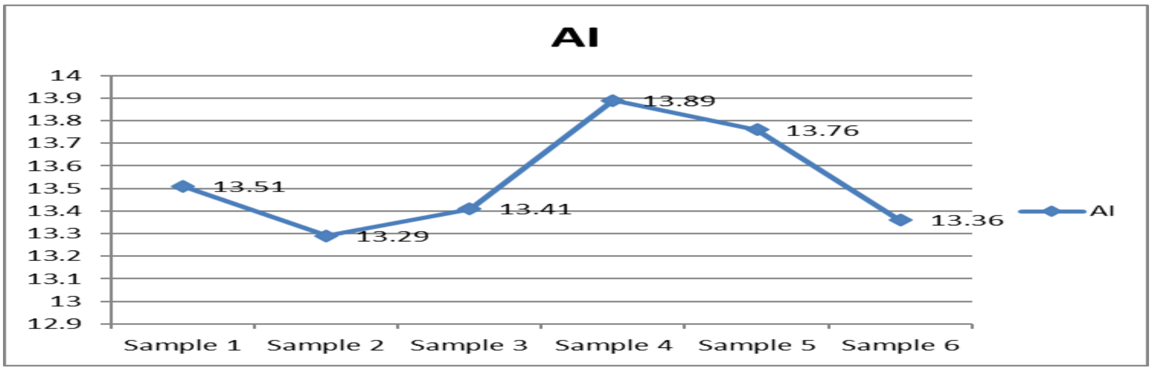

Figure 4.17. Measured Aggressive Index values

4.1.18 Langelier Saturation Index

For all the samples analyzed a calculated value of Langelier saturation index was varied from 0.76 to 1.14 with an average of 0.95 (**Table 4.8** and **Figure 4.14**). Some samples result in mild scale and remaining samples result in slight scale and this may result due to the use of groundwater without any treatment resulting groundwater samples were neither severe scale nor corrosive but frequently slight conditioning is needed. These values were interpreted based on langelier saturation index presented in **Table 4.9** which shows the appearance, index quality as well as issues of water condition. Based on our results (**Table 4.8** and **Figure 4.18**) the classification of water is conditioning usually not recommended.

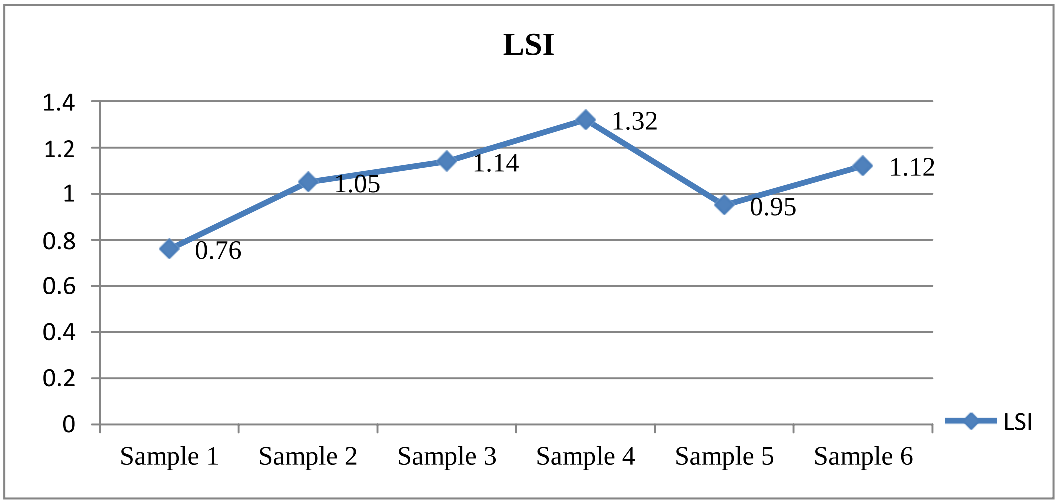

Figure 4.18. Measured Langelier saturation index values

Table 4.10. Langelier saturation index interpretation and test result Interpretation

Appearance	Index	Quality Issues of Water condition
Balanced	0.00	Conditioning usually not recommended
Mild Corrosion	-1.00	Need some conditioning
Slight Corrosion	-0.50	Should not / may need some conditioning
Moderate Corrosion	-2.00	Some conditioning is recommended
Severe Corrosion	- 3.00	Conditioning usually recommended
Very Severe Corrosion	- 4.00	Conditioning required
Faint Scale Coating	0.50	Conditioning usually not recommended
Encrustation/ Severe Scale	4.00	Conditioning usually required
Encrustation/Mild Scale	2.00	Should consider some conditioning
Encrustation/ Moderate Scale	3.00	Should use some conditioning
Encrustation/ Slight Scale	1.00	Some visual appearance concerns

4.1.19 Percentage Sodium

For all the samples analyzed the calculated values of percentage sodium were varied from 41.08 to 44.12 with an average of 42.49 (**Table 4.8** and **Figure 4.19**). As you have obtained in the data all measured samples values were of good class and suitable for irrigation purpose and employ of water having excess percentage of sodium is not appropriate for purpose of irrigational use. The minimum and maximum values were found in sample 1 and 2 respectively. The water can be classified for irrigation purpose based on the percentage of sodium value as presented in **Table 4.10**. Based on our result the classification of water is unsuitable for irrigation purpose according to the classification of water for irrigation according by Wilcox presented in 1948.

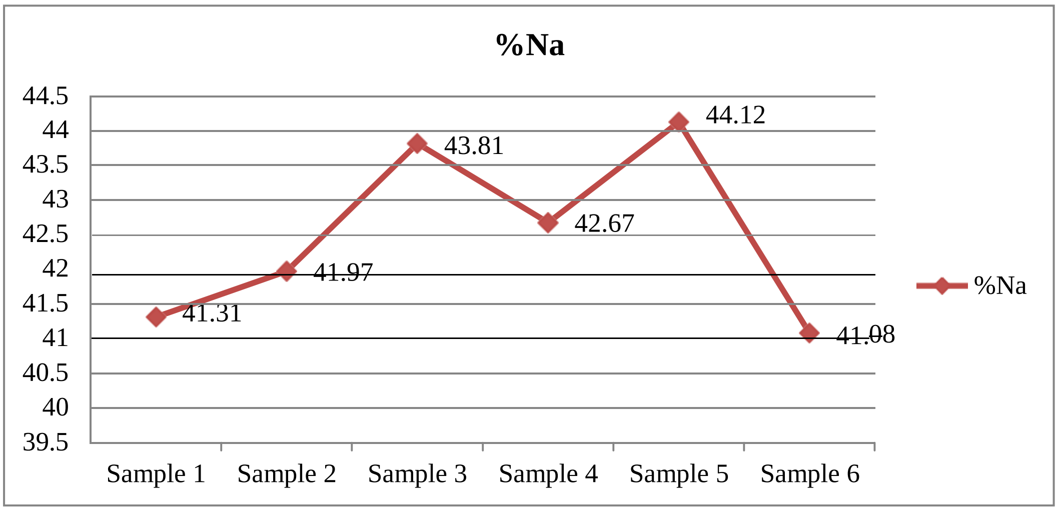

Figure 4.19. Measured Percentage Sodium values

Table 4.10 Classification of water for irrigation according to Wilcox presented in 1948

Factors	Class	Limit
Percentage of sodium	Unsuitable	> 3000
	Good	250-750
	Permissible	750-2250
	Excellent	< 250
	Doubtful	2250 -3000

4.1.20 Sodium Adsorption Ratio

For all the samples analyzed the calculated values of sodium adsorption ratio were varied from 2.88 to 3.12 with an average value of 3 (**Table 4.8** and **Figure 4.20**). The water can be classified for irrigation purpose based on the sodium adsorption ratio value as presented in **Table 4.11**. Based on our result the classification of water is Hazard for irrigation purpose according to the classification of water for irrigation reported by Richard presented in 1954.

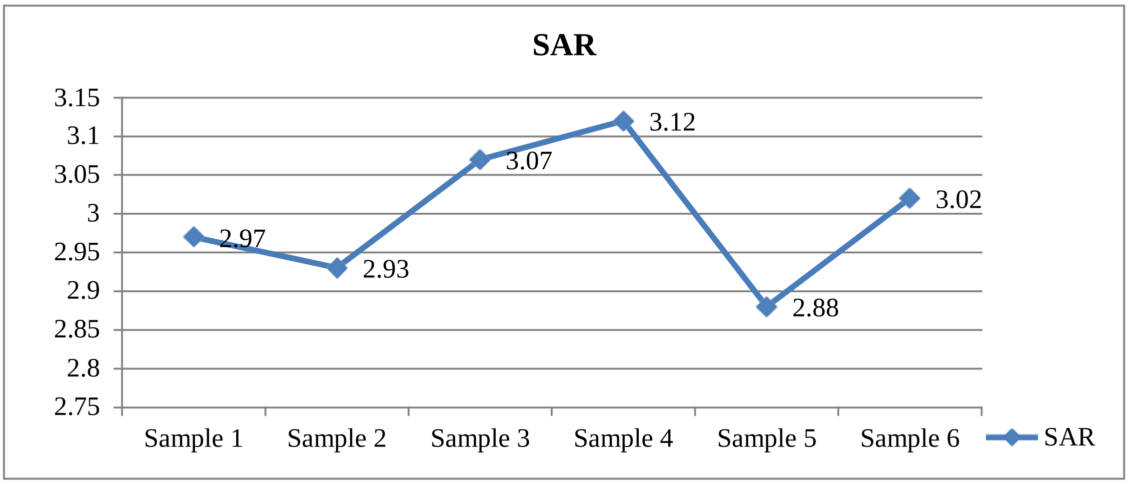

Figure 4.20. Measured Sodium Adsorption Ratio values

Table 4.11 Classification of water for irrigation according to Richard presented in 1954

Factors	Problem	Class	Limit
Sodium Adsorption Ratio (SAR)	Sodium (Alkali) Hazard	Low (S_1)	0-10
		Medium (S_2)	10 -18
		High (S_3)	18-26
		Very High (S_4)	> 26

4.1.21 Residual Sodium Carbonate

For all the samples analyzed the calculated residual sodium carbonates resulted in the maximum value of residual sodium carbonate in sample 6 (value of) 2.94 and minimum value was in sample 3 (value of 2.04) (**Table 4.10** and **Figure 4.21**).

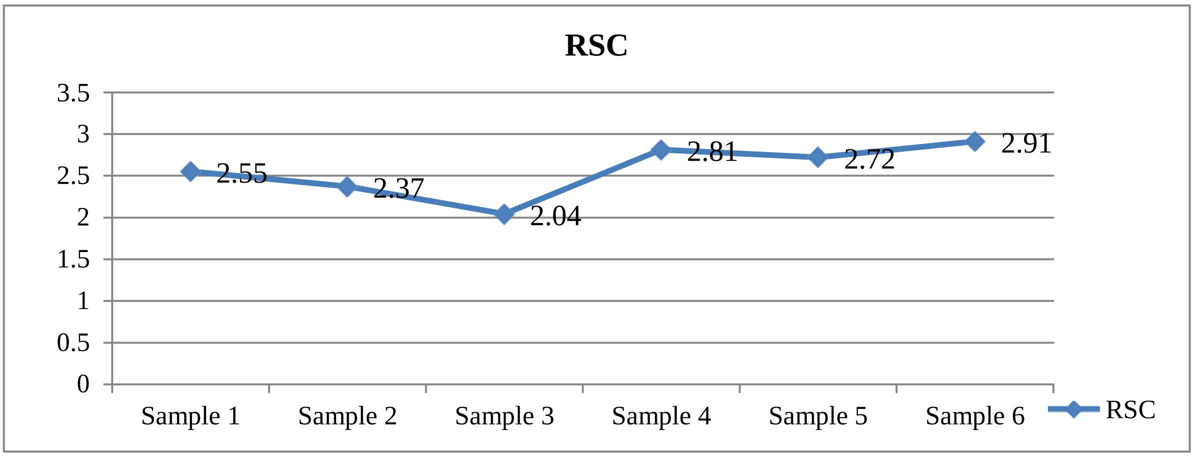

Figure 4.21. Measured Residual Sodium Carbonate values

4.1.22 Exchangeable Sodium Percentage

The minimum and maximum values of exchangeable sodium percentage were found sample 3 and sample 4 respectively. For all the samples analyzed the calculated values of exchangeable sodium percentage were ranged from 2.64 to 3.21 with an average value of 3.0 (**Table 4.8** and **Figure 4.22**).

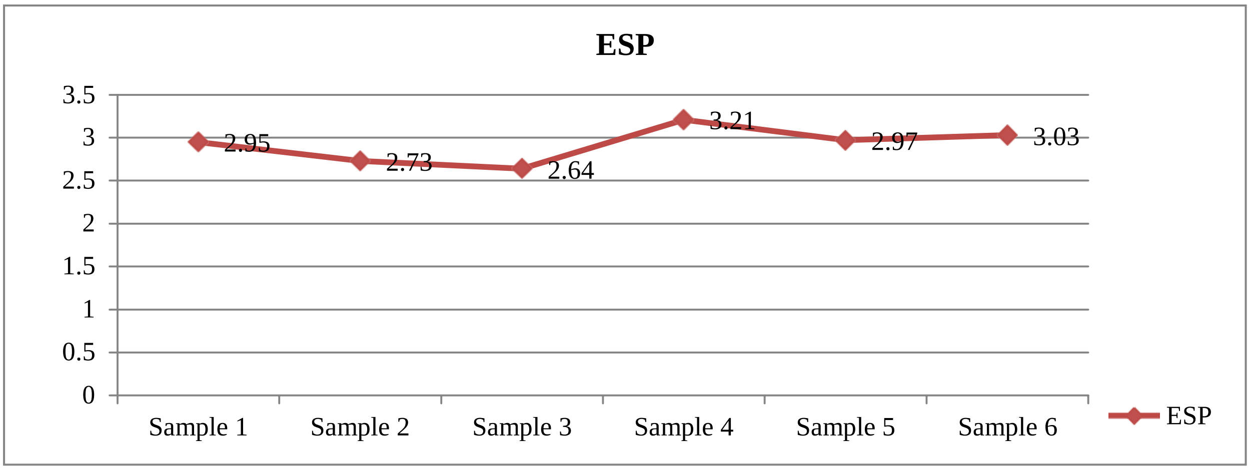

Figure 4.22. Measured Exchangeable Sodium Percentage values

The results showed that the assessment of physicochemical properties of groundwater Addis-Zemen city for six samples was employed to assess the suitability groundwater for industrial, agricultural and drinking purpose. The analysis of the result showed the deterioration of groundwater quality deteriorated. Moreover, the result indicated that the main factors which determine the groundwater hydrochemistry for the city are agriculture activities and wastewater. The result also indicated that for all kind of human usage including industrial domestic, and agricultural in the city is groundwater source.

The data also reveals that all the six samples are polluted to some extent as indicated by the values of physico-chemical factors. Also the data shows that in all the six samples TDS, EC, TA, K^+, CO_3^{2-} , NO_3^- and SO_4^{2-} were found to be inside the permissible limits as set by BIS standards but all six samples of HCO_3^-, pH, Ca^{2+},F^- and Mg^{2+}outside the permissible limits as set by BIS and WHO. Data also discloses that the quality of water all six samples is poor for and drinking and irrigation purpose. Therefore, there should be continuous checking of the pollution level so as to increase the quality of water. Moreover, the various physico-chemical factors analysis of groundwater showed that the TDS, EC, TA, K^+, CO_3^{2-} , NO_3^- and SO_4^{2-} concentration were within the allowable limit nonetheless nearly (42%) of investigated samples were high in Ca^{2+},pH, HCO_3^-, F^- and Mg^{2+} This shows that these water samples have the poor quality of water.

From the observations of the results it could easily be concluded that, the values of K^+, CO_3^{2-}, TA, NO_3^- SO_4^{2-} and TDS, were in the permissible limit while one-third of the samples studied were high in Ca^{2+}, EC, pH, HCO_3^-, Mg^{2+}, F^- and Na^+, showing the low quality of water these samples of water.

Moreover, it may be drawn out from the results that groundwater samples characteristics were inappropriate for irrigation commercial purpose, and household. But, various treatment approaches could be recommended for high values EC, pH, Na^+, NO_3^-, magnesium, calcium, and fluoride, bicarbonate, Samples collected for water-quality in this research present that all six samples of ground water comprise higher concentrations of Mg^{2+}, Ca^{2+}, HCO_3^-, and F^-.

The increase or decrease of human and biological activities may result the variations in pH values. The capacity of water to neutralize a strong acid is called alkalinity of water. For drinking water, the maximum allowable concentration of total alkalinity is 600 mg/L according to IS 10500. The hydrolysis of salts and free hydroxyl ions formed by strong bases and weak acids such carbonates and bicarbonates results in alkalinity in natural water.

Water of high total dissolved solids (TDS) restricted industrial use since it is not suitable for use in boilers. Ground water has a higher TDS load compared to surface water. The lower values could be due to the dilution of water with rainwater while the higher TDS values could be because of the concentrated water due to evaporation.

Hardness which is the property of water that avoids the lather creation with soap and enhance the boiling point of water. Calcium and magnesium are the major cat ions imparting hardness of water Bicarbonates, carbonates, chloride and sulphate are the anions accountable for hardness. Hardness is permanents if with chloride and sulphate and temporary if it is associated mainly with bicarbonates and carbonates. According to World Health Organization (WHO) hardness of water should be 500mg/L for potable water, irrigation and agriculture uses.

Magnesium presents in all sort of natural waters; however, its concentration remains lower than the calcium hardness. The variation between the total hardness and calcium hardness results in magnesium hardness.

Calcium also presents in all sort of natural waters; ion imparting the hardness to the waters and is one of the most abundant elements found in natural water. The permissible Limit For drinking and irrigation water set by WHO was given as (75mg/l).

Biological oxygen demand (BOD) was monitored in sample 1 as maximum value and biological oxygen demand was monitored in samples 2 and 3 as minimum values. The values of BOD ranged from 0.2 to 0.6 mg/L for the entire ground water samples with an average value of 0.4 mg/L. In the aspect of spatial variation, the maximum BOD value was recorded at sampling point1 and sampling point 4 respectively. This was due to the depth of boreholes and the locations of sample points from waste disposal site (the pollutant source) since in the highest in depth and downstream from the pollutant source mostly characterized by deficiency of oxygen this is indicate that the water were moderately good interims of BOD for different house hold activity because low BOD is an indicators of good quality water, while a high BOD indicates polluted water. The BOD values of groundwater guideline EPA, WHO was 5mg/l.

COD is an indicator of organic pollution, which is caused by the inflow of domestic waste, due to the fact that, most of the wastes that are being generated from the various communities (available at the dumpsite) are biodegradable or the observed pollutions of bore hole water samples studied may not be due to chemical oxidation of pollutants present but due to aerobic degradations of organic matter present by microorganism in the water samples.

The most important source of chloride in natural waters is the discharge of sewage. Chloride occurs naturally in all types of waters. In natural fresh waters, its concentration remains quite low Domestic sewage, industrial effluents, natural run-off and agricultural wastes are the important sources of it. Nitrate is one of the critical nutrients for the growth of algae and helps accelerating the eutrophication.

The higher values of sulphates content may be contributed due to bio chemical, anthropogenic sources and industrial processes etc. Sulphate is a naturally occurring anion found almost in all kinds of water bodies. This is also an important anion imparting hardness to the waters. The sulphate ion produces cathartic effect upon human beings when it is present in excess.

5. Pollution management options of ground water

In this chapter the possible pollution management options of ground water have been presented. In this part the possible ground water management options have been suggested and presented. To control the pollution of the ground water measures such as ensuring less health threats ground water should be pretreated as well as before drawing the underground water a proper planning must be executed. Moreover, checking of pesticides and fertilizers is needed since the agricultural activities and domestic waste affect the quality of groundwater. Also, the non-government and government organization should have implemented or organized the people awareness activism and water quality index is a manual way in order to understand the water quality. Hence, programs should be employed to monitor the hand pumps and bore wells that exceed the limitation of guidelines and this situation required vital treatment since the general groundwater quality is low and the following different should be taken. Firstly, chemically treatment must be done in order to convert toxic substance into harmless substance, Hence, before waste discharge wastes treatment is essential. So as to avoid pollution of water animal and human excreta must be prohibited from mixing with sources of water. The water discharged from household must be treated resulting in environmentally safe water source. Secondly, harmful pollutants should be removed before they introduce into groundwater so that the water must be treated before they flow into the drainage system. Hence, laws must be imposed on people relating to pollution. Thirdly, separating out undesirable dissolved chemicals constituents" chemical treatment must be given so that he treated water could be employed for cleaning purpose or farming. Fourthly, bathing of animals and washing of clothes make unsuitable for use and the pond water dirty. Therefore, bathing of animals and washing in the pond which is employed by human must not be made. Also, one must not put his hands into the containers of drinking water and should be kept undercover in a neat place. Moreover, the drinking water should be made free of microorganisms by boiling to kill microorganism before use. Moreover, system of sanitation should be increased by giving a chance to the people to the aware of the advantages of cleanliness on human health. Also, the governmental and non-governmental organizations may render door-to-door services to teach about environmental problems for the people so that the people should understand the cause and effect of the pollution of water.

6. Conclusion and Recommendation

6.1. Conclusion

This study shows that the water is an important parameter for a sustainability and ecological balance of biodiversity. Water is an abundant transparent liquid and physical substance on earth and it is the foundation of all form of life and an essential natural resource for life of plants, animals and human beings on water planet. Moreover, Sufficient and safe drinking water supply is a vital problem in urban and many rural areas in developing countries.

Ground water samples were collected from selected locations of Addis Zemen city and the physicochemical factors such as conductivity, TDS, pH, magnesium, total alkalinity, sulphate, nitrate, potassium, phosphate, hardness, sodium, fluoride and chloride were characterized by employing standard research methods.

The groundwater quality and its appropriateness for drinking and irrigation purpose were investigated. The average physicochemical properties of groundwater were a conductivity of 1137 µs/cm, a total hardness of 439 mg/l, a magnesium of 179.5 mg/l, a calcium of 309.5 mg/l, a total dissolved solid of 887 mg/l, a pH of 8.40, a total alkalinity of691 mg/l, a sodium of 109 mg/l, a phosphate of 0.28 mg/l, a chloride of mg/l, a potassium of 5 mg/l, a sulphate of 64 mg/l, a nitrate of 19 mg/l. bicarbonates alkalinity value of 565 mg/L.

Moreover, the most popular characterization techniques such as exchangeable s odium percentage , percentage sodium, residual sodium carbonate, sodium adsorption ratio, and Langelier saturation index showed that the groundwater samples were inappropriate for irrigation and unsuitable for drinking as it is below the standards set by World Health Organization and other standards..

Therefore, the ground water management and treatment are important and well developed treatment mechanism is also necessary.

6.2. Recommendation

The following recommendations are also made:

- Biological parameter of ground water should be analyzed and detail investigation analysis should be done at the municipality level of the city.
- Seasonal effects of the physico-chemical factors of groundwater quality with respect to seasonal effects should be done.
- The pesticides and fertilizers should be checked since needed since the agricultural activities and domestic waste affect the quality of groundwater.
- The non-government and government organization should have implemented or organized the people awareness activism in understanding the water quality.
- Household treatment such as boiling should be encouraged before the ground tap water is used for drinking purposes until well developed treatment mechanism is applied.

References

1. Dahiya S and Kaur A, Assessment of physical and chemical characteristics of underground water in rural areas of Tosham subdivision, Bhiwani-Haryana, International J. of Environment and pollution, 6(4), 281-288,**1999.**

2. Ravindra K and Garg V K, Appraisal of ground water quality for drinking purpose in Hisar city (India) with special reference to fluoride. Int. J. Env. Hlt. Res, in press**2005.**

3. Horton R K, An index number system for rating water quality, J. Wat. Poll. Control Fed., 37, 300-305,**1965.**

4. Gajendran C and Thamarai P, Study on statistical relationship between ground water quality parameters in Nambiyar River basin, Tamil Nadu, India, International J. on pollution research, 27(4), 679 – 683, **2008.**

5. Ryznar John W, An Index for determining the amount of Calcium Carbonates Scale formed by a water, Nalco Chemical Company, One Nalco Centre, Naperville, Illnois, USA,**1986.**

6. Parihar S S, Kumar A, Kumar A, Gupta R N, Pathak M, Shrivastav A, and Pandey A C, Physico- Chemical and Microbiological Analysis of Underground Water in and Around Gwalior City, MP, India.Research J. of Recent Sciences. 1(6), 62-65, **2012.**

7. Indian standard specification for drinking water. IS:10500, Ind. Standard Institute, India, ISI,**1983.**

8. Suma Latha S, Ambika S R A and Prasad S J, Fluoride concentration status of groundwater in Karnataka, India. Current Sci. 76, 730–734, **1999.**

9. Indian standards for drinking water Speciation. Bureau of Ind. Standard, New Delhi (BIS 10500),**2012.**

10. Verma S, Mukherjee A, Choudhury R and Mahanta C, Brahmaputra River Basin Groundwater: Solute Distribution, Chemical Evolution and Arsenic Occurrences in Different Geomorphic Settings. J. of Hydrology, Regional Studies, 4, 131-153,**2015.**

11. Majumdar D and Gupta N, Nitrate pollution of ground water and associated human health disorders. Ind. J. of Environ. Health 42, 28– 39, **2000.**

12. Kumar M, Ramanathan A l, Rao M S, Kumar B, Identification and evaluation of hydrogeochemical processes in the groundwater environment of Delhi, India. Environ Geol 50, 1025-1039,**2006.**

13. Bouwer H, Integrated water management: Emerging issues and challenges, agricultural water management. 45,**2000.**

14. Patel P and Bhatt S, A Fluoride Contamination in Groundwater of Patan District, Gujarat, India, International J. of Engineering Studies, 1(2), 171–177,**2010.**

15. Appelo C A J and Postma D, Geochemistry, groundwater and pollution, Second Edition. Balkema, Leiden, the Netherlands, 683, **2005.**

16. Nitrate and nitrite in drinking water Background document for development of WHO Guidelines for Drinking-water Quality, WHO, **2007.**

17. Atta A I, and Razzak B I A, Chemical and physical analysis of some ground water sample in Al- Quti wells Hodiedah, Yemen. J. Iran. Chem. Res., 1, 141-144,**2008.**

18. Mark W R, Ximing C, and Sarah A C, World Water and Food to 2025, dealing with security, International Food Policy Research Institute, NY. Washington DC, USA,**2002.**

19. Foster S S D, Groundwater for development- overview of quality

constraints. In: Nash H, McCall GJH (eds) Groundwater quality, Water Resources Bulletin, 28(3), 525-533,**1995.**

20. R M, McClelland N I, Deininger R A and Tozer R G, A water quality index: Do we dare?", Water & Sewage Works, 117, 339–343, **1970.**

21. Das P K and Malik S D, Groundwater of Khatra region of Bankura district, West Bengal: Some chemical aspects in reference to its utilization, J Ind. Water Res Soc, 8(3), 31-41, **1988.**

22. Sawyer C N, McCarty P. L. and Gene F P, Chemistry for Environ. engineering. IVth Ed., Tata McGraw-Hill, New Delhi, **2000.**

23. Ganesh R H and Kale Y S, Quality of lentic waters of Dharwad district in north Karnataka, Ind. J. Environ. Hlth., 37(1), 52-56**1995.**

24. Durvey V S, Sharma L L, Saini V P and Sharma B K, Hand book on the methodology of water quality assessment, Rajasthan Agriculture University, India,**1991.**

25. Garg M, Kavita V K and Malik R A, Groundwater quality in some villages of Haryana India: focus on fluoride and fluorosis, J. of Hazardous Material, 106B, 85-97,**2004.**

26. Tripathi I P and Singh R, Fluoride distribution in ground water at the around Chitrakoot, Ind. J. Environ. Prot. 16, 805-807, **1996.**

27. Tatawat R K and Chandel P S, Quality of ground water of Jaipur city, Rajasthan (India) and its suitability for domestic and irrigation purpose" Applied Ecology and Environ. Research, 6(2), 79-88,**2007.**

28. Todd D K, Groundwater hydrology. John Wiley and Sons, New York (1995). Vates, M.V.: Septic tank density and groundwater contamination, Groundwater, 23(5), 586-590, **1986.**

29. Banerji A K, Importance of evolving a management plan for groundwater development in the Calcutta region of the Bengal basin in eastern India. Proc. Intn. symp. Groundwater resources and planning, Koblent, Germany, 45-54,**1983.**

30. Datta N C and Gupta S S, Effect of artificial aeration on the hydrographic regime of pesticide treated aquatic system. Poll. Res., 15(4), 329-333,**1996.**

31. Handa B K, Hydrochemical zones of India. Proc. Seminar on groundwater development, Roorkee, 439-450,**1986.**

32. Rajankar P N, Wate S R, Tambekar D H and Gulhane S R, Assessment of Ground Water Quality using water quality index(WQI) in Wardha Maharashtra, J. of Environ. Science and Sustainability, NEERI, 1(2), 49-54,**2013.**

33. Reddy M, Status of groundwater quality in Bangalore and Its environs. Groundwater (Minor Irrigation), Bangalore, 44-2, **2003.**

34. Rengaraj S and Ramalingam V, Groundwater quality in suburban regions of Madras city, India. Poll. Res., 15(4), 325-328,**1996.**

35. Sharma H and Kaur B K, Environ. chemistry. Goel Publishing House, Meerut.**1995.**

36. Subba Rao C and Subba Rao N V, Groundwater quality in a residential colony. Ind. J. Environ. Hlth., 37(4), 295-300, **1995.**

37. Shrivastava V S and Patil P R, Tapti river water pollution by industrial wastes: A statistical approach. Nat. Environ. Pollut. Tech., 1(3), 279- 283, **2002.**

38. Zafar A R, Limnology of Hussain Sagar lake, Hyderbad. Phykos., 5, 115-126,**1966.**

39. Rout C and Sharma A, Assessment of drinking water quality: A case study of Ambala cantonment area Haryana India, Inter. J. of Environ. Sci. 2, 933-945,**2011.**

40. Jameel A A and Hussain A Z, Assessment of ground water quality on bank of Uyyakonda channel of river Cauvery at Tiruchirappalli, Ind. J. Environ. Prot. 27, 713-716,**2007.**

41. Saralakumari D and Rao P R, Endemic fluorosis in the village Ralla, Anantapuram in Andra Pradesh. An epidemiological study. Fluoride, 26(3), 177-180,**1993.**

42. Prevention and Cotrol of Fluorosis in India: (Health Aspects) (Ed. Susheeia, A. K.) Rajiv Gandhi National Drinking Water Mission, 1, **1993.**

43. Rao P M and Yadav Y S, Water Quality Studies on Kolleru Lake and Its Infalling Drains of A.P., India, Water Pollution. APH Publishing Corporation, New Delhi, 171, **2004.**

44. Chhatwal Gurdeep Raj, Advanced Physical Chemistry, Goel Publishing house, Meerut**(2002).**

45. Rajankar P N, Wate S R, Tambekar D H and Gulhane S R, Assessment of Ground Water Quality using water quality index(WQI) in Wardha Maharashtra, J. of Environ. Science and Sustainability, NEERI, 1(2), 49-54,**2013.**

46. Karunakaran K, Statistical study on physicochemical characteristics of groundwater in and around Namakkal, Tamilnadu, India. E-J. of Chemistry, 6(3), 909-914,**2009.**

47. Adhikary, P P, Chandrasekharan, H, Chakraborty, D, Kamble, Assessment of groundwater pollution in West Delhi, India using geostatistical approach

Environ. Monitoring and Assessment, 154 (1- 4), 41-52, **2009.**

48. Aghadeh N and Mogaddam, Assessment of Groundwater Quality and its Suitability for Drinking and Agricultural uses in the Oshnavish Area, Northeast of Iran, J. of Environ. protection, 1, 30-40,**2010.**

49. Almasri M N and Kaluarachchi J J, Assessment and management of long-term nitrate pollution of ground water in agriculture-dominated watersheds. J. of Hydrology, 295, 225-245,**2004.**

50. American Public Health Association (APHA): (1998) American Water Works Association, Water Environment Federation (1998). Standard methods for examination of water and wastewater (20th ed.). New York, USA: American Public HealthAssociation.

51. Ashley R P and Burely M J, Controls on the occurrence of fluoride in the groundwater in the Rift Valley of Ethiopia, in H.Nash and G.J.H. McCall (eds) Groundwater Quality, 17th Special Report, Chapman and Hall, 45-54,**1994.**

52. Atta A I, and Razzak B I A, Chemical and physical analysis of some ground water sample in Al- Quti wells Hodiedah, Yemen. J. Iran. Chem. Res., 1, 141-144,**2008.**

53. Mondal N C and Saxena V K, Assessment of groundwater pollution due to tannery industries in and around Dindigul, Tamilnadu, India. Environ Geol, 48,149-157,**2005.**

54. Nitrate and nitrite in drinking water Background document for development of WHO Guidelines for Drinking-water Quality, WHO, **2007.**

55. Parihar S S, Kumar A, Kumar A, Gupta R N, Pathak M, Shrivastav A, and Pandey A C, Physico- Chemical and Microbiological Analysis of

Underground Water in and Around Gwalior City, MP, India.Research J. of Recent Sciences. 1(6), 62-65, **2012.**

56. Babu K N, Padmalal D, Maya K, Sreeja R and Arun P R, Quality of Surface and Ground Water Around Tile and Brick Clay Mines in the Chalakudy River Basin, Southwestern India. J. Geol. Soc. India, 69, 279-284,**2007.**

57. Raja R E, Physico- Chemical Analysis of Some Groundwater Samples of Kotputli Town Jaipur, Rajasthan. Ind. J Environ Prot. 22(2), 137, **2002.**

58. Patel P and Bhatt S, A Fluoride Contamination in Groundwater of Patan District, Gujarat, India, International J. of Engineering Studies, 1(2), 171–177,**2010.**

59. Raja G and Venkatesan P, Assessment of Groundwater Pollution and its impact in and around Punnam Area of Karur District, Tamilnadu, India, E-J. of Chemistry, 7(2), 473-478,**(2010).**

60. Rajankar P N, Wate S R, Tambekar D H and Gulhane S R, Assessment of Ground Water Quality using water quality index(WQI) in Wardha Maharashtra, J. of Environ. Science and Sustainability, NEERI, 1(2), 49-54,**2013.**

61. Ramakrishniah C R, Sadashivaiah C, and Ranganna G, Assessment of Water Quality Index for the Groundwater in Tumkur Taluk, E-J. of Chemistry, 6(2), 523-530,**2009.**

62. Ramappa R and Suresh T S, Quality of groundwater in relation to agricultural practices in Lokapavani river basin, Karnataka, India. Proceedings of International Seminar on Applied Hydrogeochemistry, Annamalai University, 136-142,**2000.**

63. Rao S N, Seasonal variation of groundwater quality in a part of Guntur District andhra Pradesh, India. Environ. Geol., 49, 413-429,**2006.**

64. Ramesh K and Soorya V, Hydrochemical Analysis and Evaluation of Groundwater Quality in and around Hosur, Krishnagiri District, Tamil Nadu, India. International J. of Research in Chemistry and Environment. 2(3), 113-122,**2012.**

65. Rao P M and Yadav Y S, Water Quality Studies on Kolleru Lake and Its Infalling Drains of A.P., India, Water Pollution. APH Publishing Corporation, New Delhi, 171, **2004.**

66. Rao R, Satyanarayan T and Machiraju P V S, Assessment of ground water quality for application in Kakinada Coast, Der Chemica Sinica. 3, 287-291,**2012.**

67. Rao S N and Suryanarayana K, Ground water quality in a coastal area: A case study from Andhra Pradesh, India. Environ. Geology, 48(4-5), 543-550,**2005.**

68. Ratnakanth Babu M J, Assessment of Groundwater Pollution in Parts of Guntur District Using Remote Sensing & GIS, International J. of Earth Sciences and Engineering, 4(6), 1024-1030,**2011.**

69. Raval V H and Malik G M, Physico-chemical characteristics of ground water in around Surat City (India). J. Environ. Sci. and Engg. 52, 343- 348, **2010.**

70. Ray D and Sanyal P B, Physico-chemical quality of drinking water in Rohtas district of Bihar. Environ. Monitoring and Assessment. 61, 387-398,**2000.**

71. Shrivastava N and Tyagi A, Study of physicochemical Characteristics of waterbodies around Jaipur, J. Environ. Bio., 24 (2), 177–180, **2003**

72. Richard L A, Diagnosis and improvement of saline soils, U.S. Dept. Agriculture, Handbook 60, 160, **1954.**

73. Shivasharanappa S P and Mallikarjun H S, Assessment of ground water quality characteristics and Water Quality Index (WQI) of Bidar city and its industrial area, Karnataka State, India", International J. of Environ. sciences, 2(2), 965-976, **2011.**

74. The Federal Environmental Protection Authority Standards for Specified Industrial Sectors Protection Authority, E.P.A. (2012).

75. Guidelines for Drinking-Water Quality.2nd Edn. Vol., 1.World Health Organization, Geneva, WHO, **1993.**

76. Nitrate and nitrite in drinking water Background document for development of WHO Guidelines for Drinking-water Quality, WHO, **2007.**

77. WHO, International Standards for Drinking Water, World Health Organization, Geneva, **1971.**

78. WHO, "Guidelines for drinking water quality", Geneva, WorldHealth Organization, **2004.**

79. Machiwal D and Jha M K, Identifying Sources of Groundwater Contamination in a Hard-Rock Aquifer System Using Multivariate Statistical Analyses and GIS-Based Geostatistical Modeling Techniques. J. of Hydrology: Regional Studies, 4, 80-110,**2015.**

80. Prajapati R and Mathur R, Statistical studies on the ground water at the rural areas of Sheopurkalan, Madhya Pradesh, J. of ecotoxial Environ. monit., 15(1), 47-54,**2005.**

81. Westcot D W and Ayers R C, Water quality criteria in Irrigation with Reclaim municipal wastewater: A guidance resources control board sacramento, California, **1984.**

82. Warner DB et al. Water and food-aid in environmentally sustainable development: anenvironmental study of potable water and sanitation activities within the Title II Program in Ethiopia.Report for the US Agency for International Development Mission to Ethiopia. Addis Ababa: USAID, **2000.**

83. Standards methods for Examination of Water and Wastewater. American Public Health Association, American Water Work Association and Water Pollution Control Federation, 22nd, Washington, DC, **2012.**

84. American Public Health Association (APHA): (1998) American Water Works Association, Water Environment Federation (1998). Standard methods for examination of water and wastewater (20th ed.). New York, USA: American Public Health Association.