

Chapter one

Introduction and Literature review

1.1 Introduction:

Water is a chemical substance with the chemical formula H_2O . Its molecule contains one oxygen and two hydrogen atoms connected by covalent bonds. Water is a liquid at ambient conditions, but it often co-exists on Earth with its solid state, ice, and gaseous state, water vapor or steam. Water covers 70.9% of the Earth's surface and is vital for all known forms of life. On Earth, it is found mostly in oceans and other large water bodies, with 1.6% of water below ground in aquifers and 0.001% in the air as vapor, clouds (formed of solid and liquid water particles suspended in air), and precipitation. Oceans hold 97% of surface water, glaciers and polar ice caps 2.4%, and other land surface water such as rivers, lakes and ponds 0.6%. A very small amount of the Earth's water is contained within biological bodies and manufactured products.

Water plays an important role in the world economy, as it functions as a solvent for a wide variety of chemical substances and facilitates industrial cooling and transportation. Approximately 70% of freshwater is consumed by agriculture. (<https://enWikipedia.Org/wiki/water>)

1.2 Importance of Water:

Water is vital for life, and one of the basic resources and development of human society.

Water from the deferent resources is required for a variety of human uses, including domestic consumption (drinking, washing and cooking), also it is

important use in industry (industrial processes irrigation mineral extraction; washing and cooling in factories). (Brian, 1999)

1.3 Water resources:

Water resources are useful to human, animals and plants. Many uses of water including agricultural, industrial household recreational and environmental activities virtually require fresh water.

Only 3% of water on the earth is fresh water and over two thirds of this is frozen in glaciers and polar ice caps. (Mark,1981)

1.4 The hydrological cycle:

Fresh water is renewable resource of the hydrological cycle, but for all practical it is a finite one. The hydrological cycle is a continuous process by which water is a transported from the oceans to the atmosphere, to the land and back to the sea.

This cycle involves evaporation of water from the sea to the atmosphere subsequent precipitation over the sea or land and transpiration back to the atmosphere through plants, over land flow into streams, flow through the soil and infiltration and storage or flow in the ground. Other part of water flows back to the sea, along with dissolved and suspended materials. Every year solar energy converts 500,000km³ of water from sea and land into water vapor (Brian, 1999).

1.5 Water sources and uses:

Animals consume water from streams lakes ponds and smaller reservoirs of accessible water human add to this supply by forming artificial reservoirs to store water and by digging wells to obtain ground water. Of course, all to these supplies would soon be depleted in nature did not replenish them through rainfall and seepage.

Shortages and surpluses lead to the assignment of water rights and responsibilities that can be very expansive and cause much contention .It should be noted that effects of pollution on quality add complications to the already complex matter of water rights. (Frederick, 2004)

1.5.1 Fresh Water Sources:

1. Surface water:

Surface water is water in a river, lake or fresh water wetland. Surface water is naturally replenished by precipitation and naturally lost through discharge to the oceans, evaporation, evapotranspiration and sub-surface seepage.

Although the only natural input to any surface water system is precipitation within its watershed, the total quantity of water in that system at any given time is also dependent on many other factors. These factors include storage capacity in lakes, wetlands and artificial reservoirs, the permeability of the soil beneath these storage bodies, the runoff characteristics of the land in the watershed, the timing of the precipitation and local evaporation rates. All of these factors also affect the proportions of water loss.([https:// en. Wikipedia. Org/ wiki/ water- resources.](https://en.Wikipedia.Org/wiki/water-resources))

2. Ground water:

Sub-surface water, or groundwater, is fresh water located in the pore space of soil and rocks. It is also water that is flowing within aquifers below the water table. Sometimes it is useful to make a distinction between sub-surface water that is closely associated with surface water and deep sub-surface water in aquifer (sometimes called "fossil water").

Sub-surface water can be thought of in the same terms as surface water: inputs, outputs and storage. The critical difference is that due to its slow rate of turnover, sub-surface water storage is generally much larger compared to inputs than it is for surface water. This difference makes it easy for humans to use sub-surface water unsustainably for a long time without severe consequences. Nevertheless, over the long term the average rate of seepage above a sub-surface water source is the upper bound for average consumption of water from that source.([https:// en. Wikipedia. Org/ wiki/ water- resources.](https://en.Wikipedia.Org/wiki/water-resources)) .

3. Frozen water:

Several schemes have been proposed to make use of icebergs as a water source, however to date this has only been done for novelty purposes. Glacier runoff is considered to be surface water. (Taylor,1958).

1.5.2 Water Uses:

Water has many uses some of them are:

Drinking:

The human body is anywhere from 55% to 78% water depending on body size. To function properly, the body requires between one and seven liters of water per day to avoid dehydration; the precise amount depends on the level of activity, temperature, humidity, and other factors. . ([https://enWikipedia. Org/ wiki/ water](https://enWikipedia.Org/wiki/water))

Agricultural:

It is estimated that 70% of worldwide water is used for irrigation, with 15-35% of irrigation withdrawals being unsustainable. It takes around 2,000 - 3,000 liters of water to produce enough food to satisfy one person's daily dietary need. This is a considerable amount, when compared to that required for drinking, which is

between two and five liters. To produce food for the now over 7 billion people who inhabit the planet today requires the water that would fill a canal ten meters deep, 100 meters wide and 2100 kilometers long. ([https:// en. Wikipedia. Org/ wiki/ water- resources.](https://en.wikipedia.org/wiki/water-resources))

Industrial:

It is estimated that 22% of worldwide water is used in industry. Major industrial users include hydroelectric dams, thermoelectric power plants, which use water for cooling, ore and oil refineries, which use water in chemical processes, and manufacturing plants, which use water as a solvent. Water withdrawal can be very high for certain industries, but consumption is generally much lower than that of agriculture. ([https:// en. Wikipedia. Org/ wiki/ water- resources.](https://en.wikipedia.org/wiki/water-resources))

Recreation:

Humans use water for many recreational purposes, as well as for exercising and for sports. Some of these include swimming, waterskiing, boating, surfing and diving. In addition, some sports, like ice hockey and ice skating, are played on ice. Lakesides, beaches and water parks are popular places for people to go to relax and enjoy recreation. ([https://enWikipedia. Org/ wiki/ water](https://enWikipedia.Org/wiki/water))

Extinguishing:

Water has a high heat of vaporization and is relatively inert, which makes it a good fire extinguishing fluid. The evaporation of water carries heat away from the fire. However, only distilled water can be used to fight fires of electric equipment, because impure water is electrically conductive. Water is not suitable for use on fires of oils and organic solvents; because they float on water and the explosive boiling of water tends to spread the burning liquid. ([https://enWikipedia. Org/ wiki/ water](https://enWikipedia.Org/wiki/water))

Washing:

The propensity of water to form solutions and emulsions is useful in various washing processes. Many industrial processes rely on reactions using chemicals dissolved in water, suspension of solids in water slurries or using water to dissolve and extract substances. Washing is also an important component of several aspects of personal body hygiene.(<https://enWikipedia.Org/wiki/water>)

1.6 Water Quality:

Water quality is an important consideration, but there are difficulties in evaluating it. For one thing it can be quite variable. For example the water quality in river during a spring run-off period may be considerably different that it is at other time .Another significant factor is use to the water.

Quality standards are quite different for drinking water than they are for irrigation water or for industrial use water.

The importance of given factors in water quality may depend in part on the water treatment facilities that are available. (Frederick, 2004)

The workers are a water treatment plant need to know what impurities are in the water coming in the plant so they can treat it appropriately, but household user are mainly concerned with the quality of the water after it has been treated as it comes from their faucets.

Municipal water may be pumped from a nearby stream or from wells that reach the groundwater. Surface water tends to be softer, since water dissolves materials from soil and rocks on its way to the water table. (Frederick, 2004)

Water treatment plants are generally needed to assure water quality. The treatments details vary depend on circumstances, but usually include one or more filtration systems, addition of coagulant and a period of settling to remove colloidal material, and the addition of chemicals to control microbial populations. Fluorides are often added to reduce tooth decay. Hard water may be softened by chemical treatment to raise the pH and precipitate calcium carbonate and iron compounds.

Water quality standards for drinking water Table (1-1) are established by the environmental protection agency in the united state and by similar agencies in other nation. (Frederick, 2004)

Water users have several alternatives available if the quality of their water supply is inadequate to meet their personal needs or standards. One option especially useful when traveling is to purchase bottled water. At home one may choose install a water softener or a filter system. Filters range from a simple carbon filter that attaches to a faucet to a multi-stage reverse osmosis system that will even remove dissolved ions from water. (Frederick, 2004)

Table (1-1) Water –Quality Standard For Selected Contaminates In Drinking Water. (Frederick, 2004)

	U.S.EPA	Canada	World health organization
Fecal coli forms	0	0	0
Asbestos fibers/ L	7Million	-	-
Turbidity , turbidity units	-	5	5
Aluminum , mg/L	-	-	0.2
Antimony, mg/L	0.006	-	
pH	-	6.5-8.5	<8.0
Arsenic mg/L	0.05{0.01 after 1/3/2006}	-	-
Barium mg/L	2	-	-
Beryllium mg/L	0.005	-	-
Boron mg/L	-	5	0.3
Cadmium mg/L	0.005	0.005	0.003
Chromium	0.1	0.05	0.05
Chloride	-	250	250
Copper	1.3{goal}	1.0	2
Cyanide	0.2	-	-
Fluoride	4	1.5	1.5
Lead	0 {goal}	0.05	0.01
Mercury	0.002	0.001	0.001
Nitrate AS N	10	10	-
Nitrite as N	1	-	-
Selenium	0.05	-	-
Sodium	-	-	200
Sulfate	-	500	250
Tallium	0.002		
Zinc	5 {recommended}	5.0	3
DDT		30	2
Hepta chlor	0.004	-	-
Lindane	0.0002	4.0	2
PCBsmg/c	0.0005	-	-
Total Dissolve solid mg/L	-	500	1000

1.7 Water Pollution:

Water is considered polluted if some substances or condition is present to such a degree that the water cannot be used for a specific purpose. Defined water pollution to be the presence of excessive amounts of a hazard (pollutants) in water in such a way that it is no long suitable for drinking, bathing, cooking or other uses. Pollution is the introduction of a contamination into the environment. It is created by industrial and commercial waster, agricultural practices, everyday human activities and most notably, models of transportation. No matter where you go and what you do, there are remnants earths environmental and its inhabitants in many ways. The three main types of pollution are: Land Pollution, Air Pollution and Water Pollution. Both for the purpose of this research, emphasis are on water pollution and control.(Owa, 2014)

1.8 Effects of Water Pollution:

Water pollution has a duel effect on nature. It has negative effects on the living and also on the environment. The effects of pollution on human beings and aquatic communities are many and varied. Water pollution causes approximately 14,000 deaths per day, mostly due to contamination of drinking water by untreated sewage in developing countries. An estimated 700 million Indians have no access to a proper toilet, and 1,000 Indians children's die of diarrhea every day and so many other countries too. Nearly 500 million Chinese lack access of safe drinking water.

Definitely with all these, we can expect that there is going to be a reduction in productivity. Biomass and diversity of communities are to be expected when large amount of toxic materials are released into the streams, lakes and coastal waters in the ocean. Much of aquatic pollution involves sewage in which organic

waste predominate. This waste can increase secondary productivity while altering the character of the aquatic community. Most fishes especially the species desired as food by man are among the sensitive species that disappear with the least intense pollution. (Owa, 2014)

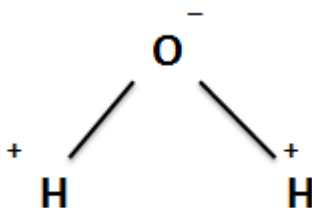
Water pollution leads to damage to human health. Disease carrying agents such as bacteria and viruses are carried into the surface and ground water. Drinking water is affected and health hazards result. Direct damage to plants and animals nutrition also affects human health. Plants nutrients including nitrogen, phosphorus and other substances that support the growth of aquatic plant life could be in excess causing algal bloom and excessive weed growth. This makes water to have odour, taste and sometimes colour. Ultimately, the ecological balance of a body of water is altered. Sulphur dioxide and nitrogen oxides cause acid rain which lowers the pH value of soil and emission of carbon dioxide cause ocean acidification, the ongoing decrease in the pH of the Earth's Oceans as CO₂ becomes dissolved. (Owa, 2014)

1.9 Water Chemistry:

Water is the most abundant molecule on the earth surface and one of the most important molecules to study in chemistry. Water is an unusual compound with unique physical and chemical properties .As a result it is the compound of life. Chemistry is important to environmental engineering and science because the ultimate fate of many pollutants discharges to air, water soil and treatment facilities is controlled by their reactivity and chemical speciation. (James, 1999)

1.9.1 Chemical Structure of Water:

Each water molecule is composing of two hydrogen atom and oxygen atom. The nature of the bond that hold these atom together is important and even more important is the bond formed between molecule of water for this bond determine water special properties .Fig(1-1) . (Madina, 2012)



Fig(1-1) Structure of Water Molecule.

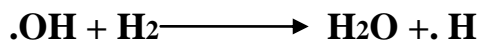
Each hydrogen atom contains one proton and one electron in 1S orbital, the atom of oxygen is contain eight proton and eight electron in 1s, 2s and 2p orbital.

When two hydrogen atom and oxygen atom united by sharing a pair of electron (this called a covalent bond). The valence or combining capacity of an atom is determined by its outer election shell. This outer shell sometime called the valance shell, when two atom share electrons their valance shell are thus joined by a covalent bond. (Madina, 2012)

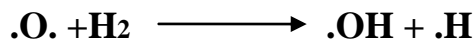
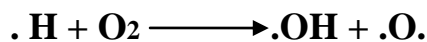
By far the most important binary compound with hydrogen in the group 16 is water, H₂O. The bonding and properties of water have been discussed extensively of contexts already. Its standard Gibbs energy of formation is strongly negative (-237.1 KJ mol⁻¹) so compound is thermodynamically stable with respect to its element. The chemical properties of water include its role as an excellent

solvent for many ionic compounds and for substance with which it can form hydrogen bond .It act normally present with about six H₂O molecules attached as ligand, via O atom. Water is a mild reducing agent but it need powerful oxidizing agent before it can release electron .It is stronger oxidizing agent.

The mechanism of reaction of hydrogen gas with oxygen gas to produce water has been extensively studied. In a simple chain a radical carrier (.OH) is consumed with the production of another carrier (.H)



In branching chain, more than one radical carrier is produced when one radical react:

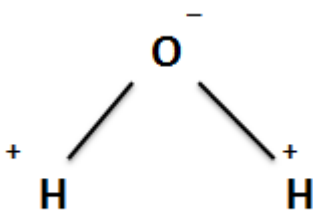


Water is unique as a solvent for ionic compound it is a mild reducing agent it act as Lewis base .The formation of water from is element occurs by a radical chain mechanism. (Atkins,1999).

In the resulting water molecules however, the electron are not shared equally the oxygen nucleus with its eight proton is more attractive to the negative charged

electron than the hydrogen nucleus with its single proton. A negative charge therefore accumulates around the oxygen atom in the molecules and a positive charge accumulates near each of hydrogen atom as shown in Fig (1 -1) .

The positive charged regions (the hydrogen) of the water molecular attracted to negative charged region the (oxygen atom) of another water molecule and strong bond called a hydrogen bond develops between the water molecule hydrogen bond are significant both in their strength and their dimensions and direction which result in water molecule being joined together in a three dimensional structure Fig (1-2). (Madina, 2012)



Fig(1-1) structure of water molecule.

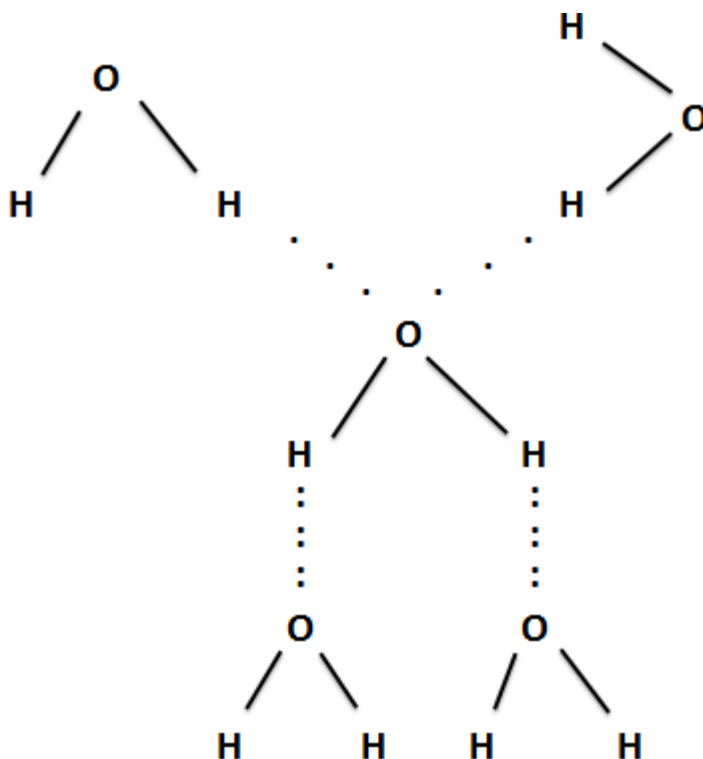
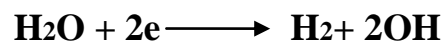
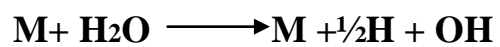


Fig (1- 2)The hydrogen bond of water molecule.

Water may act as an oxidizing agent when it acts in this way it is reduced to H_2 :

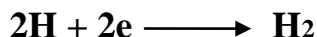


Example:



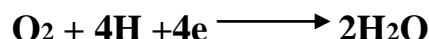
$$E = - (0.059 \text{ V}) \text{ pH}$$

However the potential required for the reduction of hydronium ion is the same:

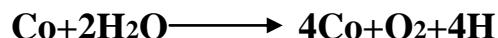


$$E = - (0.059 \text{ V}) \text{ pH}$$

Water may also act as reducing agent when it oxidized to O₂:



$$E = (1.23 \text{ V} - 0.059\text{V}) \text{ pH}$$



Water can act as reducing agent (that is be oxidized by other species) provided the over potential can be exceeded. (Atkins, 1999)

Water is naturally one of the best solvent however this unfortunately means that many contaminants can dissolve and be transport by water.

Water chemistry is frequently complex and the pH and temperature of the water as well as the presence of dissolve gases such as oxygen and / or carbon dioxide must often be measure if the analytical information is to be trusted or indeed be relevant the environmental purpose for which it is sought . Water sample can contain single-celled organisms (protoza) through to higher animal such as fish as well as course plant life. (Seamus, 2004)

1.9.2 Ligand Chemistry:

Water Lewis base character make it a common ligand in transition metal complex examples of which range from solvated ions, such as Fe (H₂O)₆³⁺ to perrhenic acid , which contains two water molecules coordinate to arhnum atom,

to various solid hydrate such as $\text{CoCl}_2 \cdot 6\text{H}_2\text{O}$. Water is typically a monodentate ligand, it forms only one bond with the central atom. ([http:// en Wikipedia. Org/ Wiki/ Properties- of -water](http://en.wikipedia.org/wiki/Properties_of_water))

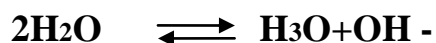
1.9.3 Organic Chemistry:

As a hard base, water reacts readily with organic carbocations. For example, in hydration reaction in which a hydroxyl group (OH^-) and acidic proton are added to the two carbon atoms bonded together in carbon-carbon double bond resulting in an alcohol.

When addition of water to an organic molecule cleaves the molecule into two parts, hydrolysis is said to occur. Notable examples of hydrolysis are saponification of fats and digestion of proteins and polysaccharide. Water can also be a leaving group in $\text{S}_\text{N}2$ substitution and $\text{E}2$ elimination reaction, the latter is known as dehydration. ([http:// en Wikipedia. Org/ Wiki/ Properties- of -water](http://en.wikipedia.org/wiki/Properties_of_water))

1.9.4 The Acid and Base Properties of Water:

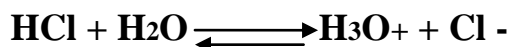
In the previous acid-base reaction we have looked at, we have noted that water can act as either an acid or base. This idea is illustrated by the following reaction in which two molecules of water react (one as acid and one as a base) to form hydronium ion (H_3O^+) and hydroxide ion (OH^-):



Substances like water that can act as either an acid or a base are said to be amphiprotic which means that they can either donate or accept hydrogen ions. Other chemicals besides water which are amphiprotic like formic acid, ethanol (David, 2011).

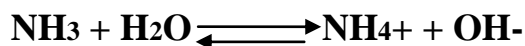


For example, when hydrogen chloride is dissolved in water the following equilibrium is established.



In this reaction water acting as a base, hydrogen chloride is much acid stronger than water and the equilibrium position is far to the right.

In an aqueous solution of ammonia on the other hand, water act as acid in the equilibrium.



Different in acid strengths between H_2O and NH_4^+ or in base strengths between NH_3 and OH^- , is however relatively small so that in aqueous solution NH_3 may be described as a weak base or NH_4^+ as a weak acid, every acid is related to a conjugate base and every base to a conjugate acid by the relationship.



Thus in ionization of HCl, Cl^- is the conjugate base of the HCl and HCl is a conjugate acid of Cl^- . (Sharpe, Alaan, 1986)

1.10 Ground Water:

Ground water is available resource both in Sudan and through the world, where surface such as lakes and rivers is scare and in accessible. Ground water supplies for more of the hydrologic needs of people everywhere. In Sudan it is a

source of drinking water for about half the total of population and nearly all rural population. It provides the rural areas with water their various needs.

This put ground water usage as an important and integral part of the hydrological cycle. Its availability depends on the rainfall and recharge condition.(Todd, 1985)

1.10.1 Ground Water Resources development On Utilization:

Ground water has been a source of drinking water and irrigation since the dawn of recorded history it's the most important of natural resource because of the physiological needs of man, animal, plant it not only support life on earth but also governs the economic industrial and agricultural growth of a nation.

Water is required not only in sufficient quantity but of potable quality to live a healthy life. (Michael, 2008)

Ground water development is usually through open wells in hard rock regions and tube well in alluvial formation. Open cum-bore wells are often employed to increase the yield of wells in water scarcity areas.

In almost cases except when artesian condition exist ground water is to be lifted by human or animal power, mechanically operated pumps or through devices operated by non conventional energy sources pumping from Streams Rivers and canals usually offer on under exploited resource for irrigation and domestic water supply in the developing countries. (Michael, 2008)

1.10.2 Ground water contamination:

Ground water differ from surface water in that it cycles more slowly, typically contains more dissolved ion and is cut off from living things that require light and gaseous oxygen .

The overlying layer of soil and rock give ground water some degree of protection against pollution, but these same layers combined with slow cycling make it very difficult to remedy any pollution that may occurs. Furthermore the sparsity of life forms reduces the ability of the wafer to eliminate organic pollutant. Thus protecting groundwater contamination is a much better alternative than attempting to correct damage after done. (Frederick, 2004)

Groundwater contamination occurs when soluble material such as nitrates are leached from the overlying soil, and when surface water find an entrance and carries both soluble and suspended contamination source are significant. Nitrate in ground water have increased only with increasing fertilizer usage especially during the latter half of the twentieth century. Most of agricultural pesticide has been detected in very low concentration in groundwater and some widely used ones, such as atrazine, are present in nearly all water samples in areas where they are used. (Frederick, 2004)

Dangerous pesticide concentrations in groundwater are rare and usually are associated with a spill of some kind but the widespread occurrence of pesticides in groundwater indicates that they do leach to some extent.

Groundwater can also contaminated by seepage from many different kind of local source .Buried underground storage tanks are major concern in the regard. Many such tanks that are stored gasoline were left behind when service station were closed. Seepage from landfills is another source that can carry toxic organic compound and heavy metal.

Pollution degrades water and can make it toxic to living entities. Small stream and ponds are easily polluted, most water pollutants can be one of four group: eroded sediment; heat; organic pollutants; and heavy metal. (Frederick, 2004)

1.10.3 Chemical Character of Groundwater:

The relatively slow movement of water percolating through the ground affords intimate and long contact of the water with the mineral that make up the earth crust.

The dissolve mineral in ground water affect its usefulness for various purpose. If one or more of the minerals are excess of the of the amount that can to related may be applied to change or remove the undesirable mineral so that the water will serve the intended purpose.

Most ground water contains no suspended matter and practically no bacteria. It is usually clear and colorless .These characteristics contrasts with those of surface water since surface water are usually turbid and contain considerable quantities of bacteria. Ground water, therefore is normally of superior sanitary quality .Its temperature is relatively constant another important factor in some cases. (Johnson)

1.10.4 Sources of Salinity:

All ground water contain salts in solution, contents range from less than 25mg/L in springs to more than 300,000 mg/L in brines. The types and concentration of salt depend on the environment movement and sources of the ground water.

Ordinarily higher concentration of dissolved constituent are found in ground water than in the surface water because is greater exposure to soluble materials in geologic strata. Soluble salts in ground water originate primary from solution of rock material. Bicarbonate usually the primarily anion in ground water, derived from carbon dioxide released by organic decomposition in soil.

Salinity varies with specific surface area of aquifer material solubility of materials and contacts mean values tend to be highest where movement of ground water is least salinity generally increases with depth. (Todd, 1985)

1.11 Zamzam water:

1.11.1 Introduction:

Water is a basic need and is essential in carrying out various physiological functions in the human body. Humans can survive without food for a month but they can survive without water for only seven days.

Only 2.8% of the total water on earth is fresh water rest is salt water is hard to use. There is a source of water called Zamzam. For Muslims it is holy water is located in the Mecca area ,one of the most scared cities for Muslims .This city is located in the western part of Saudi Arabia about 70 km south of city of Jeddah on the coast of the red sea. (Nauman, 2013)

1.11.2 Structure and hydro geology of the well:

The Zamzam well is hand excavated and about 30.5m deep; within an internal diameter ranging from (1.8-2.66m) .In hydro geologic terms, the well lies within the Ibrahim which runs through the holy city of Mecca and taps groundwater from the Wadi alluvium. Electric pumps are used to draw water from the well, replacing the previous rope and buckets.

Outside the room then exists a service area where cold Zamzam water fountains and dispensing containers are provided for drinking purpose. (Nauman, 2013)

1.11.3 Physico -Chemical Analysis of Zamzam water:

Different studies have been conducted to determine the physical and chemical parameter of zamzam water, many of researches done on different year illustrated in table below:

Table(1-2): chemical properties of zamzam water:

pH	TDS (mg/L)	CO ₃ (mg/L)	SO ₄ (mg/L)	Cl (mg/L)	Reference
–	4500	1110	528	786	Egyption commission, 1935
7.9	2278	–	515	786	Watson,4/1971
8.3	1845	320	348	180	Watson,9/1971
7	2500	770	350	485	Abdul manan

1.11.4 Mineral Profile of Zamzam Water:

Advanced techniques of multi-elemental and hydrochemical study of zamzam water were carried out by many researcher employed neutron activation inductivity coupled plasma; and other available classical technique to analyze the water sample .These technique revealed 34 elements in zamzam water with calcium(Ca) ,magnesium (Mg),sodium (Na) and chloride (Cl) in higher concentration than natural water .And element antimony(Sb),beryllium (Be),bismuth(Bi), bromine(Br) ,cobalt(Co),iodine(I) and molybdenum(Mo) were

less than 0.01ppm .Only trace of chromium(Cr) ,manganese(Mn) and titanium(Ti) were detected in zamzam water.

Hydro chemical study of zamzam water indicated that it is a sodium chloride water of meteoritic origin .The amount of four toxic elements, arsenic (As), cadmium (Cd), lead (Pb), and selenium (Se), was much below the danger level for human consumption. Many scientists suggest that certain peculiarities make Zamzam's water healthier, such as a higher level of calcium. (Nauman, 2013)

1.11.5 Some of the features of Zamzam water:

Never Dried Up: This well has never dried up. On the contrary it has always fulfilled the demand for water.

Same Salt composition: It has always maintained the same salt composition and taste ever since it came into existence.

Portability: Its portability has always been universally recognized as pilgrims from all over the world visit Ka'aba every year for Hajj and umrah, but has never complained about it. Instead, they have always enjoyed the water that refreshes them.

Universal taste: Water tastes different at different places. Zamzam water's appeal has always been universal.

No Biological Growth: This water has never been chemically treated or chlorinated as is the case with water pumped into the cities.([alishlaah 4.tripod. com/ more adivices 2/ id 21. htm](http://alishlaah4.tripod.com/moreadivices2/id21.htm)).

Biological growth and vegetation usually takes place in most wells. This makes the water unpalatable owing to the growth of algae causing taste and odour problems. But in the case of the Zamzam water well, there wasn't any sign of biological growth.

Following was written by a Japanese Scientist Masaru Emoto:

- a. The quality / purity of Zamzam water has, will not be find anywhere else in the water on this earth.
- b. He used the technology named NANO, and researched a lot on Zamzam water.
- c. And found out that if one drop of Zamzam water mix in 1000 drops of regular water, regular water will get the same quality like Zamzam water.
- d. He also found that a mineral in one drop of Zamzam water has its own importance that will not be find any other water on this earth.
- f. He also found in some tests that the quality or ingredients of Zamzam water cannot be changed, why, science does not know the reason.
- g. Even he re-cycled the Zamzam water, but no change it was still pure.

(www.sciforums.com/threads/zamzam-water-and-the-Vibrational-Effects-on-Crystal-Formation)

1.11.6 Healing Properties of Zamzam Water :

Zamzam is unique in its natural characteristics because it is “hard carbonated type water” in nature. It has been proven that there is no microbial growth in the water from the Zamzam well. (Nauman, 2013)

1.11.6.1 Zamzam Water and Dental Caries:

A comparative study between Zamzam water and other sources of water on the prevalence of dental caries and their severity in school girls was carried out by Al-Zuhair and Khounganian. Clinical examination revealed that, in the mixed dentition group, no statistical significant differences were detected, whereas among

the permanent dentition group, the mean decayed missing filled teeth (DMFT) score was the lowest in all the children using Zamzam water. The possible reason for this significance is the higher level of fluorides in Zamzam water. The role of fluoride in the prevention of dental caries is very well established. Reported an inverse relationship between the prevalence of caries and drinking water with different fluoride levels, stating that exposure to water containing about 1 ppm fluoride in drinking water reduces caries experience by 50%, whereas fluoride levels higher than 1.5 ppm in temperate countries is known to cause dental fluorosis. A large number of studies have confirmed the beneficial effects of fluoride in drinking water (Nauman, Asia ,2013).

1.11.6.2 Zamzam water and Cancer:

After Zamzam water intake statistically significant decrease in the size of tumor, and increase in lymphocyte, zamzam water cause upregulation of gene which Stimulate reduction of tumor and down regulation of gene which increase in size in the tumor and its Spread.

Experimental mice were fed with 500 cc Zamzam water daily for one month, and again a biopsy was taken after Zamzam water intake.

A significant reduction in the tumor size was observed that finally diminished in long-run study. One possible reason for the disappearance of the tumor is the biochemical nature of Zamzam water (Table1-3). Zamzam water directly affects the populations of lymphocytes.

Table (1-3) Tumor size, Lymphocytes number, and Somatastatin before and after Zamzam water intake. (Nauman, 2013)

	Before Zamzam water intake	After Zamzam water intake
Tumor size	3.1	1.5
Number of lymphocytes	10.1	688
Serum somatastain	3.3	18.2

1.12 Some Physical and Chemical Characteristic of Water:

Water quality is determined by physical, chemical and microbiological properties of water. These water quality characteristics throughout the world are characterized with wide variability. Therefore the quality of natural water sources used for different purposes should be established in terms of the specific water-quality parameters that most affect the possible use of water. That is why the aim of this chapter is to provide an overview of water quality characteristics - Physical, Chemical, Microbiological, and Biological characteristics. (echo2. epfl .ch/VICARE/mod-2/ chapt-2/ main.htm)

1.12.1 Physical Characteristics of Water:

Physical characteristics of water (temperature, color, taste, odour and etc.) are determined by senses of touch, sight, smell and taste. For example temperature by touch, color, floating debris, turbidity and suspended solids by sight, and taste and odour by smell. (echo2. epfl .ch/VICARE/mod-2/ chapt-2/ main.htm)

The boiling point of water (and all other liquids) is dependent on the barometric pressure. For example, Everest water boils at 68 °C (154 °F), compared to 100 °C (212 °F) at sea level.

Conversely, water deep in the ocean near geothermal vents can reach temperatures of hundreds of degrees and remain liquid.

The maximum density of water occurs at 3.98 °C (39.16 °F). It has the anomalous property of becoming less dense, not more, when it is cooled down to its solid form, ice. It expands to occupy 9% greater volume in this solid state, which accounts for the fact of ice floating on liquid water. (<https://enWikipedia.Org/wiki/water>)

1.12.1.1 Temperature:

The temperature of water affects some of the important physical properties and characteristics of water: thermal capacity, density, specific weight, viscosity, surface tension, specific conductivity, salinity and solubility of dissolved gases and etc. Chemical and biological reaction rates increase with increasing temperature. Reaction rates usually assumed to double for an increase in temperature of 10 °C. The temperature of water in streams and rivers throughout the world varies from 0 to 35 °C. (echo2.epfl.ch/VICARE/mod-2/chapt-2/main.htm)

1.12.1.2 Color:

Color in water is primarily a concern of water quality for aesthetic reason. Colored water give the appearance of being unfit to drink, even though the water may be perfectly safe for public use. On the other hand, color can indicate the presence of organic substances, such as algae or humic compounds. More recently, color has been used as a quantitative assessment of the presence of potentially

hazardous or toxic organic materials in water. (echo2. epfl .ch/VICARE/mod-2/ chapt-2/ main.htm)

1.12.1.3 Taste and Odour:

Water can dissolve many different substances, giving it varying tastes and odors. Humans and other animals have developed senses which enable them to evaluate the potability of water by avoiding water that is too salty or putrid.

The taste of spring water and mineral water, often advertised in marketing of consumer products, derives from the minerals dissolved in it. However, pure H₂O is tasteless and odorless. The advertised purity of spring and mineral water refers to absence of toxins, pollutants and microbes. (<https://enWikipedia.Org/wiki/water>)

1.12.1.4 Turbidity:

Turbidity is a measure of the light-transmitting properties of water and is comprised of suspended and colloidal material. It is important for health and aesthetic reasons. (echo2. epfl .ch/VICARE/mod-2/ chapt-2/ main.htm)

1.12.1.5 Solids:

The total solids content of water is defined as the residue remaining after evaporation of the water and drying the residue to a constant weight at 103 °C to 105 °C. The organic fraction (or volatile solids content) is considered to be related to the loss of weight of the residue remaining after evaporation of the water and after ignition of the residue at a temperature of 500 °C.

The volatile solids will oxidize at this temperature and will be driven off as gas. The inorganic (or fixed solids) remain as inert ash. Solids are classified as settleable solids, suspended solids and filterable solids. Settleable solids (silt and heavy organic solids) are the one that settle under the influence of gravity. Suspended solids and filterable solids are classified based on particle size and the retention of suspended solids on standard glass-fibre filters. (echo2. epfl.ch/VICARE/mod-2/ chapt-2/ main.htm)

1.12.2 Chemical Characteristics of Water:

The chemical characteristics of natural water are a reflection of the soils and rocks with which the water has been in contact. In addition, agricultural and urban runoff and municipal and industrial treated wastewater impact the water quality. Microbial and chemical transformations also affect the chemical characteristics of water. (echo2. epfl.ch/VICARE/mod-2/ chapt-2/ main.htm)

Water is a good solvent and is often referred to as the universal solvent. Substances that dissolve in water, e.g., salts, sugars, acids, alkalis, and some gases – especially oxygen, carbon dioxide (carbonation) are known as hydrophilic (water-loving) substances, while those that do not mix well with water (e.g., fats and oils), are known as hydrophobic (water-fearing) substance.

(<https://enWikipedia.Org/wiki/water>)

1.12.2.1 Inorganic Minerals:

Runoff causes erosion and weathering of geological formation, rocks and soils as the runoff travels to the surface-water bodies. During this period of contact with rocks and soils the water dissolves inorganic minerals, which enter the natural

waters. Inorganic compounds may dissociate to varying degrees, to cations and anions.

1.12.2.1.a Major Cations :

Major cations found in natural water include Calcium (Ca^{2+}), Magnesium (Mg^{2+}), Sodium (Na^+) and Potassium (K^+). Calcium (Ca^{2+}), is the most prevalent cation in water and second inorganic ion to bicarbonate in most surface water.

The principal concern about **Calcium** is related to the fact that calcium is the primary constituent of water hardness.

Calcium precipitates as CaCO_3 in iron and steel pipes. A thin layer of CaCO_3 can help inhibit corrosion of the metal. However, excessive accumulation of CaCO_3 in boilers, hot water heaters, heat exchangers, and associated piping affects heat transfer and could lead to plugging of the piping. Calcium concentration of up to 300 mg/L or higher have been reported. However, Calcium concentrations of 40 to 120 mg/L are more common. (echo2. epfl.ch/VICARE/mod-2/ chapt-2/ main.htm)

Magnesium is not abundant in rocks as calcium. Therefore, although magnesium salts are more soluble than calcium, less magnesium is found in surface water. Sodium and potassium are commonly found as free ions. The concentrations of these cations in natural water usually are low. (echo2. epfl.ch/VICARE/mod-2/ chapt-2/ main.htm)

Other constituents in natural water in concentration of 1 mg/L or higher include aluminium, boron, iron, manganese and phosphorus etc.

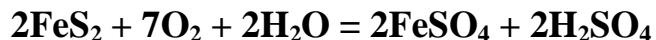
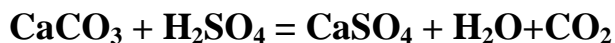
1.12.2.1.b Major Anions :

Major anions include Chloride, Sulfate, Carbonate Bicarbonate, Fluoride and Nitrate. **Bicarbonate** (HCO_3^-) is the principal anion found in natural water. These ions are very important in the carbonate system, which provides a buffer capacity to natural water and is responsible in a great measure for the alkalinity of water. One source of bicarbonate ions (HCO_3^-) in natural water is the dissociation of carbonic acid (H_2CO_3) that is formed when carbon dioxide (CO_2) from the atmosphere, or from animal (e.g. fish) and bacterial respiration, dissolves in water.

In addition to **bicarbonates** (HCO_3^-) anions such as chlorides (Cl^-), sulfates (SO_4^{2-}), and nitrates (NO_3^-) are commonly found in natural water. These anions are released during the dissolution and dissociation of common salt deposits in geologic formations. (echo2. epfl .ch/VICARE/mod-2/ chapt-2/ main.htm)

The concentration of the **Chlorides** anions (Cl^-) determines the water quality because the quality of water get worse after increasing in the concentration of this anions which limit possibilities of using of natural water for different purposes (household, agriculture, industry and etc.). Principal source of the chlorides anions (Cl^-) in natural water are magmatic rock formations that include chlorine-content minerals. The second source of this anions is Ward Ocean from where a considerably amount of chlorides anions (Cl^-) enter in the atmosphere. From atmosphere chlorides anions (Cl^-) enter in the natural water in result of interaction between precipitation and soil. (echo2. epfl .ch/VICARE/mod-2/ chapt-2/ main.htm)

The **Sulfates** anions (SO_4^{2-}) are frequently found in natural water as the result of the chemical dissolution dissolve sulfur-content minerals and oxidize sulfates and sulfur:



The sulfates anions (SO_4^{2-}) enter in natural water as the result of the oxidation of the substances from plant and animal origin. The increase concentration of the sulfates anions (SO_4^{2-}), at one hand brings about change for the worse of some physical characteristics of water (taste, smell and etc.) and on the other hand has destructive influence upon human consumption.

The concentration of the sulfates anions (SO_4^{2-}) fluctuates in a wide range in surface water - from 5 mg/l to 60 mg/l. (echo2.epfl.ch/VICARE/mod-2/chapt-2/main.htm)

Nitrate anions (NO_3) are found in natural water as the result of the bacteriological oxidation of nitrogenous materials in soil. That is why the concentration of these anions rapidly increases in summer when the process of the nitrification takes place very intensively. Another important source for dressing of the surface water with Nitrate anions (NO_3) are precipitations, which absorb nitric oxides and convert them into nitric acid. A great deal of nitrate anions (NO_3) enters in surface water together with domestic water and water from industry, agriculture and etc. Nitrate anions (NO_3) are one of the indicators for the degree of the pollution with organic nitrate-content substances.

Other anions found in water include fluorides (F^-), carbonates (CO_3^{2-}) and phosphates (PO_4^{3-}). (echo2. epfl .ch/VICARE/mod-2/ chapt-2/ main.htm)

1.12.2.2 pH and Alkalinity:

Alkalinity is defined as the capacity of natural water to neutralize acid added to it. (echo2. epfl .ch/VICARE/mod-2/ chapt-2/ main.htm)

Total alkalinity is the amount of acid required to reach a specific pH (pH = 4,3 to 4,8). Total alkalinity can be approximated by alkalinity as the following expression:

$$\text{Total alkalinity} = [HCO_3^-] + 2[CO_3^{2-}] + [OH^-] - [H^+]$$

1.12.2.3 Acidity:

Acidity is the "quantitative capacity of aqueous media to react with hydroxyl ions". Titration with a strong base (NaOH) to define end points (pH = 4,3 and pH = 8,3). Acidity indicates the corrosiveness of acidic water on steel, concrete and other materials. (echo2. epfl .ch/VICARE/mod-2/ chapt-2/ main.htm)

1.12.2.4 Hardness:

Hardness is correlated with TDS (Total dissolved solids). It represents total concentration of Ca^{2+} and Mg^{2+} ions, and is reported in equivalent $CaCO_3$. Other ions (Fe^{2+}) may also contribute. Hardness expressed as mg/L $CaCO_3$ is used to classify waters from "soft" to "very hard". This classification is summarized in Table below.

Table (1-4) Relationship of Hardness Concentration and Classification of Natural water . (echo2. epfl .ch/VICARE/mod-2/ chapt-2/ main.htm)

Hardness as mg/L CaCO ₃	Classification
0 – 60	Soft
61 – 120	Moderately hard
121 – 180	Hard
>180	Very hard

Hardness observed for streams and rivers throughout the world ranges between 1 to 1000 mg/L. Typical concentrations are 47 mg/L to 74 mg/l CaCO₃. (echo2. epfl .ch/VICARE/mod-2/ chapt-2/ main.htm)

Hardness is an indicator to industry of potential precipitation of calcium carbonates in cooling towers and boilers, interference with soaps and dyes in cleaning and textile industries and with emulsifiers in photographic development. Hard water is less corrosive than soft. Treatment usually left to consumer (domestic, industrial, etc) depending on needs. (echo2. epfl .ch/VICARE/mod-2/ chapt-2/ main.htm)

1.12.2.5 Total Dissolved Solids:

Total dissolved solids (TDS) are a measure of salt dissolved in a water sample after removal of suspended solids. TDS is residue remaining after evaporation of the water. The TDS load carried in streams throughout the world

has been estimated by Livingston (1963) to 120 mg/L. (echo2. epfl.ch/VICARE/mod-2/ chapt-2/ main.htm)

1.12.2.6 Conductivity:

The concentration of total dissolved solids (TDS) is related to electrical conductivity (EC; mhos/cm) or specific conductance. The conductivity measures the capacity of water to transmit electrical current. The conductivity is a relative term and the relationship between the TDS concentration and conductivity is unique to a given water sample and in a specific TDS concentration range. The conductivity increases as the concentration of TDS increases.

TDS and conductivity affect the water sample and the solubility of slightly soluble compounds and gases in water (e.g. CaCO_3 , and O_2). In general, the corrosiveness of the water increases as TDS and EC increase, assuming other variables are kept constant. (echo2. epfl.ch/VICARE/mod-2/ chapt-2/ main.htm)

1.12.3 Organic Materials

Organic chemicals are made up of Carbon (C), Hydrogen (H), as well as Nitrogen (N) and Oxygen (O). Organic compounds are derived from living organism as well as industrial sources. A wide variety of assortments of organic compounds are produced in the chemical and petrochemical industries.

Organic compounds also may contain Sulfur (S), Phosphorus (P), Fluorine (F), Chlorine (Cl), Bromine (Br) and iodine (I).

Organic compounds in water also affect the water quality. Organic chemicals cause disagreeable tastes and odours in drinking water.

Vinyl chloride, benzene and other organic contaminants are known carcinogenic agents, while chloroform is a cancer-suspect agent.(echo2. epfl .ch/VICARE/mod-2/ chapt-2/ main.htm).

1.12.4 Drinking Water Standard:

Safe drinking water is essential to sustain life. Therefore, water intended for human consumption should be both safe and wholesome i.e. free from pathogenic agents, free from harmful chemical substances, pleasant to the taste (free from color and odor) and usable for domestic purposes (Park, 2007).

Water has the ability to dissolve most substances, and all living organisms depend on it in their living whether these organisms are plants or animals (Abdel Magid and ELHassan, 1986).

Most of the world's available freshwater exists as ground water. This ready supply of relatively clean and accessible water has encouraged use of this resource, and in many regions ground water provides drinking water of excellent quality (Chorus and Bartram, 2005). Groundwater is the cheapest and most practical means of providing water to small communities and it is superior to surface water, because the ground itself provides an effective filtering medium (Park, 2007). Therefore, ground water is generally preferred as source for municipal and industrial water supplies (McGhee, 1991).

Wells are drilled to tap underground water supplies, however, not all wells produce enough or good quality water (Reid, 2004).

Surface pollutants, dissolved in water, percolate down through the soil. Shallow groundwater that is closest to the surface is most easily contaminated. How much pollutants reach groundwater depends on soil type, pollutant characteristics, and the distance to Groundwater Contamination sources include many types of runoff, agricultural and urban, chemical and oil spills, and landfill leach ate and anything

that may percolate through the soil into groundwater. Pathogens, especially viruses can percolate into groundwater.

The quality of drinking water in the Sudan has recently received some attention from environmentalists and water scientists. The rural population of the country, constituting about 80% of the total population, uses untreated water coming from traditional surface wells, deep bores, rivers, intermittent rainy season streams (khors), turbid water from natural rain ponds, and artificial rainwater catchments (Hafirs) during most of the year (Abdel Magid *et al.*, 1984).

Table(1-5): drinking water standard

Substance or characteristic	Unit	WHO(1983)	SSMO
pH	-	6.5-8.5	6.5-8.5
F	mg/L	1.5	1.5
NO3	mg/L	45	50
Cl	mg/L	200	250
SO4	mg/L	200	250
Ca	mg/L	75	-
Mg	mg/L	30	-
Na	mg/L	200	250
K	mg/L	10	-
TDS	mg/L	500	1000
TH as CaCO3	mg/L	100	-
Alkalinity	mg/L	-	-

* SSMO=Sudanese Standards & Metrology Organization.

* WHO=World Health Organization.

1.12.5 Objective of this work:

1. Evaluation of water quality and its suitability for drinking compared with WHO and SSMO.
2. Determination of some physical and chemical properties of water samples.
3. Comparison of water samples and Zamzam water.

Chapter Two

Materials and Methods

2.1 Collection of Samples:

Samples were collected randomly from three main sources of water (drinking water):

1. River water: - three samples (Blue Nile(Almanshiala), White Nile(Alazozab) and the main River Nile(Ab rouff)).
2. Well water: - also three samples (Alhaj Yousof, Elengaz, and Mayou).
3. Zamzam water from Saudi Arabia (Macca).

Those samples were kept in dry cleaned plastic container and carefully closed.

2.2 Chemicals and Materials:

- Hydrochloride acid, Sodium hydroxide(AnalaR), Silver nitrate, Potassium chromate, Ammonium buffer, Zirconium indicator, Murexide indicator, Methyl orange indicator, Ethylene di amine tetra acetic acid di sodium salt (EDTA)(BHD,GPR), Erochrome Black T, Potassium Chloride(AnalaR), Barium Chloride(AnalaR).

2.3 Apparatuses and Instruments:

2.3.1 Apparatuses:

-Burettes.

-Pipettes.

-Volumetric flasks.

-Conical flasks.

-Cylinders.

-Beakers.

2.3.2 Instrument:

- pH meter (JENWAY 3310) ,England.

-EC meter (RS).

-Turbid meter (HACH- 2100N), USA.

- Flame photometer (JENWAY CLINICAL PFP 7), England.

-Magnatic stirrer (Gallenkamp), England.

- Spectrophotometer (SPECORD 40), Germany.

2.4 Method of Analysis:

2.4.1 pH value:

The electrode of pH meter instrument was immersed in the sample after calibration, for 1min with stirring. The measured pH was taken. (Lenore.S,1998)

2.4.2 Conductivity:

The cell was rinsed by conductivity water and with two or more portion or standard Potassium Chloride (0.01M).The temperature was adjusted to 25°C. The conductivity was measured and the same procedure was repeated with (0.05M) Potassium Chloride. Finally the conductivity of sample was measured with the same procedure. (Lenore.S,1998)

2.4.3 Total Dissolve Solid:

-Preparation of evaporating dish: The clean dish was heated to 180 °C for (1 h) in an oven and stored in desiccator until needed. The dish was weighted immediately before used.

- Sample Analysis: sample was filtered and mixed well through a glass fiber filter. Appropriate volume of filtered sample was transferred to weighted evaporating dish and evaporates to dryness on a steam bath. Dried for (1h) in an oven at (180 °C) cooled in a desiccator and weighted. The weight was repeated until a constant weight was obtained. (Lenore.S,1998)

2.4.4 Total Hardness:

In 250ml conical flask; 50 ml from each sample was transferred. Then buffer solution (ammonium hydroxide) was added and drops of Erochrome Black T as indicator, the contents were titrated against EDTA, the titration repeated until the constant volume was obtained. (Lenore.S,1998)

2.4.5 Total Alkalinity:

To 250ml conical flask 100 ml of each sample was quantitatively transferred, then methyl orange as indicator, was added. The contents of flask were titrated against hydrochloride acid to end point, the volume was recorded. (Lenore.S,1998)

2.4.6 Determination of Calcium:

Calcium hardness was determined after removing magnesium interference by adding 2ml of sodium hydroxide, drops of murexide indicator were added. Then titrated against EDTA solution, the constant volume was recorded. (Lenore.S,1998)

2.4.7 Determination of Magnesium :

Magnesium was determined by using mathematical method by subtracted the calcium hardness from total hardness the remained amount contributed to magnesium.

2.4.8 Determination of Chloride :

50 ml of each sample transferred to conical flask by using pipette, 2ml of potassium chromate were added to contents of flask then were titrated against silver nitrate solution to end point, the constant volume was recorded. (Lenore.S,1998)

2.4.9 Determination of sulphate:

100ml of sample was transferred to conical flask, 20ml of buffer sulphate was added then stirred for 1 min and put some of contents on containers of turbidimeter device and recorded volume. (Lenore.S,1998)

2.4.10 Determination of Nitrate:

Cadmium metal reduce nitrate present in the sample to nitrite to which in acidic medium with sulfuric acid to form an intermediate diazonium salt, this salt couples which acid to form an amber colored product the intensity of color directly proportion to the amount of nitrate; by spectrophotometer was detected in mg/L nitrate. (Lenore.S,1998)

2.4.11 Determination of Fluoride:

This method involve the reaction of fluoride with a red zirconium dye solution, the fluoride reacts with part of the zirconium to form a colorless complex then bleeding the red color in amount proportional to the concentration of sample. (Lenore.S,1998)

A series of standards sample was prepared, by took the following volumes of standard fluoride solution (10micro gram) in Nessler tubes and diluted to 100 ml: 0.0,1,2,3,4 and 5 ml, the temperature of samples and standard was adjusted near the room temperature. To 100ml clear samples and standards in Nessler tubes; 5ml of acid alizarine were added, mixed thoroughly; and the concentration of F mg/L was recorded. (Lenore.S,1998)

2.4.12 Determination of Sodium and Potassium:

After preparation the sample; selected sodium (then potassium) filter put on the instrument and the pump .The air and fuel pressures are steady, The flame was ignited and adjusted. Blank solution adjusted zero emission starting with 10 mg/L calibration standard adjusted instrument to250 emission for sodium and (100 for potassium). Then also diluted and repeated the operation with both calibration to enough time to secured a reliable average reading for each solution, constructed calibration curve, compared with blank and 10 mg/L solution. The Na and,K concentrations were recorded. (Lenore.S,1998)

Chapter Three

Results and Discussion

There are various types of drinking water available in Sudan; rivers water, sea water, wells water, bottled and mineral water. Well water in Sudan is often high in mineral contents than other types, Table (3-1) illustrated samples studied in this work. Physicochemical properties, cations and anions were illustrated in Table (3-2) and Table (3-3).

Table(3-1) samples sources:

Sample No.	Source
I	River Nile
II	Blue Nile
III	White Nile
IV	Mayou
V	Elengaz
VI	Alhaj Yousof
VII	Zamzam Water

Table (3-2) physical parameters of tested samples:

	I	II	III	IV	V	VI	VII
Appearance	turbid	turbid	turbid	clear	clear	clear	Clear
Colour	Colour less	Colour less	Colour less	Colour less	Colour less	Colour less	Colour less
Odour	unobj	unobj	unobj	unobj	unobj	unobj	Unobj
Taste	unobj	unobj	unobj	unobj	unobj	unobj	Unobj

*unobj= unobjectionable.

The rivers water have unobjectionable taste and odour, also it colour less but turbid. While well and Zamzam water unobjectionable taste and odour, it colorless but it clear appearance.

Table (3-3) chemical parameters of water samples:

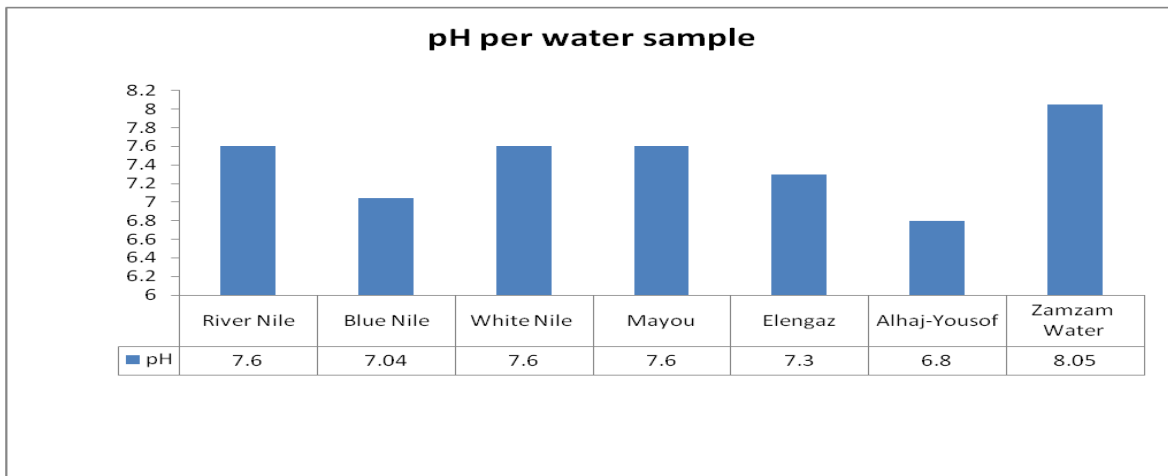
	pH	EC(μ S/cm)	TDS (mg/L)	T Hardness (mg/L)	T Alkalinity (mg/L)
I	7.6	310	185	92	140
II	7.04	300	180	130	140
III	7.6	310	185	92	140
IV	7.6	480	250	140	230
V	7.3	820	370	232	215
VI	6.8	460	275	200	210
VII	8.05	800	480	200	200

3.1 pH value:

Table (3-3) shows that the **pH** of all water samples had slightly alkaline behavior fall in the range (6.8-8.05). Stated that alkaline drinking water plays an important role in ridding the body of mercury and other toxins.(Wynn et al.,1999).

Zamzam water has been a higher pH value (8.05), while Alhaj Yousof were a lower value (6.8); then (Blue Nile, White Nile, River Nile, Elengaz, and Mayou) have (7.04, 7.6, 7.6, 7.3, 7.6) respectively.

The limit of **pH** value for drinking water according to the Sudanese Standards Materials Organization (SSMO) and WHO is specified (6.5 - 8.5)



Figure(3-1): the pH of water samples.

3.2 Electrical conductivity (EC) value:

The **electrical conductivity** of water samples were showed high variation which ranged from (300-820) μ S/cm.

The **EC** of the water samples is an indicator of their salinity. A high value of electrical conductivity generally means a high degree of salinity and a low value shows that the salinity is low.(Mohamed , 2015)

Which were lower than recommended level. The Blue Nile showed EC=300 μ S/cm which is lowest value, while Elengaz have a highest value; Zamzam water value EC=800 (μ S/cm).WHO and SSMO not detected the limit value.

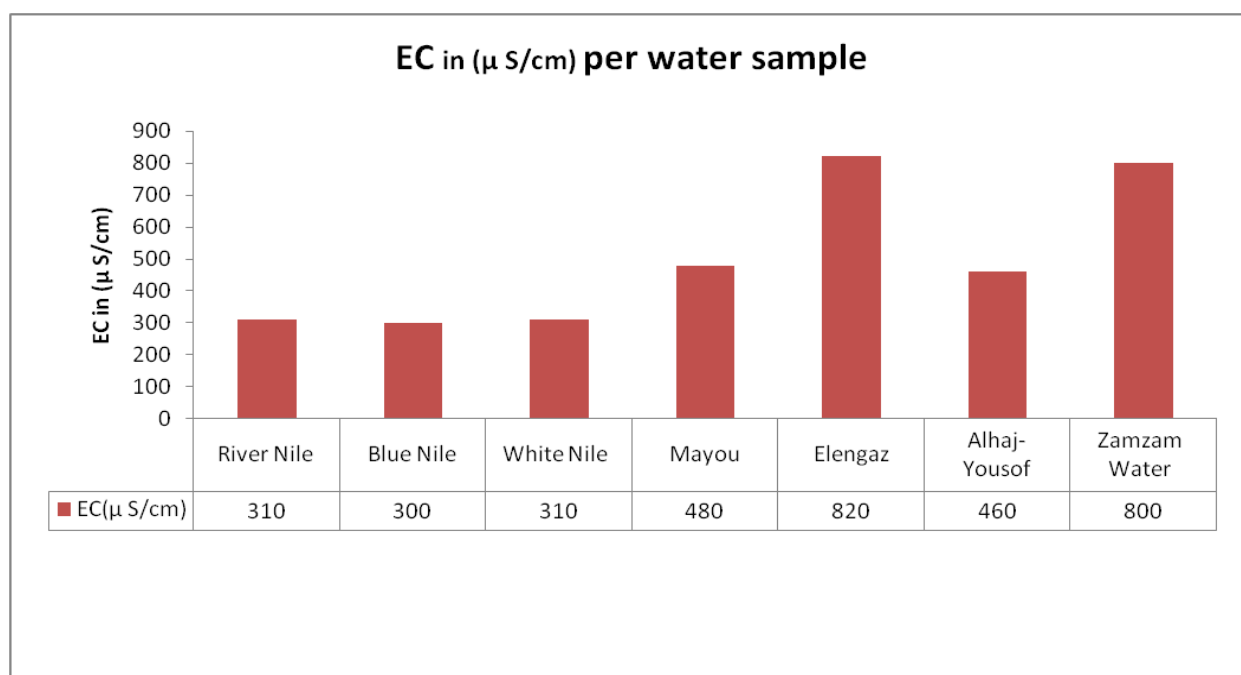


Figure (3-2): Electrical Conductivity (EC) of water samples.

3.3 Total Dissolve solid:

The results in Table (3-3) showed that the Total soluble solid salts or total dissolved solids (TDS) range from (180-480) (mg/L); Zamzam water showed TDS=480 mg/L which is highest Concentration, then (Elengaz, Alhaj Yousof , Mayou , Blue Nile, White Nile and the River Nile) TDS= (370, 275, 270, 180, 185, 185) mg/L respectively. Which all values were lower than the recommended level (1000 mg/L) according to the SSMO while WHO (500mg/L).

3.4 Total Hardness:

In Table (3-3) total hardness results of water samples were showed high variation which ranged from 92 to 232 mg/L.

River Nile is lower concentration (92mg/L), while the Elengaz water is a highest concentration (232mg/L), while Zamzam water hardness equal to (200mg/L), Compared with WHO level (100mg/L) .

3.5 Total Alkalinity:

Table (3-3) gives the summary of the results obtained in this study for concentrations of total alkalinity in water. It was a highest in well water (Mayou=230 mg/L). Then in (Elengaz = 215mg/L), (Alhaj Yousof=210mg/L) , (Zamzam water =200mg/L) and all rivers sample have a same concentration (140 mg/L) which is lowest value.

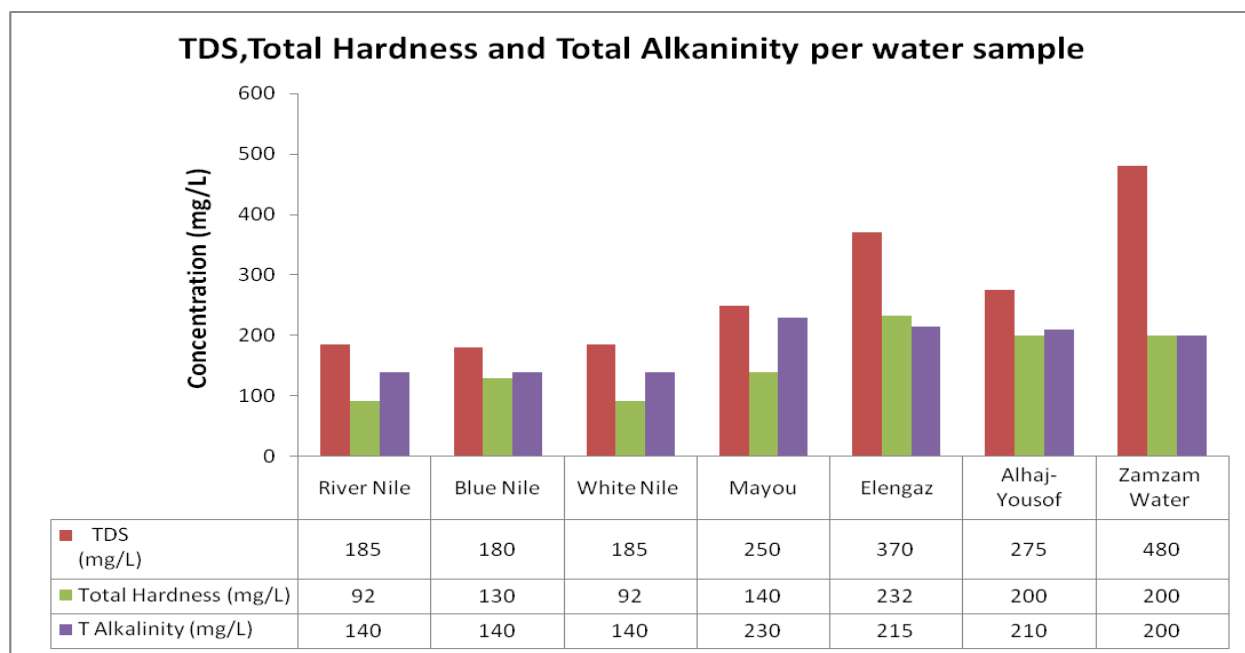


Figure (4-3): Concentration of TDS, T. Hardness and T. Alkalinity of water samples.

3.6 Cations (Ca, Mg, Na and K) :

Table (3-4) the concentrations of cations in water samples (Ca, Mg, Na and K).

Cation	Ca(mg/L)	Mg(mg/L)	Na(mg/L)	K(mg/L)
Sample No.				
I	28	7	32	13
II	36	9	22	3
III	26	7	32	13
IV	21	21	50	6
V	62	18	50	6
VI	37	26	30	2
VII	53	17	80	27

Calcium is the most abundant and the most important mineral in the body. Yet it is the most difficult to get absorbed and utilized by the cells. It raises the body's resistance to viruses, parasites, cancer as well as bacteria which causes tooth decay. (Remer,1994).

The result showed low **Calcium** concentration in well water (Mayou) were found to be 21 mg/L, while high concentration in (Elengaz) which were found to be 62 mg/L, the Blue Nile was the highest concentration in rivers samples which found (36mg/L), then the Zamzam water were(53mg/L).

Concentration of Ca was in the range of the recommended permissible level (WHO=75mg/L).

Magnesium concentration between (7-26) mg/L as shown in ;Table(3-4)

The results showed Magnesium concentration in River Nile and White Nile water were7 mg/L, while high concentration in the well water (Alhaj Yousof) were 26 mg/L, finally Zamzam water was 17mg/L.The permissible limit of WHO is(30)mg/L

The **Sodium** concentration varied from 22 to 80 mg/L. The highest Na concentration in Zamzam water were 80 mg/L, while well water concentration (Alhaj Yousof, Elengaz, and Mayou) were (30, 50and 50) mg/L respectively. Then (Blue Nile, White Nile and the main River Nile) were (22, 32, 32) mg/L respectively.Na concentration is below the recommended permissible level of SSMO and WHO.

Most of the water brands contain lower amounts of Na concentration. An excess of Na concentration over maximum limit in drinking water may cause a

salty taste or odor, as well as some long-term health effects (Derry et al., 1990, Nouri et al., 2014).

Potassium concentration ranged between 2 and 27 mg/L; it were lowest in the Alhaj Yousof which was found to be equal to 2 mg/L, while the Elengaz and Mayou water concentration were 6 mg/L. Also the River Nile and White Nile concentration were 13 mg/L, but Blue Nile concentration was 3 mg/L. Finally it was the highest value in Zamzam water 27mg/L. The permissible limit of WHO is(10)mg/L.

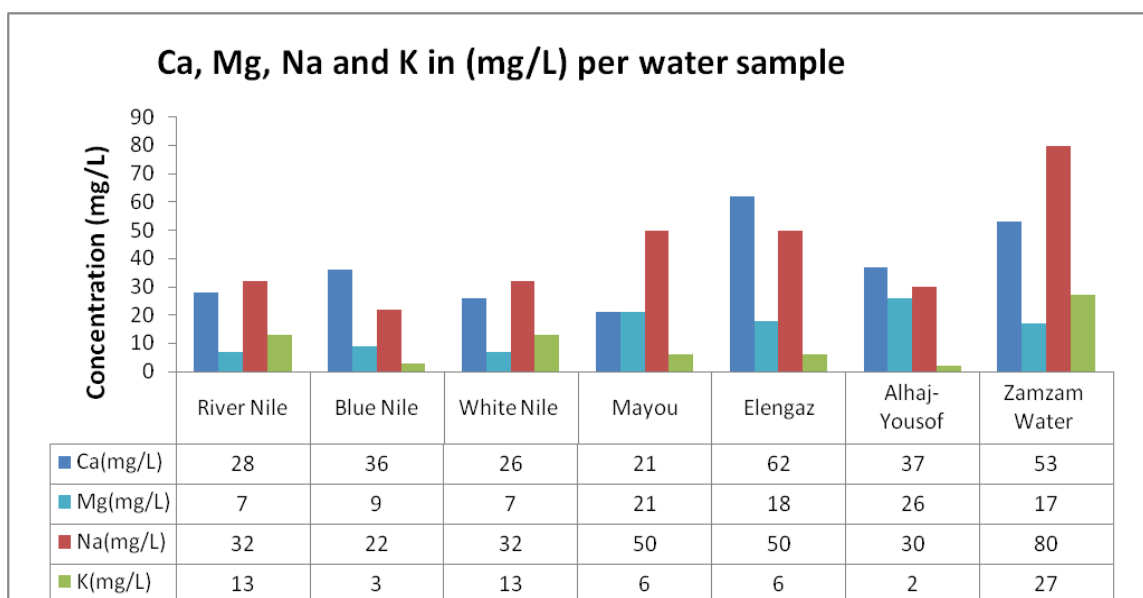


Figure (3-4): Concentration of Cations of water sample.

3.7 Anions (Cl , F,SO₄ ,NO₃) :

Table (3-5) the concentrations of anion in water samples (Cl ,F ,SO₄ ,NO₃).

	Cl	F	SO ₄	NO ₃
I	17	0.45	2	5
II	8	0	15	3
III	17	0.5	5	3
IV	14	0.4	2	0
V	69	0.45	38	2
VI	22	0.6	33	0
VII	75	0.4	74	32

From the results **Chloride** concentrations ranged from 8 to 69 mg/L, Blue Nile was lower value 8mg/L in the rivers water samples, while 69mg/L was Elengaz water concentration. It was the highest in Zamzam water which was found to be 75mg/L. concentration of Cl is lower than permissible limit for WHO and SSMO (200-250)mg/L respectively.

Fluoride concentrations were illustrated in table (3-5) and was obtained that higher concentration in the well water (Alhaj Yousof) 0.6 mg/L, the median F concentration obtained 0.45 mg/L for(River Nile and Elengaz).

While the minimum concentration was 0.4mg/L for (Mayou, Zamzam water).

Concentration in all of the water samples is below the recommended permissible level (SSMO).

The concentration of **sulphate** was vary in the range (2-74) mg/L; Zamzam water it a higher value 74 mg/L .Then Elengaz water was equal to 38mg/L, finally the Blue Nile and Mayou were lower value which equal to 2 mg/L. Also sulfate Concentration in all of the water samples was below the recommended permissible

level (SSMO).This sulphate ion is generally harmless, except its effect on taste.(Ghrefat , 2013) .

Concentrations of **Nitrate** in investigated water samples were varied from 0.0 to 32 mg/L; River Nile concentration was found to be 5 mg/L, While Blue and White Nile were 3mg/L, (Alhaj Yousof, Elengaz, and Mayou) which obtained(0.0 ,2 and 0.0)mg/L respectively .Also Zamzam water was the highest concentration of all. When the permissible limit of WHO and SSMO were (45-50)mg/L respectively.

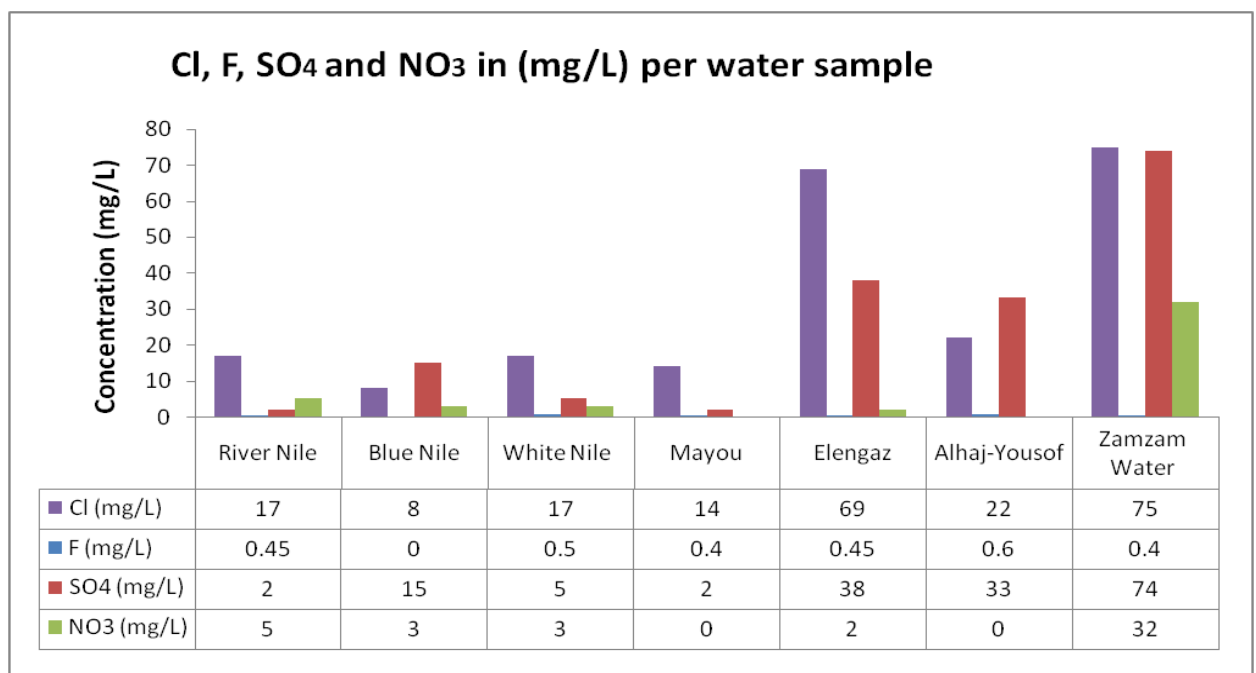


Figure (3-5): Concentration of Anions of water samples.

Chapter Four

Conclusion and Recommendation

4.1 Conclusion:

The analysis showed suitability of the analyzed water samples from the measured physical and chemical properties.

Analytical results obtained conclude the following observation:

- pH values in all samples between (6.8-8.05).
- Zamzam water was the highest concentration had been observed at (TDS, Cl, SO₄, NO₃, Na and K with 480, 75, 74, 32, 80, 27) respectively. Also pH was higher. Because it has a different geological environmental.
- High Total Hardness concentration in all samples except White Nile and River Nile according to WHO. May be that reversed to rock, soil and aquifers.
- The Healing power of Zamzam water based on chemical contents.

4.2 Recommendation for further study:

- More analysis may be needed, for example the radioactivity.
- Further research may be required to study other chemical and biological of water like COD, BOD and elements such as Hg, As, I, Ba....
- To use small electric current for purification of water.

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