



بسم الله الرحمن الرحيم

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Quality and Physicochemical Characterization of Drinking Water in Southern Kordofan State.

الجودة والتوصيف الفيزيوكيميائي لمياه الشرب، بولاية جنوب كردفان

**A thesis submitted in Fulfillment of the Requirements for the
Degree of Doctor of Philosophy in Chemistry**

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إستهلال

بسم الله الرحمن الرحيم

قال تعالى:

(أولم يرَ الَّذِينَ كَفَرُوا أَنَّ السَّمَاوَاتِ وَالْأَرْضَ كَانَتَا رَتْقًا فَفَتَقْنَاهُمَا^ط
وَجَعَلْنَا مِنَ الْمَاءِ كُلَّ شَيْءٍ حَيٍّ^ط أَفَلَا يُؤْمِنُونَ)

صدق الله العظيم

(سورة الأنبياء الآية (30))

Dedication

To my

Father and soul of my Mather,

Husband,

Sons,

Brothers and sisters.

Acknowledgement

Praiese to Allah, Almighty, for giving me health and patience to complete this work.

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Abstract

Thirteen (composite) ground water and five surface water samples were collected from different locations in South Kordofan State, during autumn and winter seasons of 2017. The samples were analyzed using various physicochemical techniques to assess seasonal variation of the quality of drinking water and compare that with international (WHO) and (SSMO) guidelines. The results show that for ground water pH value, total alkalinity as hydroxide and carbonate are within (WHO) and (SSMO), range limit to pH (8.5 to 6.5). the average value for each of; Turbidity (2.69, 2.00 NTU), EC (788.0, 644.0 $\mu\text{s}/\text{cm}$) and TDS (471.6, 387.9 mg/l), anionic composition HCO_3^- (133.6, 305.00 mg/l), F^- (1.09, 1.10 mg/l), Cl^- (37.96, 48.4mg/l), NO_3^- (19.8, 6.05 mg/l) and SO_4^- (17, 5, 19.34 mg/l) cationic composition Na^+ (4.18, 6.02 mg/l), K^+ (2.24, 2.06 mg/l), Ca^{++} (21.36, 18.68mg/l) and Mg^{++} (16.46, 18.87mg/l), in autumn and winter season respectively. BOD and COD were nill. For surface water pH value total alkalinity as hydroxide and carbonate are within (WHO) and (SSMO), the average value for each of; Turbidity (4.8, 1.74 NTU), EC (428.0, 695.0 $\mu\text{s}/\text{cm}$) and TDS (257.0, 417.0 mg/l), anionic composition HCO_3^- (30.5, 152.50 mg/l), F^- (0.59, 0.50 mg/l), Cl^- (26.3, 29.8 mg/l), NO_3^- (19.3, 1.6 mg/l) and SO_4^- (5. 5, 5. 2 mg/l), cationic composition Na^+ (2.65, 1.81 mg/l), K^+ (2.52, 5.09 mg/l), Ca^{++} (17.84, 31.2 mg/l) and Mg^{++} (4.94, 7.0 mg/l), in autumn and winter ground and surface water respectively. Fe^{++} , Al^{+++} , Zn^{++} , As^{+++} , Ba^{+++} , Pb^{++} , Cd^{++} , Cr^{+++} , Ni^{++} , Co^{++} and C^{++} were at trace levels. In comparison to WHO and SSMO standards TDS (626.6, 569, 930, 831 and 615.5 mg/l), bicarbonate (732, 427, 371.7, 326.6, 305, 323 and 266mg/l), nitrate(66.2, 49.6 and 48, 4mg/l), fluoride (4.38, 3.4, 2.66, 1.92, 1.68 and 1.56 mg/l), iron (0.40ppm) and aluminum (0.60ppm) high at Dalanj, Dalamy, Kortala, Hbila, Arashad and Kadugli .There were seasonal variations in some properties such as, TDS, bicarbonate and fluoride in winter season higher than autumn, sodium in autumn higher than winter. For two seasons (autumn and winter) all samples were suitable for drinking. Ground drinking water in Dalami, Kortala and Kadugli require treatment for TDS and fluorides before use.

المستخلص

تم جمع ثلاث عشرة عينة من المياه الجوفية (خليط) وخمس عينات من المياه السطحية من مواقع مختلفة في ولاية جنوب كردفان ، خلال موسمي الخريف والشتاء للعام 2017. استخدمت مختلف التقنيات الفيزيوكيميائية في تحليل العينات بغرض تقييم التباين الموسمي لجودة مياه الشرب ومقارنتها مع مواصفات (منظمة الصحة العالمية) و (الهيئة السودانية للمواصفات والمقاييس). أظهرت النتائج ما يلي: للمياه الجوفية فيما يتعلق بقيمة الرقم الهيدروجيني (درجة الحموضة) و القلوية الكلية مثل الهيدروكسيد والكربونات كانت في حدود ما أوصت به (منظمة الصحة العالمية) و (الهيئة السودانية للمواصفات والمقاييس) المدى المحدد للرقم الهيدروجيني (6.5 to 8.5). كان المتوسط لكل من: العكارة (2.69 ، 2.00) ، التوصيل الكهربائي (788.0 ، 644.0 ميكرو دسم) ، وإجمالي المواد الصلبة الذائبة (471.6 ، 387.9 ملغم / لتر). و التركيب الأنيوني لكل من: البيكربونات (133.6 ، 305.00 ملغم / لتر) ، الفلوريد (1.09 ، 1.10 ملغم / لتر) ، الكلوريد (37.96 ، 48.4 ملغم / لتر) ، النترات (19.8 ، 6.05 ملغم / لتر) ، ثم الكبريتات (17.5 ، 19.34 ملغم / لتر). وكان التركيب الكاتيوني لكل من: الصوديوم (4.18 ، 6.02 ملغم / لتر) ، البوتاسيوم (2.24 ، 2.06 ملغم / لتر) ، الكالسيوم (21.36 ، 18.68 ملغم / لتر) ثم المغنيسيوم (16.46 ، 18.87 ملغم / لتر) بالنسبة لموسم الخريف والشتاء على الترتيب. أيضاً كان القدر المطلوب من الأكسجين الحيوي والقدر من الأكسجين الكيميائي المطلوب صفرًا. فيما يتعلق بالمياه السطحية، كانت قيمة الرقم الهيدروجيني للقلوية الكلية في شكل هيدروكسيد وكربونات في حدود ما أوصت به (منظمة الصحة العالمية) و (الهيئة السودانية للمواصفات والمقاييس)، كان المتوسط لكل من العكارة (4.8 ، 1.74) ، كان التوصيل الكهربائي (428.0 ، 695.0 ميكرو دسم) ، إجمالي المواد الصلبة الذائبة (257.0 ، 417.0 ملغم / لتر) ، التركيب الأنيوني لكل من البيكربونات (30.5 ، 152.50 ملغم / لتر) ، الفلوريد (0.50 ، 0.59 ملغم / لتر) ، الكلوريد (26.3 ، 29.8 ملغم / لتر) ، النترات (19.3 ، 1.06 ملغم / لتر) ، ثم الكبريتات (5.5 ، 2.5 ملغم / لتر). وكان التركيب الكاتيوني لكل من: الصوديوم (2.65 ، 1.81 ملغم / لتر) ، البوتاسيوم (2.52 ، 5.09 ملغم / لتر) ، الكالسيوم (17.84 ، 1.2 ملغم / لتر) ثم المغنيسيوم (4.94 ، 7.0 ملغم / لتر). و كل من: الحديد ، الألمنيوم ، الزنك ، الزرنيخ، الباريوم ، الرصاص ، الكاديوم ، الكروم، النيكل، الكوبالت ثم النحاس (جزء في المليون) في مستوى الأثر بالنسبة لموسم الخريف والشتاء للمياه الجوفية والسطحية على الترتيب. عند مقارنة النتائج بالمعايير الموصى بها من قبل (منظمة الصحة العالمية) و (الهيئة السودانية للمواصفات والمقاييس) تمت ملاحظة زيادة في نسب إجمالي المواد الصلبة الذائبة (615.5 ، 831 ، 930 ، 569 و 626.6 ملغم / لتر) ، البيكربونات (266 ، 323 ، 305 ، 326.6 ، 371.7 ، 427 و 732) النترات (49.6 ، 48.4 و 66.2 ملغم/لتر) الفلوريد (2.66، 1.92، 1.68، 1.56، 3.40 ، 4.38 ملغم/لتر) الحديد (0.40 ملغم/لتر) و الألمنيوم (0.60 ملغم/لتر) في عينات الماء المأخوذة من محطات الدنج ، ، دلامي ، هبيلا ، كرتالا ، الرشاد وكادقلي. كانت هنالك أختلاف بين الموسم و الآخر فيما يتعلق ببعض الخواص مثل : إجمالي المواد الصلبة ، البيكربونات، و الفلوريد حيث كانت الخواص أعلي في الشتاء منها في الخريف . كانت قياسات الصوديوم أعلي في الخريف منه في الشتاء. تعتبر كل عينات المياه المأخوذة خلال الموسمين (الخريف و الشتاء) صالحة للشرب. اما المياه الجوفية في دلامي ، كرتالا و كادقلي تتطلب المعالجة لإجمالي المواد الصلبة و الفلوريد قبل الاستخدام.

Abbreviation

NTU	Nephelometric Turbidity Unit
EC	Electical conductance
TDS	Total Dissolved Solids
WHO	World Health Organization
NRWDC	National RuralWater Development Co-operation
SSMO	Sudanese Standards and Meterlogical Organization
NUWC	National Urban Water Co-operation
COD	Chemical Oxygen Demand
BOD	Biological Oxygen Demand
IAS	International Aid Service
EPA	Environmental Protection Agency
PLRS	Petroleum Laboratories Research and Study
TCU	Total color unit
DO	Dissolved Oxygen
USEPA	United State Environmental Protection Agency
IARC	International Agency for Research of Cancer
NTA	Nitrioacetic acid
UNEP	United Aation Anvironmental Program
CEHA	Center of Excellence for Health Agency
FWQP	Florida water Quality protection
DOC	Dissolved Organic Carbon
AWWA	Amarican Water Work Association
NSW	New South Wales
ICP	Indictivily Coupled Plasma

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Chapter One



Introduction

1.1-Water.

Water is the major chemical component and universal solvent of living systems. It composes 70 percent of human body weight and is the principal medium for metabolic processes (Nason, 1965). Water that exists today has been on earth for billions of years. More than 80% of the earth's surface is covered by water, but less than 1% of it is fresh and/ or drinkable water.(Armand, 1965).

1.1.1. Water Sources:

The sources of water supply are, generally,classified into surface and sub-surface. The two major sources can be specified into a number of interrelated systems/sources (Bsnraju, 1995) as show in Figure (1.1).

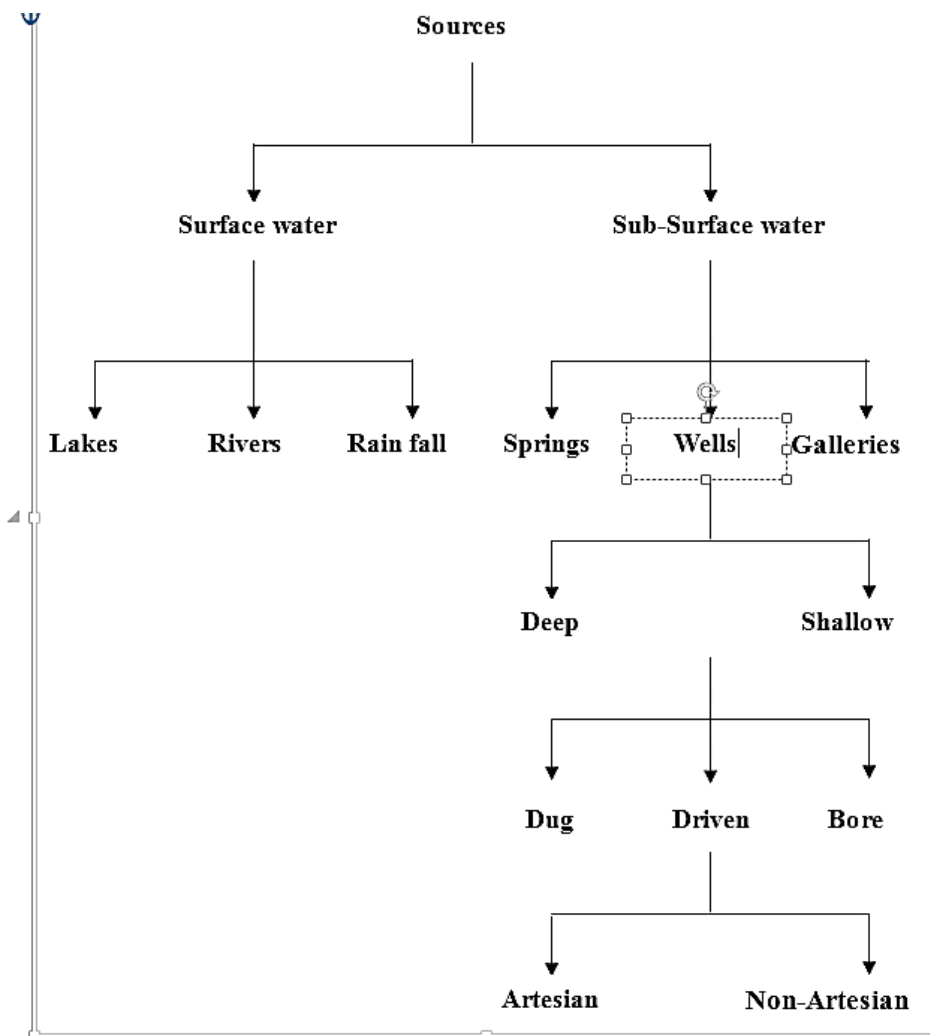


Fig. (1.1) Water Supply Sources:

1.1.1.1.Surface water:-

This includes rivers, streams, lakes and reservoirs, and they may be exposed to contamination. Therefore, proper treatment is required before human consumption. Surface water is supplied mainly from rivers, lakes, reservoirs, and marshes. Economic feasibility of surface water sources depends on their uses and development system. The primary causes of deterioration of surface water quality are municipal and domestic wastewater, industrial and agricultural wastes (organic, inorganic, heat), and solid and semisolid refuse. A municipality obtaining its water supply from a surface, may find its source so fouled by wastes and toxic chemicals that it is unsuitable or too costly to treat for use as a water supply. Fortunately, waste products discharged by cities and industry are being controlled at the point of initiation. This has been borne out by successes in cleaning up such waterways as the Delaware and Susquehanna in eastern United States. (Warren, 2005).

1.1.1.2.Ground water:-

In many countries, ground water is the main source of water for all purposes. This is because rural communities are found close to the ground water and/or away from surface water resources. In addition, the water bearing stratum from which ground water is drawn usually provides a natural storage at points of intake (WHO, 1993). Ground water occurs in the shallow aquifers along the major seasonal streams or in relatively deep aquifer such as Umm Ruwaba and/or the Nubian-Sandstone formation, which cover more than 50% of the total area of the Sudan (Whiteman, 1971). Ground water supplies are much more widely distributed than surface supplies. Nevertheless; strong local concentrations are found as a result of the variety of soils, rocks, and geological structures located underground causing mineralization. (Hammer, et al, 1985). All natural waters contain a various contaminants arising from erosion, leaching and weathering processes. These contaminants behave in different ways in water. None conservative materials including most organic, some inorganic and most micro-materials are degraded by natural self purification processes as their

concentrations are reduced with time. Many inorganic substances are not affected by natural processes so that these conservative pollutants can only have their concentration reduced by dilution or removed by different methods (Tebutt, 1982). Inorganic contaminations include both suspended and dissolved materials. Suspended materials are undesirable for esthetic reasons. Dissolved inorganic, which has health effects include aluminum, arsenic, barium, cadmium, chromium, fluoride, lead, mercury, nitrate, selenium, and silver. It has been found that drinking water with high fluoride concentration is hazardous to human and animal health (McGhee, 1991). Ground water can be classified into three classes according to the layer in which it is stored (IDC, 1981). These are

- i. Free ground water: - It is the water that collects above the first stable impervious layer of rocks. It can move freely and its surface is known as ground water surface or table. It is supplied by rainwater or percolation of rivers or lakes.
- ii. Confined / artesian water: - It is stored in a water containing layer sandwiched between and confined by two impervious layers.
- iii. Perched water:-It exists above a sectional impervious layer. It is not widely distributed and it is seasonal.

1.1.2Composition of water:

Pure water consists of two parts of hydrogen and one part of oxygen by volume, and one part of hydrogen and eight parts of oxygen by weight. (Bsnraju, 1995).

The hydrogen bonding and polar character of water explain its action as a universal solvent. Water, (perhaps because it is ubiquitous in nature) although seems to be a simple material, it is quite complex in a chemical sense. The molecule itself is not symmetric, and its unbalanced nature imparts a polar character, which permits individual molecules to join by hydrogen bonding, forming arrays, which are in a constant state of flux. A simplified presentation of this circumstance is shown in figure (1.2) (Mcghee, 1991).

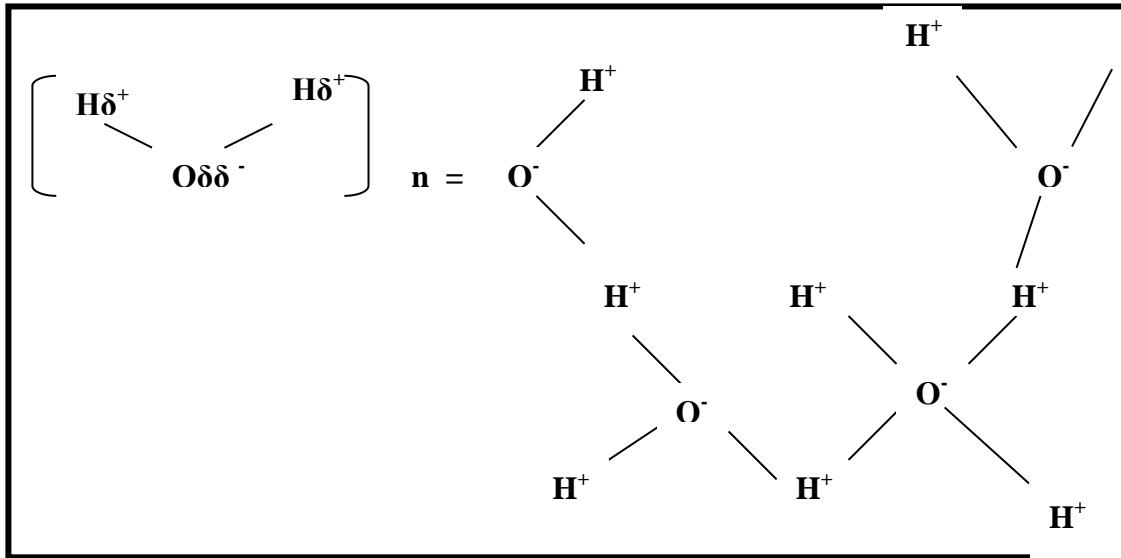
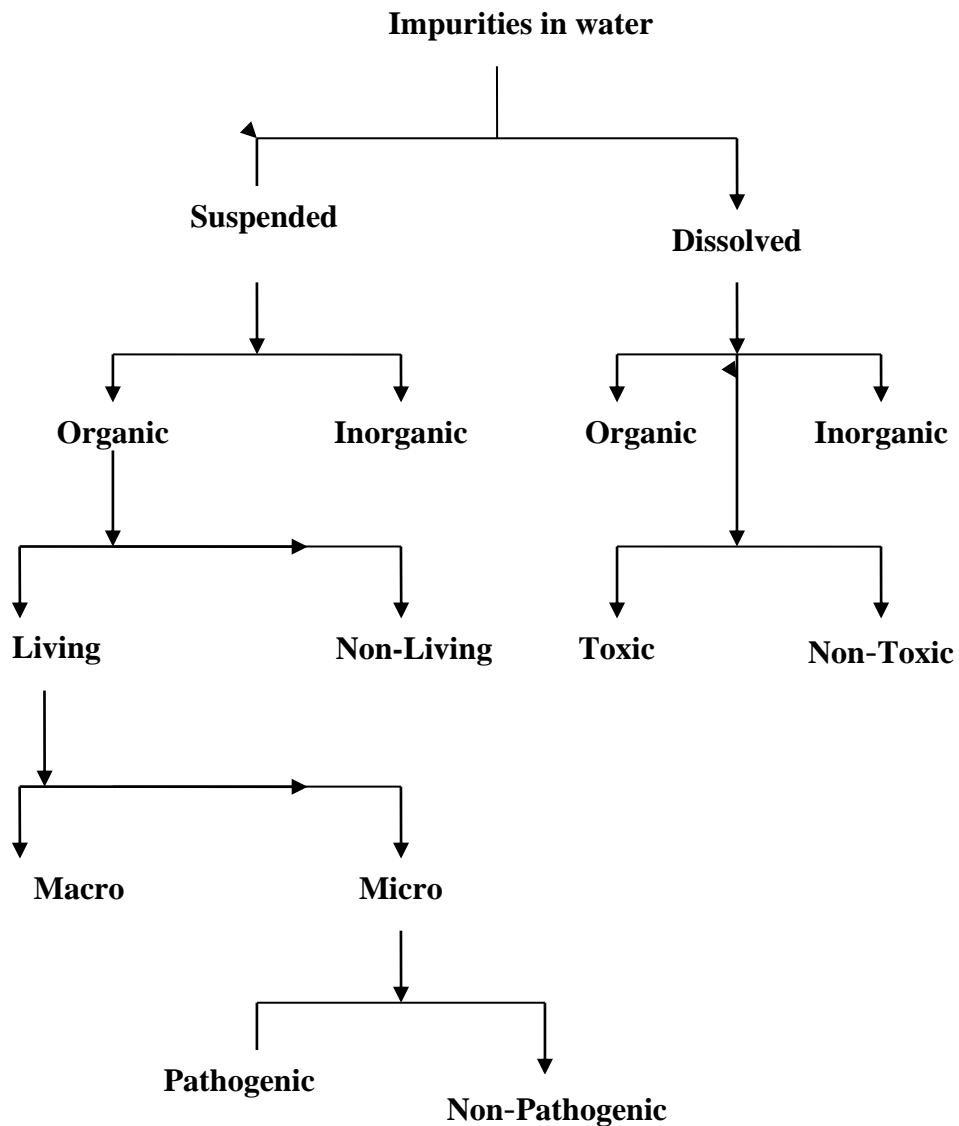


Fig (1.2)-Structure of water molecule and hydrogen bonding

1.1.3. Impurities

No water on earth is 100% pure. It acquires several types of impurities in passage from its origin to place of consumption.(Bsnraju, 1995).The common impurities in water are classified as shown in Figure (1.3)



+

Fig.(1.3) water impurities

1.1.4.Ground water pollution: -

Ground water is normally perfect, as far as suspended matter is concerned. By the straining action of reduction of rocks that water percolates through, soluble impurities are not readily removed. The pollutants, which appear to be of considerable importance with respect to ground water supply, are toxic compounds (trace elements), fluoride, radioactive elements. Pollutants are either

natural or man-caused.

a- Natural pollutants: -Natural pollution is considered as changes in constituents and properties of water in the absence of human activities. This type of natural pollution may be caused by mineral deposits, salts seeps, and sanitary sources leading to exceptionally poor water quality. Excessive turbidity and suspended solids concentration may be considered as pollutants. Ground waters are often polluted naturally by encroachment of oceanic or coastal water or adjacent ground water which is highly mineralized (Almaleak, 1997).

b- Man –caused pollutants: -Most of the water pollution caused by man’s activities can be outlined as follows:-

b. 1- Municipal wastes: -Man’s normal domestic and municipal activities result in the creation of wastes which may be broadly termed sewage. This includes wastes from commercial and industrial establishments, hospitals, hotels in addition to other utilities

b. 2- Industrial wastes: -These types of wastes are extremely complex and variable such as chemicals, suspended matters, poisonous substances, radioactive materials.

b. 3- Agricultural wastes:- Agricultural pollution is due to irrigation water or rain carrying away fertilizers, mineral salts, herbicides and pesticides.

1.1.5.Organic contaminants in ground water:

1.1.5.1.Volatile organic compounds

Enter environment when used to make plastics, dyes, rubbers, polishes, solvents, crude oil, insecticides, paints, disinfectants, gasoline products, pharmaceuticals, preservatives, spot removers, degreasers, and many more. The potential health and other effects can cause cancer and liver damage, anemia, gastrointestinal disorder, skin irritation, blurred vision, exhaustion, weight loss, damage to the nervous system, respiratory tract irritation.

1.1.5. 2.Pesticides

Enter environment as herbicides, insecticides, fungicides, rodenticides, and algicides. The potential health and other effects can, cause poisoning,

headaches, dizziness, gastrointestinal disturbances, numbness, weakness, and cancer. Destroys nervous system, thyroid, reproductive system, liver, and kidneys, (Kansas Report, 2005).

1.1.6.Rain fall Chemistry :

Chemical components of rainfall are of especial interest to hydrologist for chemical mass balance studies of river flow and recharge. Rain fall may also be considered as (a titrant) in hydrochemical processes, because it represent the initial solvent in the study of water rock interaction. Knowledge of rainfall chemistry can also contributes to the fundamental understanding of air mass circulation in present day and past climates. For Africa the available information on rainfall composition is very little.

However, a reasonable understanding of the isotopic evaluation of rainfall in semi-arid areas is emerging (Taubin *et al.* 1997 ; 2000). The isotope (2 H and 3 H) Composition of precipitation can aid identification of the origin of the precipitated water vapour and its condensation history and accordingly, the indication of the sources of air masses and the atmospheric circulation (Rozanski *et al.* 1993). Several elements in rainfall (e.g. Cl) behave inertly on entering the soil and unsaturated zone, and can be used as tracers (Hingston and Edmunds, 1999). The combined geochemical signal may provide a useful initial tracer for hydrologists as well as providing a signal of past climates from information stored in the saturated and unsaturated zones. (Cook, *et al.*, 1992, Tyler, *et al.*, 1996 ; Tyler and Edmunds, 2001). Over much of the Sahara-sahel region rainfall derived solute, following concentration by evapo-transpiration, form a significant component of ground water mineralization (Andrews, *et al.*, 1994). The rainfall chemistry may vary considerably in both time and space, especially to distance from the ocean. This is clear in temperate latitudes for North America (Junge and Werley, 1957). The basic relationship between decreasing salinity and in land distance has also been demonstrated for Australia (Hingston and Gilitis, 1996). The chemical data for Africa are very limited and it is not yet possible to generalize on rainfall chemistry across the

continent (Edmunds, 2004- 2005). The primary source of solutes is marine aerosols dissolved in precipitation, but composition may be strongly modified by inputs from the terrestrial dry deposition. Because precipitation originates in the ocean, it's chemical composition near the coast is similar to that of the ocean. Aerosol solutes are dissolved in the atmospheric moisture through release of marine aerosols near the sea surface (Winchester and Duce, 1967) This initial concentration is distinctive in retaining most of the chemical signature of sea water such as the high Mg/Ca ratio and as well as distinctive ratio of Na/Cl. As rainfall moves inland towards the interior of continents, sulphate and other ions may increase relative to the Na and Cl ions. Chloride may be regarded as inert ion in rainfall with distribution and circulation in the hydrological cycle taking place solely through physical processes. A study of rainfall chemistry in Northern Nigeria has been made by Goni *et al.*, 2001, throughout the rainy seasons from 1992 to 1997 showed weighted mean of values ranging from 0.6 to 3.4 mg/l Cl. This is an important conclusion for the use of chloride in mass balance studies. Bromide like chloride, also remains relatively inert in atmospheric processes, though there is some evidence of both physical and chemical fractionation in the atmosphere relative to chloride (Winchestery and Duce, 1967). The Br/Cl ratio may thus be used as a possible tracer for air mass circulation, especially to help define the origin of the chloride. The Br/Cl ratio is also a useful palaeoclimatic indicator (Edmunds, *et al.*, 1992), since rainfall ratio values may be preserved in ground in continental areas. The relative amounts of chloride and bromide in atmospheric deposition results initially from physical processes that entrain atmospheric aerosols and control their size.

1.1.7. Water treatment:-

The aim of water treatment is to protect the consumer from pathogens and impurities in the water that they may be injurious to human health (WHO, Geneva, 1993). The intensity of treatment must depend on the degree of contamination of the water (WHO, Amman, 1993). Water treatment involves a

physical, chemical and biological change that transforms raw water into potable water (Labib, 1971), which does not cause a health hazard or impair its usefulness to consumer (Nicosia, 1993). The more important treatment processes are coagulation, sedimentation, filtration, disinfection.(U.S.A.,1971).The most important criteria on the water treatment alternative is based on the water quality,(UNEP,Nairobi,1988).The quality of drinking water has great impact on human health and provision of a safe and adequate supply of drinking water is an essential component in the primary health care(CEHA,Nicosia,1993).

1.1.8. Water quality: -

It is the usefulness of water, determined by the solutes and gases dissolved in the water as well as the matter suspended in and floating on water. One basic measure of water quality is the total dissolved solids (TDS), which is the total amount of solids in milligrams per liter that remains when a water sample is evaporated to dryness. (WHO, Geneva, 1993). Water should conform to the following water quality characteristics:

- Free from pathogens organisms.
- Clear (i.e. low turbidity; little color).
- Less saline (salty).
- Free compounds that cause an offensive taste or odor.
- Free from compounds that have adverse effects on human health.
- Low in concentrations of compounds that are acutely toxic or that have serious long-term effects such as lead.
- Free from chemicals, which may cause corrosion of water supply system or staining clothes washed in it. (CEHA), Nicosia, 1993).

Concentration of ions in water, especially ground water originate from different sources as shown in Table (1.1).Concentration of such ions determine suitability of water uses ,especially drinking water, gauged by national and/or international standards(Table 1.2).In drawing up national standards for drinking water quality, various local, geographical, socioeconomic and cultural factors must be taken into account (WHO, Geneva.1997).As a result national standards may differ from the guideline value of WHO and SSMO standards of the maximum admissible concentrations of some elements in drinking water.

Table (1.1): Sources of ions in water.(Singbal and Gypta,(1992).

Major ions (mg/l)	Sources
Calcium	Carbonate, gypsum
Magnesium	Olivine, pyroxene, amphiboles
Sodium	Clay, feldspar, evaporate, industrial waste
Potassium	Feldspar, fertilizers, K-evaporates
Bicarbonate	Soil and atmosphere
Chloride	Windborne, rainwater, seawater and natural brines, evaporate deposits; pollution
Sulphate	Gypsum, and anhydrite, seawater, windborne, oxidation of pyrite
Nitrate	Windborne, oxidation of ammonia or organic nitrogen, contamination
Silica	Hydrolysis of silicate
Minor ions (1 to 0.1 mg/l) iron	Oxides and sulphides, e.g. hematite and pyrite; corrosion of iron pipes
Manganese	Oxides and hydroxides
Boron	Tourmaline, evaporates, sewage, seawater
Fluoride	Fluorine-bearing minerals, viz, fluorite, biotite
Trace elements(< 0.1 mg/L)	
As	Arsenic minerals, e.g. arsenopyrite, arsenic insecticides
I	Marine vegetation, evaporates
Heavy metals	Industrial waste and igneous rock weatherin, under mild reducing conditions
(Hg,Pb,Cd,Cr)Radioactive elements e.g. U, Ra	Uraniferous minerals, nuclear tests, and nuclear power plants

Table (1.2): The maximum admissible concentrations of some elements in drinking water .(Bashir, 2005)

Elements	WHO (mg/L)	SSMO (mg/L)
Aluminum	0.200	0.200
Antimony	–	0.004
Arsenic	0.05	0.007
Barium	1.00	0.500
Boron	–	0.200
Cadmium	0.005	0.003
Chloride	250.0	250.0
Chromium	0.05	0.040
Copper	1.00	1.500
Cyanide	0.1	0.050
Fluoride	1.50	1.50
Iron	0.300	0.300
Lead	0.05	0.007
Manganese	0.1	0.5
Mercury	0.001	0.007
Molybdenum	–	0.50
Nickel	0.02	0.014
Selenium	0.01	0.007
Silver	0.050	0.050
Sodium	200	–
Zinc	5.00	–

SSMO: Sudanese Standards and Meterology Organization.

1.1.9. Ground water Quality:

Ground water quality comprises the physical, chemical and biological qualities. Temperature, turbidity, colour, taste and odour make up the list of physical water quality parameters. Since most ground water is colourless, odourless and without specific taste, quality studies are typically concerned with ground water chemical and biological qualities (FWQP, 2003 series). The chemistry (quality) of ground water reflects inputs from the atmosphere, from soil and water rock reactions (weathering) as well as pollutant sources such as mining land clearance, agriculture, acid precipitation, domestic and industrial wastes (Gregory, K.J. *et al.* 1987, 1993). The relatively slow movement of ground water means that residence times in ground waters are generally orders of magnitude longer than surface water. As in the case of surface water quality, it is difficult to simplify to a few parameters. However, in the context of geo-indicators a selection has been made of a few important first-order and second order parameters that can be used in most circumstances to assess significant processes or trends at a time scales of 50 - 100 years. The following first order indicators of change are proposed, in association with a number of processes, and problems and supported by a number of second order parameter :

[1] Salinity : Cl, , So₄, Br, TDS, Mg/Ca, H, F.

[2] Acidity and Redox status : pH, H CO₃ , Eh, DO, Fe, As.

[3] Radioactivity : 3H , Cl ³⁶ , Rn ²²².

[4] Agricultural pollution : NO₃, DOC, K/Na, P, pesticides and herbicides.

[5] Mining pollution : So₄, PH, Fe, As, other metals, F, Sr.

[6] Urban pollution: Cl, HCO₃, Dissolved organic Carbon (DOC), hydrocarbons, organic solvents. During development and use of aquifer, changes may occur in the natural base line chemistry that may be beneficial or detrimental to health (e.g. increase in F or As). The quality of shallow ground water may also be affected by land slides, fires and other surface processes that increase and decrease infiltration or that expose or blanket rock and soil surfaces which interact with down ward-moving surface water. Ground water is almost

globally important for human consumption, and changes in quality can have serious consequences.

It is also important for the support of habitat and for maintaining the quality of base flow to rivers. The chemical composition of ground water is the measure of its suitability as a source of water for human and animal consumption, irrigation, and industrial purposes. It also influence ecosystem health and function , so that it is important to detect changes, (early warning changes) both in natural systems and that resulting from pollution.(Appelo *et*;1993, Berger *et al*, 1996).

1.2.Salinity:

1.2.1.Definition:

Salinity is the presence of salt in the land surface , in soil or rocks, or dissolved in water in rivers or ground water .

According to NSW Surveys (1983-91) when wind and rain weathered rocks that contain salt,or carry salt from the ocean,then salt is left in the landscape. Salts also been deposited in places that were under the sea in pre-historical times.

Salinity can develop naturally, but where human intervention has disturbed natural ecosystems and changed the hydrology of landscape, the movement of salt into the rivers and onto land has been accelerated. This is beginning to dramatically affect natural environment, reduce the viability of agricultural sector and damage private and public infrastructure.

The acceleration will continue until a new hydrological equilibrium is reached, but that equilibrium will impose an incalculable cost unless action is taken now. Evenly taking action now will not be able to reverse all the damage, or do more than slow the rate of damage over a next ten to fifteen years.

Salinity often occurs in accompany with other natural resource problems,such as decrease in soil quality,erosion,and die back of native vegetation. Salinity can be categorized into a number of different ways.

1.2.2.Types of Salinity:

The NSW (New South Wales) salinity strategy encompasses many types of salinity, dealing with salinity wherever it is found in the landscape.

1.2.3.1Dry Land Salinity:

Dry land salinity occurs due to removal or loss of native vegetation and its replacement with crops and pastures that have shallower roots and different water use requirements, result in more water recharging the ground water system. The ground water rises to near the ground surface in low lying areas or on the peak of slope. Ground water can also flow underground directly into streams. The ground water carries dissolved salts from the underlying soil and bedrock material through which it travels. In some areas, dry land salinity is not related to rising ground water (NSW, 1991). E.g. in the Liverpool plains, the removal of native vegetation, as well as some agricultural practices, have increased erosion rates and exposed naturally saline sub-soils. Run-off carries salt in these exposed sub-soils into streams. In these situations, rising ground water has little role in the development of the salinity problem. (NSW survey 1988-1991).

1.2.4.Irrigation Salinity:

The main cause of this type of salinity is the application of large volumes of irrigation water, equivalent to as much as four times the average naturally occurring rainfall, compounded by the replacement of native vegetation by plants with different water use patterns. The usual effect is to create ground water "a Ground water mound" where the water is being applied, so the impacts are very localized (The recharge and discharge zone can be the same place). The problem of irrigation salinity is better understood than those of dry land salinity.

1.2.5.Urban Salinity:

This is a combination of dry land and irrigation salinity. It is caused both by rising water table due to clearing, and by the application of additional quantities of water from:

- a) Watering of gardens and parks.
- b) Leaking water, sewerage and drainage pipes.
- c) Obstruction or modification of natural surface and subsurface drainage paths.

The mechanism that induce salinity can work very quickly to affect vegetation in drainage lines and on sporting ovals, and to damage buildings, road and pipe system.

Salinity shortens the life of infrastructure such as roads and bridges, and increases building costs due to need for protective works and use of higher specification material. Urban salinity currently affects the towns in the Murray – Darling basin as well as parts of western Sydney and the lower Hunter Valley. (NSW, 1991).

1.2.6. River Salinity:

River salinity is caused by saline discharges from dry land, irrigation and urban salinity into creeks and rivers.

1.2.7. Industrial Salinity:

Salinity both has an impact on, and is influenced by, industrial sector. Effluent from towns, intensive agriculture and industry can contain high levels of salt. Coal mines need to manage saline water emanating from ground water seepage and rain water coming into contact with mine working. Coal fired power stations use water for cooling, a process in which water is evaporated and salt concentrated.

1.3. Significance of the Research problem:-

The study area lies on a basement encompassing rocks /stoles /zone, which possibly a source of the trace elements, this may signify that ground water hosted in the basement rocks may contain leached trace elements situated or / transported. Presence of high concentration of these trace elements such as (I, As, Cr, Pb, Cu, Hg, etc) and fluoride is known to be health hazardous to human health, harmful to living organisms.

Hinders water quality with respect to its domestic agricultural, industrial, and uses in the other economic activities.

The area is characterized by the high rainfall, and move through the earth (Khors) are sources of surface and or perched ground water supply traditional shallow wells (masheesh) cause pollution and effected in the properties of water.

1.4.Objectives:

1.4.1 General Objective:-

The objective of this study is to assespossible effects of seasonal varations on water quality.

1.4.2.Specific objectives including:-

- To determine physicochemical characterstic the quality of water from different localities in South Kordofan State.
- To determine of some trace hazard elements eg Zinc,Barium,Arsenic, Chromium, and Cadmium.
- To determine some inorganic minerals eg F^- , Cl^- , SO_4^- NO_3^- .
- To coorelate any significanes of the physical and chemical properties of water.
- To compare the results with (WHO) and SSOM Guidelines.

1.5.The study area:-

1.5.1- location of the Area:

Located in the south part of the Sudan today .It lies between longitudes 29-30 east and latitudes 9-12 Fig(1.4) .The State covers an area oh 88.000 Km² and consists of Five provinces (localities).The capital “Kadugli” lies some 900 KmfromSouth west of Khartoum. Southern kordofan location is characterized by uplifted basement complexes,which includes, genesis, meta sediment, meta volcanic and older granite of precambrian age. These units are metamorphosed and affected by three periods of deformation. Basement complex is over leaned by superficial cover of Quaternary-Recentage, in some parts it is covered by Um-Rwaba formations (Tertiary). (Gibla,2007). Soil on Southern Kordofan State fall in to three main type: the “heavy clays(Vertis sols)”with clay contents greater than 60% well when wet ,the “lighterclay “ or (Gardoud) soil which is relatively fertile swell when wet but tend to compact when dry and sandy or (Goz) soil which are poor minerals organic matter and clay content.

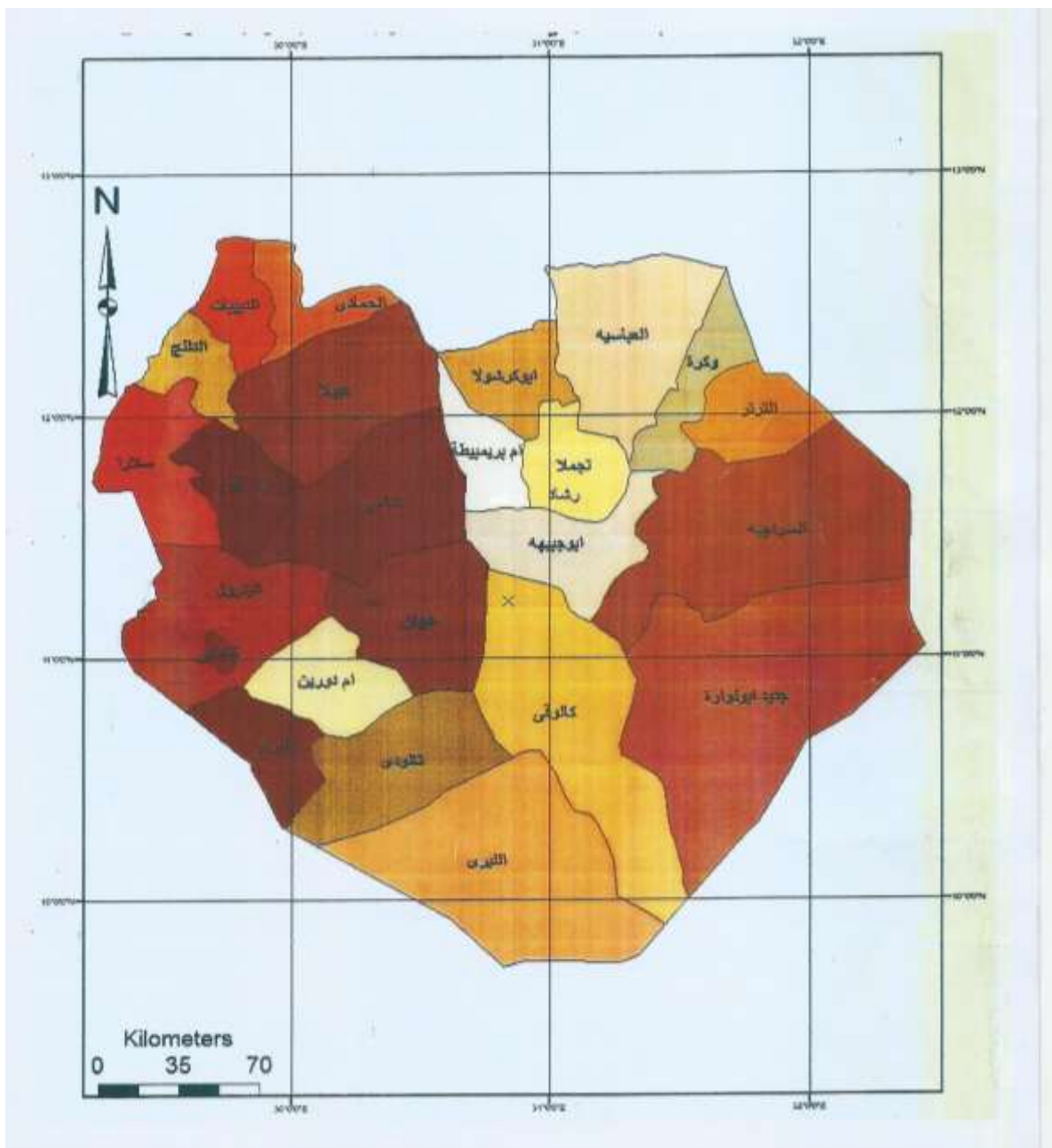


Fig (1.4) Map of South Kordofan State

1.5.2. Climate

The area is ecologically classified as semi arid and rainy savanna regin.(Ibid.2005)The international convergence zone that oscillates from north to south each year influences the climante.This oscillation causes a shift in wind direaction from south to north , carrying moist air over the area that with ascending air causes convention rain .This usually Starte at the beginning of may when the first erratic rain biging .The area remains under this influence

until the October when the winds begin to change from south to the north bringing dry air.

The dry period lasts until April . Four season are recognized(Alfred,1955).

The rainy season ,from May to October, the harvest (Winter) season ,through November to the December .with low night temperature ,the cool dry season, from December to February ,and the hot dry season with northerly winds ,through March to mid-April.(Alfred,1955).

1.5.3.Geology of the Sudan.

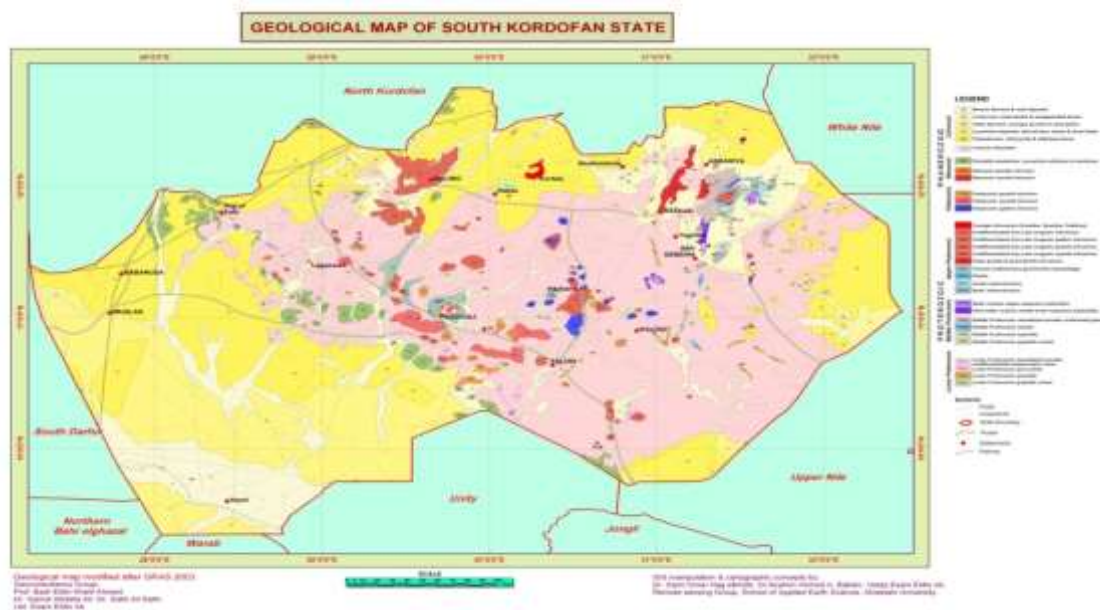
Sudan has the following geological units of structure:

- Crystalline basement rok(Precambarian)
- Nawa formation and paleozoic sandstones (combarian-carboniferrous)
- Nuri sandston (Jurassic-cretaceoua)altic out crops (Tertiary)
- Basaltic out crops (tertiary)
- Coastal deposits (Late Tertiary)
- UmmRuwaba rormation (Pliocene- Pleistocene)
- Surface deposits (Late Pleistocene).

1.5.4.Geological Background of the Study area:

Southern kordofan StateFig (2.2) is characterized by uplifted basement. The basement complex includes genesis, meta sediment, meta volcanic and older granite of Precambrian age. These units are metamorphosed and affected by three periods of deformation. Basement complex is over lained by superficial cover of Quaternary-Recentage, in some parts it is covered by Um-Rwaba formations (Tertiary). (Noor Eldeen, 2010).

The landscape is characterized by flat thorn bush savannah. (International Organization for Migration.(Komey, 2009)



Fig(1.5) Geological Map of South Kordofan State

1.5.5.Population:

The population Fig (1.6) of Southern Kordofan State is about 1,925,606.,(Bureau,Statistics in South Kordofan 2015)depending mainly on ground water as a main source of drinking water and other water uses. From physical observations, in regard to taste and the precipitation of salts, there is interest and urgency to know and identify these water sources to investigate and specify their quality physical and chemical characteristics. (Mukhtar 2000)

Economic activities in the area arebusiness activitiesdepartment of government andother institution agriculture and pastoralism as fundamental profesions for most citizens in the area as will as other activities such as leather and metal.(Ahmad 1984).The inhabitants of the area are the Nuba, a complexily of ethnic groups who are seemed as “Black African”. The Baggara (cattle herders)mainly Hawazma and Messeriya constitute the second dominant group.Other tribal groups such group from western African, Darfur, South

Sudan and other Arab group mainly who called “Jallaba” from Northern and central Sudan.(Komi,2004).

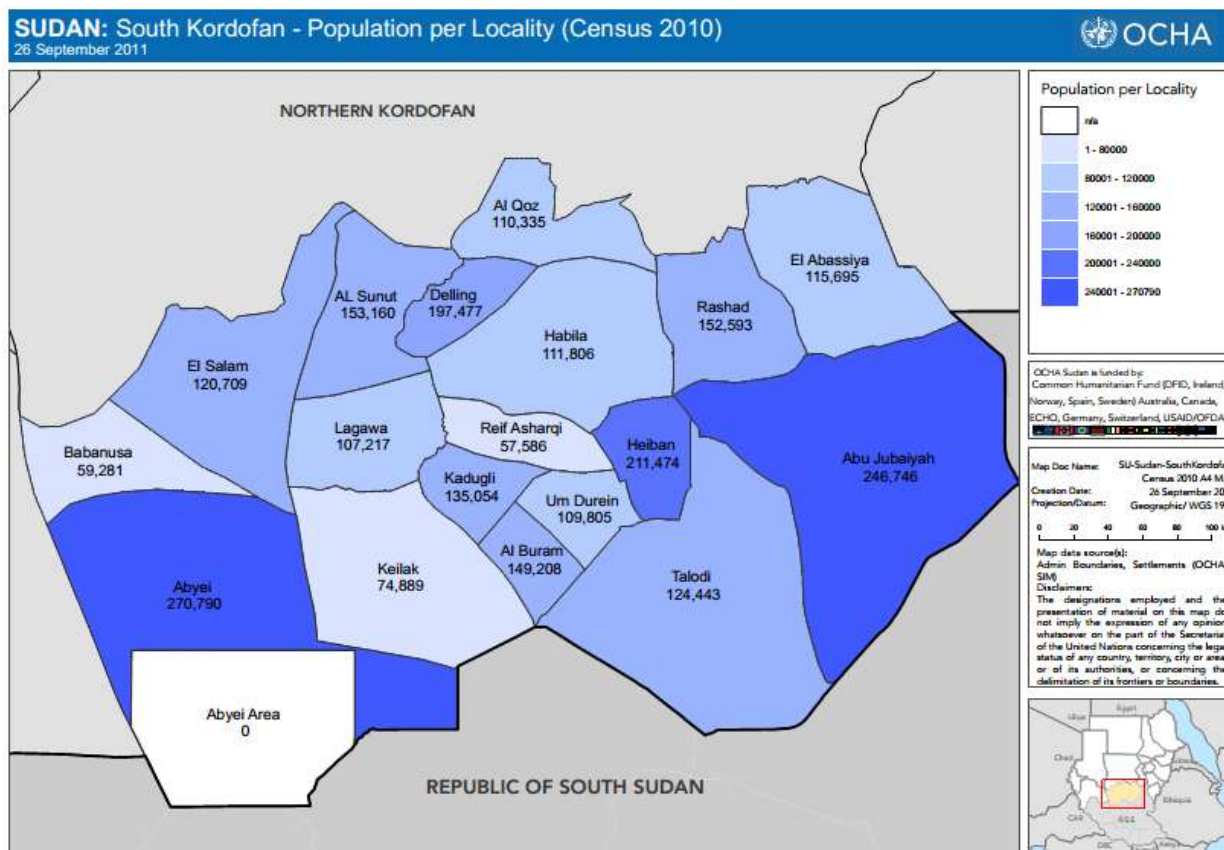


Fig (1.6)Map of population per Locality in south Kordofan Stat

1.6.The physical parameters of water:

2.6.1.Effects of pH on water quality:

The pH is the measure of the acidity or alkalinity of water.

Formally, pH is $-\log_{10} [H^+]$, where a $[H^+]$ denotes the activity of hydrogen ion in water, natural water pH is close to 7. Rocks corrosion start when pH is lower than 8.5. Dissolved minerals presence in water increases the water’s electrical conductivity, and carbon dioxide presence, at high temperature water tends to enhance corrosion, which is caused by chemical or physical process .There lease of metals such as lead, cadmium and nonmetal asbestos as toxic matter, pose serious health risks in drinking water. Zinc, copper and iron are essential nutrients for human and cause no threat to human health, unless taken at,extremely, high levels. Generally, pH above 8.5 can gives water a strong

caustic taste, (N. Argaw, 2003). A category of parameters can be used to describe water quality, to those, apparent to the senses of smell, taste, sight, and touch. As turbidity, color, taste, odor, and temperature also fall into this category

All contaminants of water contribute to solids content, can be classified by their grains size and state, solids can dispersed in water, in both suspended and dissolved forms, include inorganic solids such as silt, sand and clay. More organic matter such as plants fiber, micro organisms from natural or man-made sources. Many contaminants may result from erosive action of water flowing over flat surface area as in Golo reservoir dam in area of study.

2.6.2.Turbidity:

Turbidity is a principle physical characteristic of water and an expression of the optical property that causes light to be scattered and absorbed by particles and molecules rather than being transmitted and interfere with the clarity of water. It is the first thing that is noticed about water clarity. Clarity is, usually, measured by its turbidity. These impurities, may, include clay, silt, finely divided inorganic compounds, and landston, and other microscopic organisms. Typical sources of turbidity include, waste discharges, runoff from watersheds, especially those that are distributed or eroding, high iron concentration which gives water a rust-red coloration mainly in groundwater and ground water which lies under the direct influence of surface water turbidity is the measure of relative clarity which is important when producing drinking water for human consumption. Once considered as, mostly, aesthetic characteristic of drinking water turbidity's significant to human health, excessive turbidity or cloudiness, in drinking water is aesthetically, unappealing and may,represent a health concern. Turbidity is not direct indicator of health risk; numerous studies show that, there is a relationship between removals of turbidity and protozoa removal.(Afaf,2007).

2.6.3.Temperature:

Water freezes at 32° Fahrenheit (F) and boils at 212° F (at sea level). In fact, those are the baseline with which temperature is measured 0° on the Celsius scale is water's freezing point, and 100C° is water's boiling point.(Taylor 1958).

2.6.4. Thermal Properties:

Water has a high specific heat index. This means water can absorb a lot of heat before it is being hot.(Taylor 1958).

2.6.5. Surface Tension:

Water has a very high surface tension. In other words, water is sticky and elastic, and tends to clump together in drops rather than spread out in a thin film. Surface tension is responsible for capillary action which allows water (and in it dissolved substances) to move through the roots of plants and through the tiny blood vessels in human. It high surface tension (73 dyne/cm) at 20⁰C and 1 atm. (Sawyer, 1967).

2.2.6. Color:

Color is another physical characteristic, by which the quality of water can be judged, color can be caused by decaying leaves, plants, organic matter, copper, iron, and manganese, which may be objectionable. It is indicative of large amounts of organic chemicals, inadequate treatment, and high disinfection demand. Pure water is colorless. Water takes color when a foreign substance such as organic matter from soils, vegetation, minerals and aquatic organisms are present. Color also can be contributed to water by municipal waste. Color in water is classified as either true color or apparent color; true color is the color that remains after removal suspended matter from water, and apparent color is the color caused by suspended matter. It is difficult to connect color to health concern. Color is a physical parameter that is not necessarily related to toxicity or pathogenic contamination of water. But sudden change in color must stop people

from drinking contaminated water. The WHO set a recommendation of 15 TCU (total color unit) and maximum permissible level of 5 units, (WHO, 1984).

2.6.7.Taste and odor:

Taste and odor may cause water quality problem. They are affected by different factors, but their effects vary from tap to tap and influenced by personal likes and dislikes. Rust and metallic tastes caused by excessive iron, manganese and other metals in drinking water. This can change the taste and appearance of water. They may be, naturally, occurring or produced by water corrosion that contains dissolved iron and manganese in a reduced form., (John, 1997). In drinking water, taste and odor are not normally, a problem until consumers complain, they don't directly present a health hazard, but they can cause the consumer to seek water that is good in odor and taste. Most consumers consider that water is tasteless and odorless. When odor, taste or both are found in drinking water that means there is a contamination. Water contaminants are attributable to contact with nature or human use. It is impossible to isolate and identify an odor-produced by chemicals, but there are limits for those substances that can, commonly, cause unpleasant odor and taste in drinking water, (George Tch.banoglous, et al 2003)..Odor cannot, be, objectively, measured and guideline hasn't been specified. The provision is that drinking water should have no odor.

2.6.8.Solid Materials

Solid materials may be present in suspension or in solution and they may be divided into organic matter and inorganic matter. Total dissolved solids (TDS) are due to soluble materials, whereas total suspended solids (TSS) are discrete particles which can be measured also as settleable solids.

2.6.9.Electrical Conductivity (EC)

Conductivity is the measurement of ability of solution to carry electric current. This ability is dependent upon the presence of ions in solution. The

conductivity measurement is an excellent indicator of total dissolved solids in water, (T.Hyebbutt1998).

1.6.10.Radioactivity :

Natural back ground radioactivity can be closely related to the presence or absence of rocks and sediments containing uranium or other naturally radioactive materials. Concentration of dissolved Rn gas provide one means of detecting the presence of natural radioactivity in ground water. Of more significance from environmental point of view is the possible migration of radionuclides to ground water from thermonuclear testing, nuclear power plants and military installation. Significant amount of natural radioactivity were found in Kadogly (Saif Eldin 2006), also Magds Hassan (2006) in Sudan , the radiation doses rate in air is at the normal level except at Nubi areas. It is also showed that concentration of heavy elements in the general at the permitted levels except in the north and west regions.

Table (1.3) The Role of some physical Characteristics of water.(Sawyer 1967).

The characteristics	The importance
Temperature	<ul style="list-style-type: none"> • It's effect on other properties e.g. speeding up of chemical reaction, reduction solubility of gases, amplification of tastes and odours.
Color	<ul style="list-style-type: none"> • A highly coloured water may be unacceptable for consumers and industrial uses e.g. production of high grade art papers.
Taste and odor	<ul style="list-style-type: none"> • May causes hazards of health such as headache fainting and vomiting.
TDS	<ul style="list-style-type: none"> • May be due to the presence of large numbers of micro-organisms • It intervene impurity process
Turbidity	<ul style="list-style-type: none"> • caused by presence of large numbers of micro organisms and solids. • Also intervene in the purification and treatment
E.C	<ul style="list-style-type: none"> • An excellent indicator of total dissolved solid and hardness .
Surface tension	<ul style="list-style-type: none"> • Responsible for capillary action which allows water (and in it dissolved substances) to move through the roots of plants and through the tiny blood vessels in human.
The internal properties	<ul style="list-style-type: none"> • The ability of water to store heat helps regulate the rate at which air changes rather sudden. Also it is a valuable property of industries.

1.7.CationicCompostion:

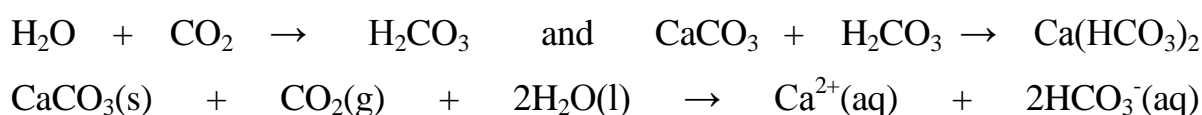
1.7.1.Calcium (Ca):

One of the main reasons for the abundance of calcium in water is its natural occurrence in the earth's crust. Calcium is also a constituent of coral.Rivers, generally, contain 1-2 ppm calcium, but in lime Areas calcium concentrations become as high as 100 ppm. Examples of calcium concentrations in water

organisms: seaweed *luctuca* 800-6500 ppm (moist mass), oysters approximately 1500 ppm (dry mass). In a watery solution calcium is mainly present as Ca^{2+} (aq), but it may also occur as CaOH^+ (aq) or $\text{Ca}(\text{OH})_2$ (aq), or as CaSO_4 in seawater. Calcium is an important determinant of water hardness, and it also functions as a pH stabilizer, because of its buffering qualities. Calcium also gives water a better taste. Calcium reacts with water at room temperature, according to the following reaction mechanism:



This reaction forms calcium hydroxide that dissolves in water as a soda, and hydrogen gas. Other important calcium reaction mechanisms are erosion reactions. These usually occur when carbon dioxide is present. Under normal conditions calcium carbonate is water insoluble. When carbon dioxide is present carbonic acid is formed, affecting calcium compounds. The reaction mechanism for carbon weathering is:



Solubility of calcium and calcium compounds Elementary calcium reacts with water. Calcium compounds are more or less water soluble. Calcium carbonate has a solubility of 14 mg/l, which is multiplied by a factor of five in presence of carbon dioxide. Calcium phosphate solubility is 20 mg/l, and that of calcium fluoride is 16 mg/l. Calcium chromate solubility is 170 g/l, and at 0°C calcium hypochlorite solubility is 218 g/l. Solubility of other calcium compounds lies between the levels of these examples, for example calcium arsenate 140 mg/l, calcium hydroxide 1.3 g/l and calcium sulphate 2.7g/l. Calcium is naturally present in water. It may dissolve from rocks such as limestone calcite (CaCO_3), marble, dolomite $\text{CaMg}(\text{CO}_3)$ gypsum $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$, fluorite and apatite. Calcium is present in various construction materials, such as cement, brick lime and concrete. It is present in batteries, and is applied in plaster as calcium sulphate. The metal is used for zirconium and thorium production. In steel industries calcium is used as a deoxidizer, and is added to aluminum, copper and lead alloys.

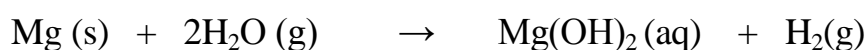
Calcium can extract sulphur dioxide from industrial exhaust, and neutralize sulphuric acids before discharge. Other examples of calcium applications are calcium hypochloride as bleach and for disinfection, calcium phosphate in glass and porcelain industries, calcium polysulphide and hydroxide as flocculants in wastewater treatment, and calcium fluoride as turbidity agent in enamel industries, in UV-spectroscopy, and as a raw material for fluid acid production. Calcium may also be applied for removal of carbon and sulphur from iron and iron alloys, and for dewatering oil. Limestone is applied as paper filler, causing paper to color whiter, and in plastics to improve stability. Calcium often positively affects soil quality and various compounds are applied as a fertilizer. For example, CaCl_2 - or $\text{Ca}(\text{NO})_3$ solutions are applied in horticulture. Calcium is a dietary requirement for all organisms apart from some insects and bacteria. Calcium carbonate is a building stone of skeletons of most marine organisms, and eye lenses. Calcium phosphate is required for bone structure and teeth structure of terrestrial organisms. Plants mainly contain calcium oxalate. Calcium storage in plants is about 1% of dry mass. In limed soils calcium may immobilize iron. This may cause iron shortages, even when plenty of iron is present in the soil. Water hardness influences aquatic organisms concerning metal toxicity. In softer water membrane permeability in the gills is increased. Calcium also competes with other ions for binding spots in the gills. Consequently, hard water better protects fishes from direct metal uptake. pH values of 4.5-4.9 may harm salmon eggs and grown salmons, when the calcium, sodium and chlorine content is low. Some environmental effects of water hardness include hardening of domestic equipment, because high temperatures cause carbonate hardness. This may dramatically decrease the lifespan of equipment, and causes an increase of domestic waste. Calcium carbonate interacts with detergents and cleansing agents. Complex formation causes a decrease in detergent efficiency, resulting in requirement for increased detergent application and softener purchases. Softening is often carried out by means of ion exchangers. These regenerate with kitchen salt, and therefore hardens wastewater. There are six stable calcium isotopes.

Today, we know of eight instable calcium isotopes. Ca^{45} is highly radioactive and toxic. Calcium is a dietary mineral for humans body in amounts of about 1.2 kg. No other element is more abundant in the body. Calcium phosphate is a supporting substance, and it causes bone and tooth growth, together with vitamin D. Calcium is also present in muscle tissue and in the blood. It is required for cell membrane development and cell division, and it is partially responsible for muscle contractions and blood clotting. Calcium regulates membrane activity, it assists nerve impulse transfer and hormone release, stabilizes the pH of the body, and is an essential part of conception. In order to stimulate these body functions a daily intake of about 1000 mg of calcium is recommended for adults. This may be achieved by consuming dairy, grains and green vegetables. Calcium carbonate works as a stomach acid remedy and may be applied to resolve digestive failure. Calcium lactate may aid the body during periods of calcium deficiency, and calcium chloride is a diuretic. Hard water may assist in strengthening bones and teeth because of its high calcium concentration. It may also decrease the risk of heart conditions. Calcium carbonate has a positive effect on lead water pipes, because it forms a protective lead (II) carbonate coating. This prevents lead from dissolving in drinking water, and thereby prevents it from entering human body. When large amounts of calcium are taken this may negatively influence human health. The lethal dose of oral uptake is about 5-50 mg/ kg body weight. Metallic calcium corrodes the skin when it comes in contact with skin, eyes and mucous membranes. Removing calcium and magnesium ions from water is carried out by water softeners. These are ion exchangers that usually contain Na^+ ions, which are released and substituted by Ca^{2+} and Mg^{2+} ions. Calcium compounds may be applied for wastewater treatment. Drinking water pH and hardness may be altered by calcium carbonate and calcium hydroxide.

1.7.2.Magnesium(Mg).

Magnesium is present in seawater in amounts of about 1300 ppm. After sodium, it is the most commonly found cation in oceans. Rivers contains approximately 4

ppm of magnesium, marine algae 6000-20,000 ppm, and oysters 1200 ppm. Dutch drinking water contains between 1 and 5 mg/l of magnesium per liter.(Raju, 1995) Magnesium and other alkali earth metals are responsible for water hardness. Water containing large amounts of alkali earth ions is called hard water, and water containing low amounts of these ions is called soft water. Magnesium metals are not affected by water at room temperature. Magnesium, generally, is a slow-reacting element, but reactivity increases with oxygen levels. Furthermore, magnesium reacts with water vapor to give magnesium hydroxide and hydrogen gas:



Magnesium fires cannot be extinguished by water. Magnesium continues to burn after oxygen is depleted. It reacts with nitrogen from air to form magnesium nitride (Mg_3N_2). When magnesium fires extinguished with water, magnesium aggressively reacts with hydrogen gas. To prevent any damage, a magnesium fire must be covered with sand. An example of a magnesium compound is magnesium phosphide (Mg_3P_2), an odorous, grey solid. When this compound comes in contact with water or moist air, it is decomposed to phosphine (PH_3) Is is a toxic compound, and it is also very flammable in air. Magnesium is mainly present as Mg^{2+} (aq) in watery , but also as MgOH^+ (aq) and Mg(OH)_2 (aq). In seawater it can also be found as MgSO_4 . Water solubility of magnesium hydroxide is 12 mg/L. Other magnesium compounds are clearly more water soluble, for example magnesium carbonate (600 mg/l). Magnesium sulphate adds a bitter taste to water, and has a water solubility of 309 g/L at 10°C. A large number of minerals contains magnesium, for example dolomite (calcium magnesium carbonate; $\text{CaMg(CO}_3)_2$) and magnetite (magnesium carbonate; MgCO_3). Magnesium is washed from rocks and subsequently ends up in water. Magnesium has many different purposes and, consequently may end up in water in many different ways. Chemical industries add magnesium to plastics and other materials as a fire protection measure or as filler. It also ends up in the environment from fertilizer application and from cattle feed. Magnesium

sulphate is used in breweries, and magnesium hydroxide is applied as a flocculant in wastewater treatment plants. Magnesium is also a mild laxative. Magnesium alloys are used in cars and planes structures. During World War II magnesium was applied in fire bombs, to cause major fires in cities. The development of these bombs introduced a method to extract magnesium from seawater. Magnesium is a dietary mineral for organism and insects. It is a central atom of the chlorophyll molecule, and is therefore a requirement for plant photosynthesis. Magnesium cannot only be found in seawater, but also in rivers and rain water, causing it to naturally spread throughout the environment. Three magnesium isotopes occur naturally, which are all stable and, consequently, not radioactive. There are also eight unstable isotopes. Guidelines for magnesium content in drinking water are unlikely, because negative human and animal health effects are not expected. Environmental problems indirectly caused by magnesium in water are caused by applying softeners. As was described earlier, hardness is partially caused by magnesium. Calcium and magnesium ions (particularly calcium) negatively influence cleansing power of detergents, because these form nearly insoluble salts with soap. Consequently, about 40% softener is added to soap. This used to be phosphates, but it was discovered that these are, hardly, biodegradable, and caused eutrophication. Today, alternative chemicals are used, mainly complexing agents such as sodium citrate, EDTA and NTA, or ion exchangers such as zeolite A. These substances do not cause eutrophication and are not toxic. Nitriloacetic acid (NTA) may be mutagenic, and is difficult to remove during water purification. Zeolite increases the amount of sludge. Additionally, other complexing agents such as ethylenediaminetetraacetic acid (EDTA) have the audacity to remove metals from compounds that are otherwise difficult to decompose. Mobile heavy metals may end up in water ways, because EDTA is difficult to remove in wastewater purification plants. Contrary to calcium, magnesium is not bound to zeolites under washing conditions. Water hardness may differ per region, therefore adding softeners to detergents is unnecessary for regions that only contain soft water. In regions

containing hard water higher doses of detergent may be used, in order to add more softener. This causes other substances in detergents to be of high, there by complicating wastewater treatment process.. Human body contains about 25 g of magnesium, of which 60% is present in the bones and 40% is present in muscles and other tissue. It is a dietary mineral for humans, one of the micro elements that are responsible for membrane function, nerve stimulant transmission, muscle contraction, protein construction and DNA replication. Magnesium is an ingredient of many enzymes. Magnesium and calcium often perform the same functions within the human body and are generally, antagonistic. There are no known cases of magnesium poisoning. At large oral doses magnesium may cause vomiting and diarrhea. High doses of magnesium in medicine and food supplements may cause muscle slackening, nerve problems, depressions and personality changes. As was mentioned before, it is unusual to introduce legal limits for magnesium in drinking water, because there is no scientific evidence of magnesium toxicity. In other compounds, for example asbestos, magnesium may be harmful

1.7.3.Sodium(Na)

Sodium compounds are very soluble so that the element is present in most natural waters. The taste for sodium drinking water, depends upon several factors such as the predominant anions present and temperature. The threshold taste concentration for sodium chloride is around 350 mg/1 (138 mg/1 as Na), Whereas threshold taste concentration for sodium sulphate Na_2SO_4 can be as high as 1000 mg/1 (343 mg/1 as Na) The use of base-exchange or lime-soda processes to soften hard water lead to a significant increase in sodium concentration (Raju, 1995).

1.7.4.Potassium (K)

potassium is an abundant natural element, however in freshwater, potassium levels are normally low. The concentration rarely exceeds 20 mg/l. Higher levels can be observed in brackish water. (Raju, 1995).

1.7.5.Arsenic (As)

Arsenic is a naturally occurring metalloid element. (Branislav. et al. 2006).In the pure state is gray- colored brittle crystalline solid and a toxic element. All around the world; arsenic is the twentieth of most bounded element in the earth's crust and, frequently, occurs as a component of volcanic rocks, absorbed and co precipitate with metal oxides and combined chemically with the other metals such as Ni, Fe and tin (especially with the iron oxides). Absorbed to clay mineral surfaces, and associated with sulfide minerals and organic carbon, (Stephen R. 1999). When, rock minerals containing arsenic contact with water in aquifers. The water pumped from these sources may be containing detectable amount of arsenic. Arsenic may be found in water which has flowed through arsenic- rich rocks. Arsenic can remain in environment over long periods, and when it occurs in high concentration, can be toxic to many life forms. Arsenic has to be essential nutrient for many animals' species, and may be essential to human as well (but in very small amount). It's a common, inorganic drinking water contaminant. Arsenic is tasteless and odorless occurs naturally in oceans, earth's crust rocks and soil. In drinking water, arsenic exists mainly in two states As^{3+} (arsenite). and As^{5+} (arsenate), arsenite As^{3+} are more toxic and more difficult to remove from drinking water supply than arsenate As^{5+} , (Stephen R., 1999). It is concentration in earth's crust ranged between 2 to 5 μ g/L. Arsenic has long been identified as toxicant. Previously arsenic contamination was associated with skin cancer, and other disorders.

Recent studies suggest that drinking water with a high level of arsenic also can lead to bladder and lung cancer, which are more likely to be fatal, (Babu, 1999). Arsenic as a component of underground rocks and soil, work its way into

groundwater and enter the food chain through either drinking water or consuming plant that have absorbed the mineral. Water from wells often has high concentration of arsenic than do surface water, such as lakes and streams. The American water works Association's, (AWWA, 1971) indicates that hard waters contain higher levels of arsenic than soft waters. In some areas, arsenic concentrations in groundwater are elevated as a result of erosion from local rocks, arsenic also can be found in plants, fish, and shell fish- mining manufacturing. Arsenic can combine with other elements in water to form two types of derivatives; inorganic and organic arsenic. In general, inorganic arsenics are more toxic than organic arsenics. Food contains both organic and inorganic arsenics. While drinking water primarily contains inorganic arsenical. Its presence in water may cause greater hazard to human health by accumulations. Arsenic can enter water through various ways, such as erosion, or broken and dissolved rocks containing arsenic. Surface arsenic, related pollutants enter the ground water system by gradually moving with flow of ground water from rain and other type of precipitation. The allowable concentration of arsenic in potable water, has been regulated by WHO as provisional guideline of about $10\mu\text{g/L}$ (0.01 mg/l) as national standard in most countries; but the most stringent standard that set for acceptable arsenic concentration in drinking water is by Australia, which has a national standard of $7\mu\text{g/l}$, (Braislav, 2006). The amount of arsenic in drinking water must be at levels that don't pose potential health risks, so that its allowable levels regarded from 0.05 to $0.01\mu\text{g/l}$, (WHO, 1993). Arsenic affects the human body, being absorbed from gastrointestinal tract into the blood. The mechanisms through which arsenic causes cancer are not well understood, but it is indicated that arsenic probably causes chromosomal abnormalities that, subsequently, cause cancer. Consuming food and water are the major sources of arsenic exposure, daily consumption of water with greater than 50 ppb of arsenic can lead to problems with the skin and circulatory and nervous systems. When arsenic is build up to toxic levels (5 years accumulate) it may cause organ cancer. A number of internal cancers and natural disorders consumption of arsenic-

contamination water may cause stomach pain, nausea, vomiting, diarrhea and blindness. Additional studies show that arsenic contamination can cause anemia and nerve damage. Arsenic concentration in water is variable from location to location, but mostly ground water contains lesser levels. Investigation studies in both India and Bangladesh has pointed to water; as the most likely source of arsenic poisoning. Arsenic in ground water in a geological origin, some scientists speculate that increased pumping lowered ground water levels, causing chemical changes that resulted in arsenic being leached out of rocks and soil, in to ground water (but that is not confirmed). Arsenic concentration average in earth's crust is low its level is about 1.7 mg/kg. Arsenic in drinking water is absorbed by the body when swallowed. And distributed by the blood stream, but arsenic don't enter through skin. Its high levels are found in nails and hair. The health effects of arsenic have been studies in Taiwan, where drinking water containing high levels of arsenic (over 0.35 ppm), and the results suggest that consuming of water containing arsenic can increase the risk of cancer in internal organs as bladder, liver and lung, consider that arsenic is a human cancer- causing agent, (Rena Haque, 2003). Its high level in drinking water for long term exposure (over many years) may also cause thickening and discoloration of skin. To protect consumers from health risks of long-term (chronic) arsenic exposure, EPA lowered the arsenic from 50 to 10 ppm. Water is the major means of arsenic transport under natural condition. But arsenic concentration in both ground and surface water is normally less than 0.01 mg/l, (Gilpn R., Robbinson, 2006). Generally, arsenic concentration in rocks varies by rocks type, and geologic setting. Its reducing forms are commonly concentrated in sulphide and sulfur salt minerals, (Hawkes, Rose, et al., 1979). Pyrite, common sulfide mineral is the a prevalent host of arsenic in most rocks.

Arsenic has an affinity for hydrated Fe oxide minerals and mineral coating. As is found at low concentration levels in many natural waters, its concentrations in groundwater exhibit a higher degree of variability from well-to-well, even within close proximity.

1.7.6.Copper (Cu):

Copper (Cu) it is reddish metal that occurs naturally in rocks, soil, water, sediment and air. It occurs in the environment in three major valence states as copper metal (Cu), (Cu⁺), (Cu²⁺). Copper is a member of the 3d transition metal series.

The average abundance of copper in the earth's crust is 68 ppm; and in groundwater is < 0.1 mg/L. copper occurs in its natural state, but also found in many minerals. The most important of these minerals are those containing sulfide compounds, and those with oxide and carbonates. Copper forms a number of complexes in natural water with inorganic and organic ligands among the amount aqueous species are Cu⁺, Cu(OH)₂, and CuHCO₃. Copper is considered an essential trace element for animals. Some copper compounds are toxic by ingestion or inhalation. The USEPA recommended the maximum level of copper in drinking water is 1.3 mg/l, (American Public Health Association, 1998).

Copper and other metals such as Cr, CO, Mn, and Zn constitute the bulk of essential metals in biological system, (WHO, 2004). Copper have unique chemical and physical properties, which make it one of the most, commercially, important metals. Copper is both essential and toxic to living system, as an essential metal. Copper is required for adequate growth functions and iron metabolism, and essential micronutrient that has multiple metabolic functions. However every large or single long-term intakes of copper may harm human health, by eating food or drinking water that contain copper, or may be harmful by skin contact with soil, water containing copper. Two factor age, dietary containing amino acids and metal ions can be affect copper bioavailability absorbing percentage. (When, an adult human ingests 1 mg of copper per day from die or drinking water, about a half of this quantity can be absorbed). Copper is naturally occurring element, that is present in drinking water, when it stagnant in rocky aquifers that containing copper. High levels of copper occur, when corrosive water comes in contact with rock-fracture copper containing and remains motionless for about six hours or more. That may raise copper levels in

drinking water, so copper levels in drinking water increase with water corrosion, and length of time it remains. Increase of copper leaching water, can increased water acidity and water temperature, and reduces its hardness. Copper can form compounds that dissolve in water and not attached to other particles, in this form, copper is most likely to affect health. Copper concentration levels in drinking water and surface water are generally, about (4µg/l) or less. Copper is an essential nutrient to human, in low concentration levels. But acute ingesting of excess of drinking water containing copper is associated with adverse health effects including gastrointestinal disturbances, and chronic ingestion of copper can cause liver toxicity in sensitive population, (Commel, 2000). Immediate effects from drinking water with elevated levels of copper, include, vomiting, diarrhea, stomach cramps or pain and discomfort, nausea, low blood pressure and kidney damage. Seriousness of these effects is genetic disorder that causes with excessive copper, accumulation of copper in liver or brain may be at high risk of health effects due to copper contamination, (Theodore, et al., 2005 The Federal Safe Drinking Water,US Environmental Protection Agency (EPA), and Nebraska Department of human health services regulated licensure of copper concentration in public water supplies at 1.3 ppm. Copper corrosion is most often associated with soft, acidic waters; water with pH below 6.5 and hardness that less than 60 mg of calcium carbonate per litter are very aggressive to copper. Copper like lead can enter the water through dissolution of corrosion products. Copper solubility is mainly a function of pH and total inorganic carbon. The relation is that, solubility decreases with increase in pH. Increasing of pH to between 8, and 8.5 usually overcome these difficulties. Copper impingement attack in water may a result of excessive flow velocities, and is aggravated in soft water at high temperature and low pH. Copper, is commonly associated with hard groundwater that has carbon dioxide concentration above 5 mg/L and high dissolved oxygen. Surface water with inorganic color may also associate with copper. Copper; contaminate drinking water as corrosion product that occurs from rocks containing copper which remain in contact with water for prolong periods.

Copper was included in the list of substances and parameter in drinking water that may give rise to complaints from consumers at a value of 1 mg/l, (WHO, 1993).

1.7.7. Lead (Pb):

Lead (Pb) Its abundance in ground waters is, generally, less than 0.1mg/L. its common aqueous species are Pb^{+2} , hydroxide and carbonate complexes. Tap water that inherently, non-corrosive or not treated may contain lead. Lead is nonessential for human or animals (American Public Health Association, 1975). Lead, is a heavy metal that can cause a variety of adverse health effects in humans, at relatively low levels of exposure. Its effects may include interference with red blood cell chemistry. It delays mental development in babies and young children and causes slight deficits in attention span, hearing, and learning abilities of children, and increases in blood pressure in adults. It is classified in EPA as human carcinogen, (Kansas Report, 2005). Lead, rarely occurs naturally in drinking water sources. The major source of lead in drinking water is the corrosive action of water on the materials used in water distribution. Lead contamination is more serious in areas with soft corrosive water.

Lead is most common of heavy metals. It exists in nature in several isotopes, but Pb 208 is being the most abundant. Lead is found in tap water as a result of dissolution from its natural sources as pipes that containing lead. Its dissolution in water depends upon several factors, including acidity (pH), water softness, and temperature and standing time of water. In Ontario; (Canada) between 1981 and 1985, lead concentration was determined for water used in the kitchens of 18 homes; found that it ranged from 0.25 to 2.76 $\mu\text{g/l}$. in recent study in Canada, the concentration of lead in, actually consumed water, was determined for several location was found as median level of about 4.8 $\mu\text{g/l}$. Lead is the major environmental health risk, and referred as number one environmental health threat to infants and young children and pregnant women's fetuses are, particularly, susceptible to the adverse health effects of lead, no amount of lead is considered to be safe. Lead poisoning can cause permanent brain damage in

serious cases, and in few cases can cause children suffer from decreased intelligence and problem with growth, development, and behavior. Lead can also harm kidney function, affect the nervous system, and damage red blood cells, when using water containing lead for many years. The national standard for lead in drinking water is 15 ppb ($\mu\text{g/l}$), and maximum national health goal is (zero) ppb. Because of size and charge similarities, lead can be substituted for calcium in bones. Children are especially susceptible to lead as their developing skeletal system require high calcium levels, lead that stored in bones is not harmful, but when a high levels of calcium are ingested later, may be replaced lead from bones by mobilized calcium. And become free in the system that may affect the central nervous system. Lead in drinking water cannot be seen, tested, or smelled. It can only be detected by laboratory testing. But it classified as being possibly carcinogenic to humans. Its poisoning is usually slow process, often taking place over months or years. However, with very high level exposure, lead poisoning can rapidly create a life- threatening emergency.

1.7.8.Zinc (Zn):

Zinc, Its average abundance in the earths is 76 ppm; but in soils is 25 to 68 ppm, and in ground water is $< 0.1 \text{ mg/L}$. Its solubility is controlled in natural waters by absorption on mineral surfaces.

Zinc occur in environment primarily in 2+ oxidation states, either as free (hydrated) zinc ion, or as dissolved in soluble complexes and compounds. In soil, it often remains strongly sorbet. And in aquatic environment it is predominantly, in the sediment, (Bryan, 1992), however, re-solubilisation of zinc into aqueous is possible under certain physical- chemical conditions as presence of soluble anions, the presence of organic matter, clay minerals and hydrous oxides of iron and manganese, low pH and increase salinity. Zinc in soluble forms (sulphate or chloride) is more likely to migrate through the environment than it is bound to organic matter or present as an insoluble precipitate. Zinc is an essential growth element for animals, and present in their tissues even at normal concentration,

but at elevated or exposed to high level it can results possible toxic effects. Zinc is the metal that is normally found in small amount in water. It's abundant and constitutes approximately 0.004 percent of the earth's crust substances.

The most common zinc mineral is sphalerite (ZnS), which is often associated with sulphides of other metallic elements such as lead, copper, cadmium and iron, (Hem, 1970). Zinc is also found as calamine ($ZnCO_3$) in carbonate sediment. Other forms of zinc are ,usually, products of the oxidation of sphalerite, carbonates, oxide and sulphides of zinc which are poorly soluble in water; therefore, zinc is present in natural waters as low concentrations. The highly soluble chlorde and sulphate salts are hydrolyzed to form hydroxide and carbonate. Absorption onto hydrated sediments further depletes the levels of dissolved zinc. Canada surface water zinc concentration ranged from 0.001 mg/L to a high of 1.17 mg/l, analysis of drinking water sources as lakes in Canada, showed that, zinc main concentration was less than 0.010 mg/l, but it is also found that zinc concentration levels varied widely with both location and season and don't exceed 0.04 mg/L(WHO, 1983). At a concentration of 40 mg/L, zinc gives water a milky appearance, water that contains zinc at concentration in excess of 5.0 mg/L has an undesirable astringent taste. Zinc solubility in water is a function of pH and total inorganic carbon concentration. So, the solubility of basic zinc carbonates decreases with an increase in pH and carbonate species concentration. In low alkalinity waters, an increase of pH to 8.5 is sufficient to control zinc dissolution, (Ontario Drinking Water Standard and Guideline, 2006). Zinc is an essential element for human and is, generally, considered to be non-toxic. Its long-term ingestion hasn't resulted in adverse effects. The USEPA recommended zinc standard in drinking water at 5 mg/l. approximately most of zinc in drinking water does not dissolve, and settles to the bottom, (Ontario Drinking Water Standard and Guideline, 2006). Drinking water is not regarded as an important source of this element. But water containing zinc concentration above 5.0 mg/L tends to be opalescent and develops a greasy film when boiled and has undesirable astringent and bitter taste and other effects. As zinc is an

essential element for all living things, including man, proteins and enzymes zinc containing as (co-enzymes) are involved in every aspect of metabolism, including translation of genetic material, (Abdelmageed A, 1998). Zinc deficiency symptoms in humans as general including, retarded growth, anorexia, metal lethargy, skin change, and night blindness. May also impair the immunesystem, slow wounds healing and lead to eczema and acne.

1.7.9.Cadmium (Cd):

Cadmium in ground water is from 1 to 10 $\mu\text{g/l}$. Cadmium occurs in sulfide minerals that also contain zinc at a ratio of about one part cadmium to 500 parts zinc in most rocks and soil. Its solubility in waters is, naturally, controlled by carbonate equilibrium. Its maximum concentration in drinking water is linked to the hardness of water, (softer water, and water with the lower permitted level of cadmium). Cadmium is nonessential element for human and is extremely toxic and accumulates in kidneys and liver. With prolonged intake at low levels it may cause dysfunction of the kidneys. Cadmium occurs naturally in zinc, lead, copper as sulfide ores, and others which can serve as sources to ground and surface waters. When it is in contacted with soft, acidic waters, some cadmium compounds are able to leach through soils to ground water. It has great tendency to accumulate in some aquatic species. Cadmium solubility in water is influenced to a large degree by water acidity. Suspended or sediment- bonded cadmium may dissolve when water acidity increases, but in natural water, cadmium is found mainly in bottom sediments particles, (Anna, 2004). Drinking water from shallow wells, in Sweden where the soil had been acidified contained concentration approaching 5 $\mu\text{g/L}$. In Saudi Arabia; it is mean concentration was found of about (1 to 26 $\mu\text{g/L}$) in private wells. Cadmium levels could be higher in areas supplied with soft water of low pH, (WHO, 2004). Cadmium is the relatively rare metal, being 67th element in order of chemicals abundance. It is found in the earth's crust in low concentration. Some sedimentary rocks, black shale's can accumulate higher levels of cadmium, (Alloway, 1990). It usually found in association with sulfide ores of zinc, copper, and lead, cadmium is more

mobile in water than most other metals, it is found in surface and ground water as either +2 hydrated ion or as ionic complex with the other inorganic and organic substances. While cadmium in soluble form may migrate in water, cadmium insoluble complexes or that absorbed to sediments is relatively immobile. Cadmium has no biochemical or nutritional function, and it is highly toxic to both plants and animals include humans. Cadmium has strong evidence that kidney is main target organ of cadmium toxicity after extended exposure, (Goyer,1996). A cadmium intake level from drinking water is usually low (less than 2 µg/day), cadmium concentration in human tissues with age. Both kidney and liver act as cadmium stores. So that about (50 – 85%) of the body burden is stored in kidney and liver, (30 – 60%) being stored in kidney alone. Only small part of cadmium absorbed in human body will be excreted in urine, but there is a large individuality variation. The allowable maximum level for cadmium in drinking water recommended by EPA is 5 ppm. This level would not cause any potential health hazard. When people are exposed to high level, than the recommended level above for relatively short periods of time this can cause; nausea, vomiting, diarrhea, muscle cramps, salivation, sensory disturbances, liver injury, shock and renal failure. Because, cadmium tends to accumulate in human body for long-term it can cause kidney, liver, bone and blood damage. These effects are clear in iron- deficient peoples (Kowalczyk. et al., 2002).

1.7.10.Chromium (Cr):

Chromium is the most abundant element in the earth's crust (Niragu, 1988). Their higher concentration is found in some igneous rocks, clay, and shale, (Alloway, 1990). Chromium is a metallic element with an atomic number of 24. It is a member of group VIB on the Periodic Table, possesses one electron in outer electron shell ($Ar_{18} 3d^5 4s^1$). It has four naturally occurring isotopes. The most common ones are ^{52}Cr (83%) and ^{53}Cr (9.5%). No non of its, natural, isotopes is radioactive, (Weast, et al., 1988). Chromium, generally, occurs in small quantities associated with the other metals, particularly iron. Its atomic weight is 51.996. Its melting point is at $1.87C^{\circ}$ and boils at $2.68C^{\circ}$ its specific

gravity is 7.19. its most common valence are trivalent and hexavalent. Chromium forms a number of salts, which are characterized by different colors, solubility's, and other properties. (The word chromium is from Greek word means colors). Its more important salts are sodium and potassium chromates, dichromate and ammonium chrome alum, (Alloway, 1990). Chromium is industrial metal, which has a potential to contaminate drinking water sources. Although many different oxidation states of chromium exist in the environment, only the trivalent (Cr^{3+}) is present predominantly in soluble form. These soluble forms may be stable enough to undergo intra-media transport, but chromium (Cr^{6+}) eventually be converted to chromium (Cr^{3+}), by reducing species such as organic substances, hydrogen sulphide, sulphur, iron sulphide, ammonium and nitrite. Trivalent form is generally not expected to migrate in natural waters or systems; instead it is rapidly precipitated and adsorbed onto suspended particles and bottom sediments. However, water chemical and physical properties, can result in changes to the chromium Cr^{3+} and chromium Cr^{6+} equilibrium, (Richard and Bourg, 1991). In soils, chromium Cr^{3+} is relatively immobile due to its strong adsorption capacity onto soils. In contrast, chromium Cr^{6+} ions, are highly, unstable and mobile, since it is poorly adsorbed onto soils under natural condition. Oxidation processes of chromium Cr^{3+} to chromium Cr^{6+} , and reduction of chromium Cr^{6+} to chromium Cr^{3+} affecting chromium toxicity in soils. Chromium oxidation; occurs in manganese and iron oxides in fresh and moist (anaerobic) soils and under slightly acidic condition, but accelerated by organic matter present in soil. The importance of this lies under the fact that whilst Cr^{3+} is an essential trace element for animals and humans, chromium Cr^{6+} is non-essential and toxic even at low concentrations, but there is no guarantee that Cr^{3+} remain in this chemical state when it is discharged into water environment. Chromium Cr^{3+} is considered an essential trace nutrient. Because it is required for glucose protein and fat metabolism in humans and animals. Its deficiency signs in humans include weight loss and the impairment of the body to remove the glucose from the blood, (Goyer, 1996). The minimum daily requirement of

Cr^{3+} to humans for optimal health; is unknown- but 50 to 200 $\mu\text{g}/\text{day}$ have been estimated to be safe and adequate. Very large doses may be harmful. Cr^{6+} compounds as are non- essential for humans and toxic and allergic skin occurs following exposure to Cr^{6+} . Chromium contamination in drinking water has become an area of concern to researchers, and the public because of the increased information on its possible toxicity. Chromate as (FeCr_2O_3) and other chromium and – bearing minerals that present in bedrocks and soils may generate natural chromium in water environment through leaching. The maximum contaminant level for total chromium in drinking water was set by the United State environmental protection Agency (USEPA) to be 5 mg/l, and level of interest for Cr^{6+} of 0.2mg/l. and total chromium of 2.5mg/l were issued by California and (IARC). The international agency for research of cancer classified hexavalent chromium as known carcinogenic in 1998. Chromium can exist in oxidation states ranging from 2- to 6+, but tri and hexavalent are the most found states, Cr^{2+} , Cr^{4+} and Cr^{5+} forms are unstable and rapidly converted to Cr^{3+} , which in turn is oxidized to Cr^{6+} . The chromium trivalent states are stable and occur in nature in ores, such as ferrochromites (FeCr_2O_4) and hexavalent states is the second most stable state, and rarely occurs naturally in mineral crocoites, both tri and hexavalent are occur as dissolved chromium. Average concentrations of chromium in rainwater range from 0.2 to 1 $\mu\text{g}/\text{l}$; the natural total chromium in surface water is approximately 0.5 - 2mg/l. In groundwater it is low than <mg/l . In Netherlands its mean concentration is 0.7mg/l with maximum of 5mg/l was measured. In India, in dug wells water was less than 2mg/l, and in USA in groundwater from shallow wells levels of up to 50mg/l have been reported (industrial activity) but most water supplies contain less than 5 μg . The international agency for research on cancer has classified chromium Cr^{6+} in group one carcinogenic to humans, and metal chromium and chromium Cr^{3+} in group three, (IARC, 1980). Chromium Cr^{6+} compounds, in drinking water can cause mutations and allied affected such as chromosomal aberrations. Cr^{3+} compounds are not active in similar system, or only at high cytotoxic

concentrations. Therefore, chromium Cr^{6+} is mutagenic while Cr^{3+} is not. The human's gastric juice as reducing agent can decrease or abolish chromium Cr^{6+} mutagenic activities. Chromate's acute exposures result in effects as gastrointestinal disorders, hemorrhagic, diathesis, and convulsions. Death may occur following cardiovascular shock. It appears that exposure to a mixture of Cr^{6+} compounds of different solubility's results in high risk to humans (Roy, .I. Irwin, 1988).

1.7.11- Nickel (Ni):

Nickel is common in drinking water. Most ingested nickel is excreted, however, some absorption from the gastro-intestinal tract does occur. Trace amounts are required by the body and about 200 to 500 $\mu\text{g}/\text{day}$ are provided in average diet. There is little useful data on chronic effect of exposure except that nickel are carcinogenic via inhalation and injection in lab-animals. In us, the incidence of respiratory tract cancers in nickel refinery workers Significantly higher (Agency of Toxic Substances and Disease Registry, year). Nickel has not, however, been shown to be carcinogenic via oral pure. General studies suggest that it is not carcinogenic at 5mg/l in (ring water given to rats and mice. NiCl_2 tested negatively in bacterial .Mutagenicity screening, however, both NiCl_2 and NiSO_4 tested positive in mutagenicity and chromosomal aberration tests in mammalian cells SEPA, 1985a, USEPA, 1990b). For ingestion USEPA considers Nickel unclassifiable regarding human carcinogenicity. (Afaf,2007).

1.7.12.Iron (Fe):

Iron (Fe) It is abundance in ground water about 0.1 to 10 mg/L. It occurs in earth in minerals hematite (Fe_2O_3), magnetite (Fe_3O_4) and pyrite (FeS_2). The ferrous ion (Fe^{2+}) solubility is controlled by the carbonate concentration. Ferric ions are not, significantly, soluble unless at a very low pH. Elevated iron levels in drinking water can cause an objectionable taste and colour, the USEPA recommended t iron concentration level in drinking water at 0.3 mg/L, which pose no direct threat to human health, water that is with less concentration should

not have an unpleasant taste, odor, appearances, or side effects. Iron, can, occur in drinking water as a result of natural earth processes or corroded pipes (in towns). It is not hazardous in drinking water, but it can be a nuisance. Iron in water can cause stain to our laundry, fixture, and give water a bitter metallic taste. Manganese is chemically similar to iron and causes similar problems. Water with soluble or oxidized forms looks clear when it comes out of faucet, but with red rust when left standing for long time. Iron is common in earth's crust. Water percolating through soils and rocks can dissolve minerals containing iron and manganese and hold them into solution. Occasionally, iron pipes in urban may be sources of iron in drinking water. High concentration of dissolved iron in water can result in poor taste and unattractive water that stains clothing (because of iron bacteria activity). At concentrations most commonly found in drinking water, the presence of iron is not considered a health problem; iron in drinking water can even provide a health benefit. Small concentration are essential to human health, because iron help oxygen to travel in blood circulation. Iron can be presented in water in four forms; none of them is considered to be a health hazard. Ferrous (clean- water) ion is the most common form and results in the most complaints by water users. At low oxygen content, as in deep aquifers, iron dissolved and water remains clear and colorless. But when it allowed setting for a period of time it will precipitate and rust colored particles will being to form and at least settle to bottom. When ferric ions present in water and exposed to atmosphere, it is oxidized and produce a reddish-brown-to-black insoluble particles or sediments that changes water color to red. In Georgia, the suggested relationship between iron and nitrate is that iron and nitrate are naturally exclusive in the ground waters, (Vendrell, et al., 2001).

1.7.13.Manganese (Mn):-

The average abundance of manganese in the earth's crust is 1060 ppm; in soil is from 61 to 10 ppm; in streams it is 7mg/l, and in ground waters it is less than 0.1 mg/L. manganese is associated with iron minerals, and occurs in nodules in fresh

waters, and soils. Its common ores are pyrolusite (MnO_2) and psilomelane (MnCO_3). Manganese common aqueous species are deduced Mn^{2+} and the oxidized Mn^{4+} . Ground water containing manganese will precipitate black MnO . Elevated manganese levels in water use stains in laundry and cooking utensils. is considered as an essential trace element for plants and animals. Manganese is a common element found in minerals, rocks, and soil. It is also a normal part of a healthy diet, but it can be harmful when consumed in excess. Manganese is found naturally in ground water. Its levels can be increased by underground pollution sources. Manganese may become noticeable in drinking water at levels greater than 50mg/l, at which water will have a brown color. The U.S. environmental Agency has recently set a drinking water advisory level for manganese of 300mg/L. manganese levels below 300mg/L are generally not a health concern.

Infants should not drink water that contains manganese concentrations above the health advisory level (300mg/l). Also people who drink more than eight cups of water a day and have a liver disease should also avoid drinking water that is above the health advisory. Exposure to high concentration levels of manganese in drinking water for many years can cause harm to the nervous system and result in Parkinson's disease, (Cook, et al., 1974). Young children appear to absorb more but excrete less quantity of manganese than old age groups. This adds up to a greater potential for exposure in the very young. Some studies suggested that early childhood and prenatal exposure to manganese (from mothers) can cause effects on child behavior and ability to learn. Manganese levels are not regulated in public water supplies. However, the USEnvironmental health agency has established and aesthetic water quality standard of 50mg/L. Manganese levels below this should prevent the staining of laundry and other equipments. Moreover; it is lower than the health advisory and will protect public health. Manganese is an essential element for all living organisms and occurs naturally in soil, water, and plants. It is often regarded as one of the least toxic metals by the oral route, because of homeostasis limits the gastrointestinal absorption

infants have more sensitive nervous system than adults, and their homeostasis is not fully developed. However there is increasing evidence of neurotoxicity of them. Manganese occurs naturally in both surface and ground waters. As a result of weathered and soluble manganese are found in dolomite and limestone rocks. it may also deposited into waters from human activities, (Liung, etal 2007).

1.8.Anionic Compostion:

1.8.1.Sulphates (SO₄)

Sulphates occur naturally water. They are introduced into treated water by the use of chemical sources such as aluminum sulphate, sodium bisulphate (dry acid) and sulphuric acid. (plain testsystem,(2000).

Sulphate comes from several sources such as the dissolution of gypsum and other mineral deposits containing sulphate from sea water intrusions, oxidation of sulphites, sulphides and thiosulphates in well aerated surface waters, and from industrial effluents where sulphates or sulphuric acid have been used in processes such as tanning and pulp paper manufacturing. Sulphurous flue gases discharged to atmosphere in industrial areas often result in rain containing appreciable levels of sulphates.

Sulphates in domestic water contribute the major part of the non- carbonate or permanent, hardness. High levels of sulphates give rise to a taste in water and a laxative effect is obtained when combined with magnesium or sodium.

Naturally occurring sodium sulphate (Glauber's Salt) and magnesium sulphate (Epsom's Salt) are both well known laxatives. On the other hand some part of world water, with a very high content have to be used because no alternative supply. Bacterial reduction of sulphates under anaerobic conditions will produce hydrogen sulphide, which is an objectionable gas (smelling of bad eggs odor). This occurs in deep Well water and the odor rapidly disappears with efficient aeration. (Raju 1995).

1.8.2.Phosphates :

Phosphate in surface water mainly originates from sewage effluents which contain the phosphate-based synthetic detergents, agricultural effluents including run off from inorganic fertilizers, or from industrial effluents. Groundwater usually contains insignificant concentration of phosphates, unless they have become polluted. Phosphorus is one of the essential nutrients for algal growth and contributes, significantly, to eutrophication of lakes and reservoirs. (Vollenweider 1968)

Phosphate test is an important control test of natural and drinking waters. Although phosphates are generally, not, considered harmful for human consumption, they do exhibit a complex effect on the natural environment. This because in the particular phosphates are associated with eutrophication of water and with rapid unwanted plant growth in rivers and lakes (Plain test).

1.8.3.Chloride

Chloride ions represent compound of chlorine with other elements or radicals. They are present in, nearly, all natural water. The concentration range of chlorides is very wide, sodium chloride forms a common salt and calcium, magnesium chlorides to lesser extent. They are the most stable components in water, with concentrations being unaffected by most natural physiochemical or biological processes. Chlorides are derived from natural mineral deposits, from sea water either by intrusion or by airborne spray, from agricultural or irrigation discharges, or from sewage and industrial effluents. Most rivers and lakes have chloride concentrations of less than 50mg/l chloride. Any marked increase in the concentration of water body is indicative of possible pollution. (WHO, 1984)

The main problems caused by excessive chloride in water concern the acceptability of supply not determined to health. The common salt sodium

chloride intake for people suffering from heart or kidney disease has to be restricted. Although the salt intake from drinking water is compared to that of foodstuffs. It is still desirable to limit the chloride concentration in water. The (WHO 1971) International Standards set an admissible level of 200mg/l of chloride with a maximum permissible level of 600mg/l in the (EC) Directive and (WHO, 1983) Guidelines recommend a much lower guide level of 25 mg/l Cl^- with the comment that undesirable effects might occur above 200 mg/l were set in relation to taste and corrosion in hot water systems. In this respect they are still relevant. The sensitive palate can detect low chlorides at a level of 150 mg/l. Whereas a concentration above 250 mg/l imparts a distinctly salty taste to water. However, waters containing more than 600 mg/l are drunk in some arid or semi-arid places due to lack of alternative supply (WHO, 1983 and Raju, 1995).

1.8.4. Fluoride:

Fluoride occurs naturally in some groundwater and, is often introduced into drinking water to prevent tooth decay (plain, text). Also fluoride may naturally occur, in water or it may be added in controlled amounts during the treatment process. The acceptable level of fluoride is 1 mg/l, which is effective and safe in substantially reducing dental caries according to (WHO, 1971).

The greatest reduction of dental decay occurs if fluoridated water is drunk in childhood during the period of tooth formation: fluoride levels have to be closely controlled, as excessive amounts can lead to fluorosis with resultant mottling of the teeth or even skeletal damage in both children and adults. Thus the optimum fluoride concentration has to be related to climatic conditions and amounts of water consumed. Specialized treatment can be used to remove excess fluorides from water, but it is costly to operate. It is often more economical to abandon a source if the fluoride level becomes unacceptable.

The addition of fluoride to water supply is considered as a non- acceptable (Raju, 1995). The WHO, 1993 International Standards recommend the high level of fluoride not more than 1.5 mg/l in water. In Sudan there were significantly high fluoride apparent in some areas in Sudan (Adam.z.A 2000) in Kas Town and the villages around it, (Madena.K.2012) and (Ali 2018) in Dalanj Area.

1.8.5.Nitrate NO₃ :-

The natural nitrate concentration in groundwater under aerobic conditions is a few milligrams per litre and depends strongly on soil type and on the geological situation. In the United States of America (USA), naturally occurring levels do not exceed 4–9 mg/l for nitrate and 0.3 mg/l for nitrite (USEPA, 1987). As a result of agricultural activities, the nitrate concentration can easily reach several hundred milligrams per litre (WHO, 1985). Significantly high concentration of nitrate were reported in some areas of Sudan (Omer A-Gibla 2007), (Afaf Boshara (2007).

Table (2.2) and (2.3) show Role of some chemical characteristics of water and drinking Water Standard WHO (1983) respectively .

Table (1.4) The Role of some chemical characteristics of water.(Afaf , 2007).

Characteristics	The importance
pH	<ul style="list-style-type: none"> • It is one of the most important determinations in water chemistry since many of processes involved in water treatment are pH dependent
Acidity	<ul style="list-style-type: none"> • Lead to corrosion problems.
Alkalinity	<ul style="list-style-type: none"> • Important in chemical coagulation • The high concentration gives rise to taste problems. • Determination of the buffering capacity.
Hardness	<ul style="list-style-type: none"> • Excessive hardness cause economic problems. • Lead to taste problems
DO	<ul style="list-style-type: none"> • Effects of micro- organisms and water life
Fluoride	<ul style="list-style-type: none"> • Excessive amount can lead to flurosis with resultant mottling of the teeth or even skeletal damage
COD	<ul style="list-style-type: none"> • Uses of treatment station designing
Chloride	<ul style="list-style-type: none"> • Above 250/mg1 impact a distinctly salts taste to a water. • Harmful to pipes and plant life
Nitrates	<ul style="list-style-type: none"> • High concentrations are poetically harmful to infants and children causes methemoglobin (as nitrogen) important in biological treatment systems. Lead to increasing of ground water pollution.
The Transitional metals such as copper, zinc and mercury.	<ul style="list-style-type: none"> • High concentrations toxic to the plants causes phototoxic effect of the biological treatment.

Table(1.5): Drinking Water StandardWHO (1983) .

Substance or characteristic	Symbol/formula	highest desirable level	Maximum permissible level
Electric conductivity	EC μs/cm	1400	
Total Dissolve Solids	TDS	500 mg/l	1500
Hydrogen (H)	pH	6.5-8.5	7.0-8.5
Alkalinity	-	-	-
Total hardness	T.H	100 mg/l	500 mg/l
Sodium	Na ⁺	200	175
Potassium	K ⁺	10	12
Calcium	Ca ²⁺	75 mg/l	200 mg/l
Magnesium	Mg ²⁺	30 mg/l	150 mg/l
Iron	Fe ²⁺	0.10 mg/l	1.0 mg/l
Manganese	Mn ²⁺	0.05 mg/l	0.5 mg/l
Zinc	Zn ²⁺	0.5 mg/l	15 mg/l
Bicarbonate	HCO ₃ ²⁻		
Sulphate	SO ₄ ²⁻	200 mg/l	400 mg/l
Nitrate	NO ₃ ⁻	45 mg/l	
Nitrite	NO ₂ ⁻		
Chloride	Cl ⁻	200 mg/l	600 mg/l
Fluoride	F ⁻	1.5 mg/l	1.5 mg/l
Copper	Cu ²⁺	-	-

Chapter Two

Material and Methods



2. Materials:

2.1 Samples:

Eighty four ground water samples were collected from different areas in Southern Kordofan State, forty two samples were collected during autumn season 2017 and winter season of 2018. The samples from each locality for each season (autumn and winter) were mixed to form thirteen composite samples (3.1). The analysis was carried for the composite samples.

Ten surface water samples were collected five during autumn season 2017 and five during winter season 2018 table (3.2). The analysis was carried from each surface water samples separately. The samples were stored in dry clean plastic container and closed then filled and labeled with collector name, location, type, season, and unique sample number.

Table(2.1) Total Ground water samples and Composite samples

Somposite samples	NO of Samples	Location
1	5	Aldalanj
2	2	Aldabibat
3	2	Alhamadi
4	3	Alfarshaya
5	1	Hbila
6	1	Kortala
7	3	Dalami
8	2	Alkorgol
9	5	Kadugli
10	4	Abujubaiyah
11	4	Alrashad
12	5	Alabassiya
13	5	Abukrshola

Table (2.2) Location of Surface water samples.

Samble NO	Location
1	Aldalanj
2	Aldabibat
3	Hbila
4	Kortala
5	Alrashad

2.2.Methods:

2.2.1.Determination of pH value:

pH meter(English 3505). was calibrated using buffers solution (4,7 and 10). The electrode was carefully rinsed, 50ml of sample were placed in a beaker left to equilibrate to room temperature and pH was noted.

2.2.2.Determination of Turbidity:

50ml of each water sample were placed in a beaker. The turbidity was recorded using (HACH 2100) turbidity meter.

2.2.3.Determination EC and TDS:

The electric conductivity meter(4320) was set to zero using distilled water and EC of 20 ml of each water sample was recorded in ($\mu\text{s}/\text{cm}$). TDS was determined by multiplying EC by a factor of (0.6).

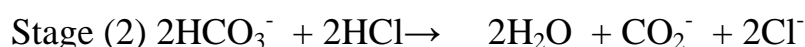
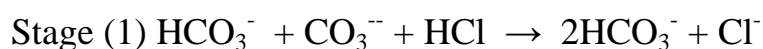
2.2.4. Determination of Mineral contents :- (ICP)

The ICP instrument was calibrated. Standard solutions with concentrations (1000mg/l) were used for measuring Al, Ba, Cd, Cu, Cr, Mn, Fe, Ni, Pb, Mo, Sr, V, Zn, Na, K, Ca, Mg, P and As.

1 ml of concentrated nitric acid was added to each 100 ml of water sample. The mixture was then filtered. A portion of each treated water sample was introduced to the (ICP) Instrumentation system. The obtained results were recorded as mineral concentration in (ppm).

2.2.5.Determination Total Alkalinity :

10 ml each water sample were quantitatively transferred to 250 ml titration flask using pipette. The contents were titrated against (0.1 M) HCl to phenolphthalein end point, the volume was recorded, titration was continued by adding two drops of methyl red and the total volume recorded .



The concentration of hydroxide OH^- , carbonate CO_3^{2-} and bicarbonate HCO_3^- ions were calculated according to the formula

Volume of titrant	OH^- alkalinity	CO_3^{2-} alkalinity	HCO_3^- alkalinity
$P = 0$	0	0	T
$P < \frac{1}{2} T$	0	2P	T-2P
$P > \frac{1}{2} T$	(2P-T)	2(2P-T)	0
$P = T$	T	0	0

Where:

P = phenolphthalein end point volume

T = Total volume

2.2.6.Determination of chloride :

10 ml of each water sample were transferred to 250 ml titration flask. The contents were titrated against standard silver nitrate solution using potassium chromate as indicator the constant volume was recorded and the chloride concentration was calculated for each sample as mg/l .

2.2.7.Determination of Nitrate : (UV-Vis-Spectrometry) (HACH) 2000DR.

10 ml of each water sample were accurately transferred to a specific round sample cell. Nitrate Ver 5 nitrate Reagent Powder Pillow was added .The mixture was left for five minute. The intensity of the developed color was measured at wavelength (λ 500 nm). The obtained nitrate concentration was then recorded as mg/l.

2.2.8.Determination of Sulphate:(UV-Vis-Spectrometry) (HACH) 2000DR.

10 ml of each water sample were transferred by a pipette to the sample cell. One Sulfa Ver 4 reagent Powder Pillow was added to the sample cell. The mixture was left for one minute and the cell was placed in to the cell holder. Sulfate concentration was measured by reading the intensity of the developed color at wavelength (λ 450 nm) the obtained nitrate concentration was recorded as mg/l.

2.2.9. Determination of fluoride: (UV-Vis-Spectrometry) (HACH) 2000DR.

10 ml of each water sample were transferred by a pipet to a dry round sample cell.

2ml of SPANDS Reagent were carefully added to the sample cell. The contents were well swirled. The mixture was left for one minute and the cell was placed in to the cell holder and the absorption was measured at wavelength (λ 580 nm) the obtained fluoride concentration was recorded as mg/l.

2.2.11. Determination of Chemical Oxygen Demand (COD):-

7.5mls of each water sample were transferred to the COD test tube .1.5 ml of distilled water, 3.5 ml of conc nitric acid, and 1.5 ml of potassium dichromate were added. The contents were introduced in to the COD Reactor at 150°C for tow hours. The contents were then titrated against iron(II) sulfate (1000ml) using ferroin indicator.

The same procedure was repeated for blank sample (distilled water) .

The result calculated.

2.2.12. Determination of Biological Oxygen Demand (BOD).

2ml of nutritious water were added to 1000 ml of each water sample.

The mixture was transferred to the oxygen pump instrument for one hour. The treated sample was divided in to three portion (BOD) tube . One portion was titrated with 2ml of, 2ml of Azide, 2ml of MnSO_4 solution (250mg/l). The contents were well shaken until yellow precipitate was formed .Sulfuric acid was added drop wise until the precipitate was disappeared.

100 ml of the treated first portion was titrated against sodium thiosulfate solution (130ml) to the starch as end point. The consumed volume of the titrant was recorded.

The same procedure was repeated for the other two portion which were kept under at 20°C for five days. The result calculated before and after incubation and for a period of 5 days.

Chapter Three

Results and Discussions



Chapter Three

Results and Discussions

3.1.1.1. Ground water Physical properties (autumn season):-

Table 3.1. shows physical properties of ground water in autumn season, pH values range from (8.3 to 7.6,) the highest value was 8.3 in sample (4) this may be due to alkaline earth, whereas, the lowest value was (7.6) in sample (11).

Table (3.1.) Ground water, Physical properties autumn season

Sample No and location	PH	EC μ /cm	TDS mg/l	Turbidity NTU
1. Aldalanj	7.9	1042	626.6	1.63
2. Aldabibat	8.0	768.5	459.5	8.63
3. Alhamadi	8.0	856.5	512.5	1.32
4. Alfarshaya	8.3	738.7	443	4.33
5. Hbila	7.7	1387	831	4.87
6. Kortala	7.9	1547	930	3.9
7. Dalami	7.8	947.7	569	4.44
8. Alkorgol	7.6	431.5	259	2.53
9. Kadugli	8.1	788	471.6	1.31
10. Abujubaiyah	8.1	585.3	351.5	2.2
11. Alrashad	7.6	1027	615.5	1.83
12. Alabassiya	7.9	671	400.4	2.89
13. Abukrshola	7.8	495	296.8	2.69

EC values range from (1547.0 to 432.5 μ s/cm) and the corresponding TDS was range from (930 to 259 mg/l) According to WHO drinking water standards and SSMO which considered the highest permissible level of TDS 500 mg/l and the maximum permissible level as 1000 mg/l, for ground water samples (1,5,6,7,11), showed high TDS value which were (626.6, 831, 930, 569, and 615, ppm) respectively.

ground water turbidity is a principle physical characteristic of water. In this study for range from (8.63 to 1.31 NTU). The high values at sample (2) was 8.63 NTU this may be due to type of earth. Table (3.2) shows the Descriptive statistic of ground water, physical properties autumn season.

Table (3.2) Descriptive statistic of ground water, physical properties, autumn season.

Parameters	Maximum	Minimum	Mean	Std. Deviation
pH Value	8.3	7.6	6.67	2.97
EC $\mu\text{s}/\text{cm}$	1547.0	431.5	868.09	325.81
TDS mg/l	930.0	259.0	520.49	195.86
TU	8.63	1.31	3.27	2.016
NTU				

3.1.1.2. Chemical Properties :-

3.1.1.2.1. Anionic composition:

Table 3.3 shows the results of anionic concentration of ground water in autumn. Fluoride concentration, ranges from (3.41 to 0.58 mg/l). WHO and SSOM suggested the maximum level is 1.5 mg/l, according to these samples

(7 and 9) their concentration (3.4 and 1.56 mg/l) respectively show high concentration of fluoride this due to the geological formation of the earth. The seasonal variation in ground water fluoride higher than surface water, it is also higher in winter season. Fig (4.9). There is strong correlation between fluoride and chloride and the correlation coefficient is 0.72

Table (3.3) Ground water anionics, composition autumn season.

Sample No	F ⁻ mg/l	Cl ⁻ mg/l	NO ₃ ⁻ mg/l	SO ₄ ⁻ mg/l	OH ⁻ mg/l	CO ₃ ⁻ mg/l	HCO ₃ ⁻ mg/l
1	1.28	52.10	23.28	36	0.00	60	371.70
2	0.795	34.70	47.45	65.5	0.00	60	61
3	0.82	32.22	24.8	17.5	0.00	60	137.2
4	0.93	37.96	33.71	10	0.00	60	162.72
5	0.59	64.50	19.30	138	0.00	60	61
6	1.50	81.94	66.24	58	0.00	60	183
7	3.41	80.24	49.63	23	0.00	60	305
8	1.34	31.30	8.43	12.66	0.00	60	180
9	1.56	51.60	18.92	15.84	0.00	120	0
10	0.82	36.62	6.87	13.75	0.00	60	133
11	1.40	102.4	11.80	35.50	0.00	60	133.63
12	1.09	26.30	19.36	11.60	0.00	60	61
13	0.58	26.30	19.84	5.54	0.00	60	122

Chloride ranges from (102.4- 26.30mg/l) with the mean value 50.62 mg/lof ground water in autumn season,WHO and SSOM reported the maximum acceptable level of chloride was 250 mg/l according to these all sample in autumn showed lower level than the permissible value,also there was strong coorelation between chloride and nitrate the coorelation coefficient is 0.92 table (3.5).

Nitrate ranges from (66.2-6.87mg/l) with a mean was 26.8831 mg/l.

All samples show nitrate less than the 50 mg/l that is set by WHO and SSMO excepted samples (6and 7) were concentration (66.2and49.6mg/l),the geological formations are expected to be the mean source in the case of ground water.

Sulphate concentration ranges from (138 to5.50mg/l) with a mean value 34.06 mg/l,WHO and SSMO suggested that 250mg/l of sulfate level likely give rise to consumer complains all sample in autumn showed lower level than the permissible value.

Total alkalinity ingredients are Hydroxide carbonate and bicarbonate contentof water sample. Throughout the studied areas the hydroxide content was zero in all samples .

Carbonate ranges from (120 to60) with a mean value Of 64.62 mg/l .There was no seasonal variation.Fig(4.17).

Bicarbonate concentration ranges from(371.7 to 0.00mg/l) with a mean of 147.01mg/l sample(9) shows zero bicarbonate content.

Table (3.4) and (3.5) show Descriptive statistic andCorrelation between Ground water anions in autumn season .

Table (3.4) Descriptive statistic of Ground water anions, autumn season.

Parameters	Maximum	Minimum	Mean	Std. Deviation
F ⁻	3.410	0.580	1.23	0.73
Cl ⁻	102.40	26.30	50.62	24.56
NO ₃ ⁻	66.20	6.80	26.88	17.66
SO ₄ ⁻²	138.00	5.50	34.06	36.36
OH ⁻	0.00	0.00	0.00	0.000
CO ₃ ⁻²	120	60	64.62	16.64
HCO ₃ ⁻	371.7	0.00	147.01	101.23

Table (3.5) Ground water, correlation between anions concentration.

		SO ₄ ⁻²	F ⁻	NO ₃ ⁻	Cl ⁻
SO ₄ ⁻²	Pearson Correlation	1	-.019-	.426**	.58
	Sig. (2-tailed)		.899	.003	.694
F ⁻	Pearson Correlation	-.019-	1	.051	-.72-
	Sig. (2-tailed)	.899		.728	.628
NO ₃ ⁻	Pearson Correlation	.426**	.051	1	-.014-
	Sig. (2-tailed)	.003	.728		.925
Cl ⁻	Pearson Correlation	.58	-.72-	-.014-	1
	Sig. (2-tailed)	.694	.628	.925	
** . Correlation is significant at the 0.01 level (2-tailed).					

3.1.1.2.2. Ground water cationic composition:-

3.1.1.2.2.1. Ground water Macro Cations:-

Table 3.6 shows macro cationic composition of ground water in autumn season.

Sodium concentrations in all samples were below the permissible drinking water levels WHO and SSOM (20 to 200 mg/L), the concentration varied between (7.65 to 0.73 ppm) with the mean value was 4.22308 mg/l. The seasonal variations apparent in autumn sodium concentration higher than winter season.

Table (3.6.) Ground water macro Cationic concentrations, autumn season

Sample No	Na ⁺	K ⁺	Ca ⁺⁺	Mg ⁺⁺
1	7.65	2.96	8.40	36.81
2	1.63	3.07	17.89	6.49
3	2.14	3.76	42.54	39.41
4	4.18	1.58	13.94	33.63
5	5.81	0.75	23.08	21.72
6	2.83	2.68	12.29	3.56
7	6.68	9.76	11.97	15.25
8	0.73	4.64	24.79	13.17
9	6.39	1.79	39.67	16.46
10	2.87	1.81	28.90	19.47
11	5.27	2.17	21.25	4.23
12	4.02	2.24	28.09	21.93
13	4.64	1.12	21.36	11.12

Potassium there is no sample high than the permissible drinking water level of WHO (10 to 12 mg/l) the concentration ranges from (9.763 to 0.757 mg/l) with the mean value was 2.9533 mg/l, potassium has no effect in water quality in the study area.

Calcium concentration in all samples showed low levels beyond the permissible drinking water levels of WHO, (200 mg/l), the concentration ranges from (42.54 to 8.4 ppm) with the mean value was 22.629 ppm.

Magnesium concentrations ranges from (39.41 to 3.565) with a mean value was 25.62 ppm, WHO and SSMO reported that the permissible levels was 30 mg/l, samples (1,3,4) their concentrations were (36.8, 39.4, 33.6 ppm).

All samples have high concentration collected from handpump that means the source and the depth of source effects to the concentration of the metals.

Table (3.7) Descriptive statistic of ground water macro cationic autumn season.

Elements	Maximum	Minimum	Mean	Std. Deviation
Na ⁺	7.65	0.73	4.22	2.10
K ⁺	9.76	0.75	2.95	2.30
Ca ⁺⁺	42.54	8.40	22.62	10.34
Mg ⁺⁺	39.41	3.57	18.71	11.87

3.1.1.2.2. Ground water micro cations, autumn season:-

Chromium, Copper, Cadmium, Zinc, Lead, Nickel, Cobalt, and barium were at trace levels. Therefore, no effect in water quality in the areas of study. Iron concentration in most sample showed low level that set by WHO and SSMO except samples (1, 3 and 7) concentration (0.409 ppm).

Aluminum concentration in all sample showed low levels than the permissible levels of WHO and SSMO of drinking water 0.3 ppm except sample (1) showed 0.622 ppm.

Table (3.8) Descriptive statistic of ground water microcations, autumn season.

Elements	Maximum	Minimum	Mean	Std.
Cr	0.001	.00058	0.00058	0.00
Cu	0.007	.005	0.0058	0.05
Cd	0.0002	.0002	0.0002	0.00
Zn	0.0001	.00011	0.000	0.00
Pb	0.01410	.00473	0.005	0.01
As	0.00255	.00255	0.002	0.00
Fe	0.40930	.00076	0.09	0.18
Al	0.62280	.00033	0.005	0.17
Ni	0.0047320	.0001	0.002	0.02
Co	0.0002	.0002	0.002	0.004
Ba	0.014	.0006	0.002	.0004

3.1.2.1. Ground water Physical properties, Winter season.

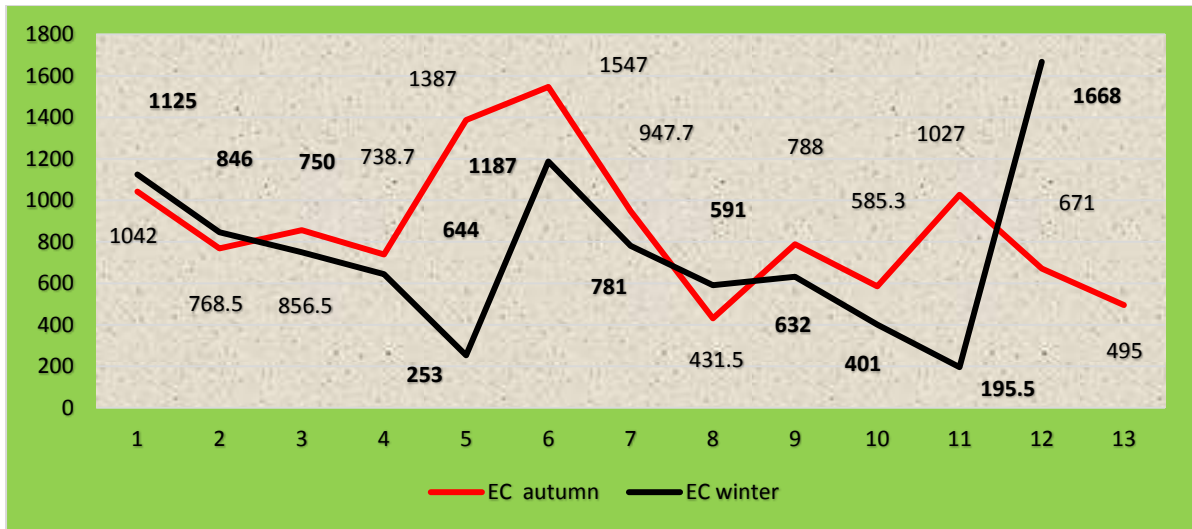
Table 3.9 shows ground water physical properties in winter season.

pH value ranges from (8.3 to 7.4) the highest value was 8.3 in sample (9) where as the lowest value was (7.4) in sample (6) with the mean value was 7.792.

Table (3.9) Ground water physical properties winter season.

Sample No and location	pH	EC $\mu\text{s}/\text{cm}$	TDS Mg/l	TU NTU
1. Aldalanj	7.8	1125	674	2.00
2. Aldabibat	7.8	846	518	7.81
3. Alhamadi	7.8	750	448	2.5
4. Alfarshaya	7.8	644	387	2.53
5. Hbila	7.8	253	151.5	1.43
6. Kortala	7.4	1187	713	1.91
7. Dalami	7.5	781	469	1.79
8. Alkorgol	8.0	591	355	1.96
9. Kadugli	8.3	632	380	2.11
10. Abujubaiyah	7.8	401	240	1.67
11. Alrashad	7.8	195.5	116.6	2.00
12. Alabassiya	7.8	1668	887	1.92
13. Abukrshola	7.7	259	154.8	4.8

EC value ranges from (1668 to 195.5 $\mu\text{s}/\text{cm}$) with a mean value of 717.88 $\mu\text{s}/\text{cm}$, and the corresponding TDS ranges from (887 to 116.6 mg/l, with the mean value was 422.608 mg/l. According to WHO drinking water standards and SSMO which considered the highest permissible level of TDS 500 mg/l and the maximum permissible level as 1000 mg/l, samples (1, 6, 12) show high value of (674, 713, and 887 ppm) respectively. Fig(3.2).



c

Figjuy5 (3.1) Seasonal variations of ground water EC,in autumn and winter seasons.

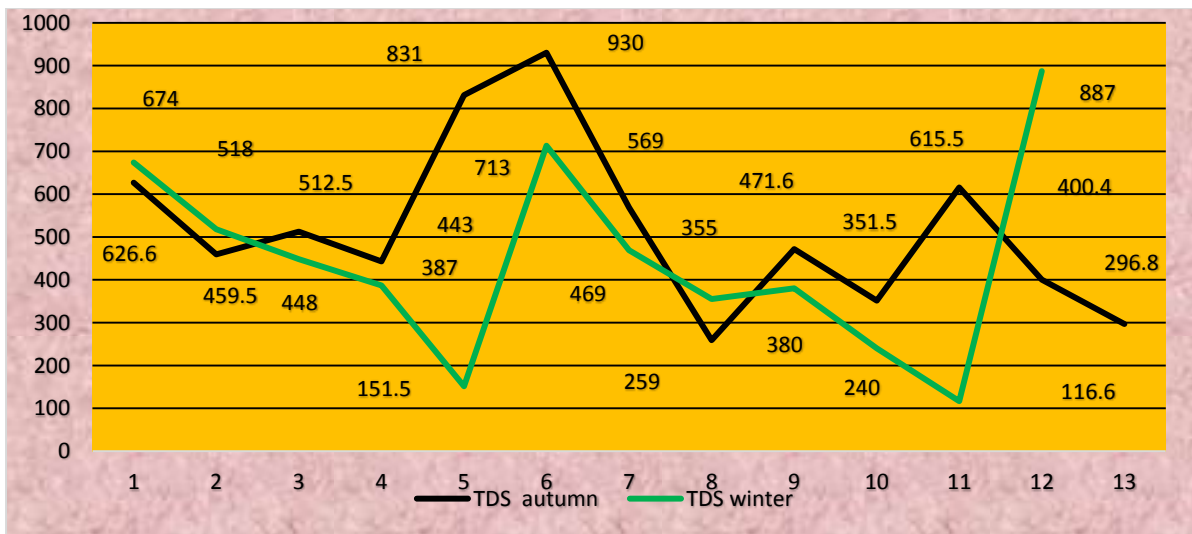
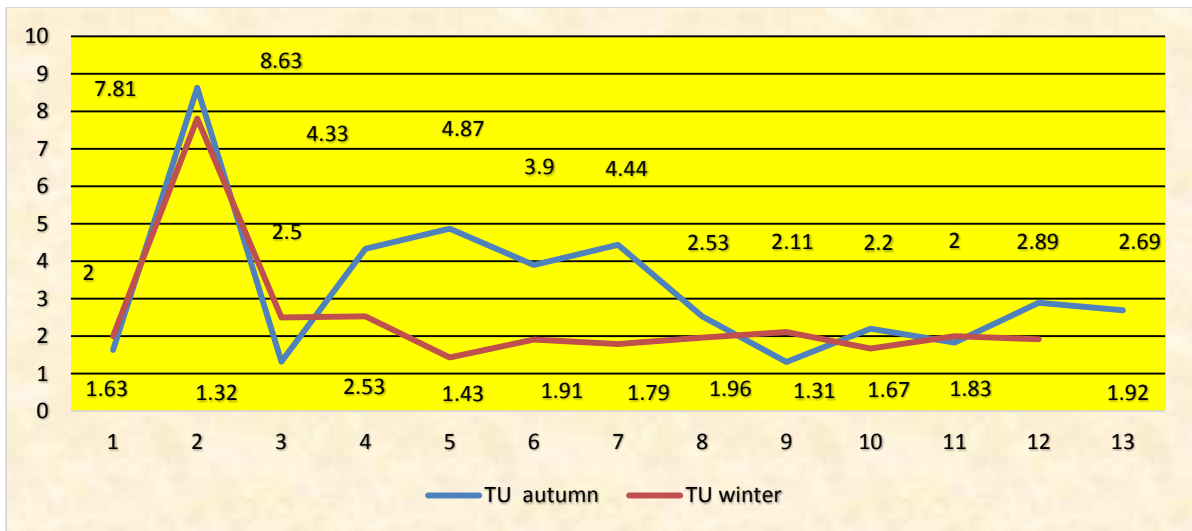


Fig (3.2) Seasonal variations of ground water TDS,in autumn and winter seasons.

Turbidity ranges from(7.81 to 1.43NTU) with a mean value 2.646 mg/l in. The high values in sample (2) was 7.81NTU .In autumn season high than winter.Fig 3.3.



Fig(3.3) Seasonal variations of ground water, turbidity autumn and winter seasons.

Table(3.10) Descriptive statistic of ground water physical properties, winter season.

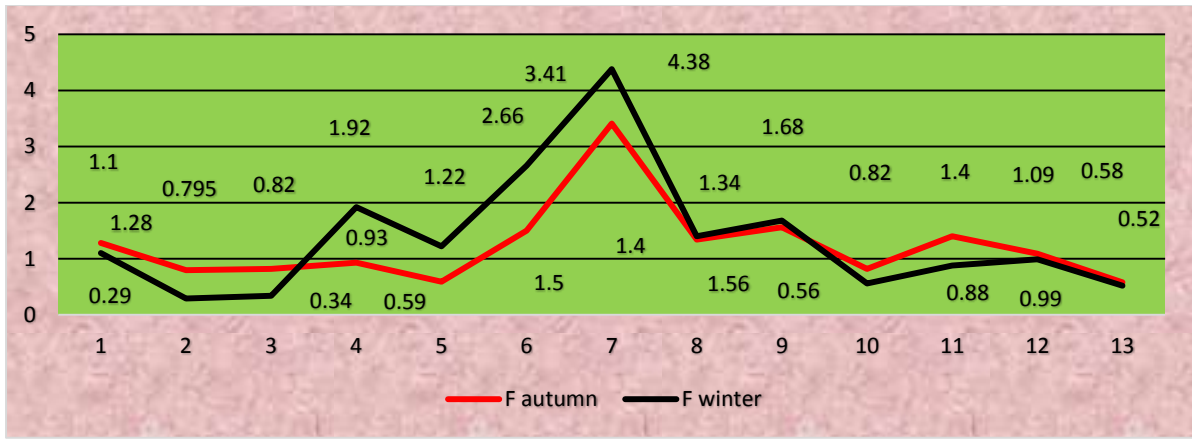
Parameters	Maximum	Minimum	Mean	Std. Deviation
pH Value	8.3	7.4	7.79	0.22
EC $\mu\text{s}/\text{cm}$	1668	195.5	717.88	422.19
TDS mg/l	887.0	116.6	422.61	233.62
TU NTU	7.81	1.43	2.65	1.76

3.1.2.2. Chemical Properties :-

3.1.2.2.1. Anionic composition:

Tables 3.11 shows the results of anionic composition of ground water in winter season .

Fluoride concentration ranges from (4.38 to 0.29 mg/l). WHO and SSOM suggested the maximum level is 1.5 mg/l, accordingly samples (4,6,7 and 9 mg/l) show high concentration of fluoride (1.92, 2.66 ,4.38 and 1.68mg/l) these due to the geological formation of the earth .There was seasonal variation of fluoride in ground water higher than surface water, also in winter greater than autumn season. Fig(3.3).



Fig(3.4) Seasonal variations of ground water flouride,autumn and winter seasons.

Table (3.11) Ground water anionic concentration ,winter season.

Sample No	F ⁻	Cl ⁻	NO ₃	SO ₄ ²⁻	OH ⁻	CO ₃ ²⁻	HCO ₃ ⁻
1	1.1	41.18	9.68	19.34	0.00	60	427
2	0.29	48.4	15.8	18	0.00	60	427
3	0.34	33.5	6.05	18	0.00	60	326.6
4	1.92	26.46	3.7	4.66	0.00	60	305
5	1.22	77.4	11.6	235	0.00	60	305
6	2.66	69.5	48.8	215	0.00	60	732
7	4.38	84.36	30.5	15.66	0.00	90	186.8
8	1.4	49.6	11.9	177.5	0.00	90	137.2
9	1.68	50.6	2.08	19.6	0.00	60	262.7
10	0.56	34.1	2.64	19.34	0.00	60	266.8
11	0.88	121.5	4.08	18	0.00	60	221.1
12	0.99	27.36	2.32	18	0.00	60	323.3
13	0.52	28.26	2.84	4.66	0.00	60	58.6

In this study chloride ranges from (121 to26.46mg/l) with ta mean value 53.248 mg/lWHO and SSOM reported the maximum acceptable level of chloride was 250 mg/l according to these all sample showed lower level than the permissible value .

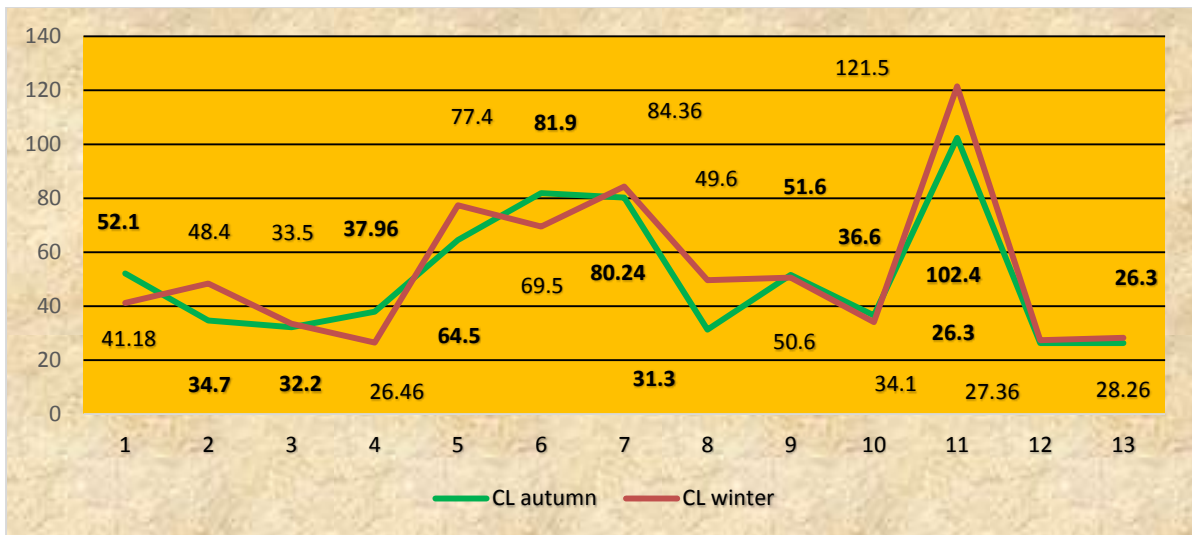


Fig (3.5) Seasonal variations of ground water, chloride autumn and winter seasons.

Nitrate in all samples showed nitrate less than the 50 mg/l that is set by WHO and SSMO, was range from (48.8 to 2.08 mg/l), with the mean was 11.691 mg/l

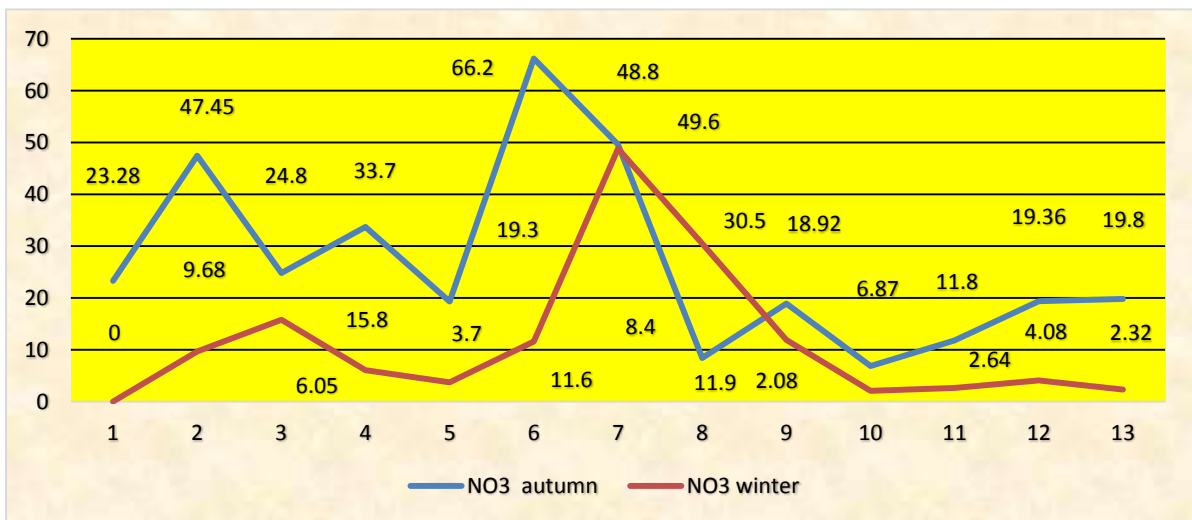


Fig (3.6) Seasonal variations of ground water, nitrate autumn and winter seasons.

WHO and SSMO suggested that 250 mg/l of sulfate level likely give rise to consumer complains subsequently the concentration was ranges from (235 to 4.66 mg/l) a mean value 61.02 mg/l The highest value was 235.00 mg/l at (5) the concentration in winter higher than autumn season. Fig (3.7).

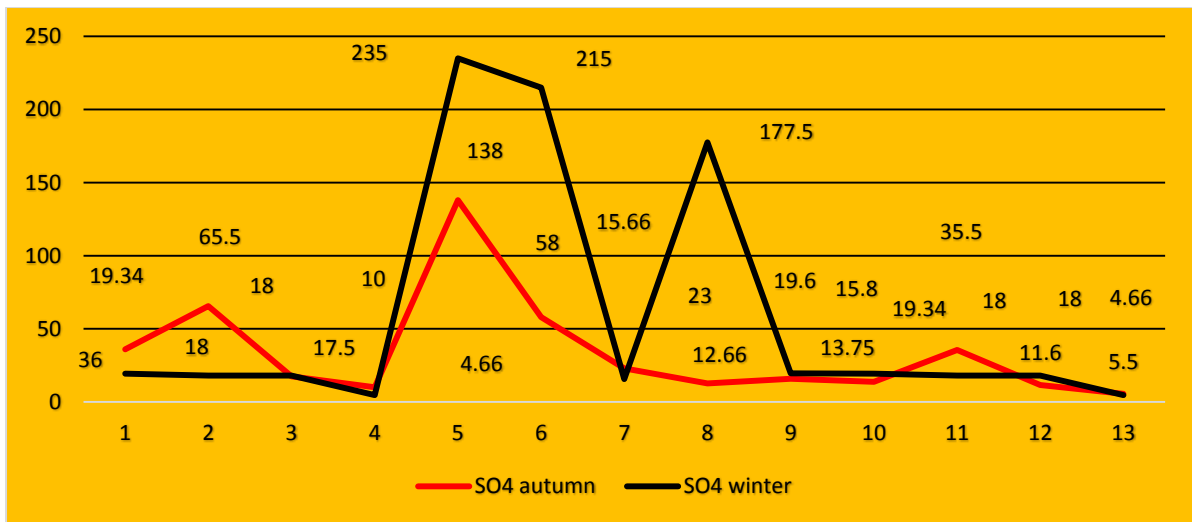


Fig (3.7) Seasonal variations ofground water sulphate, autumn and winter season.

Hydroxide content was zero in all samples.

Carbonate was ranges dfrom (120 to 60) with a mean value 64.62 mg/l There was no seasonal variation.

Bicarbonate concentration ranged from (732.0 to 58.6mg/l) with the mean 306.08 mg/l. all samples show high bicarbonate concentrations except samples (7,8 and13).Ingeneral in autumn or winter bicarbonate was high.but in winter seasonhigher than autumn season ,fig (3.8).

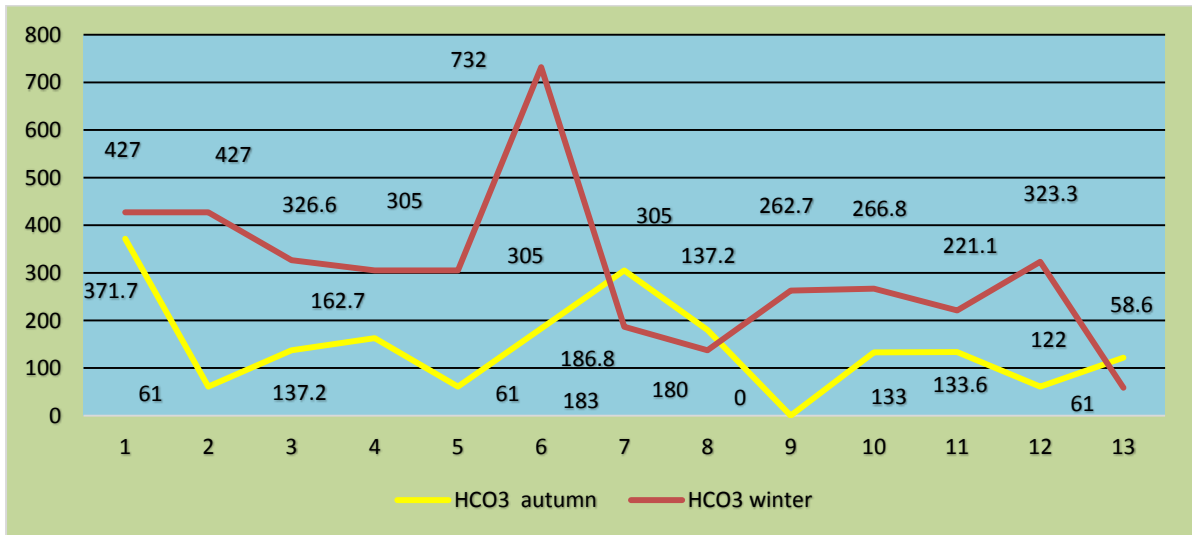


Fig (3.8) Seasonal variations ofground water, bicarbonate autumn and winter seasons.

Table (3.12) Descriptive statistic of ground water,anionswinter season.

Parameters	Maximum	Minimum	Mean	Std. Deviation
F ⁻	4.38	0.29	1.380	1.13
Cl ⁻	121.50	26.46	53.25	28.03
NO ₃ ⁻	48.80	2.08	11.69	13.68
SO ₄ ²⁻	235.00	4.66	61.03	85.42
OH ⁻	0.00	0.00	0.00	0.000
CO ₃ ²⁻	90	60	64.62	11.27
HCO ₃ ²⁻	732.0	58.6	306.08	164.83

3.1.2.2.2.Cationic composition :

3.1.2.2.2.1.Macro Cations:-

Tables 3.13 shows the results of macro cationic composition winter season.

The concentration of sodium was varied between(9.33 to2.72 mg/l ppm) with a mean value was 27.3746mg/l .Seasonal varitaions are apperant in autumn the concentration higher than winter season .

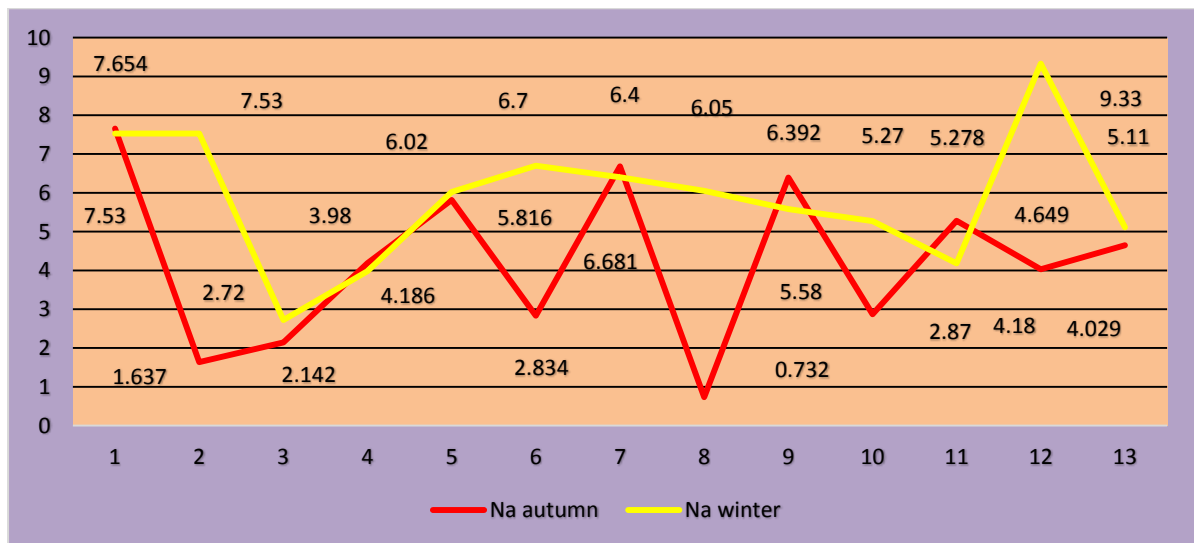


Fig (3.9) Seasonal variations of ground water, sodium in autumn and winter seasons.

Table (3.13)Ground water m acro cationicconcentration, winter season

Sample No	Na ⁺	K ⁺	Ca ⁺⁺	Mg ⁺⁺
1	7.53	6.56	11.9	31.11
2	7.53	6.56	11.9	25.06
3	2.72	5.02	47.44	27.91
4	3.98	1.94	13.57	14.32
5	6.02	0.76	11.49	4.97
6	6.7	2.89	27.45	55.97
7	6.40	9.94	33.99	72.82
8	6.05	1.44	28.92	13.29
9	5.58	2.42	46.91	17.92
10	5.27	2.06	12.8	14.86
11	4.18	2.52	15.2	18.87
12	9.33	1.25	20.39	13.45
13	5.11	0.94	18.15	22.53

Potassium concentration ranges from(9.94 to 0.76) with a mean value was3.03 mg/l.No seasonal variation.

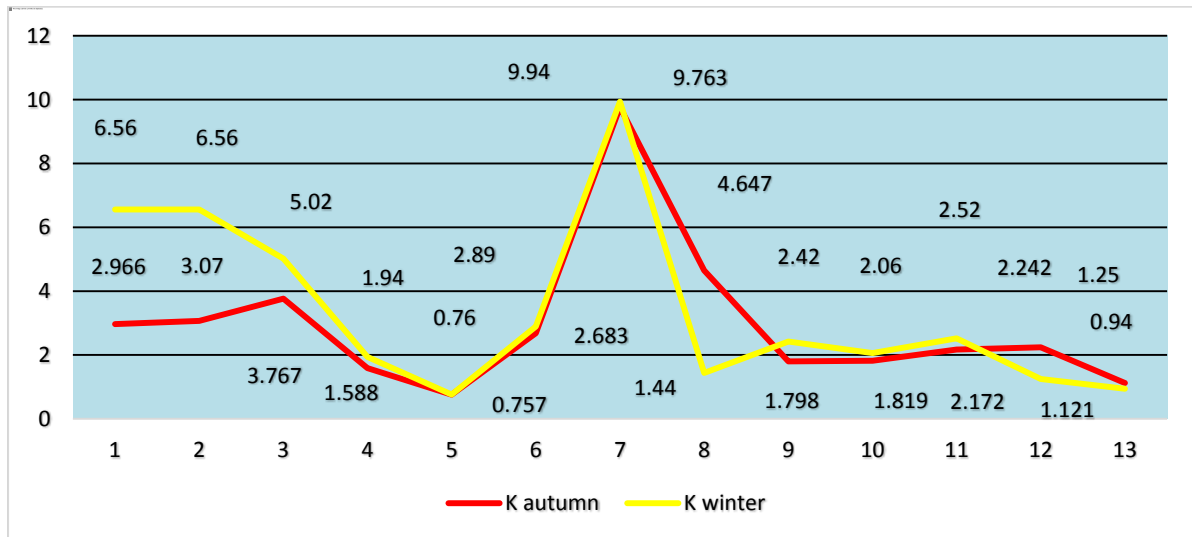


Fig (3.10) Seasonal variations ofground water,potassium, autumn and winter seasons.

Calcium in all samples showed low levels than the permissible value. was ranged from (47.4 to11.9 ppm) a mean value was23.60ppm.

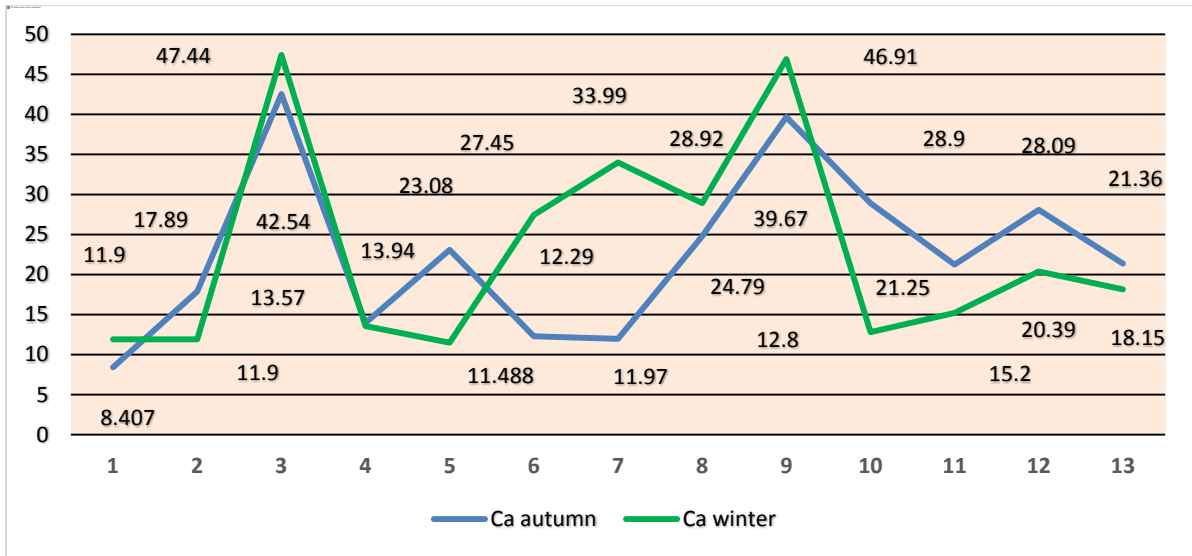
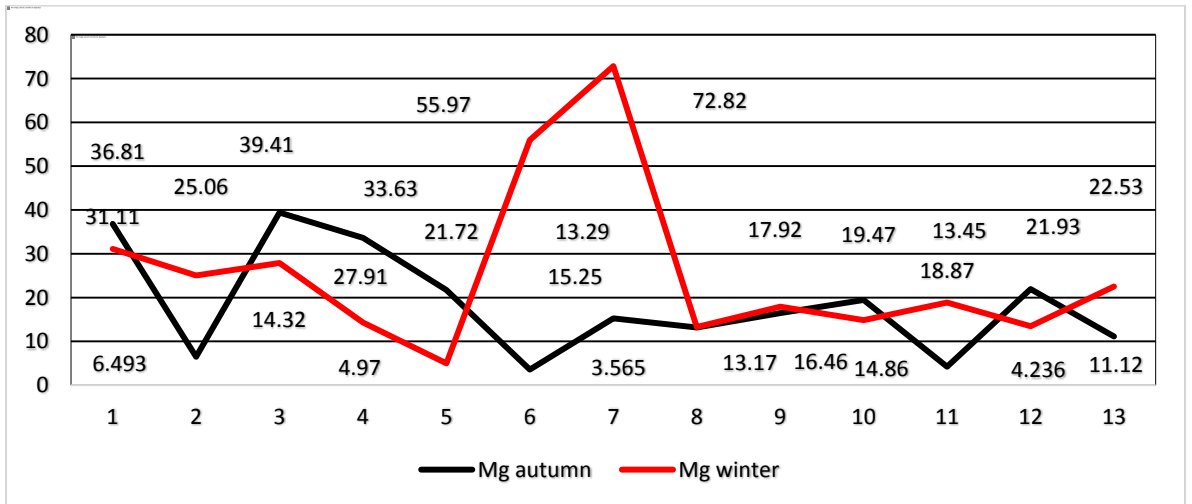


Fig (3.11) Seasonal variations of ground water calcium, autumn and winter seasons.

Magnesium, in all samples, showed low levels, below the WHO and SSMO permissible levels of 30mg/l. except samples(1,6 and 7) their concentration (31.1, 55.97 and 72.8ppm) mean value was 18. The concentration in winter season higher than in autumn.



Fig(3.12) Seasonal variations of ground water magnesium , autumn and winter seasons.

Table (4.14) Descriptive statistic of ground water cations, winter season.

Elements	Maximum	Minimum	Mean	Std. Deviation
Na ⁺	9.30	2.72	27.37	78.03
K ⁺	9.94	0.76	3.04	2.64
Ca ⁺⁺	47.44	11.49	23.61	12.58
Mg ⁺⁺	72.82	4.97	25.62	18.86

There is strong Correlation between sodium and chloride the Correlation value was 0.74 between potassium and nitrate 0.50 fluorid and nitrate 0.68, sulphate and nitrate 0.57. Table (3.15). The Correlation being strong and positive significant at 0.5 and above .

Table (3.15) Correlations between (Na⁺, K⁺, Ca⁺, NO₃⁻, SO₄⁻, F⁻ and Cl⁻): -

Relations	Pearson Correlation value	Sig. (2-tailed)	Relation type	decision
Na * Cl ⁻	- 0.366	0.135 (greater than 0.05)	Negative	in significant
Na ⁺ * Ca ⁺⁺	- 0.129	0.610 (greater than 0.05)	Negative	in significant
Na ⁺ * Cl ⁻	0.74**	0.000 (less than 0.01)	positive	significant
Na ⁺ * F ⁻	0.41	0.093 (greater than 0.05)	positive	in significant
Na ⁺ * SO ₄ ⁻	0.38	0.116 (greater than 0.05)	positive	in significant
Na ⁺ * NO ₃ ⁻	0.29	0.263 (greater than 0.05)	positive	in significant
K ⁺ * Ca ⁺⁺	0.35	0.152 (greater than 0.05)	positive	in significant
K ⁺ * Cl ⁻	- 0.09	0.717 (greater than 0.05)	Negative	in significant
K ⁺ * F ⁻	- 0.06	0.801 (greater than 0.05)	Negative	in significant
K ⁺ * SO ₄ ⁻	0.26	0.301 (greater than 0.05)	positive	in significant
K ⁺ * NO ₃ ⁻	0.50*	0.034 (less than 0.05)	positive	significant
Ca ⁺⁺ * Cl ⁻	0.22	0.388 (greater than 0.05)	positive	in significant
Ca ⁺⁺ * F ⁻	0.04	0.861 (greater than 0.05)	positive	in significant
Ca ⁺⁺ * NO ₃ ⁻	0.34	0.162 (greater than 0.05)	positive	in significant
Ca ⁺⁺ * SO ₄ ⁻	0.28	0.267 (greater than 0.05)	positive	in significant
Cl ⁻ * F ⁻	0.36	0.145 (greater than 0.05)	positive	in significant
Cl ⁻ * SO ₄ ⁻	0.37	0.133 (greater than 0.05)	positive	in significant
Cl ⁻ * NO ₃ ⁻	0.40	0.097 (greater than 0.05)	positive	in significant
F ⁻ * SO ₄ ⁻	0.26	0.298 (greater than 0.05)	positive	in significant
F ⁻ * NO ₃ ⁻	0.68**	0.002 (less than 0.01)	positive	significant
SO ₄ ⁻ * NO ₃ ⁻	0.57*	0.013 (less than 0.05)	positive	significant
**. Correlation is significant at the 0.01 level (2-tailed).				
*. Correlation is significant at the 0.05 level (2-tailed).				

3.1.2.2.2. Ground water micro cationic composition, winter seasons:-

Chromium, Copper, Cadmium, Zinc, Lead, Nickel, Cobalt, and barium showed very low concentration than the permissible levels WHO and SSMO.

Aluminum concentration in all sample showed low levels than the permissible level of WHO and SSMO of drinking water 0.3ppm .

Table (4.16) Descriptive statistic of ground water micro cationic winter season.

Elements	Maximum	Minimum	Mean	Std.
Cr ⁺⁺	0.000383	0.000383	0.000383	0.000
Cu ⁺⁺	0.005200	0.000298	0.0010615	0.002
Cd ⁺⁺	0.000198	0.000198	0.000198	0.000
Zn ⁺⁺	0.411300	0.000112	0.03174	0.1140
Pb ⁺⁺	0.00477	0.00477	.0047700	0.000
As ⁺⁺⁺	0.014870	0.000700	0.003280	0.00354
Fe ⁺⁺	0.000673	0.000673	0.000673	0.0002
Al ⁺⁺⁺	0.025600	0.000333	0.003674	0.008
Ni ⁺⁺	0.000067	0.0000674	0.000067	0.000
Co ⁺⁺	0.000198	0.000198	0.000198	0.000
Ba ⁺⁺	0.12530	0.00057	0.031774	0.034437

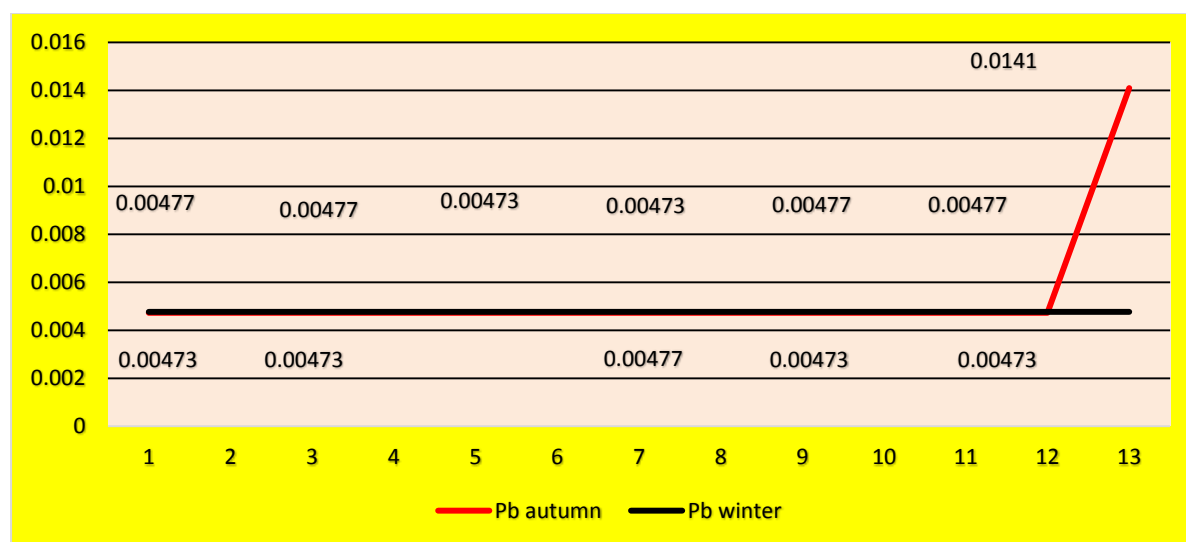


Fig (3.13) Seasonal variations of ground water, lead, autumn and winter seasons.

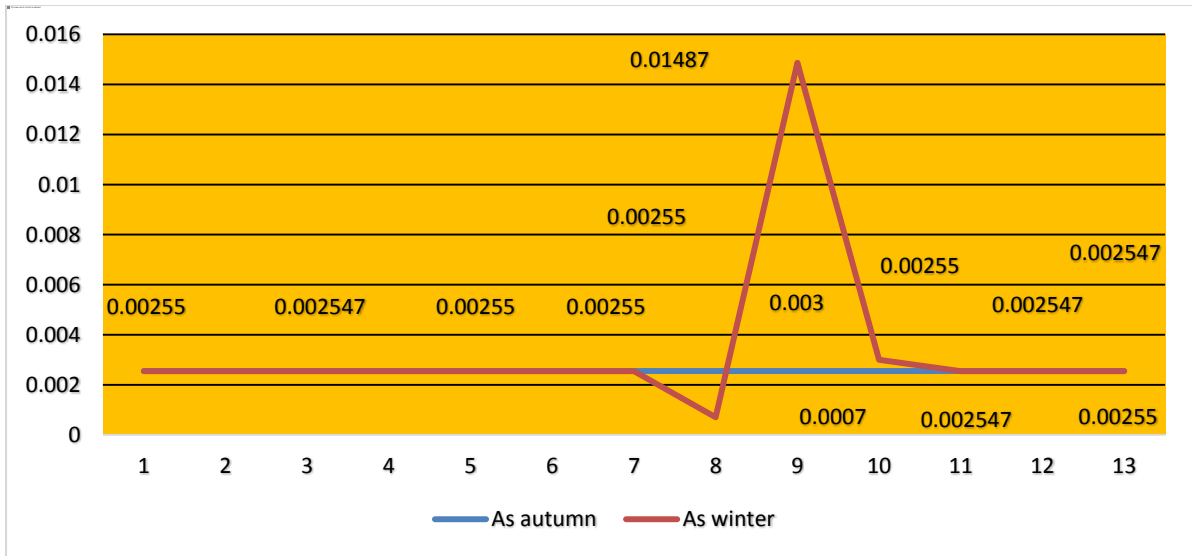


Fig (3.14) Seasonal variations of ground water,arsenic,autumn and winter seasons.

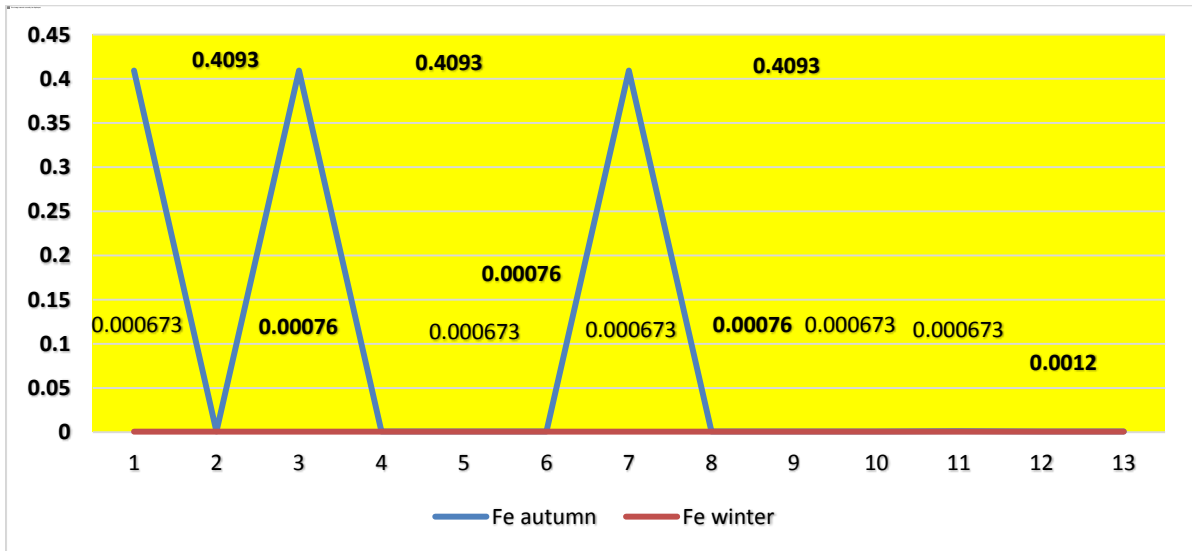


Fig (3.15) Seasonal variations ofground water,iron, autumn and winter seasons.

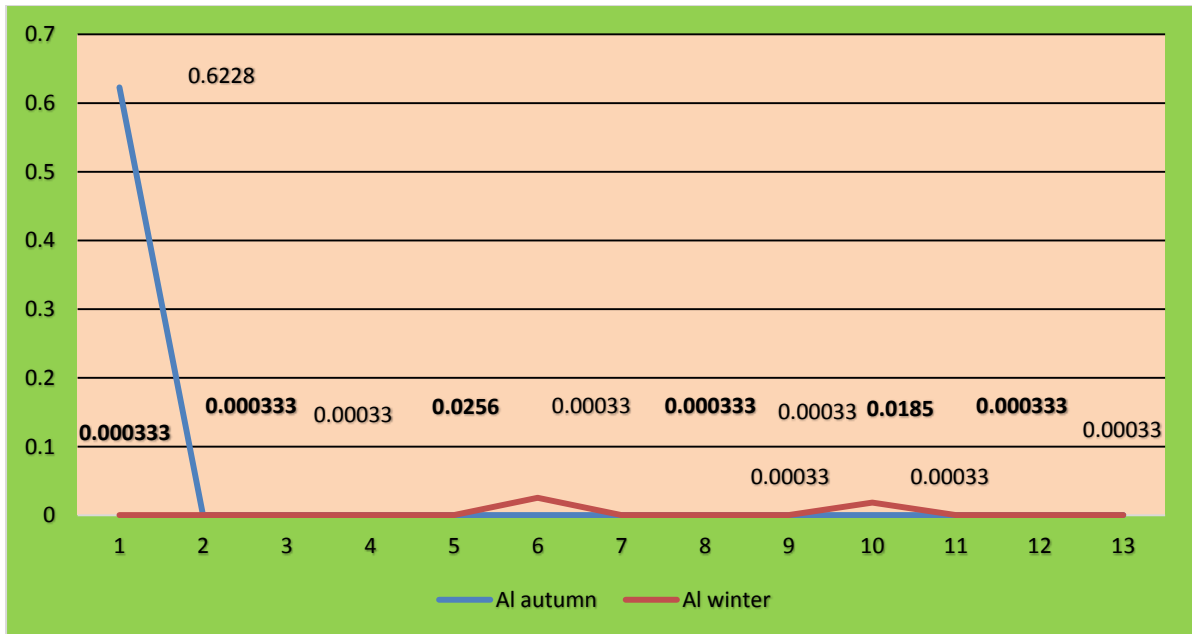


Fig (3.16) Seasonal variations of ground water, aluminum, autumn and winter seasons.

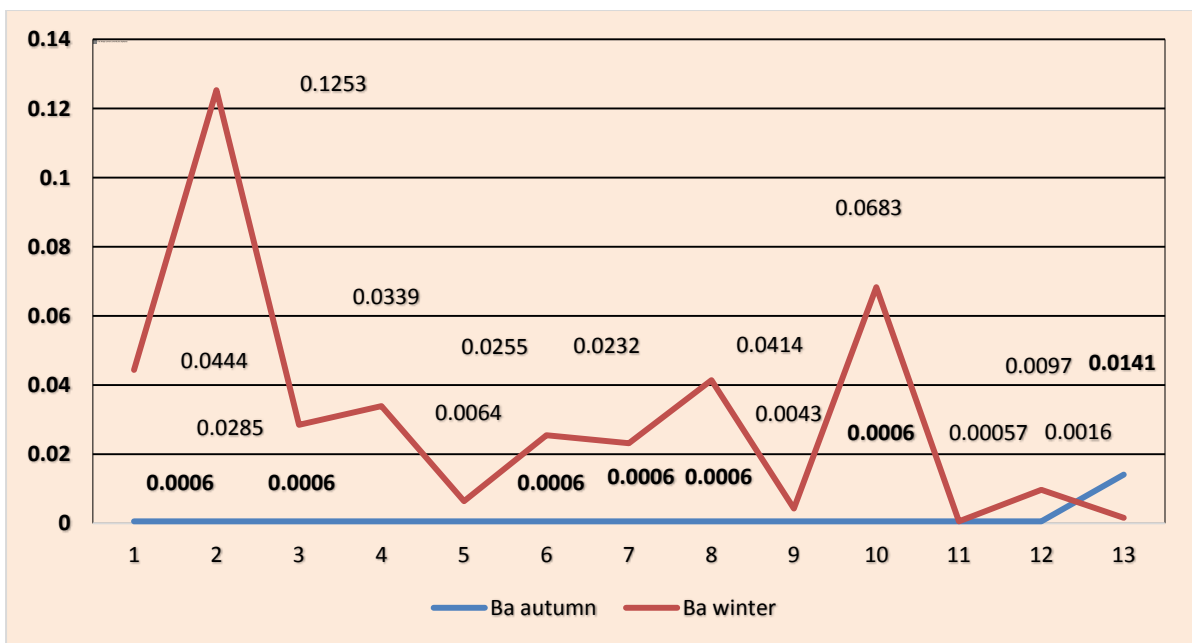


Fig (3.17) Seasonal variations of ground water, barium, autumn and winter seasons.

3.2.1.1. Physical properties of Surface water, Autumn Season:-

Table 3.17 shows physical properties of surface water in autumn season.

pH value ranges from (7.9 to 6.9), the highest value was 7.9 in sample 5 whereas the lowest value was (6.9) in sample (1), with a mean value was 6.00. In general the pH in surface water lower than the pH in ground water, this may be due to the geological formation and alkaline earth.

Table (3.17) Surface water physical properties, autumn season.

Sample No	PH	EC $\mu\text{s}/\text{cm}$	TDS Mg/l	TU NTU
1. Aldalanj reservoir	6.9	106	63.8	63.7
2. Aldabibat Manago	7.7	1387	831	1.12
3. Hbila	7.6	1027	615.5	4.8
4. Kortala	7.8	428	257	1.39
5. Alrashad reservoir	7.9	146.8	87.9	51.9

EC ranges from (1387 to 106 $\mu\text{s}/\text{cm}$) with a mean value was 618.9600 $\mu\text{s}/\text{cm}$. WHO drinking water standards and SSMO recorded the maximum EC values less than 1400 $\mu\text{s}/\text{cm}$, all samples low than the maximum permissible level set by WHO and SSMO.

TDS ranges from (831 to 63.8 ppm) samples numbers (2, 3) which were (831, 615.5 ppm) high TDS compared with WHO and SSMO. This explains surface water contains tiny particles that increase the TDS. The use of these sources may be unsafe for human drinking, samples (2 and 3) may be classified as unsafe for drinking.

Turbidity ranges from (63.7 to 1.13 NTU) with a mean value 24.85 mg/l. The highest value appeared in sample (1) was 63.7 NTU and (5) was

51.9 NTU. Table (3.18) shows descriptive statistics of Surface water, physical properties, autumn season.

Table (3.18) Descriptive statistic of Surface water physical properties autumn season.

Parameters	Maximum	Minimum	Mean	Std. Deviation
pH Value	7.9	6.9	6.00	3.38
EC $\mu\text{s}/\text{cm}$	1387	106	618.96	565.45
TDS mg/l	831	63.8	371.04	338.71
TU NTU	63.7	1.13	24.58	30.64

3.2.1.2. Chemical Properties :-

3.2.1.2.1. Anionic composition:-

Tables(3.19) shows the results of anionic composition of surface water, autumn season .

Flurided was ranged from (1.4 to 0.35 mg/l), all samples show lower levels than WHO and SSMO. concentration in ground water higher than surface water, also strong correlation between fluoride and chloride correlation value (0.72) table (3.17) .

Table(3.19) Surface water anionics concentration, autumn season.

Sample No	F ⁻	Cl ⁻	NO ₃ ⁻	SO ₄ ⁻	OH ⁻	CO ₃ ⁻	HCO ₃ ⁻
1	0.35	22.3	19.8	4	0	0	525
2	0.59	64.5	19.3	138	0	90	0
3	1.4	102.4	11.8	35.5	0	60	61
4	0.58	26.3	19.8	5.5	0	60	91.5
5	0.73	25.3	17.3	5	0	122	0

Chloride ranges from (102.4 to 22.31 mg/l) with a mean value was 48.16 mg/l WHO and SSOM reported the maximum acceptable level of chloride was 250 mg/l according to these all sample lower level than the permissible value, Chloride concentration in surface water in autumn season higher than winter.

Nitrate was varied between (19.8 to 11.8 mg/l) with a mean value was 17.60 mg/l, the concentration in autumn season less than winter this may be due

to the decay of the rock. In general the concentration of nitrate in ground water higher than surface water as a result of geological formation.

Sulphate was ranging from (138 to 400 mg/l) with the mean value 37.60 mg/l the highest value was 138 mg/l at sample (2), the concentration of sulphate in autumn season higher than winter, in general all samples showed low level than the permissible level that set by WHO and SSMO 250 mg/l.

Hydroxide in all samples were zero.

Carbonate one sample shows zero carbonate at (1) was ranged from (122 to 0.00 mg/l) with the mean value 55.33 mg/l.

There were two samples shown zero Bicarbonate (2 and 5) and the highest concentration was 525 mg/l with the mean value was 112.9 mg/l.

The obtained results show agreement with previous analysis (IAS, Afaf, Hala and Madena) in the same area. Table 3.19 shows descriptive statistics of anionic of Surface water autumn season.

Table (3.20) Descriptive statistics of Surface water anionic composition, autumn season.

Parameters	Maximum	Minimum	Mean	Std. Deviation
F ⁻	1.40	0.35	0.73	0.40
Cl ⁻	102.4	22.3	48.16	34.92
NO ₃ ⁻	19.8	11.8	17.60	3.40
SO ₄ ²⁻	138	4.00	37.60	57.68
OH ⁻	0.00	0.00	0.00	0.00
CO ₃ ²⁻	122	0.00	55.33	48.62
HCO ₃ ⁻	525.0	0.00	112.92	205.53

3.2.1.2.2. Cationic composition for surface water autumn season:-

3.2.1.2.2.1. Macro cationic composition for surface water autumn season:-

Table 3.21 showed the result of surface water, macro cationic concentration autumn season.

The concentration of sodium was ranged from (8.38 to 0.03 ppm) with a mean value was 3.8852 ppm.

Table (3.21) Surface water macro cationic concentration, autumn season

Sample No	Na ⁺	K ⁺	Ca ⁺⁺	Mg ⁺⁺
1	0.03	4.70	10.9	2.57
2	8.23	2.52	17.53	6.49
3	8.38	1.83	17.84	3.56
4	2.66	1.98	26.42	4.74
5	0.12	3.51	19.7	13.52

Potassium concentration was ranged from (6.55 to 3.316) with a mean value was 0.906mg/l.

Calcium was range from (26.4 to 10.90), with a mean value was there was 18.4780 ppm.

Magnesium concentration was ranged from (13.52 to 2.566) with a mean value was 6.177ppm, compared with WHO (1984) and SSMO 30ppm the maximum permissible levels according to this all sample within the range.

Table 4.22 show Descriptive statistic of surface water, macro cationic autumn season.

Table (3.22) Descriptive statistic of surface water, macro cationic, autumn season.

Elements	Maximum	Minimum	Mean	Std. Deviation
Na ⁺	8.38	.03	3.88	4.17
K ⁺	4.70	1.83	2.91	1.11
Ca ⁺⁺	26.42	10.90	18.48	5.55
Mg ⁺⁺	13.52	2.57	6.18	4.36

3.2.1.2.2.2. Micro Cationic composition for surface water autumn season:-

Chromium, Copper, Cadmium, Zinc, Lead, Nickel, Cobalt, and barium at trace level than the permissible levels WHO and SSMO. Iron concentration in most sample showed low level that set by WHO and SSMO except samples (1,2) their concentrations 0.409ppm). Aluminum concentration in all sample showed low levels than the permissible level of WHO and SSMO of drinking water

0.3ppm that except sample (1) showed 0.622ppm. Table 4.26 showed descriptive statistic of surface water, micro cationic, autumn season.

Table (3.23) Descriptive statistic of surface water, micro cationic composition autumn season.

Elements	Maximum	Minimum	Mean	Std.
Zn ⁺⁺	0.0002	0.0001	0.0002	0.00
Cd ⁺⁺	0.0002	0.0002	0.0002	0.00
Pb ⁺⁺	0.0047	0.003	0.004	0.01
Cr ⁺⁺⁺	0.00058	0.001	0.001	0.00
Cu ⁺⁺	0.008	0.005	0.01	0.001
Co ⁺⁺	0.0002	0.0002	0.0002	0.00
Ni ⁺⁺⁺	0.00007	0.0001	0.0001	0.00
Al ⁺⁺⁺	0.62	0.0003	0.125	0.28
Fe ⁺⁺	0.41	0.001	0.17	0.22
Ba ⁺⁺⁺	0.0028	0.001	0.001	0.001
As ⁺⁺⁺	0.0025	0.002	0.002	0.00

3.2.2.1. Physical properties Surface water Winter Season:-

Table 3.23 shows physical properties of surface water in winter season. pH value was ranged from (7.9 to 7.1), the highest value was 7.9 in sample (3), where as the lowest value was (7.1) in sample (1), with the mean value was 7.64.

Table (3.24) Surface water, physical properties winter season.

Sample No	PH	EC $\mu\text{s/cm}$	TDS mg/l	TU NTU
1	7.1	233	139.8	1.74
2	7.8	1328	797	1.55
3	7.9	404	242	2.3
4	7.6	695	417	2.11
5	7.8	1229	738	1.58

EC was ranges from (1328 to 233 $\mu\text{s/cm}$) with a mean value was 777.80 $\mu\text{s/cm}$ WHO drinking water standards and SSMO recorded the maximum EC values less than 1400 $\mu\text{s/cm}$, all sample low than the maximum permissible level that set by WHO and SSMO.

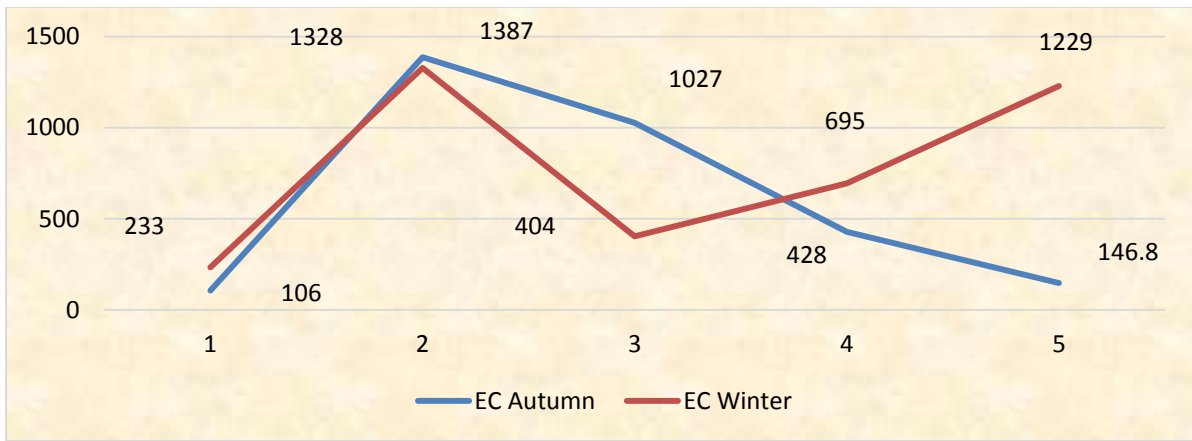


Fig (3.18) Seasonal variations of surface water, EC autumn and winter seasons.

TDS ranges from (797.0 to 139.8 ppm), samples (2 and 5) which were (797, and 738 ppm) respectively high TDS compared with WHO and SSMO. Generally TDS in surface water in autumn season lower than winter season. Fig(4.19).

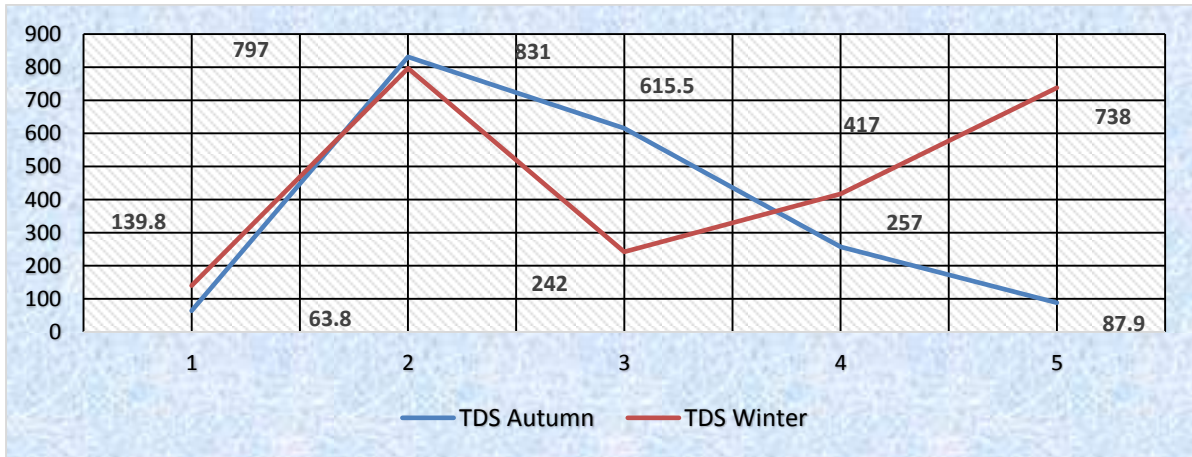


Fig (3.19) Seasonal variations of surface water, TDS, autumn and winter seasons.

Turbidity was ranging from (2.11 to 1.55 NTU) with a mean value was 0.3335. All samples show low level compared with WHO and SSMO, a seasonal variation turbidity value in autumn high than winter season. Fig(3.20).

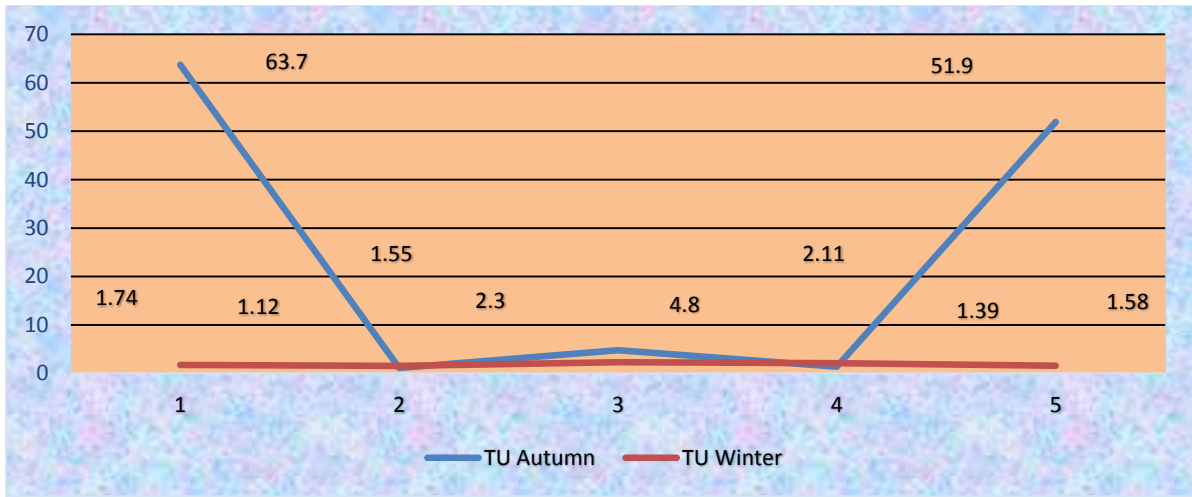


Fig (3.20) Seasonal variations of surface water, turbidity, autumn and winter seasons.

Table 3. 24 shows descriptive statistic of surface water physical properties winter season.

Table (3. 25) Descriptive statistic of surface water, physical properties winter season.

Parameters	Maximum	Minimum	Mean	Std. Deviation
pH Value	7.9	7.1	7.64	0.32
EC $\mu\text{s}/\text{cm}$	1328	233	777.80	487.26
TDS mg/l	797.0	139.8	466.76	292.63
TU NTU	2.11	1.55	1.85	0.33

3.2.2.2. Chemical Properties :-

3.2.2.2.1. Surface water Anionic for winter season

Tables 3.26 shows the results of surface water anionic concentration winter seasons.

Flurided was ranged from (1.58 to 0.14 mg/l) sample (2) was 1.58 mg/l showed high level compared with WHO and SSMO. There were no seasonal variation fig (4.10), but in ground water fluoride concentration higher than that of surface water, also strong correlation between fluoride and chloride correlation value (0.72) table (4.17) .

Table (3.26) Surface water anionics concentration, winter season.

Sample No	F ⁻	Cl ⁻	NO ₃ ⁻	SO ₄ ⁻	OH ⁻	CO ₃ ⁻	HCO ₃ ⁻
1	0.14	32.2	2.4	3.5	0.00	60	361
2	1.58	24.8	1.6	7.1	0.00	60	61
3	0.98	19.8	3.2	2	0.00	60	122
4	0.26	29.8	1	5.2	0.00	60	152.5
5	0.5	66.5	0.7	15	0.00	60	183

Chloride was ranging from (66.5 to 19.8mg/l) with a the mean value was 34.620 mg/l, all sample in showed lower level than the permissible value. In surface water chloride concentration in autumn season higher than winter fig (3.33)

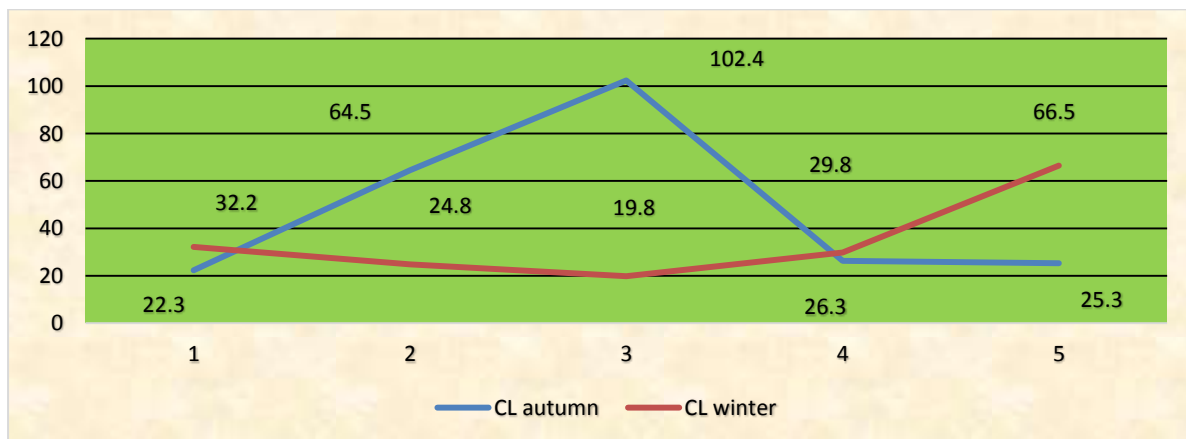


Fig (3.21) Seasonal variations of surface water, chloride autumn and winter seasons.

Nitrate for surface water was varied between (3.2-0.7mg/l), nitrate concentration in autumn season lower than winter, in general the concentration of nitrate in ground water higher than that of surface water due to geological formation. Fig(3.22)

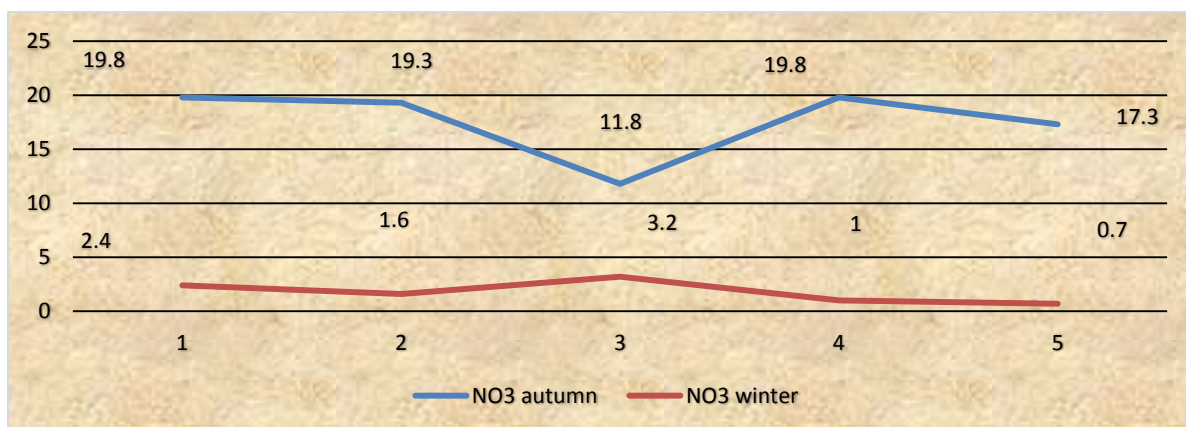


Fig (3.22) Seasonal variations of surface water ,nitrate autumn and winter seasons.

Sulphate was ranged from (15 to 2mg/l) with a mean value was 6.560 mg/l, the concentration in autumn season higher than winter may be as a result of contamination of surface water by moving of water on earth, fig (4.23), in general all samples ground and surface showed lower level than the permissible level that set by WHO and SSMO 250 mg/l.

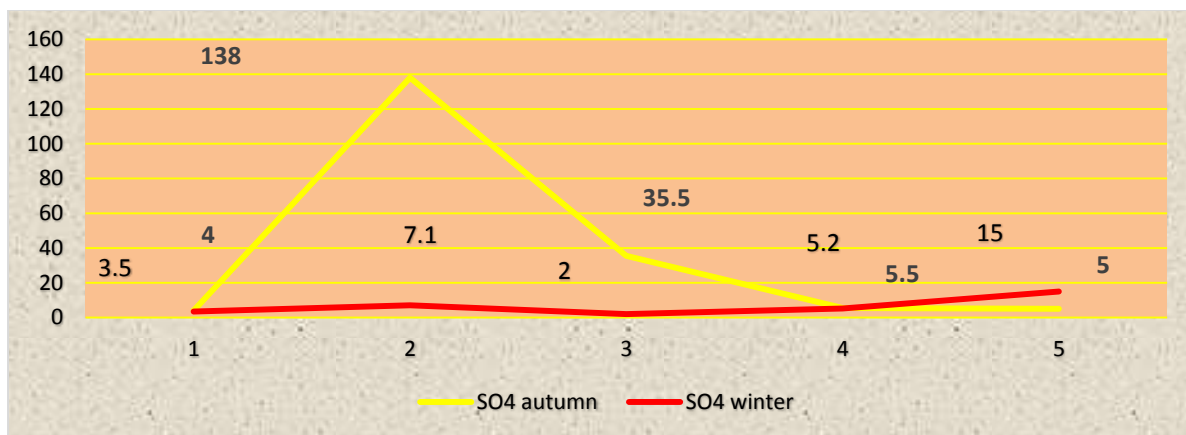


Fig (3.23) Seasonal variations of surface water, sulphate in autumn and winter seasons.

Hydroxide for surface water winter season all samples showed zero.

Carbonate all five samples showed 60mg/l with a mean value was 72mg/l fig(3.24), this may be due to seasonal variations in winter season low than autumn season.

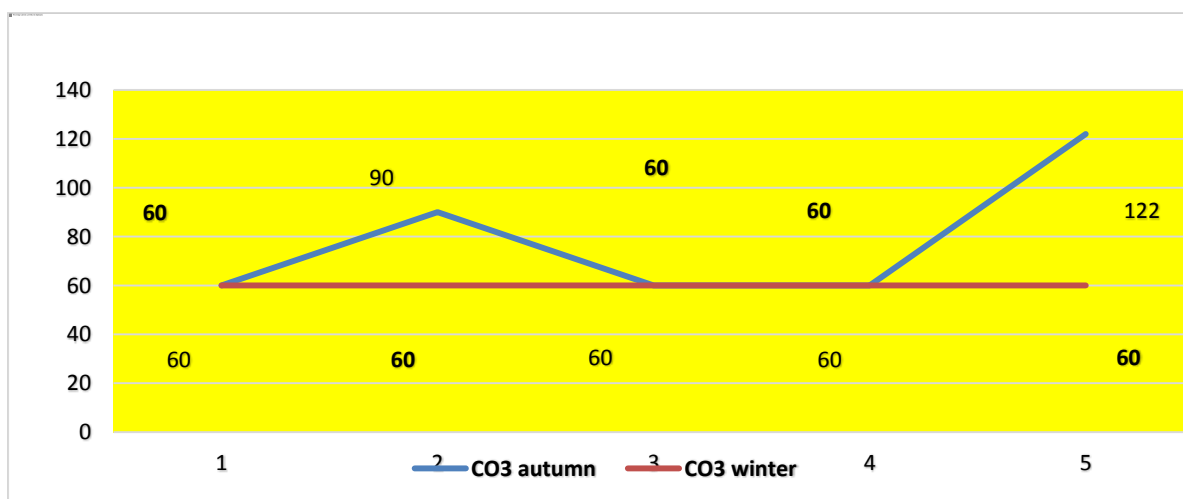


Fig (3.24) Seasonal variations of carbonate for surface water in autumn and winter seasons.

Bicarbonate was ranged from (361 to 61mg/l) with a mean value was 134.2mg/. Sample (2) showed low level.

Table 3.26 shows descriptive statistic of surface water, anionic composition winter season.

Table (3.27) Descriptive statistic of surface water anions concentration winter season.

Parameters	Maximum	Minimum	Mean	Std. Deviation
F ⁻	1.58	0.14	0.69	0.59
Cl ⁻	66.5	19.8	34.62	18.45
NO ₃ ⁻	3.2	0.7	1.78	1.26
SO ₄ ⁻	15	2	6.56	5.09
OH ⁻	0.00	0.00	0.00	0.00
CO ₃ ⁻	120	60	72.00	26.83
HCO ₃ ⁻	361	61	134.20	46.25

3.2.2.2.2. Cationic composition for surface water winter season:-

3.2.2.2.2.1. Macro Cationic for surface water winter season:-

Tables 3.27 showed the result of surface water, macro cationic, winter seasons. Sodium concentration ranges from (5.55-1.21 ppm) with a mean value was 2.570600mg/l, sodium in autumn higher than that of winter season fig (3.25).

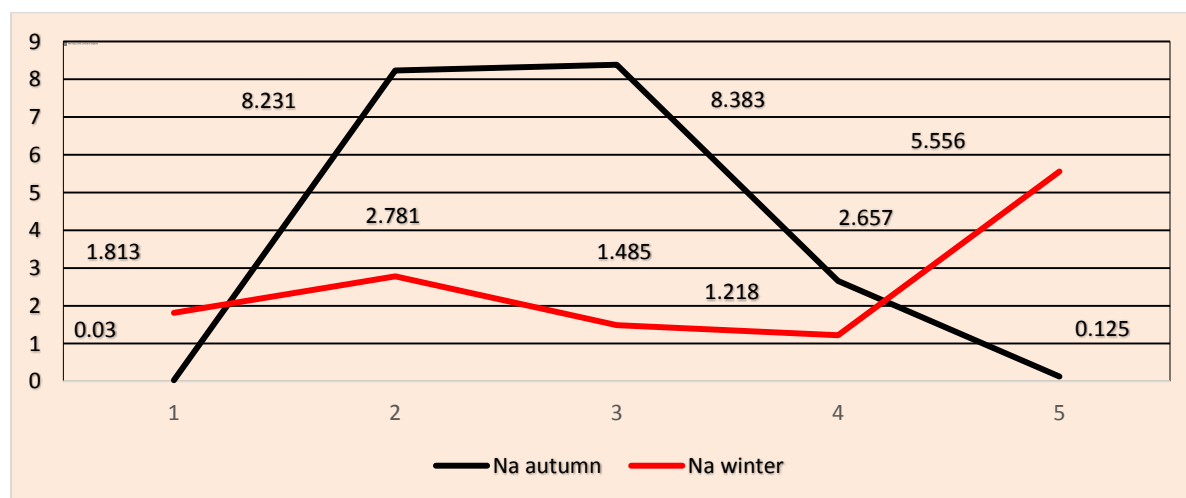
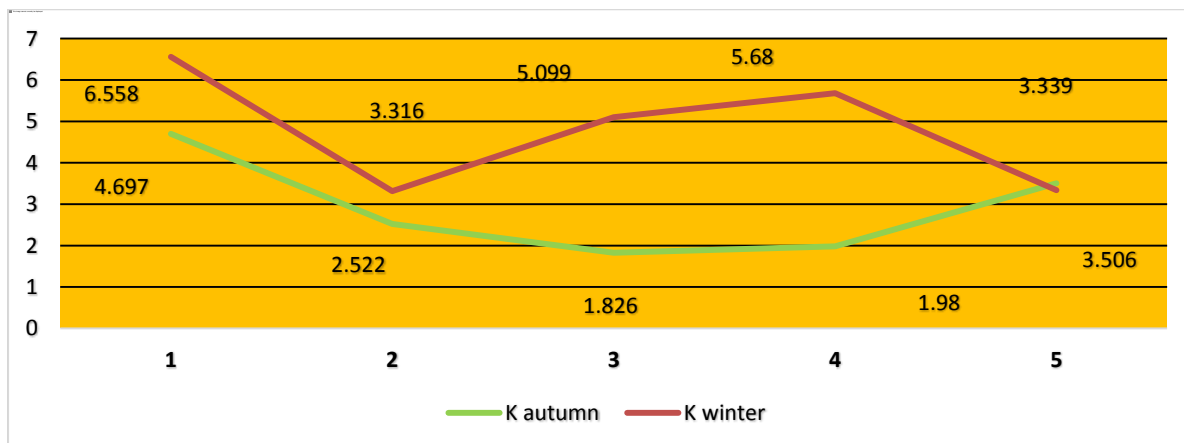


Fig (3.25) Seasonal variations of surface water, sodium, autumn and winter seasons.

Table(3.28) Surface water, macro cationic concentration winter season

Sample No	Na ⁺	K ⁺	Ca ⁺⁺	Mg ⁺⁺
1	1.813	6.558	21.54	5.299
2	2.781	3.316	38.46	30.71
3	1.485	5.099	18.36	4.77
4	1.218	5.68	31.21	7.018
5	5.556	3.339	44.39	7.337

Potassium ranges from (4.697 to 1.826) with a mean value was 2.906 mg/l all samples showed lower level than WHO and SSMO.



Fig(3.26) Seasonal variations of potassium for surface water in autumn and winter seasons.

Calcium range from (44.39 to 18.36 ppm), there was small seasonal variation in winter season the concentration high than autumn fig(3.39) this is due to decay and deposition of rocks.

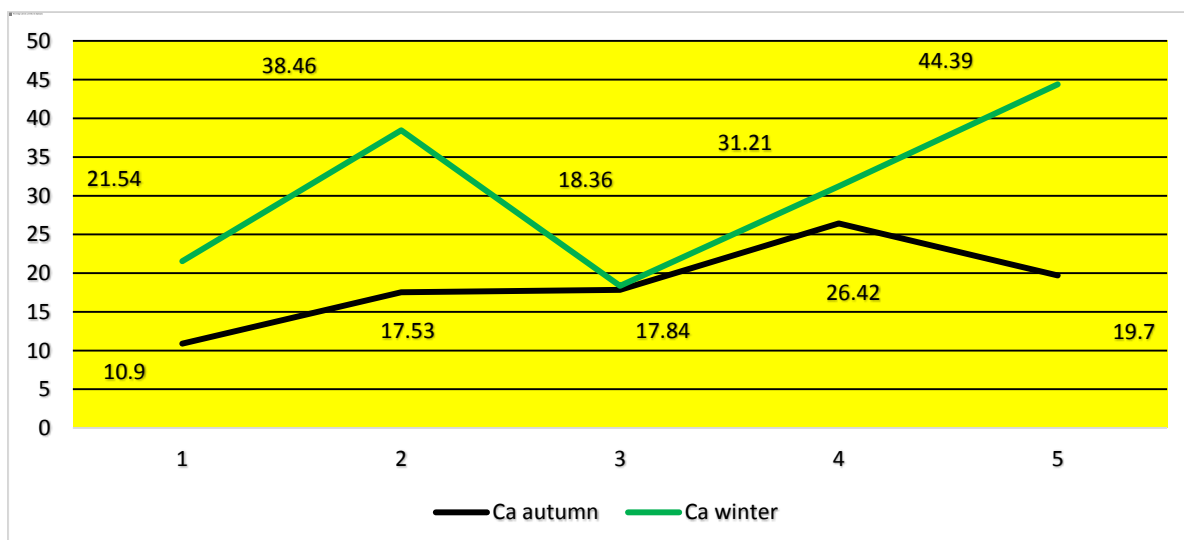
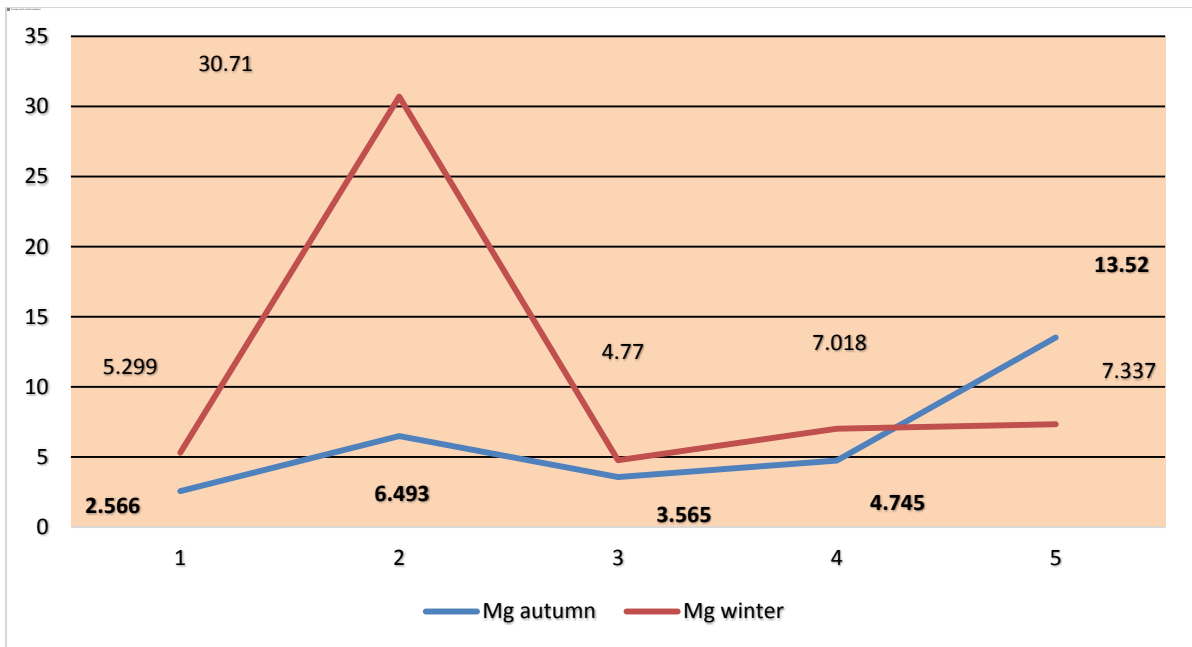


Fig (3.27) Seasonal variations of surface water, calcium autumn and winter seasons.

Magnesium concentration was ranges from (30.71 to 4.77) ppm with a mean value was 11.027 ppm in, sample (2) the concentration was 30.71 ppm showed high level compared with WHO (1984) and SSMO 30 ppm of magnesium in drinking water. In winter magnesium higher than autumn fig (3.28).



Fig(3.28) Seasonal variations of surface water, magnesium ,autumn and winter seasons.

Table 3.29 shows descriptive statistic of surface water macro Cationics in winter season.

Table (2.9) Descriptive statistic of Surface water macro cationics winter season.

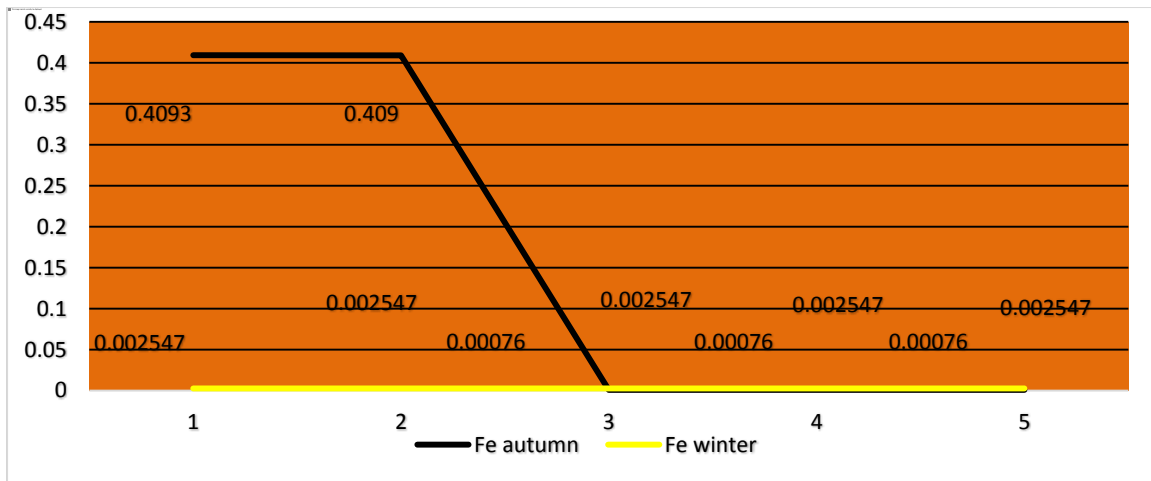
Elements	Maximum	Minimum	Mean	Std. Deviation
Na ⁺	5.56	1.22	2.58	1.77
K ⁺	6.56	3.32	4.80	1.44
Ca ⁺⁺	44.39	18.36	30.79	11.00
Mg ⁺⁺	30.71	4.77	11.03	11.06

3.2.2.2.2. Micro Cationic for surface water winter season:-

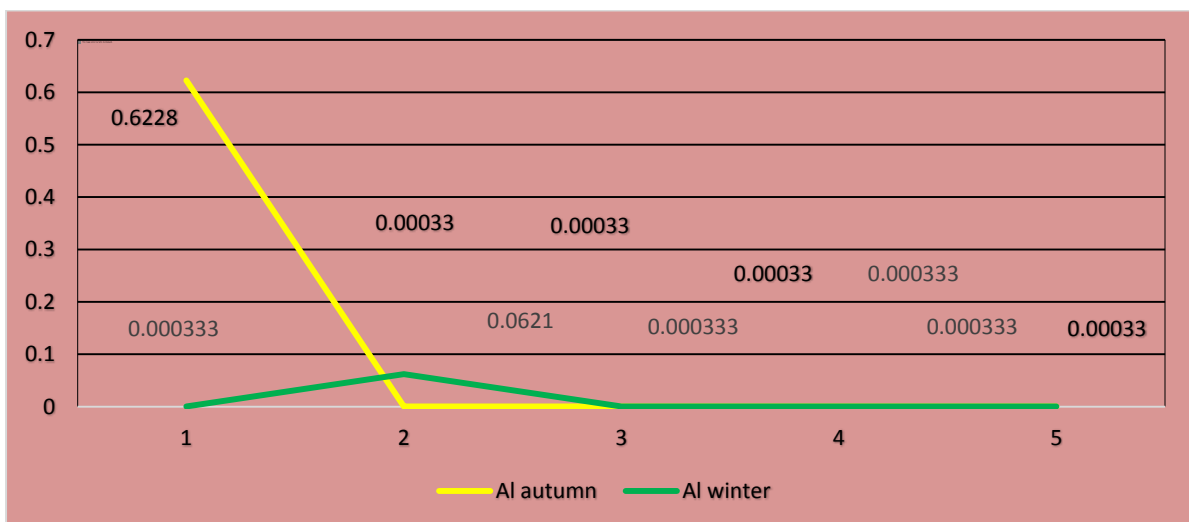
Chromium, Copper, Cadmium, Zinc, Lead, Nickel, Cobalt, barium and iron at a trace levels than that of permissible levels of WHO and SSMO ..Aluminum concentration in all sample showed low levels than the permissible level of WHO and SSMO of drinking water 0.3ppm that except sample No(2) showed 0.621ppm.

Table (3.30) Descriptive statistic of surface water, microcations, winter season.

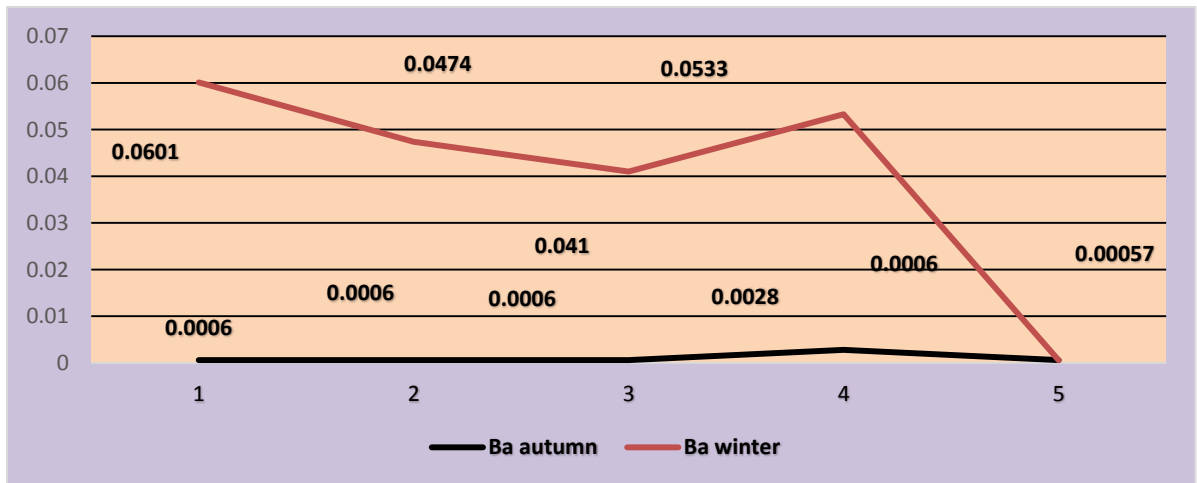
Elements	Maximum	Minimum	Mean	Std.
Cr	0.00038	0.000383	0.000383	0.000
Cu	0.00500	0.000298	0.00123	0.000
Cd	0.000198	0.000198	0.000198	0.0000
Zn	0.000112	.0.000112	0.000112	0.0000
Pb	0.000473	.0.0004727	0.000473	0.0000
As	0.00255	0.00057	0.00255	0.0234
Fe	0.00033	0.002547	0.00255	0.0000
Al	0.062	0.000333	0.0127	0.0276
Ni	0.0000674	0.0000674	0.0000674	0.0000
Co	0.00019	0.00019	0.00019	0.0000



Fig(3.29) Seasonal variations of surface water, iron for autumn and winter seasons.



Fig(3.30) Seasonal variations of surface water, aluminum autumn and winter seasons.



Fig(3.31) Seasonal variations of surface water Barium, autumn and winter seasons.

Conclusion:

In conclusion, this study reports the Physical and chemical properties show general suitability of analyzed ground and surface water samples.

- PH value in all samples are between (6.9 to 8.5), for ground water in autumn season higher than winter season.
- Total Dissolved Solids content appeared to be high in some samples (Aldalanj, Habila, Kortala, Dalami and Alrashad) (Aldabibat and Habila) for ground and surface water respectively.
- High Fluoride concentration had been observed at samples (Aldabibat Manaqu, Kortala hand pump, Dalami, and Kadugli) also fluoride in ground water higher than surface water.
- Nitrate in ground water higher than surface water which is possibly due to the decay of rocks formation.
- Zinc show very low concentration in all samples for ground and surface water, in both seasons.
- There was a seasonal variation between (concentration) in most of parameters due to sources of water samples (ground and surface).
- The results showed good quality in, winter season

Recommendations:-

- Further research may be required for (it) determination of fluoride and iodide content in drinking water.
- Other studies are needed (environmental, economical, agricultural and social studies).
- Radioactive elements and isotopes analysis is needed in the areas of study to complete the radiochemical data base information's.
- An increase in certain in mineral water may cause a health problem to consumers; It is recommendeds that medical studies can be under take in the areas of the studies to eliminate these effects.
- Coagulation, filtration and adsorption methods are needed to remove the high concentrations of TDS and other high elements.
- To solve the drinking water quality in the areas of study completely, It is highly recommended that reservoir should be used for supply of drinking water, rather than surface water resources.
- Further research may be required for determination of seasonal variation of summe season.

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