Sudan University Of Science and Technology

College Of Graduate Studies

DRINKING WATER INVESTIGATION IN AL KAMLEIN LOCALITY INDUSTRIAL AREAS

A Thesis Submitted In Fulfillment Of the Degree Of Doctor Of Philosophy

By :Gamereldawla Osman ElnourYeasa

Supervisor : Dr. AbdEl-slam AbdallaDafaAlla

Associate Professor Of Chemistry
Sudan University Of Science and Technology,Khartoum

April 2015

وَهُوَ الَّذِي يُرْسِلُ الرِّيَاحَ بُشْرًا بَيْنَ يَدَيْ رَحْمَتِهِ حَتَّى إِذَا أَقَلَّتْ سَحَابًا
ثِقَالًا سُقْنَاهُ لِبَلَدٍ مَيِّتٍ فَأَنْزَلْنَا بِهِ الْمَاءَ فَأَخْرَجْنَا بِهِ مِنْ كُلِّ الثَّمَرَاتِ
كَذَلِكَ نُخْرِجُ الْمَوْتَى لَعَلَّكُمْ تَذَكَّرُونَ (٥٧) الاعراف

أَفَرَأَيْتُمُ الْمَاءَ الَّذِي تَشْرَبُونَ (٦٨) أَأَنْتُمْ أَنْزَلْتُمُوهُ مِنَ الْمُزْنِ أَمْ نَحْنُ
الْمُنْزِلُونَ (٦٩) الواقعة

Dedication

To
The best,
whom I love more than my self,
The prophet **Mohammed ibnAbdAlla**

ACKNOWLEDGEMENT

At the outset, I express my deep sense of gratitude to my supervisor Dr. AbdelslamAbdAllaDafalaand Dr. MutassimMaknoon for initiating me to research and providing constant inspiration, guidance and encouragement. The kind cooperation, technical support and help of the laboratory staff of GIAD. My due thanks to My sister Dar al naeem for typing out script.

Abstract

This study was conducted during the period of march 2012 to may2014 in tow locations of Al Kamlein locality industrial areas ; Giad complex and Al Bagair factories. Theyhave many factories and these factories produce and discharge significant quantity of untreated waste water which eventually gets into the underground water ,and there are some villages around these factories. The objective of this study is to assess the quality of wells drinking water in the areas (villages) around Giad industrial complex and Al Bagair industrial area .

Samples were taken from twenty wells for drinking water and assigned S1 to S20 to cover all wells in the tow areas.Some parameters and ten heavy metals were measured and the results were compared with standard values stipulated by WHO for drinking water. Some methods for treatment have been suggested . The methods used in analyzing the water samples are; titrations, spectrophotometric ,and atomic absorption spectroscopic. There are many ions or constituents exceed WHO recommended values and considered as risky contaminant .The results show that temperature and EC of the samples were in the range of (19 to 28.7 ^{o}C) and (173 to 681 µS/cm) respectively. All samples were found to be within WHO limit for pH , except tow samples (5.4, and 9.8), low pH may be due to the addition of acidic rain water. High pH may be due to alkaline soil nature that consist of high calcium carbonate content . None of the samples have turbidity value greater than 5 NTU, which is the WHO (2008) maximum desirable limit in drinking water . Most of the samples were found to contain the metals in varying concentrations. The highest concentration of these metals were detected in chromiumwith concentration of 1.180 mg/L, lead (0.063 mg/L) and cadmium (0.91 mg/l). Zinc copper, nickel, iron, cobalt, mercury, and arsenic were obtained in the range of (0 0.81 to 1.043 mg/L), (0.004 to 0.1 mg/L) , (0.005 to 0.019 mg/l), (0.08 to 4.25 mg/L),(0.56 to 3.7 mg/L), (0.001 to 0.002

mg/L),and (below the limit of detection to 0.013 mg/L) respectively. groundwater samples did not exhibit significant elevated levels in Arsenic **,** mercury, manganese ,Nickel ,Zinc, and copper .The samples were found to have elevated contents in Chromium (total)**,** lead**,** iron, cadmium and sulfide ,suggesting that waste water drains may be leaking to some extent. A certain amount of Mn and Co was likely to be re-mobilized from natural soils due to the changes in local redox conditions, while Iron may also be derived from steel corrosion as a result of prolonged flow of water into pipes. samples collected appeared to be virtually free from anyCobalt contaminations.

For S6 and S7 sites ,the study suggests that water from these bore wells should be totally abandoned for high concentration of many ions specially Chromium (total)**,** leadandcadmium . It recommended the researchers to study the environmental impacts of the complex in these areas.

ملخص الرسالة

تمت هذه الدراسة في الفترة من مارس ٢٠١٢ الي مايو ٢٠١٤ في منطقتين صناعيتين بمحلية الكاملين هما منطقة الباقير الصناعية ومجمع جياد الصناعي وما جاورهما من قرى. المصانع التي توجد في هاتين المنطقتين تنتج كميات وافرة من مخلفات المياه غير المعالجة والتي غالبا ما تتسرب وتلوث مياه الشرب . الغرض من اجراء هذه الدراسة هو تقييم مياه الشرب في منطقة الباقير الصناعية ومجمع جياد الصناعي وما جاورهما من قرى وتحديد مدي صلاحيتها للشرب.

تم اخذ عدد عشرين عينة من عشرين بئر يستخدم للشرب بغرض تغطية كل الابار في المنطقتين قيد الدراسة وتم وضع علامات لها لتمييزها ابتداء من S1 وحتى S20 . تم فحص وقياس مجموعة من المعايير التي يتم على اساسها معرفة صلاحية المياه للشرب كما تم قياس عشر عناصر ثقيلة ومقارنة النتائج المقاسة مع المعايير التي تم وضعها بواسطة بعض المنظمات العالمية وعلى رأسها منظمة الصحة العالمية واقتراح بعض المعالجات لها.

الطرق التي تم استخدامها لمعرفة مكونات مياه الشرب عند التحليل هي : طريقة المعايرة ، جهاز الامتصاص الذري و جهاز المطيافية . وجد ان هنالك عددا من المكونات والعناصر الكيميائية التي تجاوز تركيزها الحد المسموح به بواسطة منظمة الصحة العالمية وبالتالي اعتبرت كمواد ملوثة لمياه الشرب في تلك العينات .

اوضحت نتائج الدراسة ان مدى قيمة درجة الحرارة و مدى قيمة الموصلية الكهربية يتراوح بين (19 to 28.7 ^{o}C) و (173 to 681 µS/cm) على التوالي. كل العينات التي تم دراستها فيما يخص الاس الهيدروجيني وجد انها داخل المدى المسموح به بواسطة منظمة الصحة العالمية باستثناء عينتين قيمتهما تساويان (5.4, and 9.8). الاس الهيدروجيني الحمضي (5.4) ربما يكون بسبب الامطار الحمضية الناتجة عند ذوبان الغازات المتصاعدة من تلك المصانع في مياه الامطار. الاس الهيدروجينى القاعدي ربما يكون بسبب طبيعة التربة القاعدية والتي تحتوي على نسبة عالية من كربونات الكالسيوم في تركيبها. لا توجد اي من العينات فد تجاوزت الحد المسموح به من العكارة 5 NTU والموصى به بواسطة منظمة الصحة العالمية. محتوي العينات من العناصر الفلزية تراوح في مدى واسع حيث اعطت العينات نتائج متفاوتة . اعلى التراكيز وجد في ايونات عنصر الكروم 1.180 mg/L يليه الرصاص (0.063 mg/L) ثم الكادميوم (0.91 mg/l) . وجد ان تراكيز ايونات الخارصين ،النحاس ، النيكل ،الحديد، الكوبلت ، الزئبق،و القصدير في مدي يتراوح بين (0 0.81 to 1.043 mg/L), (0.004 to 0.1 mg/L) , (0.005 to 0.019 mg/l), (0.08 to 4.25 mg/L),(0.56 to 3.7 mg/L), (0.001 to 0.002 mg/L),and (below the limit of detection to 0.013 mg/L).

على التوالي.يلاحظ من نتائج التحليل ان تراكيز كل من ايونات القصدير الزئبق ،المنجنيز ،النحاس، النيكل ، الكوبلت لم تكن مرتفعة في اغلب العينات. اما تراكيز ايونات كل من الكروم الرصاص الكادميوم الحديد الكبريت فقد كانت مرتفعة في بعض العينات وربما يكون السبب هو تسرب بعض هذه الايونات من مخلفات المياه واتصالها بماء الشرب. الارتفاع الطفيف في تركيز المنجنيز و الكوبلت لبعض العينات ربما يعود لطبيعة الارض المحتوية لهذين العنصرين.التركيز المرتفع في تركيز الحديد ربما يعود الي تحرر ايونات الحديدمن مواسير مياه الشرب نتيجة للاستخدام الطويل. في كل العينات التي خللت لم يلاحظ ارتفاع تركيز الكوبلت على الاطلاق.
البئران اللذان تم تحليل العينتان S6 و S7 منهما اوصت الدراسة بتجنب استخدامهما للارتفاع الملاحظ فيعدد من تراكيز الايونات بهما خاصة الكروم والكادميوم والرصاص . كما اوصت الدراسة توجيه الباحثين لاجراء المزيد من الدراسات في هولاء المناطق لتاكيد النتائج ومن ثم اجراء اللازم.

List of contents

Chapter one : Introduction

Chapter two

CHAPTER THREE

CHAPTER F0UR

List of tables

List of figures

Acronyms and Abbreviations Used In This Thesis

Symbol	**Description**
µ	Micro
cm	centimeter
EDTA	Ethylene Di amine Tetra Acetic Acid
g	Gramm
EC	Electrical Conductivity
Mg	Milligram
L	Liter
M	Morality
Ml	milliliter
pH	The negative logarithm of the hydrogen ion activity
ppm	parts per million
TDS	Total Dissolved Solids
WHO	World Health Organization
EPA	International Protection Agency
LBD	Limit Below Detection

Chapter one

INTRODUCTION

1-**INTRODUCTION**

Water is the major chemical component and universal solvent of living system. Almost three fourths of the earth's surface is covered by water [1]

It makes up about 70 percent of human body weight. The water content of organisms range widely from as a high as 96% in some jelly fish to extremely low levels in seeds and certain lower invertebrate animal [2]

Water is essential in the process of digestion, circulation, elimination, and the regulation of the body temperature [3].

1-1-Standards & guidelines of drinking water quality

Water quality is the composition of water as affected by natural processes and human activities. water quality is the constituents dissolved or contained within the water. It is often thought that the chemical composition is the only factor involved. However, other conditions, such as biological, physical, and radiological factors should be considered when mentioning water quality. [4]

Drinking water must be safe from water borne or associated diseases and must contain reasonable quantities of required chemicals (salts) [5]

Water should be clear, Palatable, Fresh, and free from excessive concentration of chemicals and free from all toxic chemicals that are injurious to life. [6] Based upon these requirements, permissible (standard) limits have been prescribed for potable drinking water by various agencies like British standards (BS) and World Health Organization(WHO).

1-2-Sources of drinking water

The source of water supply is divided into two major classes:-

1-2-1- Surface water:

Rain and glacier are the main sources of water .Water from these sources flows over the surface to form lakes, ponds, reservoirs, rivers, canals and creeks and as termed as surface water. [7].

The common characteristic of the surface water are that it contain few minerals, it is not very hard, it is usually large in volume, and it is convenient for many people, it is easily contaminated, and total bacterial contents are high .The quality of river water varies with the season and with the rate of the flow. During the dry season, the turbidity as usually low, but the degree of hardness and salt content; are high. During flooding, turbidity and total bacterial counts are high, whereas the degree of hardness and salt content decrease. [7]

1-2-2-Ground water:

The water which gets absorbed into the ground to be tabbed as springs or wells, is termed as ground water[8].

Ground water is naturally supplied mainly from rivers , lakes reservoirs, and marshes, Small portion of this water is economically feasible [8] 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 resources. Also, the water beaming stratum from which it is drawn usually provides a natural storage at point of intake [8]

Deep ground water may contain various kinds of salts and can be very hard. Some sources of deep ground water have a high concentration of iron, fluoride and magnesium. Most of these sources contain few bacteria [9]

Ground water occurs in the sand, gravel, and rock materials beneath the earth surface. Nearly all ground water begins as rain or snow that seeps directly into the soil and rocks or from rivers, streams, and lakes (this is known as ground water recharge).[10]

Ground water comes from small percentage of precipitation that falls, in filtrates, traveling downward, and fills the available pore spaces within rock sand, gravel, and clay. This forms a large subsurface storage area of water which interacts with various rocks, minerals, microorganisms, and any manmade or natural materials that may seep from the surface),[10].

Ground water depletion affected by; evaporation, use of water by plants, natural outflow to seeps and springs, and pumping from wells (known as ground water discharge) [11].

Rock materials that store and transmit substantial quantities of ground water are known as aquifers. The amount of water that an aquifer can store and transmit depends upon the nature of its material and for the aquifer thickness .There are main two types of aquifers: unconfined and confined. An unconfined aquifer has no low permeable layer, such as clay, overlying it .It is present at shallow depths within the ground and water can reach it from the surface by percolating through the over lying soil. A confined aquifer is contained under a low permeable layer, known as the confining bed ; this bed greatly restricts the vertical movement of water.As water slowly percolates through the ground layers, through which it passes, act as a filtering material and have purifying effect on it [12]

Ground water can be classified into three types , according to the layer which it is stored [13]

1-2-2-1-Ground water:

The water that collected above the first stable impervious layer of rock it can move freely, and its surface is known as the ground water surface. Generally there is no pressure in ground, it is supplied mainly by rain water or the percolation of rivers or lakes, the layer permeable and for good water storage.

1-2-2-2-Artesian water:-

Is stored in a water-containing layer sand which confined between two impervious layers. Geologic variations are such that the upper and lower impervious layers are not continually horizontal.

The water flows freely to the surface under pressure, the well is known as an artesian well. If the water rises but does not reach the ground surface it is termed sub- artesian water. Most water used for agricultural irrigation is artesian ground water: the supply varies in different areas, sometimes coming from very far away.

1-2-2-3-Perched water:-

Perch water exists above a sectional impervious layer. It is not widely distributed and is seasonal; it is not significant in the drilling of wells for irrigation. Therefore, deep well water is usually clear, colorless and low in bacterial content, although mineral content is generally higher .

A good amount of rain water percolates through ground layers. The top surface of saturated zone below which water is available is indicated by ground water table [14]

Reservoirs generally store drinking water and supply regularly to different localities, while lakes are water bodies for supplying water to small town's .Rivers mostly give continuous water supply throughout the year, but some rivers have less flow in summer. Besides lakes and rivers, water is available below ground level due to storage in subsoil water [15].

Ground water is collected by dug wells or tube wells depending upon the depth at which adequate quantity is available .Ground water held depends on the rate of replenishment. Although water is collected mostly from surface [through intakes] as well as underground sources [through pumping] [16].

Water mash also be collected from the rivers by infiltration pipes and galleries only a very small percentage [less than o.5] of entire rain fall is available for human use since water from different sources ultimately flows down and join the ocean Impurities. [16].

1-3-potable water properties:

There are three principal media which can be used for aquatic monitoring; water, particulate matter and living organisms. The quality of water and particulate matter is determined by physical and chemical analysis, whereas living organisms can be used for so-called biological water quality monitoring.

The choice of the water quality variables will depend on the objectives of the programme, the occurrence of the variables, the potential impacts (toxicity) and financial resources. Water used for irrigation will require quite different monitoring variables than water used for recreational purposes or drinking water extraction. All substances present in water do not necessarily have harmful effects. In fact, some are essential for the water to be potable [17].

To be consumable, water should be:

-Uncontaminated and hence free from germs causing water borne diseases

-Free from toxic substances

-Free from excessive amounts of mineral and organic matters.

To be potable, water should be significantly free from colour, turbidity, bad taste and odour and should be stored at moderate temperature during summer and winter [18].

Water becomes impure when it contains one or more substances in excess concentrations, or toxic chemicals which might have adverse effects on the user. [18]

Water quality depends upon the catchment area conditions. Water qualities from a storage reservoir appears to be good as suspended solids settle down and upper layers are exposed to more aeration.[19]

As more nutrients are available at the bottom of the reservoirs, they may stimulate algal growth. However, rubbish from the town, fertilizers and pesticides from agricultural fields, domestic and industrial effluents may join any water course and completely change water characteristics. [19].

Impurities, generally found in water, may be classified .according to their characteristics as:

-physical, chemical, bacteriological

-Suspended, colloidal, dissolved

-Organic, inorganic

1-4-Mineral salts toxic chemicals.

Chemical characteristics of water are measured by using the following parameters: Acidity, alkalinity and pH: Acidity is caused by CO_2, mineral acids and salts from strong acids. Alkalinity is due to carbonates, bicarbonates and hydroxides. It is the capacity to neutralize acid. PH value denotes the nature and intensity of water towards acidity or alkalinity [20]. Chemical treatment is usually prohibitive because of high cost and the lack of skilled workers needed for the application . the use of slow sand filters as an alternative has met with success but there are problems of initial cost and maintenance for small communities. [21].

1-4-Physical characteristics of water are measured by using the following parameters:

1-4-1-Color:

Is influenced by natural (e.g. humic acid) and anthropogenic sources; it may be important in view of the aesthetic quality of the water. water color , may indicate presence of organic or inorganic substances, dissolved or suspended solids, because pure water is always colorless.[22]

1-4-2-Taste and odor:

Is often caused by decomposition of organic compounds yielding organic acids, sulfides, etc.
Odor is often an indication for bad water quality conditions (reduced O_2).Decomposed organic material, minerals salts and manganese , vegetation, phenols, chloride and algae impart typical tastes odors' to water. They are unpleasant and undesirable [23].

1-4-3-Turbidity:

It is caused by suspended and fine insoluble particles and colloidal impurities like clay, silt, algae and plankton .Water **n**eeds treatment to reduce turbidity and other substances (microorganisms) in water. The processes include coagulation, flocculation, sedimentation, rapid sand filtration and post chlorination. .Coagulationand flocculation may be classified as : a) Oxidants , such as chlorine or ozone. b) weighting agents such as bentoanite clay, c) activated silica ; and d) polyelectrolytes ([24].

1-4-4-Conductivity:

This easily determinable parameter presents a good measurefor the total irons present in the water, in many cases there is a good correlation with the NaCl concentration . [25] TDS affect The electrical conductivity of water.

1-4-5-Total dissolved solids (TDS):

Total dissolved solids (TDS), is defined as the concentration of all dissolved minerals in the water. (TDS) are a direct measurement of the interaction between ground water and subsurface minerals.

High (TDS), greater than 1000 mg/l, is commonly objectionable or offensive to taste. TDS levels over 2000 mg/l are generally considered undrinkable due to strongly offensive taste. A higher concentration of TDS usually serves as no health threat to humans until the values exceed 10,000 mg/l .At this level the water is considered a brine and defined as undrinkable [26]

A high TDS (levels above 1,000mg/l) may cause corrosion of pipes and plumbing systems .To remove TDS to acceptable levels, a water softener with a reverse osmosis (R/O) system is usually effective .In the reverse osmosis process a cellophane – like membrane separates purified water from contaminated water. Under enough pressure, pure water is squeezed through the membrane to the dilute side. Salts dissolved in water as charged ions are repelled by the RO membrane.

Water being a good solvent, dissolves a number of salts, chlorides, sulfates, bicarbonates of Na, Mg, Ca, K, etc. But all dissolved substances are not undesirable [26].

1-4-6-Total suspended solids (TSS):

May especially be increased in rivers ("turbidity") during storm floods; TSS may carry the large bulk of micro pollutants (heavy metals, pesticides, etc) .[3]

The suspended solids may be inorganic in nature. Such as clay, silt, sand, silica and calcium carbonate , they may be organic matter e.g. oil, fats or grease. [27]

1-4-7-Temperature:

A basic parameter, important for all chemical and biological processes. Large fluctuations are to be expected in deep lakes and reservoirs. palatability, solubility, viscosity, chemical reaction and odors' are influenced by temperature. [28]

1-4-8-pH:

just as temperature a basic water quality parameter, of importance to virtually all biological and chemical processes. Another common problem is that of low pH. A low pH is acidic. The primary cause of a low pH is the addition of acidic rain water .Other ions found in ground water such as nitrates and sulfates may result in lower pH [29].

High pH causes a bitter taste , water pipes become encrusted ,depresses the effectiveness of the disinfection of chlorine .The negative effects of acidic water may result in pipe corrosion, causing the possible release of iron, lead, or copper into the tap water. A low pH may discolor the water and give a bitter taste [30]

The best method in which to reduce the acidity of ground water is to increase the pH, by filtering the water through a neutralizer such as calcite chips, running the water through the calcite raises the pH to a neutral level, thus reducing release of metals through pipe corrosion [31]

1-5-Chemical characteristics of water are measured by using the following parameters:

1-5-1-Alkalinity and acidity :

Representing the buffering capacity of water with respect to acids and hydroxides addition, respectively. The terms are dominantly brought about by the CO_2, bicarbonate,and limestone system in nature [32]. Water does not have to be strongly basic (high pH) to have high alkalinity. Total alkalinity, typically expressed as CaCO3 equivalent, is the sum of HCO3-, CO32-, HPO42-, PO43-, H3SiO4-, H2BO2-, CH3COO-, OH- minus H+. The constituents of alkalinity commonly found in drinking water applications are: HCO3-, CO32-, and OH-. Bicarbonates represent the major form of alkalinity in naturalwaters; its source being the partitioning of CO2 from the atmosphere and the weathering of carbonate minerals in rocks and soil. [6]There are three different tests used for measuring alkalinity, usually performed in this order: pH (to obtain OH- alkalinity), phenolphthalein test (to obtain OH- and CO3-2 alkalinity), and methyl orange test (to obtain total alkalinity [3]. Neither alkalinity nor acidity, have any known adverse health effects.Nonetheless, highly acidic and alkaline waters are considered unpalatable. Knowledge ofthese parameters may be important because:(5) The alkalinity of a body of water provides information about how sensitivethat water body will be to acid inputs such as acid rain.(1) Turbidity is frequently removed from drinking water by coagulation and flocculation. This process releases H+ into the water. Alkalinity must bepresent in excess of that destroyed by the H+ released for effective andcomplete coagulation to occur.(3) Hard waters are frequently softened by precipitation methods. The alkalinityof the water must be known in order to calculate the lime (Ca(OH)2) and sodaash (Na2CO3) requirements for precipitation.(7) Alkalinity is important to control corrosion in piping systems[13].

1-5-2-Hardness :

Is defined as water that is rich in calcium (Ca^{+2}) and/or magnesium (Mg^{+2}).Hardnessis due to multivalent metallic actions (Ca, Mg in Isolation associated with anions like(sulfates, chlorides and bicarbonates) . Hard water generally contains more than 150 mg/l of $CaCO_3$, where as soft water mash contain less than 75 mg/l [33] .Generally, calcium may precipitate as calcium carbonate within the plumbing and clog pipes .Detergents and soaps do not readily dissolve in hard water, which limits the formation of lather and soap suds .Calcium and Magnesium are primarily found in ground water due to the dissolving of limestone (primarily composed of calcium carbonates)[16].The dissolving of limestone occurs when the limestone reacts with rainwater which has become slightly acidic through a reaction with carbon dioxide. Calcium and Magnesium ions are also released when the water reacts with naturally occurring gypsum [34].

Although hard water can an annoyance, it is commonplace and has no ill effects on humans. The primary preventive measure is to install water softener. The results are that the water has little if any soda taste and the formation of soap curd and mineral deposits are eliminated.So total hardness can be removed lime and soda ash coagulation. [35]

1-5-3-Fluoride:

Fluoride (fluorine) is a trace element. Trace elements occur in tiny amounts or traces. They play a major role in health, for even minute portions of them can signicantly _affect health. Since some fluoride compounds in the Earth's upper crust are fairly soluble in water, fluoride exists in both surface- and groundwaters[25]. The fluoride concentrations in groundwater fluctuate within wide limits, e.g., from <1 to 25 mg or more per liter1. Fluoride, bromide and iodide ions except for chloride are found in low concentrations in natural waters. The main source of the fluoride in waters is CaF2, which can be soluble up to 16 mg per liter at 18_C and is found in the composition of volcanic rocks. Minerals such as fluorapatite CaF2.3Ca3(PO4)2, fluorspar (CaF_2), cryolite $3NaF.AlF_3$ and mica also contain fluoride. Fluoride exists in volcanic gases more than in rocks2. Fluoride also is frequently added to some consumer products, such as toothpaste, toothpowder, mouthwash and vitamin supplements for various reasons[8] . Excessively high levels of fluoride intake cause crippling skeletal fluorosis and possibly increased bone fracture risk. Ingestion of excess fluoride during tooth development, particularly at the maturation stage, may also result in dental fluorosis. These effects may be mitigated by co-exposure to some minerals, such as calcium or magnesiumWhen the fluoride concentration in drinking water is greater than 2 mg L^{-1}, it may cause fluorosis related to the concentration, to the amount of watertaken up and to the amount of additional fluoride from using toothpaste and gargle, etc[19]. When the fluoride concentration exceeds 2.4 mg L^{-1}, children under the age of four years must drink from another water source having a known suitable fluoride level or from a water treated with reverse osmosis2;4;5. In the determination of the fluoride levels in various samples, deferent techniques have been used, such as potentiometer (withfluoride sensitive electrodes) or spectrophotometry6−11.

Ground water is likely to have excessive concentrations of fluoride, bearing rock formations, exist industrial effluents also contribute fluoride compounds to water sources [36].

1-5-4-Chloride:

Chlorides are leached from various rocks into soil and water by weathering. The chloride ionis highly mobile and is transported to closed basins or oceans. Chloride in surface and groundwater from both natural and anthropogenic sources, such as run-off containing road de-icing salts, the use of inorganic fertilizers, landfill leachates, septictank effluents, animal feeds, industrial effluents, irrigation drainage, and seawater intrusion in coastal areas (4). Chloride in water may be considerably increased by treatment processes in which chlorine or chloride is used The toxicity of chloride salts depends on the cation present; that of chloride itself is unknown.

Although excessive intake of drinking-water containing sodium chloride at concentrations above 2.5 g/litre has been reported to produce hypertension (12), this effect is believed to be related to the sodium ion concentration. Chloride increases the electrical conductivity of water and thus increases its corrosivity. In metal pipes, chloride reacts with metal ions to form soluble salts (8), thus increasing levels of metals in drinking-water. In lead pipes, a protective oxide layer is built up, but chloride enhances galvanic corrosion (14). It can also increase the rate of pitting corrosion of metal pipes.

Chlorides of Ca, Mg, and Na are present commonly in natural water as they are highly soluble. Excessive concentration may be due to sea water intrusion or contamination from domestic sewage or industrial waste(.Chloridein water can be reduced by activated carbon filters. Water is passed through granular or block carbon material which made of petroleum coke, bituminous coal , lignite ,and wood product .[37].

1-5-5-Sulfates:

Calcium, magnesium and sodium sulphates are generally found in water.$MgSO_4$ produces laxative effects and hardness . [38].

1-5-7-Toxic chemicals:

Chemicals containing Zn, Cu,Pb , As, Ba, Cr, Hg, Ni. Se and Th cause damage to internal organs of human body; (Kidney, liver and brain) [40].

1-5-8-Major ions:

(Ca^{2+} ,Mg^{2+},Na^{+} ,K^{+} ,Cl^{-} ,SO_4^{2-},CO^{3-}) these are mainly due to geological climatic and geographical conditions .In this respect, these parameters can be monitored less intensively because of their less adverse (or even beneficial) effects [41].

1-5-8-1Sodium

Sodium (Na) is the most abundant element of the alkali metal group. Elemental sodium has an atomic weight of 22.99 and is a soft, bright silvery metal[4]. Pure metallic sodium is highly reactive and burns in air to form sodium oxide, which in turn readily hydrolyzes in water to form sodium hydroxide. Because elemental sodium is so highly reactive, it is not found freely in nature. Rather, sodium is found in nature only as the sodium ion ($Na+$) combined with a variety of anions to form a number of different salts. Common sodium salts are chloride, carbonate, hypochlorite, and silicate. Sodium ions are a normal and essential component of the human body, playing a key role in controlling and maintaining the proper osmolarity (concentration) and volume of extracellular body fluids[25]. Both the body content of sodium and its concentration in body fluids are under homeostatic control. In addition to its role in regulating osmolarity and extracellular fluid volume, sodium is important in the regulation of acid-base balance and the membrane potential of cells. Sodium ion is ubiquitous in water, owing to the high solubility of its salts and the abundance of sodium-containing mineral deposits. [5]Seawater contains about 30,000 mg of sodium chloride per liter (mg/L). Sodium chloride can also be found in many rivers and inland lakes and seas, in concentrations varying from 20 mg/L in the Mississippi River to 120,000 mg/L in the Great Salt Lake (Chemistry Explorer 2000). Groundwater typically contains higher concentrations of minerals and salts than surface waters, especially in areas with an abundance of sodium mineral deposits or in areas with sea or estuarine water intrusions .There are a number of anthropogenic sources of sodium that can contribute significant quantities of sodium to surface water, including road salt, water treatment chemicals, domestic water softeners, and sewage effluents. Water treatment chemicals such as sodium fluoride, sodium silicofluoride, sodium hydroxide, sodium carbonate, sodium bicarbonate, sodium phosphate, sodium silicate, and sodium hypochlorite provide a relatively small contribution when used individually, but when used together may result in concentrations of up to 30 mg/L .The addition of sodium compounds during water treatment for adjustment of pH and water softening are the uses most likely to increase the sodium content of drinking water. Sodium hydroxide, sodium carbonate, and sodium bicarbonate are used for pH adjustment and can contribute from 27 to 57 mg/L sodium to water at their approved maximum use levels . Domestic water softeners can increase sodium levels to more than 300 mg/L in drinking water .Salt that has been used to deice roads can also be a problem for drinking water systems. Salt mixed with ice dissolves and creates a brine with a lower freezing point than water, effectively melting ice . Salt is a cheap and effective solution to ice-covered roads, but can become an environmental concern as runoff that affects local vegetation and soil quality, as well as groundwater and surface water supplies. In general, sodium salts are not acutely toxic because of the efficiency with which maturekidneys excrete sodium. However, acute toxicity and death have been reported in cases of very high sodium intake. Acute effects and death have been reported in cases of accidental overdoses of sodium chloride. Acute effects may include dryness of mucous membranes, violent inflammatory reaction and ulceration in the gastrointestinal tract, along with dehydration and congestion of internal organs, particularly the ménages and brain. Central nervous system disturbances such as convulsions, confusion, and coma may result, and generalized and pulmonary edema are possible. Death may occur from respiratory failure secondary to an acute encephalopathy[22]

1-5-8-2 Potassium

Potassium is an essential element in humans and is seldom, if ever, found in drinkingwater at levels that could be a concern for healthy humans. It occurs widely in the environment, including all natural waters. It can also occur in drinking-water as aconsequence of the use of potassium permanganate as an oxidant in water treatment[9]. In some countries, potassium chloride is being used in ion exchange for household water softening in place of, or mixed with, sodium chloride, so potassium ions would exchange with calcium and magnesium ions. Possible replacement or partial replacement of sodium salts with potassium salts for conditioning desalinated water has been suggested[7]. The latter seems to be an unlikely development at this stage, inview of the cost difference. Although concentrations of potassium normally found in drinking-water are generally low and do not pose health concerns, the high solubility of potassium chloride and its use in treatment devices such as water softeners can lead to significantly increased exposure. Adverse health effects due to potassium consumption from drinking-water areunlikely to occur in healthy individuals[29]. Potassium intoxication by ingestion is rare, because potassium is rapidly excreted in the absence of pre-existing kidney damage and because large single doses usually induce vomiting.

1-5-8-3 CALCIUM

Calcium is an element that a human body needs for numerous functions, such as building and maintaining the bones and teeth, blood clotting, transmitting of the nerve impulses and regulating heart's rhythm. Ninety nine percent of calcium in a human body is stored in bones and teeth. The remaining one percent is found in the blood and other tissues[4]. The body gets calcium bypulling it from the bones when blood levels of calcium drop toolow, usually when quite a long time passes since having takencalcium with meal[1]. Over 99% of total body calcium is found in bones and teeth, where it functions as a key structural element. The remaining body calcium functions in metabolism, serving as a signal for vital physiological processes, including vascular contraction, blood clotting, muscle contraction and nerve transmission[11].Inadequate intakes of calcium have been associated with increased risks of osteoporosis, nephrolithiasis (kidney stones), colorectal cancer, hypertension and stroke, coronary artery disease, insulin resistance and obesity. Most of these disorders have treatments but no cures. Owing to a lack of compelling evidence for the role of calcium as a single contributory element in relation to these diseases, estimates of calcium requirement have been made on the basis of bone health outcomes, with the goal of optimizing bone mineral density. Calcium is unique among nutrients, in that the body's reserve is also functional: increasingbone mass is linearly related to reduction in fracture risk[23].

1-5-8-Magnesium

Water calcium and magnesium result from decomposition of calcium and magnesium aluminosilicates and, at higher concentrations, from dissolution of limestone, magnesium limestone, magnesite, gypsum and other minerals[5]. Anthropogenenic contamination of drinking water sources with calcium and magnesium is not common but drinking water may be intentionally supplemented with these elements while treated, as happens with deacidification of underground waters by means of calcium hydroxide or filtration through different compounds counteracting acidity such as $CaCO_3$, $MgCO_3$ and MgO, and possibly also with stabilization of low-mineralized waters by addition of CaO and CO_2[7].In low- and medium-mineralized underground and surface waters (as drinking waters are), calcium and magnesium are mainly present as simple ions Ca^{2+} and Mg^{2+} , the Ca levels varying from tens to hundreds of mg/l and the Mg concentrations varying from units to tens of mg/l. Magnesium is usually less abundant in waters than calcium, which is easy to understand since magnesium is found in the Earth's crust in much lower amounts as compared with calcium. In common underground and surface waters the weight concentration of Ca is usually several times higher compared to that of Mg, the Ca to Mg ratio reaching up to 10[2].Nevertheless, acommon Ca to Mg ratio is about 4, which corresponds to a substance ratio of 2.4 (Magnesium is the fourth most abundant cation in the body and the second most abundant cation in intracellular fluid. It is a cofactor for some 350 cellular enzymes, many of which are involved in energy metabolism. It is also involved in protein and nucleic acid synthesis and is needed for normal vascular tone and insulin sensitivity. Low magnesium status has been implicated in hypertension, coronary heart disease, and metabolic syndrome[26].

1-6-Heavy Metals

1-6-1-Iron:

Water containing iron does not show deleterious effect on human health,its presence in drinking water is objectionable for various reasons. Excessive iron content makes the water turbid, discoloured and imparts an astringent taste to water[24]. As per the standards set by BIS, the permissible level of iron is 0.3 mg L-1. Above 1.00 mg L-1 of iron in drinking water is not considered to be suitable for drinking purposes.U.S. Federal regulations limit the amount of iron to less than 0.3 ppm (0.3 mg/L) in municipal drinking water[16]. Although iron is only toxic at very high concentrations, it acts as a useful surrogate for other heavy metals, whose presence in drinking water is a real danger to public health.Iron($Fe^{+2,+3}$) in ground water provides the typical well water "rust" taste. Not only is the taste unpleasant, iron can also stain plumbing fixtures, clothes and dishes[42]. Most ground water has at least trace amounts of iron because its presence in nature is so common. Iron is generally derived from minerals contained within the underlying bedrock. Limestone, shale, and coal which often contain the iron-rich mineral pyrite, are large contributors of iron[37]. Like calcium and magnesium, acidic rainwater releases iron ions into solution, [43].

Treatment for the reduction of iron can be done by several methods depending upon the concentration and the pH of the water. Initially a water softener can be used to eliminate iron to tolerable levels.Secondly, potassium permanganate or "green sand" filters are highly successful. Finally, aeration, the addition of oxygen to the water, can aid in the precipitation of iron, thus removing it from the water. [44].

1-6-2-Manganese

Manganese is one of the most abundant metals in Earth’s crust, usually occurring with iron. It is a component of over 100 minerals but is not found naturally in its pure (elemental) form . Manganese is an element essential to the proper functioning of both humans and animals, as it is required for the functioning of many cellular enzymes[94]. resulting in encrustation problems. At concentrations as low as 0.02 mg/l, manganese can form coatings on water pipes that may later slough off as a black precipitate. A number of countries have set standards for manganese of 0.05 mg/l, above which problems with discoloration may occur. Manganese is used principally in the manufacture of iron and steel alloys and manganese compounds and as an ingredient in various products. Manganese dioxide and other manganese compounds are used in products such as batteries, glass and fireworks. Potassium permanganate is used as an oxidant for cleaning, bleaching and disinfection purposes. Manganese compounds may be present in the atmosphere as suspended particulates resulting from industrial emissions, soil erosion, volcanic emissions and the burning of MMT-containing petrol. Anaerobic groundwater often contains elevated levels of dissolved manganese[91]. The divalent form (Mn2+) predominates in most water at pH 4–7, but more highly oxidized forms may occur at higher pH values or result from microbial oxidation . It should be noted that the presence of manganese in drinking-water will be objectionable to consumers if the manganese is deposited in water mains and causes water discoloration. Concentrations below 0.05 mg/l are usually acceptable to consumers, although this may vary with local circumstances[25]

1-6-3-Chromium

Chromium a d-block transition metal of periodic group VLB has the ground state electronic configuration [Ar] 18; $3d^5$. $4s^1$. Chromium is present in all soils and in all plants. It is a trace constituent of most plants and is present at concentration of only 3 to 100 ppm[92] . It is a non –essential trace metal. No plant or animal disease due to lack of chromium have been reported. Chromium salt in very small concentrations have been found toxic to plant growth, and chromium in the forms of chromate is particularly toxic .The action of toxicity depends on its oxidation state. The hexavalent from is more toxic than trivalent chromium form. This toxicity becomes important as the acidity of the soil increases. This toxic action can be avoided by supplying limestone and more basic calcium phosphate amendments to soil[93]. Attempts use the spent liquors resulting from chrome tanning of leather showed these products to be very toxic, but when applied to high lime soils the toxic effect was largely nullified . Agriculturally, Chromium must be considered a deleterious element. The chief exposure to hazardous chromium substances is acid soluble, water insoluble chromate-chromite mixture. Chromos and chromic salts provide little industrial hazard. The physiological responses to chromium and its compounds are wide and varied, because, associated with each of the three chromium .Valences +2, +3 and +6 are different toxicological potential. Toxicity varies according to solubility, CrO_3 highly corrosive and toxic, Cr^{+2} ,Cr^{+3} salts are ascribed a far lower order of toxicity. Allergic contact dermatitis, skin ulcer, nasal membrane inflammation and ulceration, nosebleed, liver damage, edema, erosion and discoloration of the teeth. All these effects have been associated with hexavalent chromium forms except lung cancer; in which evidence suggest the trivalent chromium[92] .

Uses of chromium chemical[80]

(i) Tanning agent: basic chromium (111) sulfate.

(ii) Dye- metalizing agent: chromium (111) in solution .

(iii) Pigments: Cr_2O_3 (chrome oxide green).

(iv)Catalysts: Cr_2O_3 with other oxides e.g. AI_2O_3 (dehydrogenation)

(v)Corrosion inhibitors: soluble chromates $BaCrO_4,$ $Li_2\,Cr_2\,O_7$

(vi) Fungicide: $4CuO. CrO_3.XH_2O$

(vii)Wood preservation: soluble chromate

(viii) Metal anodizing agent: CrO_3

Important uses of pure chromium are for plating and for alloying with iron to from stainless steels. Chromate and dichromate also have many applications in electric cells, explosive, matches and rubber goods. In medicine, gamma active radioisotope chromium is used clinically to label erythrocytes in hematological studies . Chromium is not well absorbed in intestinal tract, chromium (VI) is absorbed better than the biologically active Cr^{3+}.

It is transported by the blood protein and excreted in urine and feces. Bones liver and spleen have a high affinity for chromium while the affinity of muscle and brain is low. Chromium (111) coordinates with proteins. High concentration of chromium has been found in beef liver RNA. The final biological effective form of chromium is produced as a result of sequence of reactions of chromium (111) with ligands present in the biological system.

1-6-4-Lead

Lead is used in the production of lead acid batteries, solder, alloys, cable sheathing, pigments, rust inhibitors, ammunition, glazes and plastic stabilizers (*82*). Tetraethyl and tetramethyl lead are important because of their extensive use as antiknock compounds in petrol. Lead is present in tap water to some extent as a result of its dissolution from natural sources, but primarily from household plumbing systems in which the pipes, solder, fittings or service connections to homes contain lead. Polyvinyl chloride (PVC) pipes also contain lead compounds that can be leached from them and result in high lead concentrations in drinking-water. The amount of lead dissolved from the plumbing system depends on several factors, including the presence of chloride and dissolved oxygen, pH, temperature, water softness and standing time of the water, soft, acidic water being the most plumbosolvent (*82*). Although lead can be leached from lead piping indefinitely, it appears that the leaching of lead from soldered joints and brass taps decreases with time (*24*). Soldered connections in recently built homes fitted with copper piping can release enough lead (210–390 μg/l) to cause intoxication in children (*13*). The level of lead in drinking-water may be reduced by corrosion control measures such as the addition of lime and the adjustment of the pH in the distribution system from <7 to 8–9 (*15*). Lead can also be released from flaking lead carbonate deposits on lead pipe and from iron sediment from old galvanized plumbing that has accumulated lead from lead sources such as plumbing and service connections, even when the water is no longer plumbosolvent. Lead reaches humans from natural as well as anthropogenic sources, e.g., drinking water, soils, industrial emission, car exhaust, contaminated food and beverages, etc Lead can be absorbed through the digestive tract, the lungs and the skin. It accumulates in the body and can cause lead poisoning. Even at low concentrations, when there are no outward symptoms, lead can damage the brain, kidneys, nervous system and red blood cells. Some effects of lead poisoning

may diminish if the source of exposure is removed,but some damage is permanent. Symptoms of lead poisoning include tiredness, a short attention span, restlessness, poor appetite, constipation, headaches, sudden behavior change, vomiting and hearing loss. Adults with lead poisoning may be irritable and disoriented.

1-6-5-Cadmium:

Cadmium is a rare natural element which is widely distributed in the earth’s crust in very small amounts. In its pure form, cadmium is a soft, bluish-white metal, but cadmium always exists in nature combined with other chemical elements (for example sulfur and zinc) in a range of chemical compounds.

Cadmium is mainly obtained as a by-product from the processing of the ores of other metals (e.g. zinc and copper) which contain cadmium in very small amounts as an impurity. World-wide production of cadmium is therefore quite small, but cadmium metal and cadmium compounds have many uses. Cadmium metal is used mainly as an anticorrosive, electroplated onto steel. Cadmium sulfide and selenide are commonly used as pigments in plastics[101]. Cadmium compounds are used in electric batteries, electronic components and nuclear reactors. No cadmium is added at sewage treatment works as part of the treatment process. Any cadmium in sewage is there because it has somehow entered the sewerage system via drains in homes, or business premises, or from drains in the streets and roads. Because cadmium occurs naturally in all water sources, minute quantities are present in drinking water; so anybody using water for drinking, cooking, washing, bathing or going to the toilet, flushes water containing tiny amounts of cadmium into the sewer[97]. cadmium is always present in zinc metal as an impurity; so corrosion of zinc galvanised tanks used in water systems will also add trace amounts of cadmium to the water supply. Although the natural level of cadmium in drinking water is very low, when this is multiplied by the huge quantities of water used in peoples' homes every year, the total weight of cadmium discharged into sewers that originates from drinking water is significant (over 30% of the total).There is also a relatively high contribution of cadmium from domestic activities (around 30% of the total)[100]. Over 90% of the cadmium from domestic activities comes from faeces, because all of the food contains natural amounts of cadmium. Where zinc galvanised fittings areused in water systems this may result in additional cadmium in entering sewage (around 4.5% of cadmium from domestic activities), because cadmium is an impurity in all zinc products and will leach out as the zinc corrodes.

Industrial activities such as electroplating and textile dyeing and printing make a smaller contribution (approximately 15% of the total). Recycling operations, especially for the recovery of batteries, may also result in small amounts of cadmium entering the drains. Run-off from roads and pavements also makes a small but significant contribution (around 13%). This is mainly explained by the use of cadmium in vehicle tyres and fall-out from burning vehicle fuels and coal.Fertilizers produced from phosphateores constitute a major source of diffuse cadmium pollution. [85] Levels of cadmium could be higher in areas supplied with soft water of low pH, as this would tend to be more corrosive in plumbing systems containing cadmium.The solubility of cadmium in water is influenced to a large degree by its acidity; suspended or sediment-bound cadmium may dissolve when there is an increase in acidity[48] . In natural waters, cadmium is found mainly in bottom sediments and suspended particles.

It was estimated that a daily intake of 100 µg of cadmium per person would lead to the critical cadmium concentration in the renal cortex being exceeded in 2% of the population . More severe cadmium damage may also involve the glomeruli, detected by increased inulin clearance. Other possible effects include aminoaciduria, glucosuria and phosphaturia. Disturbances in renal handling of phosphorus and calcium may cause resorption of minerals from bone, which can result in the development of kidney stones and osteomalacia.MMany cases of itai-itai disease (osteomalacia with various grades of osteoporosis accompanied by severe renal tubular disease) and low-molecular-weight proteinuria have been reported among people living in contaminated areas in Japan and exposed to cadmium via food and drinking-water. The daily intake of cadmium in the most heavily contaminated areas amounted to 600–2000 µg/day; in other less heavily contaminated areas, daily intakes of 100–390 µg/day have been found (WHO, 1992). A relationship between chronic occupational exposure to cadmium or chronic oral exposure to cadmium via the diet in contaminated areas and hypertension could not be demonstrated. Cadmium replace zinc biochemically in the body and causes high blood pressure.[46].

1-6-6-Mercury

Naturally occurring mercury has been widely distributed by natural processes such as volcanic activity[103]. The use of mercury in industrial processes significantly increased following the industrial revolution of the 19th century. Mercury is or has been used for the cathode in the electrolytic production of chlorine and caustic soda, in electrical appliances, in industrial and control instruments . in laboratory apparatus and as a raw material for various mercury compounds. The latter are used as fungicides, antiseptics, preservatives, pharmaceuticals, electrodes and reagents. However, mercury's industrial uses are decreasing because of environmental concerns and environmental legislation in many countries. Mercury has also been widely used in dental amalgams. A less well characterized use is in ethnic and folk remedies, some of which can give rise to significant exposure of individuals. The solubility of mercury compounds in water varies: elemental mercury vapour is insoluble, mercury(II) chloride is readily soluble, mercury(I) chloride is much less soluble and mercury sulfide has a very low solubility. Methylation of inorganic mercury is an important process in water and occurs in both fresh water and seawater. Bacteria (*Pseudomonas* spp.) isolated from mucous material on the surface of fish and soil were able to methylate mercury under aerobic conditions. Some anaerobic bacteria that possess methane synthetase are also capable of mercury methylation . Once methylmercury1 is released from microbes, it enters the food-chain as a consequence of rapid diffusion and tight binding to proteins in aquatic biota. The enzymology of $CH3Hg+$ hydrolysis and mercury(II) ion reduction is now understood in some detail. Environmental levels of methylmercury depend on the balance between bacterial methylation and demethylation. Levels of mercury in rainwater are in the range 5–100 ng/litre, but mean levels as low as 1 ng/litre have been reported. Naturally occurring levels of mercury in groundwater and surface water are less than 0.5 µg/litre, although local mineral deposits may produce higher levels in groundwater. A small number of groundwaters[103]. and shallow wells surveyed in

the USA were shown to have mercury levels that exceeded the maximum contaminant level of 2 µg/litre set by the US Environmental Protection Agency for drinking-water. An increase in the mercury concentration up to 5.5 µg/litre was reported for wells in IzuOshima Island (Japan), where volcanic activity is frequent . The concentration range for mercury in drinking-water is the same as in rain, with an average of about 25 ng/litre. Mercury will cause severe disruption of any tissue with which it comes into contact insufficient concentration, but the two main effects of mercury poisoning are neurological and renal disturbances. The former is characteristic of poisoning by methyl- and ethylmercury(II) salts, in which liver and renal damage are of relativelylittle significance, the latter of poisoning by inorganic mercury.In general, however, the ingestion of acute toxic doses of any form of mercury will result in the same terminal signs and symptoms, namely shock, cardiovascular collapse, acute renal failure and severe gastrointestinal damage[3]. Acute oral poisoning
results primarily in haemorrhagic gastritis and colitis; the ultimate damage is to the kidney. Clinical symptoms of acute intoxication include pharyngitis, dysphagia, abdominal pain, nausea and vomiting, bloody diarrhoea and shock. Later, swelling of the salivary glands, stomatitis, loosening of the teeth, nephritis, anuria and hepatitis occur.[42]

1-6-7-Arsenic

Arsenic occurs naturally in the earth's crust. Most arsenic in drinking water comes from natural rock formations. As water flows through these formations, it can dissolve arsenic and carry it into underground aquifers, streams, or rivers that may become drinking water supplies. Arsenicals are used commercially and industrially as alloying agents in the manufacture of transistors, lasers and semiconductors, as well as in the processing of glass, pigments, textiles, paper, metal adhesives, wood preservatives and ammunition[27]. They are also used in the hide tanning process and, to a limited extent, as pesticides, feed additives and pharmaceuticals.. In the past, it was used in commercial wood preservatives and agricultural chemicals. In well oxygenated surface waters, arsenic (V) is generally the most common arsenic species present ,under reducing conditions, such as those often found in deep lake sediments or groundwater, the predominant form is arsenic(III) . An increase in pH may increase the concentration of dissolved arsenic in water Arsenic exists in oxidation states of −3, 0, 3 and 5. It is widely distributed throughout Earth's crust, most often as arsenic sulfide or as metal arsenates and arsenides. In water, it is most likely to be present as arsenate, with an oxidation state of 5, if the water is oxygenated. However, under reducing conditions (<200 mV), it is more likely to be present as arsenite, with an oxidation state of 3[39]. The level of arsenic in natural waters, including open ocean seawater, generally ranges between 1 and 2 µg/l .Concentrations may be elevated, however, in areas with volcanic rock and sulfide mineral deposits; in areas containing natural sources, where levels as high as 12 mg/l have been reported; near anthropogenic sources, such as mining and agrochemical manufacture; and in geothermal waters (mean 500 µg/l, maximum 25 mg/l) arsenic concentrations in sediment range from 5 to 3000 mg/kg; the higher levels occur in areas of contamination (USNRC, 1999) but are generally unrelated to arsenic concentrations in water. Long-term exposure to arsenic in drinking water is known to increase risks of skin, bladder, lung, liver, colon, and kidney cancer. Other health effects may include blood vessel damage, high blood pressure, nerve damage, anemia, stomach upsets, diabetes, and skin changes.Very high exposure to arsenic can cause noticeable changes to skin and nails. Arsenic exposure can cause a certain pattern of skin changes that resemble warts, called "hyperkeratosis." Fingernails may show ridges and yellowing. Dark or light spots may also appear. Consult your physician if you have any health problems that you think may be caused by arsenic exposure[24].

1-6-8-Cobalt

Cobalt is a hard silver-grey metal of the first transition series of Group 9 of the periodic table[99]. It is a relatively rare element of the earth's crust with concentration approximately 25 µg/g .

Cobalt is essential in trace amounts for humans and other mammals as it is an integral component of the vitamin B12 complex[66]. Although, metallic cobalt is insoluble in water, the solubility of cobalt salts is highly variable and depends on its form. Most cobalt resources are present in nickel-bearing laterite deposits, with the remainder occurring primarily in nickel-copper sulfide deposits present in mafic and ultramafic rocks and in sedimentary copper deposits. Currently, the major use for cobalt is in some types of steel, and in several types of alloys. Cobalt is used in magnets to increase the saturation of magnetization of iron. It is also used as a pigment in glass, ceramics, and paints, as paint drier, as a catalyst for the petroleum industry, and in batteries. Many fertilizers are enriched with cobalt, generally in the range of 1 mg/kg to 12 mg/kg in order to amend agricultural soils that are cobalt-deficient. Natural sources of cobalt to the environment include volcanic eruptions, seawater spray and forest fires. Anthropogenic sources of cobalt to the atmosphere include coal-fired power plants and incinerators, and exhaust from vehicles. Cobalt mining and processing activities, the production of alloys and chemicalscontaining cobalt, sewage effluents, urban run-off, and agricultural run-off are major anthropogenic
Cobalt is essential in trace amounts for human life. It is part of vitamin B-12, and plays a key role in the body's synthesis of this essential vitamin. Cobalt has also been used as a treatment for anemia, because it causes red blood cells to be produced. The toxicity of cobalt is quite low compared to many other metals in soil.Exposure to very high levels of cobalt can cause health effects. Effects on the lungs,including asthma,pneumonia, and wheezing.[52]

1-6-9-Copper

Metallic copper is malleable, ductile and a good thermal and electrical conductor. It has many commercial uses because of its versatility. Copper is used to make electrical wiring, pipes, valves, fittings, coins, cooking utensils and building materials. It is present in munitions, alloys (brass, bronze) and coatings. Copper compounds are used as or in fungicides, algicides, insecticides and wood preservatives and in electroplating, azo dye manufacture, engraving, lithography, petroleum refining and pyrotechnics. Copper compounds can be added to fertilizers and animal feeds as a nutrient to support plant and animal growth . Copper compounds are also used as food additives (e.g., nutrient and/orcoloring agent) . Copper sulfate pentahydrate is sometimes added to surface water for the control of algae (NSF, 2000). Copper sulfate was once prescribed as an emetic, but this use has been discontinued owing to adverse healtheffects. The fate of elemental copper in water is complex and influenced by pH, dissolved oxygen and the presence of oxidizing agents and chelating compounds or ions . Surface oxidation of copper produces copper(I) oxide or hydroxide. In most instances, copper(I) ion is subsequently oxidized to copper(II) ion. However,copper(I) ammonium and copper(I) chloride complexes, when they form, are stable in aqueous solution. In pure water, the copper(II) ion is the more common oxidation state (US EPA, 1995) and will form complexes with hydroxide and carbonate ions. The formation of insoluble malachite [Cu2(OH)2CO3] is a major factor in controlling the level of free copper(II) ion in aqueous solution. Copper(II) ion is the major species in water up to pH 6; at pH 6–9.3, aqueous CuCO3 is prevalent; and at pH 9.3–10.7, the aqueous [Cu(CO3)2]2- ion predominates. Copper discharged to wastewater is concentrated in sludge during treatment. Various studies of leaching from sludge indicate that the copper is not mobile (ATSDR, 2002). Free copper ionsare chelated by humic acids and polyvalent organic anions Copper concentrations in drinking-water vary widely as a result of variations in water characteristics, such as pH, hardness and copper availability in the distribution system.. Copper concentrations in drinking-water often increase during distribution, especially in systems with an acid pH or high-carbonate waters with an alkaline pH (US EPA,1995). At lower doses, copper ions can cause symptoms typical of food poisoning (headache, nausea, vomiting, diarrhoea). Records from case-study reports of gastrointestinal illness induced by copper from contaminated water or beverages plus public health department reports for 68 incidents indicate an acute onset of symptoms. Symptoms generally appear after 15–60 min of exposure; nausea and vomiting are more common than diarrhea.

1-7-Nitrogen:

Nitrogen typically is present in ground water in three forms: Ammonia (NH_3), nitrate (NO_3^{-1}), and nitrite (NO_2^{-1}). Of the three, nitrite is the most toxic, yet usually occurs in the lowest concentration [47].

Most nitrogen compounds found in the ground water are partially derived from the atmosphere. Specific plants can "fix" nitrogen from the atmosphere onto their roots. Nitrogen not used by the plant is released into the soil. In the soil, a free reaction with water, minerals, and bacteria takes place. Secondary sources of nitrogen compounds include fertilizers, manure and urine from feedlots and pastures, sewage, and landfills.

1-7-1-Nitrates:

.

Nitrates are naturally occurring. All rainfall and groundwater aquifers contain some nitrate-nitrogen. However, contaminated rural water supplies provide a clue for discovering other nitrate sources. Nitrates in drinking water as such are not toxic to health and about 85% of ingested nitrates are rapidly adsorbed from gastrointestinal tract in normal healthy individuals and adsorbed nitrates are excreted by the kidneys. But, if the nitrates are converted into nitrites which occur commonly, then toxic effects are encountered and may cause potential health hazardsNitrate accumulates in agricultural watersheds where farmers spread inorganic fertilizers and animal manures on cropland. Nitrogen not taken up by crops can leach through the soil to groundwater and then flow to recharge areas or private wells. Residents in rural communities typically use on-lot septic systems and some homeowners rely on lawn fertilizers. These too can be sources of nitrate in drinking water.High levels due to fertilizer run-off and/or nitrification. Nitrate can be the "limiting nutrient" for algal growth, especially in saline and brackish water [47]. Decomposed organic matter (from sewage) or agricultural (from fertilizer) drainage may join water sources and result an excessive nitrates . Nitrates are especially toxic to children less than six months of age, children who ingest nitrate may not have developed an immune system that can ward off the compound. The condition Known as "blue-baby syndrome" may occur A variety of methods can be employed to remove nitrogen compounds from water. An R/O system with a water softener can remove as much as 95% of nitrate and nitrite contamination; however, ammonia may pass through. A negative ion-exchange method may also be used. This method is similar to the softening process and is also very effective in reducing nitrates and nitrites. Finally, if the origin is known, elimination of the source of nitrogen contamination may be the best corrective measure [47].

1-8-**Sulfur:**

Sulfur appears in two species, that of sulfate (SO_4^{-2}) and sulfide. Sulfide is generally in the form of dissolved hydrogen sulfide gas (H_2S). Sulfides originate from areas such as marshes, oil wells, mines, and manure pits. Sulfates are principally derived from the dissolving of minerals such as gypsum ($CaSO_4.2H_2O$) and anhydrite ($CaSO_4$). Secondary sources of sulfates are from the weathering of pyrite and the dissolving of ammonium sulfate fertilizers. Hydrogen sulfide gives the characteristic rotten egg smell that many people associate with sulfur. Sulfides can cause corrosion to plumbing, darken water, and create a foul odor and taste. Sulfates, Sulfates are discharged into water from mines and smelters and from kraft pulp and paper mills, textile mills and tanneries. Sodium, potassium and magnesium sulfates are all highly soluble in water, whereas calcium and barium sulfates and many heavy metal sulfates are less soluble. Atmospheric sulfur dioxide, formed by the combustion of fossil fuels and in metallurgical roasting processes, may contribute to the sulfate content of surface waters. Sulfur trioxide, produced by the photolytic or catalytic oxidation of sulfur dioxide, combines with water vapour to form dilute sulfuric acid, which falls as "acid rain". The mean sulfate level in municipal drinking-water supplies may be increased by treatment. Sulfate (SO4) may cause water to have a bitter taste. In addition, it may have a laxative effect on humans, especially if they are not accustomed to drinking water containing sulfate. For this reason, the U.S. Environmental Protection Agency (EPA) has established a secondary drinking water standard or *secondary maximum contaminant level* (SMCL) of 250 milligrams per liter (mg/L) for sulfate. High sulfate levels in water are of particular concern with infants, who may suffer from dehydration due to diarrhea. Young livestock may also be at risk. With time, most humans and livestock will become acclimated to sulfate and any associated symptoms will disappear. Like other minerals present in household water, sulfate may cause scale accumulation in or on plumbing fixtures. If present in a water supply system, bacteria that feed on sulfur can produce a dark slime, which can stain clothing and clog plumbing[48].

Treatment for the removal of sulfur in water can be done through many methods. Aeration is very effective in removing H_2S gas. Chlorination may be used to eliminate bacteria and the gas Removal of sulfates may be conducted by an R/O system or a negative ion-exchanger [49].

Sulfide in the environment[50]:

Sulfide is often present in water and wastewater and sewage as a result of microbial action on organic matter under aerobic conditions and from certain industrial wastes. Scheele (1777). The gas is a colorless, but at even 0.03ppm level identified hydrogen sulfide gas (H2S) evolved by the action of acid on metal sulfide, has an offensive odour.It occurs naturally in most petroleum and matural gas deposits and is present in volcanic gases, where it is produced by the action of steam on sulfide at high temperature. It is also found in sulfur spring from the same source. Hydrogen sulfide is found wherever there are sulfur-containing deposits especially those formed under aerobic conditions in nature Hydrogen sulfide can also be formed by bacterial reduction of sulfate, which accounts for occurrence of the gas in the hydrosphere. Sulfur oxidation occurring in soils is thought to be biochemical in nature. A number of autotrophie bacteria including those of the genus Thiobacillus. Accomplish it sulfites tend to be unstable in anaerobic environments. They are reduced to sulfide by a number of bacteria of two; Genera, Desulfovibro and d Desulfotomaculum

The organisms use the combined oxygen in sulfate to oxidize organic material a representative reaction is

$R_2\text{-}CH_2OH \quad + \quad SO_4\text{-}^{2nnn} \rightarrow 2R\text{-}COOH+2H_20+S^{-2}$

Organic alcohol Sulfate organic acid sulfide

Sulfur reductions take place, with compounds other sulfates e.g:-

Sulfites (SO_3^{-2}) thiosulfates (S_2O3^{-2}) and elemental sulfur (S) and these are rather easily reduced to the sulfide form by bacteria and other organism. [50].

Health effects:-

Hydrogen sulfide is very toxic and has killed numerous workers in sewage (Kumar, 1987) it is a highly toxic material with strong water irritating to eyes, nose and lung, darkens exterior of paints, corrodes and tarnish metals levels of poisoning from hydrogen sulfide are classified as acute poisoning sub-acute poisoning and chronic poisoning on decreasing order. Acute poisoning occurs after exposure to the highest concentration of the gas and is characterized by rapid onset of systematic effects mainly affecting the nervous system, concentration above 250ppm may be fatal to human beings, even after a quite short time of exposure. Concentration of a bout 500ppm can lead to death in less than one hour, and concentration of 2000ppm and above cause death almost instantaneously . Sub-acute hydrogen sulfide poisoning is characterized by irritating effects of gas and the mucus membrane of eyes and respiratory tracts these effects can appear after prolonged exposure to concentrations as low as 50ppm. Chronic hydrogen sulfide poisoning is described as those conditions with less defined symptoms resulting from prolonged exposure to levels at a bout 20ppm.

1-9-Waste effluents treatment processes:-

These are divided into two:-

In plant measure for specific types of effluents in particular plants and measures for the effluents as a whole. The aim of in-plant measure is to reduce the quantity of effluent and remove, partially or completely. Constituents, with may prove troublesome at a later stage "Sulfide, chromium (iii) salts" these methods included reducing the water consumption "shorter floats, shorter rinsing of washing processes, reuse of the rinsing or washing floats to make up tanning baths, receding of, for example liming pickle and chrome, tanning floats. Chrome tanning with products with particularly good exhaustion working in tanning machines instead of the drum. There are various, relatively simple ways of removing sulfide from the alkaline liming liquors before they are mixed with the rest of the effluent. A simple method from the technical point of view is catalytic oxidation with air in the presence of approximately 200g/m3 Manganese (ii) sulfate as a catalyst. The oxidation of the sulfide with air can also be carried out after all the effluents have been mixed, but then the volumes to be aerated are considerably larger. Another means of removing sulfide is filtering off long with other constituents precipitated at the same time and suspended solids the black filtered cake must be deposited on special drums. [50].

1-10-Bacteriological characteristics of water:

It concern with diseases caused by pathogenic microorganisms, like viruses, bacteria, protozoa and helminthes worms , which remain in the intestines of sick human beins and when discharged through faucal/oral route , contaminate water sources. [51].

Microorganisms, more specifically bacteria, can be found virtually in any water sample. Bacteria thrive in environments which contain iron, nitrogen, or sulfur compounds. Sources of these compounds may be derived from sewage, animal manure, and leaky septic systems. Well water serves as excellent living environments for bacteria. For example, iron-rich water encourages growth of iron bacteria. Proliferation of the bacteria can be so rapid that clogging of pipes may occur due to the formation of bacterial mounds. Dark brown slimy masses within toilet holding tanks health hazards exist for the presence of iron in water, however, a high concentration of iron bacteria may cause health risks. [52]

Wells high in nitrate (>10 mg/L) and sulfate levels should be bacteriologically tested. Bacteria can convert nitrate in water to the more dangerous nitrite. Water rich in sulfur could contain bacteria which may convert sulfate ions to potentially toxic sulfide ions. [53].

1-10-1-Microbiological contaminants found in ground water:

The most important one is coliform bacteria that occur naturally in the environment from soil and plants and in the intestines of humans and other warm-blooded animals, used as an indicator for the presence of pathogenic bacteria ,viruses, and parasites from domestic sewage, animal waste, or plant or soil material.[54]

If it is determined that excessive amounts of bacteria are present in well water, few corrections exist. Probably the least expensive method is that of chlorination. Chlorination is highly effective in destroying pathogenic (disease causing) organisms other more expensive methods include ultraviolet light radiation and physical filtration [55].

1-10-2-Bacteriological water analysis is a method of analysing water to estimate the numbers of bacteria present and, if needed, to find out what sort of bacteria they are. It is a microbiologicalanalytical procedure which uses samples of water and from these samples determines the concentration of bacteria. It is then possible to draw inferences about the suitability of the water for use from these concentrations. This process is used, for example, to routinely confirm that water is safe for human consumption or that bathing and recreational waters are safe to use. The interpretation and the action trigger levels for different waters vary depending on the use made of the water. Very stringent levels applying to drinking water whilst more relaxed levels apply to marine bathing waters where much lower volumes of water are expected to be ingested by users.[53]

The common feature of all these routine screening procedures is that the primary analysis is for indicator organisms rather than the pathogens that might cause concern. Indicator organisms are bacteria such as non-specific coliforms, *Escherichia coli* and *Pseudomonas aeruginosa* that are very commonly found in the human or animal gut and which, if detected, may suggest the presence of sewage. Indicator organisms are used because even when a person is infected with a more pathogenic bacteria, they will still be excreting many millions times more indicator organisms than pathogens. It is therefore reasonable to surmise that if indicator organism levels are low, then pathogen levels will be very much lower or absent. Judgements as to suitability of water for use are based on very extensive precedents and relate to the probability of any sample population of bacteria being able to be infective at a reasonable statistical level of confidence,[53].Analysis is usually performed using culture, biochemical and sometimes optical methods. When indicator organisms levels exceed pre-set triggers, specific analysis for pathogens may then be undertaken and these can be quickly detected (where suspected) using specific culture methods or molecular biology.[54].

1-10-2-1-Methodologies

Because the analysis is always based on a very small sample taken from a very large volume of water, all methods rely on statistical principles.[51].

1-10-2-1-1-Multiple tube method

One of the eldest methods is called the multiple tube method[1] Procedures. In this method a measured sub-sample (perhaps 10ml) is diluted with 100ml of sterile growth medium and an aliquot of 10ml is then decanted into each of ten tubes. The remaining 10ml is then diluted again and the process repeated. At the end of 5 dilutions this produces 50 tubes covering the dilution range of 1:10 through to 1: 10000. The tubes are then incubated at a pre-set temperature for a specified time and at the end of the process the number of tubes with growth in is counted for each dilution. Statistical tables are then used to derive the concentration of organisms in the original sample. This method can be enhanced by using indicator medium which changes colour when acid forming species are present and by including a tiny inverted tube in each sample tube. This inverted tube catches any gas produced. The production of gas at 37 Degrees Celsius is a strong indication of the presence of *Escherichia coli[*56*].*

1-10-2-1-2-ATP Testing

An ATP test is the process of rapidly measuring active microorganisms in water through detection of a molecule called Adenosine Triphosphate, or ATP.

ATP is a molecule found only in and around living cells, and as such it gives a direct measure of biological concentration and health. ATP is quantified by measuring the light produced through its reaction with the naturally-occurring firefly enzyme Luciferase using a Luminometer. The amount of light produced is directly proportional to the amount of biological energy present in the sample

2nd Generation ATP tests are specifically designed for water, wastewater and industrial applications where, for the most part, samples contain a variety of components that can interfere with the ATP assay,[57].

1-10-2-1-3-Plate count

The plate count method relies on bacteria growing a colony on a nutrient medium so that the colony becomes visible to the naked eye and the number of colonies on a plate can be counted. To be effective, the dilution of the original sample must be arranged so that on average between 30 and 300 colonies of the target bacterium are grown. Fewer than 30 colonies makes the interpretation statistically unsound whilst greater than 300 colonies often results in overlapping colonies and imprecision in the count. To ensure that an appropriate number of colonies will be generated several dilutions are normally cultured.

The laboratory procedure involves making serial dilutions of the sample (1:10, 1:100, 1:1000 etc.) in sterile water and cultivating these on nutrient agar in a dish that is sealed and incubated. Typical media include Plate count agar for a general count or MacConkey agar to count gram-negative bacteria such as *E. coli*. Typically one set of plates is incubated at 22°C and for 24 hours and a second set at 37°C for 24 hours. The composition of the nutrient usually includes reagents that resist the growth of non-target organisms and make the target organism easily identified, often by a colour change in the medium. Some recent methods include a fluorescent agent so that counting of the colonies can be automated. At the end of the incubation period the colonies are counted by eye, a procedure that takes a few moments and does not require a microscope as the colonies are typically a few millimetres across [58].

1-10-2-1-4-**Membrane filtration**

Most modern laboratories use a refinement of total plate count in which serial dilutions of the sample are vacuum filtered through purpose made membrane filters and these filters are themselves laid on nutrient medium within sealed plates. [2] (mE-EIA)The methodology is otherwise similar to conventional total plate counts. Membranes have a printed millimetre grid printed on and can be reliably count a much greater number of colonies under a binocular microscope. [58].

1-10-2-1-5-**Pour plates**

When the analysis is looking for bacterial species that grow poorly in air, the initial analysis is done by mixing serial dilutions of the sample in liquid nutrient agar which is then poured into bottles which are then sealed and laid on their sides to produce a sloping agar surface. Colonies that develop in the body of the medium can be counted by eye after incubation.

The total number of colonies is referred to as the Total Viable Count (TVC). The unit of measurement is cfu/ml (or colony forming units per millilitre) and relates to the original sample. Calculation of this is a multiple of the counted number of colonies multiplied by the dilution used. [58].

Pathogen analysis:

When samples show elevated levels of indicator bacteria, further analysis is often undertaken to look for specific pathogenic bacteria. Species commonly investigated in the temperate zone include *Salmonella typhi* and *Salmonella typhimurium* Depending on the likely source of contamination investigation may also extend to organisms such as *Cryptosporidium spp*. In tropical areas analysis of *Vibrio cholerae* is also routinely undertaken. [51].

1-10-2-2-Degradable organic matter:

high concentrations are due to wastewater discharges. The term can be expressed as COD or BOD: Chemical and Biochemical Oxygen Demand, and is thus related to the dissolved oxygen levels .

1-10-3-Survey of methods for determination of BOD and COD.: -

There are many analytical methods for organic matter detection in wastewater which can be classified into two general types of measurements, and these are biochemical oxygen demand (BOD) and chemical oxygen demand (COD) [59].

1-10-3-1-Biochemical oxygen demand (BOD):-

BOD determination test is an empirical test in which standardized laboratory Procedures were used to determine the relative oxygen Requirements of wastewater effluents and polluted water, the test has its widest application in measuring waste loading to treatment plants and in evaluating the BOD removal efficiency of such treatment systems[60].

The test measure the oxygen utilized during a specified incubation period for the biochemical degradation of organic material (carbonaceous demand) and the oxygen used to oxidize inorganic material such as sulfides and ferrous ion. It also measures the oxygen used to oxidize reduced form of nitrogen (nitrogenous demand) unless their oxidation was preventable by an inhibitor the seeding and dilution procedures provide and estimate of the BOD at pH 6.5 to 7 although only the 5-day BOD (BOD_5) was described here, many variation of oxygen demand measurements exist. [60].

These include using shorter and longer incubation periods, tests to determine rates of oxygen uptake, and continue oxygen uptake measurement by respirometeric techniques. Alternative seeding, diffusion and incubation conditions. The environmental effects of waster and effluents, [60].

1-10-3-2-Carbonaceous versus Nitrogenous BOD:-

A number of factors, for example, soluble versus particulate organic settleable and floatable solids, oxidation of reduced iron and sulfur compounds, or lake of mixing may affect the accuracy and precision of BOD measurements. [61]. Presently, these are no way to include adjustments or corrections to account for the effect of these factors.Oxidation of reduced form of nitrogen, much as microorganisms can mediate ammonia and organic nitrogen, and exerts nitrogenous demand.

Nitrogenous demand historically has been considered interference in the determination of BOD. As clearly evidenced by the inclusion of ammonia in the dilution water.The interference from nitrogenous demand can now be prevented by an inhibitory chemical if an inhibiting chemical is not used, the oxygen demand measured is the sum of carbonaceous and nitrogenous demand. [61]Measurements that include nitrogenous demand generally are not useful for assessing the oxygen demand associated with organic material. Nitrogenous demand can be estimated directly from ammonia, nitrogen and carbonaceous, can be estimated by subtracting the theoretical Equivalent of the reduced nitrogen oxidation from uninhibited test results. However, this method is cumbersome and is subjected to considerable error. Chemical inhibition of nitrogenous demand provide a more direct and more reliable measure of carbonaceous demand. The extent of oxidation of nitrogenous compound during the 5-day incubation period depends on the presence of microorganism carrying out this oxidation.

Such organisms usually are not present in raw sewage or primary effluents in sufficient numbers to oxidize significant quantities of reduced nitrogen from in 5-day BOD test.

Many biological treatment plant effluents contain significant numbers of nitrifying organism to cause nitrification in BOD test. The BOD concentration in most water exceeds the concentration of dissolved oxygen (DO) available in an air saturated sample. It is necessary to dilute the sample before incubation to bring the oxygen demand and supply into appropriate balance.

Because bacterial growth requires nutrients such as nitrogen, phosphorous and trace elements, these are added to the pH of the dilution water which to be buffered to ensure that pH of the incubated sample remain in a range suitable for bacterial growth, the complete stabilization of sample requires a period of incubation too long for practical purpose, 5 days been accepted as the standard incubation period ,if the dilution was of poor quantity effectively it will appear as BOD sample. These effects will be amplified by the dilution factor. [62].

A positive bias will result. The following method contains both a dilution water check and dilution blank. Seeded dilution water is checked further for acceptable quality by measuring their consumption of oxygen from a known organic mixture. Usually glucose and glutomic acid.

The source of the dilution water is not stricted and may be distilled, tap or receiving stream water free of biodegradable organic and bio inhibitory substance such as chlorine or heavy metals. Distilled water may contain ammonia or volatile organic .Deionized water often are contaminated with soluble organic leached from the resigned.

Use of copper-lined stills or copper fittings attached to distilled water lines may produce water containing excessive amount of copper. [63].

1-10-3 3-Sample and Storage:-

As sample for BOD analysis may degrade significantly during storage between collection and analysis, resulting in low BOD values. Analyzing sample promptly does minimize the reduction of BOD or by cooling them to near freezing temperature during storage is kept. However, even at low temperature the holding time should be kept to the minimum. The chilled samples are warmed to 20 C before analysis [60].

1-10-4-Chemical Oxygen Demand COD:-

The COD is used as measure of oxygen equivalent of the organic matter content of sample that is susceptible to oxidation by a storage chemical oxidant, for a sample with a specific COD; this can be related empirically to BOD, organic carbon, or organic matter. Test useful for monitoring and control after correlation has been established, the dichromate reflux method is preferred over procedures using other oxidants because of superior oxidizing ability, applicability to a wide variety of samples and ease of manipulation [59].

Oxidation of most organic compounds is 95 to 100% of the theoretical value. Pyridine and related compounds resist oxidation and volatile organic compounds are oxidized only to the extent that they remain in contact with oxidant. Ammonia, present either in the waste or liberated from nitrogen containing organic matter is not oxidized in the absence of significant concentration of free chloride ions .

1-10-5-Interference and limitation:-

Volatile straight-chain aliphatic compounds are not oxidized to only appreciable extent. This failure occurs partly because volatizes organic are present in the vapor space and does not come in contact with the oxidizing agent. Straight-chain aliphatic compounds are oxidized more effectively when silver sulfate (Ag_2SO_4) is added as a catalyst. However, Ag_2SO_4 reacts with chlorine, bromide and iodide to produce precipitates that are oxidized only partially. The difficulties caused presence of the halides can be overcome largely, through not completely by complexion with mercuric sulfate ($HgSO_4$) before the refluxing procedures.

Although 1g of $HgSO_4$ is specified for 50 ml sample, lesser amount may be used where the sample chloride less than 2000 ml/l, as long as 10:1 ratio $HgSO_4$: CL is maintained the test is-not used for the sample containing more than 2000 mg Cl/L [59].

1-10-6-Sampling and Storage for COD:-

Preferable sample are collected in glass bottles. Unstable sample are to be tested without delay. If delay before analysis is unavoidable, sample are to be preserved by acidification to PH < 2 using concentrated sulfuric acid , (H_2SO_4), Samples containing settleable solid are blended, to reduce the error inherent in measuring small volumes [59].

1-11-Water pollution

That is, water from any source is likely to have impurities in some form or the other and there is no pure water, practically, anywhere .Trace elements are present in natural water; ground and surface and their sources are associated with either natural processes or man activities , most trace elements, especially heavy metals; do not exist in soluble forms for along time in water[64].

They are present mainly as suspended colloids or are fixed by organic and mineral substances.Thus, their concentrations in bottom sediments or in plankton are most often an adequate indication of water pollution of trace elements. Waste water discharge out from tanneries and leather tanning factories increase the concentration of heavy metals like chromium and it is possible to lead to contamination. Wastewater, which is discharged in cultivated area leads to accumulation of the heavy metals in the soil surface [65].

1-11-1-Ground water pollution:

Ground water pollution is either natural or non-made [66].

1-11-1-1-Natural pollution:

Natural water pollution is considered as changes in constituents and properties of water in the absence of the man activities. This type of natural pollution may be caused mineral deposits, salts seeps, and similar sources of exceptionally poor water quality. Excessive turbidity and suspended solids concentration may be considered as pollutant. Ground water is sometimes polluted naturally by encouragement of oceanic or coastal water or adjacent ground water which is highly mineralized.

1-11-1-2-Man-made pollutants:

Most of the water pollution is a direct result of man activities. The polluting substances produced by man activities can be outlined as follows[66]:

1-11-1-3-Municipal wastes:

Normal domestic and municipal activities result in the certain of wastes which may be broad by termed sewage. Thus includes wastes from commercial and industrial establishment, hospitals, and hotels in addition to other institutions.

1-11-2-Industrial wastes:

These types of wastes are extremely complex and variable chemicals; suspended matter, poisonous substances, radioactive materials, heads, color, tastes and odors[66].

1-11-3-Agricultural wastes:

Agricultural pollution is due to irrigation water or rain carrying away fertilizers, minerals salts, herbicides and pesticides . All natural waters contain a variety of contaminants arising from erosion leaching and weathering process. These contaminants behave in different ways in water[67].Non-conservative materials including most organics, some in organs 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 .

Ground water is normally effectively purified, as for as suspended matter is concerned, by the straining action of the reduction of rocks water percolated through it, soluble impurities are not readily removed [67].

Rain water collects dusts and gases from the atmosphere, similarly surface water during its movement on the surface of earth collects more of suspended dissolved and colloidal matters which may be organic or in nature.River contains more dissolved oxygen, underground water is in contact with soil formation and dissolves more minerals and salts .Suspended impurities are likely to be less in ground water as subsurface porous soil acts as a filter [66].

1-11-4-Soil contamination

Soil is a very specific component of the biosphere.Trace elements originating from various sources may finally reach the surface of the soil and ground water, especially the aqueous chromium, and their further fate depends on soil chemical and physical properties. [68].The persistence of contamination in soil is much longer than other components of the biosphere and contamination of soil, especially by heavy metals appears to be virtually permanent[66].

Metals accumulated in soils are depleted slowly by leaching, plant uptake, erosion, or deflation. have observed that long term use of sewage sludge increased the soil levels of Zn, Cu, Ni ,Cr, Pb, Cd, and Hg. Although higher doses of sewage sludge may probably be acceptable because of the relatively low availability of heavy metals to plants [69].

Soil contaminated with heavy metals can produce apparently normal crops that may be unsafe for human or animal consumption. Different soil type's, plant species ,and growing condition contribute to divergent influences of soil contamination on trace element status in plants.Loamy neutral soils may accumulate higher amount of trace elements with less environmental risk [69].

Kloke 1979 calculated that if the content of Cr in the soil is not higher than the threshold values it can be expected that the content of Cr in human diets will not exceed weekly tolerable intakes established by FAO/WHO.

To evaluate permissible levels of addition of chromium to the soil we must study the soil characteristics, e.g., pH, free carbonates, organic matter, clay contents and moisture, then we must calculate the initial amount of chromium content in soil and total addition amounts . It is important to know other factors like interaction of chromium with other elements and the sensitivity of plants to it[67].

Plants can accumulate trace elements, especially metals, in their tissues due to their great ability to adapt to variable chemical properties of the environment [68] .Thus plants are intermediate reservoirs through which trace elements from soils, and partly from water and air move to man and animal.

One of the basic environmental problems relates to the quantities of accumulated metals in plant parts used as food. Special attention also should be given to the forms of metals distributed organisms. There are many ways can protect ground water. The best way is to prevent contamination. This can be done by[66].:

a) Reducing the sources of contamination.

b) Laws should be passed to regulate toxic waste and other sources of ground water contamination.

c) Ensuring that suitable clay is placed between the waste and the soil.

Chapter two

Literature review

2-Literature review

2-1-Location and aerial extent

El Kamlien locality lies between longitudes 32 40-32 12 east and latitudes in 14-57-15 28 north. It surrounded by Khartoum locality in the north, Gezira north locality in the east, Hassahiesa locality in the south and the west.

The area of the locality is about 1899.4km [70]

2-1-1-Geneal to geography:

El Kamlein locality is generally flat, with slope from south to the north. It covered by Gezira cotton soil and by Gezira canals network. [70]

2-1-2-**Population**:

The population of kamlean locality is about 324,055, representing of Gezira state population. Kamlienlocality is considered the second locality in population density amounts for 171 person perkm^2. [70]

2-1-3-The Climate:

The climate is dry with a showed raining season from July to September. The rainfall is about 250 mlm per year.

The manual mean temperature is about 29 CA^0 with relative humidity range between 30-50% The mean wind speed at 2 meters, height range from 1.5 to 3m/sec^{-1} [70]

2-1-4-Plants of the area:

Plants structure of this part has changed as a result of the introducing of permanent irrigation, therefore plants of this area predominantly [70].

2-2-Background

There are many factories in AL Kamlin locality , the biggest two are EL Bagir factories and GIAD industrial complex.

GIAD industrial area has many factories such as ; Aluminum , Paints, pipes ,stainless steel ,cables ,electrical wires, and the copper factory.Most of GIAD factories doesn’t produce high quantity of waste water except stainless steel factory , Its waste water used as raw water .The number of labor in GIAD industrial complex estimated by (4212) , they drink surface water which **pumped** from blue river .Closed to GIAD industrial cmoplex small village called {ELshigla} Its population about (1762) all of them drink water from Giad complex.

EL Bagair industrial area has many factories such as; Tannery ,textile, medicine, Glucose , soap , oils , sweets , flour, engine oil , soda , cement, and many others. The two factories which are still working and producing high quantity of waste water are Eili group for soap and Afrotan tannery. Afrotan tannery has wide area for waste water outside and closed to the factory. Waste water evaporates or absorbs from this pond. Eili group for soap does not have basins, it discharges its waste water away from the factory , about three kilo meters west .

There is no treatment of waste water applied to these two factories. The number of labors in Eili group is estimated by (200) , and (600) in Afrotan factory, they use ground water as drinking water. Distance between the two factories is 3 kilo meters. The two factories are surrounded by many villages ;Bantio village in front of them with population of 15700.EL garia El numoozgeia village north to Eili group – with population about 1235. EL Bagirelgiddami village right to afrotan factory ,its population about (2558).

There are two factories in GIAD complex which produce high quantity of waste water: Aluminum factory and painting factory.The number of habitants inside GIAD complex is about 3000. Waste water flows through pipes from different places and locations to join with waste industrial water in certain point , mixed and flow to a large pond water comes from workshops with high concentration of wax but it retained in process called grease trap then joined to the drainage system. No treatment of stinky smell applied for these ponds by addition of any chemicals.

The volume of water in pond is 45000 m3 ,allow to precipitate large particles and alluvial mud, transfer to pond of 1000m3 volume to be treated with alum. About 2\3 of alluvium precipitate in the pond . Water flows through filters to reduce quantity of mud. Chlorine gas is added to water as disinfectant from bacteria.

Drinking water undergoes analysis in clarification station inside GIAD coplex for determination of concentrations of cations and anions with device called palinetest photometer system its issue photometer 7000Se NA2ISO-010 .This instrument determines the concentration of (35) ions .Alum dosage is determined by Flucclatar sw6 olevice. Number of colonial bacteria is estimated before and after treatment of water with membrane filtration in presence of indicate liquid media ampoule 2ml and m-indo total coli form Broth . Water flows from clarification station to GIAD complex and Elshigla village. The quantity of treated water is 3000 - 4000 m^3 daily. 1800-2000 m^3 is used for drinking . $1500m^3$ for irrigation. $500m^3$ for steel .

CHAPTER THREE

MATERIALS AND METHODS

3-MATERIALS AND METHODS:

3.1 MATERIALS:

3.1.1 SAMPLE COLLECTION:

These methods were obtained from Vogel's A.L.(1978): Text book of quantitative inorganic analysis , fourth edition [71] , revised Bassel, J. D., London , Gloterman ,H.L., Clymo R.S.(1969): Methods for chemical analysis of fresh water.(IBP Hand book No. 8). International biological program. London[72], and Fishman , M.J., ed., 1993, Methods of analysis by U.S. Geological survey national water quality laboratory – Determination of inorganic and organic constituents in water and fluvial sediments:U.S. Geological survey open- file 93-125 ,217 p[73].

3.1.1.1 Drinking Water Sampling

Ground drinking water samples have been collected from 20 densely populated areas of the region representing all wells in El Bagir industrial area and Giad industrial area in January, may and September 2012 and 2013 from the study area . All the samples were obtained directly from the tap after allowing the water to run for at least 20 min so as to stabilise the variation in EC and Temperature . Freshly prepared doubled distilled water, from a quartz still, was used in all experiments Then, some of the samples were filtered through cellulose acetate membrane filter (pore diameter 0,45 μm), acidified to 1% with nitric acid to prevent adsorption of metal ions on the sides of the container and were stored in 500 mL double caped polyethylene or glass bottles to prevent reaction, because trace metals may be depleted by adsorption if stored in other materials. The samples were subsequently stored at 4 ^{0}C for as short a time as possible before analysis to minimize changes of the physicochemical characteristics of the metals and to minimize the biological degradation of nitrate . The water samples for (Hg-tot) analyses were collected in extensively cleaned teflon bottles. They were not filtered nor preserved. All the samples were taken from chlorine treated ground water sources. Sometimes ,sodium thiosulphate solution (75 mg Na_2SO_3 per liter of water) was added to these sampling bottles before sterilization, to dechlorinate the sample. Sufficient air space was left in the bottle to facilitate mixing by shaking, before examination. The concentrations of inorganic constituents ions in all wells were determined , using titrimetric measurement and instruments,and the results were expressed in mg\ L .

3.1.1.2.Apparatus

Prior to analysis, all instruments were calibrated according to manufacturer's recommendations. pH was measured by using Nel pH 900 digital pH meter with combined glass electrode. Conductivity was determined using a Jenway PCM1 portable conductivity meter. Chloride was determined using the Volhard Argent metric Method. Determination of hardness, and total alkalinity were done by titrimetric measurement. Calcium and magnesium with a Perkin Elmer 3110 model flame atomic absorption spectrometer were determined directly. A Perkin-Elmer Analyst 100 model atomic absorption spectrometer equipped with deuterium background correction and HGA-800 graphite furnace was used for the heavy metal determinations. Chromium was analyzed at wavelength of 357.87 nm, Nickel at 232.00 nm, Cadmium at 228.80 nm, Iron at 248.33 nm, Zinc at 213.86 nm, Lead at 283.31 nm and Copper at 324.75 nm.
The analysis were carried out at the environmental and constructional lab center in Khartoum , GIAD laboratory for water analysisandSudan university lab.

3.1.2 **REGENTS**:-

1. Standard buffer solution of pH 4,7 and 9.

Buffer tablets of pH 4,7 and 9 were used. Each tablets was dissolved in 100 ml distilled water to from the buffer solution.

2. potassium chloride KCL (0.01 M).

74.58mg of A.R KCL was dissolved and diluted to lit with distilled water.

3. Ammonia buffer solution (pH=10).

16.9 g ammonium chloride was added to 143ml concentrated ammonium hydroxide, and diluted to 250 ml with distilled water.

4. Standard EDTA titrant (0.0IM).

3.723 g of sodium EDTA salt ($Na_2H_2C_{10}H_{12}O_8N_2 . 2H_2O$) was dissolved in distilled water and diluted to 1000 ml.

5. Eriochrome black T indicator.

1 g Eriochrome Black T was mixed with 10g potassium nitrate.

6. Barium chloride solution.

10 gm of A.R.$Bacl_2$-$2H_2o$ water dissolved and diluted to 100ml with distilled water.

7. Potassium chromate indicator.

5mg of A.R.K_2CrO_4 were dissolved in distilled water, few drops of standard $AgNO_3$ were added till red precipitate formed, the solution was filtered and the filtrate was diluted to 1000ml with distilled water.

8. Silver nitrate titrant (0.014M).

2.396gm $AgNO_3$ were dissolved in distilled water and diluted to 1000ml. The solution was then stored in dark bottle.

9. Hydrochloric acid (0.059M), 1.2, 35%.

8.5ml of concentrated HCL was diluted to 1000ml with distilled water.

10. Phenolphthalein indicator solution. 0.5gm of phenolphthalein was dissolved in 50ml 95% ethanol and diluted to 100ml with distilled water.

11. Methyl orange indicator solution.

0.05gm Methyl orange powder was dissolved in 50ml distilled water and diluted to 100ml.

12. Stock sodium chloride solution,

2.542g of dried NaCl were dissolved in distilled water and diluted to 1000ml, to give 1000ppm of Na^+.

13. Standard sodium solution.

Stock sodium- Solution was diluted with distilled water to produce standard sodium solution ranging from 10-50ppm Na.

14. Stock potassium solution.

1.907gm of A.R.KCL was dissolved in distilled water and diluted to 1000ml to give 1000ppm. K

15. Standard potassium solution.

Stock potassium was diluted with distilled water to give standard potassium solution ranging from 5-25ppm K.

16. Sodium hydroxide (1M).

4gm of A.R. NaOH were dissolved in distilled water and diluted to 100ml.

17. Murex ide (Ammonium purprate) indicator tablet. Each weighs 0.2gm.

18. Hydrochloric acid HCL (1.1).

2ml of concentrated HCL was diluted with 2ml of distilled water.

3.2 **METHODS**:

3.2.1 **pH**:

pH value was measured by Kent ELL model 7055 pH meter. The pH meter was calibrated by the standard solution of pH4.7 and 25C^{o} pH values of the samples were then recorded.

3.2.2 ELECTRICAL CONDUCTIVTY (EC):

Electrical conductivity was measured by kent EIL 5003 model Mc-l, mark V. Electrolytic conductivity measuring set was used with specific conductance cell and it was calibrated with solution (2). The conductivity of samples were then determined in m mohs.

3.2.3 TOTAL DISSOLVED SOLIDS (TDS):

100ml of the water samples were transferred to five weighted beakers and evaporated to dryness at room temperature.

The time of evaporation vary between 10and 15 days; the TDS was obtained by the difference in weights.

3.2.4 **HARDNESS**

EDTA titrimetric method was used as described in (APHA et, al 1971).1 ml of solution (3) and about 30mg of (5) were added to 50ml water samples in 250 conical flask, then the solution was Titrated with solution (4) till the color changed from wine red to blue end point

CALCULATION:

Hardness as mg/l of CaCO3=V_A xWx1000/ML sample

V_A=mls of EDTA required for titration

W= mg of $CaCO_3$ equivalent to 1.00ml EDTA titrant.

Therefore hardness=Vx0.01x100x100/50

Hardness=20 V ppm

V=volume of EDTA required for titration.

3.2.5 SULPHATE:

50ml of water samples were transferred to 250 conical flasks. The pH was adjusted with HCL (1:1) to PH 4-5 by using PH meter. The solution then heated to boiling. Warm solution (6) was added while stirring until complete precipitation. The solution was kept over- night, filtered through ash less filter paper, dried ignited at 800C^0 for one hour. The residue was cooled in a desiccator and weighed (Elhussin, 2000).

CALCULATION

Mg/l SO_4=mg of Bacl2X411.5/ml sample

3.2.6 **CHLORIDE**:-

To 100 ml water sample in 250 ml conical flask 1 ml of solution (7) was added, then the solution was titrated with solution (8) To pinkish yellow end point. Distilled water was used as blank, was treated in the same way as mentioned above.

Calculation: mg/l Cl V_A-V_BXMX35.45/MLSAMPLE

Where:-

V_A=mls of titration for sample

V_B=mls of titration for blank

M=morality of silver titrate

There for:

Cl^-= (V_A-V_B)X0.01X35.45/100ml

3.2.7 CARBONATE AND BICABONTE:

The method was described in Horwit, et al. (1970)

To 100 ml sample few drops of solution (10) were added and the solution was titrated with solution (9). The burette reading (say x) is recorded. Another sample of equal volume (100ml) is then titrated with same standard solution (9) using solution (11). The volume of solution (9) used (say Y) is recorded.

CALCULATION:

X =volume of acid =1/2 carbonate

Therefore 2x=All carbonate in 100 ml sample

Y =Volume of acid =All carbonate + All bicarbonate.

Therefore y-2x =bicarbonate in 100 ml.

The results were expressed as mg/l

32.2.8 SODIUM AND POTASSIUM:

Sodium and potassium were determined by flame photometry. The method was described in (Volges 1978)

Calibration curves were constructed from the standard solution of each element (solution 13 and 15).

For sodium all samples were diluted. The samples were analyzed and their concentrations were obtained from the standard curves. (figs 1 and 2)

3.2.9 CALCIUM:

EDTA titrimetric methods (APHA, et. Al, 1971)50 ml of water sample were placed in 250- ml conical flask, 2 ml of solution (16) were added to get a pH of 12-13 and the Solution was stirred. One tablet indicator was added, while stirring and solution (4) was added slowly till the end point is reached when the colour changed from pink to purple.

CALCULATION:

Mg/l Ca^{++} $=V_A X W X 400.8/ML$ sample

V_A = mLs titration for sample

W = mg $CaCO_3$ equivalent to 1.00 ml EDTM titrant.

3.10.Survey of methods for determination of sulfide:-

Many analytical methods for sulfide determination have been reported in the literature science the early work that used volumetric methods . The modern methods have aimed to lower detection limits of sulfide concentration in samples, simple or rapid assay, sometimes using automation for large number of samples handling titrimetric methods are useful for the determination of sulfide up to **3.2** g/liter, present as a major constituent. But for minor and trace levels the alternatives are either spectrophotometric methods or the use of sulfide ion selective electrodes.

Titrimetric Methods:-

The original iodometeric method for sulfide oxidation still provides the most precise method for its determination. In this method the sulfide ion reacts with iodine according to the following equation :

$I_2+S^{-2}\rightarrow S+2I^-$ 1.1

And the half reactions represented as:-

$I_2+2e\rightarrow 2I$ E=0.536V 1.2

$S^{-2} \rightarrow S+2e$ E=0.444 V 1.3

The standard iodine solution or potassium iodide- iodate in acidic media is added in excess to the sulfide sample. Unreacted iodine is back titrated with standardized thiosulfate solution the standard solution is prepared by dissolving a weighted amount of potassium iodate in a solution containing slight excess of pure potassium iodide and diluting it to a definite volume. This solution can then be used to standardize the thiosulfate solution.

Detection of the end point:-

Solution of iodine in aqueous iodide has an intense yellow to brown color; iodine can serve, as its own indicator. The test is made more sensitive by the use of solution of starch as indicator. Starch reacts with iodine to form an intensely blue color complex even when the iodine concentration is in the order 10-4 M. The advantage of using starch is that it is inexpensive, but has the its disadvantage of giving a water insoluble complex with iodine, the formation of which

Precludes the addition of indicator early in the titration, for this reason the starch indicator solution is added just prior to the end point when the color begins to fade. The shortcomings of starch may be overcome by the use of modified starch solution called sodium starch glycollate, which can be added at any stage of the reaction. However it has been observed that sodium starch glycollate is not quite sensitive as starch .

Another useful way for the end point detection of the reaction between iodine and thiosulfate is the dead- stop end point shows the apparatus for this procedure. The principle of this method lies in the fact that iodine reaction is reversible at first.

$I2+2e \rightarrow 2I-$

Current flow. However, the oxidation of thiosulfate is irreversible.

$2S_2O_3^{-2} \rightarrow S_4O_6^{-2}+2e-$

Thus the current therefore flows very slowly before the end point and there is a (dead-stop) at the ends which resemble a reversed L-type graph .

Other electrochemical method:-

Micro amounts of sulfide were determined indirectly by coulometric method . In this method iodine added to the sulfide sample and the iodine produced is oxidized with electro generated Cr (vi). The end point was detected by ampermetry with two polarized platinum electrodes in the pH range of 6.3 to 8.0.

Spectrophotometric Method:-

The reduction of bis (2.9-dimethyl-l, 10-phenanthroline) Cu at pH 10 by sulfide is used for the colorimetric determination of sulfide. The resulting orange-red color produced in the reaction is due to the formation of Bis (dimethyl-l, 10. Phenonthroline) Cu, which is extracted in chloroform and its absorbance is, read at 457nm with E value of 7.9x103. Sulfide concentration in the range of 0.0 to o.25ppm were determined with the limit of detection of 0,001ppm and the precision of about+_3% the interference from sulfite was eliminated by the addition of formaldehyde .

The method chosen here for the determination of sulfide in wells was the standard **iodometric** method due to the availability of reagent .

3.11.Determine the chromium content in water

2.1: Sampling

Samples of wastewater and soil were collected from different location from the area supposed to be affected by wastewater. Samples of water were collected from 20 Samples were taken sesonly for 3 sesons for tow years. The collected samples were acidified at the time of collection with nitric acid to minimize precipitation and adsorption of the chromium cation on the walls of the container. Time interval between collection of samples and analysis was about 24 hours.

Three methods were used to determine the chromium content in the water (back titration, spectrophotometric and atomic absorption spectroscopic methods).

Back titration method

Principle

Chromium (III) is oxidized to dichromate by boiling with excess persulfate solution for a short time destroys the excess persulfate. The dichromate content of the resultant solution is determined by addition of excess of standard ferrous solution and titration of the excess ferrous solution with standard potassium dichromate.

2.2.1.2 General procedure

50ml of the well-shaken water sample were transferred to a conical flask. 20 ml of silver nitrate (0.1M) were added, followed by 50ml potassium per sulfate. The resulting solution was boiled gently for 30 minutes and then cooled and diluted to 250ml. 50ml of the solution was removed with a pipette to the conical flask 50ml of 0.0m ammonium ferrous sulfate solution 1 ml phosphoric acid, and 5 drops of sodium diphenylamine sulfonate (0.2%) indicator were added. The excess of the ferrous salt was titrated with a standard (1.667x10-3 M) potassium dichromate until the color changed
from green to violet.

2.2.1.4 Calculation

The excess volume of the ferrous solution which was oxidized by (1.667x10-3M) potassium dichromate is subtracted from 50ml to find the volume of the ferrous solution which reacted with the dichromate in the 10ml water sample. The concentration was calculated according to the equation bellow

$Cr_2O_7^{2-} + 14H^+ + 6Fe^{2+} \rightarrow 2Cr^{3+} + 6Fe^3 + 7H_2O$

Spectrophotometric method

Principles

Hexavalent chromium reacts with diphenylcarbazide in acidic medium to produce a red violet coloration of unknown composition; it is suitable for determination of low chromium concentration. The reaction is very sensitive the colored product not very stable, appreciable fading is noted after about 1 hours. Direct mixing of chromium (III) solution and diphenylcarbazide fails to yield the violet color in all probability the reaction involves unhydratedchronnium (III) ions fromed during the oxidation of the diphenylcarbazide to diphenylcarbazone.

Diphenylcarbazide only forms metal-chelates after its oxidation to diphenylcarbazone

The reaction of diphylcarbazide is nearly specific for chromium molybdenum (Mo) and mercury (Hg) salts will react to give color with reagent, but with lower intensities than in the case of chromium. Also vanadium up to ten times chromium concentration caused no trouble.

Instrumentation:

A double- beam spectrophotometer (Uv-150-0.2 shimadru) was used to analyze the sample. The double-beam spectrophometer for the ultraviolet and visible regions normally uses some sort of beam splitter between the exit slit of the monochrometor and the two cuvets. After passing through the cuvets the beam may fall on the same detectorThe radiation is obtained from tungsten (W) lamp source. The wave length for chromium determination is 540nm, light path 1 cm, detection limit 1 ug and green filter is used automatically (Ewing, 1975).

Reagents:

1- stock chromium solution: solution of 0.01667M potassium dichromate was prepared by dissolving the contents of potassium dichromate convol bottle in distilled water and diluted to 1 liter

2- Standard chromium solution: 10ml from stock solution was diluted to 100ml, and then 10ml from the diluted solution was taken and also diluted to 100ml (1.667x10-4M)

3- diphenylcarbazide solution o.25g, 1.5 diphenycarbazide was dissolved in 50ml acetone and was stored in a brown bottle.

Calibration curve:

The chromium standard is treated by the same procedure as the sample was treated to compensate for possible slight losses of chromium during digestion.

General procedure :

Chromium (III) was oxidized to dichromate by addition of potassium persulfate in the presence of silver nitrate as a catalyst (see 2.2.1.4) `10ml of the oxidized sample was diluted to 100ml, and10ml from dilute oxidized sample was taken and also diluted to 100 ml with distilled water in a volumetric flask. 1ml sulfuric acid (1+1) and 1ml diphenylcarbazide solution were added an mixed well. After full development of color the absorption was measured at wavelength 540nm. The oxidized sample was diluted to suitable concentration, after the development of color, to give absorption within the calibration curve range.

Calculation

The concentration of chromium is determined by measuring the absorption and comparing it to those in the standard curve (fig. 1)

2.2.3 Atomic absorption spectroscopic method (AAS)

(AAS) is a well- established analytical method. It is the method of choic for determination of large number of metals, especially but not exclusively at trace levels. It is widely used in water analysis field (parker, 1972).

Instrumentation

Atomic absorption spectrophotometer obeys the same general laws as absorption molecules. The metallic elements of sample Convert from solution to dissociation vapor by heat energy in flame. Careful control of the temperature is needed for optimum conversion to the atomic vapor, because, high temperature will ionize the fraction of atoms and ions do not absorb at the same lengths as neutral atoms compressed air and acetylene are most commonly used as oxidant and fuel for atomic absorption spectrophotometer A continuous source of

Radiation should be used to give sharp emission lines for specific elements. The successful source is the hollow – cathode lamp that consists of two electrodes one of the specific element. The lamp is filled with low- pressure noble gas. Positive ions provided by the inert gas removing metal atoms by sputtering. These atoms accept energy of excitation and emit radiation plus these of the fill gas. The desired line can be isolated by a narrow band pass monochromator. The metal atoms in the flame or vapor absorb the energy from the incident light beam and raises to excite level these atoms will emit resonance at exactly the same wavelength that the monochromator is set to transmit (Ewing 1975)

Procedure

To a 100ml sample, 2ml nitric acid {HNO3 (1+1)} AND 5ml hydrochloric acid (HCL) were added, then the solution was heated for 15 minutes on a hot plate. The solution was cooled slightly and filtered with suction through a sintered – glass into a clean flask. The filtrate was transferred to 100ml – volumetric flask. The solution was diluted to the 100.ml mark and mixed thoroughly and used directly for determination of chromium by atomic absorption spectrophotometer model (PERKIN, ELMER TYPE)

Calculation

Data were taken directly from atomic absorption spectrophotometer.

3.12.Determination of BOD and COD: -

5-day BOD test:-

In these methods the flask was filled with sample and incubated at the specified temperature 20 C for 5-day, dissolved oxygen is measured initially and after incubation, and the BOD is computed from the difference between initial and final (DO) results.

Open reflux method:-

Principle**:-**

Boiling mixture of chromic and sulfuric acids oxidize most types of organic matter. A sample is refluxed in strongly acid solution with a known excess of potassium dichromate ($K_2Cr_2O_7$) after digestion, the remaining unreduced ($K_2Cr_2O_7$) is to be titrated with ferrous and ammonium sulfate determine the amount of $K_2Cr_2O_7$ consumed and the oxidizable organic matter is calculated in the terms of oxygen equivalent.

Ratios of the reagent weight, volume, and strength are to be kept constant when sample volumes other 50 ml are used.

The standard 2 hours reflux time may reduced since it has been shown that a shorter period give same results.

C: - Closed reflux Titrimeteric Method:-

Volatile organic compounds are more completely oxidized in the closed system because of longer contact with oxidant. Before each use culture-caps is to be inspected. linear Culture-tube size is to be selected for the degree of sensitivity desired .

D: - Closed Reflux Colorimeteric Method:-

Colorimetric reaction vessels are sealed glass ampoules or capped culture tubes . Oxygen consumed is measured against standard at 600 nm with a spectrophotometer[73].

CHAPTER F0UR

RESULTS AND DISCUSSION

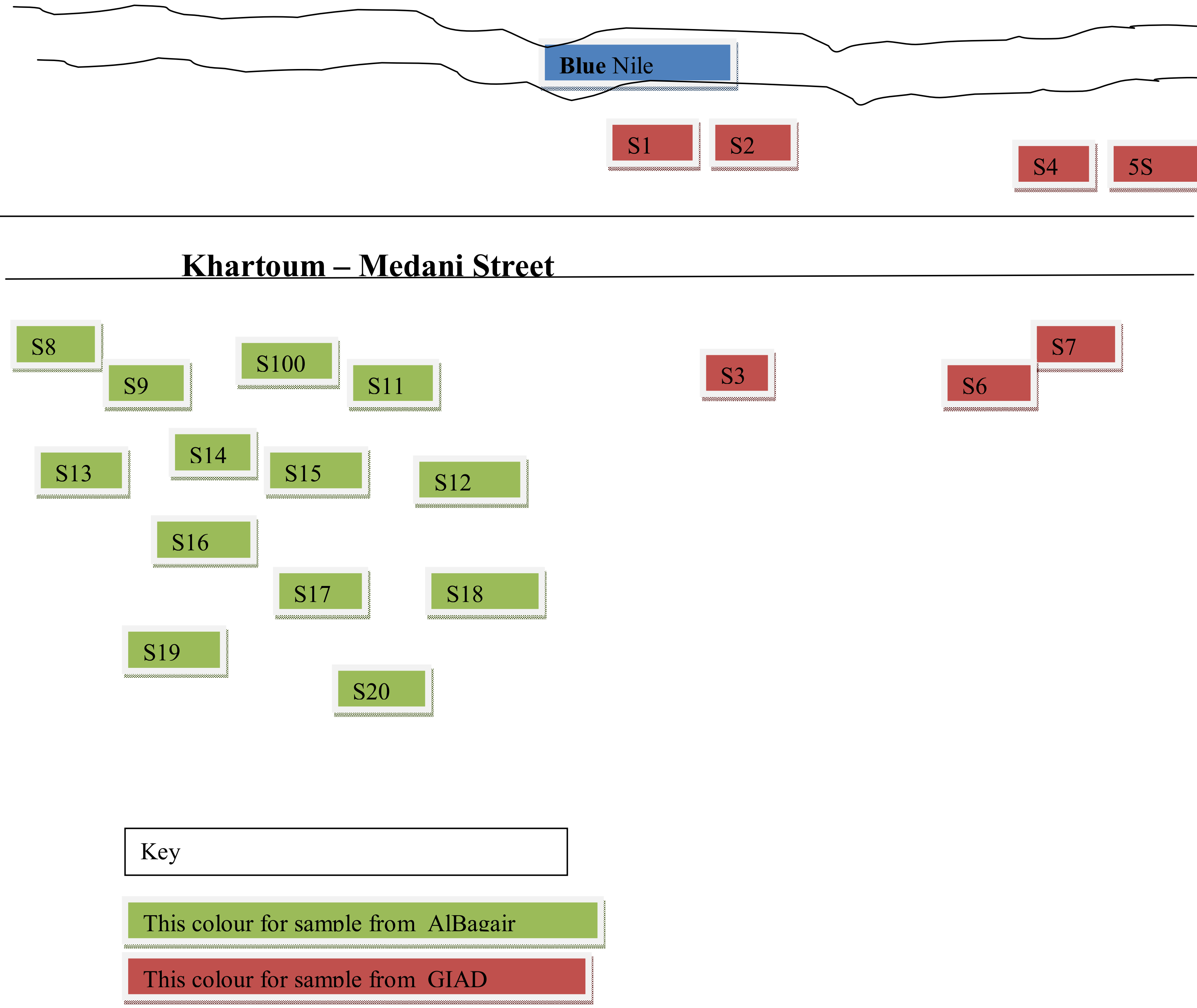

Fig.[1]:Location of the samples

Table (4- 1)

The maximum permissible concentration of some ions for drinking water in some countries :

Analysis type	saudispecifica fions	America specifications	WHO specifications
Color	(15) Unit	15	15
Turbidity (NTU)	(5)Units	-	-
Taste	pass	-	pass
Odor	pass	-	pass
pH	6.5-8.5	6.5-8.5	6.5-8.5
TDS	100-1000	500	1000
Conductivity	160-1600	755	1600
Magnesium	150	-	-
Calcium	200	-	-
Hardness	500	-	500
Sodium	200	-	200
Sulfates	400	250	400
Chlorides	250	250	250
Aluminum	0.2	-	0.2
Iron	0.3	0.3	0.3
Copper	1	1.3	1

Zink	5	-	-
Manganese	0.1	0.05	0.007
Arsenic	0.05	0.05	0.007
Cadmium	0.005	0.005	0.005
Cyanide	0.05	1.2	0.1
Mercury (Total)	0.03	0.002	0.001
Selenium	0.01	0.05	0.01
Chromium (total)	0.05	0.003	0.05
Nitrate	10	10	10
Nitrite	<1	1	-
Fluoride	0.6-1.7	4	0.05
lead	0.05	0	0.05
Antimony	0.001	0.001	0.004
Barium	1	0.8	0.5
Boron	0.5	1	0.5
Molybdenum	0.001	0.001	0.0007
Nickel	0.05	0.05	0.05

Table (4-2)

Values of Measurement of Volume required , Preservation, and Maximum holding time:

No.	Measurement	Volume required ml	Container material	Preservation (Preparation methods)	Maximum holding time
1	Acidity	100	P,G	Cool, 4 ^{0}C	24 hours
2	Alkalinity	100	P,G	Cool, 4 ^{0}C	24 hours
3	Aluminum	50	P,G	Filter on site , acidity with HNO_3 to pH less than 2	6 months
4	Arsenic	100	P,G	Acidity with HNO_3 to pH less than 2	6 months
5	Bromide	100	P,G	Cool, 4 ^{0}C	24 hours
6	COD	50	P,G	Acidity with H_2SO_4 to pH less than 2	7 days
7	Chloride	50	P,G	None	7 days
8	Color	50	P,G	Cool, 4 ^{0}C	24 hours
	Copper	50	P,G	HNO_3 to pH less than 2	6 months
9	Chromium	100	P,G	Filter on site	6 months
10	Cyanide	500	P,G	Cool, 4 ^{0}C, NaOH to pH 12	24 hours
11	Fluoride	300	P,G	Cool, 4 ^{0}C	7 days
12	Hardness	100	P,G	Cool, 4 ^{0}C	7 days
13	Iodine	100	P,G	Cool, 4 ^{0}C	24 hours
14	Iron	50	P,G	Filter on site , HNO_3 to pH less than 2	6 months
15	Manganese	50	P,G	Filter on site , HNO_3 to pH less than 2	6 months
16	Mercury dissolved	100	P,G	Filter on site , HNO_3 to pH less than 2	38 days (glass), 13 days (plastic)

17	Ammonia	400	P,G	Cool, 4 ^{0}C, H_2SO_4 to pH less than 2	24 hours
18	Nitrate	100	P,G	Cool, 4 ^{0}C, H_2SO_4 to pH less than 2	24 hours
19	Nitrite	50	P,G	Cool, 4 ^{0}C	24 hours
20	Oil & grease	1000	G only	Cool, 4 ^{0}C, H_2SO_4 to pH less than 2	24 hours
21	pH			Determination on site	
22	Phosphate	50	P,G	Filter on site	24 hours
23	TDS	50	P,G	Cool, 4 ^{0}C , Filter on site	24 hours
24	Sulfate	50	P,G	Cool, 4 ^{0}C	7 days
25	Sulfide	50	P,G	2 ml zinc acetate	24 hours

For container; P for plastic, G for glass.

Table (4-3) :

Results of chemical analysis for physical parameters in drinking water in the studied area :

Parameters	Temperature	pH	EC	TDS	Turbidity
Samples					
S1	23.2	8.9	346	283	0.24
S2	21.8	5.2	361	498	0.61
S3	24.2	7.4	473	219	1.71
S4	22.7	7.8	284	305	0.24
S5	21.2	7.0	581	282	0.26

S6	19.0	6.5	491	187	1.44
S7	20.2	7.2	538	473	0.08
S8	22.5	7.0	390	253	1.91
S9	19.7	8.4	146	280	1.71
S10	22.2	8.2	271	612	0.09
S11	26.8	7.0	352	163	2.20
S12	22.3	7.7	149	270	0.013
S13	28.6	8.0	183	242	1.059
S14	23.4	7.0	641	481	0.028
S15	19.2	7.9	205	588	0.071
S16	25.2	9.7	406	279	0.64
S17	21.4	7.4	359	174	1.05
S18	19.6	6.9	101	506	2.78
S19	21.8	7.1	596	411	1.82
S20	28.4	8.1	237	261	0.15

Table (4-4)
Results of chemical analysis for anions in drinking water in the studied area.

	Nitrate	Nitrite	Chloride	Sulphate	Sulphide	Tot. Hardness
S1	3.07	0.02	19.3	91	0.021	156,4
S2	8.014	2.86	111	249	0.214	380
S3	Nil	0.38	293	83	0.030	116.2
S4	BDL	BDL	71.3	23.6	0.012	223.0
S5	0.09	1.01	26.9	135	0.008	146.1
S6	1.02	1.58	201.8	218	0.221	413
S7	0.06	Nil	121.2	99.5	0.280	538
S8	2.08	1.96	37.7	25.1	0.001	129.7
S9	6.01	2.79	19.0	123	0.074	98.5
S10	Nil	0.08	58.2	154.7	0.269	52.4
S11	5.01	1.00	106.6	71	0.010	341
S12	4.04	0.04	17.4	111	0.1 21	209.1
S13	3.08	1.11	101	48.1	0.243	192.4
S14	11.8	2.09	287.3	11.5	0.011	357.0
S15	1.15	1.62	10.5	19.9	0.006	72.9
S16	Nil	0.70	32.8	86.0	0.021	88.2

S16	1.63	2.54	27.2	95.4	0.003	112.3
S18	4.08	1.44	254.3	17.4	0.052	80.5
S19	0.56	0.93	43	61.5	0.01	137
S20	1.04	2.00	14.5	10.2	0.006	209.9

Table (4-5) :

Results of chemical analysis for cations in drinking water in the studied area.

	sodium	**potassium**	**calcium**	**magnesium**	**Aluminum**
S1	81.6	8.0	21.4	11.8	0.004
S2	129	3.0	17.6	1.5	0.012
S3	24.0	1.7	40	36.7	0.035
S4	8.5	1.4	6.8	17.5	0.031
S5	13	8.8	19.5	0.3	0.001
S6	2.4	0.9	88.4	8.1	0.210
S7	89.1	0.1	8.9	46.9	0.27
S8	11	0.5	64.6	3.6	0.005
S9	43	2.8	9.3	0.91	0.022
S10	1.6	18.9	10.2	1.8	0.045
S11	12	6.0	108.0	11	0.027

S12	50	14	30.9	0.5	0.01
S13	253	16.5	25.0	104.0	0.09
S14	69	3.7	1.1	155.1	0.010
S15	94	24.8	4.8	14.3	0.065
S16	207	11.5	2.4	99.2	0.14
S16	177	8.7	14.4	91.4	0.08
S18	47	17.6	76.1	3.7	0.002
S19	83	6.2	9.8	0.8	0.071
S20	66.2	3.8	47.9	23.1	0.083

Table (4-5) :

Results of chemical analysis for essential heavy metals in drinking water in the studied area.

	Iron	**Copper**	**Zink**	**Manganese**	**Nickel**	**Cobalt**
S1	0.295	0.003	0.156	4.60	0.008	8.07
S2	0.037	0.028	0.019	8.0	0.027	0.05
S3	0.090	0.009	1.10	0.23	0.003	0.64
S4	0.024	0.017	0. 004	3.58	0.001	1.82
S5	0.073	0.038	0.152	18.5	0.009	0.39

S6	0.329	0.820	0.006	6.4	0.037	4.15
S7	0.406	0.784	0.111	19.9	0.022	0.37
S8	0.104	0.043	0.007	1.55	0.017	0.11
S9	0.162	0.077	0.170	0.09	0.012	0.41
S10	0.028	0.008	0.181	0.75	0.008	6.82
S11	0.060	0.03	0.194	1.78	0.007	0.08
S12	0.001	0.075	0.018	3.21	0.021	0.03
S13	0.022	0.070	0.16	15.24	0.033	0.29
S14	0.174	0.016	2.10	82.52	0.001	0.96
S15	0.008	0.056	0.001	35.09	0.006	2.021
S16	0.130	0.019	1.14	0.35	0.015	0.03
S17	0.099	0.171	0.002	2.95	0.019	0.07
S18	0.377	0.004	0.882	0.007	0.009	0.55
S19	0.069	0.110	0.505	0.82	0.027	4.20
S20	0.106	0.005	0.093	Nil	0.032	0.85

Table (4-6) :

Results of chemical analysis for the most hazard heavy metals in drinking water in the studied area.

	(total) Chromim	Cadmium	Mercury	Lead	Arsenic
S1	0.020	0.071	Nil	0.001	0.003
S2	0.01	0.0012	0.001	0.012	Nil
S3	0.26	Nil	Nil	0.007	Nil
S4	0.07	0.001	Nil	0.015	0.001
S5	0.01	0.006	Nil	0.005	Nil
S6	1.11	0.091	0.0012	0.051	0.013
S7	1.108	0.080	0.0009	0.063	Nil
S8	0.022	0.004	Nil	0.004	Nil
S9	0.001	0.007	Nil	0.018	0.0032
S10	0.925	0.073	Nil	LBD	0.005
S11	0.004	0.006	Nil	0.002	0.02
S12	0.008	0.002	Nil	0.010	Nil
S13	0.011	Nil	Nil	0.006	Nil
S14	0.002	0.006	Nil	0.003	Nil
S15	0.031	0.002	Nil	0.022	Nil

S17	0.017	0.008	0.0008	0.025	0.0033
S16	0.006	0.005	Nil	0.001	Nil
S18	0.081	0.001	Nil	Nil	0.002
S19	0.001	0.006	Nil	0.011	0.001
S20	0.025	0.001	Nil	0.006	0.0005

Table (4-7) :

The number of bacteria in the samples of tap water after incubation at 27°C in Cfu / ml (or colony forming units per millilitre) in every 100 mL of water

	Enterococcus spp	Escherichia coli	Pseudomonas aeruginosa
S1	BLD	3	BLD
S2	BLD	BLD	3
S3	5	14	BLD
S4	BLD	BLD	BLD
S5	BLD	8	11
S6	BLD	BLD	6
S7	2	BLD	BLD
S8	BLD	BLD	BLD

S9	BLD	BLD	BLD
S10	BLD	BLD	2
S11	1	BLD	11
S12	6	1	BLD
S13	BLD	BLD	BLD
S14	BLD	9	BLD
S15	11	BLD	2
S16	BLD	13	BLD
S16	2	BLD	BLD
S18	BLD	16	1
S19	4	BLD	6
S20	BLD	2	BLD

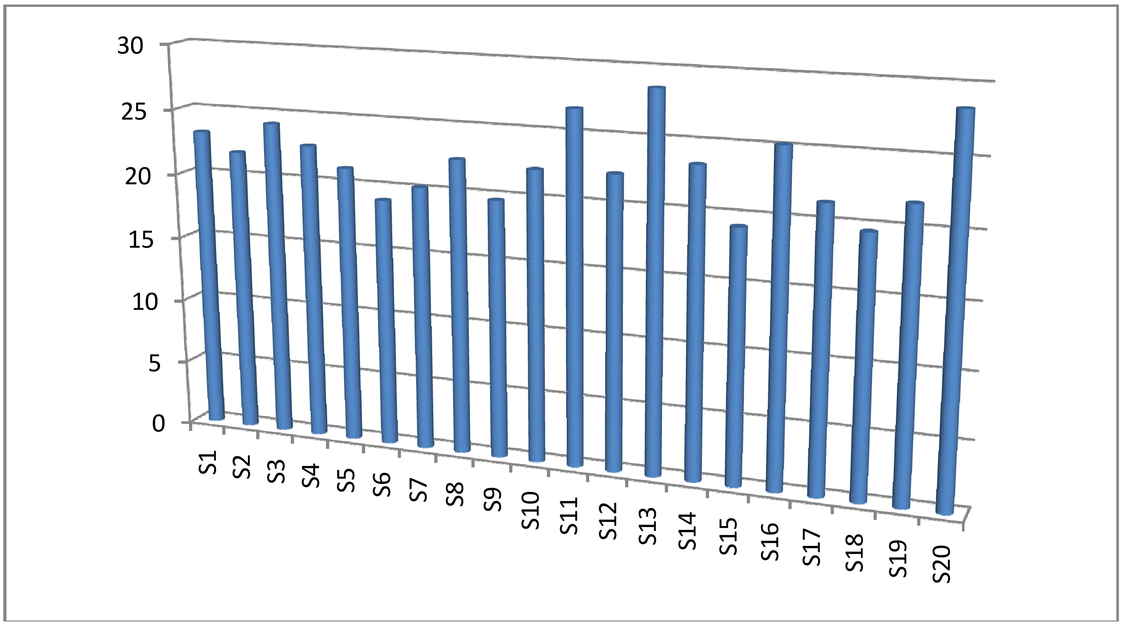

Fig. (2) Temperature

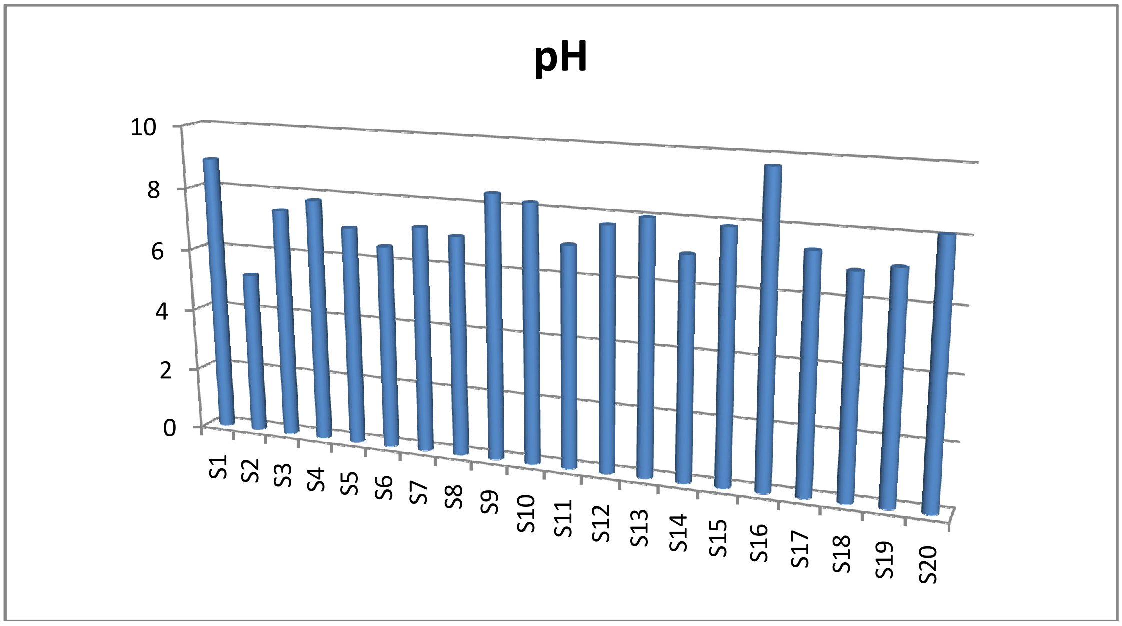

Fig. 3: pH values

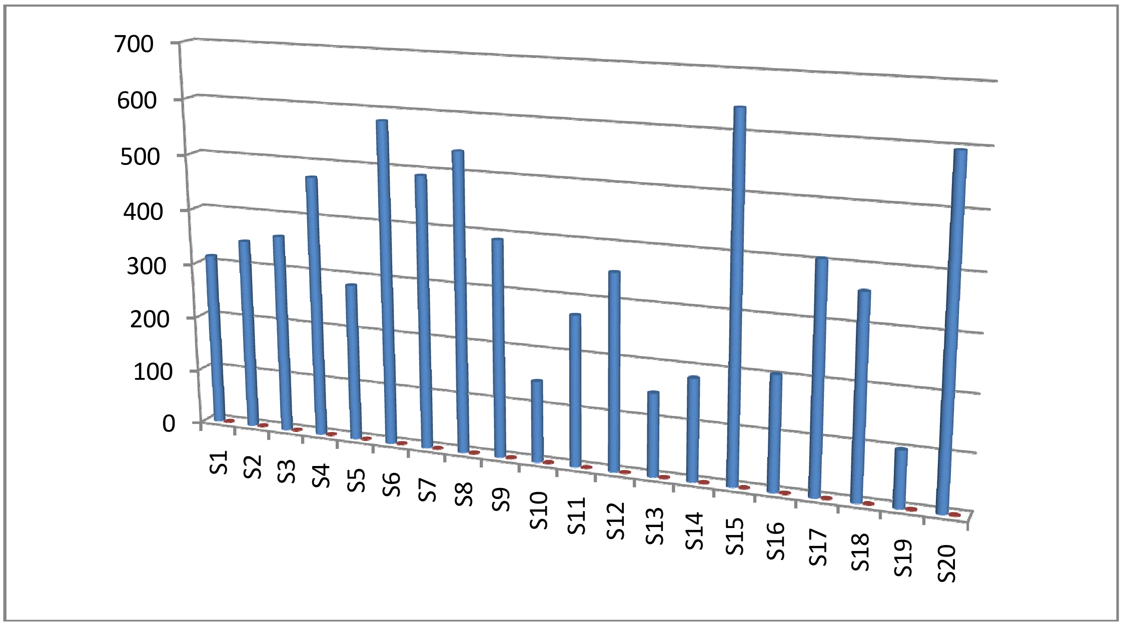

Fig. (4) **EC**values

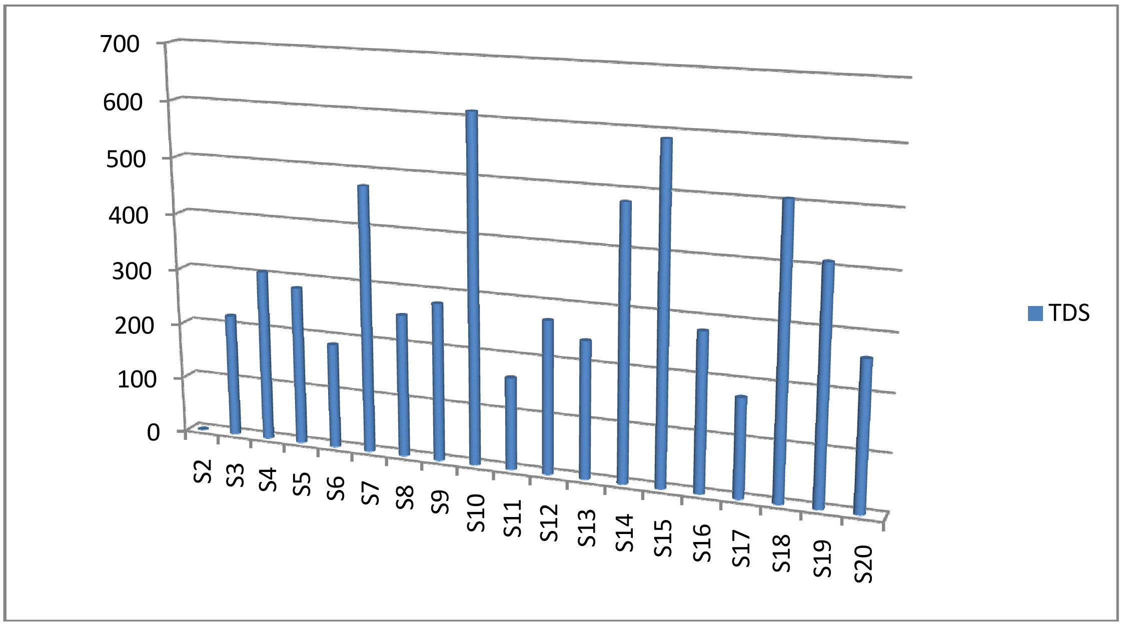

Fig. (5) **TDS**values

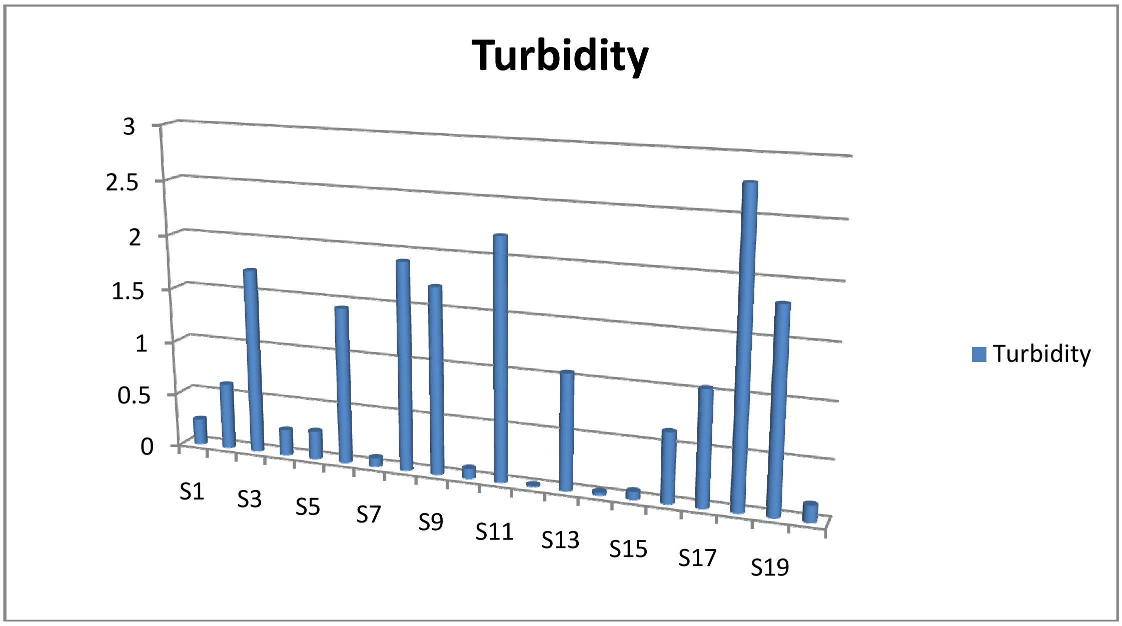

Fig. (6) Turbidityvalues

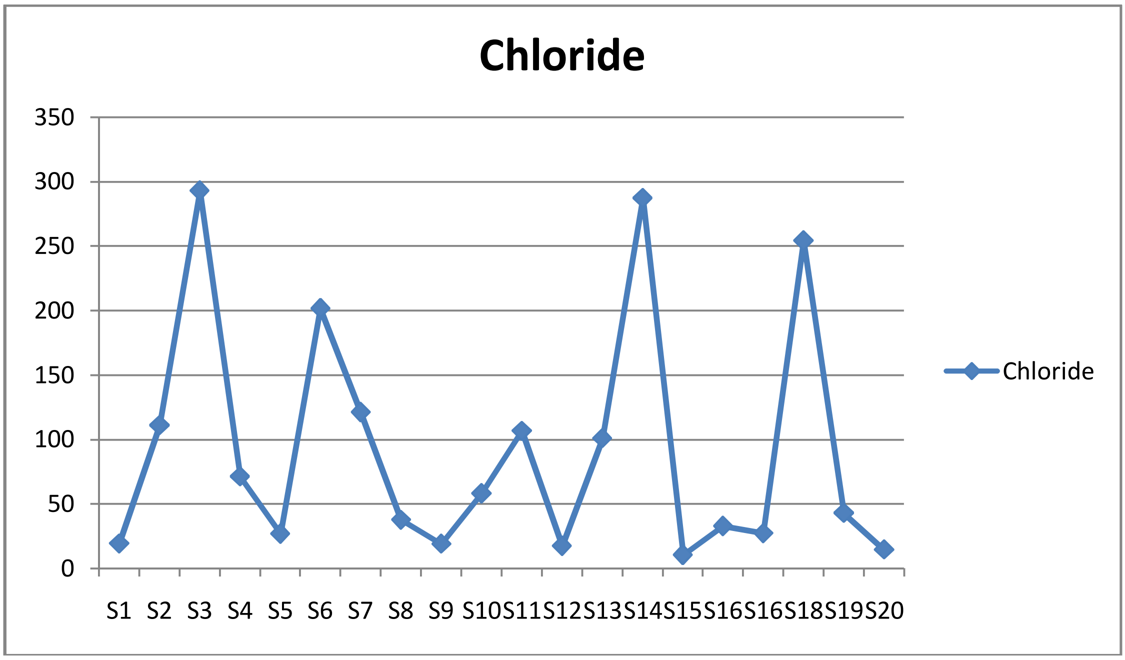

Fig. (7) Chloride concentrations

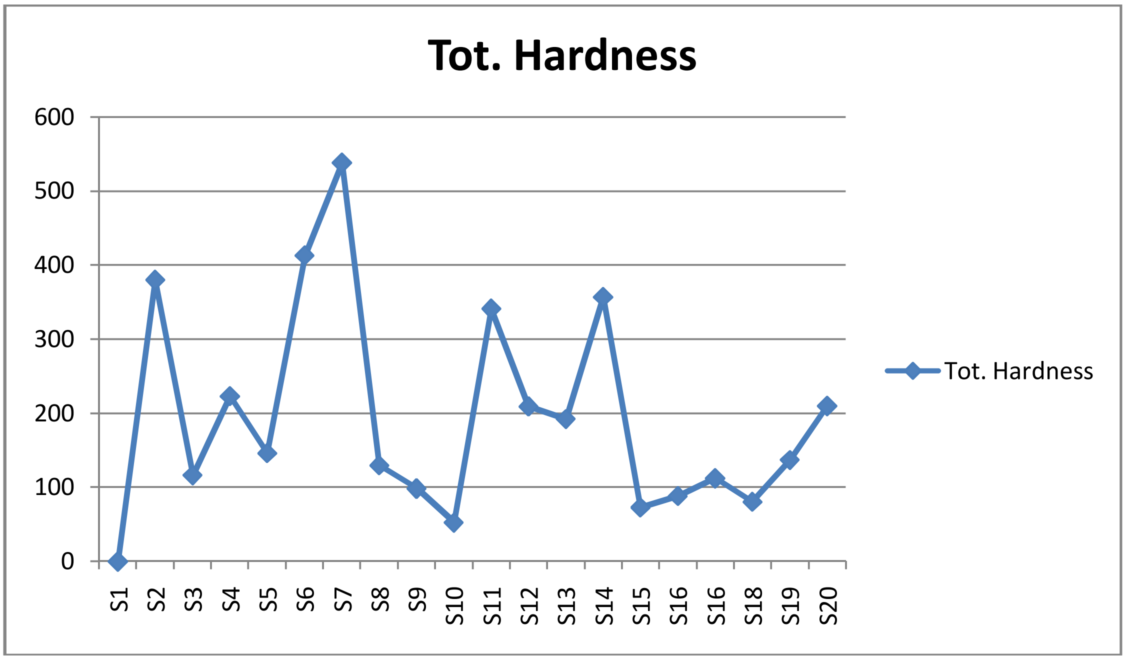

Fig. (8) **Total Hardness**concentrations

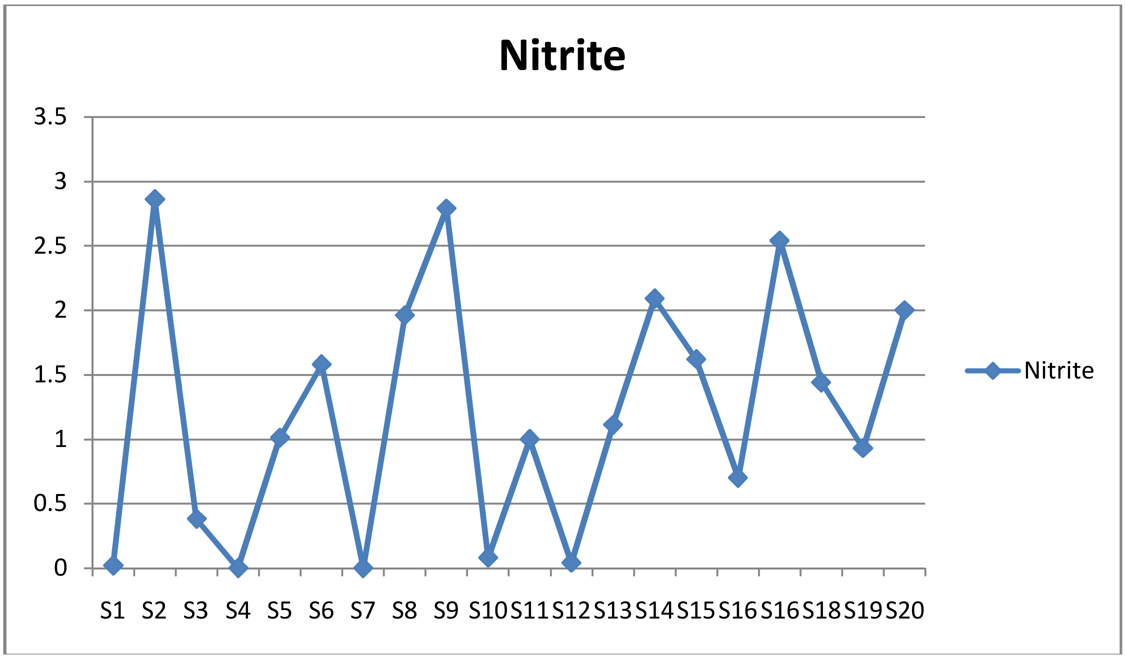

Fig. (9) :Nitrite concentrations

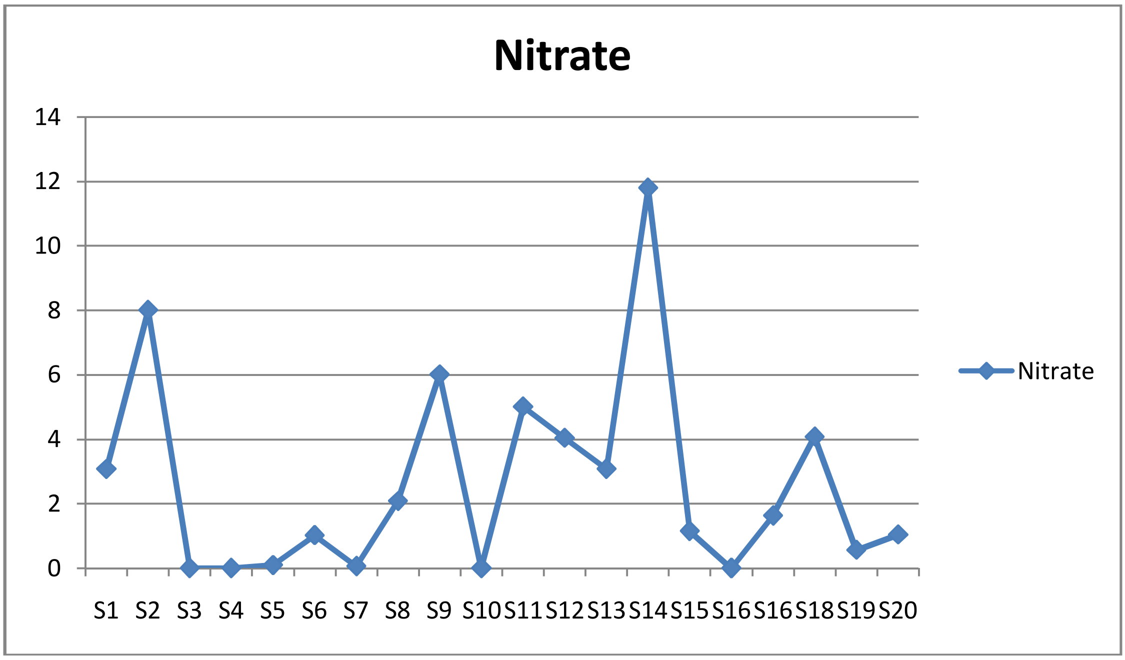

Fig. (10) :Nitrate concentrations

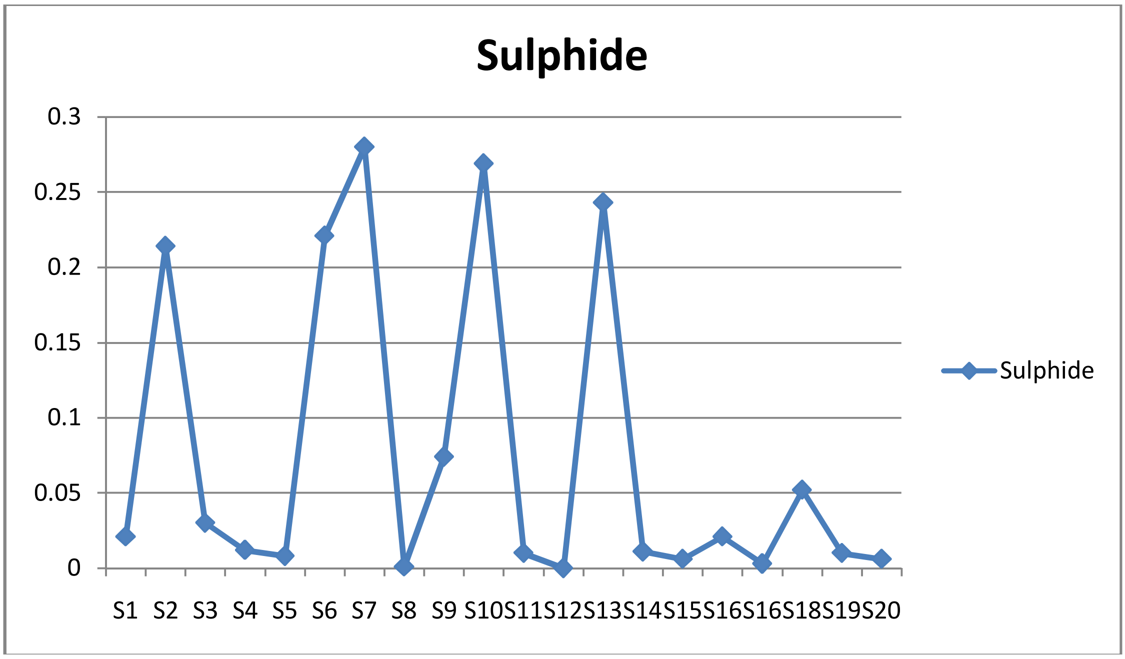

Fig. (11) : SULFIDE Concentrations

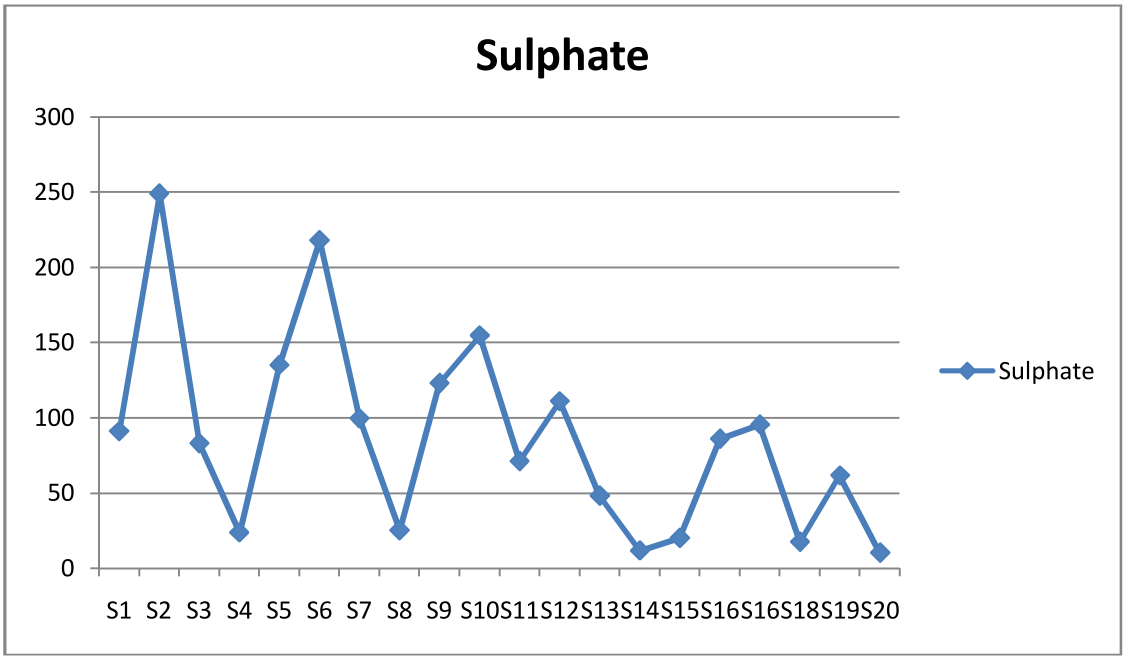

Fig. (12): Sulfate

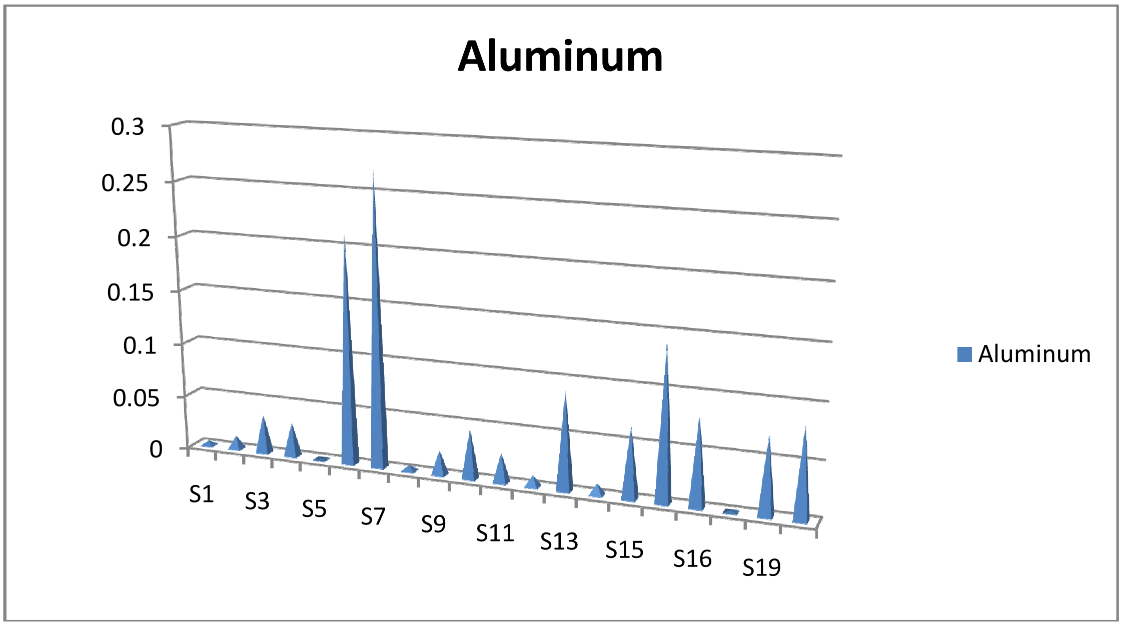

Fig. (13) :Aluminum

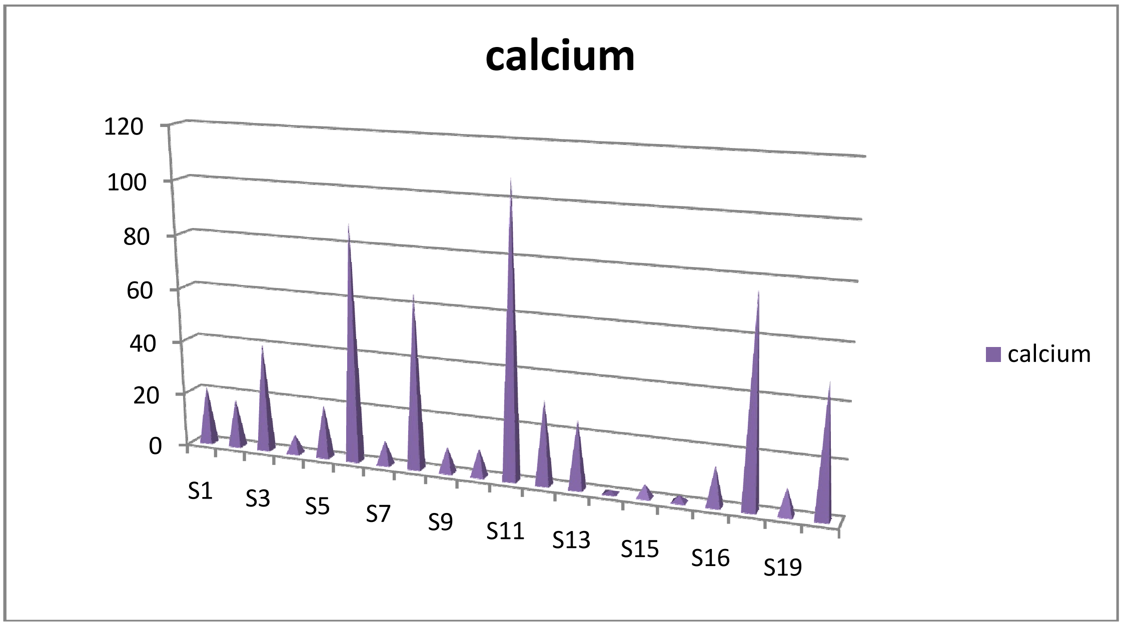

Fig. (14) :Calcium

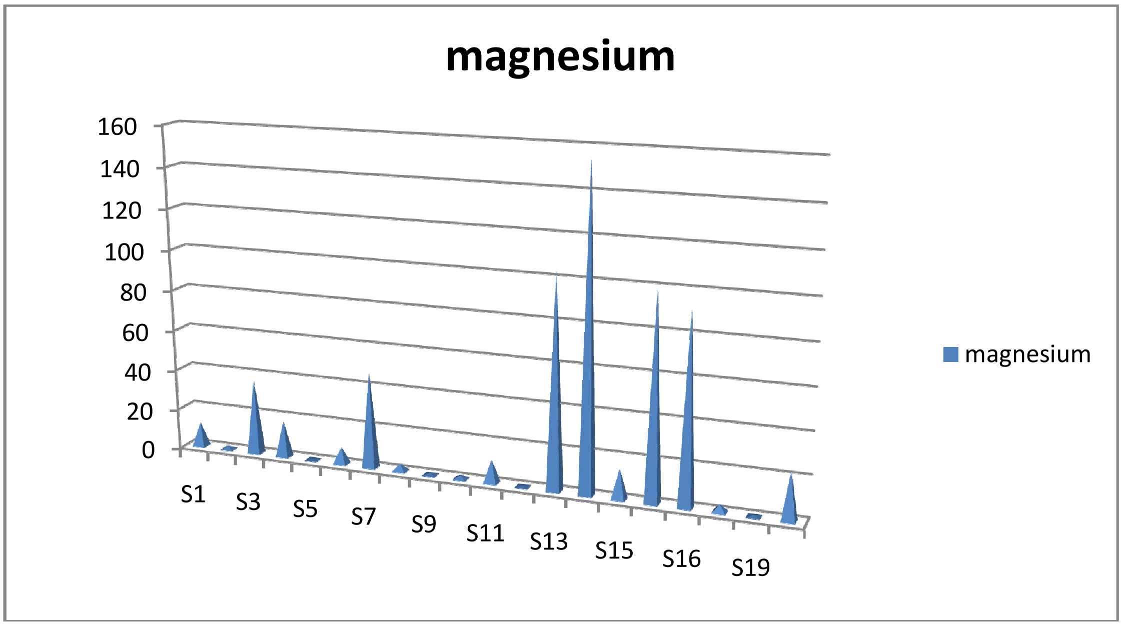

Fig. (15) : Magnesium

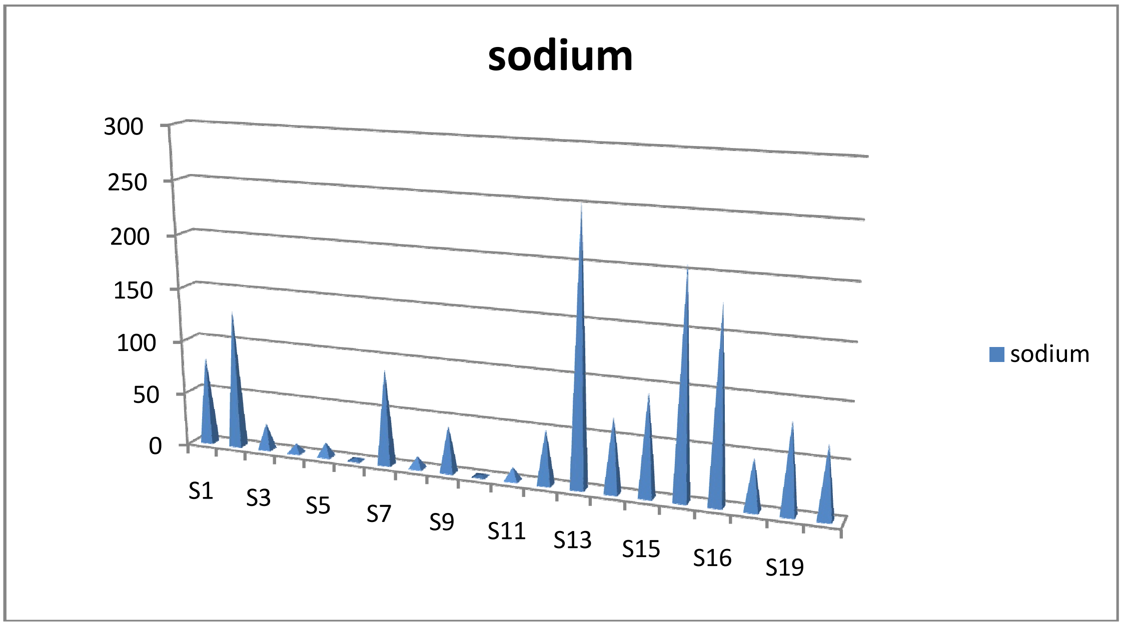

Fig. (16): Sodium

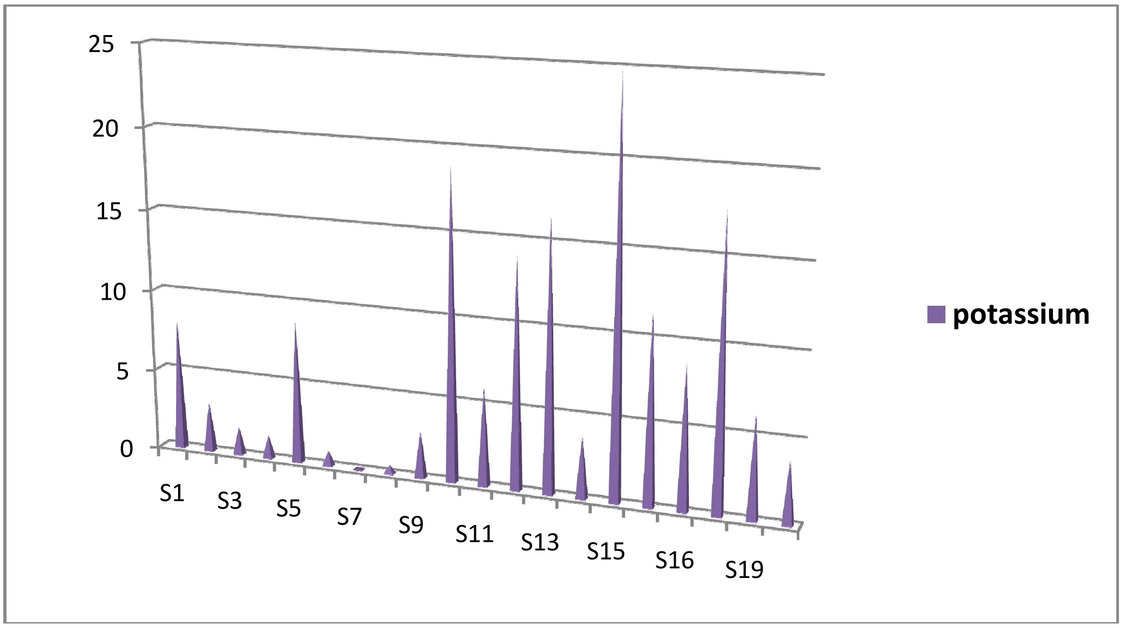

Fig. (17) Potassium

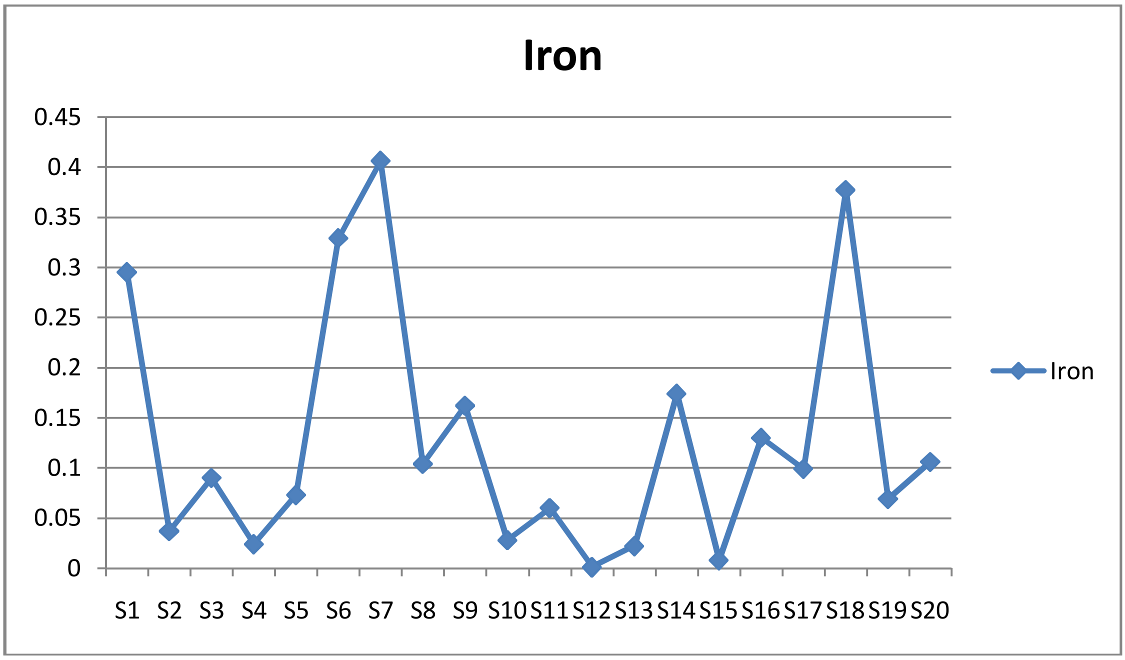

Fig. (18) Iron

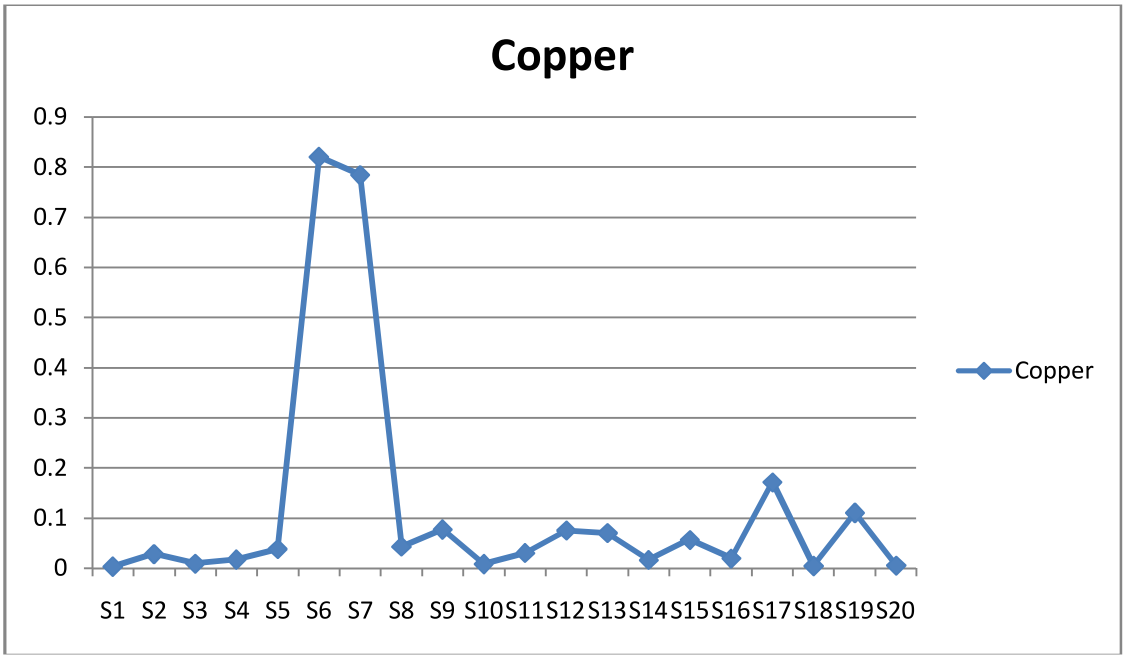

Fig. (19): Copper

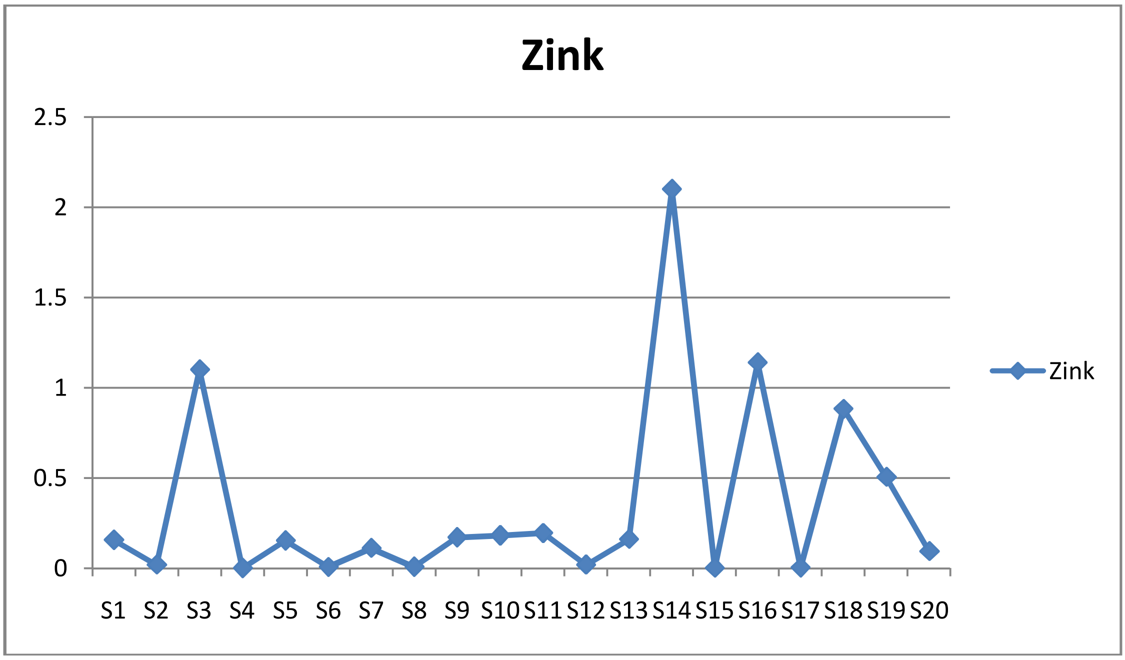

Fig. (20): Zink

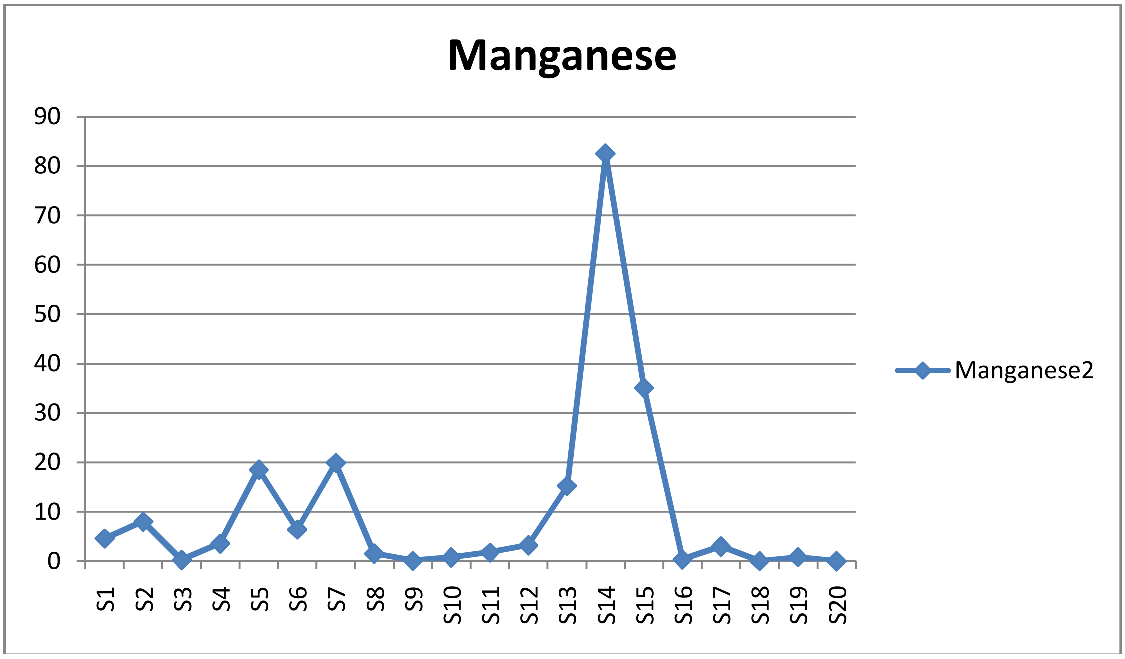

Fig. (21): Manganese

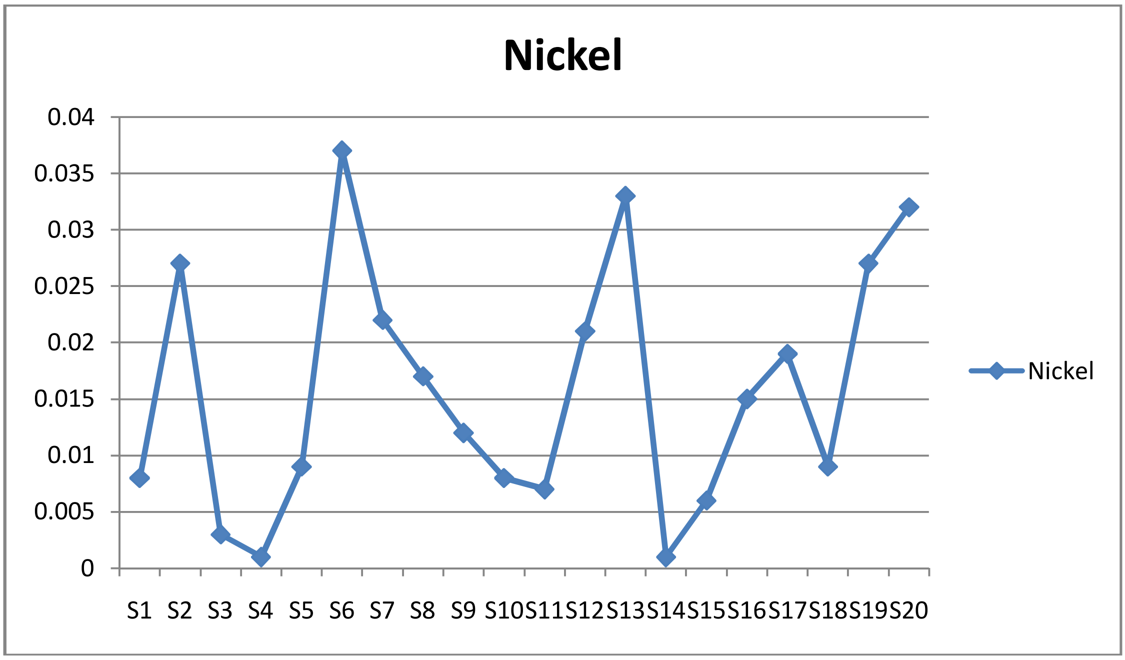

Fig. (22):Nickle

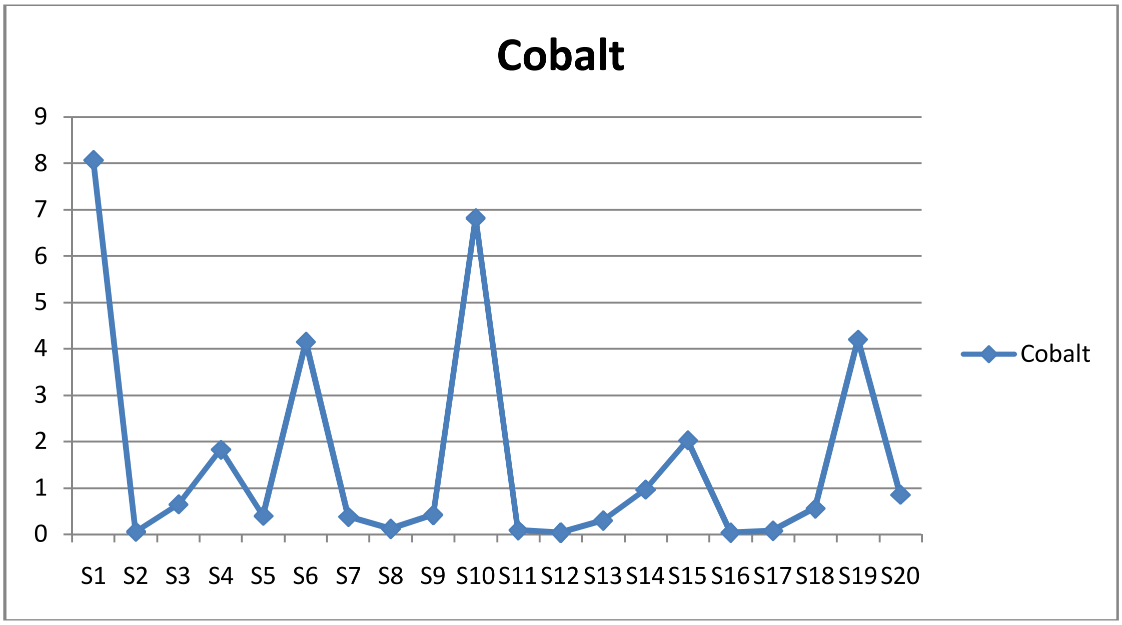

Fig. (23): Cobalt

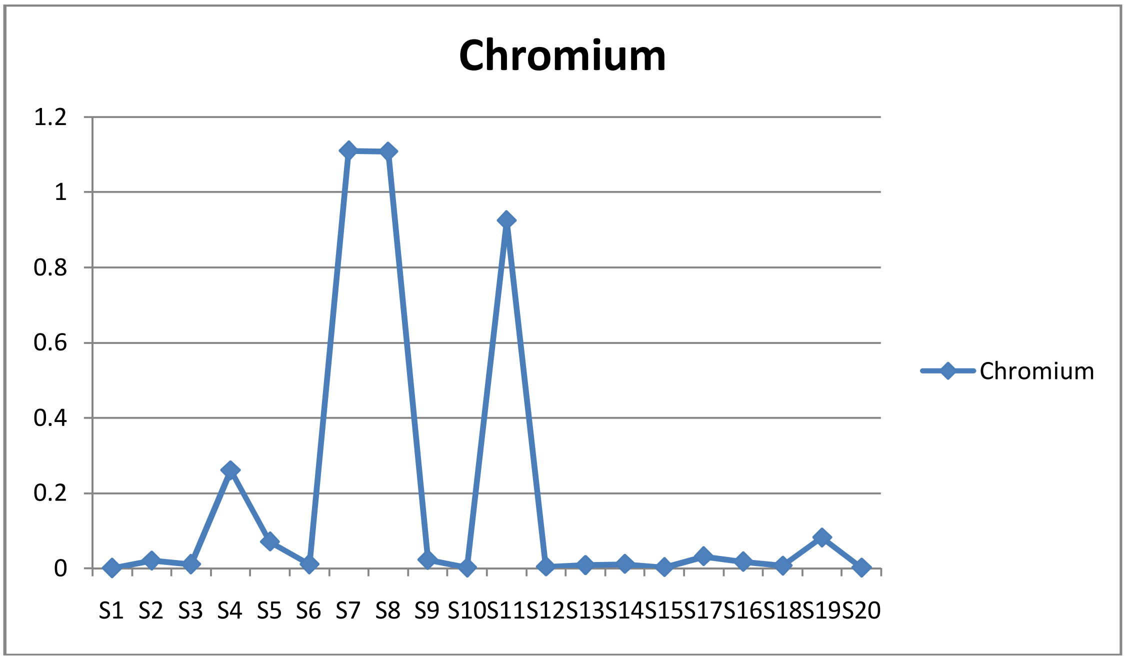

Fig. (24): Chromium

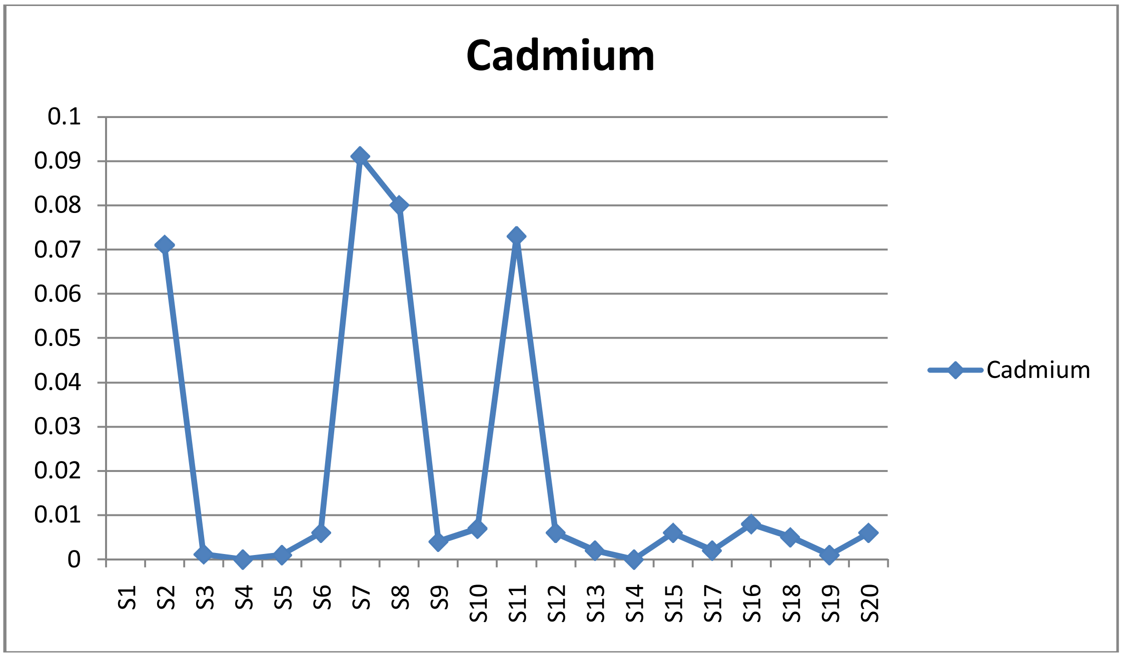

Fig. (25): Cadmium

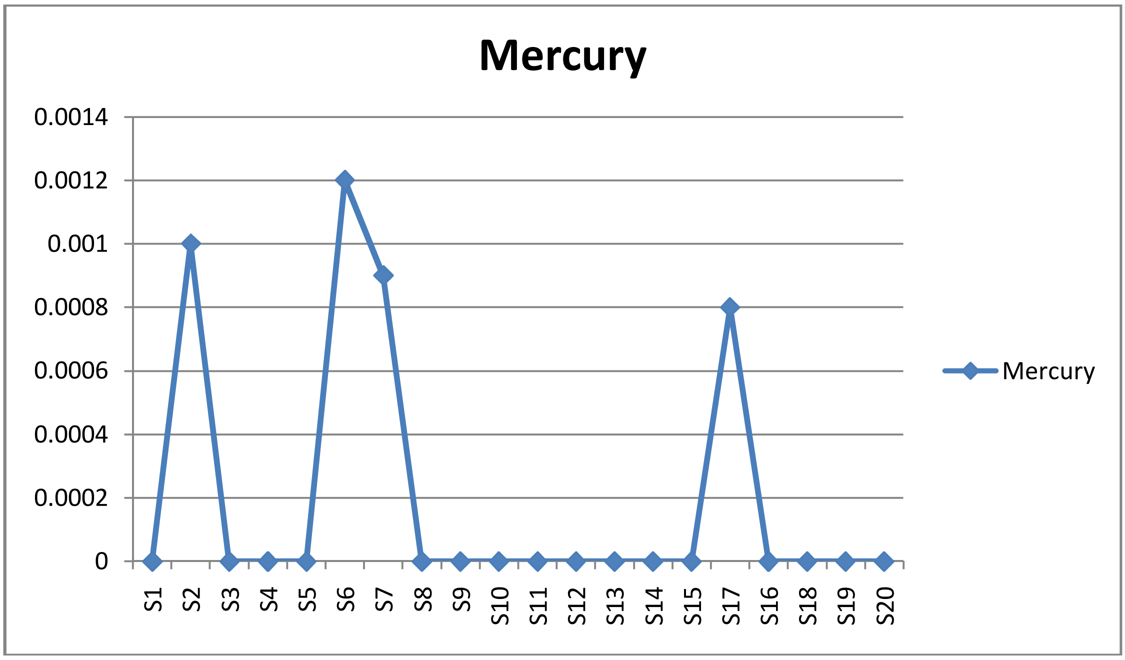

Fig. (26): mercury

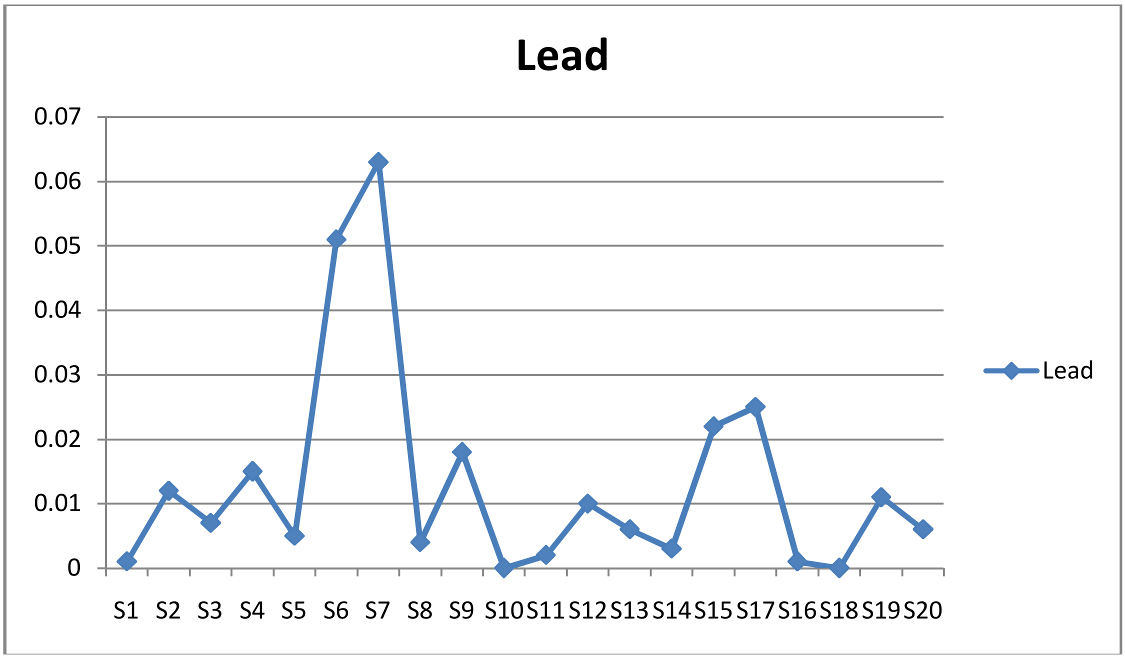

Fig. (27): Lead

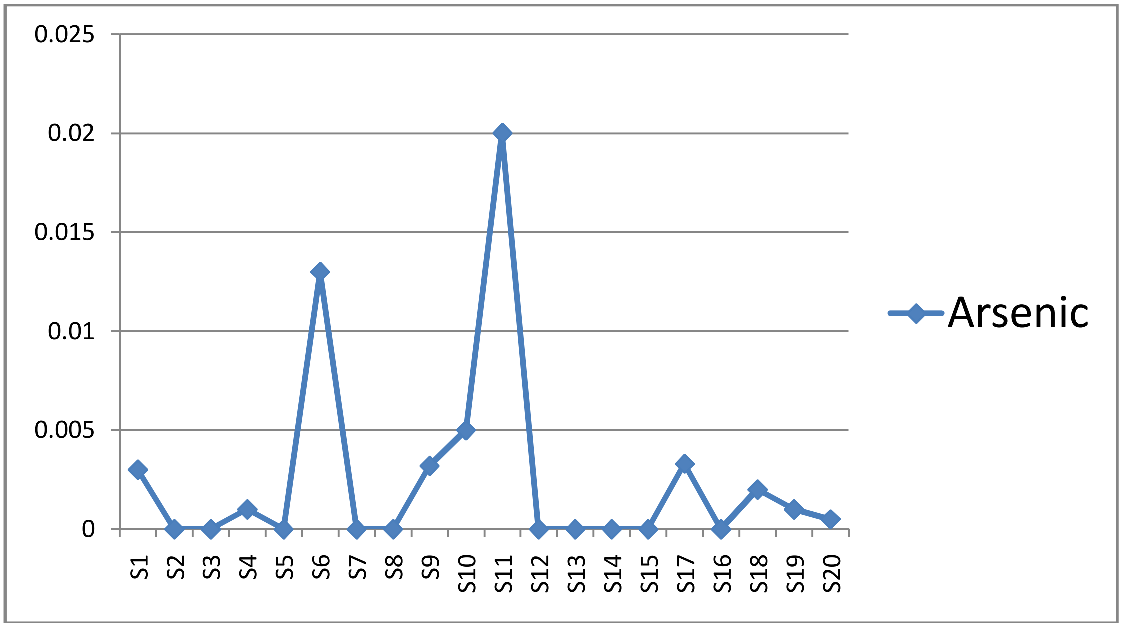
0.025
0.02
0.015
0.01
0.005
0
S1
S2
S3
S4
S5
S6
S7
S8
S9
S10
S11
S12
S13
S14
S15
S17
S16
S18
S19
S20
Arsenic

Fig. (28)

4.RESULTS AND DISCUSSIONS

Data given in Tables (4-3) through (4-7) illustrated the results of some inorganic ions concentrations in twenty locations used as source (wells) for drikingwarer, assigned from (S_1 to S_{20}) ,namely ; El GadeedOmran, El Gadeed El Atsha, El Gadeed El Debab, Al Masudeia well -1, Al Masudeia well -2 , GIAD well -1 , GIAD well -2, El Gadeed El thura-1 well -1 , El Gadeed El thura-1 well -2, Afrotan tannery, Al esfanj , Al rassas , Al hadeed , S.M.A for soap, al allaf, fine fair for sweet , bantio village , Al garia village, Al Munazmma well, and Al mahlajvillage,respectively.

The range and the average value, ± 1SD, of the physical parameters including temperature, conductivity, TDS, salinity, pH and turbidity of the drinking water samples are given in Table (4-3). **Temperature** of the samples was in the range of 19 to 28.6 ^{o}C, with minimum value (19) from(S_6) and maximum 28.6^{o}C from (S_2). **Electrical conductivity (**EC) which is a measure of water's ability to conduct an electric current is related to the amount of dissolved minerals in water, but it does not give an indication of which element is present but higher value of EC is a good indicator of the presence of contaminants such as sodium, potassium, chloride or sulphate[3]. Analysis of the results showed that all the samples have EC value less than the WHO (2008) e.i. (1000 µS/cm) maximum admissible limit. The range of EC of the samples was from 101 to 641 µS/cm, with minimum (173 µS/cm) from S_{18} and maximum (681 µS/cm) from S_{14}. According to WHO (2008), there is no health based limit for **TDS** in drinking water, as TDS occurs in drinking water at concentrations well below toxic effects may occur, but the palatability of water with TDS level of less than 500 mg/L is generally considered to be good [4]. Drinking water becomes significantly and increasingly unpalatable at TDS Levels greater than about 1000 mg/L .TDS greater than 1200 mg/L may be objectionable to consumers and could have impacts for those who need to limit their daily salt intake e.g. Severely hypertensive, diabetic, and renal dialysis patients[3]. Of the samples analyzed an only one sample was found to contain TDS value of greater than 500 mg/L. Highest TDS value (612 mg/L) was recorded in drinking water sample from S_{10} and lowest (163 mg/L) from S_{11}. pH of the samples was between 5.2 and 9.7 for (S16), it is pH laying in the alkaline range. There is no guideline value by WHO for pH but 18 of the samples analyzed were within the US EPA admissible limit (6.5-8.5) . For (S_2) of pH 5.2, the primary cause of a low pH may be due to the addition of acidic rain water. It also may be due to presence of ions in ground water such as nitrates (2.86 ppm) and sulfates (249 ppm) may result in lower pH [6] . A low pH may discolor the water and give a bitter taste [6]. **Turbidity** is a measure of cloudiness of water. It has no health effects[1]. Turbidity can interfere with disinfection and provide a medium for microbial growth. High turbidity may indicate the presence of disease causing organisms[8]. These organisms include bacteria, viruses, and parasites that can cause symptoms such as nausea, cramps, diarrhea, and associated headaches [8]. None of the samples have turbidity value greater than 5 NTU (Nephelometric Turbidity Units), which is the WHO (2008) maximum desirable limit in drinking water .

In the present study, **nitrates** is detected in water only from S_{14} area(11.8 ppm), where nitrates value is above the WHO (2008) recommended value (10µg/L).High levels of nitrates may be due to fertilizer run-off. It may also due to decomposed organic matter (from sewage) or agricultural (from fertilizer)[37]. High concentration of nitrates in (S14) might be due to drainage that may join water sources . Nitrates are especially toxic to children less than six months of age, children who ingest nitrate may not have developed an immune system that can ward off the compound. The condition Known as "blue-baby syndrome" may occur [37] . **Sulfide** is often present in water and wastewater and sewage as a result of microbial action on organic matter under aerobic conditions and from certain industrial wastes[50]. It is a highly toxic material with strong water irritating to eyes, nose and lung, darkens exterior of paints, corrodes and tarnish metals[48].Sulfide level were found to be above the permissible limit recommended by WHO standards i.e. (0.2 ppm) for five samples.The highest value for S_7 (0.280 ppm). H_2S gas usually present in water with high levels of iron and low pH. This slightly high concentration might be due to waste water leaked from aluminum plating , painting or from afrotan tannery waste water. **Chlorides** are leached from various rocks into soil and water by weathering [4]. The chloride ions highly mobile and is transported to closed basins or oceans[8] . Chloride in surface and groundwater from both natural and anthropogenic sources, such as run-off containing road de-icing salts, landfill leaches, septic tank effluents, animal feeds, irrigation drainage, and seawater intrusion in coastal areas[4]. Chloride toxicity has not been observed in humans except in the special case of impaired sodium chloride metabolism, e.g. in congestive heart failure. Healthy individuals can tolerate the intake of large quantities of chloride provided that there is a concomitant intake of fresh water[11]. It has been shown that (S_3,S_{14} and S_{18}) revealed noticeably higher concentration inChloride (294 , 287.3 and 254.3 ppm) respectively. It was found to be above the permissible limit recommended by WHO standards(250 ppm).High concentration in these samples might be due to the use of inorganic fertilizers or landfill leaches from S.M.A. and ELI soap factories in Al Bagair industrial area .

The highest concentration of **Iron** (0. 406 ppm) was detected in (S_7). ; this is almost crossing the permissible limit of iron in drinking water (0.3 ppm).Most ground water has at least trace amounts of iron because its presence in nature is so common [42]. High concentration ofIron in (S6 , S7and S18) sites may be due to acidic water may result in pipe corrosion, causing the possible release of iron into the tap water.It also may be attributed to leaked waste water from stainless steel factory inside GIAD complex. Iron ($Fe^{+2,+3}$) in ground water provides the typical well water "rust" taste [42]. **Copper** is essential metal for all living organisms because of it's key role in many enzymatic reaction. However at high concentration it become essentially pollutant. [74] Contamination of drinking water with high level of copper may lead to chronic anemia. Excess copper intake also induces toxicity indirectly by interacting with other nutrients ..Excess copper intake produces anemia by interfering with iron transport and/or metabolism [75]. Copper was found in the range of 0.004 to 0.820 ppm in the samples. Cu was found very lower in most samples compared to the prescribed limit of WHO (2008) maximum admissible limit of copper in drinking water (1 ppm). Low concentration of copper may be due to the low cupper related industrial activities in the sampling areas.**Zinc** is an essential beneficial metal for human being it enters in water supply and water body from deterioration of galvanized iron and dezincification of brass [76] .Zinc was observed in the range of (below detected limit) for S20 to (2.95 ppm) for S16 which is in the permissible range by WHO (5 ppm). Although Zinc being a cofactor of digestive enzymes such as carbonic anhydrates, is essential for human health but too much Zn can cause health problems, like stomach cramps, skin irritation, vomiting, nausea and anemia. In humans, the liver is the primary organ of copper induced toxicity. Other target organs include bone and the central nervous and immune system[77].**Manganese** level varies from below detection in samples from (S_{20}) area to 18 µg/L from (S_5). WHOs' (2008) limit for manganese is 400 µg/L and none of the drinking water samples analyzed show above the limit. **Nickel** was observed in the range from 0.001 (S_4) to 0.019 ppm (S_{17}), which appears to be belw the WHO prescribed limit of 0.02 ppm. Number of studies have pointed out that Nickel has nutrient importance, where it is engaged in the composition of nucleic acid .how ever nickel related health effect such as cardiovascular has been reported [78].**Cobalt** concentration was found to be below the detection limit in all of the sampling areas .It is concentration ranges from 0.03 to 8.07 µg/L with the maximum (8.07 µg/L) in drinking water sampled from S1 and minimum (0.03 µg/L) from S12. Though the maximum admissible limit, MAL of cobalt is not mentioned by WHO (2008), all the samples analyzed comply the New Zealand (1000 µg/L) and US EPA (100 µg/L) maximum admissible limits of cobalt in drinking water . **Chromium** is naturally occurring element and essential for good health i.e. synthesis of fat from glucose and also for the oxidation of fat to Carbon dioxide[79]. Chromium hexavalent is more toxic than chromium trivalent .It is carcinogenic and is 1000 times as toxic as trivalent chromium [80]. Trace elements originating from various sources may finally reach the surface of the soil and ground water, especially the aqueous chromium, and their further fate depends on soil chemical and physical properties[81]. Hexavalent chromium in industrial wastewaters mainly originates from tanning and painting. As a result of improper treatment prior to discharge[82]. The EPA standard for total Cr is 0.1 ppm, while 0.05 ppm as per WHO standards, in this way we observe that Cr (total) is above the standard value in most of the samples. Higher values of Chromium at (S7 ,S10 and S6) are (1.108 mg/L ,0.925 and 1.11 mg/L) respectively . The relatively high concentration of chromium may be attributed to their sites closed to GIAD complex and afrotan tannery waste water . **Cadmium** content is in the range of (Nil) in S3 and S13 to (0.91) ppm in S6. Its permissible limit as per WHO is less than 0.003 ppm, in this way we conclude that cadmium is higher in most samples. This may be due to waste of electroplating like aluminum industries percolated into ground water[83] **.** The action level for cadmium recommended by the Environmental Protection Agency (EPA) is 0.005 µg/l. Cadmium is consider to be one among the environmentally hazardous metal because it has higher toxicity greater capability of accumulation and retention in the body of organism including human[84]. Drinking water with very high Cadmium levels severely irritates stomach, leading to vomiting, diarrhea and sometimes death. Consuming low level of cadmium over a long period of time can lead to build-up of cadmium in kidneys and causes kidney damage. It also causes bones to become fragile and break easily[85]. In present study the maximum values of **Mercury** in the drinking water samples is found in Site S6 (0.002 ppm) **.** Traces of Mercury were found presence in some water samples (S2 , S7 and S17). All water samples showed the content of mercury within permissible BIS guidelines i.e. 0.001 mg/L except site S6. However the content of Mercury should not exceed 0.002 mg/L as per WHO guidelines .For fetus, infants and children, primary health effect of mercury leads to impaired neurological development[86]. In adults symptoms may include tremors, emotional changes (e.g.; mood swings, irritability, nervousness, excessive shyness), insomnia, neuromuscular changes (e.g. as weakness, muscle atrophy), headaches etc. At higher exposure it may cause kidney damage, respiratory failure and death[86]. **Lead** was found to be in the range of 0.001 ppm to 0.063 ppm which is well above the permissible limit (0.01ppm as per WHO standards). Increase in lead content is indicative of an input from rain water runoff, effluents and house hold sewage sanitation[87]. The study was found to have elevated contents in lead in most samples, suggesting that water drains may be leaking to some extent to ground water. It may also due to the combustion of leaded petrol. Exposure to Lead may have subtle effects on the intellectual development of infants and children[88]. Once in the body, Lead circulates in the blood and either builds up in bone or is eliminated from the body, mostly in urine. Lead can stay in the body for over 30 years following exposure[89]. Health effects associated with exposure to high levels of Lead include vomiting, diarrhea, convulsions, coma or even death[90]. **Arsenic** in drinking water is highly undesirable because of its toxicity[91]. In present work the maximum value of arsenic in drinking water samples collected from S11 (0.020 mg/L) ,which is below permissible limit of WHO values for drinking water *i.e.* 0.05 mg/L.

4.2.CONCLUSION

This study enable us to conclude that, measurement of parameters chosen according to table (4-3) e.i Temperature, EC, Turbidity, total dissolved solids TDS are within WHO. Two samples exceeds WHO maximum value for pH [9.7] and [5.2] . According to table (4-4) ;Nitrate , Chloride ,and total hardness in some samples were found to be above the permissible limit recommended by WHO standards,whilesulphate, sulphide,, Ca, Na, and Mg concentrations within the permissible limit. According to table (4-5) concentrations of heavy metals like Chromium, cadmium, iron and mercury in some samples were found to be above the permissible limit recommended by WHO standards ,while Copper, Zinc lead, arsenic , cobalt and nickel were found almost within the permissible limit in the study area. The level of heavy metals in most samples is high. It may be attributed to their sites next to Giad complex and afrotan tannery waste water dump.

In our knowledge, this is the first comprehensive study of drinking water assessment in the studied area. The results may be applied for other areas with similar levels of untreated waste water to understand the potential threats to groundwater resources.

4.3.Recommendations:

For S6 and S7 sites , it is suggested that water from these bore wells should be totally abandoned and alternative arrangement for water supply be made . Due to the toxic effect of Cr this should be done once again by other researches to verity these results and try to find different solutions for this problem. For effluent of factories in the studied area, reuse should be applied for treated waste water from heavy metals .The treated water may be used in industry or irrigation. Ensuring that suitable clay is placed between the waste and the soil to prevent leakage and seep . This study, therefore, support further study to be conducted on other physical, chemical and biological parameters of significant health concern and on identification of potential sources of the contaminants including heavy metal contaminants.

References

1- Baker,M. N. (1949): The quest for pure water. American water association. Edited by Jahn , S. A.Publ, Germany.

2- 2- Fletcher G.Drisocll.(1989) .Ground water and wells. Second edition Chapter six, p 90-120.

3- Mark J. Hammer (1979): Water and waste water technology.

4- Shelton T.B. (2001): Interpreting drinking water quality analysis, published by Rutgers university .

5- Allen, E.H. and K.H. Nancy, (1972), Design of measurement systems for water analysis, in Lenard .L.C. (ed) ,water and water pollution handbook, p(179 – 197).

6 – American Puplic Health Association (APHA), American Water Work Association (AWWA),Water Pollution Control Federation (WPCF),(1971), Standard methods for examination of water and waste water 13th edition. London.

7- Devirs J; Femeitas F.C.R.(1976) Physical and chemical methods of soil and water analysis (1967) Rom – Italy.

8-Water Quality and Treatment: A Handbook of Community Water Supplies. American Water Works Association. McGraw Hill, 1999.

9-U.S. Environmental Protection Agency. *National Recommended Water Quality Criteria: 2002*. EPA-822-R-02-047. November 2002.

10- Elhussin, I.T.(2000). Analysis of some inorganic constituents of drinking water in Port Sudan area M.Sc. Thesis, University of Gezira.

11- Forrest B. Wright (1976) , Supply and Sanitation, second Edition.

12- Jackson ,M.L.(1985), Soil chemical analysis ,Prentice – Hall, New York

13- Chen Kuo and Ysri Ali Hassan. (1986): A review of the drink in water supply and sanitation sector.WHO Report (Sequ-No. 499).

14-Twort, A.C., F.M. Law and F.W Crowley (1985) : Water Supply third edition.

15- Mark J. Hammer, Kenneth A. Mackichan, (1951),Hydrology and quality of water resources.

16- TWAS. 2002. Safe drinking water-the need, the problem, solutions and an action plan, Third world academy of sciences, Trieste, Italy.

17- Abdalla,A.I.(2001), Analysis of some inorganic constituents of drinking water in Singa Area M.Sc.Thesis,University of Gezira.

18- Abdelsalam,A.M(1984): Ground water investigation El Gamosi rural water administration , Centre regional Wad Medani.

19- Bergh, H. and W. Y.Magar(1956): Micronutrients in Gezira soil and cotton. Min. of Agric. Sudan.

20- Ali M. F. (2003): Determination of individual cations and anions of soluble salts in soils and water of farm No. 3/185 Um sunnut wad medani. M.Sc. Thesis, University of Gezira.

21- Gamareldawla O.E. (2004), Treatment of some inorganic constituents of waste water from the pepsi factory at wad medani by clarifying clays, M.Sc. Thesis, University of Gezira.

22- Abdelgafar,A.M. (1999), Analysis of some inorganic constituents of drinking water in some parts of Gezira state M.Sc. Thesis, University of Gezira.

23- American Puplic Health Organization (APHO) : Standard methods for the examination of water and waste water,18 th edition (1992).

24 – APHA AWWA,WPCF,(1998), Standard methods for examination of water 20th edition and Bilt , E. H.Donald,j. London.

25- Elewa, A. A. 1985.Preliminary analysis of khorwaers in Lake Nasser . Bul. Nat. Inst. Oceanogr. Fish, 11:43 -52.

26- Elewa, A. A. Sayyah , S. H.&Fouda , A. 1990. Distribution of some pollutants in Lake Nasser and River Nile at Aswan . Reg. Symp. Environ. Study. (MNARK), Alex ., 382-402.

27 – Emelyanov , E. M. Moussa, A. A. &Mitropolsky , A. Ju. 1978.Mineralogical and chemical composition of the Nile alluvial deposits. LIthol& Miner. Resour ., 4: 143 – 139

28- Fired, J. J. (1975). *Groundwater pollution* (p. 330). Amsterdam: Elsevier Scientific.

29-Ghulman, B.A., EL-Bisy, M.S & Ali, H. 2008. Ground water assessement of makkah al-mokarama. Proceedings of the 12th International Water Technology Conference, Umm Al-Qura University, Makkah, pp. 1515-1527.

30- WHO(1993):Guide lines for drinking water quality, vol. 1.

31-Clup G. M. and Gordon (1987): Handbook of advanced waste water treatment, second edition , chapter 1. P (11-12).

32- Tothill J. D. (1946) : The origion of Sudan Gezira clay plain

33-Patterson, J.W., 1985. Industrial wastewater treatment technology: Butter Worths: Boston. Petrilli, F.L., DeFlora, S., 1977.

34-Reimann, C, Bjorvatn, K., Frengstad, B., Melaku, Z., Teklehaimanot, R &Siewers, U. 2003. Drinking water quality in the Ethiopian section of the east African rift valley I – data and health aspects. *The Science of Total Environment*, **311**:65-80.

35-Tuzen, M &Soylak, M. 2006. Evaluation of metal levels of drinking waters from the Tokat-black sea region of Turkey. *Polish Journal of Environmental Study*, 15(6):915-919.

36 – Mawda E. M.M. (2009): Detemination of fluoride in drinking water of Khartoum state, M.Sc. Thesis, University of Gezira.

37-Bishnoi, M &Arora, S. 2007. Potable ground water quality in some villages of Haryana, India: focus on fluoride. *Journal of Environmental Biology*, 28(2): 291-294.

38-National Research Council of Canada. Sulphur and its inorganic derivatives in the Canadian environment. NRCC No. 15015, Associate Committee on Scientific Criteria for Environmental Quality, Ottawa (1977).

39-Acharya, G.D., Hathi, M.V., Patel, A.D &Parmar, K.C. 2008. Chemical properties of groundwater in BailodaTaluka region, north Gujarat, India, viewed 23 June, 2010.

40-Hanaa, M., Eweida, A &Farag, A. 2000. Heavy metals in drinking water and their environmental impact on human health. International Conference on Environmental Hazards Mitigation, Cairo University, Egypt, pp. 542-556.

41-Atalay, A., Pao, S., James, M., Whitehead, B & Allen, A. 2008. Drinking water assessment at underserved farms in Virginia's coastal plain. *Journal of Environmental Monitoring and Restoration*, **4:**53-64.

42-Bag **h.,** Turker A.R., Tunceli a., lale m. Determination of Fe(II) and Fe(III) in water by flame atomic absorption spectrophotometry after their separation with Aspergillusniger immobilized on sepiolite, Anal. Sci., **17,** 901, **2001.**

43- Soylak m, Divrikli u, Saracoglu s, elci l. Monitoring trace metal levels in Yozgat-Turkey: Copper, iron, nickel, cobalt, lead, cadmium, manganese and chromium levels in stream sediments, Polish Journal of Environ mental Studies, **11,** 47, **2002**.

44- Patterson, J.W., Minear, R.A., 1975. Physical – chemical methods of heavy metals removal. In: Kernkel, P.A. (Ed.), Heavy Metals in the Aquatic Environment. Ten, USA,pp. 273 – 276.
45-GARDINER, J. The chemistry of cadmium in natural waters. 11. The adsorption of cadmium on river muds and naturally occurring solids. Water Res. 8 (1974), 187-164.
46-HEM, J. D. Chemistry and occurrence of cadmium *and* zinc in surface water and groundwater.WaterResour. Kes. 8 (1972), 661-G79.
47- Ozha, D.D. and S. Rai (1993) : Distribution of nitrates in ground water of arid – zone of Rajsthan , current-agriculture.

48-Booras, S.G. Hydrogen sulphide health effects and recommended air quality standard. NTIS PB-233843, Illinois Institute for Environmental Quality (1974).

49- Faki E. F. M. (2009): Tannery wastes treatment and recycling. M.Sc. Thesis, University of Gezira.

50-Hill, J.M. The acute toxicity of hydrogen sulphide -- a literature review and application to storm sewage discharges. Report ER 675-M, Water Research Centre, Medmenham, U.K. (1984).

51- Mattthess, G., and Pekdeger,A.,1981, Survival and transport of pathogenic bacteria and viruses in ground water. First international conference on ground water quality ,research , Houston, Texas.

52-Standards Australia 1995. AS 4276.6—1995: *Water Microbiology—Thermotolerant Coliforms and* Escherichia coli*—Estimation of Most Probable Number (MPN).* Standards Australia, Sydney.

53-Standards Australia 1995. AS 4276.5—1995: *Water Microbiology—Coliforms—Membrane Filtration Method.* Standards Australia, Sydney.

54Jayana, B.L., Prasai, T., Singh, A &Yami, K.D. 2009. Assessment of drinking water quality of madhyapur-thimi and study of antibiotic sensitivity against bacterial isolates. *Nepal Journal of Science and Technology,* **10**:167-172.
55-Oguntoke, O., Aboderin, O.J &Bankole, A.M. 2009. Association of water-borne diseases morbidity pattern and water quality in parts of Ibadan City, Nigeria. *Tanzania Journal of Health Research,* **11(4)**:189-195.

56-Standards Australia 1995. AS 4276.8—1995: *Water microbiology—Faecal streptococci – Estimation of Most Probable Number (MPN).* Standards Australia, Sydney.

57-EPA - Method 1106.1: Enterococci in Water by Membrane Filtration Using membrane-Enterococcus-Esculin Iron Agar.

58-EPA- Method 1680: Fecal Coliforms in Biosolids by Multiple-Tube Fermentation

59-Standard Methods for the Examination of Water and Wastewater (20th Edition).
American Public Health Association. McGraw Hill, 1999.
60- Canter, L. W., and Knox , R. C. (1985):Septic tank system effects in ground water quality : Chelsea, Mich ,Lwispuplishers, 336p.

61-Critto, A., Carlon, C., &Marcomini, A. (2003). Characterization of contaminated soil and groundwater surrounding an illegal landfill (S. Giuliano, Venice, Italy)
by principal component analysis and kriging. *Environnemental Pollution, 122*, 235–244.
62- Georgat, Sackhein and Ronald M. Schultz ,(1993): Chemistry of health sciences, third edition ,New York , P (114- 129).

63 – Mohammed M. M. B. (2007): Biological treatment of Al nasr tannery liquid waste. M.Sc. Thesis, University of Gezira.

64-Acharya, G.D., Hathi, M.V., Patel, A.D &Parmar, K.C. 2008. Chemical properties of groundwater in BailodaTaluka region, north Gujarat, India, viewed 23 June, 2010, <http://www.e-journals.in/PDF/V5N4/792-796.pdf>.
65-Akoto, O &Adiyiah, J. 2007. Chemical analysis of drinking water from some communities in the brongahafo region. *International Journal of Environmental Science and Technology,* **4(2)**:211-214.
66-Ahmed, A. M., &Sulaiman, W. N. (2001). Evaluation of groundwater and soil pollution in a landfill area using electrical resistivity imaging survey. *Environmental*
Management, 28(5), 655–663.
68- John R.,Sonia,C; Kard, H; Abdul Rashed;(1977), A soil and plant analysis manual adopted for west asia and north Africa region ICARDA (Syria).

69- Adam I. A. (1982). Mineral and micronutrients status of the major soils in the Gezira scheme (Sudan- Africa). Ph.D. degree, college of Texas.

70- Kevie Vander , (1973). Climate zones; the sudan soil survey administration , Wad medani, sudan.

71- Vogel's A.L.(1978): Text book of quantitative inorganic analysis , fourth edition, revised Bassel, J. D., London.

72- Fishman , M.J., ed., 1993, Methods of analysis by U.S. Geological survey national water quality laboratory – Determination of inorganic and organic constituents in water and fluvial sediments :U.S. Geological survey open- file 93-125 ,217 p.

73- Gloterman ,H.L., Clymo R.S.(1969): Methods for chemical analysis of fresh water.(IBP Hand book No. 8). International biological program. London.

74- ATSDR (2002). Toxicological profile for copper (draft for public comment). Atlanta, GA, US Department of Health and Human Services, Public Health Service, Agency for Toxic Substances and Disease Registry (Subcontract No. ATSDR-205-1999-00024).

75-G. E. BATLEP :Determination of the chemical forms of trace metals in natiiral waters, with special reference to copper, lead, cadmium and zinc. Talanta 24 (1977), 151-158.

76-Hanaa, M., Eweida, A &Farag, A. 2000. Heavy metals in drinking water and their environmental impact on human health. International Conference on Environmental Hazards Mitigation, Cairo University, Egypt, pp. 542-556.

77- Oyeku, O.T &Eludoyin, A.O. 2010. Heavy metal contamination of ground water resources in a Nigerian urban settlement. *African Journal of Environmental Science and Technology,* **4(4):**201-214.

78-Ghaedi, M., Fathi, M.R., Marahel, F &Ahmadi, F. 2005. Simultaneous preconcentration and determination of copper, nickel, cobalt and lead ions content by fame atomic absorption spectrometry. *Fresen. Environ. Bull.,***14**:1158-1165.

79-Chromium cycling in soils and water: links, gaps and methods. EnvironHealth Prospect. 92:17-24. Basu, M., Paul, A.K., 1999.

80-Ball, J.W. &Izbicki, J.A., 2004. Occurrence of Hexavalent Chromium in Ground Water in the Western Mojave Desert, California. *Applied Geochemistry*, 19:7:1123.

81-Palmer, C.D., and P.R. Wittbrodt, 1991.Processes affecting the remediation of chromium-contaminated sites. Environ. Health Perspect. 92:25 – 40.

82-Fabiani, C., F. Ruscio, M. Spadoni and M. Pizzichini, 1997. Chromium(III) salts recovery process from tannery wastewaters. Desalination., 10: 183-191.

83-WHO(2004)Cadmium in Drinking-water,Background document for development of WHO Guidelines for Drinking-water Quality, 7 pages.

84-Latino *J.C,* Sears D.C, Portala F., shutter I.L. The simultaneous determination of dissolved Ag, Cd, Pb and Sb in potable waters by ETAAS, Atom. Spectrosc, 16, 121, **1995.**

85-Funari F and Ottavini M (1997). Hygiene and health aspects of drinking water. National Technical information Service (97-98) 180.

86- Bhaskar, C.V., Kumar, K &Nagendrappa, G. 2010. Assessment of heavy metals in water samples of certain locations situated around Tumkur, Karnataka, India', viewed 12 June, 2010.

87- Salonia J.A., wuilloud R.G, Gasquez J.A, Olsina R.A., Martinez L.D. Determination of lead in tap water by ICP-AES with flow-injection on-line adsorption preconcentration using a knotted reactor and ultrasonic nebulization, J. Anal. At. Spectr., **14,** 1239, **1999.**

88-Committee on Biologic Effects of Atmospheric Pollutants. Lead: airborne lead inerspective. Washington, DC: National Academy of Sciences, 1974.

Eary, L.E., and D. Rai, 1987.

89-Cutler J Cleveland (2008). Health effects of Lead. *In:* Encyclopedia of Earth. Environment Information Coalition National Council for Science and Environment. Washington DC.

90-Adverse Health Effect of heavy Metals in Children, Children's Health and Environment (2011).

91-Anawara, H.M., Akaib, J., Mostofac, K.M.G., Safiullahd, S &Tareqd, S.M. 2002. Arsenic poisoning in groundwater- health risk and geochemical sources in Bangladesh. *Environ. Int.,* **27**:597-604.

92-Ganguli, A., and A.K. Tripathi. 2002. Removal and recovery of chromium and chromium speciation with MINTEQA2. Talenta, 57: 23-30.

93-Komori, K., A. Rivas, K. Toda, and H. Ohtake, 1990.A method for removal of toxic chromium using dialysis-sac cultures of a chromate-reducing strain of Enterobacter cloacae. Appl. Microbiol. Biotechnol. 33:117

94- Anawara, H.M., Akaib, J., Mostofac, K.M.G., Safiullahd, S &Tareqd, S.M. 2002. Arsenic poisoning in groundwater- health risk and geochemical sources in Bangladesh. *Environ. Int.,* **27**:597-604.

95-ATSDR ToxFAQs - Cobalt; Environmental HealthCenter, A Division of the National Safety, Washington DC Cobalt Chemical Backgrounder.

96. ATSDR. Toxicological Profile for Manganese. Atlanta, GA: Agency for Toxic Substances and Disease Registry. **2000**.

97-GERBER G.B., LEONARD A., HANTSON P. Carcinogenicity, mutagenicity and teratogenicity of manganese compounds. Crit. Rev. Oncol. Hematol. **42**, (1), 25,**2002**.

98-Anawara, H.M., Akaib, J., Mostofac, K.M.G., Safiullahd, S &Tareqd,S.M. 2002. Arsenic poisoning in groundwater- health risk and geochemical sources in Bangladesh. Environ. Int., 27:597-604.

99-Ros JPM, Slooff W, eds. (1987) Integrated criteria document. Cadmium. Bilthoven, National Institute of Public Health and Environmental Protection (Report No. 758476004).

100-ISO (1985) Water quality — determination of cadmium. Geneva,International Organization for Standardization (ISO 5961:1985).

101- Araya M et al. (2001) Determination of an acute no-observed-adverse-effect level (NOAEL) for copper in water. *Regulatory Toxicology and Pharmacology*, 34:137–145.

102-Buchanan SD et al. (1999) Copper in drinking water, Nebraska, 1994. *International Journal of Occupational and Environmental Health*, 5:256–261.

103-Bidstrup FL (1964) *Toxicity of mercury and its compounds*. Amsterdam, Elsevier.

104-Chiarle S, Ratto M, Rovatti M (2000) Mercury removal from water by ion exchange resins adsorption. *Water Research*, 34(11):2971–2978.