Analysis of the Physiochemical Properties and Some Heavy Metals in Ground Water of ALmanagil Locality, Gezira State, Sudan

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Analysis of the Physiochemical Properties and Some Heavy Metals in
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Date: May/ 2018.
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Date of Examination: 3/May/ 2018.
Dedication

To My father and Mother,

My dear sisters and brothers

And My Friends

Amal
Acknowledgements

I am grateful to Allah who best owed upon me patience, and the opportunity to bring this research to fruition.

I am so grateful my Supervisor Dr. Mohammed Osman Babiker for his guides, he always encourages me to work in this field. He offered me much confidence and freedom to work. I appreciate his helpful suggestions and considerable cooperation. I shall always remember him with gratitude, and god blesses you.

May boundless thank extended to my co-supervisor Dr. Fath ALRahman.

My thank also to all staff of chemistry department in Gezira University.

I am deeply grateful to ALmanar water supply, and geological research laboratory for this for their support and help to use their facilities to carry out this work. And thankful my father, Ahmed Ibrahim, Ismail Hummada.
Study one the Physicochemical Properties and some Heavy Metals in Ground Water of ALmanagil Locality, Gezira State, Sudan

Amal Mohammed Babiker Mohammed

Abstract

Water quality varies from source to another which are largely influenced by natural and human factors. One of the factors is that the levels of various trace elements and compounds in available water supplies vary, due to difference in geological and geographical factors and due to treatment before supply. The aim of the study is to determine the quantity of some heavy metals in water, namely lead, cadmium, zinc, cobalt, and copper, in addition to measure and assessment some physiochemical parameters such as pH, turbidity, temperature, electric conductivity and total dissolved solids. Water samples were taken during Autumn season August 2017. The samples were collected from tap water labeled as follows: the first sample ($S_1$) was taken from Dar Nail North, the second sample ($S_2$) was taken from Dar Nail south, the third ($S_3$) from the eastern area, and ($S_4$) from Aldasees. Lead, Cobalt, Zinc, Cadmium and copper, were determined by direct flame atomic absorption spectrophotometer. Physicochemical parameters were determined using pocket pH meter, Turbidimeter, electric conductivity test pH, temperature, turbidity and TDS, respectively. The results showed that the average value of pH is 7.44, temperature $23.95^0$C, turbidity 3.695 NTU and TDS 496.86 mg/L. All these values are less than the national and international levels standards. Whereas the concentrations of Pb and Cd were 0.2885, 0.006 mg/L, respectively, while Cu, Co and Zn were not detected. However the concentrations of Pb was slightly high compared with the local and international standards. Water of Almangil locality is valid and utilisable. The study recommended the analysis of organic matter. Also recommend a frequent analysis of the water samples using colorimetric methods rather than AAS, which is expensive to run.
دراسة الخواص الفيزيوكيميائية وبعض المعادن الثقيلة في مياه محلية المناقل، بولاية الجزيرة، السودان.

أمل محمد بابكر محمد

ملخص الدراسة

تختلف جودة المياه من مصدر إلى آخر وتتأثر بنسبة عالية بسبب عوامل طبيعية انسانية واحدى ىذه العوامل هو مستوى العناصر والمركبات المتكونة الموجودة في مياه المناقل. تهدف الدراسة إلى تقدير كمية بعض المعادن الثقيلة مثل الرصاص - الكادميوم - الكوبالت - الخارسين والنحاس) في مياه الدراسة وأيضاً قياس الخصائص الفيزيوكيميائية الممثلة في الاش ترسيجيجي، درجة الحرارة، العكارة، الموصمية الكريبي، الاملاح الكلية الذائبة. أخذت العينات في فصل الخريف أغسطس 2012 ثم صنفت كالأتي: العينة الأولى (S1) بئر دار نايل شمال (S2) بئر دار نايل جنوب و (S3) بئر الحي الشرقي (S4) بئر الدسيس. استخدمت في الدراسة جهاز قياس المطيافية الذرية (AAS) لتقدير المعادن الثقيلة. واختبارات الخصائص الفيزيوكيميائية استخدمت أجيزت القياس الآتيو ثيرموميتر جيبي، جهاز العكارة، جهاز قياس الموصمية الكريبي وذرئ قياس pH، درجة الحرارة، العكارة والإملاح الكلية الذائبة. خصصت الدراسة إلى أن متوسط pH 7.44 ودرجة الحرارة 0.44 0°C، العكارة 3.695 NTU ونسبة الأملاح الكلية الذائبة 496.86 مجم/لتر وىي جميعها أقل من قيمة المعياري والمقياس المحلي والمировية لمياه الشرب. أما تحديد المعادن الثقيلة فقد خصصت الدراسة بان تركيز الرصاص والكادميوم 0.02886 و0.066 مجم/لتر على التوالي بينما النحاس، الكوبالت والخارسين لم يتم تحديدها. وهي تشير على أن تركيز المعادن الثقيلة أقل من قيمة الحد الأقصي المسموح به محلياً وعالمياً. هذا الرصاص الذي تركيزه أعلى نسباً من التركيز حسب المعياري المحلي والمировية أوضح النتائج أن مياه محلية المناقل صالحة الاستخدام. أوصت الدراسة بتحليل المواد العضوية وكذلك أوصت بتحليل عينات المياه باستخدام التجفيف اللوني لأنه أقل تكلفه، بدلاً عن جهاز امتصاص المطيافية الذرية.
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Chapter One
Introduction
Chapter One

1.1 Introduction

Human life without water is impossible. Water is not only required for metabolic systems in human body but also required for other associated activities with human life. The specifications of water required for different purposes are different. Distilled water for laboratory, medical factories, minerals in drinking water, industries, agricultural, aquatic cultures, and so forth all diverse. Human body is approximately 70-80% water by weight, with 99.5% of all molecules containing water. Water is the delivery system that carries nutrients to the cells, maintains energy production, and removes toxic wastes from the body. Biological processes including circulation, digestion, absorption, and extraction depend on water to function properly.

Water quality varies from source to source which are largely influenced by natural and human factors. One of the factors is that the levels of various trace element and compounds in available water supplies vary, due to a difference in geological and geographical factors and also sometimes due treatment before supply. Though these trace elements often seem to be very insignificant, they do have an important role in life. The characteristic properties of a complex system and many interesting problems that arise in different spheres are derived or can be explained from the absence or the Presence of specific element at these low level of concentration. So, harmful action of different element is different. If it crosses the limit, it may develop severe diseases for human, animals, and plants and sometimes may cause death. Chromium reduces fatty acids and cholesterol and regulates sugar and insulin rates in the blood, but chronic exposure to high chromium levels causes lung cancer.

Most water quality regulation pertaining to drinking water such as maximum contaminant levels (MCL) and treatment technique requirements for microbial
and chemical concentration are applied before or at the point where water enters the distribution system. Epidemiological studies and outbreaks investigation conducted for several years suggest that a substantial proportion of waterborne disease outbreak, both microbial and chemical, is attributable to problems within distribution systems. In public water supply is distribution systems a more sophisticated and enhanced skill for proper sample collection and preservation, as well as better understanding of aquatic chemistry and biology, is required. Also in many systems the new regulations created a shift in the use of disinfectants in the distribution systems from a relatively simple application of chlorine to rather complicated application and maintenance of chloramines.

Polluted water can be very dangerous for human health and cases of serious diseases are often caused by various bacteria and viruses. Toxic metals such as Cd, Hg, Pb, As and Ni tend to accumulate in certain reservoirs (water, soils, sediments, etc.) from which they may be released by various processes of remobilization and their solubility becomes available to the biological food chain. Metallic pollution of fresh waters may take place from large scale discharge of industrial effluents into the rivers. This poses potential health hazard for human life.

The available information provided general indication of where water–quality constituent concentrations met or exceeded water–quality standards. The elements determined is Pb, Zn, Cd, Cu, Co. Some of the important physicochemical properties of water such as pH, turbidity, conductivity.

1.2 Elements in Nature

Nature is made out of various elements and scientists have agreed on a classification scheme based on atomic mass and electron orbital configuration, which are related to some of the important physicochemical properties of the elements. Classification of elements is given by periodic table, which is
separated into groups, and for the purpose they are represented by three major classes. The first class represented the light metals composed of group 1, 2, and aluminum (1A). They are located on the left–hand side of the periodic table, except for Al. The second class represents the heavy or transition metals, located in the middle of the periodic table. Also included in this class are the elements Ga, Ti, Sn, Pb, Bi, which are referred to as post–transition metals. The third class represents the nonmetals or metalloids right hand side of the periodic table, which includes group 3–7. Finally, a subclass represents those elements found in the atmosphere. It includes the noble gases (group 8) as well as nitrogen (N₂) and (O₂) gases.

1.2.1 Light Metals (Group 1, 2 and Aluminum)
Light metals have low density (<3g cm⁻³) and occur in nature mainly as ionic compound (such as, Na⁺¹ and Ca⁺²) associated with Cl⁻, SO₄⁻², PO₄⁻³, NO₃⁻, and so on. Aluminum is commonly associated with the oxide ion O⁻²(such as, soil minerals). Light metals are used in industrial applications and some serve as nutrients to various organisms and higher plants.

1.2.2 Heavy Metals (transition Metals)
Heavy metals have a density greater than 3g cm⁻³. They are found in nature as elements such as gold or as metal sulfides or metal oxides. Heavy metals are widely used in various industries and also serve as micronutrients to microorganisms and higher plants.

1.2.3 Nonmetals or Metalloids
Metalloids are extracted from the earth’s solid surface. Some metalloids are environmentally important because they react with oxygen to form oxy-anions. Some oxy-anions are toxic to organisms (such as, arsenate, As O₅⁻; arsenate As O₄⁻; chromate, Cr O₄⁻). Other may serve as nutrients (such as nitrate).
1.3 Basic Information about Water Chemistry

Water is made up of two hydrogen and one oxygen. Oxygen has six frontier electron. Four of this electron come in pairs of two; the other two electrons are unpaired chemical bond between two elements take place when the elements donate electrons to each other so that all frontier electrons are paired. In the case of water, the oxygen two unpaired electrons are paired by bonding with two hydrogen's, each donating an electron. After the covalent bonds of the oxygen with the two hydrogen atoms are formed, the oxygen has four sets of paired electrons and each hydrogen has one set of paired electrons. This makes the water molecule stable.

Pairs electrons exert repulsive forces against each other. Bond–forming electron pairs exert repulsive force against each other. Bond–forming electron. It follows that electron–pair distribution in the oxygen becomes skewed and the water molecule "the universal solvent." The two unshared pair electrons pair attract hydrogen's of other water molecules, forming weak hydrogen bonds. When many H₂O molecules are present they create a three–dimensional "scaffolding" of molecules held together by the weak hydrogen bonds. The force created by these weak hydrogen bonds is known as cohesion. Hydrogen bond are also created between water and solid substances such as soil minerals (inorganic or organic). The force that binds water to other solid substances (such as, soil minerals) is called adhesion. Generally, substances exhibiting are known as hydrophobic. Cohesion as well as hydrophobicity are part of many important natural occurrences, such as water retention and movement in soil, as well as solubility of pollutants in the groundwater.

1.3.1 Physical States and Properties of Water

Water is encountered in nature states; (1) the vapor state [H₂O, (H₂O)₂ or (H₂O)₃] at or above 100° C, (2) the solid state (ice sheets of puckered hexagonal rings, at or below 0° C), and (3) the liquid state (between 0 and 100° C) which
is described by the flickering cluster model [ monomers and up to \((\text{H}_2\text{O})_{40}\) molecules ] with an average life of \(10^{-10}\) to \(10^{-11}\) sec.

The forces holding water molecules together and the ideal molecular structure of water, give rise to some of the most important properties of water contributing to supporting life, as we know it, on earth. For example, Table 1.10 shown that water exhibit a rather large surface tension relative to other liquid, which helps explain the potential of water molecules to attract each other or stay together under tension and thus its ability to reach the highest leaves on a tall tree (e.g., redwood). The data in table 1.11 show that water possess the highest specific heat capacity in comparison to the other substances listed, which may help explain freezing of lakes and oceans only on the surface, thus protecting aquatic life. Similarly, the viscosity of water is not being affected dramatically by temperature until it reaches the boiling or freezing point. Finally, the data in reveal the large transformation heat that water possesses relative to some other liquids. One may find water in its liquid phase. Also, because of waters high heat of transformation, its used to heat buildings and to protect crops from freezing.

The potential of water to dissolve other polar substances can be explain on the basis of its dielectric constant. A dielectric constant is a measure of the amount of electrical charge a given substance can withstand at a given electric field strength. Dielectric constant regulates the force of attraction between two oppositely charged particles (such as , \(\text{Ca}^{2+}\) and \(\text{SO}_4^{2-}\)) in a liquid medium (such as, water).

1.3.2 Effects of Temperature, Pressure, and Dissolved Salts

The physical properties of water are subject to change as temperature and/or pressure change. The major physical changes, commonly observed under changing temperature, pressure, and salt content include:

1. Molecular clusters decrease as temperature and pressure decrease
2. Freezing point decreases as salt content increases.
4. Volume increases as temperature increases.
5. Boiling point increases as salt content increases.
6. Surface tension increases as salt content increases.
7. Viscosity increases as salt content increases.
8. Osmotic pressure increases as salt content increases.

Even though water is affected by temperature and pressure, such effects are minimized until the boiling or freezing is reached. Furthermore some of these effects are not as obvious as one might expect. For example, water reaches a minimum volume at 4°C, and below 4°C, its volume starts to increase again, explaining the potential of ice to float in water, helping to protect aquatic life. The solubility of gases in water (such as oxygen, O) also depends on pressure and temperature. This can be explained by the ideal gas law:

\[ n = \frac{PV}{RT} \] (1-1)

\( n \) = number of mole of gas
\( P \) = pressure
\( V \) = volume
\( T \) = temperature
\( R \) = universal gas constant

Considering that water possesses a certain "free" space because of its molecular arrangement, and assuming that this "free" space is negligibly affected by temperature, Equation 1.1 demonstrates that under a constant atmospheric pressure (P), as temperature increases, the expansion potential of the gas causes its apparent solubility to decrease. This explains large fish skills in shallow waters during extremely hot weather, a condition that suppresses the solubility of atmospheric air.

1.4 Hydration

Because of its polarity, water tends to hydrate ions. The phenomenon of hydration is demonstrated, which show three types of water surrounding the sodium ion (Na⁺). The first water layer, nearest the ion, is very rigid owing to
its strong attraction to the actions electronic sphere. Some researchers equate this water's structural arrangement to that of ice. The dielectric constant of this water is reported to be as low as 6, as opposed to 80 for pure liquid water. The next water layer is somewhat rigid with slightly higher dielectric constant (such as .20), and finally, the third water layer is made of "free" water. One may envision the same triple-layer water arrangement on hydrophilic solid surfaces (such as, wet soil minerals). Generally speaking, the greater the charger density of anion, the more heavily hydrated it will be. Anions are hydrated less than cations because of lesser charge density. Cations are heavily hydrated because of their higher charge density, and the process can be demonstrated as follows:

\[ Na^+ + (n + 4H_2O) \rightarrow Na(H_2O)_4(H_2O)_n^+ \]  \hspace{1cm} (1-2)

Commonly, two processes take place when a metal salt is added to water:

Hydration (H_2O molecules adsorb onto the ions).

1.5 Research Methodology

Research depends upon quantitative data obtained from laboratory experiments.

1.5.1 Sampling

The ground water samples are collected from different area of Almanagil locality of the study area (Almanagil locality) in autumn season 2017 sample were analyzed for trace metals (Pb, Cd, Cu, Zn and Co), as well as testing physicochemical parameters.

To determine the trace heavy metals Atomic absorption spectrophotometer (AAS) model AA-7000 shimadzu, Jaban were used. In order to measure physicochemical parameter used pocked PH meter, 2100P turbidimeter-Hach.
1.6 Objectives of the Study
The main aim of this study was to determine the quantity of heavy metals in Almangil drinking water, and this includes lead, cadmium, copper, zinc and cobalt. Moreover assessment and measuring of physiochemical parameters such as pH, turbidity, temperature, conductivity, total dissolve solids, and compare the results with national and international standards.
Chapter Two
Literature Review
Chapter Two
Literature Review

2.1 Introduction
The groundwater resources are the most requested to meet the water to supply population, industrial and agricultural activities. In the world 50% of drinking water, 40% of water intended for industrial activities, and 20% of water for agriculture are groundwater (Foster and Chilton, 2003). The daily water needs of the population increase with population growth. Therefore the concepts of sustainable management of water resources become indispensable. For that one of the major problems encountered in the management of groundwater resources is the evaluation of groundwater recharge to quantify groundwater reserves. Its estimation contains several constraints linked to the topography, the soil, the density of vegetation cover, geological heterogeneity and reliability of hydro-climatic data (Sibanda et al., 2009). Several represents are followed to quantify this parameter which represents the core of groundwater management.
Reviews of groundwater recharge, estimation technique lot of methods were used method is the Hydrological water budget (HWB), Chemical trace [Chloride mass balance (CMB); and isotopic tritium profile method] (Scanlon et al., 2006), and the soil water budget; and the water fluctuation level (WFL) method.

2.2 Ground Water
Most of the Earth’s liquid freshwater is found, not in lake and rivers, but is stored underground in aquifers. Indeed, these aquifers provide a valuable base flow supplying water to rivers during periods of no rainfall. They are therefore an essential resource that requires protection so that ground water can continue to sustain the human race and the various ecosystems that
depend on it. The contribution from ground water is vital; perhaps as many as two billion people depend directly upon aquifers for drinking water, and 40 percent of the world’s food is produced by irrigated agriculture that relies largely on ground water. In the future, aquifer development will continue to be fundamental to economic development and reliable water supplies will be needed for domestic, industrial and irrigation purposes.

2.3 Ground Water in Cities
In the 2000, twenty-three cities of the world had a population of more than 10 million, and are thus classed as megacities. Over half of these rely upon, or make significant use of local ground water. China alone has more than 500 cities, and two-thirds of the water supply for these drawn from aquifers (Chene, 1996). This high urban dependency is mirrored elsewhere in Asia and in Central and South America. Urban reliance on ground water is independent of climate and latitude. Thus, almost a third of the largest cities of Russia meet their water demands mainly from ground water, as do many of the capital of the central and west African countries. It is estimated that that many hundreds of cities worldwide are groundwater dependent.

2.4 Ground Water in Agriculture
During the last 30 to 40 years there has been an enormous rise in food production in many countries through the increased use of irrigation. Much of this irrigation water has been drawn from groundwater as people realise the advantages to increased productivity of timely irrigation and security of application. The rapid rate of growth in irrigation is perhaps best illustrated in India. Where the amount of land irrigated by surface water has doubled between 1950 and 1985, but the area irrigated from aquifers has increased by 113 times so that 1990s aquifers supplied more than half of the irrigated land. Perhaps the best example in the developed world that of the USA which, with the third highest irrigated area in the world, uses groundwater for per cent of its irrigated farmland.
Irrigation can bring many advantages, but poor management can have disastrous effects both on land productivity (for example land salinization in the Indus Basin in Pakistan) and on major ecosystems (for example in the Aral Sea in Central Asia).

2.5 Ground water Contamination
Ground water contamination is nearly always the result of human activity. In areas where population density is high and human use of the land is intensive, ground water is especially vulnerable. Virtual any activity whereby chemicals or accidentally, has the potential to pollution ground water. When ground water becomes contaminated, it is difficult and expensive to clean up.

To begin to address pollution prevention or remediation, we must understand how surface waters interrelate. Ground water and surface water are interconnected and can be fully understood and intelligently managed only when that fact is acknowledged. If there is a nearby river or stream, that water body may also become polluted by the ground water.

2.6 Source of Ground Water Contamination
Ground water can become contamination from natural sources or numerous types of human activities. Residential, municipal, commercial, industrial, and agricultural activities can all affect ground water quality. Contaminants may reach ground water from activities on the land surface, such as releases or spills from stored industrial wastes. From source below the land surface but above the water table, such as septic systems or leaking underground petroleum storage systems; from structures beneath the water table, such as wells; or from contaminated recharge water.

2.6.1 Natural Sources
Some substances found naturally in rocks or soils, such as iron, manganese, arsine, fluorides, sulfate, or radionuclides, can become dissolve in groundwater. Other naturally occurring substances, such as decaying organic matter, can move in ground water as particles. Whether any of these substances appears
in ground water depends on local conditions. Some substances may pose a health threat if consumed in excessive quantities; others may produce an undesirable odor, taste, or color. Ground water that contains unacceptable concentrations of these substances are not used for drinking water or other domestic water uses unless it is treated to remove these contaminants.

2.6.2 Surface Impoundments

Surface impoundments are relatively shallow ponds or lagoon used by industries and municipalities to store.

2.6.3 Active drinking water Supply wells

Poorly constructed wells can result in ground water contamination. Construction problems, such as faulty casings, inadequate covers, or lack of concrete pads. Allow outside water and any accompanying contaminants to flow into the well. Sources of such contaminated fill packed around a well can also degrade well water quality. Well construction problems are establishment of well construction standards and in domestic and livestock.

2.7 Effects of Ground Water Contamination

Contamination of ground water can result in poor drinking water quality, loss of water supply, degraded surface water systems, high cleanup costs, high costs for alternative water supplies, and/or potential health problems. The consequences of contaminated ground water or degraded surface water are often serious. For example, estuaries that have been impacted by high nitrogen from ground water sources have lost critical shellfish habitats. In terms of water supply. In some instances, ground water contamination is so severe that the water supply must be abandoned as a source of drinking water. In other cases, the ground can be cleaned up and used again, if the contamination is not too severe and if the municipality is willing to spend a good deal of money. Follow-up water quality monitoring is often required for many years. Because groundwater generally moves slowly, contamination often contaminated water supply difficult, if not impossible. If a cleanup is
undertaken, it can cost thousands to millions of dollars (a) Containing the contaminant to prevent migration (b) Pumping the water, treating it, and returning it to the aquifer.

2.8 International and Sudanese Standards of Drinking Water

The standard of drinking water quality from country to other, policy statement regarding water pollution control can be found within the legislative frame work of most countries. Identifying chemicals of concern to public health of these chemicals and probability of exposure, in many developing countries and in rural area of some developed countries water quality data are limited and this making Difficult to determine priorities for risk. The measurement and standards of potable water vary from countries to other and between concern agencies. The international and Sudanese standards of chemicals in drinking water are illustrated in Table (1). Whereas illustration the international and Sudanese physicochemical parameters for WHO, European, USEPA and Sudanese standards are shown in Table (2).

Table 1: International and Sudanese standards of chemicals in drinking water

<table>
<thead>
<tr>
<th>Element</th>
<th>WHO</th>
<th>European</th>
<th>USEPA</th>
<th>Sudanese</th>
</tr>
</thead>
<tbody>
<tr>
<td>Copper</td>
<td>0.3</td>
<td>0.3</td>
<td>0.3</td>
<td>0.1</td>
</tr>
<tr>
<td>Cadmium</td>
<td>0.005</td>
<td>0.01</td>
<td>0.03</td>
<td>0.03</td>
</tr>
<tr>
<td>Lead</td>
<td>0.01</td>
<td>0.05</td>
<td>0.005</td>
<td>0.007</td>
</tr>
<tr>
<td>Cobalt</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Zinc</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
</tbody>
</table>
Table 2: The international and Sudanese physiochemical parameters standards

<table>
<thead>
<tr>
<th>Parameter</th>
<th>WHO</th>
<th>European</th>
<th>USEPA</th>
<th>Sudanese</th>
</tr>
</thead>
<tbody>
<tr>
<td>Turbidity(NTU)</td>
<td>5</td>
<td>10</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>pH</td>
<td>6.5-8.5</td>
<td>6.5-8.5</td>
<td>6.5-8.5</td>
<td>6.5-8.5</td>
</tr>
<tr>
<td>TDS mg/L</td>
<td>800</td>
<td>300-1500</td>
<td>500</td>
<td>1000</td>
</tr>
<tr>
<td>Color(TCU)</td>
<td>15</td>
<td>10</td>
<td>15</td>
<td>15</td>
</tr>
</tbody>
</table>

2.9 Heavy Metals

Heavy metals are individual metals and metal compounds that can impact human health if present in water. Five common heavy metals are discussed briefly: arsenic, lead, and others. In large amounts, these metals can be dangerous.

2.9.1 Cadmium

Cadmium is a metal with an oxidation state of +2. Its chemistry is similar to zinc and occurs naturally with zinc and lead in sulfide ores.

Physiochemical Properties

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical state</td>
<td>soft white solid</td>
</tr>
<tr>
<td>Density</td>
<td>8.64g/cm³</td>
</tr>
<tr>
<td>Melting point</td>
<td>320.9 C°</td>
</tr>
<tr>
<td>Boiling point</td>
<td>765 C° at 100 k Pa</td>
</tr>
<tr>
<td>Solubility</td>
<td>soluble in dilute nitric and concentrated sulfuric acids</td>
</tr>
</tbody>
</table>
Cadmium concentration in unpolluted natural waters are usually below 1g/l (Freiberg et al., 1986). Median concentration of dissolve cadmium measured at 110 stations around the world were <1µg/l, the maximum value recorded being 100 µg/l in the Rio Rimao in Peru (WHO/UNEP, 1989). Average levels in the Rhine and Danube in 1988 were 0.1µg/l (range 0.02-0.3µg/l) (ARW, 1988) and 0.025µg/l (AWBR, 1988), respectively. In the sediments near Rotterdam harbor, levels in mud ranged from 1 to 10mg/kg dry weight in 1985-1986, down from 5-19 mg/kg dry weight in 1981 (Ros and Slooff, 1987).

Concentration of drinking water may occur as a result of the presence of cadmium as an impurity in the zinc of galvanized pipes or cadmium-containing solders in fittings, water heaters, water coolers and taps. Drinking water from shallow wells of a raisin Sweden where the soil had been acidic contained concentrations of cadmium approaching 5µg/l (Freiberg et al., 1986). In Saudi Arabia, mean concentrations of 1-26µg/l were found in samples of potable water, some of which were taken from private wells or cold corroded pipes (Mustafa, 1988). 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. In the Netherlands, in a survey of 256 drinking water plants in 1982, cadmium (0.1-0.2µg/l) was detected in only 1% of drinking water samples (Ros and Slooff, 1987).

2.9.2 Lead

Element lead is a heavy metal, soft, bluish metal, and occur in nature in the ores. Once Pb is mined, processed, and introduced into the environment, it is a potential problem forever. There is no technology that will destroy lead or render it permanently harmless. Nearly all of the Pb in the environment is due to mans activities. The history of Pb use is quite extensive Objects made of Pb have been excavated and dated around 6500 B.C. During the Roman Empire, pb production was at 80,000 tons. In the industrial, age of the 1800se
the use of Pb further increased. It was used for a variety of things including: utensils, food storage container lining, pottery glaze, water and sewer pipes, ink, and paint. Much of it, usefulness is due to its plasticity and softness.

Pb in the ambient air exists primarily as Pb vapors, very fine Pb bromide and chloride. The most common sources in the atmosphere are gasoline additives, nonferrous smelting plants, and battery and ammunition manufacturing. In 1985, motor vehicle emission accounted for 81% of Pb emission nationwide. Today, transportation is responsible for less than 30%. The national strategy for controlling Pb has been to decrease the Pb content in gasoline.

As of December 31, 1995 Pb was banned from use in gasoline. Pb emissions from stationary sources have been substantially reduced by control programs oriented toward attainment of the particulate matter and Pb ambient standards. Pb is unique among the toxic heavy metals in that it is relatively abundant in the earth's crust. Natural sources of atmospheric Pb include soil erosion by wind, volcanic dust, forest fires, sea salt, and the decay of radon gas. However, the greatest risk of exposure is from man–mad processes and products. Centuries of mining, smelting and the use of large quantities of Pb have resulted in extensive environmental contamination. Pb is present in food, water, air, soil, paint, and other materials with which the general population comes in contact. Each are potential pathways for human Pb exposure via inhalation or ingestion.

2.9.3 Copper

Copper occurs in nature as the metal and in minerals, most commonly cuprite (Cu₂O) and malachite (Cu₂CO₃(OH)₂. The principal copper ores are sulphides, oxides, and used carbonates. Copper has been known, mined, and used by humans for more than 500 years. It is probably second only to iron in its usefulness to humans. Copper
pipe is used extensively in plumbing, especially for domestic water systems. Copper is used in production of electrical wire and bronze. It is also used in electroplating, in photography, as roofing, as a catalyst in the chemical industry, and for the removal of mercaptans in oil refining. Copper is used extensively in pesticide formulations as a fungicide and antimicrobial agent, particularly for the treatment of wood and water supplies for drinking water and recreational use.

The world in 1981 production of copper from mines was 8.33 percent of the total production. The world production of refined copper was 9.69 million tons. Canada ranked sixth, producing 0.477 million tons.


2.9.4 Zinc

Zinc is a member of transition element; its atomic number is 30, atomic mass 65.39 and density 7.14g/cm³. Zinc alloys an important role as essential trace element in all living systems from bacteria to human (Mohammed, 2014). Zinc is an essential trace element found in virtually all foods and potable water in the form of salts or organic complex the diet is normally the principal source of zinc although levels of zinc in surface and ground water normally don't exceed 0.01 and 0.05mg/l respectively concentration of tap water can be much higher as a result of dissolution of zinc from pipes, the daily requirement for adults men is 15 to 20mg/day (WHO, 2006). Females needs 12mg per day from zinc, drinking water typically contributes about 1% to 10% of this requirement (Raymond, 1999).

Zinc is used in soldering compounds, galvanized wire, batteries, steel words with galvanizing lines, fiber production, newspaper print production and certain paints, other products cosmetics and pharmaceuticals. The major sources of zinc contamination in the aquatic environment are industrial wastes, metal plating, plumbing, and acid mine drainage, presently zinc is not considered mutagenic, carcinogenic, or teratogenic to human (Evanelou, 1998).
Zn is not very toxic significant excesses are toxic and produce signs similar to lead poisoning, concentration above about 3mg/L can give rise to problems with appearance and taste of the water, the equivalent of 40 mg/L zinc cover along period would cause muscular weakness and pain, irritability, and nausea, excess zinc also interferes with the absorption of other trace metals such as copper and iron (Raymond, 1999; Terrence, 2007).

Zinc usually enters the bodies when a person consumes foods, drinks, or dietary supplements containing element. For human and animals, a deficiency of zinc can cause anorexia and growth depression, normally, zinc leaves the body in urine and feces. There are a lot of health effects of zinc if people are exposed with elevated levels. It may interfere with the body's immune system and effect the body's ability to utilize other essential minerals and cause digestive problem such as stomach cramps, nausea, and vomiting. When large amounts of zinc are inhaled, a short term disease called metal fume fever may occur. Scientists doubt that zinc play a role in cancer (Mohammed, 2014).

2.9.5 Cobalt

Cobalt is a naturally occurring element (atomic number 27) in the first transition series of group 9 of the periodic table chart of element Co$^{59}$ is the only stable isotope. There are 26 known radioactive isotopes, of which only Co$^{57}$ Co$^{60}$ are commercially important. Cobalt occurs in the 0.+2, +3 valence state Co (11) occurs in association with other metals such as copper, nickel manganese and arsenic. Small amounts are found in most rocks, soil, surface and underground water, plants and animals. Natural sources of cobalt in the environment are soil, dust, sea water, volcanic eruption and forest fire. It also released to the environment from burning coal and oil, from car, truck and airplane exhausts and form industrial processes that use the metal or its compounds. Cobalt released to water may
sorbs to particles and settle into sediment or sorbs directly to sediment, the distribution coefficient of cobalt varies due to pH, redox conditions, ionic strength, and dissolved organic matter concentration factor affecting the speciation and fate of cobalt in water, sediments and soil include organic ligands such as humic acid anions, pH, and redox potential. The soil mobility of cobalt is inversely related to the strength of the adsorption by soil constituents, although plants may take up cobalt from the soil, the translocation of cobalt from the roots to other parts of the plant is not significant (WHO, 2006 fact sheet, 2001).

Cobalt and its salts are used in a variety of process to make super alloys which maintain their strength at high temperature as paint drier as ground coat for porcelain enameling used on steel bath room fixtures and large appliances and as an ingredient of colored pigments. Some radioactive isotopes of cobalt, such as cobalt-60, are used in treating patients in nuclear medicine and in research. Pregnant women medically treated with cobalt can. Natural cobalt can stay in the air for few days, but it will stay for years in water and oil.

Cobalt is essential in trace amounts for human life; it is a part of vitamin B-12 and plays a key role in the body 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 to very high level of cobalt can cause health effects, effects on the lungs including asthma, pneumonia, and wheezing, have been found in workers who breathed high levels of cobalt in the air, the gastrointestinal effects include nausea. Vomiting, and diarrhea, effects on blood, liver injury and allergic dermatitis.

The international agency for research on cancer in US has determined that cobalt is a possible carcinogen to human (Fact sheet, 2001; 2001 hazard summary, 2000).
Chapter Three
Materials and Methods
Chapter Three
Materials and Methods

3.1 Sampling
The ground water were collected during autumn 2017. In 1L capacity polyethylene bottles. Four samples were collected from different area of Almanagil locality. They are sample $S_1$ from Dar Nail North, $S_2$ from Dar Nail South, $S_3$ from eastern area, and $S_4$ from Aldasses (Table 3). The bottles were labeled with and sampling source. Standard procedures, pH and temperature of the samples were measured while collecting the samples for analysis according to recommended procedures (Kafia, 2009).

The following water quality parameters were determined which were chosen as the major indicators namely pH, TDS, Temperature, and turbidity, And the concentration of five heavy metals include (Lead, Cadmium, Cobalt and zinc).

<table>
<thead>
<tr>
<th>Sample location</th>
<th>Sample symbol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tap water from Dar Nail North</td>
<td>$S_1$</td>
</tr>
<tr>
<td>Tap water from Dar Nail South</td>
<td>$S_2$</td>
</tr>
<tr>
<td>Tapwater from The eastern area</td>
<td>$S_3$</td>
</tr>
<tr>
<td>Tap water from ALdasses</td>
<td>$S_4$</td>
</tr>
</tbody>
</table>

Table 3: Summarized sampling areas and symbols

3.2 Chemicals
All chemicals used in this study were analytical grade:-

(a) Conc Nitric acid: BDH India.
(b) Conc Hydrochloric acid: Aldrich, UK.
(c) Potassium Iodide: BDH UK.
(d) Sodium borohydride (98%) (Smith, 1983).
3.3 Preparation of Reagent

(a) Cs – La interference suppressor: -
400 ml Conc. HCl were added slowly and carefully to 47.09 lanthanum oxide, in 2L pyrex. Beaker. Mixture was stirred until be lanthanum oxide is completely dissolved, then 12.7g Cesium chloride (AR grade) was added and stirred until dissolved. Cool the solution and add it to 800 ml of deionized distilled water. Dilute to 2L with deionized water. This solution contains 5g/L Cs and 20g/L La.

(b) Hydrochloric acid 500ml/L:
500ml hydrochloric acid (conc. AR grade) were added slowly and carefully to 500ml deionized distilled water, contained in a 2L beaker.

(c) Potassium iodide solution ,200g/L:
200 gm potassium iodide (AR grade) were dissolved in deionized distilled water and dilute to 1L with deionized distilled water.

3.4 Apparatus

Each metal Lead, Cobalt, Zinc, Cadmium, Copper determination by atomic absorption spectrophotometer (AAS) model AA -700 Shimadzu. Japan.

For test physicochemical parameters used HG300D –Hach, pocket pH meter, 2100 P Turbidimeter-Hash to test conductivity, pH, temperature turbidity and TDS respectively.

3.5 Preparation of Standard Solution

Standard stock solution of each metal (1000mg /L). were already prepared 100 ml of the standard stock solution each metal (except Cd) were transferred to 1 liter flask and diluted with distilled water to give 100ppm solution. 20 ml of Cd solution were treated in same way. This solution contains 100 mg/L of Zn, Co, Pb, Cu and 20 mg/ L Cd this called stock solutionA. Transfer, by pipette, 100ml of stock solution A to 1L standard volumetric flask, and dilute to 1L with deionized water. This solution contains 10mg/L Co, Zn , Cu and 20 mg Cd. This called working solution B.
Add the following quantities of stock solution B that represent in table (4) to 250ml standard volumetric flaks, each containing 2.5 ml nitric acid and 25 ml cesium–lanthanum solution and dilute to 250 ml with deionized distilled water.

Table 4: Preparation of Standard Solutions

<table>
<thead>
<tr>
<th>Standard NO</th>
<th>Volume of working solution B added ml</th>
<th>Concentration of Cd [mg/L]</th>
<th>Concentration of Cu,Co,Pb,Zn elements [mg/L]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>0.63</td>
<td>0.005</td>
<td>0.025</td>
</tr>
<tr>
<td>3</td>
<td>2.5</td>
<td>0.02</td>
<td>0.1</td>
</tr>
<tr>
<td>4</td>
<td>1.5</td>
<td>0.012</td>
<td>0.06</td>
</tr>
<tr>
<td>5</td>
<td>12.5</td>
<td>0.1</td>
<td>0.5</td>
</tr>
<tr>
<td>6</td>
<td>25</td>
<td>0.2</td>
<td>1</td>
</tr>
<tr>
<td>7</td>
<td>50</td>
<td>0.4</td>
<td>2</td>
</tr>
<tr>
<td>8</td>
<td>100</td>
<td>08</td>
<td>4</td>
</tr>
</tbody>
</table>

3.6 Preparation of Samples

5.0 ml of Cs – La solution were transferred to a 50 ml volumetric flask and diluted to volume with the water sample.

3.7 Processing at AAS

AAS instrument was then used to record the absorbance of standard and sample solutions. Table (5) shown the experimental conditions.
Table 5: Experimental condition for each elements

<table>
<thead>
<tr>
<th>Element</th>
<th>Wave length [nm]</th>
<th>Slit width [nm]</th>
<th>Atomization temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cu</td>
<td>327.4</td>
<td>0.2</td>
<td>1850-2050</td>
</tr>
<tr>
<td>Pb</td>
<td>217</td>
<td>0.5</td>
<td>1200-1300</td>
</tr>
<tr>
<td>Zn</td>
<td>213.9</td>
<td>0.8</td>
<td>1000-1100</td>
</tr>
<tr>
<td>Cd</td>
<td>228.8</td>
<td>0.8</td>
<td>900-2100</td>
</tr>
<tr>
<td>Co</td>
<td>240.7</td>
<td>0.2</td>
<td>2000-2100</td>
</tr>
</tbody>
</table>

3.8 Data Analysis

All assays result were carried out at least three times and average value is reported mean, minimum, maximum.
Chapter Four
Results and Discussions
Chapter Four

Results and Discussions

4.1 Physicochemical Parameters Results

The standard of drinking water quality varies from country to other, policy statement regarding water pollution control can be found within the legislative frame work of most countries.

Identifying chemicals of concern to public health in drinking water is based on the hazard to health of these chemicals and probability of exposure, in many developing countries and in rural area of some developed countries water quality data are limited and this making difficult to determine priorities for risk. In this chapter should be carried out the data of experiments result and correlating with both international and Sudanese criteria.

Samples were collected from study area (Almanageil) they were analyzed for physiochemical parameters such as (turbidity, total dissolved solids, EC, pH, and temp). All ground water samples represented by $S_1, S_2, S_3, S_4,$ are found to be fit for according to the values of different physicochemical parameters of samples that which are summerized in table (6).
Table 6: The result of physicochemical parameters

<table>
<thead>
<tr>
<th>Samples</th>
<th>Parameters</th>
<th>S1</th>
<th>S2</th>
<th>S3</th>
<th>S4</th>
<th>Mean</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>EC</td>
<td>797</td>
<td>1068</td>
<td>884</td>
<td>746</td>
<td>873.75</td>
<td>746</td>
<td>1068</td>
<td></td>
</tr>
<tr>
<td>TDS</td>
<td>438.35</td>
<td>587.4</td>
<td>486.2</td>
<td>395.45</td>
<td>476.85</td>
<td>395.45</td>
<td>587.4</td>
<td></td>
</tr>
<tr>
<td>Ph</td>
<td>7.37</td>
<td>7.37</td>
<td>7.57</td>
<td>7.46</td>
<td>7.44</td>
<td>7.37</td>
<td>7.57</td>
<td></td>
</tr>
<tr>
<td>TC</td>
<td>23.9</td>
<td>24</td>
<td>23.9</td>
<td>24</td>
<td>23.95</td>
<td>23.9</td>
<td>24</td>
<td></td>
</tr>
<tr>
<td>Turbidity NTU</td>
<td>0.72</td>
<td>0.66</td>
<td>2.4</td>
<td>11</td>
<td>3.695</td>
<td>0.66</td>
<td>11</td>
<td></td>
</tr>
</tbody>
</table>
4.2 Physiochemical Parameter Results and Discuss

Firstly physicochemical parameters such as Electrical conductivity and TDS, pH values, temperature, turbidity, has been tested and evaluated. In accordance with the values of different physiochemical parameters for several ground water samples (S1 to S2) the following.

From the results obtained, the electrical conductivity and TDS has strong positive correlation between total dissolve solids and each of electrical conductivity in such ground water samples, attribute to high and lowest values of both TDS and EC, table (6) the values of mean is 324.1 mg/L all this values in acceptable limited (1000 mg/L) of Sudanese standard and as well as that WHO (750 mg /L).

The pH values for all samples (S1 to S4) range from 7.37 to 7.46 (Table 6) the mean is 7.44 all these values are within the acceptable limit (6.5 to 8.5) of Sudanese standards and as well as that WHO.

Temperature for samples waters are in the range from 23.9 to 24°C (Table 6) S1 has lowest temperature while that of S4 is the highest, the mean is 23.95°C all values is acceptable.

The values of turbidity of all water samples range from 0.72 NTU in S1 to 11 NTU in S4 (Table 6) and the mean is 3.695 the values except S4 are within the acceptable limit (5 NTU) of both Sudanese standard and WHO.

4.3 Heavy metals Analysis Results and Discussions

The water samples from Almanagil has been analyzed for determination heavy metals cadmium, copper, lead, zinc and cobalt.

For all samples represented by S1 to S4 have assessment and the recorded results illustrated in table (7).

The results achieved indicate that, the concentration of the elements were mostly below the maximum allowed concentration. However, the concentration of Pb in all waters samples was relatively high, when compared to the Sudanese and WHO values 0.007, 0.01 ppm, respectively.
The metals concentrations were found to be within the prescribed national and international limits.
Table 7: The result of chemical analysis (ppm)

<table>
<thead>
<tr>
<th>Metal Conc. in ppm</th>
<th>Sample</th>
<th>S₁</th>
<th>S₂</th>
<th>S₃</th>
<th>S₄</th>
<th>Max</th>
<th>Min</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pb</td>
<td></td>
<td>0.329</td>
<td>0.175</td>
<td>0.314</td>
<td>0.336</td>
<td>0.336</td>
<td>0.175</td>
<td>0.2885</td>
</tr>
<tr>
<td>Cd</td>
<td></td>
<td>0.013</td>
<td>0.004</td>
<td>0.002</td>
<td>N.D</td>
<td>0.013</td>
<td>0.002</td>
<td>0.006</td>
</tr>
<tr>
<td>Co</td>
<td></td>
<td>N.D</td>
<td>N.D</td>
<td>N.D</td>
<td>N.D</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Cu</td>
<td></td>
<td>N.D</td>
<td>N.D</td>
<td>N.D</td>
<td>N.D</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Zn</td>
<td></td>
<td>N.D</td>
<td>N.D</td>
<td>N.D</td>
<td>N.D</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>
The concentration of Lead in water samples is high, that indicates the presence of element in soil is very high, it may be leaches and percolates to ALmanagil aquifer enhanced this result the shadow wells (traditional) represent by S₂ and S₃, their concentration is relatively low compared to S₁ S₄ and which represent boreholeble wells from Almanagil. According to table (7) the max value is 0.336 in S₄ whereas min values 0.175 in S₂ and the mean 0.2885 ppm. All this range above the permissible values.

The Cadmium values for samples range from 0.013 S₁ is highest to 0.002S₃ is lowest and the mean equal 0.006, all this concentrations fall in acceptable water supplies is 5ppm (Table 1).
Chapter Five

Conclusion and Recommendations
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5.1 Conclusion

The physicochemical characteristic of drinking water is important, identification and qualification of these elements in drinking water become necessary. Because the absence or, the presence of specific elements at low levels concentrations lead to harmful action, if it crosses the limit, it may develop severe problem to human, animals and plants.

The main aim of this study is determination some heavy metal (Pb, Zn, Cu, Co, Cd) in underground water of different areas in Almanagil city, however, the study investigation to physicochemical parameters such as temperature, turbidity, TDS, electrical conductivity, and pH. The result shown that all physicochemical parameter within the permissible values of local and international standards, where the results of heavy metals analysis indicates that concentration of Pb in all waters samples were relatively high, when compared to the Sudanese and international standard.

5.2 Recommendation

- The quality of ground water vary with time according to many climate conditions this changed the geochemical of aquifers therefore sometime
- Need evaluating after time by other.
- A change in the drinking water sector approach from a demand responsive approach calls for full community participation, and they defined in terms of their primary role as users clients.
- It is always better to protect water from contaminants than to treat it after it has been contaminated.
• Control the environmental pollution by avoiding adding of waste water and litter to the underground aquifers.

• This study will help to have a better idea in taking further steps for possibly enhancing the quality of water in Almanageil. The study recommended the analysis of organic matter. Also recommend a frequent analysis of the water samples using colorimetric rather the AAS.
References


WHO. (2006). Core question on drinking water and sanitation for household surveys.
