# Analytical Study of Sirt Drinking Water Obtained from Desalination Plant

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بسم الله الرحمن الرحيم

(( وَهُوَ الَّذِي مَرَجَ الْبَحْرَيْنِ هَذَا عَذْبٌ فُرَاتٌ وَهَذَا
مِلْحٌ أُجَاجٌ وَجَعَلَ بَيْنَهُمَا بَرْزَخًا وَحِجْرًا مَّحْجُورًا ))

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سرت

إن الديمقراطية ليست غاية في حد ذاتها
وإنما الغاية هي خلق الإنسان النموذجي الجديد

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## Faculty of Science
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Title of Thesis

# Analytical Study of Sirt Drinking Water Obtained from Desalination Plant

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## Chapter III

## 3. Results and Discussion

## 4. Conclusion and Recommendations

## *Dedication*

*To*
*My father and mother*
*My brothers and sisters*

*My beloved husband*

*My beloved son*

*Hanan Ali Ali Omar Emlettaan*

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# ABBREVIATION

| | |
|---|---|
| WHO | World Health Organization |
| GMmR | Great Man-made River |
| LS | Libyan standard |
| MPN | Most Probable Number |
| CFU/1m | Colony Forming Unit Per 1ml |
| EC | Electric Conductivity |
| TDS | Total Dissolved Salts |
| Ca-H | Calcium Hardness |
| FCF | Faecal Coliforms |
| SD | Standard Deviation |
| TC | Total Count of Bacteria |
| TCF | Total Count of Coliform |
| TH | Total Hardness |
| +Ve | Positive test |
| -Ve | Negative test |

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# ABSTRACT

# Abstract

This study focused on chemical and biological parameters of Sirt drinking water obtained from desalination plant. The researcher observed that the desalination plant produces water without chemical treatments which gives the produced water the required level of salts for drinking water. The researcher established a mini chemical treatment unit in the plant laboratory to suggest suitable method of treating the producing desalted water to overcome the problem and provide a healthy and save drinking water that meet with the required standards.

A total of 15 sites were selected for samples water analysis. Chemical and biological parameters were determined and compared to the WHO and Libyan Standard.

From the results of physical and chemical analysis it can be observed the fluctuated values during period of the study specially production of plant the sample (2) due to breakdown of plant between period and other, and corrosion and erosion in units of plant. In addition, the production water of plant is unsuitable as potable water according to international drinking water standards (WHO) and the Libyan standards as a result of the produces water without chemical treatment. but, the outer samples of plant were suitable as drinking water where mixed by ratio 3:1 water of GMmR with desalted water from the plant in company reservoir for gives the production water the required level of salts for drinking water, but mostly use the random mixing is for fluctuation of water quality for studied samples in addition to the transport of water *via* unhealthy, old and unsuitable trucks to the consumers, and the contamination in perception reservoir sample (2) which supply water to plant from seawater.

Results of biological analysis indicates that the highest count values of total count of bacteria (T.C) of collected samples was in sample (9) mixing water 3:1 GMmR water with desalted water which was (>300CFU/1m) in June, September and December. However, the highest value of total coliform (T.C.F) values of collected samples was found in samples (1), (2), and (7) which reached 4CFU/100 ml. The total coliform feacal (T.C.F) shows contaminated by E.coli bacteria in perception reservoir sample (2).

It is noticed that lack of maintenance of plant leads to low quality of produced water. Furthermore, the corrosion of the plant units, in addition there are two factors contributing in the contamination of environment which are: opened Precipitation reservoir (feeding of the plant) and the smoke rise from the plant.

# Chapter I

## *INTRODUCTION*

## Chapter one: Part I

## 1. Introduction

### 1.1. An overview

Water is the basis of life. and the problem of water will always remain as a mysterious phenomenon that confronts human beings and should be treated wisely with long-term planning. Most water on earth is found in seas and oceans (72.8%) and accounts for 97.2% of the total amount. The remaining 2.8% is metaphorically considered as useful drinking water. 2.1% is found as solid snow and 0.001% as vapour water that is found in the aerosphere, only 0.6% is fresh water (Asillawi. 1989). Therefore, most of the water on earth is salty and not used in agriculture, industry and drinking. Consequently it becomes more important to think seriously about providing a useful source of water to fill the gap in natural drinking water in many parts of the world. One way of producing useful drinking water is desalination which is the process of removing salt from seawater; it has been used in many arid countries around the world to provide a reliable source of drinking water. The process dates back to the 4th century B.C (Asillawi. 1989).

Desalination separates saline water into two products: fresh water and water containing the concentrated salts. or brine. Such separation can be accomplished by a number of processes. The three most common processes are distillation. electrodialysis, and reverse osmosis (Spiegler & laird. 1980). Distillation works by heating salty water to produce water vapour which then condenses to form fresh water. Both the electrodialysis and the reverse osmosis processes use membranes to separate salts from water (Spiegler & laird, 1980). Sirt city in Libya lacks fresh water because of it is location next to the Mediterranean coast. Sirt desalination plant pumps desalinated water into the drinking water network. This water has to be treated and its natural properties may be changed due to the type of pipes being used and its mixing process with water from other artesian wells that are pumped simultaneously in the network.

## 1.2. Nature Water

The classification of greatest geologic interest is a genetic classification of subsurface water. Eventually somewhat detailed genetic classification may be possible; at the present, however, even the most general genetic classifications are filled with uncertainty. The main problem in water lies in its distribution around the world, availability, and quality (Fellmann *et al.*, 2003). Despite the fact that the total amount of water on the earth is enormous, only a small part of the hydrosphere is suitable or available to be used by human beings, plants, or animals. Less than 1% of the world's water supply is available for human use in fresh water lakes and from wells. An additional 2% is effectively locked in glaciers and polar ice caps (Fellmann *et al.*, 2003; Baeneeowe, 1996; Gleick, 1996).

The total amount of water on the ground and under it is estimated to be 1500 million cubic km. Some of this water is chemically related to substances that compose the atmospheric cortex with different chemical bonds and this water is known as water of crystallization and it amounts to 230 million cubic km. This amount of water decreases yearly by 170 cubic km, this quantity comes to the atmospheric surface and is known as juvenile water and this increases the amount of sources of surface ground water (Gleick, 1996). Hence, we find that the amount of free water is estimated to be 1270 million cubic km and this quantity equals the amount of water with a thickness of 2700 m above the surface of the atmosphere which amounts to 510 million cubic km water and land or equals the thickness of 3700m above the total area of seas and oceans only which amounts to 361.1million km$^2$. Despite the vast amount of water, in terms of quantity we find that about 97.2% of it is saline water which is not used in agriculture, industry or drinking (Davis and DeWiest , 1996) .

There is a quantity of water estimated to at 2.1% as solid snow and vapour water amounting to 0.001% which is found in the atmosphere therefore, this kind of water cannot be use for any human purposes (Montgomery, 2003).

The remaining quantity above 0.6% of the total amount of water in the world equals 8.36 million cubic km and is found as surface water in lakes, streams, and rivers and underground and surface water, and ground humidity found on the land and amounts to 148.9million km$^2$ (Asillawi, 1989; Al-Gariiri and Al-Sallhi , 2004).

### 1.3. Water pollution:

Water pollution problems have been known since ancient times. The early historical evidence of such problems are seen in the descriptions of changing Nile water into the colour red in certain periods, especially flood seasons, hence flood water carries a great amount of basic nutrient elements which increase phytoplankton's reproduction in greater rates and its spread on wide areas of water makes it change to the colour red . In modern times population growth and the development of a variety of industrial activities causes continually increasing pollution of rivers, seas, and ocean water to the degree that most rivers, lakes, and sea coasts are incapable of auto fining Abd-Aljawad (1989). In 1961 WHO issued the following definition of fresh water pollution:

water stream is considered polluted when its elements structure changes or its position changes directly or indirectly because of mankind's activity. whosesoever, this water becomes less suitable to its specialized or specified natural uses (lafoun. 1977;Baahasi and Al-Auoodat, 1997).

This definition includes water changes in terms of natural, chemical and biological properties which may make water useless for drinking, home, industrial, and agricultural consumption according to thermal changes resulting from thermal pollution (lafoun, 1977; Baahasi and Al-Auoodat, 1997).

There are many possible sources of chemical contamination; these include wastes from industrial chemical production, metal-plating operations, and pesticide runoff from agricultural lands. Some specific pollutants include industrial chemicals such as chlorinated hydrocarbons; heavy metals, including cadmium, lead, and mercury; saline water; bacteria, particularly Coli Forms and general municipal and industrial wastes (Manahan, 2000).

In Libya most industrial systems are linear (unrecycled); they move in one direction. In other words, the water is used and then dumped with out reuse and with out any attention given to the impact of dumped water on the environment (Bindra, 2003).

The effects of anthropogenic activities, industrialization and urbanization on the accumulation of heavy metals and nutrients in sediments on water quality have been investigated. The contamination by heavy metals represents one of the serious problems to water supplies due to the discharge of raw or insufficiently treated industrial waste into waters or waste dumping (Zhao *et al.*, 2002; Cheung *et al.*, 2003).

Many chemicals have contaminated water supplies. These include insecticide and herbicide runoff from agricultural land, and industrial discharge into surface waters. Also, there is a threat to groundwater from waste chemical dumps and landfills, storage lagoons, treating ponds, and other facilities (Baahasi and Al-Auoodat, 1997; Viessman and Hammarr, 2005). General types of water pollutants include trace elements, heavy metals, inorganic pollutants, algal nutrients, acidity, alkalinity, salinity in excess, trace organic pollutants, pesticides, petroleum wastes, sewage, human and animal wastes, pathogens, detergents, sediments, taste, odour and colour, asbestos and radio nuclides. Sources of polluted runoff are acid rain, automobiles, and combined sewer overflows, construction sites, erosion, excess fertilizers, herbicides, and insecticides, faulty septic systems, faecal deposits from domestic animals and wildlife, improper disposal of chemicals. One of the reasons for pollution of potable water is through use of the plastic pipes (Holsen *et.al.*, 1991; Manahan, 2000).

## 1.4. Water analysis

### 1.4.1 pH

pH value is one of the most important values used in analyzing water. The pH indicates activity and efficiency of hydrogen ion in water. pH value in natural water is usually balanced, light base or acidic, and it is generally located between (4-9). A raising or lowering in this value is due to the existence of water pollutants. Most natural water tends lightly towards the base as a result of the existence of carbonate and bicarbonate in it.

A decrease of pH value in water affects the balance of carbonate and bicarbonate, which leads to in the release of $CO_2$ gas. Consequently this can affect the life of water livings. However, if the value of pH is lower than 4.5, this will lead to melting some materials such as iron, aluminium and magnesium which in turn increases the concentration of these metals in water. Therefore, when treating water it is important to indicate that the pH value should be known before and after its entrance to the treating stations and during the stages of treatment. because of its direct effect on operations inside stations and on the transportation tubes (Abaadi. 1990; Pontius & Clark. 1999).

### 1.4.2. Hardness

The ability of water to sedimentate soap is called hardness. The hard water is the water that requires a quantity of soap to give foam. Salts of hardness are found in the form of carbonate, bicarbonate, chlorites, sulphates and nitrates of calcium, magnesium and iron ions. Hard water is found when the rain falls on the ground and solves salts. Solvability of salts with rain water is due to the existence of $CO_2$ gas in the soil.

Sea water is the natural water that contains high concentrations of sodium irons which cause soap sedimentation which fills water with foam due to the quality of common ion, but it is not accounted from the hard water because sodium does not cause the hardness, and this is called pseudo hardness (Abaadi, 1990; WHO, 2004).

According to the water resource, the hardness of water differs. Therefore surface water has less hardness than ground water in sequence with the geological feature of the ground on which water flows and passes through. The measure of hardness is an important issue according to which different water uses are determined and considered as a basis in designing desalination units. Hardness results from other causes. such as iron especially when found in water with important concentrations. This must be taken into consideration. knowing that their concentrations in natural water are few because of its solvability in water in the natural pH of drinking water. In the Tripoli water network it was noticed that high value of water hardness increases led to blocked tubes of the water network and the damage to heaters in a very short period (Al-Asaawi, 1998).

Hard water also damages clothes quickly as a result of sedimentation of iron salts which is oxygenated to produce ferrite which leaves red spots on the fabric.

### 1.4.3. Alkalinity

Alkalinity can be defined as the measure of water's ability to balance the level of acid to a certain value of pH. The existence of this alkalinity in natural water is in accord with the existence of the light salts of acids and the light and strong salts of alkalis such as salts of carbons and bicarbons. These form the greatest part of alkalinity in addition to the hydro-oxides which increase the alkalinity in water whereas the salts of boracites and silicates represent a low amount of alkalinity in water.

Alkalinity can be classified according to the pH value, therefore, water that has more than 4.6 value of pH will contain alkalinity, and water that has a value of 9.5 of pH will contain hydroxide alkalinity (Abaadi, 1990).

In most kinds of water, alkalinity is found in three basic states: Carbonate alkalinity, Bicarbonate alkalinity and Hydroxide alkalinity. These three types correlate with each other. Hence, any change in the concentration of each will change this equilibrium and consequently will change the pH value. There is another reason behind the increase of alkalinity in water; this is the growth of parasites that consume dioxide carbon from water during day time. The high amount of alkalinity causes the erosion of tubes and boilers, so it is very important to determine the alkalinity of water for the purpose of determining its uses and to control erosion, treat water and solve the problems of parasite growth (Abaadi, 1990; Trudgill *et. al.*, 1999).

### 1.4.4. Electrical conductivity (EC)

Electrical conductivity is defined as a numeral value that shows the ability of water to carry an electric current. This value depends directly on the concentration and equivalent of the solvable ions that are found in water with water temperature while measuring, because they have a direct effect on the motion and direction of different ions. The EC of water increases at the rate of 2% when its temperature increases by one degree percent (Patnaik. 2004; Pierce *et al.* 1984).

Most of the non-organic acids, alkalis, and salts, which are solvable in water, are good conductors for electrical current, whereas the organic salts and acids are bad conductors because they are lightly ionized in water (Abaadi. 1990).

### 1.4.5. Total dissolved solids (TDS)

The Origin of Total Dissolved Solids in drinking-water from natural resources, urban runoff, industrial waste water and sewage. Concentrations of TDS in water vary considerably in different geological regions. They consist of inorganic salts such as potassium, calcium, sodium, magnesium, sulphates, chlorides and bicarbonates in addition to amounts of organic matter that are dissolved in water. The limited value of TDS should not be more than 1000mg/L, and the standard also recommends that the ideal limit in drinking water is 500mg/L (WHO. 2004).

### 1.4.6. Turbidity

Turbidity is caused by the existence of hanged matter in water such as soil, sand, mud, organic furry bodies and the other microscopic livings (WHO, 2004).

The volume of bodies that cause turbidity in water is estimated to be 10nm (about 0.1mm). It is also possible for organic turbidity to result from the accumulation of microscopic livings with amounts that are enough for the water to have unpleasant taste and turbid colour. an example of this turbidity is the blue parasites that are green in summer in surface water. The healthy side of turbidity is that if it exceeds the indicated value which is 5 units of turbidity on NTU, water will be unacceptable for the consumer (WHO, 2004; Abaadi, 1990).

### 1.4.7. Temperature

Temperature plays a vital role in soluble matters and gases in water particularly in dissolving oxygen and carbon dioxide. In addition, it is an important factor in determining the activities and efficiency of hydrates and bacteria (Abaadi, 1990). The temperature of water depends on the season and the temperature of the earth. In surface water, the temperature is affected by the raising and lowering of the level of sea surface, the season, the sun, flow and depth of water.

As the temperature increases, the speed of the chemical reactions in water will increase with the increasing of evaporation and flutter out of some matter from the water. Increased temperature also decreases the solubility of gases such as oxygen, carbon dioxide, nitrogen and ammonia. It also affects the micro livings in water. In warm water the rate of breathing increases, therefore, this increases the consumption of oxygen which in turn increases thermolysis of organic matters. And also the growth of bacteria will be multiplied which subsequently increases turbidity of water. It is important to indicate that the best degree of temperature for drinking water is between 7 and 11°C; at this rate water has a good and refreshing taste, because soluble gases in water will be decreased in hot water, and its taste won't be good and won't stop thirst (Aoown, 2000).

Temperature also has an effect on corrosion in the systems of water treatments; it increases according to the increase of temperature (WHO, 2004).

### 1.4.8. Colour

Natural water gains a colour because of the existence of some ions such as iron and magnesium or resulted from the black matter humics which is residue from the corrosion of plants and animals that exist in water or because of the existence of the little pimples of soil, plants and parasites or as a result of throwing domestic and industrial residues into it (Abaadi, 1990).

Colour and turbidity in water determine the depth that can be reached by light. Pure water is colourless in shallow levels , but it is bluish-green in deeper levels , natural water ranges in its colour from less than five degrees in pure water to three hundred degrees in water with dark colour (Aoown, 2000) .

### 1.4.9. Taste & Odour

The taste of water is the feeling resulting from the reaction between saliva and dissolved matters in water. Odour usually indicates abnormal biological activity and may be of natural or man-made origin (WHO, 1984). Hot water increases the rate of degeneration and digestion that cause odour. Also pH and its different levels affect the rate of chemical reactions within matter that cause odour. The need to investigation taste and odour increases when the control on odour should be in stations of treating water (Abaadi, 1990). Problems of taste and odour are considered to be the most familiar problems of consumers.

### 1.4.10. Sulphate

Sulphates are found in water. They have limited solubility, so their concentrations are low in surface water but they increase in ground water. Most sulphates either originate from the melting of sulphate oxides by rain water which are thrown into the air as a result of scorching fuel that finally goes to water, or as a result of dissolving sulphate structures that are found in terrestrial cortex by water, or as a result of throwing liquid residues that contain sulphate, particularly residues of fertilizers, paper and oil filtering industries.

Sulphates are considered to be one of the factors that cause permanent hardness of water and also cause saltiness when their concentration is more than 200 mg/L (Abaadi, 1990).

### 1.4.11. Chloride

Chloride is considered to be the most important negative ion that exists in natural water and gives water the salty taste specially when it joins with another ion and forms sodium chloride (NaCl). The existence of chloride ions in high concentration gives mineral tubes an erosive effect in addition to its effect on plants (Abaadi, 1990; Reeve, 1994).

Determiners of taste for chloride in drinking water have levels: 210 mg/L for Sodium Chloride, 310 mg/L for Potassium Chloride, 222 mg/L for Calcium Chloride. All these levels are within the rate of chloride concentration 200-300 mg/L (WHO, 2004) whereas the concentration of chloride in sea water reaches 2000 mg/L. (Abaadi, 1990). Concentration of Cl in drinking water varies according to the nature of the rocks through which the water passes.

### 1.4.12. Calcium and Magnesium

Calcium and magnesium are alkaline earth metals. Magnesium is found in water with various concentrations and it is mostly found in mineral water and seas, whilst in hard water, concentrations of calcium and magnesium increase on account of two alkaline elements which are sodium and potassium .

Calcium is related closely to the hardness, concentration of Ca & Mg in natural water should not exceed 200 and 50 mg/L respectively according to WHO standards (WHO, 2004).

### 1.4.13. Potassium and Sodium

Potassium is found in drinking water with very little concentration, about 20 mg/L, whereas in salt water it can be more than 100 mg/L (Abaadi, 1990; WHO, 2004).

In ground water, levels of sodium differ largely but naturally it is about 130.6 mg/L, and the high levels are related to salty soils. But in surface water, sodium concentration may be less than 1 mg/L or more than 300 mg/L in accordance with the geographical area (WHO. 2004). Salts of sodium cannot cause sedimentation or participate in raising the hardness of water, but it can raise alkalinity of water *(*Asillawi. 1989*)*.

Sodium and potassium are usually accounted together because of the difficulty of chemical analysis and the monologic importance is considered jointly. In addition, both of them belong to alkaline elements that have similar chemical characteristics and properties.

### 1.4.6. Nitrogen compounds

Nitrogen compounds are found in water in many forms such as nitrate, ammonia and organic nitrogen in addition to nitrogen gas and all of them are part of the components of the nitrogen cycle in nature and the sources of these compounds in water are variable.

Sources include the use of fertilizers, materials of dead plants and animals, liquid domestic residues, land drainage, industrial residues and leakage of refuse collections (Abaadi, 1990; WHO, 2004).

Levels of nitrate in water are less than 5 mg/L (Binahmeeda, 1997; Al-Asaawi, 1998; Salameh *et. al.*, 2002) but it may be found with levels more than 10 mg/L in some small sources of water. Many studies demonstrate that nitrate levels are in the range of 20 to more than 200 mg/L, but this seldom occurs. The maximum allowed limit of nitrate in drinking water is 45 mg/L (WHO, 2004).

### 1.4. 7. Metals

The existence of some metals in natural water, domestic water, and industrial residues is a critical problem because of their toxic property, especially through daily use which eases the leakage of it to the environment and particularly to water where the existence of some metals with certain concentrations is toxic and harmful. Some metals are not harmful; rather, they are essential for the nutrition of hydrological livings and necessary for their growth such as calcium, iron, potassium and sodium. High concentration of metals such as Cu, Ni, Cr, and Fe in water may harm and poison hydrological livings because of their toxic effects, and that is because metals cannot be degenerated by bacteria, but they assemble, their concentrations increase gradually, they may be stored in the tissues of living cells and may travel long distances from their source in water.

### 1.4.8. Heavy metals

Heavy metals are among the most harmful of the elemental pollutants and are of particular concern because of their toxicities to the human and aquatic environments. The presence of heavy metals has been reported in several studies on natural water (Ashelmani. 2004; Abaadi, 1990; Ziadat. 2005) this indicates the contamination occurred due the leak of industrial waste to the drinking water path or reservoirs.

### 1.4.8.1. Iron

Natural water contains iron and its concentration may naturally reach 1mg/L in surface water and its rate may increase in groundwater.
The existence of iron in water takes the form of $Fe^{+3}$ unless the water is under the conditions of reduction and the absence of ventilation where the iron is found in the form of $Fe^{+2}$. Iron in water is exposed to constant reduction and oxidation with the assistance of bacterial existence (Abaadi. 1990).

The main source of iron in water is the industrial residues which contain structures of iron (Abaadi, 1990), or from the dissolved earth cortex components (Abaadi, 1990), and it may be as a result of the rust of pipes that transport water (Abaadi, 1990). If water contains a concentration of iron more than 2 mg/L, then the taste of water will be bitter, in addition clothes would be coloured when they are washed with such water (Abaadi, 1990). Usually, concentrations of iron in drinking water are less than 0.3 mg/L. (WHO, 2004; Asillawi. 1989; Ashelmani. 2004)

### 1.4.8.2. Manganese:

Manganese is found in natural water, both surface and groundwater in two forms, dissolved and suspended, and in fresh water. Manganese is found in amounts of one microgram up to thousands of micrograms per litre in accordance with the location. Its concentration increases in the air surrounding industrial areas and reaches $0.3 \mu g/m^3$ and decreases to $0.05 \mu g/m^3$ in non-industrial areas (Gray, 1999; WHO, 2004; Abaadi, 1990).

### 1.4.8.3. Zinc

Zinc is an element that is found abundantly and represents about 0.04 g/kg of the earth's crust. The commonest zinc metal is zinc sulphate which mostly associates other metallic elements, such as lead, copper and iron. The natural content of zinc in soil is between 1 and 300 mg/kg. The existence of zinc in tap water is clearly much more than that in surface water because the pipes, yellow copper and structures containing zinc cause water leakage. In general its concentration in tap water ranges from 0.01 to 1 mg/L (WHO, 2004).

### 1.4.8.4. Nickel

Nickel is found rarely, however, it represents 0.01% of the earth's crust and usually results as an output of washing soil from metals. Many of the nickel salts are solvable in water and their levels in surface water reaches the amount of one mg/L, though levels are usually less than 5-20 micrograms per litre (WHO, 2004).

### 1.4.8.5. Copper

Copper and its structures are found largely everywhere in the environment, consequently it is found much more in surface water. Copper may reach water by way of industrial residues or from the erosion of pipes that contain copper. In drinking water, at the consumer tap the concentration of copper is higher than that at the water source or the water treatment within the distribution network. Levels of copper in drinking water vary and range from 0.01 to 0.05 mg/L, whereas the recommended indicator value is 1.0 mg/L (WHO, 2004).

### 1.5.2. Bacteria

Aerobes and anaerobes bacteria may be found in water and perhaps the most important in drinking water are the *coliform* group. One of the members of the *coliform* group is *Escherichi coli (E.coli)* which is facultative and not pathogenic when ingested (Gray, 1999; Barnes, 1981; Singleton, 2004; Enger and Ross, 2003).

## 1.6. Desalination of water

There is a shortage of fresh water supplies in the world. The shortage of water is expected in 2010 to be less than 10 million m3 per day in the Mediterranean countries alone. Seawater is the largest water source available and is still relatively unpolluted compared with existing fresh natural water (Cooley, 2006).

In some places in the world such as south Asia, the Middle East and East Africa groundwater is not preferred due to the high levels of arsenic, fluoride, iron, or salt levels. In addition, the irrigation water is often the only water available for drinking water, bathing, and washing. The quantity and quality of irrigation water available for drinking and domestic hygiene is more important than the quality of water. Many countries have faced a continuous sequence of dry seasons and have limited water resources. For that reasons desalination is used to reduce the potable water shortage (Tabet, 2005; Goto, 2002).

The desalination process may be defined as the recycling of salty water such as sea water to produce usable water by removing the unwanted materials by one or more of the following techniques or methods which can be classified into two groups: those that remove salt from the water such as Electro dialysis, Ion Exchange, Adsorption and Liquid Extraction and those that separate the water from the solution, such as Multi-Stage

Flash Multi-Effect Evaporation, Vapor Compression, Solar Desalination Freezing and Reverse Osmosis (Workshop on water and wastewater treatment, 1995).

### 1.6.1. Seawater Qualities

Seawater is not a homogeneous solution, and it varies by time and location. Feature of sea water include its level of salinity and its TDS. While standard sea water and the Atlantic Ocean have about 37500ppm TDS, Mediterranean seawater has about 38500 to 39500ppm TDS. The Red Sea average and the Gulf area are 42500 to 45000ppm TDS, and 45000 to 52000ppm TDS respectively. The contents of seawater such as calcium sulphate, calcium carbonate, and magnesium hydroxide, are important for desalination (Al-Bassiouny, 2003; Final report, 2004).

There are some reasons for seawater desalination which can be summarized as; seawater is a large source of available water for current and future use, and the level of pollution is low compared with other source of water (Cooley, 2006; Fath, 2003).

### 1.6.2. Product water quality

The product water through the desalination process for drinking water should have total dissolved solids (TDS) contents that vary from 50-500 or higher. Also the distillation plants can produce product water with fundamentally zero TDS contents using membrane processes. However, the product water for drinking water should be complying with World Health Organization's guidelines which are shown in the table in the appendix (Cooley, 2006; Al-Bassiouny, 2003; Alghariani, 2003).

### 1.6.3. Classification of the Methods of Desalination

These methods vary but it is possible to classify the process into two groups: those that remove salt from the water; namely, Multi-Stage Flash, Multi-Effect Evaporation, Vapour Compression, Solar Desalination, Freezing, and Reverse Osmosis. And those that separate the water from the solution; namely, Electro dialysis and Ion Exchange.

#### 1.6.3.1. Ion exchange

This method involves the removal from solution of one type of ion and its replacement by an equivalent quantity of another ion of the same charge. However, ion exchange can also be used for selective removal of certain ions such as scale-forming ions. One such unit utilizing weakly bond to replace of $Na^+$ ions, and removal of ions such as $Ca^{+2}$ and $Mg^{+2}$, from water. (Cooley, 2006; Al-Abaar and Al-Mabrook, 2006; Arfiida, 1995; Final report, 2004).

#### 1.6.3.2. Solar Desalination

This method depends on the solar system for evaporation the sea water which is condensed on cold surfaces then collected in pipes and finally becoming ready for drinking. This method has many advantages such as its suitability for remote and sunny areas, being inexpensive makes it very attractive, and it has little impact on the desalination water produced globally (Cooley, 2006; Al-Abaar and Al-Mabrook, 2006; Arfiida. 1995; Final report, 2004).

### 1.6.3.3. Freezing:

In theory this technique needs low energy compared with other desalination methods. However, this method has some drawbacks such as a high consumption of power and is quite expensive because it requires large compressors for its low pressures. In addition, the contamination of product water with salt water is a problem, and the efficiency of operation is low because of need to wash ice with product water. This method is based on the idea that crystals of ice made from saline water are free of salt which is similar to distillation that produces steam without salts. The difference between this and the desalination method is that the surrounding temperature is lower. The freezing technique consists of direct (vacuum flash process) and indirect freezing. The main advantage of this method is reducing the corrosion and the precipitation due to the fact that the process works at relatively low temperature (Cooley, 2006; Al-Abaar and Al-Mabrook, 2006; Arfiida, 1995; Final report, 2004).

### 1.6.3.4. Multi Effect Distillation (MED)

Multi Effect Distillation contains three multi-effect distillers which utilize the vapours that arise from the first evaporator so the vapour will be condensed in the second evaporator. Accordingly, the temperature of the condensing is used for boiling the seawater in the second evaporator. As can be observed, the second evaporator works as a condenser for the vapour from the first evaporator. The vapour from the first evaporator has the same function of the heating vapour in the first evaporator. These procedures are applied in same way for the third evaporator. The evaporator in this chain is called the effect (Cooley, 2006; Al-Abaar and Al-Mabrook, 2006; Arfiida, 1995; Final report, 2004).

### 1.6.3.5. Electro dialysis (ED)

In Electro dialysis, the salted solution contains dissolved ions which spread in water to neutralize their charges. Therefore, when the electrical polars are connected with external electrical power, to reach neutralization, these ions move toward opposite directions. In other words, positive ions will go to anode and vice-versa. In using this method for desalination, more than one membrane is utilized. One of the membranes is for positive charges and the other for the negative charges and between the membranes two plates are used. One of the plates works as a channel for carrying feed water and the produced water and the other plate works as a channel for brine discharge.

The ions move in opposite directions through the selected membrane either for the positive or the negative. Two solutions are obtained, one is concentrated and the other is not, between the membranes which called the cell. The electro-dialysis unit contains hundreds of pairs of cells that are connected with electro-polar which called the assembled membranes (Cooley, 2006; Al-Abaar and Al-Mabrook, 2006; Artiida, 1995; Final report, 2004).

### 1.6.3.6. Multistage Flash (MSF)

In the Multistage Flash method the heated sea water is passed through low pressure rooms from stage to stage in sequence. First, the water turns to steam which condenses over cold surfaces. After that, the condensed steam i.e. water is collected and treated to be ready for drinking. This method is employed in a large capacity desalination plant. By using this process from source water which has high salt content (60.000 to 70.000 ppm TDS), can be produced high quality fresh water with a very low salt concentration (10ppm or less) (Cooley, 2006; Al-Abaar and Al-Mabrook, 2006; Artiida, 1995; Final report, 2004).

### 1.6.3.7. Methods of Compression

There are two basic methods used to compress water vapour. The first is to use a compressor which can be powered by any rotating source such as an electric motor, diesel engine, steam turbine, etc. Normally, either electric or diesel power is used. The second method is to use a steam ejector. This method is often considered feasible where a quantity of surplus waste steam exists; otherwise, producing steam solely for the purpose of operating an ejector would not be economical. Both methods of compression produce the same result–potable water. The steam ejector plant is easy to install and start up, and requires considerably less care and attention than a plant using a compressor. However, it is not as thermally efficient in producing water as a compressor operated plant (Final report, 2004).

### 1.6.3.8. Vapor Compression

The vapour compression process (also referred to as "vapour recompression") differs from the MSF and MED in the sense that it does not use an external vapour source but uses its own vapour after it has been compressed. This process has high economy of energy but the necessary presence of mechanical energy by using a steam-ejector compressor (Cooley, 2006; Al-Abaar and Al-Mabrook, 2006; Arfiida, 1995; Final report, 2004).

### 1.6.3.9. Reverse Osmosis (RO)

The Reverse Osmosis process has more recently been shown to be the most remarkable improvement among existing desalination processes, owing to advancements in membrane technology. RO is called by this name due to it being the opposite of direct osmosis. In other words, direct osmosis can be explained as a movement of a solvent from a weak solution to the two solutions (Al-busaidi. 2004). This movement is free to rise and fall through the membrane. After that the strong solution level will move up but the weaker will fall. This process continues to reach a high pressure between solutions which equals the osmotic pressure over the membrane where the two solutions reach the equilibrium. The process is worked in reverse when a pressure is higher than the osmotic pressure that performed to a strong solution. In addition, the solvent moves through the membrane into the weaker solution in the compartment. This is known as reverse osmosis (RO) (Cooley, 2006; Al-Abaar and Al-Mabrook, 2006; Revans. 1994; Grossblatt, 2002).

### 1.6.4. Desalination in Libya

Libya has a total surface area of 1,760,000km$^2$ mostly Saharan desert and it is a very arid country. In addition, it has coastal area ranged about 2000km and 85% of the population is concentrated along it. For this reason desalting of seawater is very important to offer potable water (Ghurbal & Ashour, 2003; Busreewil, 1980; Arfiida, 1995).

In this study we consider the MSF plant here in Sirt City in Libya which was first constructed in 1990 and compare the results with our new model. In fact the MSF plant type which is in operation here in Sirt City is a once through model with tube length 24m and tube diameter of 17mm with 0.5mm thickness being a 1:1 heat exchanger type (Al-Bassiouny, 2003; Al-Abaar, 2006).

Sirt city is one of Libya's coastal cities and suffers from a shortage of natural drinking water. The main source of drinking water in Sirt city is GMmR water and desalination water, produced by the Sirt desalination plant.

### 1.6.5. Sirt desalination plant

The desalination unit works in multistage flash (MSF) which means heating the sea water in a vessel, above boiling point, without allowing it to evaporate in this vessel. The seawater is taken to another vessel to evaporate.

This desalination plant consists of six units which are divided into 39 stages and a thermal heating unit. The seawater is pumped from the sea basin by turbine brine to the 39 stages where the water passes through multiple thin pipes (15mm diameter) (Al-Bassiouny, 2003).

These pipes start in a serial order from 39 to the number 1 stage and from this stage to the thermal heating unit where it is heated by the vapour which comes from a boiler where the vapour closes the thermal heating group from outside (whereas the sea water passes through) and heats it by the thermal removal thin pipes to take out hot brine from the thermal heating to the units starting in a serial order from first stage till the stage number 39 where the vapour separated at a height from hot sea water then returns to condensate around a group of units at a height where the cold brine passes through to the thermal heating. The condensate vapour of the brine gathers as produce water inside collection water basins which are designed under multiple pipes in each stage and all collection water basins are connected to each other (Al-Bassiouny, 2003).

The produce water is pumped from the last stage by the product water pump and expels (forces out) the extra brine, which is not vaporized by seawater expulsion pump to the sea. Thus, the process of desalination continues. The collected water is stored in three reservoirs each one of which measures: 3000m$^3$ then transmuted to drinkable water in the treatment unit. The gases which are formed inside the units are eliminated by a gas vacuum system which sucks the gas at high pressure vapour propulsive force to the filters. The condensed vapour inside the thermal heating, which is used in heating, is pumped to feed water reservoir for transmutation to a vapour in the boiler once again and for operating the turbine in place of the electro pumps. The addition of poly malic, which is artificially known as (belgard EV) with injection ratio 2.5 ppm, will prevent salts of precipitation. And to prevent the accumulation of the foam and gas turbine inside the vapour, inorganic substance (170 propanol) is added and its oxides which are known as (Bellte M8) with ration injection 0.16 ppm. If it is needed, concentrated sulphuric acid is used to clean the units and pipes. The desalination unit is provided with steam by two boilers each having two Bunsen burners. Each Bunsen burner has a fan. The boilers are of the flame pipe type and each has the capacity to produce vapour by 90% load equal to 27.5% vapour with pressure 10.40 BAR. Also, the addition of some chemicals to the water reservoir prevents the boiler feed water reservoir from erosion and corrosion (Al-Bassiouny, 2003).

There are chemicals added such as *Sodium sulphate* ($Na_2SO_4$) which absorbs the oxygen which is available in the boiler water, this oxygen increases with the risen temperature to prevent erosion and corrosion. *Sodium phosphate* ($Na_3PO_4$) is added to increase pH of the water to minimize the erosion and corrosion of the internal parts of the boiler and to form a viscous layer between the water and the internal surface of the boiler. The addition of these salts with minimum ratio to distilled boiler water is enough to keep the adequacy of boiler to produce the quality vapour. There should be a control on the conductivity coefficient of boiler feed water which should not increase to more than 25μs.

## 1.7. Literature Review

The purpose of this section is to describe the previous studies. It covers the importance of water, lack of water, desalination of water, technology, analysis of water and level of compliance with international and local standards of potable water.

Ziadat (2005) focuses on the impact of shortage tanks on drinking water quality in Jordan. The study also investigates the differences between the quality of water from the source (the groundwater) and the stored water. In addition, he explores the influence of the external environmental factors such as the winds, the temperature and dust on quality of stored water. The study intends to look at the heavy metals whose existence indicates the corrosion level linked to the type of the tanks which were made from galvanized steel. The results indicate that there was no direct impact of water and galvanized tanks on the heavy metals. Furthermore, there was no difference between the quality of the source and the tanks waters. Heavy metals are high in the storage water compared with low level in the source. The ionic concentration is lower than the International Water Standard.

A study carried out in Mexico City by (Robales *et al.*, 1999) analyzed bacteriological and physico-chemical parameters of 265 samples from 39 brands of bottle water sold and the sample divided into 5 groups. The bacteriological test included the detection of faecal and coli form bacteria. While total coliforms ranged between 0.95 to 2.26 cfu 100 $ml^{-1}$, faecal coliforms were ranged from 0.71 to 1.07 cfu 100 $ml^{-1}$ which is above the Mexican standards that is 0 cfu 100 $ml^{-1}$. The biological analysis indicates that there were problems in handling, washing, purification, and in the filling stage of the bottles. The study also found that even if there were more than one plant for one brand for purification, there were still differences in the bacteriological quality between plants. In order to overcome this problem the authors suggest a need for efficient internal control.

In Bahrain a study carried out by Musaiger and Khunji (1990) on the chemical quality of drinking water which come from three main sources: private treated, tap, and bottled water. The results show increasing chemical levels in tap water compared to other waters. The level of sodium in tap water was ranged between 100-545.9 mg/L on average of 309.4 mg/L which did not comply with the drinking water standards as required by WHO i.e. 200 mg/L. On the other hand, the average level of fluoride was about 0.28-0.85 in carbonated mineral water and tap water respectively.

Another study by Alabadula'aly and Khan (1995) examined the microbiological quality of sixty-six bottled water samples in Saudi Arabia. The aim of this study was to determine total coliform bacteria and plate count by using membrane filtration method. In addition, the researchers took three local brands which have large capacity and stored samples for two and a half months to observe the effect of storage time on increasing levels of bacteria, the results for detection of bacteria in large bottles were 3-276/ml, while for small bottle were 0-1/ml. In other words, the storage of bottle for a certain time contributes to an increase of bacteria. However, the small bottles are consumed faster without spending long storage time and this reduces the amount of bacteria.

Al abdula'aly and Khan (1999) evaluated the chemical composition of bottled water in Saudi Arabia which is sourced from wells; spring, glaciers or municipal, and the water may be distilled. The researchers aimed to study the effect of the source of water, treatment type, container type and storage on the quality of bottled water. In addition, they analyzed and compared the results of two bottles of the same brand. The average metal concentrations in both of two bottles (local and imported brands) were low with percentage variation not found significant and important. However, when they compared the results for physic-chemical parameters with the drinking water standards set by Saudi Arabia and the WHO, they found the levels met different drinking water standards. Fluoride was below the recommended values (WHO, for fluoride are 1.5 mg/L) which ranged between 0.25 to 0.82 mg/L and the pH exceeded the recommended values (WHO, for pH are 6.5-8.5 mg/L) in one of the imported brand about 6.0-8.2 mg/L.

Due to the increased consumption of bottled water in South Africa as well in many countries, there is a very high concern about the microbiological quality of bottled water. Ehlers *et al.*, (2004) studied the microbial quality of bottled water by taking 10 samples of bottled water (8 local and 2 imported) then testing for detection of heterotrophic plate count (HPC) bacteria, total and faecal coliform bacteria. The results showed that most met the recommendations set by the South Africa Bureau of Standards (SABS) which for HPC the result was less than 100 counts/ml and in two bottled water samples exceeded the recommended (SABS) guideline which were $2.64x10^2$ cfu/ml and $8.89\ x10^3$ cfu/ml. However, there was no detection for total and faecal coliform bacteria in all samples analyzed.

Batarseh (2006) collected four samples of potable water from different sources; these are: tap water, desalinated water in private plants; homes filtrated and sealed bottled water, for analysis of physiochemical parameters and trace metals. The results show that the concentration levels of several analyzed parameters did not comply with the local and international guidelines for drinking water. Decreasing TDS value of potable water which produced from homes filters ranged 20.50-125.00 mg/L but in tap water the trace metals were very high especially Ni which ranged 445.0-1117.5 mg/L and salinity was very high and ranged 319.50-1985.70 mg/L. In addition, when used the home purification filters were more useful in reducing the trace metals and salinity levels than filters used in private desalination plants for this purpose. Further, the results showed little differences between locally and imported bottled water brands.

A work for Salameh *et al.*, (2002) on concentration of heavy metals in Amman City, Jordan found the concentrations of heavy metals were lower than national and international standards and observed increases in these levels in winter relative to the summer season. This can be attributed to flushing of these metals by runoff of rainfall and percolation to the aquifer. Further, the researchers explain the reasons for this increase; namely, from soil during the dry summer season, accumulation of metals on the streets, vehicle exhausts, and corrosion of the old galvanized water distribution pipes of Amman City.

A study in Jordan by Obeidat *et al.*, (2007) aimed to evaluate the nitrates concentration in ground water. They report that the presence of nitrates in water, when increased by more than the recommended value, can be viewed as an indicator of potential ground water contamination.

The samples were taken from 16 wells in several sites in Jordan. The results were 10-330mg/L in 2006 with an average of 77mg/L and about 22% of the collected samples containing about 20mg/L $NO_3^-$. In addition, the study shows there was a relationship between the nitrate concentration and the wastewater effluents as a source of contamination. About 47% of the samples give results of $NO^-_3$ concentration in the range of 20-40mg/L.

A study by Alabadula'aly (1997) about the level of fluoride in drinking water supplies of Riyadh (Saudi Arabia) where the sources in this city are about 34% ground water and 66% desalinated water. The researcher collected the samples from different sources of water: selected wells, treatment plants, desalinated seawater, distribution networks and 19 locally and imported bottled waters. The results show the fluoride level in seven groundwater samples are 0.63-1.6 mg/L and about 0.23to 1.1 mg/L for their final product water. In addition, for the desalinated seawater the fluoride was ranged from 0.01-0.5 mg/L in the distribution network. The results of the local bottled water was 0.2-0.83mg/L, in the imported bottled water was 0.04-0.2 mg/L.

Research in Nigeria Ukhun *et al.,* (2005) aimed to determine the concentration of some heavy metals, CN, $NO_3$, and the microbes in water supply such as total *coliform*, E.*coli* and fecal streptococci. The results illustrate that the levels of Fe, Zn, Cu, and Mn complied with safe limits and CN was not detected in collected samples. The concentration of nitrate was higher than the recommended value of 10.000 µg/L. The results for biological tests showed the presence of total coliform counts which ranged between 3 to 2.400 cells/100mL, E.*coli (fecal coliform)* counts ranged between 3 to 1.100 cells/100mL and *fecal streptococci* counts ranged from 3 to 240 cells/100mL.

In China Cheung *et al.*, (2003) studied the effects of anthropogenic activities, industrialization and urbanization on the accumulation of heavy metals and nutrients in sediments on water quality of river, where they found contamination with Cd, Pb, and Zn.

High concentrations of cadmium is considered to be one of the present serious problems to the Chinese water supply due to the discharge of raw or insufficiently treated industrial waste waters or waste dumping. In addition, there are heavy metals which increase the contamination for the water supply such as mercury up to 8μg/L$^{-1}$, cadmium up to 100μg/L$^{-1}$, lead up to 190μg/L$^{-1}$, and chromium up to 200μg/L$^{-1}$. Zhao *et al.*, (2002)

Virkutyte and Sillanpaa (2006) studied the physical and chemical parameters in China. The results show high levels of some heavy metals such as Fe was up to 1.9 mg/L, as up to 0.1mg/L and Ni was 0.05mg/L which cause negative effects for human health. However, the level of Pb, Cu, Cd and Cr did not exceed the National Chinese and WHO drinking water standards.

Research by Chifamba (2007) about trace metal pollution of water which causes disposal of solid waste in Zimbabwe found high concentrations of Hg and Pb and the rain water samples showed higher levels which resulted from atmospheric deposition associated with rain.

In Libya, a report by Al Marriee (1994) shows high increase of Electro Conductivity (EC) which was 25 ms an increase in TDS specially sodium and chloride salts in comparison with calcium and magnesium salts and that was due to interference with seawater.

Another report in Libya by Arfiida (1995) aimed to follow up the chemical and bacteriological properties of four treatment plants. The results were as following: For the first plant the researcher found a decreasing level of pH and an increase in Pd and Cr level during the period of study and did not find any type of bacteria in this plant. In the second plant there were decreasing levels of pH and increasing levels of EC, Cl, $SO_4$, Pd and Cr. However, the results for the third and fourth plants showed increasing levels of EC, $HCO_3$, and Cl. However. the pH, $NO_3$ and the heavy metals concentration complied with the standard. Regarding the biological test; it showed the presence of *E.coli* bacteria in the storage tank of these the plants.

A study was carried out by Hassan *et al.*, (1990) to evaluate the microbial situation of seaside water in the United Arab Emirates. The researchers studied the distribution and count of bacteria which were non self feeding, living in salt and negative germs and *E.coli* bacteria. The result show the intensity of microbes increased in all studied sites remarkably then decreased during the summer months followed by high increases in the month of October then decreased during the winter months. In addition, the results show a high presence in counts of *E.coli* bacteria. These high numbers of bacteria in studied sites were due to the effect of the flow of sewage near to seaside water and the presence in open seaside water of the Arabian Gulf.

A study of three major MSF plants in the Eastern Province of Saudi Arabia was carried out by Kutty *et al.*, (1995) for an analysis of produced water and seawater samples to determine the presence of six heavy metals and their effect on the quality of desalinated water on order to avoid any contamination of drinking water from desalination plants. The results show no indication of the presence of As, Cd, Se, Pd and Cr above SASO regulation levels in drinking water especially in produced water. The average concentration of Cd was 0.63μg/L: while the highest level of Hg found in two studied stations were 0.11 and 0.04 μg/L respectively.

The contamination that comes from desalination plants with heavy metals has many sources such as corrosion of construction materials, contaminated well water or seawater used for blending purpose, or carry over from feed seawater to distillates.

Kuttyy *et al.*, (1992) studied $CaCO_3$ precipitation tendency in desalinated water and found the water produced from MSF plants did not contain enough Ca and alkalinity to impart $CaCO_3$ precipitation tendency to the water. The researcher indicates that the MSF and RO product desalinated water has very low pH ranged 6.5-7.5 and 6-6.5 respectively and very low dissolved salts <25 mg/L. In addition, the RO has high chloride content.

The results from a study by Kutty (1990), of the water quality which derived drinking water from the three seawater MSF plants in Saudi Arabia shows the concentrations of all inorganic parameters are within the limits of WHO guidelines except fluoride.

Fytianos *at el.*, (2002) aimed to assess the quality of water in Greece for one year. The result show insignificant differences between sites of samples, or between periods of sampling. However, the results of heavy metals indicate that there is a relationship between the geology of an examined area and the influence from anthropogenic sources.

AShelmani (2004) studied the effects of quality of Algardabiya reservoir (Libya). The results show that no pollution came from heavy metals where the concentrations were within the allowed ranges. However, the results of chemical parameters indicate a steady decrease as result of water pumping to the reservoir but the tests of pathogenic bacteria were negative. While the tests of T.C, T.C.F and F.C.F were positive during the study period, the researcher found the bacteria count corresponded with the movement of water and the increase in temperature.

The main purpose of Al-Asaawi's (1998) study was to analyse and evaluate some physical and chemical properties of drinking water for Misurata city (Libya) where the researcher indicated to the mixing process of drinking water with lower quality of water which has important role in getting water with acceptable criteria for human use. He argued that it would be much better if water of good quality alone were used and found that the sample collected from the desalination plant of Libyan Iron & Steel Company was the only one that complied with standards of drinking water compared with other studied samples.

Kalaf-allah *et al.*, (1990) aimed to study the level of water pollution of Banghazi City that resulted from the presence of ions. These cause hardness and some other inorganic components such as TDS, EC and pH. The results of pH ranged from 7.09 to 8.05. the hardness ranged from 400 mg/L to 790 mg/L and EC was between 2000µs/cm to 4800 µs/cm. In addition. there was an increase of TDS. In general the water of Benghazi city has a very high level of total dissolved salts and this is out of the accepted range for drinking water.

Al-kertihe (2005) studied the physical and chemical properties and the levels of some heavy metals in treated waste water samples collected from the recycle unit at the maintenance and development complex located at Temenhent, a village in the south of Libya. The study shows that the water samples obtained from both internal and secondary treatment units have lower pollution levels with heavy metals compared with the final reservoir which reflects the efficiency of the recycling process.

# Chapter II

## *Materials and methods*

# Chapter Two

## 2. Materials and methods

### 2.1. Sample collection

The samples for chemical analysis were taken in plastic bottles made from polyethylene. The bottles were washed by using distilled water. The bottles were then filled and closed tightly. For biological analysis, samples were collected in sterilized glass bottles and kept closed to avoid contamination (Gaber, 1998; WHO, 2004).

The samples were kept at -4C°, (biological analysis) and analyzed within 48 hours. However, pH, EC, and temperature were carried out at the collection site (Gray, 1999, Encyclopaedia of analytical chemistry, 2000; chapman, 1992).

### 2.2. Places of Samples Collection:

All samples were collected in 500ml bottles from the following sites as show in Figure (1):

*Site 1:* seawater and more specifically coastal water.

*Site 2:* the precipitation reservoir which receives the seawater for removal and precipitates any sands and impurities which accompany the seawater.

*Site 3:* the production water which is taken before it is passed to the storage tanks of the plant, (directly from the plant).

*Site 4:* D412 tank which receives and stores the production water after its immediate exit from the plant.

*Site 5:* D414 tank which connects with D412 tank and the production water passing to it for storage ready for distribution to the water company.

*Site 6:* desalination plant laboratory which is considered as first point of distribution for the production water as this laboratory connects with D414 tank (the main tank) via a network of pipes.

*Site 7:* Desalination water company water reservoir. this sample was (pipe of desalted water) prior to mixing with the river water. This reservoir contains two pipes, one of them carries the desalination water from the plant and the other pipe carries the river water that is then collected in the company water reservoir.

*Site 8:* water company reservoir (pipe of GMmR water) before mixing with desalted water.

*Site 9:* Sample of standard mixing (3:1) which was taken by mixing three quantities of GMmR water with one quantity of desalted water.

*Site 10:* water company reservoir after mixing desalted water and river water without exact mixing ratio.

*Site 11*: tank of 750, this tank has direct line from desalination plant and another direct line from water company reservoir. In addition, this tank feeds the Guest House directly.

*Site 12*: Guest House which is usually supplied with water from desalination plant.

*Site 13*: Youth Camp sample which is supplied from water company reservoir.

*Site 14*: Al-Maharri Hotel whose water comes from the water company reservoir. Generally, the water supply to the hotel is via water trucks.

*Site 15*: Public Works Corporation which is supplied with water from the company reservoir.

| No | Site of Sample |
|---|---|
| 1 | Seawater |
| 2 | Precipitation reservoir |
| 3 | Production water |
| 4 | Tank D412 |
| 5 | Tank D414 |
| 6 | Laboratory of plant |
| 7 | Desalted water |
| 8 | River water |
| 9 | Mixing 3:1 |
| 10 | Company Reservoir |
| 11 | Tank 750 |
| 12 | Guest House |
| 13 | Youth Camp |
| 14 | Al-Maharri Hotel |
| 15 | Public Works Corporation |

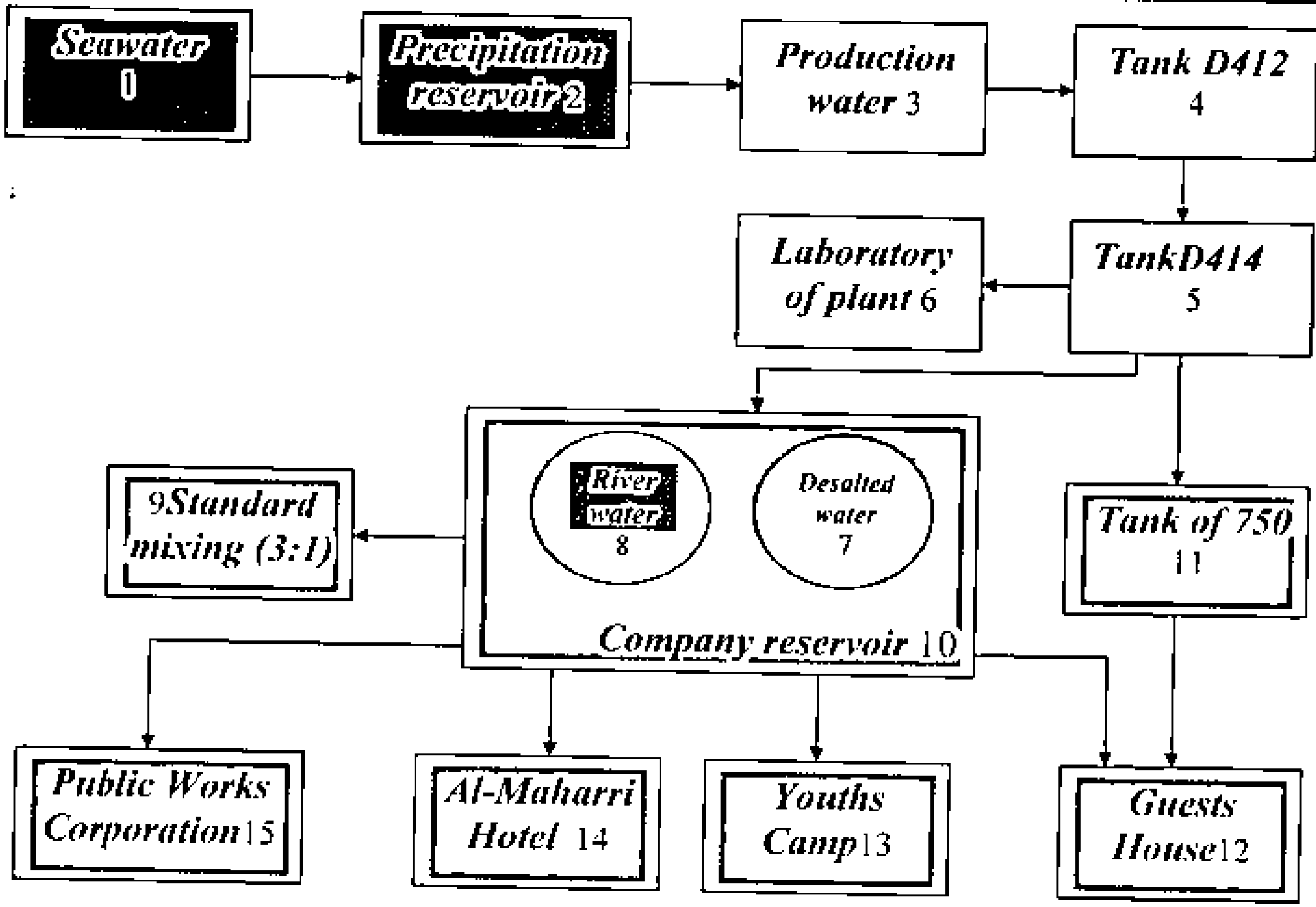


Fig. (1) Sites of collected samples

## 2.3. Chemical Analysis:

Chemical analyses carried out in this study were based on standard methods, 1998 for water analysis and which have been adopted by the GMmR laboratory. Analyses for the chemical treatment were carried out in the laboratory of Sirt desalination plant. The rest of the analysis has been done in other laboratories around Al Jamahiriya such as Raslanov and the Laboratory of GMmR in Benghazi.

### 2.3. 1. Determination of Taste and Odour

All analysed samples were colourless, odourless and tasteless apart from the odour evident from the tanks that suffered from corrosion, such as tank D412

### 2.3. 2. Determination of pH

The pH of the samples was measured immediately after collection using a pH meter, type (HANNA), model (HI 9835)

### 2.3. 3. Electrical conductivity (EC) determination

Samples were analysed for determined EC value using a conductivity meter provided by electrode-Model (Jenway).

### 2.3. 4. Determination of total dissolved salts TDS

Total dissolved salts were determined by TDS meter (HI 9835)

### 2.3. 5. Determination of sodium and potassium

Samples were analyzed by flame photometer type model (410 Corning, England). The instrument is calibrated by using required standard solution to obtain calibration curve which is then used in determining the concentration of Na & K.

### 2.3. 6. Determination of sulphate

Samples were analysed using the Cecil double-beam spectrophotometer found inclusively in (standard methods. 427A, 1998). The wave length is set to 492 nm and 10 mm cells were used.

### 2.3. 7. Determination of nitrate

Samples were analysed by Cecil double-beam spectrophotometer, type (CE5501, 5000 Series, England), at wavelength 220nm (Standard methods, 4500B, 1998).

### 2.3. 8. Determination of chloride

Chloride of all samples was determined according to standard methods, 408A (1998). By using argent metric method (Mohr method),

### 2.3. 9. Determination of total alkalinity

Total alkalinity is measured according to the (standard method. 403, 1998) by titrated with a standard solution of hydrochloric acid using the indicators phenolphthalein and bromocresol green-methyl red.

### 2.3. 10. Determination of hardness

Total hardness and calcium hardness of water samples are determined according to (Standard Methods, 209B, and 1998) by titrated with a standard solution of (EDTA) at a pH of 10.0, and Eriochrome Black T was used as the indicator (Gaber, 1998).

### 2.3. 11. Determination of heavy metals

The metals such as iron (Fe), manganese (Mn), copper (Cu), nickel (Ni), zinc (Zn), magnesium (Mg), cadmium (Cd)), are determined by using the atomic absorption spectroscopy, model (PU 9200X) fisone, England. The work methods are followed as the standard methods 1998.

### 2.4. Biological Analysis:

Bacteria may be detected by many methods such as the growth of visible colonies plates of gel, or by most probable number (MPN) via reactions in special solutions, and by observation through microscopy (Gray, 1999, Branes *et la.*, 1981; Gaber, 1998).

Water samples were taken from sites of samples directly in 250 ml glass topped bottles (Branes *et la.*, 1981). Samples were placed in ice containers and transported as rapidly as possible to the central laboratory in Bengahzi. The samples were tested on the day of sampling whenever this was possible, but those which had to be carried some distance were held overnight at (-4°C) and tested the next day.

### 2.4.1. Procedures of Biological Analysis:

### 2.4. 1. 1. Total Colony Counts (T.C) Test:

**Procedure:**

The sample bottle was mixed. 0.1 ml was pipetted into a petri dish which was placed on a level bench (sterilizing by ethanol 70%). 20ml of molten agar was poured into each plate. The samples were immediately mixed by gentle circulation movements for (5-10) Seconds. The petri dishes were kept flat throughout, allowing the agar to set inverted. The dishes were incubated at *(37°C)* for 24 hours. After incubation all visible colonies were counted and recorded by using a colony counter. The counts of up to 300 in number were made and more than 300 recorded as > 300 colony/1 ml (Gray, 1999: Chapman, 1992; Siaala, 1990: Gaber, 1998).

**Quality Control:**

0.1ml volume of sterile distilled water were spread with each batch of sample as a blank, and incubated at the same incubation temperatures (37°C) to check the sterility of the procedure.

### 2.4.1.2. Faecal Coliform Test (F.C.F)

**Procedure:**

All presumptive fermentation tubes showing any amount of gas and heavy growth or acidity within 48 hours of incubation were submitted to the confirmative test. The positive presumptive fermentation tubes were gently shaken with sterile loop; growth from each positive presumptive fermentation tube was transferred to Macconkey broth. The inoculated tubes were incubated in a water bath at (44.5°C) for 24h.Gas and acid produced after 24h was considered as positive feacal coliform reaction (Gray, 1999; Chapman, 1992; Gaber, 1998).

### 2.4.1.3. The Multiple Tube Fermentation Test for Total Coliform Count:

**Procedure:**

**The Presumptive Test:**

Three (Double strength) Macconkey and nine (single strength) Macconkey tubes were set up in a test tube rack. The bottles of water to be tested were mixed by being shaken 25 times. With a10ml pipette, 10ml of water were transferred to each of the double strength Macconkey tubes. With a 1.0 ml pipette 1 ml of water was transferred to each of the middle set tubes and 0.1ml to each of the last three single strength Macconkey tubes. The tubes were incubated at (35°C) for 24h. The tubes were examined and the number of tubes was recorded in each set that had

(10%) gas or more. The MPN was determined from the table (Gaber. 1998; Siaala. 1990).

**The Confirmative Test:**

A plate of E.M.B agar was streaked with positive presumptive tubes. The plate was incubated for 24h at (35°C). Typical colonies were looked for on the E.M.B agar plate.

**The Completed Test:**

Nutrient agar slants were inoculated and the tube of Macconkey broth marked a final check of the colonies which appeared on the confirmatory media. After incubation for 24h at (35°C) the tube was examined for gas production and a Gram-stain slide was made from the slants (Gray. 1999; Chapman. 1992; standards methods. 1998).

**2.4.1.4. *Streptococcus faecalis:***

**Presumptive Test Procedure:**

A series of azide dextrose broth tubes was inoculated with appropriate quantities of each sample. Samples of 10ml portions or less was used. Double strength broth was used for 10ml inoculation. Decimal multiples of 1 ml only were used. Inoculated tubes were incubated at (35°C). Each tube was examined for turbidity at the end of 24h. Tubes were incubated again at the end of 48h if definite turbidity was not present (Gaber. 1998).

**Confirmative Test Procedure:**

All azide dextrose broth tubes showing turbidity after 24h or 48h incubation were subjected to the confirmative test. A portion of growth from each positive azide dextrose broth tube was streaked on bile esculin azide agar. The inverted dish was inoculated at (45°C) for 24h. The presence of faecal *streptococci* was confirmed by brownish-black colonies with brown halos. Colonies of brownish-black with brown halos were transferred to a tube of brain-heart infusion broth containing 6.5°%NaCI. The colony belonged to the *Enterococcus* group if it was grown in 6.5 % NaCl broth and at 35°C for 24h.

**Computing and Recording of MPN:**

Faecal *streptococci* densities were estimated from the number of tubes in each dilution series that were positive on bile esculin agar. Similarly, *enterococci* densities were estimated from the number of tubes in each dilution containing *streptococci* that could grow in 6.5%NaCI broth. The combination of positives were computed and recorded as the most probable number (MPN).

### 2.4.1.5. Fungi Test:

**Procedure:**

A sample was taken, and a streaked on the surface of the media.

**Incubation**

The dishes were kept in temperature (25°C) for a period of (5-7) days. The result was recorded as (+ve or -ve) for growth. The identification of fungi was carried out by inspection under microscope (Gray. 1999: Chapman. 1992; Gaber. 1998).

# Chapter III

## *Results and discussion*

# Chapter III

## 3. Results and discussion

### 3.1. Results of Chemical Analysis:

The tables 9 part (1), (2), (appendix .1) cover the results of descriptive statistical and analyses of variances between the groups under the study. The main parameters included in the table are: EC, pH, TDS, K, Na, Cl, $SO_4$, $NO_3$, Ca.H, T.H and T.ALK. Thirteen sites are presented in the table. The sites consist of pre-production sites which are: seawater, precipitation reservoir in a desalination plant, tank D412, tank D414, plant laboratory and the main distribution site (company reservoir) along with distribution sites which are: river water mixing tank 3:1, tank750, guesthouse, youth campus, AL-Mahaari hotel and Public Works Corporation.

### 3.1.1. Temperature

All analyzed samples were at 25-30°C during summer season and at 17-18°C in winter season during the study period. Ziadat (2005) found that the temperature mean was 23.30 to 25.50°C for residential storage tank, and in water resource was ranged 18.5 to 19.8°C. However, Al-Asaawi (1998) found that the temperature value was 23.0 to 43.0°C for all collected samples and in sample of desalinated water was 38.00°C.

Can be observed effect of temperature on bacteria growth where the bacteria count increasing during summer months, but, decreasing this growth in winter season. Where, the highest values of bacteria and fungi were in June and September month comparing with December month (Gray, 1999; Al-Asaawi, 1998; Twort, 1985).

### 3.1.2. Taste and Odour

Taste, like odour, is a subjective test which relies upon description rather than quantitative results. There are many potential causes of tastes and odours in water, in principal ones being algae, decaying vegetable matter, products resulting from chlorination (WHO, 2004; Twort, 1985).

All analysed samples were colourless, odourless and tasteless apart from the odour released from the tanks that suffer from corrosion such as tank D412. Natural water ranges in its colour from less than five degrees in pure water to three hundred degrees in water with dark colour Aoown (2002).

### 3.1.3. Hydrogen Ion Concentration (pH)

To minimize the corrosion of water must be controlled the pH of water to protect the distribution system and pipes in household water systems where the limited level of pH ranged from 6.5-8.0. In addition, according to the composition of water and the nature of the construction materials used in the distribution system the pH required will vary in different supplies. (WHO, 2004; Twort, 1985; Moftaah, 2007)

Figure (2) shows that the means of pH of the collected samples varied between 6.50 and 8.25. The WHO standards and Libyan standards for pH is 6.5-8.39 for waters and potable water purposes which indicates that the water is suitable for drinking purposes (WHO, 2004; Aoown, 2002). The results show (P value was 0.000 that is < 0.05) insignificant differences in hydrogen ion value between the sampled groups. The maximum concentration of pH was 8.4 at sample (8), and the minimum value was 6.5 at sample (6).

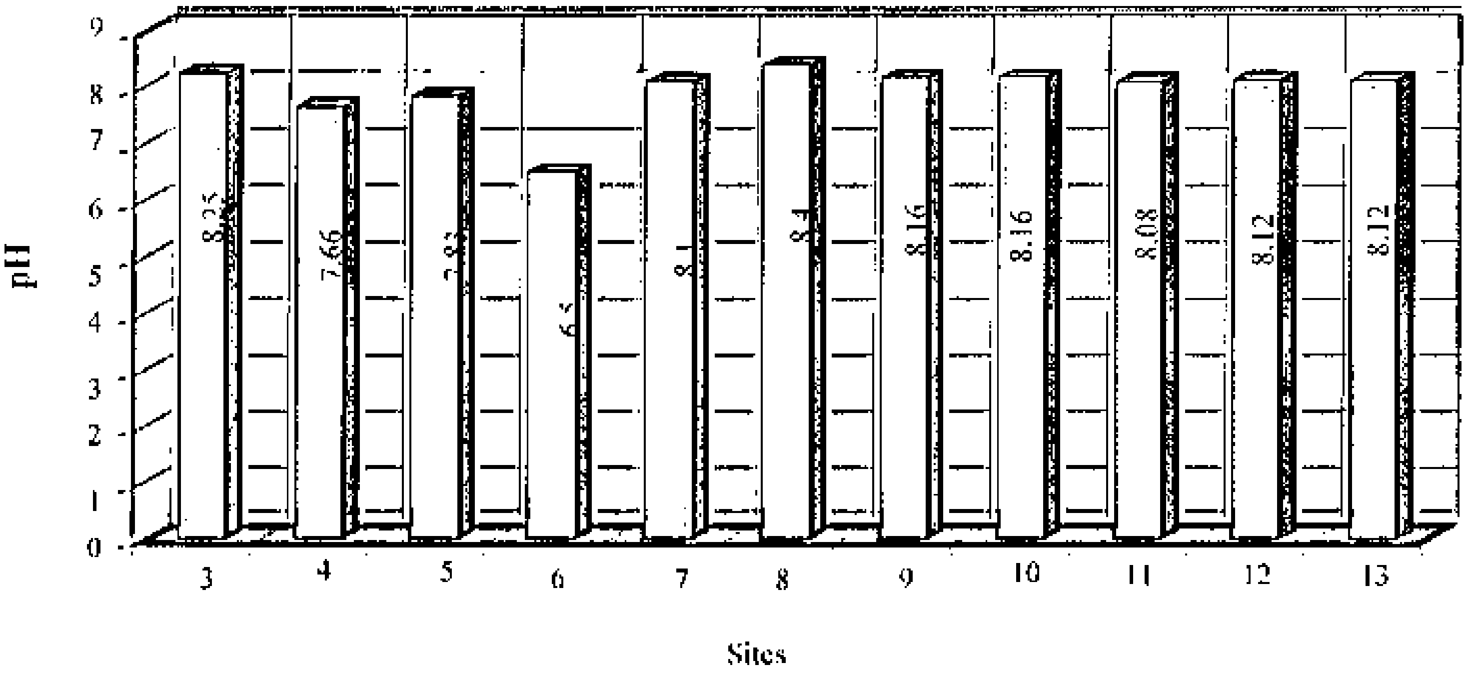


Fig. (2)The monthly average of pH

### 3.1.4. Electrical Conductivity (EC)

The conductivity dependent upon the presence of ions in solution, and it is measurement is an excellent indicator of the total dissolved solids in water. Conductivity is temperature dependent and a reference temperature (usually 20-25°C) is used when expressing the result (Twort, 1985; WHO, 2004).

The average of EC of the studied sites is shown in Figure (3) and reveals that it was ranged from 54720.10 to 54466.18ms/cm for seawater samples. However, it was ranged from 24.66 to 72.68 μs for the samples in the desalination plant and 385.40 to 666.408μs/cm for the remaining samples (including the sites from company reservoir to the distribution sites). The WHO Standards for EC is 400 to maximum level 22300 μs /cm for waters and potable water purposes (WHO, 2004; Aoown, 2002). The results show (P value was 0.000 that is $< 0.05$) insignificant differences of the means of electrical conductivity between the sampled groups. The result is in line with the WHO and the Libyan Standards. However, the finding is not in line with desalination plant rules (see appendix) because conductivity, as documented during the chemical treatment that was working in 1990-1993, was ranged from 223 to 640 μs /cm. The maximum concentration of electrical conductivity EC was 711.6μs/cm at sample (7), and the minimum was 24.66μs/cm at sample (3).

A study by Batarseh (2006) found the value of EC ranged from 221.00-457.65μs/cm. Another study by Al-Asaawi(1998) indicated that the level of EC was 0.130 ms/cm. However, Ziadate (2005) found that the EC was 888.0-921.0 μs/cm for water source and 967.0-991.0 μs/cm for residential storage tank.

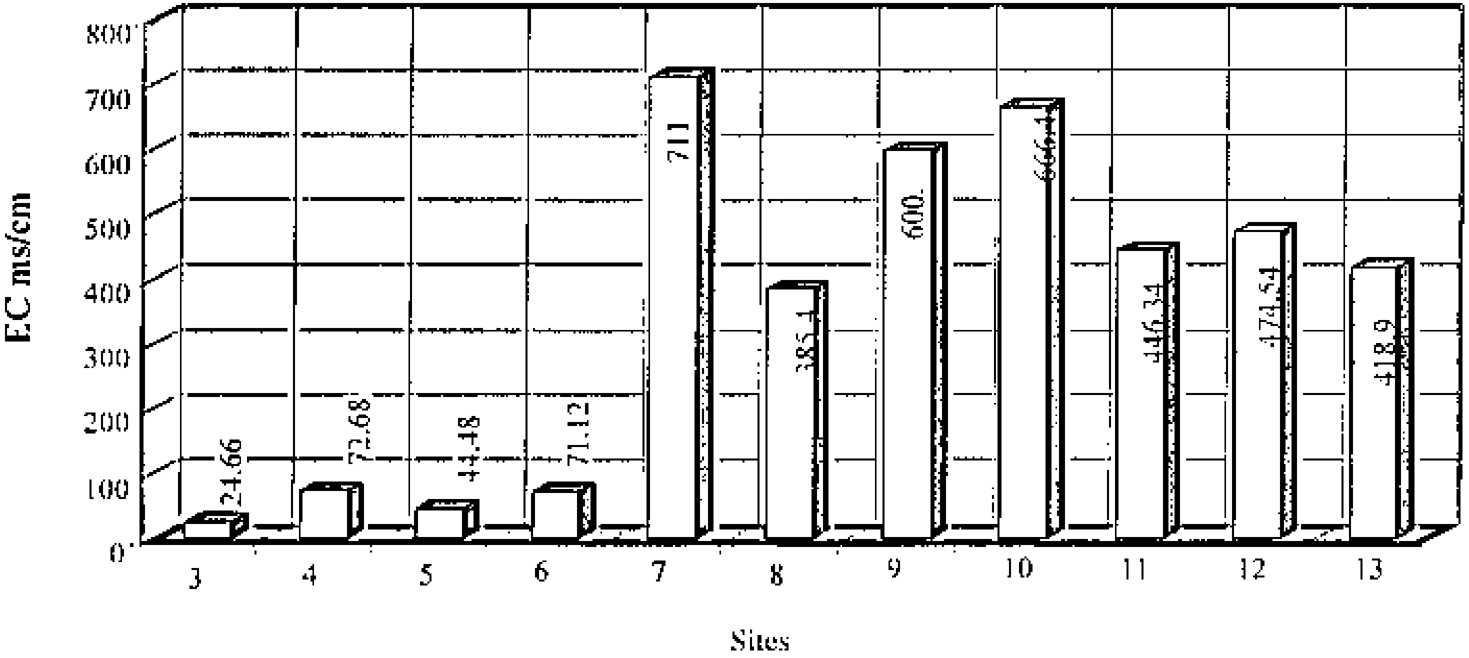


Figure (3) The monthly average of EC

### 3.1.5. Total Dissolved Solids (TDS) mg/l

Origin TDS in drinking-water are from natural resources such as industrial waste water, sewage, and urban runoff. TDS include inorganic salts above all sodium, sulphates, chlorides, calcium, magnesium, potassium. and bicarbonates in addition, small amounts of organic matters. The limited value of total salts is more than 1000mg/L, and the international and local standards recommend that the perfect limit of drinking water is 500mg/L (Twort. 1985; WHO, 2004).

It can be seen from Figure (4) that the average value of total dissolved solids is ranged from 35568.00 to 35106.60 mg/L for seawater samples. However. it ranged from 16.23 to 47.27 mg/L for the samples in the desalination plant and 247.85 to 425.89 mg/L for the remaining samples (including the sites from company reservoir to the distribution sites). The results are within the WHO recommendation i.e. 1000 mg/L as a maximum value for waters and potable water purposes (WHO, 2004; Aoown. 2002). This also agrees with the Libyan Water Standards and the Rules of the desalination plants that is 117 to 561mg/L(see appendix 1). The results show (P value was 0.000 that is < 0.05) insignificant differences in total dissolved solids between the means of the sampled groups. The maximum concentration of total dissolved salts was 461.8 mg/L at sample (7), and the minimum was 16.24 mg/L at sample (3)

### 3.1.6. Potassium Concentration ($K^+$) mg/l

Although potassium is one of the abundant elements, the concentration found in most natural water rarely exceeds 20mg/L. the European Community directive recommends a maximum concentration of 12mg/L with a guide level of 10mg/L (Twort, 1985; WHO, 2004). .

Figure (5) shows that the average of potassium concentration is about 269.47 to 270.64 mg/L for seawater samples. However, it was ranged

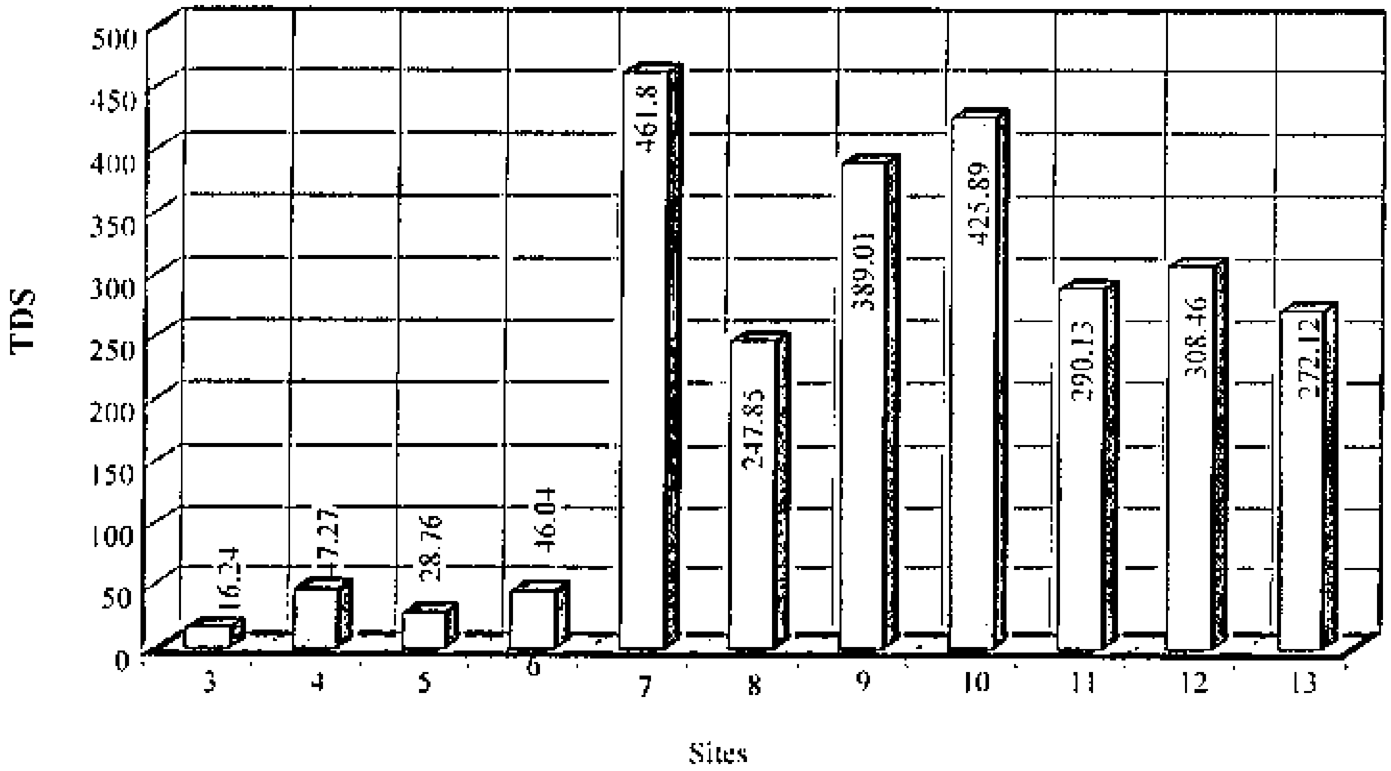


Figure (4) The monthly average TDS

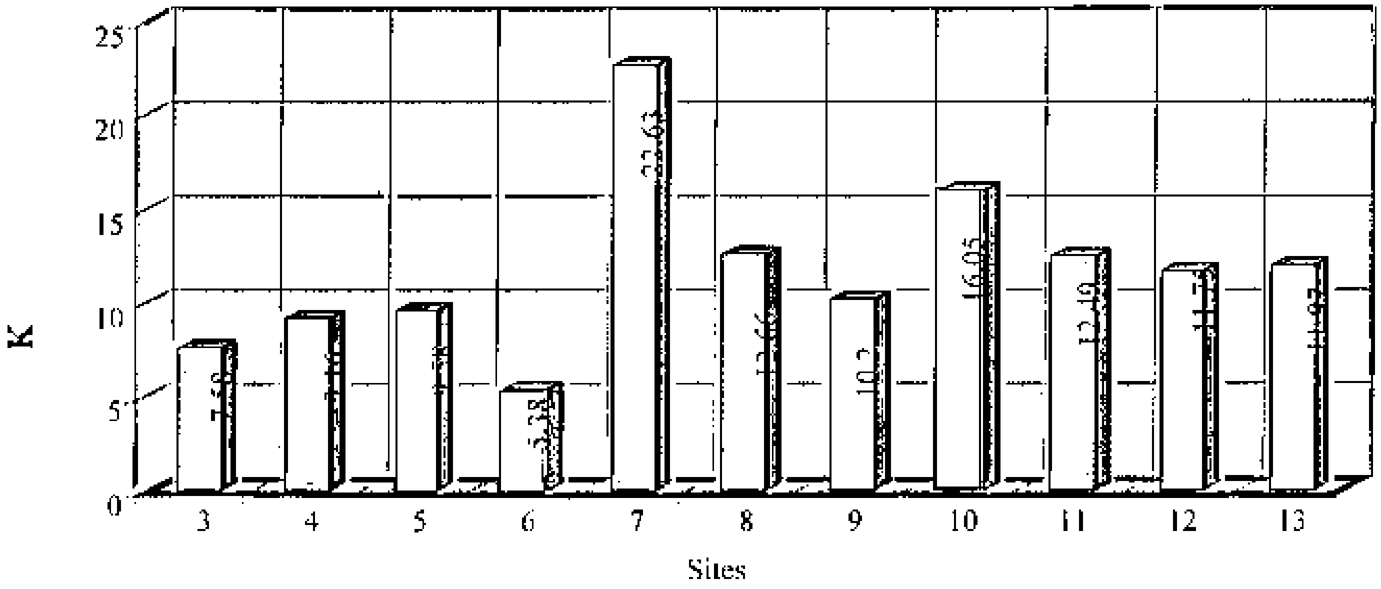


Figure (5) The monthly average of potassium from 5.38 to 9.57 mg/L for the samples in the desalination plant and 10.20 to 22.63 mg/L for the remaining samples (including the sites from company reservoir to the distribution sites). The result is within the WHO standards i.e. 12 to 20 mg/L as a maximum value for waters and potable water purposes (WHO. 2004; Aoown, 2002).The finding is also within the Libyan Water Standards and the rules forwarded by the Desalination plant administration. The results show the P value is less than 0.05 which is considered an insignificant difference in potassium concentration between the means of the sampled groups. The maximum concentration of potassium was 22.63 mg/l at sample (7), and the minimum was 5.38 mg/L at sample (6). Batarseh (2006) found the concentration of potassium in desalination plants ranged from 0.58-1.91mg/L. the level of sodium in tap water ranged 27.31-93.10 mg/L and in bottled water 29.78 mg/L for local bottled and 19.43 mg/L for imported bottled Al-Asaawi(1998) found the maximum concentration of sodium was 1401.5 mg/L and 69.8 mg/L for potassium concentration. However in the sample from the desalination plant the concentration of sodium has a lower value ranged 0.024-0.226 mg/L.

### 3.1.7. Sodium Concentration ($Na^+$) mg/l

Sodium components are very soluble so that the element is present in most natural water. Levels can range from less than 1mg/L to several thousand mg/L in brines. The threshold taste for sodium in drinking water depends upon several factors such as the predominant anion present and the water temperature. The threshold taste concentration for sodium chloride is around 350mg/L however, the concentration of sodium sulphat can be as highest 1000mg/L (Twort, 1985; WHO, 2004).

It can be observed from Figure (6) that the means of sodium concentration ranged between 2042.03-2041.89 mg/L for seawater

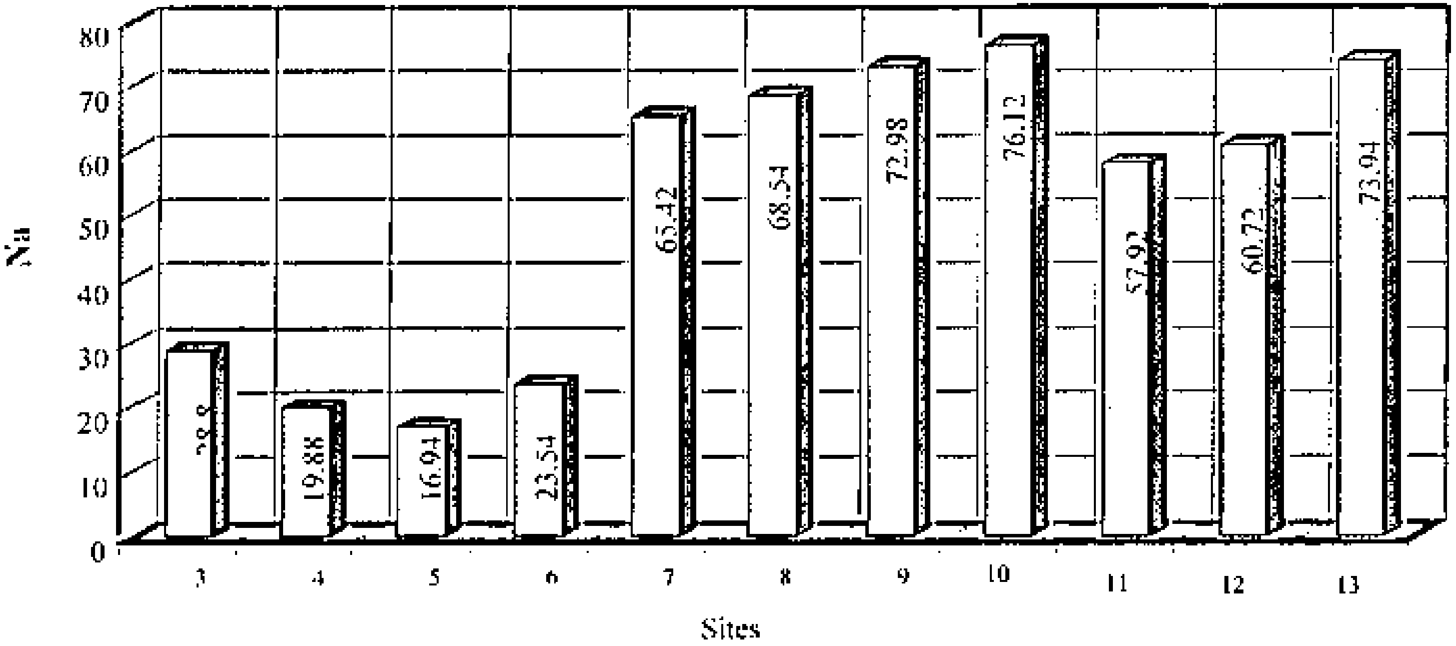


**Figure (6) The monthly average of Sodium**

samples. However, it ranges from 16.94-28.79 mg/L for the samples in the desalination plant and 57.92-73.94 mg/L for the remaining samples (including the sites from company reservoir to the distribution sites). The results are within the WHO standards i.e. 200 mg/l as a maximum value for waters and potable water purposes (WHO, 2004; Aoown. 2002). The finding is also within the Libyan Water Standards and the rules forwarded by the Desalination plant administration. The results show (P value was 0.164 that is > 0.05) no significant difference in total dissolved solids between the means of the sampled groups. The maximum concentration of sodium was 76.12 mg/L at sample (10), and the minimum was 16.94 mg/L at sample (5). Batarseh (2006) found the concentration of sodium in desalination plants ranged from 15.39-57.40mg/L, the level of sodium in tap water ranged 27.31-93.10 mg/L and in bottled water 29.78 mg/L for local bottled and 19.43 mg/L for imported bottled. Al-Asaawi(1998) found the maximum concentration of sodium was 1401.5 mg/L, however in the sample from the desalination plant the concentration of sodium has a lower value ranged 20.15-26.0 mg/L.

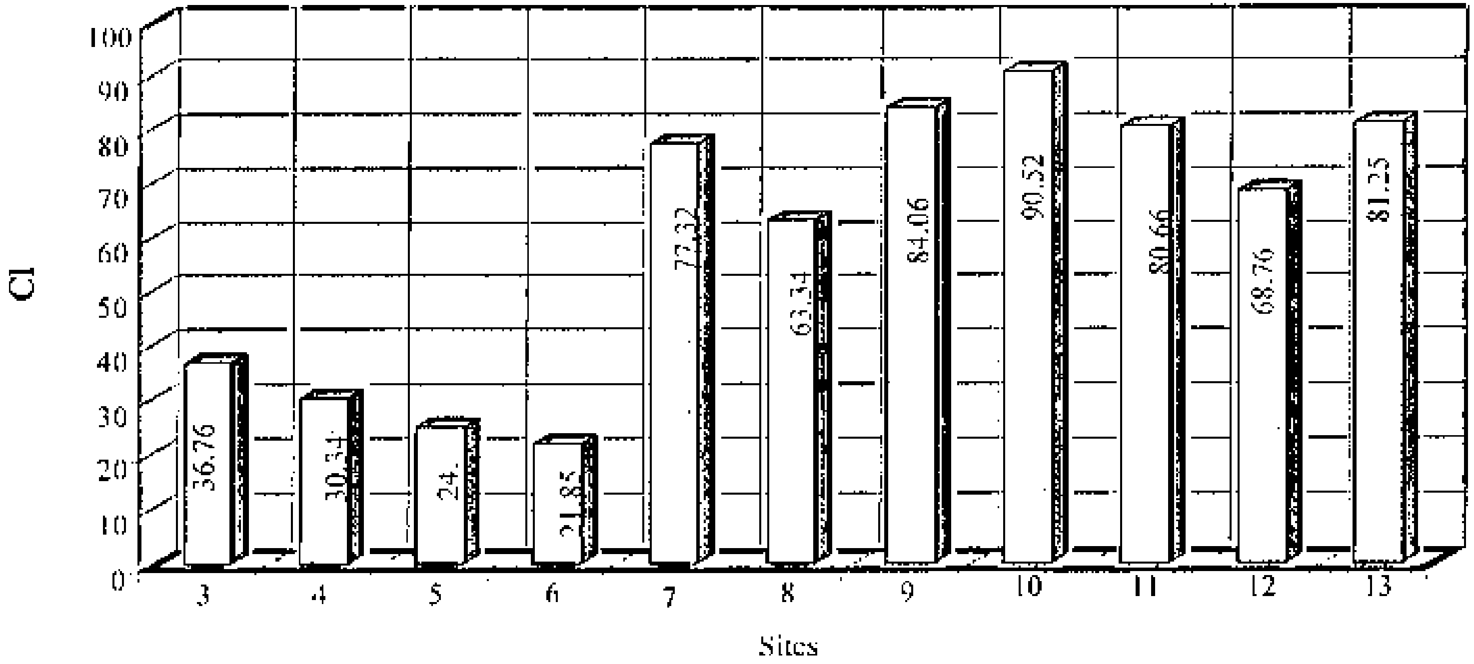
### 3.1.8. Chloride Concentration ($Cl^-$)

Chlorides, i.e. compounds of chlorine with another element or radical, are present in nearly all natural water and the range of concentrations can be very wide, but most combinations are with sodium (NaCl common salt). The concentration of chloride above 250mg/L can impart a distinctly salty taste to water. However, water containing more than 600mg/L is drunk in some arid places where there is no alternative supply (Twort *et al.*, 1985).

Figure (7) reveals that the average of chloride Cl of the studied sites ranged from 3459.40 to 3463.60 mg/L for seawater samples. However, it ranged from 21.85 to 36.76 mg/L for the samples in the desalination plant and 63.34 to 90.52 mg/L for the remaining samples (including the sites from company reservoir to the distribution sites). The WHO standard for Cl is 250 mg/L as a maximum value for waters and potable water purposes (WHO, 2004; Aoown, 2002).

The findings are also within the Libyan Water Standards and less than the rules forwarded by the Desalination plant administration that is 85.7-157.5mg/L. The results show (P value was 0.006 that is < 0.05) insignificant differences in chloride concentration between the means of the sampled groups. The maximum concentration of chloride was 90.52 mg/L at sample (10), and the minimum was 21.85 mg/L at sample (6).

A study by Binahmeeda (1997) found the concentration of chloride was very high, ranging from 580-705mg/L, which is considered as not suitable for irrigation and agriculture whereas a study by Ashelmani (2004) indicates that water from GMmR ranged between 228-463.6 mg/L. Al-Assawi (1998) found that the concentration of chloride ranged 29.3-36.0mg/L in the desalination plant of an iron and steel company. A study by Batarseh (2006) found that the concentration of chloride in desalination plants ranged from 32.84-61.82 mg/L. A study carried out by Kutty (1990) found that the chloride level ranged ND-149 mg/L.


CI
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Sites

### 3.1.9. Sulphate Concentration (SO4$^{--}$)

The concentration of sulphate in natural waters can vary over a wide range from a few mg/L to several thousand mg/L. It can come from several sources such as the dissolution of gypsum and other mineral deposits containing sulphate, from seawater intrusion, from the oxidation of sulphides, sulphites, and from industrial effluents. Bacterial reduction of sulphates under anaerobic conditions can produce hydrogen sulphide, which is an objectionable gas smelling of bad eggs (Twort *et al.*, 1985).

Figure (8) indicates that the monthly average of the sulphate concentration during the period of study was ranged from 33.38-68.36 mg/L for the samples in the desalination plant and 66.56-112.37mg/L for the remaining samples (including the sites from company reservoir to the distribution sites). However, it ranged from 718.56-734.34 mg/L for the seawater samples. The WHO standards and the Libyan Standards for $SO_4$ is 250 mg/L as a maximum value for waters and potable water purposes (WHO. 2004: Aoown, 2002). Comparing the results with desalination plant rules that range 12.4-28.9mg/L (see appendix 2): it can be found that the concentration level is high. The results show (P value was 0.000 that is < 0.05) insignificant differences in sulphate concentration between the means of the sampled groups. The maximum concentration of sulphate was 112.37 mg/L at sample (7), and the minimum was 33.38 mg/L at sample (4).

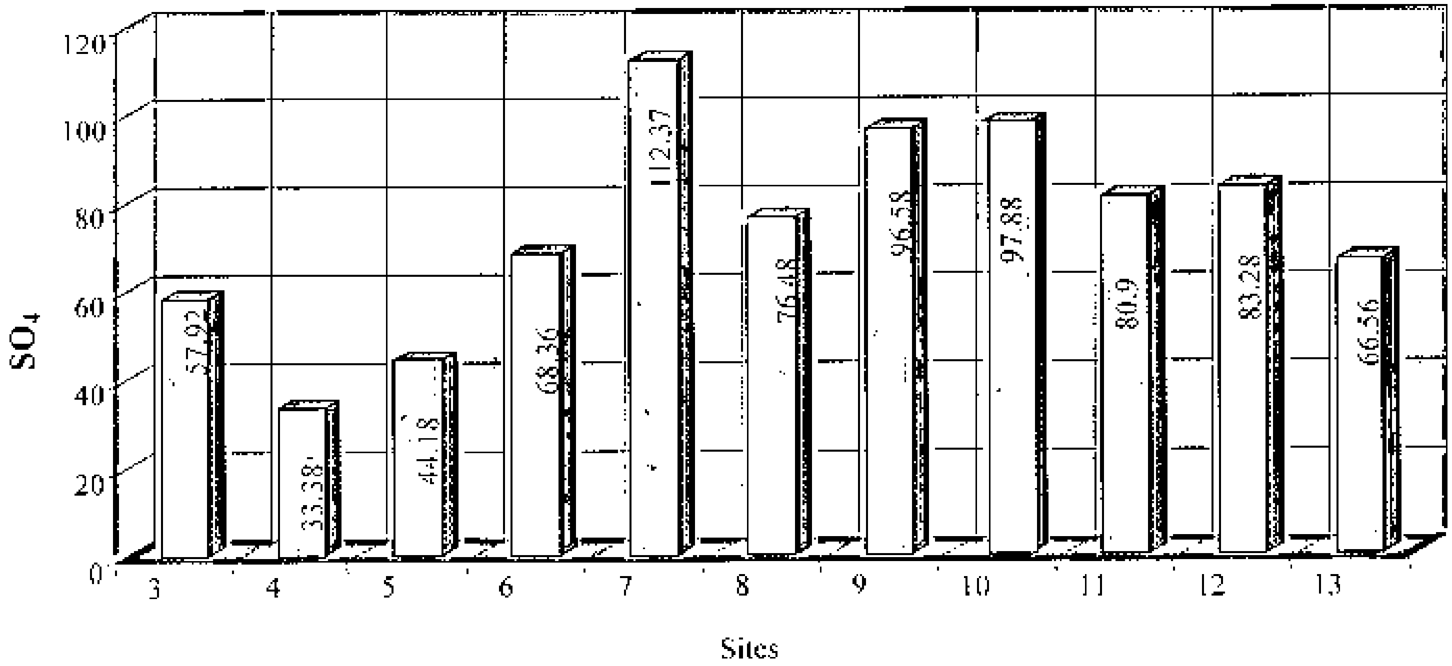

Figure (8) The monthly average of sulphate

The concentration of sulphate found in one study showed the maximum value 564mg/L and the minimum value of 251.7mg/L Ashelmani (2004). However, in another study carried out by Omar (2007) the highest level of the sulphate found was 416mg/L.

### 3.1.10. Nitrate Concentration ($NO_3^-$) mg/l

Nitrate is the final stage of oxidation of ammonia and the mineralization of nitrogen from organic matter. Nitrate levels in surface water often show marked seasonal fluctuations, with higher concentrations being found during the winter months compared to the summer months. Water containing high nitrate concentrations is potentially harmful to infants and young children (Twort *et al.*, 1985).

Figure (9) indicates that the monthly average of the nitrate concentration during the period of study ranged from 1.16-6.26 mg/L for the samples in the desalination plant and 7.90-10.82 mg/L for the remaining samples (including the sites from company reservoir to the distribution sites). However, it ranged from 4.60-4.92mg/L for the seawater samples. The WHO standards for $NO_3$ are 50mg/L as a maximum value for waters and potable water purposes. The results show (P value was 0.065 that is $> 0.05$) no significant difference in nitrate concentration between the means of the sampled groups. The maximum concentration of nitrate was 10.82 mg/L at sample (13), and the minimum was 1.16 mg/l at sample (6). In an analysis conducted by the Dutch Water Research and Tests Institute from 1985 to 1989 and analyses conducted by the central laboratory of Great Man-Mad River the concentration of $NO_3$ in Tawurghaa Pond was found to vary from 21-30mg/L whereas in Alasawna wells the concentration was found to be 37-99mg/L Binahmeeda (1997).

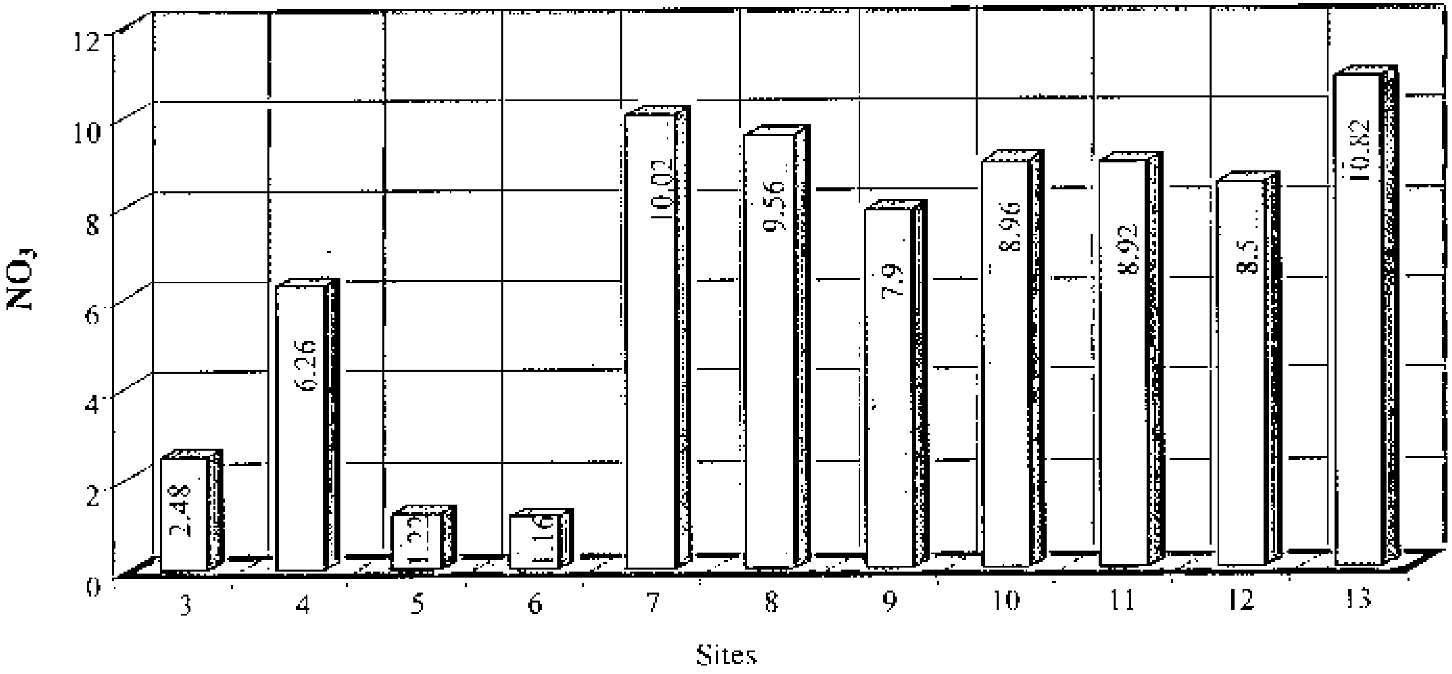

Figure (9) The monthly average of Nitrate

Another study carried out by Salameh *et. al.*, (2005) found that the concentration of nitrate ranged 3.5-122.5 mg/L in winter and 9.5-113.5 mg/L in summer. Ziadat (2005) found that the concentration of nitrate was 16.0-20.9 mg/L for residential storage tanks and 15.4-60.0 mg/L for the water source. In a study of the pond of Tawurghaa in Misurata (Libya) 1997, it was found that the mean of nitrate concentrations ranged 6.07-18.53 mg/L, nitrite was 0.01-0.15 mg/L, and the ammonia concentration was ranged 0-1.57 mg/L. Binahmeeda (1997). However, Fytianos (2002) found that the concentration of nitrate was 1.47 to 2.23 mg/L.

### 3.1.11. Calcium Hardness Concentration (Ca.H) mg/l

Figure (10) reveals that the monthly average of calcium hardness Ca.H of the studied sites ranged from 2903.94-3303.04 mg/L for seawater samples. However, it ranged from 5.60-37.86 mg/L for the samples in the desalination plant and 49.64-83.90mg/L for the remaining samples (including the sites from company reservoir to the distribution sites). The WHO standards for Ca.H are 400 mg/L as a maximum value and the level of calcium about 100-200 mg/L for waters and potable water purposes. The results show (P value was 0.006 that is $< 0.05$) insignificant differences in calcium hardness concentration between the means of the sampled groups. The maximum concentration of calcium hardness was 83.9 mg/l at sample (10), and the minimum was 5.6 mg/ L at sample (5).

Moftaah (2007) found the highest value of Ca-H was 100mg/L in July 2006, and lowest value was 8.10mg/L in June 2006.

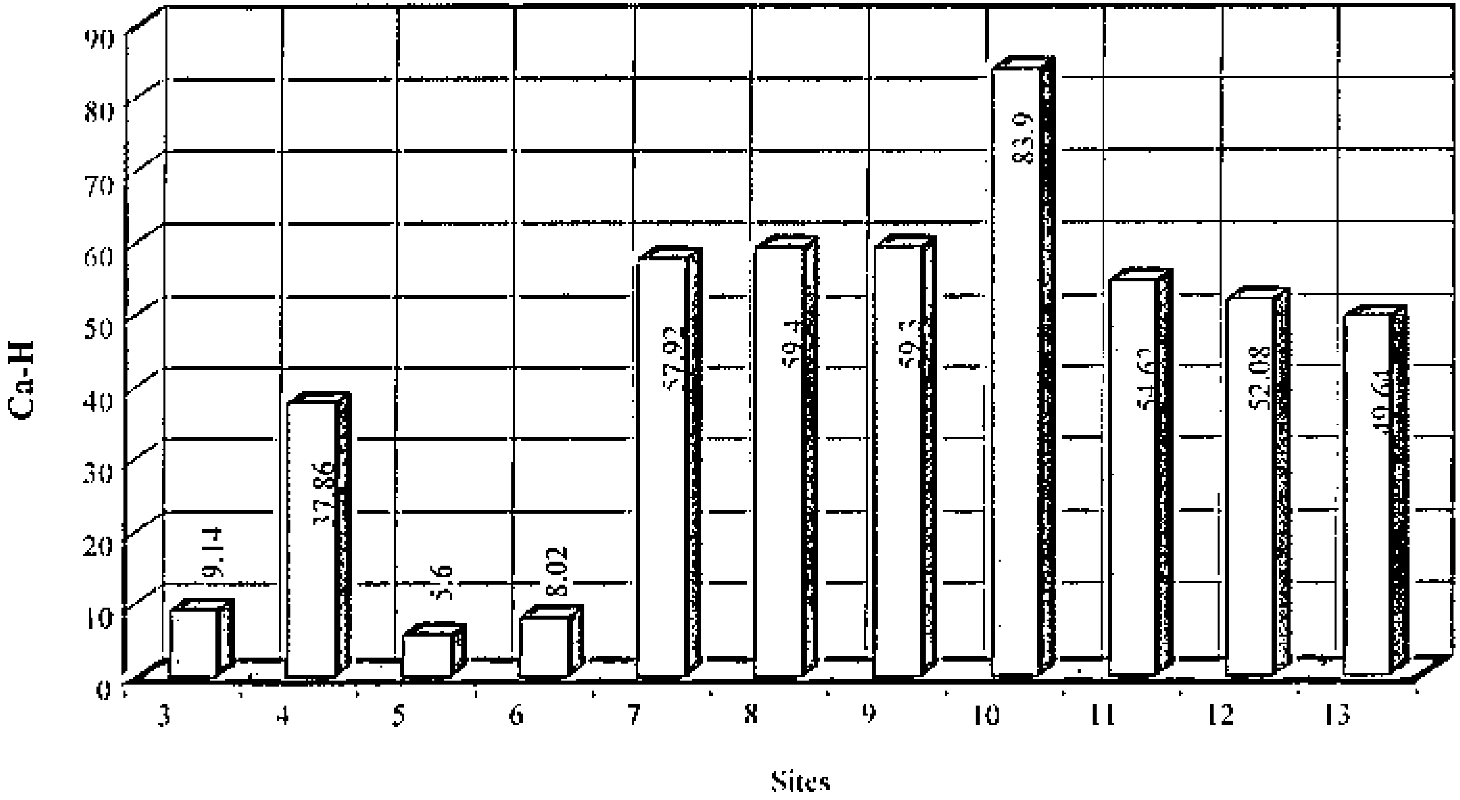

Figure (10) The monthly average of Calcium Hardness

### 3.1.12. Total Hardness Concentration (T.H) mg/l

The total hardness consists of carbonate or temporary hardness and non-carbonate or permanent hardness. Hardness is usually expressed in mg/L as $CaCO_3$. The problems caused by excessive hardness are mainly economical in terms of scale formation in boilers and hot water systems. From Tables (9 part 1 and 9 part 2) it can be noticed that the monthly average of total hardness T.H during the period of study was between 13.13 to 42.74 mg/L for the samples in the desalination plant and 61.63 to 118.11 mg/l for the remaining samples (including the sites from company reservoir to the distribution sites). However, it was ranged from 4281.45 to 5092.65 mg/L for the seawater samples. The results are in line with the WHO recommendation and the Libyan Accounting Standards for T.H; that is 500 mg/L as a maximum value for waters and potable water purposes (WHO, 2004; Moore and Moore. 1999; Aoown, 2002). Although the result is higher than the rules of the desalination plant – that is 20.85-79 mg/L – it is still within an accepted level. The results show (P value was 0.012 that is <0.05) insignificant differences in total hardness concentration between the means of the sampled groups. The maximum concentration of total hardness was 118.11 mg/L at sample (10), and the minimum was 13.13 mg/L at sample (3) (Fig. 11).

The physiochemical analysis of different sources of drinking water in the city of Misurata in Libya found that the total hardness of desalinated water was 56.7mg/L Al-Asaawi (1998) while in a study in Mexico City on bottled water quality the T.H ranged between 18.45-150.52mg/L. Robales (1999), in another study Al-abdula'aly & Khan (1999) examined the physical and chemicals parameters of local and imported bottled water and found that in one of them T.H was 12-146mg/L for local bottled water and 16-312mg/L for imported bottled water. Aother study of the water quality which derives drinking water from three seawater MSF plants in the Eastern Coast of Saudi Arabia to serve 10 important cities was carried out by Kutty (1990) and found the T.H $CaCO_3$ ND- 158 mg/L.

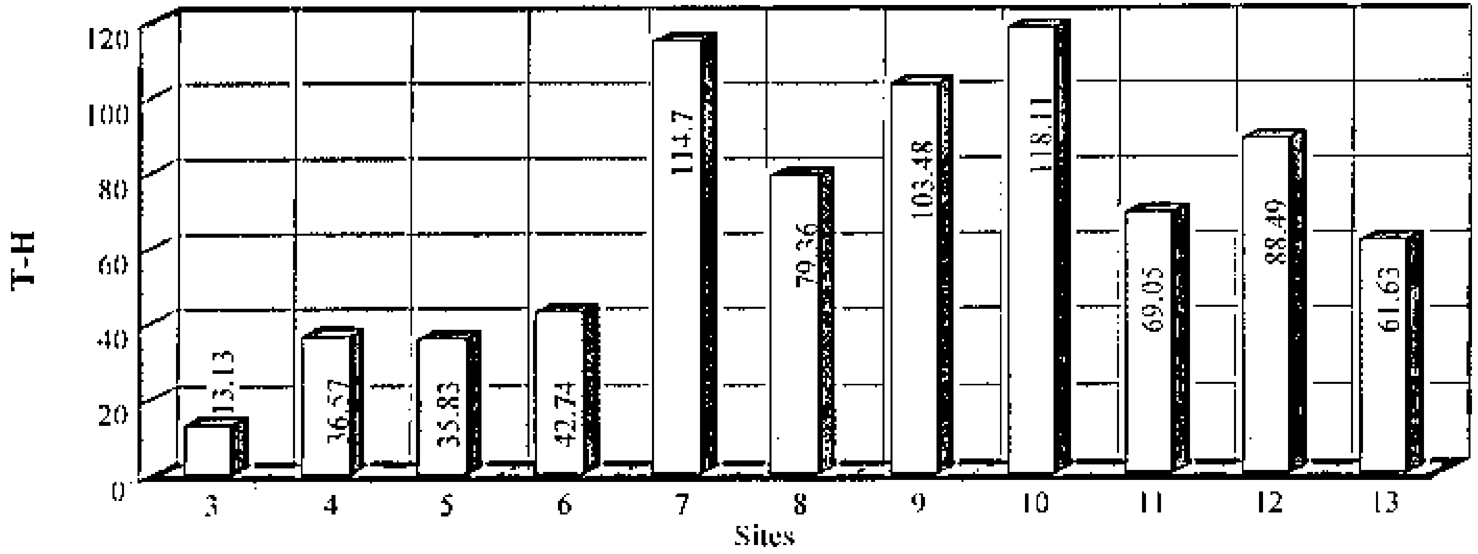

Figure (11) The monthly average of Total Hardness

### 3.1.13. Total Alkalinity (T.ALK) mg/l

Alkalinity is almost entirely due to the bicarbonate, carbonate, and hydroxide ions in the water, usually in association with calcium, magnesium, sodium and potassium. Alkalinity can exist in water below the neutral point of pH 7.0 because of the relationship between alkalinity, carbon dioxide, and pH value and between pH values 9.4 and 10.0 the alkalinity is all due to caustic or hydroxide alkalinity.

The values in Figure (12) illustrate the monthly means of total alkalinity T.ALK which were between 135.33 to 135.86 mg/L for seawater samples: from 7.97 to 11.13 mg/L for the samples in the desalination plant; and 81.26 to 203.76 mg/L for the remaining samples (including the sites from company reservoir to the distribution sites). The results show (P value was 0.000 that is $< 0.05$) insignificant differences in chloride concentration between the means of the sampled groups. The results are higher than the desalination plant rules that set a level of 42-45. The maximum concentration of total alkalinity was 203.76 mg/L at sample (10). and the minimum was 7.97 mg/L at sample (5) (Fig. 12).

Batarseh (2006) found the value of alkalinity of desalinated water was 40.27 to 51-81mg/L, 215.84 to 127.30 mg/L for tap water, 1.21 to 6.34 mg/L for home filtered and 117.65 to 134.73 mg/L for bottled water.

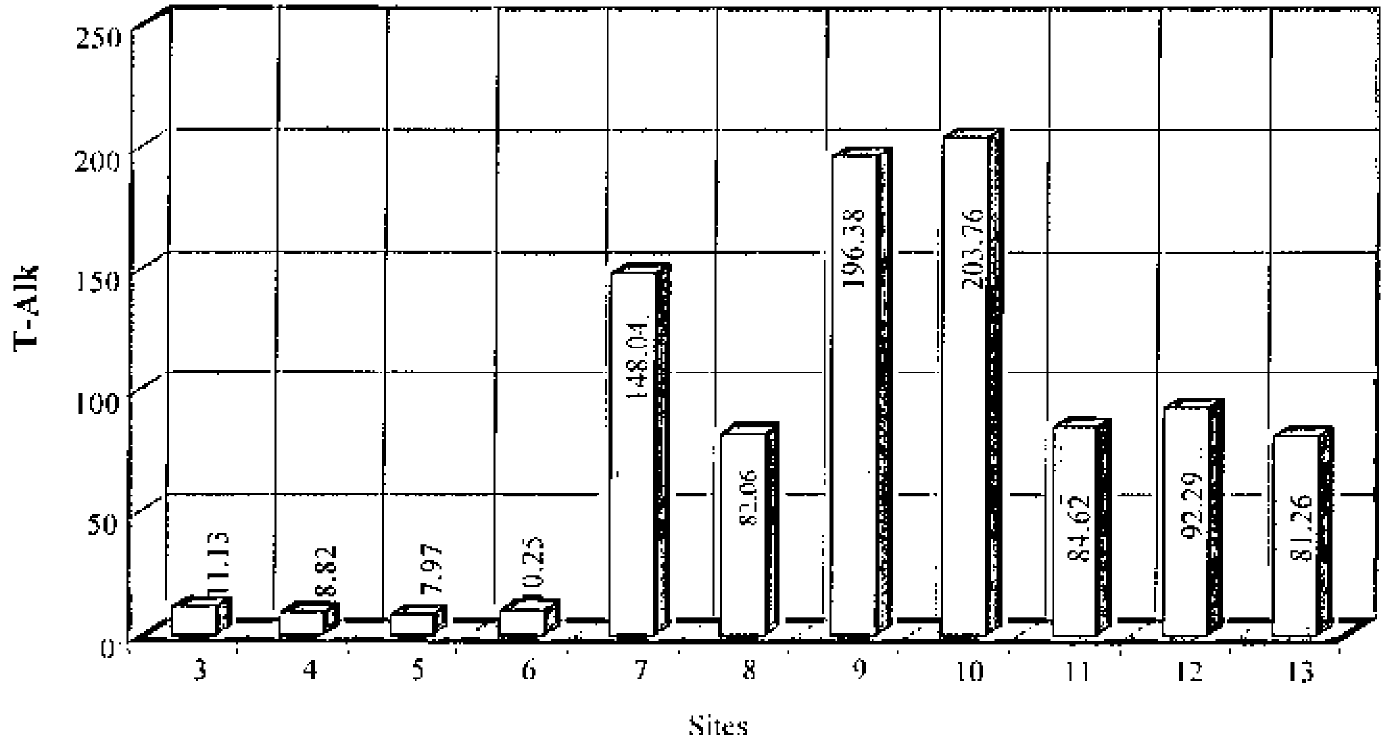

Figure (12) The monthly average of Total Alkalinity

### 3.2. The result of heavy metals:

The results analysis of Zn, Cd, Mg, Mn. and Fe was carried out for all sites which showed that all concentrations were Nil for heavy metals. This complies with the limits set by Libyan and WHO standards for drinking water.

Okasha (2001) found the results of heavy metals analysis in Wadi Al-Shati reached to (Cu) 4μg/L, (Cr) 4μg/L, (Cd) 1.2μg/L, (Hg) 350μg/L, (Zn) 2μg/L. Ashelmani (2004) in his study of heavy metals found the all values were within the international guidelines and acceptable concentrations for drinking water. The average concentration of Cd was 0.63μg/L Kutty *et. al.*, (1995). Virkutyte & Sillanpaa (2006) studied the physical and chemical parameters of water and the results showed high levels of some heavy metals which cause negative effect for human health; Fe was up to 1.9 mg/L and Ni was 0.05mg/L. However, the level of Pb, Cu, Cd and Cr did not exceed the National Chinese and WHO drinking water standards.

These values were changed according to the environmental monological study in 1996-1997 by Binahhmida (1997) which found the concentrations of iron much higher, about 0.019 – 1.73 mg/L. and this is considered being above the allowed limit of WHO and Libyan standards. The concentration of iron in desalination plants was 20.48-156.80 μg/L, the level of iron in tap water was 20.93-141.95 μg/L, and bottled water ranged 20.09- 95.60 μg/L (Salameh *et al.*, 2002; Kutty, 1990; Batarseh, 2006).

Manganese assists the growth of some livings that lead to a taste; Al-Asaawi (1998) studied the concentration of Mn and found that the concentration reach to 805μg/L. However, Batarseh (2006) found the concentration of Manganese in desalination plants ranged nd-1.05 μg/L, the level of Manganese in tap water was nd-0.50 μg/L. and bottled water was not defined. Kutty (1990) found the concentration of Manganese ranged 0.32- 3.77µg/L in his study.

## 3.4. Results of biological analysis

### 3.4.1. Total count of bacteria (T.C):

Tables 1, 2 and 3 show the values of total count of bacteria (T.C) of all collected samples. The highest count was in sample (9) mixing water 3:1 GMmR water with desalted water which was (>300CFU/1m) in June, September and December. The lowest count in most of the samples was 0.0CFU/1m.

A study carried out by Hassan *et. al.*, (1990) to evaluate the microbial situation of seaside water in UAE to three emirates Ajman, Sharka and Dubai. The researchers studied the distribution and count of bacteria which were non self feeding, living in salt and negative germs and E.coli bacteria. The results showed a high presence in counts of E.coli bacteria. These high numbers of bacteria in studied sites are due to the effects of sewage near to seaside water and their presence in open seaside waters of the Arabian Gulf.

### 3.4.2. Total Coliform Count (T.C.F):

Table.1 shows the total coliform (T.C.F) values of all collected samples. The highest value was found in sample (2) which reached 11CFU/100mL, while the lowest value of 0.0CFU/100mL found in most collected samples except samples (1)(9)(11)(13)(14) was>2. Table.3.4 shows the results of the total coliform (T.C.F) values of all collected samples. The highest value was found in sample (2) which reached 9CFU/100mL, and the remaining samples were as 0.0CFU/1m. The highest value was found in samples (2) (7) which reached 23CFU/100mL, 4CFU/100mL in sample (1) sea water and the lowest value of 0.0CFU/100mL in the remaining samples.

Moftaah (2007) in her study found the result of T.C.F had the highest value of 1100CFU/100mL and the lowest value of 0.0CFU/100mL.

### 3.4.3. Faecal Coliform Test (F.C.F):

Tables 1, 2and 3 show the total coliform feacal (T.C.F) values of all collected samples in June, September and December 2006. The highest value was found in sample (1), (2), (7) which reached 4CFU/100mL, however, sample (2) was contaminated by E.coli bacteria and the other samples were not identified.

Ashelmani (2004) studied T.C.F in his study into the Al-Gardabiya reservoir water in Sirt, and found the values to exceed the permissible limit during the study period.

### 3.4.4. Fungi

From tables 1, 2 and 3 can be seen the fungi values in CFU/1m of all collected samples where the highest values were found in sample (11) which was (>300CFU/1m) and in samples (2), (9) were (300CFU/1m). The lowest value between all samples was recorded in the period of study as it reached 0.0CFU/1m except in sample (14) in which were found 25 Pinicillum Fungi.

The isolated species of fungi from Al-gardabiya reservoir water in Sirt were examined by Ashelmani (2004) who found no risky species and indicated no effect on water quality.

Tables 1, 2 and 3 show the results of Streptococcus bacteria. The highest values during the months of study were 23, 9, and 4 in sample (1, 2, and 7) respectively. However, in the remaining samples the values were 0. The confirmative test was carried out for all samples and the results indicate NA for most of the samples except samples (2, 3, 4, 5, 6, and 7) which were –ve during June and December 2006. However, sample (1, 2) were +ve.

**Table.1.The monthly results of biological analysis period one (June, 2006)**

| Samples No. | | TESTS | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | T.C CFU/1mL | T.C.F CFU/100 M | F.C.F CFU/100 M | EMB | FUNGI | Streptococcus | Bile Aesculin |
| SEAWATER | 1 | 16 | <2 | NA | NA | 0 | 0 | NA |
| PRECIPTION RESERVOIR | 2 | - | 11 | 4 | *E.coli* | 300 yeast | 0 | -ve |
| PROODUCTION WATER | 3 | 4 | - | NA | NA | 0 | 0 | NA |
| TANK D412 | 4 | 20 | 0 | NA | NA | 0 | 0 | NA |
| TANK D414 | 5 | 16 | 0 | NA | NA | 0 | 0 | NA |
| LABRATORY OF PLANT | 6 | 37 | 0 | NA | NA | 0 | 0 | NA |
| DESALINTED WATER | 7 | 0 | 0 | NA | NA | 0 | 0 | NA |
| RIVER WATER | 8 | | 0 | NA | NA | 0 | 0 | NA |
| MIXING 3:1 | 9 | >300 | <2 | NA | NA | 0 | 0 | NA |
| TANK750 | 10 | 13 | 0 | - | - | 0 | 0 | NA |
| GUEST HOUSE | 11 | 30 | <2 | - | - | >300 yeast | 0 | NA |
| CAMPUS | 12 | 0 | 0 | - | - | 0 | 0 | NA |
| HOTELL | 13 | 25 | <2 | - | - | 0 | 0 | NA |
| PUBLIC WORKS CORPORATION | 14 | 25 | <2 | - | - | 25 Pinicillum | 0 | NA |

CFU/1mL :Colony Forming Unit Per 1mL   T.C.F: Total Count of Coliform   MPN: Most Probable Number   T.C: Total Count of Bacteria   F.C.F: Faecal Coliforms

-Ve: Negative test   +Ve: Positive test   -: Not Done   NA: Not Applicable

**Table.2.The monthly results of biological analysis period two (September, 2006)**

| Samples No. | | TESTS | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | T.C CFU/1mL | T.C.F CFU/100 M | F.C.F CFU/100 M | EMB | FUNGI | Strepto coccus | Bile Aesculin |
| SEAWATER | 1 | 4 | 0 | NA | - | 0 | 0 | NA |
| PRECIPTION RESERVOIR | 2 | - | 9 | 4 | *E.coli* | 300 yeast | 0 | -ve |
| PROODUCTION WATER | 3 | 0 | - | NA | NA | 0 | 0 | NA |
| TANK D412 | 4 | 9 | - | - | - | 0 | 0 | NA |
| TANK D414 | 5 | 3 | 0 | NA | - | 0 | 0 | NA |
| LABRATORY OF PLANT | 6 | 0 | 0 | NA | - | 0 | 0 | NA |
| DESALINTED WATER | 7 | 6 | 0 | NA | NA | 0 | 4 | -ve |
| RIVER WATER | 8 | 3 | 0 | NA | NA | 0 | 0 | NA |
| MIXING 3:1 | 9 | >300 | - | - | - | 300 yeast | 0 | NA |
| TANK750 | 10 | 0 | 0 | NA | NA | 0 | 0 | NA |
| GUEST HOUSE | 11 | 0 | 0 | NA | NA | 0 | 0 | NA |
| CAMPUS | 12 | 0 | 0 | NA | NA | 0 | 0 | NA |
| HOTELL | 13 | 0 | 0 | NA | NA | 0 | 0 | NA |
| PUBLIC WORKS CORPORATION | 14 | 0 | 0 | NA | NA | 0 | 0 | NA |

Table.3.The monthly results of biological analysis period three (December, 2006)

| Samples No. | | TESTS | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | T.C Cfu/1mL | T.C.F PN/100 M | F.C.F PN/100 M | EMB | FUNGI | Strepto coccus | Bile Aesculin |
| SEAWATER | 1 | - | 4 | 4 | NEC | 0 | 23 | +ve |
| PRECIPITION RESERVOIR | 2 | - | 23 | 4 | NEC | 0 | 9 | +ve |
| PROODUCTION WATER | 3 | 0 | - | NA | NA | 0 | 0 | -ve |
| TANK D412 | 4 | - | 0 | NA | NEC | 0 | 0 | -ve |
| TANK D414 | 5 | 3 | 0 | NA | NEC | 0 | 0 | -ve |
| LABRATORY OF PLANT | 6 | 0 | 0 | NA | - | 0 | 0 | -ve |
| DESALINTED WATER | 7 | - | 23 | 4 | *E.coli* | 0 | 4 | -ve |
| RIVER WATER | 8 | 3 | 0 | NA | NA | 0 | 0 | NA |
| MIXING 3:1 | 9 | >300 | - | - | - | 300 yeast | 0 | NA |
| TANK750 | 10 | 0 | 0 | NA | NA | 0 | 0 | NA |
| GUEST HOUSE | 11 | 0 | 0 | NA | NA | 0 | 0 | NA |
| CAMPUS | 12 | 0 | 0 | NA | NA | 0 | 0 | NA |
| HOTELL | 13 | 0 | 0 | NA | NA | 0 | 0 | NA |
| PUBLIC WORKS CORPORATION | 14 | 0 | 0 | NA | NA | 0 | 0 | NA |

### 3.5. Concluding remarks

It can be observed from the collected results during the study that the highest levels for parameters under investigation come from the production sample (3) and D412 Tank. This contradicts the anticipated results for these two samples which were expected to have low levels because the pre-treated water showed no additional salts to be suitable for drinking. This can be attributed to the break down of the plant many times and the enduring corrosions of the plant unit. It can also be noticed that during the collection the sample from Tank D412 had yellow water (Al-Abaar and Al-Mabrook, 2006; Ziadat, 2005).

Out plant samples have fluctuating values during the period of study due to the random mixing water rate by the Public Water Authority. The highest levels come from Tank 750 and the Guest House sample because these are channeled by two means, one from the Company Reservoir and directly from the desalination plant even during the time the plant is not working properly. The main problem contributing to fluctuations in water qualities can be related to the absence of the chemical treatment unit since 1993 until writing this work. The suggested solution to this problem is mixing water with 3 quantities of water from river and 1 quantity from the desalination plant. However, this remedial solution is randomly applied. The other source of low quality of distributed water is that it is transported via unhealthy, old and unsuitable trucks to the consumers.

## 3.6. THE CHEMICAL TREATMENT UNIT

This section describes the chemical treatment unit and then suggests a solution to the current problem to help produce drinkable water. In this part I would like to mention that the plant suffers from the breakdown of the chemical treatment unit which has a major effect on the quality of product water.

### 3.6.1. Description of plant

Evaporator and distillate units, carbonizing and supplying drinking water to the consumers.

### 3.6.2. Description of process

The plant serves for the carbonization and saltiation of evaporated distillated water.

The carbonization and salting are effected by adding carbonic acid to the distillate and subsequent chemical setting by means of marble. This leads to the forming of carbonate hardness. The salting is effected by adding sea-water (approx. 0.6% of the quantity of distillate). At the same time the sea-water also brings slight non-carbonate hardness into the distillate. Additionally, the water is treated as follows:

Oxygen enrichment of the distillate by adding compressed air.

Chlorination of the finished water for the purpose of germ destruction and for avoiding bacterial after-growth.

Addition of phosphate as protective agent against corrosion.

Sodium fluoride is blended to the phosphate as protective agent against dental caries.

In accordance with the process, compressed air is added to the distillate before entering the mixing line, the excessive amount of compressed air quantity of distillate led into the lower section of the container. Here the addition of carbonic acid gas is effected before the quantity of distillate passes through a further special mixing line up to the outlet of the mixing container. The distillate to be treated passes over several marble filters where the setting of the carbonic acid is affected while the forming of carbonate hardness occurs.

Subsequently, sea water, chlorine and phosphate sodium chloride are added to the carbonized water. Behind the dosing points again a special mixing line is provided so that, at the outlet of the plant, drinking water becomes available having the following average analysis values:

**Table.4. average analysis values of chemical treatment unit**

| PH | 7.3-7.8 |
|---|---|
| Chlorine approx. | 0.1-0.5 mg/L |
| Total Salt content approx. | 380 mg/L |
| Bicarbonate of calcium approx. | 150 mg/L |
| Chloride approx. | 130 mg/L |
| Carbonate hardness approx. | 5.6 mg/L |
| Non-carbonate hardness approx. | 2.4 mg/L |
| Fluorine approx. | 0.45 mg/L |
| Calcium approx. | 40 mg/L |
| Magnesium | 10 mg/L |
| Sulphate approx. | 20 mg/L |
| Sodium approx. | 70 mg/L |
| Total hardness approx. | 8 mg/L |
| Potassium approx. | 2 mg/L |
| Bromine approx. | 1 mg/L |
| Phosphate approx. | 3 mg/L |

The efficiency of the treatment depends essentially on the quality of marble material applied by the customer. We recommend the use of Juraperle JW with a grain size of 1.2 to 1.8 mm. In any case at least a marble material having the aforementioned grain size with the lowest possible portion of dust should be used having purity in accordance with the analysis indicated hereafter:

**Table.5.The components of marble (mg/g)**

| | |
|---|---|
| Manganese Mn | 0.00047 |
| $Al_2O_2$ | 0.3000 |
| Copper | 0.0002 |
| Cao | 55.814 |
| $CO_2$ | 42.802 |
| $Fe_2O_3$ | 0.0347 |
| HCl –Insoluble | 0.506 |
| Humidity | 0.024 |
| $SiO_2$ | 0.118 |
| MgO | 0.116 |
| Specific Weight | 2.6312 |
| pH –Value | 8.6 |

In connection with the treatment of water we give the following indications:

On average the addition of chlorine should be to 0.5 mg/L max. During average operation there shall only be left a slight excess of chlorine of less than 0.1 mg/l at the consumer points.

The addition of phosphate sodium fluoride should always be maintained for avoiding corrosions in the steel pipe lines. The finished water possesses a certain remaining aggressively which has to be attributed. On the one hand, the water in question is synthetic, and, on the other hand, the carbonization is carried out in the course of a cooling down process. Water, which is brought into a state of equilibrium at a temperature of approx. 40°C during the normal treatment process, becomes slightly aggressive as a result of displacement of the equilibrium curve during the cooling down process or in the course of temperature decrease. The addition of phosphate should permanently be maintained in the amount of approx. 3g, since here the blended-in sodium fluoride corresponds to an addition quantity of 1 g of NaF, where the fluorine addition itself amounts to approx. 0.45 g/m$^3$. An increase of the dosage of mixed product should not exceed a plus of 50%, since the double addition quantity results in an excessively high addition of fluoride.

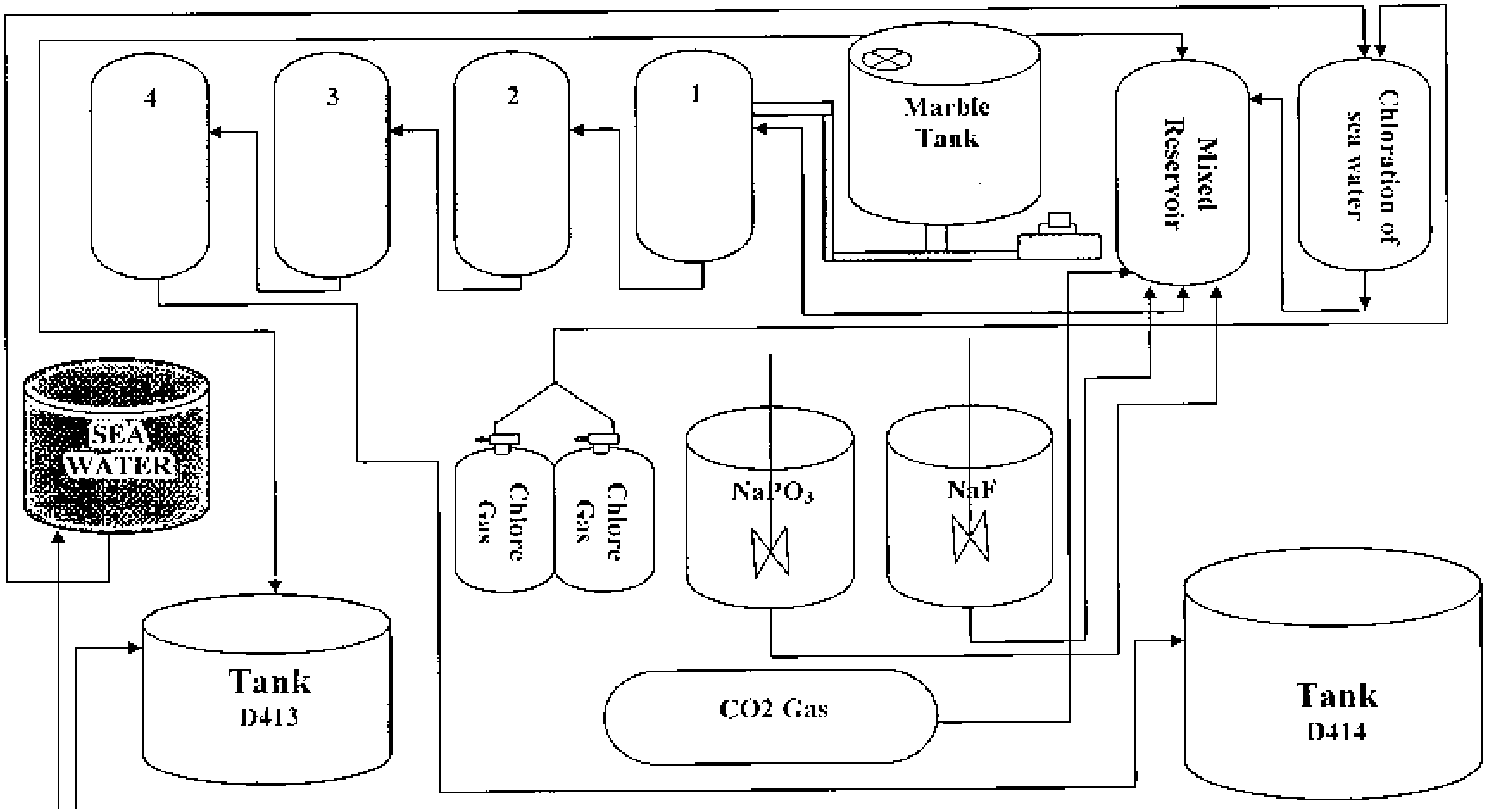

Figure. (13) Scheme of chemical treatment unit

### 3.7. The suggested solution for unit breakdown

***The objective:*** treat the produced water chemically to reach the required level of drinking water levels.

***Material and methods:*** the following table shows six experiments for treatment of produced water, which was produced without any chemical. The proposed chemical treatment for produced water is a major step in the production of water from a desalination plant. As mentioned earlier the unit in the Sirt desalination plant has been broken-down since 1993, therefore, produced water cannot be distributed to the consumer and considered to be healthy and save.

We established a mini chemical treatment unit in the plant laboratory to suggest a way of treating the produced desalted water to overcome the problem and provide a healthy and safe drinking water to meet with the required standards.

***Chemical treatment***

The main purpose of the chemical treatment unit in the desalination plant is to add the required amount of minerals to the desalted water produced by the plant.

The substances used to enrich the water were sea water or GMmR water, polyphosphate sodium, fluoride sodium, $CO_2$ gas, chloride tablets and marble.

The main additive used and concentrated on in this experiment was the type, shape and amount of the marble.

Two different types were available yellow marble and gray marble. The marble was grained to small pieces (0.5-1cm) to expose maximum surface of it to the water passed or mixed with the obtained values for the desalination water.

Table (6) shows six experiments of chemical treatment of produced water from the plant which carried out in plant laboratory. The purpose and the motivation of these treatments to find out the method for treatment of the produced water from the plant (this water does not comply with WHO standards for drinking water) and to avoid the inconsistent method of mixing water in the plant. The motivation behind these exterminates is that during my site visit I noticed that the produced water was untreated due to break down of the treatment unit. So, I thought about this way to avoid using some materials that deteriorate the work of the plant.

In order to conduct these treatments, six tests were carried out by the researcher. Different volumes of distilled water ranged from 500mL to 20L were used. In this regard the chemicals also were different base on the amount of the marble and the marble conditions such as its heating, mixing, soaking, and bounding. It is worth mentioning that all added chemicals were added relative to the amount used in the plant when the unit of treatment was working.

For example, 20 L of distilled water used that contains amount of marble which was soaked (and was bounded).Before adding any chemicals additives, the electric conductivity of the water and the marble was measured and found to be 25μs.In the following procedure I added chemicals for treatment of the produced water where 0.035g of poly phosphate sodium, 0.04g of Sodium Fluoride, 100 mL of filtered and purified seawater, that reach to the half level of the 20 L tank were added. Having added all these chemicals, the electrical conductivity was measured and it found to be 534 μs. The rest of parameters of this experiment were measured and they appear in table (7).

**Table.6.The experiments of chemical treatment of desalinated water which carried out in laboratory**

| *Test NO.* | *D.W* | *sodium Poly phosphate* | *sodium Fluoride* | *Sea water* | *marble* | ***EC Before treatment*** | ***EC After treatment*** |
|---|---|---|---|---|---|---|---|
| 1 | 500 mL | 10 mL | 10 mL | 0.375 mL | Quantity of marble | **64.5µs/cm** | **340µs/cm** |
| 2 | 1000 mL | 30 mL | 30 mL | 1 mL | With mixing for many hours and heating | **64.5µs/cm** | **450µs/cm** |
| 3 | 1000 mL | 30 mL | 30 mL | 1 mL | More marble without heating and mixing | **133.6µs/cm** | **490µs/cm** |
| 4 | 1000 mL | 10 mL | 10 mL | 1 mL | Little marble without heating and mixing | **134µs/cm** | **550µs/cm** |
| 5 | 500 mL | 10 mL | 10 mL | 0.375 mL | Quantity of marble without heating and mixing | **134µs/cm** | **473µs/cm** |
| 6 | 20 L | 0.035g | 0.04 | 100 mL | Soaking the marble and then bound it | **25µs/cm** | **534µs/cm** |

D.W: Distilled Water

Table.7.The results of chemical treatment of desalinated water

| Samples NO. | EC | pH | TDS | T | NaCl% | $Cl^-$ | T.H | ALK. | $Na^{++}$ | $K^+$ | $Ca^{++}$ | $SO_4^{-}$ | $NO_3^-$ | $HCO_3^-$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 840µs | 8.48 | 420 | 16.9C° | 1.6% | 23.43 | 24 | 172 | 6 | 7 | 70.4 | 0.025 | - | 225.7 |
| 2 | 473 µs | 8.99 | 237 | 17.1 C° | 0.9% | 15.62 | 6.72 | 98 | 14 | 4.5 | 52.8 | 0.05 | - | 134.2 |
| 3 | 472 µs | 8.42 | 236 | 16.7 C° | 0.9% | 14.2 | 11.52 | 84 | 17 | 4 | 48 | 0.051 | - | 115.9 |
| 4 | 512 µs | 8.50 | 256 | 16.5 C° | 1.0% | 11.36 | 14.4 | 116 | 21 | 4 | 115.2 | 0.08 | - | 152.5 |
| 5 | 320 µs | 7.64 | 160 | 18.0 C° | 0.6% | 16.33 | 60 | 52 | 25 | 16 | 16 | 0.02 | - | 79.3 |
| 6 | 534 µs | 7.50 | 266 | 17.1 C° | 1.0% | 28.4 | 29.76 | 54 | 23 | 10 | 80 | 0.025 | - | 67.1 |

Marble was added to desalinated water directly without any chemical additives and a comparison between yellow marble and gray marble was carried out. The results are shown in table (8.A):

Table (8.A) The comparison between yellow marble and gray marble

| | EC µs/cm | TDS | NaCl% | T°C | pH |
|---|---|---|---|---|---|
| **Yellow Marble** | 236.5 | 118.3 | 0.5 | 24.7 | 7.4 |
| **Gray Marble** | 98.6 | 49.3 | 0.1 | 23.8 | 9.85 |

It can be observed from the table that yellow marble is much better than gray marble in producing water with suitable salts.

Table (8.B ) shows the comparative values between the parameters directly after the addition of sodium fluoride + poly phosphate sodium +seawater + $CO_2$ gas + chloride tablets. The results were as follows:

Table (8.B) The comparison between yellow marble and gray marble

| | Yellow Marble | Gray Marble |
|---|---|---|
| **EC** | 556µs/cm | 387 µs/cm |
| **TDS** | 278 mg/L | 194 mg/L |
| **NaCl%** | 1.1% | 0.7% |
| **T°C** | 20.5°C | 22.7°C |
| **pH** | 7.48 | 9.99 |
| **$Cl^-$** | 25.6 mg/L | 15.62 mg/L |
| **$Ca^{++}$** | 23.64 mg/L | 52.8 mg/L |
| **T.H** | 73 mg/L | 6.72 mg/L |
| **Na+** | 10 mg/L | 14 mg/L |
| **$K^+$** | 18 mg/L | 4.5 mg/L |
| **$HCO_3^-$** | 30.5 mg/L | 134.2 mg/L |
| **Alk.** | 30 mg/L | 98 mg/L |
| **$SO_4^{--}$** | 0.725mg/L | 52.8 mg/L |

The remaining results of gray marble for other parameters as explained in the table of the results for chemical treatment, where all experiments was carried out using gray marble.

***Findings:*** Experiments 5 and 6 showed the best results because they comply with the chemical treatment during its working time. Accordingly, these results can be utilized for large volumes by the plant administration with some modifications to serve their purposes in the absence of a working chemical treatment unit.

# *Conclusion And Recommendations*

### 4. 1. Recommendations:

Depending on the findings of this study the following recommendation are thought to have a direct effect on improving the quality of drinking water:

#### 4.1.1. For general purposes:

- Water authorities should give more attention to study water quality to comply with the international and local standards.
- Water reservoirs should be subjected to periodic inspection to mitigate the problems of corrosion. This can be done by replacing the existing water tanks with an established water distribution channel.
- Monitoring the quality of water transferred to individual consumers via trucks and finding another way of transferring water.
- Water supply tanks should be secured as observed to be left open which may lead to more pollution.
- For public health, tanks should be hygienic to prevent the growth of microorganisms.
- Establish water centres in Sirt city that are concerned with the quality and monitoring of the water supplies.

#### 4.1. 2. Recommendations for the desalination plant:

- Study the quality of feeding waters for the plant to enhance the industrial process and to maintain the plant unit working in an efficient way; for example, the boilers, the condensers, water reservoir.
- The examined reservoir for seawater that feeds the plant was not in good condition; it was fungal, rusty, corroded, and the

water was surfaced with oil which impacts on the work of plant units and the produced water quality.

- The chemical additives such as tgose for the anti foam of seawater, anti shells and anti-corrosion should be used in a right way and according to standards methods.
- Avoiding dumping the wastes into the sea to protect the environment by a recycling process before discharging it into the environment.
- Upgrading and training the current staff in the plant to keep them up to date with new developments.

## 4.2. Conclusions

- The corrosion of the plant units, shells within the units, spills of oil on seawater surface, and smoke arising from the plant; all of these lead to environmental pollution.
- Due to the lack of periodical maintenance and renewal of the old units of the desalination plant, the plant cannot provide water ready for drinking.
- The quality of desalting water produced by the plant meets with the standards of desalting water.
- Simpler and cheaper ways of chemical treatment were suggested which can be adopted by simple modification.
- Due to the continuous break down of the plant, great damage was caused to its units.
- Lack of maintenance of plant leads to low quality of produced water.
- The use of different types of marbles (grey) may cause deterioration of the chemical treatment units.

- Growth algae in the examined reservoir (site, 2) leads to contamination of feeding water.
- Efficiency of yellow marble in terms of different minerals to desalted water is much better than grey marble.

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# *Appendix*

# Appendix (1)

***Table.9. Part (1) the monthly average, standard deviation and P.value during the period of study***

| | Sample1 | | Sample 2 | | Sample 3 | | Sample 4 | | Sample 5 | | Sample 6 | | Sample 7 | | *p. value* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | AV | STD | AV | STD | AV | STD | AV | STD | AV | STD | AV | STD | AV | STD | |
| *EC* | 54720.10 | 2359.40 | 54466.18 | 2731.10 | 24.66 | 29.78 | 72.68 | 64.82 | 44.48 | 33 41 | 71.120 | 35.60 | 711.60 | 147.17 | .000 |
| *pH* | 7.87 | .0797 | 7.83 | .4218 | 8.25 | .5112 | 7.66 | 1 6977 | 7.83 | 1.613 | 6.50 | .9935 | 8.10 | .0404 | .000 |
| *TDS* | 35568 00 | 1533.64 | 35106.60 | 1556.54 | 16.235 | 19.24 | 47.272 | 42.12 | 28.764 | 21.77 | 46.045 | 23.28 | 461.80 | 92.60 | .000 |
| *K* | 269.47 | 201.39 | 270.64 | 202.21 | 7.58 | 3.997 | 9.16 | 9.736 | 9.58 | 10.795 | 5.38 | 3.819 | 22.63 | 4.966 | .022 |
| *Na* | 2042.03 | 3089.367 | 2041.89 | 3092.412 | 28.80 | 25.661 | 19.88 | 15.660 | 16.94 | 17.351 | 23.54 | 13.880 | 65.42 | 27.718 | .164 |
| *Cl* | 3463.60 | 1570.216 | 3459.40 | 1666.324 | 36.76 | 34.642 | 30.34 | 22.310 | 24.96 | 23.035 | 21.85 | 5.781 | 77.32 | 27.789 | .006 |
| $SO_4$ | 734.34 | 131.012 | 718.56 | 96.903 | 57.92 | 81.143 | 33.38 | 30.750 | 44.18 | 31.951 | 68.36 | 57.448 | 112.37 | 41.239 | .000 |
| $NO_3$ | 4.92 | 2.618 | 4.60 | 1.673 | 2.48 | 2.272 | 6.26 | 11.626 | 1.22 | 1.163 | 1.16 | 1.385 | 10.02 | 11.226 | .065 |
| *Ca.H* | 2903.94 | 1429.826 | 3303.04 | 1511.737 | 9.14 | 9.844 | 37.86 | 77.457 | 5.60 | 2.191 | 8.02 | .045 | 57.92 | 43.626 | .006 |
| *T.H* | 4281.44 | 2434.477 | 5092.65 | 3008.036 | 13.13 | 14.001 | 36.57 | 48.318 | 35.83 | 56.339 | 42.74 | 47.691 | 114.70 | 71.546 | .012 |
| *T.ALK* | 135.86 | 16.490 | 135.33 | 15.345 | 11.13 | 5 242 | 8.82 | 3.368 | 7.97 | 2.861 | 10.25 | 3.526 | 148.04 | 8.486 | .000 |

Where:
**AV=** *Average*
**STD** = *standard deviation*
**P.v** = *p. value*

## Table.9. part (2) the monthly average, standard deviation and P.value during the period of study

| | Sample 8 | | Sample 9 | | Sample 10 | | Sample 11 | | Sample 12 | | Sample 13 | | p. value |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | AV | STD | AV | AV | AV | STD | AV | STD | AV | STD | AV | STD | |
| *EC* | 385.40 | 259.69 | 600 20 | 124.37 | 666.40 | 105.81 | 446.34 | 357.84 | 474.54 | 279.35 | 418.90 | 307.47 | .000 |
| *pH* | 8.40 | .3115 | 8.16 | .1050 | 8.16 | .1504 | 8.08 | .2134 | 8.12 | .1949 | 8.12 | .1539 | .000 |
| *TDS* | 247.85 | 171.06 | 389.01 | 81.99 | 425.69 | 68.93 | 290.13 | 232.59 | 308.46 | 181.58 | 272.12 | 199.96 | .000 |
| *K* | 12.66 | 9.850 | 10.20 | 11.900 | 16.05 | 7.688 | 12.49 | 9.202 | 11.75 | 7.922 | 11.97 | 7.315 | .022 |
| *Na* | 68.54 | 11.553 | 72.98 | 11.002 | 76.12 | 17.444 | 57.92 | 34.830 | 60.72 | 19.632 | 73.94 | 8.868 | .164 |
| *Cl* | 63.34 | 19.552 | 84.06 | 20.060 | 90.52 | 19.774 | 80.66 | 27.129 | 68.76 | 17.024 | 81.25 | 16.200 | .006 |
| *SO4* | 76.48 | 53.633 | 96.58 | 30.862 | 97.88 | 24.499 | 80.90 | 66.457 | 83.28 | 49.737 | 66.56 | 66.755 | .000 |
| *NO3* | 9.56 | 9.497 | 7.90 | 9.802 | 8.96 | 9.687 | 8.92 | 9.687 | 8.50 | 9.266 | 10 62 | 8.836 | .065 |
| *Ca.H* | 59.40 | 60.982 | 59.30 | 31.007 | 83.90 | 22.854 | 54.62 | 40.564 | 52.08 | 30.041 | 49.64 | 42.760 | .006 |
| *T.H* | 79.36 | 54.320 | 103.48 | 41.780 | 118.11 | 12.705 | 69.05 | 61.261 | 88.49 | 53.754 | 61.63 | 34.880 | .012 |
| *T.ALK* | 82.06 | 39.961 | 196.38 | 165.810 | 203.76 | 167.078 | 84.62 | 66.216 | 92.29 | 46.102 | 81.26 | 43.436 | .000 |

Where:

**AV**= *Average*

**STD** = *standard deviation*

**P.v** = *p. value*

Table (10) results of chemical parameters for period one (*June, 2006*)

| *Site of sample* | Sample | EC | pH | TDS mg/l | K mg/l | Na mg/l | CL mg/l | SO4 mg/l | NO3 mg/l | Ca.H mg/l | T-H mg/l | T-Alk |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SEAWATER | 1 | 53100.0 | 8.0 | 34515.0 | 505.8 | 7500.0 | 6045.0 | 561.4 | 2.4 | 1089.7 | 2724.3 | 157.6 |
| PRESIPATION RESERVOIR | 2 | 53100.5 | 8.4 | 34715.0 | 506.9 | 7505.0 | 6065.0 | 663.3 | 2.78 | 1355.2 | 2755.02 | 160.3 |
| PRODUCTION WATER | 3 | 5.9 | 8.2 | 3.8 | 9.1 | 15.80 | 11.7 | 8.2 | 1.8 | 4.0 | 4.0 | 11.8 |
| Tank D412 | 4 | 5.99 | 8.3 | 4.0 | 25.6 | 4.82 | 7.6 | 3.7 | 1.8 | 3.9 | 7.8 | 8.2 |
| Tank D414 | 5 | 6.2 | 8.5 | 4.0 | 27.9 | 4.10 | 7.8 | 3.9 | 1.8 | 4.0 | 8.0 | 7.9 |
| LABORATORY. OF PLANT | 6 | 49.88 | 5.5 | 31.95 | 8 | 33.4 | 21 | 31.3 | 0.5 | 8 | 14.66 | 11.8 |
| RIVER WATER | 7 | 617 | 8.09 | 400.4 | 20.43 | 50 | 50.7 | 66.4 | 3.8 | 60 | 124.11 | 136 |
| MIXING 3:1 | 8 | 189 | 8.2 | 115 | 7.4 | 60.5 | 43.2 | 35 | 3.1 | 14 | 33.04 | 34.3 |
| TANK750 | 9 | 610.0 | 8.1 | 396.5 | 1.4 | 62.30 | 58.5 | 96.9 | 1.7 | 52.5 | 144.1 | 145.8 |
| GUESTHOUSE | 10 | 598.0 | 8.2 | 388.7 | 23.7 | 65.80 | 58.5 | 82.4 | 4.6 | 52.5 | 124.1 | 145.8 |
| YOUTHS CAMPUS | 11 | 95.5 | 8.3 | 62.1 | 4.9 | 9.6 | 78.0 | 0.0 | 3.7 | 8.1 | 12.0 | 15.8 |
| AL-MAHARRI HOTELL | 12 | 477.0 | 8.1 | 310.1 | 4.2 | 50.00 | 50.7 | 69.8 | 3.8 | 44.4 | 104.1 | 118.2 |
| PUBLIC WORKS CORPORATION | 13 | 269 | 8.3 | 174 | 8.5 | 70.1 | 81.25 | 18.92 | 3.0 | 21.2 | 50 | 98.9 |

Table (11) results of chemical parameters for period two (*September, 2006*)

| *Site of sample* | Sample | EC | pH | TDS mg/l | K mg/l | Na mg/l | CL mg/l | SO4 mg/l | NO3 mg/l | Ca.H mg/l | T-H mg/l | T-Alk |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SEAWATER | 1 | 57800 | 7.87 | 3757 | 35.9 | 269 | 3750 | 715.4 | 5.6 | 4120 | 6745.98 | 148.15 |
| PRESIPATION RESERVOIR | 2 | 57800 | 7.7 | 3757 | 36.3 | 265 | 3980 | 811.6 | 6 | 4520 | 6766.68 | 136.14 |
| PROODUCTION WATER | 3 | 10 | 8.3 | 7.56 | 12 | 15.99 | 15.1 | 9.0 | 1.98 | 4.5 | 5.2 | 8.01 |
| Tank D412 | 4 | 36.4 | 9 | 23.66 | 8.6 | 40.3 | 65.2 | 45.1 | 3 | 1 | 3 | 12 |
| Tank D414 | 5 | 38.3 | 9.6 | 24.22 | 8.6 | 41.0 | 65.4 | 54.1 | 3.3 | 4 | 3 | 12 |
| LABORATORY. Of PLANT | 6 | 50.2 | 6.2 | 32.198 | 8.4 | 33.1 | 18.75 | 32.5 | 0.8 | 8.1 | 16 | 12.53 |
| RIVER WATER | 7 | 617 | 8.12 | 401.05 | 22.3 | 55.3 | 62.4 | 94 | 9.6 | 52 | 124.11 | 148 |
| MIXING 3.1 | 8 | 200 | 8.7 | 130 | 7.9 | 65.8 | 53.2 | 44.2 | 4.1 | 20 | 44.04 | 44.04 |
| TANK750 | 9 | 488 | 8.1 | 317.2 | 9.5 | 77 | 95.3 | 69.7 | 5.9 | 76 | 92.08 | 112 |
| GUESTHOUSE | 10 | 621 | 8.07 | 403.65 | 10.3 | 89 | 102.5 | 78.6 | 6 | 96 | 120.11 | 148 |
| YOUTHS CAMPUS | 11 | 608 | 7.86 | 395.2 | 10 | 92 | 120.8 | 63.5 | 5.6 | 88 | 128.12 | 152.2 |
| AL-MAHARRI HOTELL | 12 | 445 | 7.91 | 289.25 | 9.8 | 78 | 84.5 | 57.9 | 4.8 | 40 | 132.21 | 100.1 |
| PUBLIC WORKS CORPORATION | 13 | 266 | 8.06 | 172.9 | 8 | 68 | 80.2 | 19.8 | 2.6 | 20 | 48.04 | 60.06 |

Table (12) results of chemical parameters for period three (*December, 2006*)

| *Site of sample* | Sample | EC | pH | TDS mg/l | K mg/l | Na mg/l | CL mg/l | SO4 mg/l | NO3 mg/l | Ca.H mg/l | T-H mg/l | T-Alk |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SEAWATER | 1 | 534005 | 7.87 | 34710 | 95.60 | 122.20 | 3003 | 827.7 | 3.2 | 4510 | 6565.90 | 117.3 |
| PRESIPATION RESERVOIR | 2 | 534804 | 7.9 | 34757 | 94.90 | 120.54 | 3120 | 831.6 | 4.2 | 4620 | 6570.33 | 118.9 |
| PRODUCTION WATER | 3 | 15.4 | 7.47 | 10.01 | 7 | 32 | 70.8 | 200.7 | 0.1 | 25 | 32.03 | 7.82 |
| Tank D412 | 4 | 37 | 4.74 | 24.05 | 7.9 | 30.2 | 15.6 | 34.5 | 0.1 | 4 | 16 | 3.91 |
| Tank D414 | 5 | 39.5 | 5.23 | 25.675 | 8.2 | 29.9 | 15.6 | 42.9 | 0.4 | 8 | 16 | 3.91 |
| LABORATORY. OF PLANT | 6 | 49.5 | 5.77 | 32.175 | 8.1 | 33.4 | 19.5 | 30.5 | 0.5 | 8 | 14 | 11.73 |
| RIVER WATER | 7 | 618 | 8.05 | 405.1 | 22.91 | 45.89 | 63.8 | 92.55 | 9.20 | 52 | 123.99 | 148 |
| MIXING 3.1 | 8 | 206 | 8.7 | 128.7 | 7.92 | 65.62 | 54.2 | 44.9 | 4.21 | 23 | 44.6 | 99.84 |
| TANK750 | 9 | 500 | 8.2 | 319.4 | 9.7 | 78 | 100.2 | 71.3 | 5.9 | 76 | 92.08 | 492 |
| GUESTHOUSE | 10 | 687 | 8.4 | 410.2 | 10.8 | 91 | 110.0 | 79.5 | 6 | 95 | 122.2 | 501 |
| YOUTHS CAMPUS | 11 | 44.2 | 8.23 | 28.73 | 8.8 | 42 | 57.9 | 44.2 | 2 | 13 | 16.01 | 10.98 |
| AL-MAHARRI HOTELL | 12 | 48.7 | 8.39 | 31.655 | 8.9 | 40 | 54.3 | 21 | 3.4 | 12 | 16.00 | 11.01 |
| PUBLIC WORKS CORPORATION | 13 | 84.5 | 8.1 | 54.925 | 8.5 | 70 | 55.2 | 14.8 | 15.9 | 15 | 20.02 | 15.2 |

Table (13) results of chemical parameters for period four (*January, 2007*)

| *Site of sample* | Sample | EC | pH | TDS mg/l | K mg/l | Na mg/l | CL mg/l | SO4 mg/l | NO3 mg/l | Ca.H mg/l | T-H mg/l | T-Alk |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SEAWATER | 1 | 52600.0 | 7.81 | 34190 | 414 | 11681 | 2320 | 895 | 2.6 | 2800 | 4250 | 128.13 |
| PRESIPATION RESERVOIR | 2 | 51200.0 | 7.23 | 33280 | 416 | 11681 | 1911 | 614 | 6.80 | 4000 | 8250.1 | 132.13 |
| PRODUCTION WATER | 3 | 14.5 | 8.4 | 9.43 | 1.2 | 8.2 | 8 | 28.4 | 0.9 | 12 | 24.02 | 20.02 |
| Tank D412 | 4 | 133 | 8.55 | 86.5 | 1.6 | 19.4 | 36 | 5.6 | 0.4 | 4 | 36.03 | 8.01 |
| Tank D414 | 5 | 39.9 | 8.07 | 25.9 | 1.6 | 5.2 | 16 | 29.5 | 0.6 | 4 | 16.01 | 8.01 |
| LABORATORY. OF PLANT | 6 | 132 | 7.86 | 85.8 | 1.2 | 14.2 | 32 | 162.3 | 0.1 | 8 | 44.04 | 4.004 |
| RIVER WATER | 7 | 953 | 8.16 | 613 | 17.0 | 113.8 | 120 | 168.9 | 8.3 | 124 | 200.18 | 148.2 |
| MIXING 3 1 | 8 | 725 | 8.4 | 471 | 9.9 | 88.8 | 92 | 162.3 | 4.2 | 84 | 152.14 | 120.12 |
| TANK750 | 9 | 798 | 8.33 | 518.7 | 0.39 | 86.6 | 100 | 146.0 | 5.6 | 8 | 144.13 | 116.12 |
| GUESTHOUSE | 10 | 842 | 8.1 | 547.3 | 10.26 | 84.3 | 88 | 128.9 | 5.2 | 68 | 128.12 | 112 |
| YOUTHS CAMPUS | 11 | 857 | 7.85 | 557.05 | 10.26 | 91 | 92 | 161.8 | 6 | 76 | 140.13 | 124.12 |
| AL-MAHARRI HOTELL | 12 | 818 | 7.97 | 531.7 | 10.66 | 85.1 | 88 | 127.7 | 4.8 | 84 | 140.13 | 120.12 |
| PUBLIC WORKS CORPORATION | 13 | 831 | 7.9 | 540.15 | 9.87 | 89.6 | 96 | 141.3 | 5.6 | 88 | 112.1 | 116.12 |

Table (14) results of chemical parameters for period five (*February, 2007*)

| *Site of sample* | Sample | EC | pH | TDS mg/l | K mg/l | Na mg/l | CL mg/l | SO4 mg/l | NO3 mg/l | Ca.H mg/l | T-H mg/l | T-Alk |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SEAWATER | 1 | 56700.0 | 7.8 | 36855 | 296.05 | 11508.6 | 2200 | 672.2 | 3.8 | 2000 | 11210.1 | 128.13 |
| PRESIPATION RESERVOIR | 2 | 56750.0 | 7.9 | 35211 | 299.1 | 11508.0 | 2221 | 672.3 | 4.0 | 2020 | 11211.0 | 129.20 |
| PROODUCTION WATER | 3 | 77.5 | 8.89 | 50.375 | 8.6 | 72 | 78.2 | 43.3 | 2.6 | 0.2 | 0.4 | 8.01 |
| Tank D412 | 4 | 151 | 7.73 | 98.15 | 2.1 | 4.7 | 27.3 | 78 | 27 | 176.4 | 120 | 12 |
| Tank D414 | 5 | 98.5 | 7.74 | 64.025 | 1.58 | 4.5 | 20 | 90.5 | 0.3 | 8 | 136.12 | 8.01 |
| LABORATORY. OF PLANT | 6 | 74 | 7.19 | 48.1 | 1.2 | 3.6 | 18 | 85.2 | 0.1 | 8 | 125 | 11.2 |
| RIVER WATER | 7 | 753 | 8.1 | 489.45 | 30.5 | 62.1 | 89.7 | 140 | 29 | 1.6 | 1.1 | 160 |
| MIXING 3-1 | 8 | 607 | 7.99 | 394.55 | 30.2 | 62.0 | 74.1 | 96 | 26 | 156 | 123 | 112 |
| TANK750 | 9 | 605 | 8.08 | 393.25 | 30.0 | 61.01 | 66.3 | 99.0 | 25 | 84 | 45 | 116 |
| GUESTHOUSE | 10 | 584 | 8.02 | 379.6 | 25.2 | 50.5 | 93.6 | 120 | 26 | 108 | 96 | 112 |
| YOUTHS CAMPUS | 11 | 627 | 8.18 | 407.55 | 28.5 | 55.0 | 54.6 | 135 | 26 | 88 | 49 | 120 |
| AL-MAHARRI HOTELL | 12 | 584 | 8.23 | 379.6 | 25.2 | 50.5 | 66.3 | 140 | 25 | 80 | 50 | 112 |
| PUBLIC WORKS CORPORATION | 13 | 644 | 8.22 | 418.6 | 25 | 72 | 93.6 | 138 | 24 | 104 | 78 | 116 |

*Table (15) Results of frequencies samples for 5 sites*

| *Site of sample* | Sample | EC | pH | TDS mg/l | K mg/l | Na mg/l | CL mg/l | $SO_4$ mg/l | $NO_3$ mg/l | Ca.H mg/l | T-H mg/l | T-Alk |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SEAWATER | 1 | 49100 | 7.4 | 31915 | 532.89 | 11422.3 | 2600 | 811.1 | 3.5 | 3600 | 10409.4 | 128.13 |
| SEAWATER | 1 | 56700 | 7.8 | 36855 | 296.05 | 11508.6 | 2200 | 672.2 | 3.8 | 2000 | 11210.1 | 128.13 |
| SEAWATER | 1 | 58500 | 7.87 | 38025 | 315.79 | 12198.3 | 2320 | 851.3 | 3.7 | 2000 | 9608.64 | 124.12 |
| TANK D414 | 5 | 98.9 | 7.39 | 64.285 | 13.42 | 17.9 | 20 | 141.9 | 0.6 | 20 | 12.01 | 12 |
| TANK D414 | 5 | 115 | 8.09 | 74.75 | 1.18 | 6 | 20 | 136.0 | 0.8 | 20 | 8.01 | 4.004 |
| TANK D414 | 5 | 98.5 | 7.74 | 64.025 | 1.58 | 4.5 | 20 | 90.5 | 0.3 | 8 | 136.12 | 8.01 |
| RIVER WATER | 7 | 753 | 8.1 | 489.45 | 30.5 | 62.1 | 89.7 | 140 | 29 | 1.6 | 1.1 | 160 |
| RIVER WATER | 7 | 564 | 8 | 366.6 | 20.1 | 45.2 | 89.7 | 145 | 25 | 84 | 49 | 156 |
| RIVER WATER | 7 | 726 | 8.14 | 471.9 | 28 | 60.4 | 89.7 | 143 | 26.1 | 76 | 35.9 | 156 |
| TANK 750 | 11 | 605 | 8.08 | 393.25 | 30.0 | 61.01 | 66.3 | 99.0 | 25 | 84 | 45 | 116 |
| TANK 750 | 11 | 726 | 8.24 | 471.9 | 28 | 61.0 | 70.2 | 99 | 22 | 92 | 47.9 | 112 |
| TANK 750 | 11 | 596 | 8.16 | 387.4 | 25.2 | 50.5 | 74.1 | 98 | 23.7 | 72 | 38 | 112 |
| PUBLIC WORKS CORPORATION | 15 | 644 | 8.22 | 418.6 | 9.85 | 70 | 93.6 | 138 | 24 | 104 | 78 | 116 |
| PUBLIC WORKS CORPORATION | 15 | 896 | 8.29 | 582.4 | 12 | 77 | 101 | 102 | 24.5 | 108 | 87 | 116 |
| PUBLIC WORKS CORPORATION | 15 | 711 | 8.27 | 462.15 | 25 | 72 | 89.7 | 114 | 21.4 | 88 | 44.9 | 112 |

## Appendix (2)

The monthly report for chemical analysis of desalinated water
(Sirt Desalination Plant, 1991, 1992, 1993)

| | 1991 | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EC | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| Dist. | 2.09 | 2.1 | 2.36 | 2.09 | 2.11 | 3.2 | 3.1 | 3.6 | 13.0 | 27 | 33 | 2.99 |
| Dist. | 2.0 | 1.85 | 5.05 | 2.0 | 1.83 | 1.6 | 1.2 | 2.0 | 11.0 | 27 | 30 | 3.00 |
| Cond. | 0.82 | 0.75 | 0.98 | 0.82 | 0.66 | 1.0 | 0.9 | 1.0 | 1.0 | 1.2 | 1.35 | 1.0 |
| B.F.W | 5.23 | 18 | 6.0 | 5.23 | 4.79 | 5.2 | 8.0 | 4.1 | 2.0 | 6.0 | 10 | 3.0 |
| Boiler-1 | 429 | 413 | 575 | 429 | 407 | 400 | 350 | 149 | 156 | 530 | 405 | 897 |
| Boiler-2 | 393 | 419 | 522 | 393 | 368 | 180 | 192 | 185 | 110 | 386 | 429 | 726 |
| Potable water 414 | 404 | 385 | 492 | 404 | 426 | 670 | 700 | 500 | 490 | 425 | 510 | 178 |

| | 1992 | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EC | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| Dist. | 2.3 | 2.56 | 3.0 | 18.7 | 4.4 | 4.73 | 5.0 | 3.2 | 2.4 | 12 | 2.07 | 3.9 |
| Dist. | 13.8 | 2.3 | 2.89 | 18.0 | 4.1 | 4.73 | 4.98 | 2.5 | 2.0 | 3.7 | 3.0 | 2.9 |
| Cond. | 0.72 | 1.31 | 1.0 | 16.0 | 0.83 | 1.42 | 0.98 | 2.1 | 0.9 | 0.8 | 0.43 | 1.0 |
| B.F.W | 3.4 | 3.11 | 19.5 | 30.0 | 16.3 | 2.81 | 3.65 | 7.6 | 3.6 | 4.1 | 2.9 | 8.3 |
| Boiler-1 | 359 | 272 | 270 | 350 | 281 | 249 | 229 | 280 | 277 | 506 | 249 | 237 |
| Boiler-2 | 346 | 295 | 272 | 308 | 197 | 233 | 221 | 243 | 252 | 299 | 257 | 282 |
| Potable water 414 | 314 | 770 | 580 | 535 | 433 | 385 | 414 | 420 | 595 | 710 | 560 | 408 |

| | 1993 | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EC | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| Dist. | - | - | - | - | - | - | - | - | - | - | - | - |
| Dist. | 5.3 | 7.98 | 4.2 | 4.0 | 4.4 | 4.9 | 5.3 | 2.01 | 5.0 | 3.22 | 4.5 | 2.0 |
| Cond. | 0.82 | 1.42 | 0.9 | 1.0 | 0.9 | 0.8 | 1.2 | 1.4 | 1.0 | 1.4 | 1.2 | 0.8 |
| B.F.W | 4.06 | 7.6 | 3.7 | 8.1 | 5.3 | 3.0 | 8.2 | 10.4 | 4.2 | 4.8 | 6.2 | 2.4 |
| Boiler-1 | 300 | 273 | 289 | 300 | 285 | 310 | 337 | 332 | 340 | 339 | 318 | 317 |
| Boiler-2 | 273 | 266 | 266 | 306 | 294 | 284 | 312 | 307 | 321 | 283 | 297 | 299 |
| Potable water 414 | 540 | 708 | 565 | 550 | 525 | 560 | 550 | 155 | 304 | 437 | 324 | 360 |

*Where:*
*Dist.: Distilled water into the plant*
*Cond.: Condenser*
*B.F.W: Boiler Feed Water*
(-): Not Done

## Appendix

### The monthly report for chemical analysis of desalinated water

| pH | 1991 | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| Dist. | 7.2 | 7.3 | 7.0 | 7.1 | 7.3 | 7.0 | 7.3 | 7.3 | 7.1 | 7.0 | 6.8 | 6.8 |
| Dist. | 7.2 | 7.4 | 6.7 | 6.9 | 7.0 | 6.9 | 7.4 | 7.4 | 7.1 | 7.0 | 6.8 | - |
| Cond. | 7.25 | 7.2 | 7.0 | 7.0 | 7.0 | 7.2 | 7.5 | 7.3 | 7.1 | 7.05 | 6.9 | 6.8 |
| B.F.W | 7.25 | 7.6 | 7.0 | 7.1 | 7.0 | 7.4 | 7.5 | 7.5 | 7.25 | 7.2 | 7.1 | 7.0 |
| Boiler-1 | 10.7 | 10.7 | 10.7 | 10.6 | 10.6 | 10.4 | 10.0 | 10.1 | 10.0 | 9.7 | 10.4 | 7.1 |
| Boiler-2 | 10.2 | 10.2 | 10.3 | 10.3 | 9.7 | 10.0 | 10.1 | 10.0 | 9.6 | 9.9 | 10.4 | 7.1 |
| otable water 414 | 7.7 | 9.0 | 7.4 | 7.5 | 7.4 | 7.05 | 9.1 | 9.0 | 8.0 | 7.5 | 8.0 | 8.9 |

| pH | 1992 | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| Dist. | 6.9 | 6.9 | 6.8 | 7.0 | 6.9 | 7.0 | 7.0 | 6.9 | 6.9 | 7.0 | 7.0 | 6.9 |
| Dist. | 6.8 | 7.0 | 7.0 | 7.0 | 7.0 | 7.0 | 6.9 | 6.8 | 7.0 | 7.0 | 7.0 | 7.0 |
| Cond. | 6.7 | 6.9 | 6.9 | 7.0 | 6.9 | 7.0 | 7.0 | 6.9 | 7.2 | 7.0 | 7.0 | 7.0 |
| B.F.W | 7.0 | 7.0 | 7.0 | 7.1 | 6.9 | 7.1 | 7.0 | 7.1 | 7.2 | 7.2 | 7.0 | 7.1 |
| Boiler-1 | 10.7 | 10.7 | 10.5 | 10.7 | 9.6 | 10.2 | 10.2 | 10.4 | 10.5 | 10.5 | 10.3 | 9.8 |
| Boiler-2 | 10.7 | 10.7 | 10.5 | 10.6 | 9.4 | 10.2 | 10.2 | 10.4 | 10.5 | 10.5 | 10.3 | 9.7 |
| Potable water 414 | 7.6 | 7.3 | 7.0 | 7.9 | 7.6 | 8.9 | 7.4 | 7.5 | 7.6 | 7.3 | 7.8 | 7.5 |

| pH | 1993 | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| Dist. | - | - | - | - | - | - | - | - | - | - | - | - |
| Dist. | 7.0 | 7.0 | 7.0 | 6.9 | 6.9 | 6.8 | 7.0 | 7.0 | 7.0 | 7.0 | 7.0 | 7.0 |
| Cond. | 7.0 | 7.0 | 7.0 | 7.0 | 6.9 | 6.9 | 7.0 | 7.0 | 7.0 | 7.0 | 7.0 | 7.0 |
| B.F.W | 7.1 | 7.0 | 7.1 | 7.1 | 7.0 | 7.1 | 7.2 | 7.1 | 7.1 | 7.1 | 7.1 | 7.1 |
| Boiler-1 | 10.4 | 10.3 | 10.4 | 10.1 | 10.2 | 10.1 | 10.2 | 10.0 | 10.5 | 10.3 | 10.3 | 10.4 |
| Boiler-2 | 10.3 | 10.2 | 10.3 | 10.1 | 10.1 | 10.0 | 10.2 | 10.0 | 10.4 | 10.3 | 10.2 | 10.4 |
| Potable water 414 | 7.9 | 7.9 | 7.8 | 7.6 | 7.8 | 7.5 | 8.1 | 9.0 | 9.1 | 8.8 | 9.0 | 9.0 |

The monthly report for chemical analysis of desalinated water

| | 1991 | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Chloride ppm | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| Dist. | - | - | - | - | - | - | - | - | - | - | - | - |
| Dist. | - | - | - | - | - | - | - | - | - | - | - | - |
| Cond. | - | - | - | - | - | - | - | - | - | - | - | - |
| B.F.W | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil |
| Boiler-1 | 10.66 | 8.8 | 8.8 | 8.9 | 6.5 | 7.10 | 4.9 | 5.04 | 3.9 | 92.5 | 38 | 223 |
| Boiler-2 | 6.1 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 5.6 | 5.0 | 3.0 | 71 | 40 | 197 |
| otable water 414 | 127.98 | 145 | 142 | 153 | 160 | 142 | 104 | 110.65 | 100 | 89.6 | 118.6 | 61 |

| | 1992 | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Chloride ppm | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| Dist. | - | - | - | - | - | - | - | - | - | - | - | - |
| Dist. | - | - | - | - | - | - | - | - | - | - | - | - |
| Cond. | - | - | - | - | - | - | - | - | - | - | - | - |
| B.F.W | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil |
| Boiler-1 | 53.3 | 15.7 | 18.0 | 28 | 19.9 | 18.7 | 18.9 | 17.6 | 18.6 | 27.0 | 18.5 | 17.9 |
| Boiler-2 | 51.9 | 16.5 | 17.9 | 24 | 15.2 | 18.2 | 18.8 | 17.2 | 18.5 | 20.1 | 18.6 | 18.3 |
| otable water 414 | 93 | 177.3 | 158 | 130 | 144 | 95.7 | 108 | 108 | 129 | 145 | 151 | 121 |

| | 1993 | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Chloride ppm | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| Dist. | - | - | - | - | - | - | - | - | - | - | - | - |
| Dist. | - | - | - | - | - | - | - | - | - | - | - | - |
| Cond. | - | - | - | - | - | - | - | - | - | - | - | - |
| B.F.W | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil |
| Boiler-1 | 19.8 | 17.8 | 18.9 | 18.8 | 18.8 | 18.8 | 17.4 | 19.2 | 18.9 | 18.1 | 17.7 | 18.3 |
| Boiler-2 | 19.5 | 17.4 | 18.8 | 18.8 | 18.8 | 18.8 | 17.1 | 19.0 | 18.7 | 17.8 | 17.5 | 18.2 |
| otable water 414 | 136.5 | 141 | 134 | 133 | 112 | 126 | 131 | 27 | 93 | 118 | 93 | 103 |

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| | 1991 | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Chlorine ppm | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| Dist. | | | | | | | | | | | | |
| Dist. | | | | | | | | | | | | |
| Cond. | | | | | | | | | | | | |
| B.F.W | - | - | - | - | - | - | - | - | - | - | - | - |
| Boiler-1 | - | - | - | - | - | - | - | - | - | - | - | - |
| Boiler-2 | - | - | - | - | - | - | - | - | - | - | - | - |
| otable water 414 | 0.05 | 0.13 | 0.13 | Nil | 0.17 | 0.13 | Nil | 0.12 | 0.13 | 0.12 | 0.12 | Nil |

| | 1992 | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Chlorine ppm | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| Dist. | | | | | | | | | | | | |
| Dist. | | | | | | | | | | | | |
| Cond. | | | | | | | | | | | | |
| B.F.W | - | - | - | - | - | - | - | - | - | - | - | - |
| Boiler-1 | - | - | - | - | - | - | - | - | - | - | - | - |
| Boiler-2 | - | - | - | - | - | - | - | - | - | - | - | - |
| Potable water 414 | 0.18 | 0.14 | 0.08 | 0.12 | 0.13 | 0.06 | 0.12 | 0.12 | 0.08 | 0.15 | 0.09 | 0.11 |

| | 1993 | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Chlorine ppm | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| Dist. | | | | | | | | | | | | |
| Dist. | | | | | | | | | | | | |
| Cond. | | | | | | | | | | | | |
| B.F.W | - | - | - | - | - | - | - | - | - | - | - | - |
| Boiler-1 | - | - | - | - | - | - | - | - | - | - | - | - |
| Boiler-2 | - | - | - | - | - | - | - | - | - | - | - | - |
| Potable water 414 | 0.08 | 0.08 | 0.08 | 0.10 | 0.11 | 0.1 | 0.1 | 0.1 | Trace | 0.06 | Trace | 0.05 |

The monthly report for chemical analysis of desalinated water

| | 1991 | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hardness ppm | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| Dist. | | | | | | | | | | | | |
| Dist. | | | | | | | | | | | | |
| Cond. | | | | | | | | | | | | |
| B.F.W | Trace | Trace | Trace | Trace | Trace | Trace | Trace | Trace | Trace | Trace | Trace | Trace |
| Boiler-1 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| Boiler-2 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| otable water 414 | 77.5 | 79 | 85 | 80 | 81 | 57 | 63 | 45 | 44 | 50 | 50 | 25 |

| | 1992 | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hardness ppm | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| Dist. | | | | | | | | | | | | |
| Dist. | | | | | | | | | | | | |
| Cond. | | | | | | | | | | | | |
| B.F.W | Trace | Trace | Trace | Trace | Trace | Trace | Trace | Trace | Trace | Trace | Trace | Trace |
| Boiler-1 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| Boiler-2 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| Potable water 414 | 28.9 | 65.4 | 61.5 | 58 | 56.7 | 40.2 | 55.1 | 58 | 57.6 | 63 | 56 | 57 |

| | 1993 | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hardness ppm | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| Dist. | | | | | | | | | | | | |
| Dist. | | | | | | | | | | | | |
| Cond. | | | | | | | | | | | | |
| B.F.W | Trace | Trace | Trace | Trace | Trace | Trace | Trace | Trace | Trace | Trace | Trace | Trace |
| Boiler-1 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| Boiler-2 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| Potable water 414 | 53.2 | 65.2 | 53 | 55.5 | 54 | 56.5 | 50.3 | 18.2 | 50 | 51.8 | 41.7 | 50 |

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| PO4 ppm | 1991 | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| Dist. | | | | | | | | | | | | |
| Dist. | | | | | | | | | | | | |
| Cond. | | | | | | | | | | | | |
| B.F.W | 0.9 | 0.6 | 1.0 | 0.6 | 0.4 | 0.65 | 0.5 | 0.2 | 0.12 | 0.55 | 0.4 | 1.3 |
| Boiler-1 | 21 | 29.8 | 22.0 | 12.8 | 26 | 29.6 | 22.2 | 11.2 | 14.6 | 9.5 | 7.2 | 1.9 |
| Boiler-2 | 14 | 12.5 | 14.5 | 12.9 | 12.5 | 12.8 | 10.9 | 10.8 | 9.7 | 10.35 | 7.4 | 1.8 |
| otable water 414 | 1.0 | 0.9 | 0.75 | 1.0 | 1.2 | 1.0 | 0.8 | 0.9 | 1.0 | 0.2 | 0.25 | 0.26 |

| PO4 ppm | 1992 | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| Dist. | | | | | | | | | | | | |
| Dist. | | | | | | | | | | | | |
| Cond. | | | | | | | | | | | | |
| B.F.W | 0.4 | 0.17 | 0.17 | 0.18 | 0.05 | 0.11 | 0.14 | 0.2 | 0.5 | 0.3 | 0.21 | 0.28 |
| Boiler-1 | 10.8 | 10.8 | 10.2 | 10.5 | 4.5 | 10.3 | 9.0 | 9.2 | 9.8 | 8.9 | 8.8 | 8.4 |
| Boiler-2 | 10.7 | 10.9 | 10.1 | 10.5 | 4.2 | 10.3 | 9.0 | 9.1 | 9.7 | 8.8 | 8.8 | 8.5 |
| Potable water 414 | 0.21 | 0.30 | 0.4 | 1.0 | 0.75 | 1.2 | 1.2 | 1.3 | 1.3 | 1.4 | 1.4 | 1.4 |

| PO4 ppm | 1993 | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| Dist. | | | | | | | | | | | | |
| Dist. | | | | | | | | | | | | |
| Cond. | | | | | | | | | | | | |
| B.F.W | 0.22 | 0.21 | 0.27 | 0.21 | 0.16 | 0.16 | 0.18 | 0.17 | 0.20 | 0.20 | 0.22 | 0.19 |
| Boiler-1 | 9.0 | 8.9 | 9.0 | 7.1 | 9.7 | 8.6 | 8.6 | 9.1 | 9.4 | 9.3 | 9.3 | 9.3 |
| Boiler-2 | 8.9 | 8.8 | 8.9 | 7.1 | 9.6 | 8.5 | 8.6 | 9.0 | 9.4 | 9.3 | 9.1 | 9.3 |
| Potable water 414 | 1.4 | 1.4 | 1.4 | 1.4 | 1.4 | 1.4 | 1.38 | 1.2 | 1.3 | 1.38 | 1.38 | 1.2 |

The monthly report for chemical analysis of desalination

| | 1991 | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| P-Value ppm | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| Dist. | | | | | | | | | | | | |
| Dist. | | | | | | | | | | | | |
| Cond. | | | | | | | | | | | | |
| B.F.W | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil |
| Boiler-1 | 17.8 | 18 | 18 | 18.0 | 18.0 | 15 | 16.8 | 10.9 | 8.2 | 6.0 | 6.7 | Nil |
| Boiler-2 | 10.0 | 9.8 | 10 | 10.2 | 10 | 9 | 10.0 | 10.8 | 7.4 | 6.2 | 6.9 | Nil |
| Potable water 414 | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil | 4.3 |

| | 1992 | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| P-Value ppm | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| Dist. | | | | | | | | | | | | |
| Dist. | | | | | | | | | | | | |
| Cond. | | | | | | | | | | | | |
| B.F.W | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil |
| Boiler-1 | 9.0 | 9.1 | 8.9 | 9.0 | 9.3 | 8.7 | 8.8 | 8.1 | 8.8 | 8.7 | 8.6 | 8.0 |
| Boiler-2 | 9.0 | 9.1 | 8.8 | 8.8 | 9.3 | 8.7 | 8.8 | 8.4 | 8.6 | 8.6 | 8.6 | 8.0 |
| Potable water 414 | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil |

| | 1993 | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| P-Value ppm | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| Dist. | | | | | | | | | | | | |
| Dist. | | | | | | | | | | | | |
| Cond. | | | | | | | | | | | | |
| B.F.W | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil |
| Boiler-1 | 8.7 | 8.7 | 8.8 | 8.8 | 8.8 | 8.8 | 8.7 | 8.3 | 8.8 | 8.6 | 8.5 | 8.7 |
| Boiler-2 | 8.7 | 8.7 | 8.8 | 8.7 | 8.7 | 8.7 | 8.7 | 8.3 | 8.7 | 8.6 | 8.5 | 8.6 |
| Potable water 414 | Nil | Nil | Nil | Nil | Nil | Nil | Nil | 0.62 | 0.5 | 0.48 | 0.5 | 0.52 |

## The results of chemical analysis for desalinated water (Sirt Desalination Plant, 1991)

| *Month*<br>*Analysis* | *5* | *6* | *7* | *8* | *9* | *10* | *11* |
|---|---|---|---|---|---|---|---|
| EC | 640-885 | 60-975 | 525-880 | 410-705 | 400-2250 | 380-1030 | 425-760 |
| pH | 7.0-7.8 | 7.0-8.0 | 7.0-9.0 | 7.0-9.1 | 7.2-8.8 | 7.2-8.1 | 7.0-8.4 |
| Hardness ppm | 55-75 | 20-85 | 50-80 | 40-60 | 45-180 | 41-90 | 48-79 |
| Calcium ppm | 7.1-12.5 | 6.0-13.6 | 4.3-12 | 4.2-12 | 4.9-2 | 9.7-12.3 | 8.2-11.9 |
| Magnesium ppm | 0.5-11.99 | 0.48-12.3 | 4.0-9.41 | 3.9-9.5 | 4.0-17.3 | 6.5-9.8 | 5.7-8.8 |
| Chloride Cl ppm | 101-171 | 18-196.5 | 129-183 | 85-220 | 91-497.6 | 79-213 | 88.8-157.5 |
| Alkalinity ppm | 0-0.3 | 0-0.26 | Nil -4.0 | 4.2- | Nil –Nil | 0-0 | 0-0 |
| Alkalinity  ppm | 40-44 | 41-45 | 40-45 | 40-45 | 41-45.6 | 43-45 | 42.0-44.2 |
| Sulphate ppm | 17-31 | 17.9-34 | 19-33 | 17.3-33 | 18-35 | 17.6-32 | 28.9-19.2 |
| Phosphate ppm | 0.2-0.8 | 0.8-1.3 | 1.0-1.2 | 1.0-0.8 | 0.6-1.1 | 0.22-1.8 | 0.20-0.30 |
| Chlorine gas ppm | 0.12-0.16 | 0.12-0.16 | 0.05-0.15 | 0.13-0.1 | Nil -0.13 | 0.02-0.19 | 0.09-0.15 |
| T.D.S ppm | 384-561 | 117-567 | 418-483 | 423-246 | 305-750 | 266-721 | 327.5-532 |

## The results of chemical analysis for desalinated water (Sirt Desalination Plant, 1992)

| *Month*<br>*Analysis* | *1* | *2* | *3* | *4* | *5* | *6* | *7* |
|---|---|---|---|---|---|---|---|
| EC | 223-720 | 445-790 | 345-685 | 332-640 | 379-730 | 382-535 | 281-570 |
| pH | 6.9-7.9 | 6.9-7.9 | 6.6-8.0 | 7.0-7.9 | 7.1-8.9 | 7.2-9.0 | 7.1-8.0 |
| Hardness ppm | 20.9-72 | 54-67.2 | 54.2-61.9 | 48.5-59 | 41-64 | 40-58 | 40.3-60 |
| Calcium ppm | 5.65-11.7 | 6.2-10.4 | 8.1-12.3 | 7.92-12 | 6.4-12.7 | 6.5-12.3 | 6.2-12.5 |
| Magnesium ppm | 4.12-8.5 | 4.8-8.1 | 5.5-9.7 | 5.86-9.5 | 5.2-9.8 | 5.1-9.0 | 5.4-8.7 |
| Chloride Cl ppm | 85.7-184 | 142-188.6 | 147-173 | 113-164 | 113-184 | 95.3-124 | 97.4-125 |
| Alkalinity ppm | 0-0 | 0-0 | 0-0 | 0-0 | 0-4.3 | 0-3.4 | 0-0 |
| Alkalinity ppm | 42.2-43.9 | 43.5-44.7 | 44.6-44.8 | 44.3-44.5 | 42.1-44.8 | 44.5-44.6 | 44.2-44.8 |
| Sulphate ppm | 12.39-25.9 | 15.3-26.4 | 15-24.2 | 13.9-23.8 | 14.9-24.3 | 14.3-21.2 | 12.9-22.3 |
| Phosphate ppm | 0.21-.030 | 0.30-0.40 | 0.35-1.2 | 0.73-1.4 | 0.9-1.4 | 1.0-1.3 | 1.1-1.3 |
| Chlorine gas ppm | 0-0.21 | 0.08-0.18 | 0-0.12 | 0.08-1.5 | 0.11-0.13 | 0.06-0.12 | 0.11-0.12 |
| T.D.S ppm | 156.1-504 | 311.5-550 | 287-359.5 | 232.4-448 | 265-511 | 267-374.5 | 254-381.6 |

*WHO, EC, AC and Libya Guide Drinking Water Directive Standards for the Parameters*

*From WHO, European commission and Arabic commission (Gray, 1999). Libyan standards guideline, (Libyan national center for standards, 1992).*

| Parameters | units | WHO guide line | EC | Libyan guide line | AC |
|---|---|---|---|---|---|
| Colour | Unit | 15 | | 15 | |
| Turbidity | Unit | 5 | | 5 | |
| temperature | C | 15-25 | 15-25 | | 15-25 |
| Taste | - | Acceptable | Acceptable | | |
| Odour | - | Acceptable | Acceptable | | |
| pH | Unit | 6.5-8.5 | 6.0-9.0 | 6.5-8.5 | 5.5-9.5 |
| Electrical conductivity | | 1500-2000 | 1500-2000 | | 2000 |
| Total dissolved salts | Mg/l | 1000 | 1000 | 500-1000 | 1500 |
| ORP | Mv | 250 | 250 | | 300 |
| Dissolved oxygen | Mg/l | 6.0-9.0 | 6.0-9.0 | | 6.0-9.0 |
| Total alkalinity | Mg/l | 500 | 250 | | 250 |
| Total hardness | Mg/l | 400 | 300 | 200-250 | 300 |
| sodium | Mg/l | 200 | 200 | 20-200 | 200 |
| Potassium | Mg/l | 12 | 12 | 40-10 | 12 |
| Calcium | Mg/l | 200 | 150 | 75-200 | 200 |
| Magnesium | Mg/l | 50 | 50 | 30 | 25-50 |
| Chloride | Mg/l | 200-250 | 200-250 | 200-250 | 100-250 |
| carbonate | Mg/l | 3.0-4.0 | 3.0-4.0 | | 2.0-5.0 |

| Parameters | units | WHO guide line | EC | Libyan guide line | AC |
|---|---|---|---|---|---|
| Sulphate | Mg/l | 250 | 250 | 200-400 | 200-250 |
| Aluminum | Mg/l | 0.05-0.2 | 0.05-0.2 | 0-0.2 | 0.1-0.2 |
| Nitrates | Mg/l | 50 | 50 | 45 | 50 |
| Nitrites | Mg/l | 0.2 | 0.1-0.2 | 1 | 0.1-0.2 |
| Iron | Mg/l | 0.3 | 0.3 | 0.1 | 0.3 |
| Manganese | Mg/l | 0.1 | 0.1 | 0.05-0.1 | 0.1 |
| Copper | Mg/l | 1 | 1 | 0.01-0.1 | 1 |
| Phosphorus | Mg/l |  |  |  |  |
| Total bacterial count | No /ml at22C° | 20-100 | 20-100 |  | 20-100 |
| Total coli form | No /100ml | 0.01 | 0.01 | 0.03 |  |

**Used Apparatuses of chemical Analysis:**

1. pH meter (Jenway, England)
2. Electro Conductivity meter (Jenway, England)
3. Termometer (Jenway, England)
4. TDS meter (Jenway, England)
5. Flam Photometer 410, Coring, England
6. Atomic Absorption Spectrophotometer PU 9200X. (Fisone, England)
7. Spectrophotometer 500. (Cecil double beam, England)

## The used media for Biological Analysis in the study:

The media that were used in bacterial analysis are the following:

Brilliant green bile lactose broth(BGBLB)

Eosion methylene blue agar(EMB)

Nutrient Agar (NA),or TGE agar

Azide dextrose broth(ADB)

Brain he'art infusion broth.

Sabouraud dextrose agar.

Mac Conky broth (MB).

Bile esculin azide agar.

Titra thionate broth.

**Medias, Reagents and Equipment of Biological Analysis:**

**TotalColony Couuts(T.C) Test:** Nutrient Agar or TGE Agar, and Ethanol 70%.

Petri dishes, 0.1 ml pipette, air incubator set at (37 C), and colony counter

## Faecal Coliform Test (F.C.F)

**Media and Equipment:**

Macconkey broth.

Water bath, incubator set at *(44°C)*, and sterile loop.

## The Multiple Tube Fermentation Test for Total Coliform Count:

0.1 ml volume of sterile distilled water, vere spreaded with each

**Media and Reagents and Equipment:**

Macconkey broth (double +single strength) or lauryl tqrptose broth brilliant green broth,EMB agar.and nutrient agar.

Test tubes, Durham tubes, air incubator set at *(37°C)*, 10 ml, 1.0ml, 0.1ml pipettes, Petri dishes, and racks.

## *Streptococcus faecalis:*

**Media, Reagents and Equipment:**

Azide dextrose broth ,bile esculin azide agar, and brain heart.

3 small tubes of double strength azide broth,6 small tubes of single strength azide broth,10 ml pipettes,1ml pipette ,0.1 ml plate, rack, and incubator (35°C).

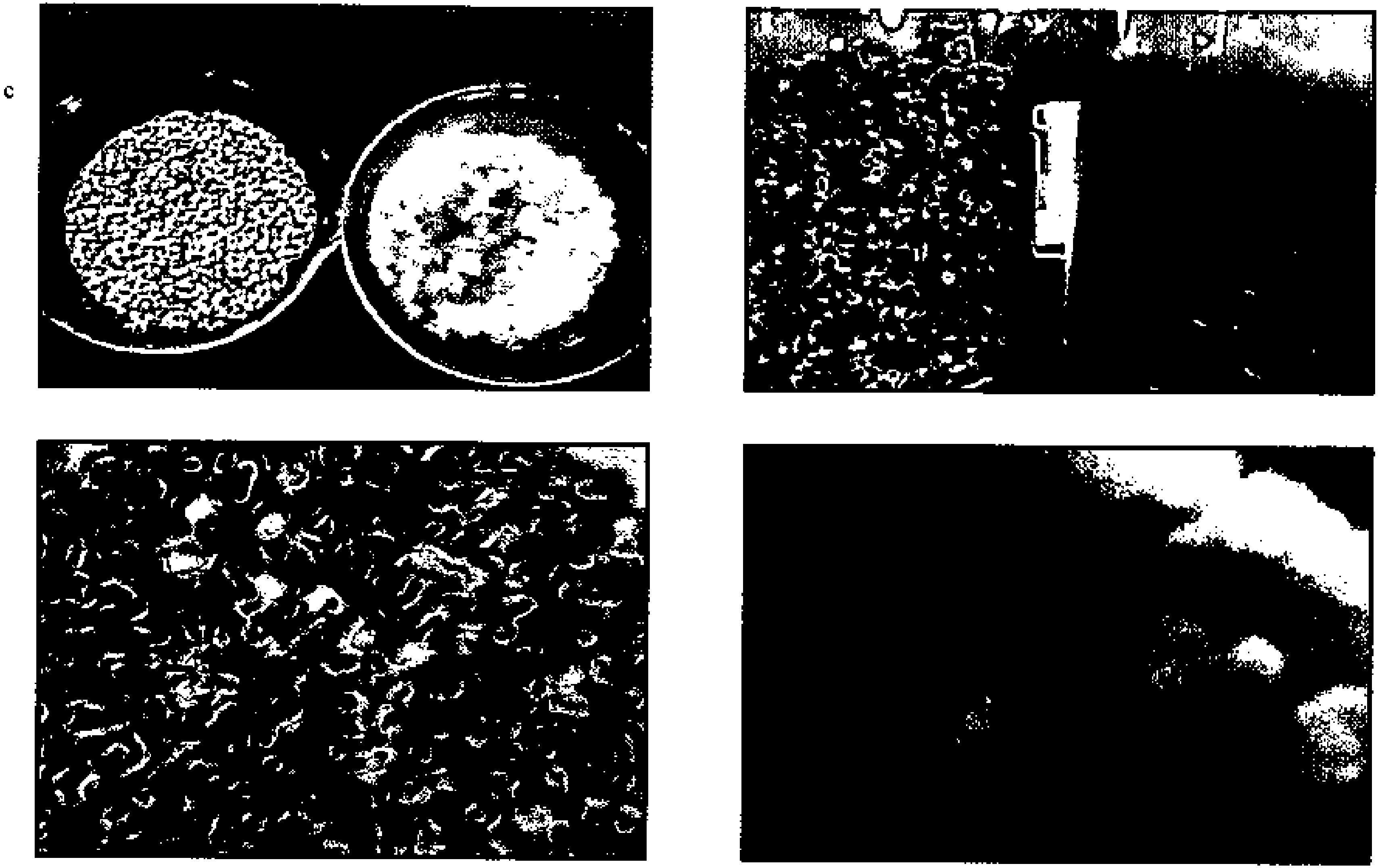
## Fungi Test:

**Media Preparation:**

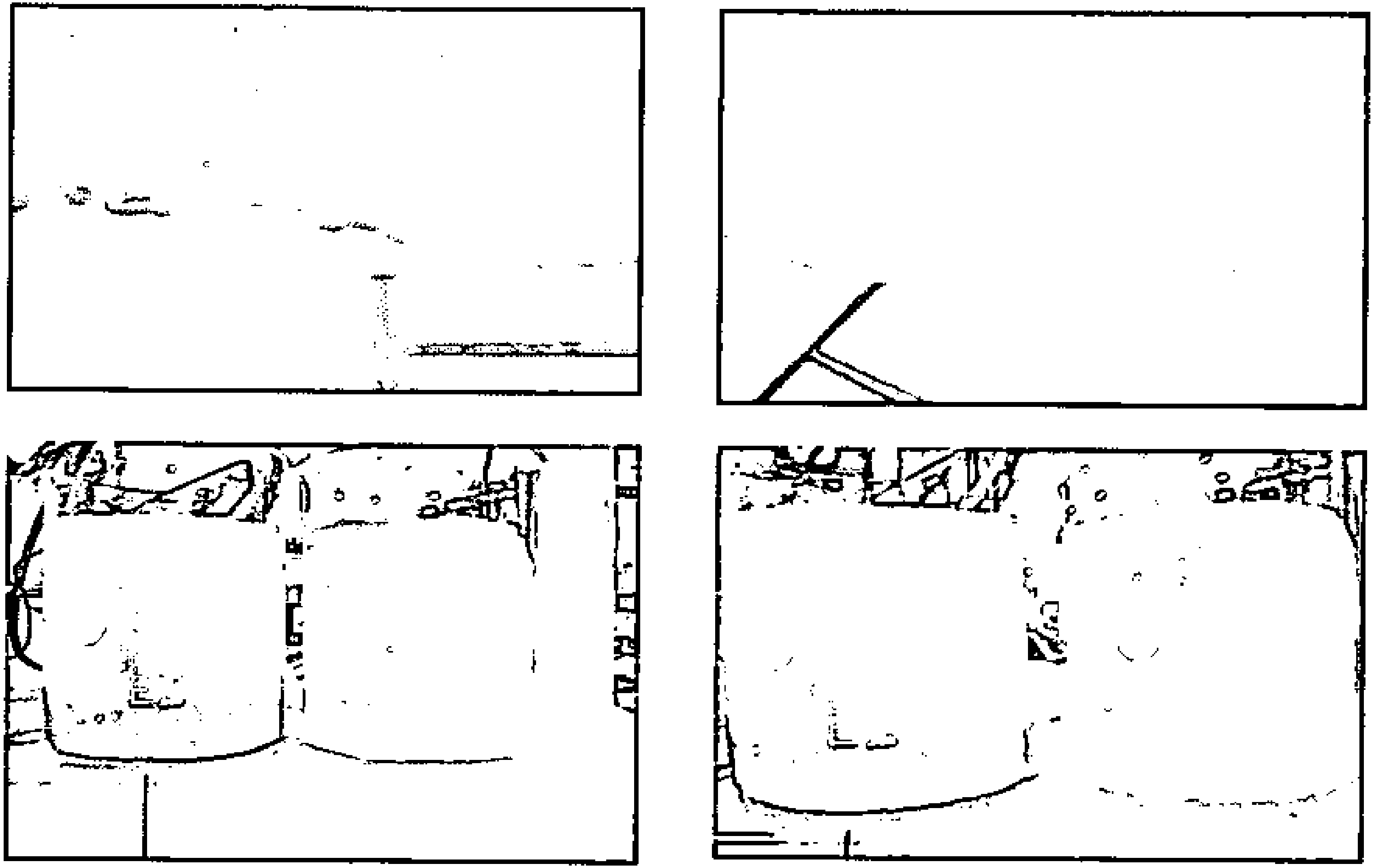
47g Sabouraud 2%glucose agar.1 litter distilled water. The flask was put on thehot plate-stirrer, and autoclaved at (121°C*)* for 15 min. The media was poured in Petri dishes, and the dishes were put in refrigerator.

**Equipment:**

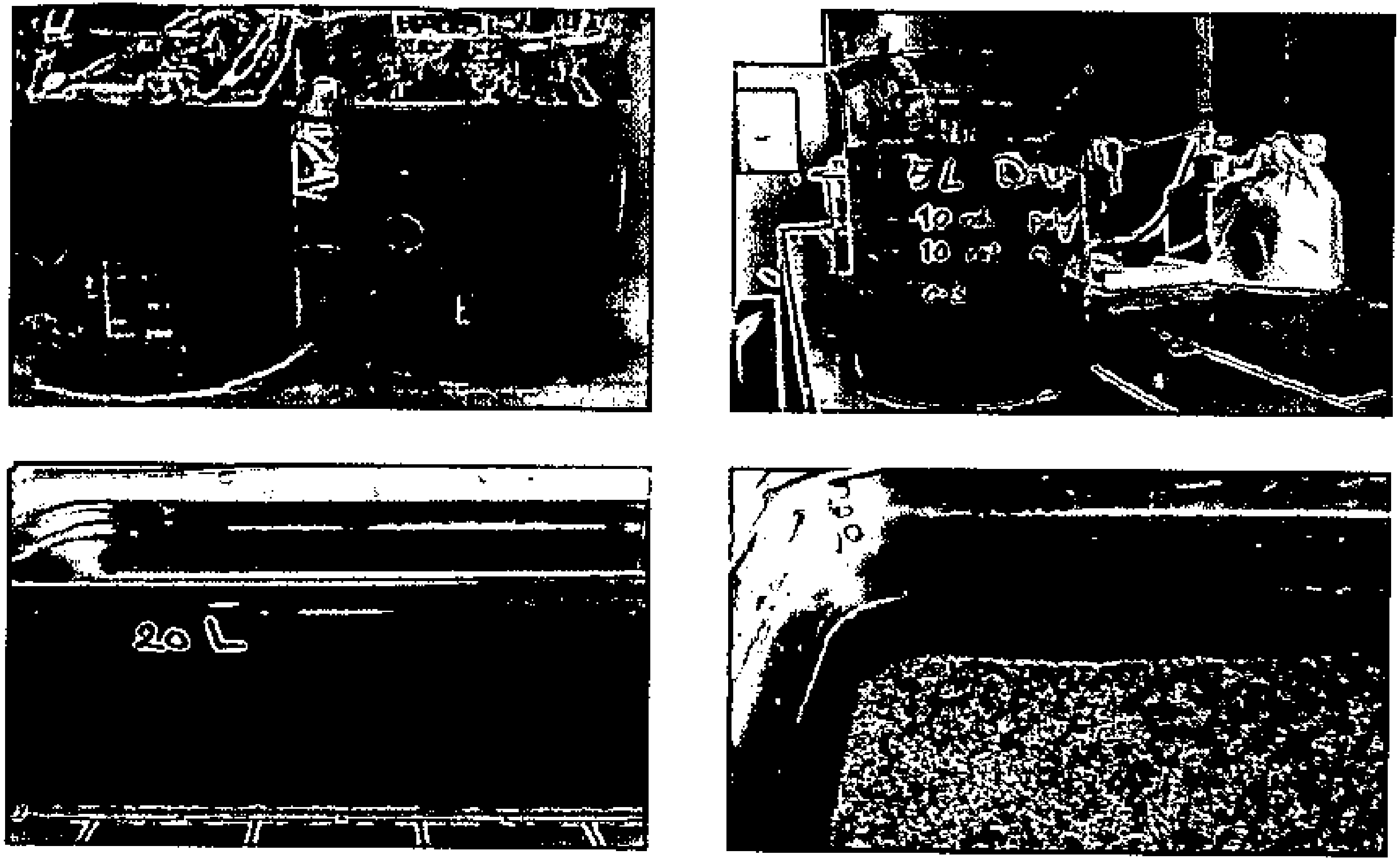
Flask, heater+ mixer (hotplate-stirrer), magnet, Petri dishes, and distilled water.



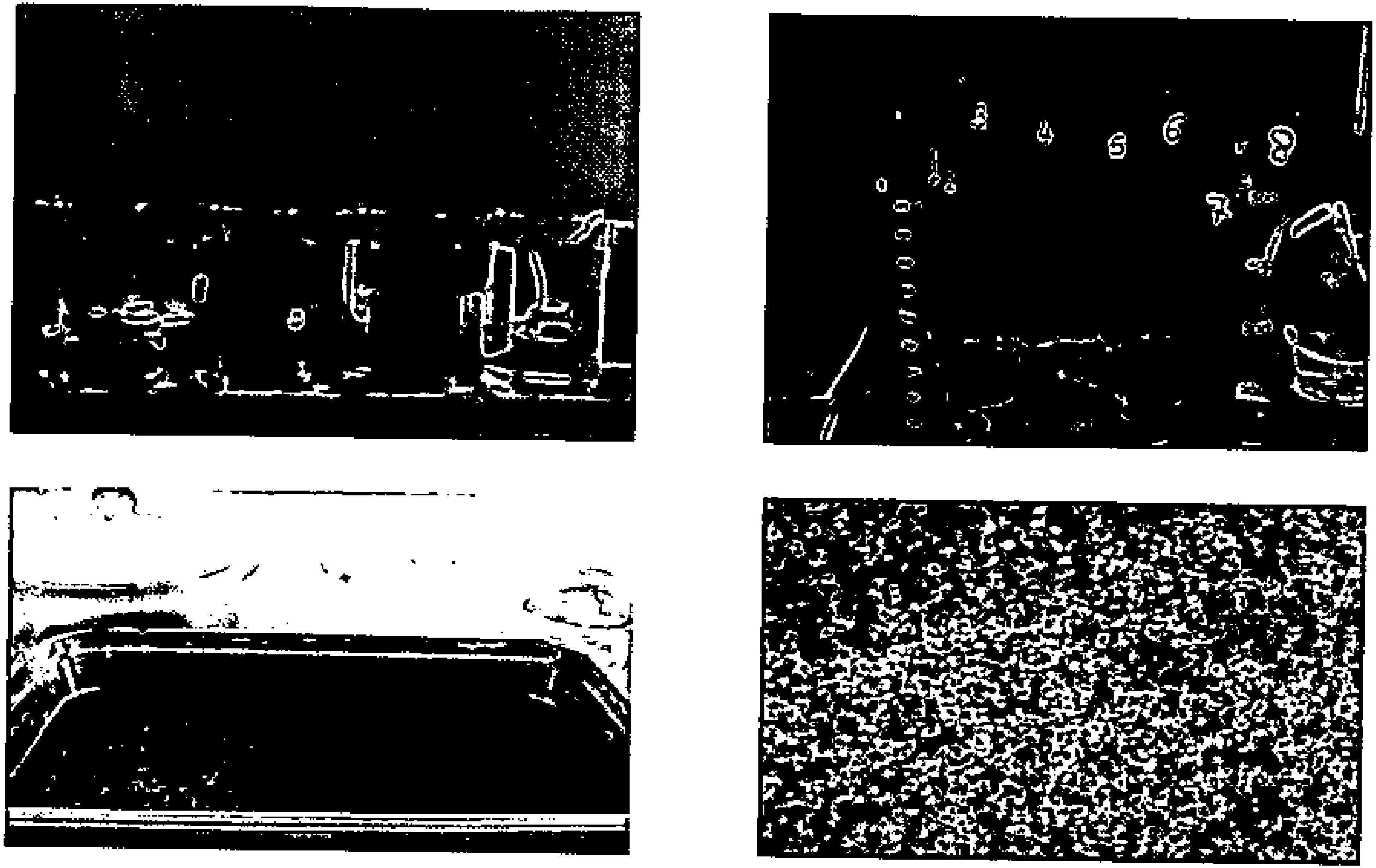
Type of used marble (Yellow + Gray)



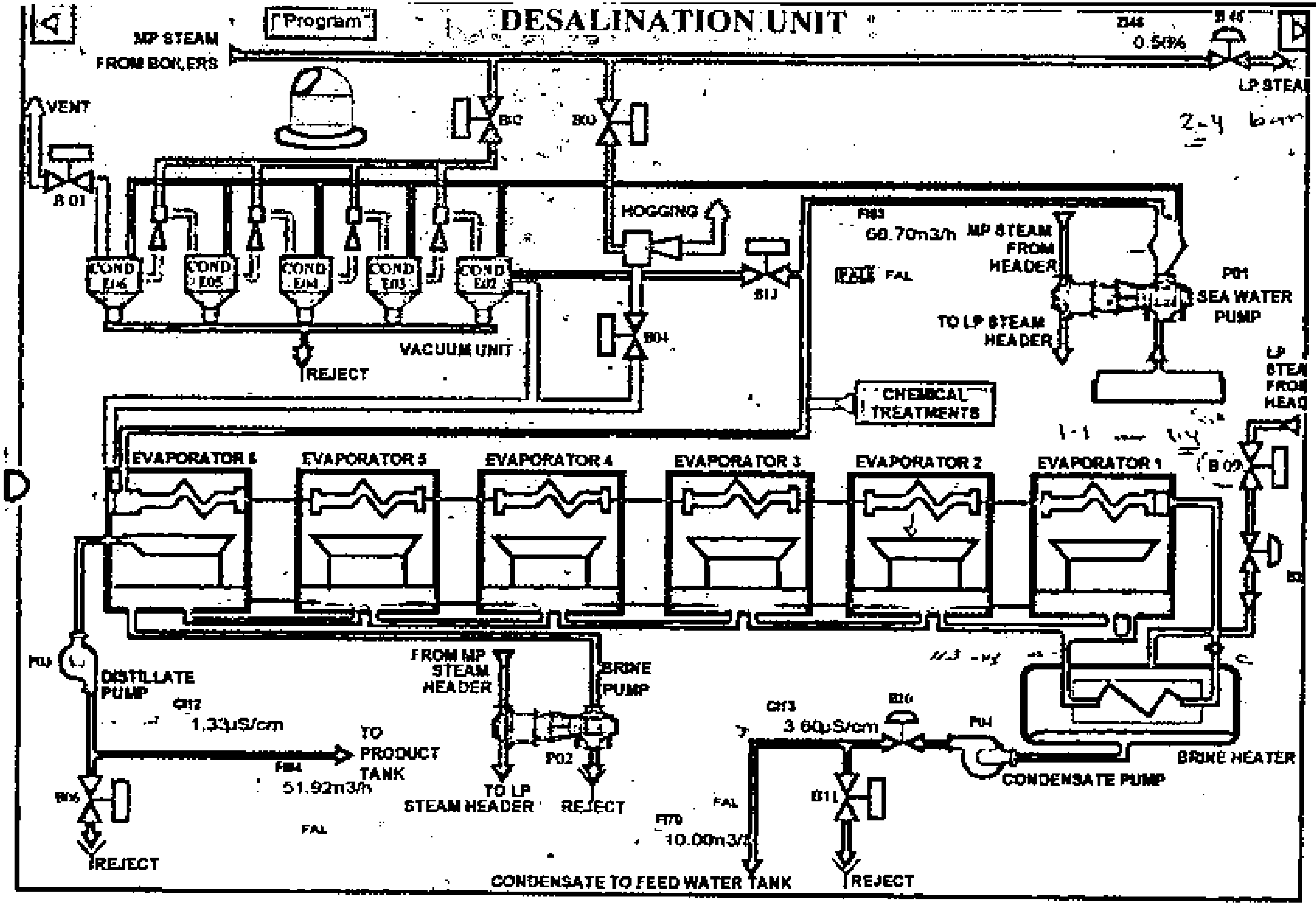
Experiment for comparison between yellow and gray marble



The experiments of chemical treatment of desalinated water which carried out in laboratory (A)



The experiments of chemical treatment of desalinated water which carried out in laboratory (B)



Scheme of Sirt Desalination Plant

# ARABIC ABSTRACT

# الملخص العربي

هذه الدراسة ركزت على المتغيرات الكيميائية والبيولوجية لمياه الشرب بمدينة سرت والمتحصل عليه من محطة التحلية. لاحظ الباحث بأنّ المحطة تُنتجُ ماءا بدون معالجةِ كيميائيةِ مما يؤدي لإنتاج مياه بها أملاح ادني من المستوى المطلوب لمياه الشرب. مما دعا الباحث إلى أنشاء وحدة معالجةِ كيميائيةِ صغيرةِ في مختبر التحلية لاقتراح طريقة لمُعَالجَة الإنتاج كحل لعطل وحدة المعالجة وتوفير ماء صحي وأمن للشرب وفقا للمعايير القياسية.

تم اختيار 15 موقع لتحليل الماء كيميائيا وبيولوجيا وقورنت النتائج مع المعايير القياسية الليبية والعالمية لمياه الشرب.

من نتائج التحاليل الفيزيائية والكيميائية نلاحظ أن القيم تراوحت بين الارتفاع والانخفاض خصوصا في العينة رقم (2)عينة إنتاج المحطة بسبب عطل المحطة بين الفترة والأخرى والتآكل والصدأ في وحدات المحطة. إضافة أن محطة التحلية تنتج مياه بدون معالجة كيميائية وهذا يجعل مياه المحطة غير صالحة للشرب وفقا للمعايير العالمية لمياه الشرب في حين أن نقاط التوزيع خارج المحطة تكون مياه صالحة للشرب حيث يتم خلطها في خزانات الشركة بمياه النهر لإكساب المياه الأملاح التي تحتاجها , حيث يتم خلط 3 كميات منْ ماء النهر وكميةِ وحدة من مياه محطة التحلية أي بنسبة 3:1. و هذه الخطوة أحد الأسباب في تقلب نوعيةِ الماء للعينات المدروسة إضافة لنقلَ المياه عن طريق الشاحناتِ الغير مناسبةِ والقديمةِ والغير صحّيةِ إلى المستهلكين أما نتائج التحليل البيولوجي لاختبار العددِ الكليْ للبكتيريا أظهرت أن العينة (9) عينة الخلط بين مياه النهر ومياه التحلية أعطت أعلى قيمة للبكتيريا حيث كانت (>300CFU/1m) في حين أعلى قيمة لاختبار coliform fcacal (T.C.F) كانت في العينة (1), (2), (7) التي وصلت ل (4CFU/100ml), أما اختبار الكشف عن بكتيريا E.coli أعطى نتيجة في حوض الترسيب العينة (2).

من الدراسة نلاحظ أن النوعية المنخفضة للمياه المنتجة من المحطة من أسبابها قلة صيانة المحطة بشكل دوري إضافة للتآكل والصدأ في وحدات المحطة. إضافة إلى أن للمحطة مساهمة في تلوث البيئة من خلال الدخان المتصاعد من المحطة وتلوث الماء في حوض الترسيب المفتوح لدخول الملوثات ا ليه.

# الملخص العربي

بسم الله الرحمن الرحيم

وَهُوَ الَّذِي مَرَجَ الْبَحْرَيْنِ هَذَا عَذْبٌ فُرَاتٌ وَهَذَا مِلْحٌ
أُجَاجٌ وَجَعَلَ بَيْنَهُمَا بَرْزَخًا وَحِجْرًا مَّحْجُورًا

صدق الله العظيم

الآية (53) سورة الفرقان

يرية العربية الليبية الشعبية الاشتراكية العظمى
جامعة التحدي
سرت

إن الدراسة ليست غاية في حد ذاتها
وإنما الغاية هي خلق الإنسان النموذجي الجديد

التاريخ: ..........
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# كلية العلوم
## قسم الكيمياء
## عنوان البحث

**دراسة تحليلية لمياه شرب مدينة سرت المتحصل عليها من محطة التحلية وتحديد مدى تغير مواصفاتها**

مقدمة من الطالبة

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جامعة التحدي - كلية العلوم

جامعة التحدي

كلية العلوم

قسم الكيمياء

# دراسة تحليلية لمياه شرب مدينة سرت المتحصل عليها من محطة التحلية وتحديد مدى تغير مواصفاتها

**بحث مقدم كجزء من متطلبات درجة الماجستير في الكيمياء**

مقدم من

**حنان علي علي عمر مليطان**

بكالوريس علوم(كيمياء)

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2000

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سرت- ليبيا
2008