Palestine Polytechnic University

College of Engineering &Technology

Civil & Architecture Engineering Department

Graduation Project

Evaluation of Drinking Water Quality in the Hebron City

Project Team

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Project Supervisor

Dr. MAJED ABU SHARKH

Hebron - Palestine

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CERTIFICATION

Palestine Polytechnic University

Hebron-Palestine

Collage of Engineering & Technology

Department of Civil and Architectural Engineering

The Senior Project Entitled:

EVALUATION OF DRINKING WATER QUALITY IN THE HEBRON CITY

BY

MOHAMMAD R. M. HASAN **SOLAIF A. H. DABABSAH**

In accordance with the recommendations of the project supervisor, and the acceptance of all examining committee members, this project has been submitted to the Department of Civil and Architectural Engineering in the College of Engineering and Technology in partial fulfillment of the requirements of Department for the degree of Bachelor of Science in Engineering.

Project Supervisor Signature:

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Examining Committee Signature:

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Department Chairman Signature:

…………………..

June 2004

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إلى الأم الحنـــونة والأب الغـــالي

إلى أستاذنا الدكتـــور ماجـــد أبو شـــرخ

إلى أحـــبائنا الذين تتـــوق أنفســـهم للتفوق والنجاح

إلى أعـــزائنا الذين تهفو قلـــوبهم للـــسمو وتشـــرئب أعناقهم للمعـــالي

إلى الذيـــن يجعلـــون الاجـــتهاد هدفهم والجد دأبهم

إلى كل الراغبين بالاستزادة من العلم والمعرفة

إلى كل هؤلاء نهدي هذا الجهد المتواضع

سليف عبدالله حافظ دبابسة

محمد رمضان محمد حسن

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Mohammad R. M. Hasan

Solaif A. H. Dababsah

ABSTRACT

EVALUATION OF DRINKING WATER QUALITY IN THE HEBRON CITY

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Water quality is a concept referring to the chemical, biological and physical characteristics of the water. The water quality must be good and meet World Health Organization (WHO) domestic water standards. Accordingly, the present work attempts to study the physical, chemical and biological characteristics of drinking water in the Hebron city. Samples from 100 houses were collected ,tested, and analyzed for chemical and biological constitutes.

The chemical analysis show that none of the parameters exceeded WHO standards with the exception of same high value to some parameter. This mean that the water is of good quality and suitable from chemical side for drinking and domestic purposes. The biological data obtained reveals that around 30% of the samples tested are contaminated with coliforms (total or Escherichia coliform). Even this it was still concluded that the water in the Hebron city is in general, of good quality. Since, generally the contamination was slight and the situation can be improved by taking care with the cleanliness, of water source environment.

Chapter 1

INTRODUCTION

1.1 GENERAL

1.2 PREVIOUS STUDIES

1.3 OBJECTIVES

1.4 STUDY AREA

1.5 STRUCTURE OF THE PROJECT

CHAPTER ONE
INTRODUCTION

1.1 General

Water quality is a concept referring to chemical, biological and physical characteristics of water. The required water quality is determined by the purpose for which the water is to be used (domestic, agricultural or industrial). Evaluation of water, for any purpose, is based on characteristics of water compared to standard for that use. By "standard" is meant the concentration of a constituent which causes no negative effect to the health of the consumer over the life of consumption [15]. However, local requirements depend on the availability of water resources, the national economy, the political situation and scientific progress, may modify these standards. The water quality short-term deviation from a standard for a specific purpose is not mean that the water is unsuitable for that purpose. Suitability here is judged by the amount and the length of the deviation time as well as by the nature of the constituent involved. This study covers determination of water quality in the Hebron city and suitability of this water for domestic uses.

1.2 Previous Studies

A study of cisterns rainwater quality in south of the West Bank [2], examined the chemical and biological contamination. Samples from 200 cisterns were collected, tested and analyzed.

The chemical analysis included the determination of the concentration of major cations (calcium, magnesium, sodium, potassium) and anions (chloride, carbonate, bicarbonate). The analysis also included measurement of pH, electrical conductivity, and total dissolved solid and total hardness. The analytical chemical results are presented in Table (1.1). The analysis revealed that none of the chemical constituents exceeded WHO standards with the exception of high and low values of certain parameters. This means that the cisterns water is of high quality and very suitable from chemical point of view for drinking and domestic purposes.

Table (1.1) - Results of the Chemical Analysis of Cisterns Water Samples [2]

Constituents	WHO Standards in (mg/l)	Concentration Observed in (mg/l)		
		Minimum	Maximum	Average of 200
pH (dimensionless)	6.5 – 9.2	7.5	9	8.1
EC (μ mho/Cm)	< 250	0.17	1.2	0.45
TDS	200 – 500	80	560	237.5
TH	200 – 500	70	423	182.6
Calcium	75 – 200	18.1	94.6	45.1
Magnesium	50 – 150	1.0	92	20.8
Sodium	100 – 200	5	41	11
Potassium	0 – 10	1	12	3.3
Chloride	200 – 600	18	138	41.7
Carbonate	0 – 50	1.2	67.2	21.1
Bicarbonate	0 – 500	41.6	315.5	146.9

The study of biological contamination was limited to the investigation of the presence of total coliforms. Samples from 200 rainwater cisterns were tested. 54 out of 200 samples contained coliforms and 146 samples ware free of coliforms. The total coliform colony counts are presented in Table (1.2). This mean that 27% of the cisterns water in south of the West Bank is contaminated by coliforms and did not meet WHO drinking water standards, were 73% is not contaminated and meet WHO drinking water standards. Despite this finding, it was still concluded that potentially cisterns water in general is safe and of good quality for drinking and domestic uses [2].

Table (1.2) - Total Coliform Counts in 100 ml Samples for Stored Rainwater in Cisterns in South of the West Bank [2]

Total Coliform Counts in 100 ml samples	Total Number Of Sample	% Total Number of Samples
0	146	73
1 – 10	10	5
11 – 20	15	7.5
21 – 30	12	6
31 – 40	7	3.5
41 – 50	4	2
> 50	6	3
Total	200	100

Abed Rabbo et al. (1997) in the unpublished final report for the Ford Foundation presented the results of an extensive study of springs and wells throughout the West Bank. The study aimed to determine the levels of biological and chemical pollution and recommended means of improving the situation [1].

Qannam (1997) in his M.Sc. thesis studied, classified and evaluated the water quality of major springs and wells in the southern part of the West Bank, for both drinking and irrigation purposes and highlighted the main environmental water- hyphen related issues. The study showed that the area is dominated by earth alkaline water with prevailing bicarbonate, followed by earth alkaline with increased portions of alkalis and prevailing bicarbonate, then earth alkaline water with increased portions alkalis and prevailing chloride and alkaline water with lastly prevailing chloride. Most of the water samples were found to be oversaturated with respect to calcite, aragonite, dolomite and chalcedony, while under saturated with respect to gypsum and magnetite mineral phases. Only deep wells were found to be free of coliform bacteria. The water of a few springs exceeds the WHO guidelines for NO_3^-. The water of all springs and wells tested is good for irrigation [1].

1.3 Project Objectives

The overall objective of this project is to evaluate the water quality in the Hebron city. More specifically the main objectives of this study may be classified as follows:

1. Determine the physical characteristics of drinking water as color, odor and taste.
2. Determine the chemical characteristics of drinking water, such as total dissolved solid, concentration of major cations (calcium, magnesium, sodium, potassium) and anions (chloride, carbonate, bicarbonate) , pH, total hardness and electrical conductivity.
3. Determine the biological characteristics of drinking water, including total coliform and Escherichia coliform (E. coli.)
4. Evaluation of water quality for drinking and home uses.
5. Give some suggestions and recommendations regarding the quality of drinking water in the Hebron city.

1.4 Study Area

Hebron is situated some 35 Km south of Jerusalem, as shown on the project location plan, Fig. (1.1). The population within the municipal boundary has been determined

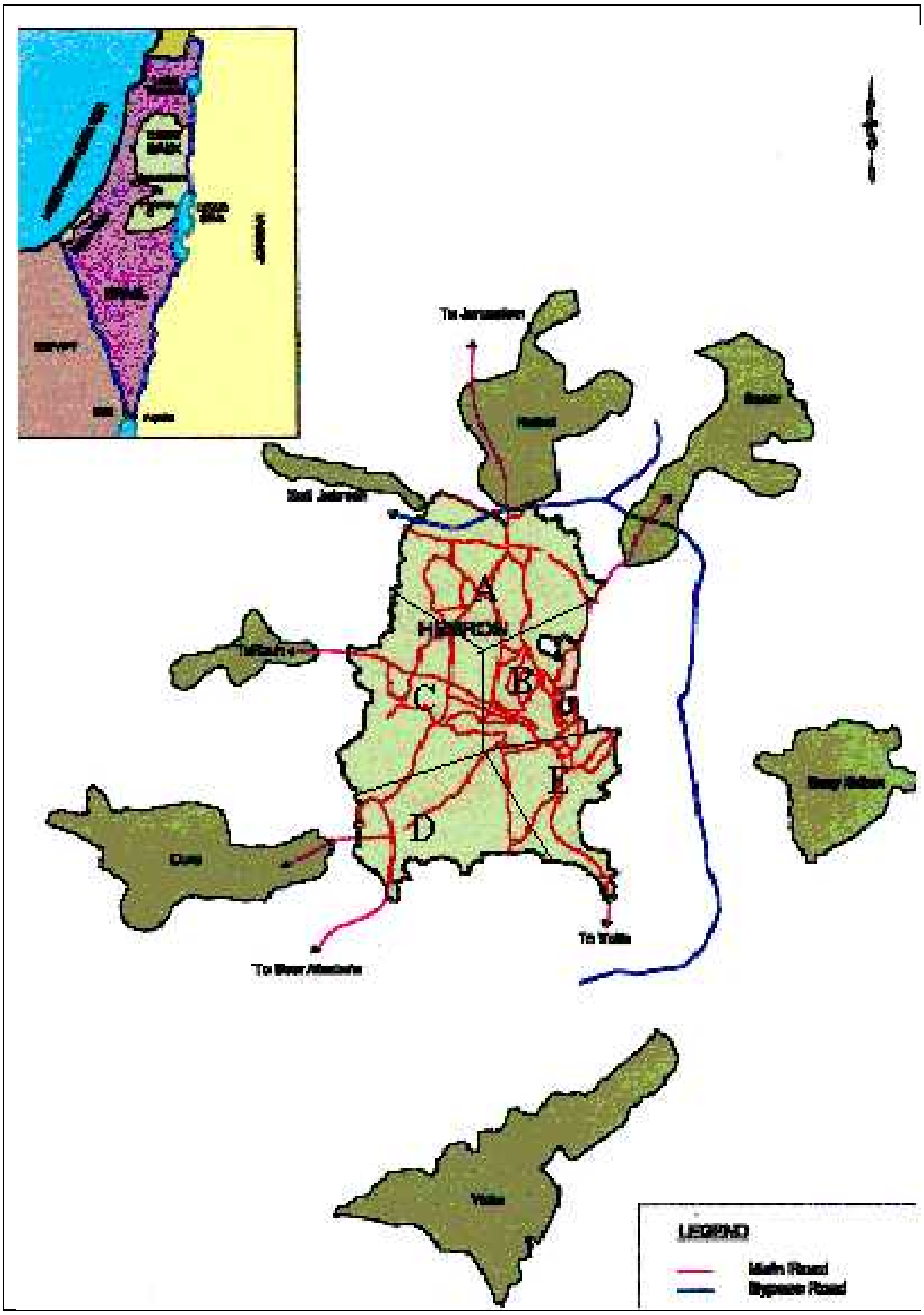


Fig. (1.1) Location Map of the Hebron City

By a census carried out by the Palestinian Bureau of Statistics on the night of 9 December 1997. The population is 119320 habitant. The present population of the city is around 150000 for year 2004.

The topography within the municipal boundary is extremely hilly. This is illustrated on Figure (1.2), which shows the topography of the project area. The main part of the city is situated within a wadi system falling from north to south with steeper sided wadis leading into this, particularly from the west. The ground elevations within this area range from +1000 m with respect to sea level in the north, to around + 800 m with respect to sea level in the south-east, where the main industrial area is situated. The commercial centre of the city is situated in the east central part of the area with dense housing on the adjacent hillsides. There is also extensive commercial development along the main roads leading from the city centre to Yatta and Jerusalem [5].

Hebron city has a typical Mediterranean climate with two main seasons: the dry season from May to October and the rainy season from November to April, spring and autumn are short and have special characteristics. The average annual rainfall in the Hebron city for the last five years is approximately 460 mm, of which about 98 percent falls between October and April. The mean maximum temperature is 28 ^{0} C and mean minimum temperature is 5^o C. The relative humidity in the Hebron city ranges from 30% - 80%. According to the data obtained from the Hebron Meteorological station, average wind velocity in winter is about 12 m/s and in summer 8 m/s [5].

For the purpose of the study, Hebron city is divided into five relatively homogenous areas namely area A, area B, area C, area D and area E as shown in Fig. (1.1).

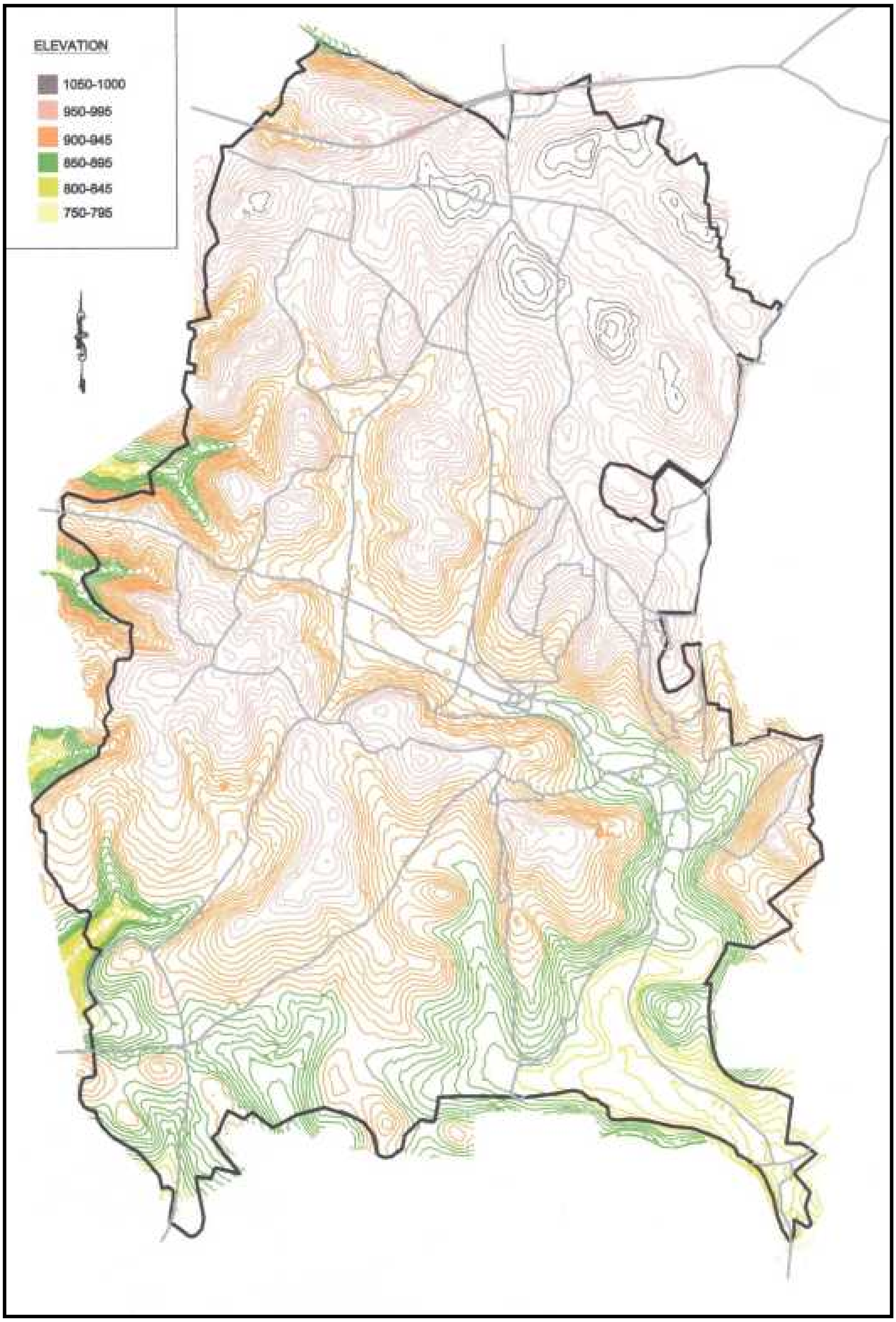


Fig. (1.2) Topographic Map of the Hebron City

1.5 Structure of the Project

The subject matter of the project is presented in five chapters. The first chapter entitled “Introduction” outlines the problem; previous studies project objectives and the study area (project area, topography and climate). The second chapter entitled “Characteristics of Water” describes physical, chemical and biological characteristics of water. The third chapter entitled “Methodology” deals with water sampling, water quality analysis (fieldwork, laboratory work), and data collection. Chapter four on “Results and Discussion” displays Hydro chemical and biological results, and evaluation of water quality in the Hebron city. “Conclusions and Recommendations” are given in chapter five.

Chapter 2

CHARACTERISTICS OF WATER

CHAPTER TWO
CHARACTERISTICS OF WATER

2.1 General

Water in natural form is seldom pure. Even rain water, pure-originally, picks up gases and impurities during its fall from the atmosphere and further contaminates during its flow over the surface and through the soil. Water quality is defined by the suspended and dissolved solids it contains and pertains to suitability for a particular use like domestic, industrial, irrigation, etc. Three major characteristics which define the quality of water are:

(i) Physical characteristics.

(ii) Chemical characteristics.

(iii) Bacterial and microscopic characteristics.

2.2 Physical Characteristics

1. **Turbidity:** Water containing visible material in suspension is termed as turbid. Turbidity in water consists of clay, silt, finely divided organic matter, macroscopic organisms. Turbidity may result from living or dead algae or other organism. It is generally caused by soil erosion in natural waters. River water is normally most turbid when storms are most numerous. Turbidity depends on fineness and concentration of particles in the water. It is measured by the interference caused by the sample of water to the passage of light rays with the help of an instrument called turbidmeter. Turbidity more than 0.5 mg/l can be detected when water is held in a white enamelled container. Turbidity of potable water is limited to 10 mg/l (silica-

scale) preferably not exceeding 5 mg/l. Turbidity of less than 0.1 mg/l can be obtained by water treatment [2].

2. **Color:** Pure water is colorless. Color is imparted to water by material in solution or in colloidal suspension or mineral and is distinguished from turbidity which may cause an apparent color. Surface water flowing through swamps or passage of ground water through solution of minerals pick up coloring materials. Acceptable intensity of color in water is limited to 5 mg/l [2].

Sunlight has natural disinfecting and bleaching effect on the coloring matter but this action is limited to a shallow layer of a few centimeters near the surface in turbid water. However, in clear water, the bleaching effect extends to a depth of 1.5 m.

3. **Odor and Taste**. Pure water is odorless and tasteless but potable water while being essentially odorless is pleasant to the taste. Taste in water is generally due to presence of dissolved salts. Iron salts and sulphates are offenders while the taste imparted by dissolved oxygen and carbon dioxide is desirable. Odor and taste is imparted to the water by the presence of microorganisms, mineral substances, dissolved gasses and organic matters. Methods for removal of undesirable taste and odor include aeration, use of potassium permanganate and application of activated carbon, coagulation, sedimentation and filtration [2].

4. **Temperature:** Natural water is seldom below 5°C. In a water supply system, the desirable temperature is 5°C to 10°C, temperature above 25°C is not desirable.

2.3 Chemical Characteristics

1. **pH Value:** most water are more or less alkaline because alkaline salts are very common in the ground . Carbonates and bicarbonates of calcium, sodium and

magnesium are the common impurities. Alkalinity is expressed in milligrams /liter in terms of equivalent calcium carbonate. Acidity in water is caused by carbon dioxide. It is measured in terms of calcium carbonates needed to neutralize the carbonic acid and is expressed in milligrams per litter. Alkalinity and acidity are also expressed in terms of pH. pH value of water is of importance in water treatment and industrial processes . Pure water has a pH value of 7; below 7 it is acidic and above 7 it is alkaline. Acidic water results in corrosion of pipe line [2].

2. **Hardness:** Hardness of water is a matter of great concern for public water supply. Hard water requires more soap before a lather is formed. Hardness is indicated by the formation of insoluble precipitate or curd, rather than lathering with soap and formation of scale in utensils. Hard water contains solution of carbonates and sulphates of calcium and magnesium, their chlorides and nitrates besides iron and aluminum. Temporary hardness, removed by boiling or addition of lime to the water, is rendered by the presence of bicarbonates of calcium and magnesium. Permanent hardness, softened by special treatment, results from the presence in water of sulphates, chlorides and nitrates of calcium and magnesium. Hardness is expressed in mg/l by weight in terms of calcium carbonates. Table (2.1) indicates classification of various degrees of hardness of water. Hardness of nature water suitable for public water supply ranges approximately between 10 to 1800 mg /l [2].

Table 2.1 - Hardness Classification of Water

Hardness (mg/l) as $CaCO_3$	**Degree of Hardness**
0 – 60	Soft
61 – 120	Moderately hard
121 – 180	Hard
Over 181	Very hard

3. **Electrical conductivity (EC):** The total amount of dissolved salts present in water can be easily estimated by measuring the specific conductivity of water. Specific electrical conductivity defines the conductivity of a cubic centimeter of water at a standard temperature of 25° C. The unit of conductivity is mho (1 ampere/1 volt). It is determined by a potable diomic water taster. Pure water at 25° C has a specific conductivity of 5.5 x 10-8 mho and sea water about 5 x10^{-2}mho [2].

4. **Total Dissolved Solid (TDS):** The mineral constituents and organic materials dissolved in water constitute the total dissolved solids. The measurement of total dissolved solid in water is essential for water used in drinking, irrigation, and industrial purposes. The recommended maximum concentration for TDS is 1000 mg/l, but more than 600 mg/l is undesirable for drinking and many industrial. Classification of the drinking water quality in terms of TDS published by World Health Organization (WHO) is given in Table (2.2) [2].

Table 2.2 - Classification of the Drinking Water in Terms of the Total Dissolved Solids (TDS)

Water Quality	Total Dissolved Solid (mg/l)
Very good	<300
Good	300 – 600
Fair	600 – 900
Poor	900 – 1200
Not acceptable	> 1200

5. **Calcium and Magnesium (Ca^{++}, Mg^{++}):** The most important divalent metallic cations in water. The major natural sources of calcium and magnesium are amphiboles, pyroxenes, dolomite, and clay minerals. The recommended maximum concentration in drinking water is 100 mg/l for calcium, and 50 mg/l for magnesium.

Hardness which is caused by calcium and magnesium ions interferes with laundering of clothes by reducing the cleaning action of the soap or detergent and at high concentration produces scale in water pipes and on plumbing fixtures.

6. **Sodium and Potassium (Na^{++}, K^{+}):** The main sources of sodium and potassium are feldspars, clay minerals, and industrial waste. The recommended maximum content in drinking water is 100 mg/l for sodium, and 10 mg/l for potassium.

Sodium and potassium affect the suitability of water for irrigation. High sodium concentration adversely effects the soil and plant growth. More than 50 mg/l sodium and potassium causes corrosion in boilers.

7. **Chloride (Cl^{-}):** Chief source of chloride is sedimentary rock. Excess chloride causes bad taste. Water which contains chloride with concentration between 200 - 600 mg/l can be used for domestic use. The recommended maximum concentration for chloride in drinking water is 250 mg/l.

8. **Carbonate and Bicarbonate (CO_3^{-}, HCO_3^{-}):** In general, the dissolved carbonate materials and CO_2 are the major source of carbonate and bicarbonate in water. The bicarbonate ion and carbonate ion content in water is referred to as alkalinity. Below pH of 8.3 the total alkalinity is in the form of the bicarbonate ion.

Water contains less than 500 mg/l of carbonate and bicarbonate can be used for drinking. The recommended concentration is 50 mg/l for carbonate, and 500 mg/l for bicarbonate. Water containing large amounts of bicarbonate is undesirable in many industries. The carbonate combines with calcium and magnesium to form calcium carbonate and magnesium carbonate which cause hardness.

9. **Dissolved Oxygen (DO):** The primary effect of dissolved oxygen in water is on oxidation-reduction reactions, involving iron, manganese, copper and compounds

that contain nitrogen and sulphur. In certain distribution systems there may be a tendency for the level of dissolved oxygen to fall with residence time. Although such changes are normally indicative of corrosion processes, it is also possible that microbial respiration of organic material, especially in sediments and deposits, within pipes may be responsible. Thus, dissolved oxygen may decrease without a marked increase in the concentration of iron in the water. Conversely, water containing high levels of iron as a result of corrosion may show little depletion of dissolved oxygen content.

One milligram of oxygen per litter will produce 3.5 mg of ferrous iron per litter so that a large amount of iron corrosion may occur with little perceptible change in dissolved oxygen when the available oxygen in water has been depleted; anaerobic corrosion processes precede involving the activity of the sulphates-reducing bacteria that may be present.

Frequently, depletion of the level of dissolved oxygen below about 80% saturation leads to an increased incidence of consumer complaints, especially regarding taste, odor and discolored water [8].

10. **Nitrates and Nitrites** (NO_3,NO_2): The presence of nitrites and nitrates indicates an organic contact sufficiently remote to permit some oxidizing action on organic matter. Nitrate in water is commonly reported in terms of the nitrogen equivalent, but in mineral analyses results are reported in terms of the acid radical (NO) and, as such, in ground waters it may have sanitary significance as a cause of mathemoglobinemia. The total nitrogen in natural waters is seldom sufficient to require its removal by water-treatment processes. It has, however, been found in concentrations as high as 40 to 60 ppm in natural waters [3].

11. **Ammonia (NH_3):** The presence of free ammonia in water indicates the presence of undecomposed organic matter, and for potable water, its value should not exceed 0.15 mg/l. The very presence of organic nitrogen in water indicates pollution, and for potable waters, it should not exceed a value of about 0.3 mg/l [6].

12. **Chlorine (Cl_2):** Dissolved free chlorine is not found in natural waters. Its presence in treated water results from disinfection with chlorine and because a residual is left as a safety measure to ensure the killing of pathogenic bacteria. The customary residual is in the order of 0.1 to 0.2 ppm. Residuals up to 2 ppm are successfully carried but may result in complaints of unpleasant tastes. Chlorine must not be confused with chlorides, for they are not the same thing [5].

2.4 Biological Characteristics

Ground water normally dose not contain many bacteria because filtration, exposure to unfavourable environment and the time element eliminates most of them. Surface water may contain various kinds of organic life, some of which are detrimental to public water supply. Living organisms may be classified into:

1. Macroscopic.
2. Microscopic.
3. Bacteria.

Macroscopic organism's species are distinguished by a naked eye but microscopic organisms require the aid of microscope to distinguish the species. The bacteria are so small that the species can not be identified even under a microscope and is done with the aid of strains, reaction to nutrient media or other environmental conditions. Bacteria which if present in water cause diseases are called ‘Pathogenic’ while those considered normal to natural water and many not be removed in the process of purification and are not harmful in human consumption but may cause some difficulties in industrial processes are known as non–pathogenic bacteria. pathogenic bacteria, indigenous to the intestinal tract of men and warm blood animals, cannot be isolated from natural water in the laboratory. However, the presence in water of harmless bacterium called ‘Escherichia Coil’ normally present in intestinal tract of warm blood animals and easily isolated and identified is taken to indicate presence of pathogenic bacteria. The quality of water for public water supply is determined by the presence or absence of this bacterium through E-Coli test of water coliforms bacteria is also important as its presence is indicative of pathogenic.

Microscopic organisms like Fungi and Algae are found in ground water. Algae are small plants which live in water. When present in large number they may cause turbidity and apparent colors. They impart undesirable taste and odors to the water. The use of copper sulphates or chloride checks the excessive growth of Algae [2].

Macroscopic organisms like cattails, hyacinth and seaweeds are troublesome plants if present in water. The deterioration in taste, colors and odors caused by these organisms may be removed in the process of purification. Cultivation of fish in reservoir helps in control undesirable small macroscopic and some microscopic organisms.

Viruses in water are defined as a group of infectious agents smaller than ordinary bacteria. Chlorination in combination with other treatment inactivates viruses although relatively heavy doses and long contact period are necessary.

1. **Total Coliforms:** As mentioned earlier Water may contain various kinds of organic life such as bacteria and microscopic organisms. Coliforms are important harmless micro-organisms which are found in the human intestine. Harmless organisms of coliform group live longer water than pathogenic bacteria. Therefore,

water is safe if it is free of bacteria in it. Also coliform organisms are considered suitable indicators of pollution because they die in a short time and can be identified easily [2].

The quality of water for public water supply is determined by the presence or absence of total coliform. In order that the water is safe for drinking water and is free from pathogenic bacteria, it is generally necessary that no one coliform organism is present.

2. **Escherichia coliform:** The fecal coliform group includes all of the rod-shaped bacteria that are non-spore forming, Gram-Negative, lactose-fermenting in 24 hours at 44.5 °C, and which can grow with or without oxygen. Fecal coliform is a type of fecal bacteria. Another type of fecal bacteria is Fecal Streptococcus. Fecal Streptococcus is a group of bacteria normally present in large numbers in the intestinal tracts of warm-blooded animals other than humans.

Some strains of Escherichia coliforms, related to fecal coliform family, can cause intestinal illness. This is found in the digestive tract of cattle.

2.5 Quality of Water Required for Domestic Uses

Municipal water required for domestic uses, particularly the water required for drinking, must be colorless, odorless and tasteless. It should be free from turbidity, and excessive or toxic chemical compounds, harmful micro-organisms and ratio activity must be absent. The quality of water for municipal supplies is, therefore, generally controlled throughout the world, and even World Health Organization (WHO) has lead down its international standards specifying the minimum water quality requirements. When these water standards are not fulfilled, the water may not be 100 percent fit for drinking, and may be termed as "contaminated it may not healthy and tasty, or may cause the speared of some diseases. The standard of quality of municipal supply is indicated in Table (2.3).

Table (2.3) - Standards of Quality of Municipal Water [9].

Type of Impurity	Limits		Bad Effect
	Permissible (mg/l)	Excessive (mg/l)	
Physical			
Color (on platinum cobalt scale)	5	25	Undesirable appearance, discoloration of clothes, complicates coagulation treatment.
Odor	Odorless	-	Aesthetic and sanitary point of view
Taste	Pleasant	-	
Temperature	20 ºC	-	
pH	7 - 8.5	< 6.5 >9.2	Acidity is detrimental to portability. Acidity is considered undesirable in source of public water supply because natural waters are alkaline.
Turbidity	5 (turbidity units)	25	Sediments composed of fine particles of sand and clay producing visible turbidity is not particularly detrimental to the potability of water or to most industrial uses.
Chemical			
Total dissolved solid, suspended and dissolved (mg/l)	500	1500	Objectionable to cooking, taste, hardness and corrosiveness

Total hardness (as Ca, CO_3, mg/l)	300	600	Inhabitation of lathering with soap, formation of scale in water-heating vessels and cooking utensils. Fuel wastages, increased water of utensils, decreased life of fabrics washed
Chloride (Cl)	250	1000	Undesirable odor and taste.
Sulphates (SO_4)	250	400	Laxative effect on human body.
Magnesium	50	150	
Zinc (Zn)	5	15	Extremely small concentration of zinc is sometimes considered hygienically desirable but concentration greater than 15 mg/l are undesirable.
Copper (Cu)	1.0	3.0	Harmful to lungs and respiratory system. Indicative of pollution. Extremely small quantity of copper is considered hygienically desirable
Arsenic (As)	-	0.2	Poisonous. Rarely found in natural water.
Selenium	-	0.05	
Fluorides (F)	0.3	1.0	0.6 to 1.0 essential for teeth formation. Over 1.5 causes spotting and discoloration of teeth.
Iron (Fe)	0.3	1.0	Unpleasant taste, stains on cloth and plumbing fixtures and textiles in the laundry. Offers difficulty in the manufacturing processes. Corrosive to metals. Hardness.
Manganese (Mg)	0.1	0.5	

Lead	-	0.1	Presence undesirable in water because of tendency to accumulate in body resulting in plumbism, toxic, lead poisoning.
Phenol	0.001	0.002	Undesirable because of taste produced in combination with chorine.
Biological			
B-coli			No B-coil in 100 ml.
Most probable number (M.P.N.)			One number in 100 ml.
Radiological			
α emitters			1 μμ c/l
β emitters			10 μμ c/l

Chapter 3

METHEDOLOGY

3.1 GENERAL

3.2 WATER SAMPLING

3.3 WATER QUALITY ANALYSIS

3.4 DATA COLLECTED

CHAPTER THREE
METHODOLOGY

3.1 General

As mentioned earlier, the main objective of this project is to asses the drinking water quality in the Hebron city. Physical, chemical and biological characteristics of water are supposed to be determined for the purpose of the study. The study area (Hebron city) is divided into five homogenous areas in which 100 sampled are collected and tested. Water samples are taken from different houses from an-external source and internal one, the latter to be the last container used before drinking. This chapter deals with water sampling, water quality analysis and collected data.

3.2 Water Sampling

In order to study the physical, chemical and biological characteristics of drinking water, 100 samples were collected, tested and analyzed. The samples covered all the places of the Hebron city.

For the purpose of the study and in order to know the quality of drinking water, determine the extent of purification necessary due to different pollutants, and to identify the possible sources of its pollution, simple questionnaire were prepared to take all the information about each house and the source of drinking water (see Table A.1 – Appendix A). The questionnaire includes general questions about the house in addition to questions related to cistern and tanks such as source of water, design and construction of cistern, cistern and tank environment, physical properties of water, etc.

The questionnaire for all the houses wear filled before water sampling and all the information in the questionnaire were tabulated in a tabular form (see Table A.2– Appendix – A).

In sampling drinking water for analysis, glass bottles 250 ml volumes were used, one bottle for each chemical and biological analysis. After sterilizing the bottles in an ordinary oven for one hour at 120º C and rinsing them with the stoppers by distilled water. The samples are then collected and securely sealed; this was done using cleaned bucket. Samples of water tap have been taken after keeping few minutes of opining the tap to collect the representative samples. The bottles were usually stored in a cool place and transferred promptly to a laboratory for analysis. Water sampling were usually done in the morning time.

3.3 Water Quality Analysis

A complete water quality analysis was performed at the laboratories two times for each house during the course of the research to assess the drinking water quality in Hebron city of the West Bank. Tests for pH, conductivity, total dissolved solid, total hardness, major cations and anions (Calcium and Magnesium, Potassium, Chloride, Carbonate and Bicarbonate, Dissolved oxygen, Nitrates, Ammonia, Nitrites, Chlorine) and along with tests for total coliform and Escherichia coliform were conducted in the Renewable Energy and Environmental Unit laboratory at Palestine polytechnic University (PPU).

3.3.1 Field Work

Comprehensive sampling program concerning drinking water in the Hebron city of the West Bank were carried out from January 2004 to June 2004. Our procedure in the field is to have one sampling bottle for each site for intended biological test in the laboratory. For the physical and chemical analysis direct measurements were made at each site with potable water meter and water kit giving reading for the following parameters:

1. Temperature ^{o}C.
2. pH.
3. Electrical conductivity (EC).
4. Total Dissolved Solid (TDS).
5. Total Hardness (TH).
6. Calcium (Ca^{++}).
7. Magnesium (Mg^{++}).
8. Potassium (K^{+}).
9. Chloride (Cl^{-}).
10. Chlorine (Cl_2).
11. Carbonate (CO_3^{-}).
12. Bicarbonate (HCO_3^{-}).
13. Nitrate (NO_3^{-}).
14. Nitrite (NO_2^{-}).
15. Ammonium (NH_3).
16. Dissolved Oxygen (DO).

The procedures for the analysis of each chemical parameter are given in Appendix-B.

3.3.2 Laboratory analysis

As mentioned earlier, the test of total coliform and Escherichia coliform were conducted in the laboratory of Renewable Energy and Environmental Unit at PPU. The samples were analyzed according to the American Health Association (1995) standard methods for examination of water and wastewater [2]. The procedures for the biological test are given in Appendix - C.

3.4 Data Collected

As mentioned earlier, and for the purpose of the present study, simple questionnaire were prepared and filled for each sample (house). The data collected are shown in Appendix A.

In spite of the almost availability of water network in all the places as socio-economic survey show (95% of house are connected to public network), the water which comes through the network is not enough and the different place supplement their water supply through cisterns or tankers. The data obtained show that more than 90% of house in city have cisterns.

The socio- economic survey show that 70% of the Hebron city areas are several with sewage system and 30% of the houses using cesspits or vacuum tanker for the disposal of wastewater which polluted the drinking water in some houses as the results will show latter in chapter four.

Chapter 4

RESULTS AND DISCUSSION

CHAPTER FOUR
RESULTS AND DISCUSSION

4.1 General

The present study of drinking water quality in the Hebron city examined physical, chemical and microbiological contamination. Samples from 100 houses were collected and tested. The data obtained were analyzed to evaluate the quality of drinking water, detect the processes controlling water quality and to assess the suitability of the water for drinking and domestic uses in the Hebron area. Analysis and discussion of results are given below.

4.2 Physical Characteristics Results

The physical characteristics include color, odor, taste, turbidity, and temperature. In the present study, the physical characteristics are not measured accurately in the laboratory. Only some parameters such as color, odor and taste were distinguished in the site of sampling.

Results of physical characteristics show that most of the water samples are without color, odor or taste, but some samples have one or all of these features. By comparing the results with the environment of the house and water source, it is found that house environment has big effect on physical characteristics. The environment where there is animals, insects, and sewage, most of the time, the water has color or odor or taste and vise versa. So, the water will be safe for drinking purpose if the environment of water source is clean and far away from any water pollution.

4.3 Hydro Chemical Results

As mentioned earlier, the chemical analysis of water quality includes the determination of the concentration of major cations (calcium, magnesium, sodium, potassium) and anions (chloride, chlorine, carbonate, bicarbonate, nitrate, and nitrite). The analysis also includes measurement of pH, electrical conductivity, ammonium, dissolved oxygen, total dissolved solid and total hardness. The chemical analytical results of the 100 samples which were considered to be representative for the water quality are presented in Table (4.1). The values of minimum, maximum, and average concentration for each constituent are given in the table beside WHO standards.

Table (4.1) - Results of the Chemical Analysis for Drinking Water in the Hebron City

Constituents	Units	WHO Standards in (mg/l)	Concentration Observed		
			Min.	Max.	Ave. of 100 Samples
pH	Dimensionless	6.5 - 9.2	6.50	8.50	7.5
EC	µS/cm	< 250	170	840	527
TDS	mg/l	200 – 500	82	408	256
TH	mg/l	200 – 600	67	623	203
Ca	mg/l	75 – 200	7	99	45
Mg	mg/l	50 – 150	2	92	22
K	mg/l	0 – 10	2	7	3
Cl	mg/l	0 – 50	> 40	> 40	>40
Cl_2	mg/l	0 – 10	0.1	0.1	0.1
CO_3	mg/l	0 – 50	1	87	22
HCO_3	mg/l	0 – 500	12	320	147
NO_3	mg/l	0 –10	< 4	< 4	<4
NO_2	mg/l	0 –3	< 0.05	< 0.05	<0.05
NH_3	mg/l	< 0.5	< 0.1	< 0.1	<0.1
DO	mg/l	> 4	3	9	6

The results of the chemical analysis reveal that water samples are alkaline in character, hence, the values of pH ranges between "6.5 - 8.5". All the values of pH are within the acceptable WHO standards.

As mentioned earlier, the specific conductivity for pure water is $5.5x10^{-2}$ micromhos/cm. However, water quality is considered to be very good if it is electrical conductivity is less than 250 micromhos/cm. Results of the tests indicate that electrical conductivity values are very low and ranges between 170 – 840 micromhos/cm, which means that the concentration of dissolved solids in water is very low and water quality of samples in terms of electrical conductivity is very good and meets the guideline of the WHO.

Total dissolved solid in water samples includes all solid materials in solution. Classification of the drinking water quality in terms of total dissolved solid (TDS) published by World Health Organization (WHO) is given in Table (4.2).

Table (4.2) - Classification of the Drinking Water in Terms of Total Dissolved Solids (TDS)

Water Quality	Total Dissolved Solid (mg/l)
Very good	<300
Good	300 – 600
Fair	600 – 900
Poor	900 – 1200
Not acceptable	> 1200

In the present study of water quality in the Hebron city, the values of total dissolved solid ranges between 82 mg/l and 408 mg/l. The average of 100 samples is 256 mg/l, which means that water quality of cisterns in the study area is very good for drinking and domestic purposes.

The results of Tables (4.1) indicate that the values of total hardness varies from 67 to 623 mg/l, which are within the acceptable WHO standards (<500 mg/l). Even this, the values of total hardness are comparatively high, so, drinking water in the Hebron city is considered generally moderately hard or hard. The reason may be because the study area is famous in rock industry and the atmosphere is full of dust containing calcium carbonates and calcium chlorides which causes hardness.

The results of major cations (calcium, magnesium, and potassium) given in Table (4.1) indicate that the water quality in the Hebron city is suitable for drinking and domestic purposes. The results show a low concentration to these cations. The values of Ca^{++} and Mg^{++} ranges between 7– 99 mg/l and 2 –9.2 mg/l respectively. The values of k^{+} varies from 2-7 mg/l, which are within the acceptable WHO standards. In some water samples, the values of major cation are comparatively high because the source of water is municipal or springs and because some cisterns are very old and the water is collecting to them through dirty area around them.

The concentration of chloride is grater than 40 mg/l that suitable for drinking purpose. For water disinfection, chlorine concentration should be less than 10 mg/l. The values obtained for chlorine are 0.1 mg/l which is good and meets WHO standards. The concentrations of other anions (carbonate and bicarbonate) are within the WHO standards. The values of carbonate and bicarbonate varies between 1 - 87 mg/l and 12 - 320 mg/l respectively, and the water to be suitable for drinking purpose the concentration of carbonate and bicarbonate should by less than 500 mg/l. So, the water sampling in the Hebron city is, in general, suitable for drinking and domestic uses in terms of anions concentrations.

The values obtained for nitrite, nitrate and ammonium are within the WHO standards with very low values of nitrite and ammonium. The concentration of nitrate is less than 4 mg/l where the concentration of nitrite and ammonium are less than 0.05 mg/l and 0.1 mg/l respectively. The concentration of these parameters should be very low in water because it causes poison.

The dissolved oxygen standard establishes lower limits to maintain a suitable quality of water. A typical minimum standards for water supply is 4 mg/l. The values of dissolved oxygen are ranges between 3 and 9 mg/l that is acceptable for drinking and domestic uses.

4.4 Biological Results

Of two potential types of water biological contamination microbiological and bacteriological, the decision was made to limit the study to the investigation of the presence of total coliform and Echreachi coliform in order to evaluate the quality of drinking water in the Hebron city. This is an important indicator of whether or not water is safe to drink and use for domestic purpose.

Samples from 100 houses were collected and tested. 28 out of 100 samples contained total coliform and 72 samples was free from total coliform. The total coliform colony counts revealed through the test of samples are presented in Table (4.3). According to WHO for drinking water standards water is contaminated by coliform if it contains more than zero coliform / 100 ml water sample. This means that 28 % of the drinking water in the Hebron city are contaminated by total coliform and did not meet WHO drinking water standards, and 72 % are not contaminated and meet WHO drinking water standards, (see Figure 4.1).

Table (4.3) - Total Coliform Counts in 100 ml Samples for Drinking Water in the Hebron City

Total Coliform Counts in 100 ml	Total Number of Samples	% Total Number of Samples
0	72	72
1 – 10	-	-
11 – 20	2	2
21 – 30	2	2
31 – 40	1	1
41 – 50	2	2
>50	21	21
Total	100	100 %

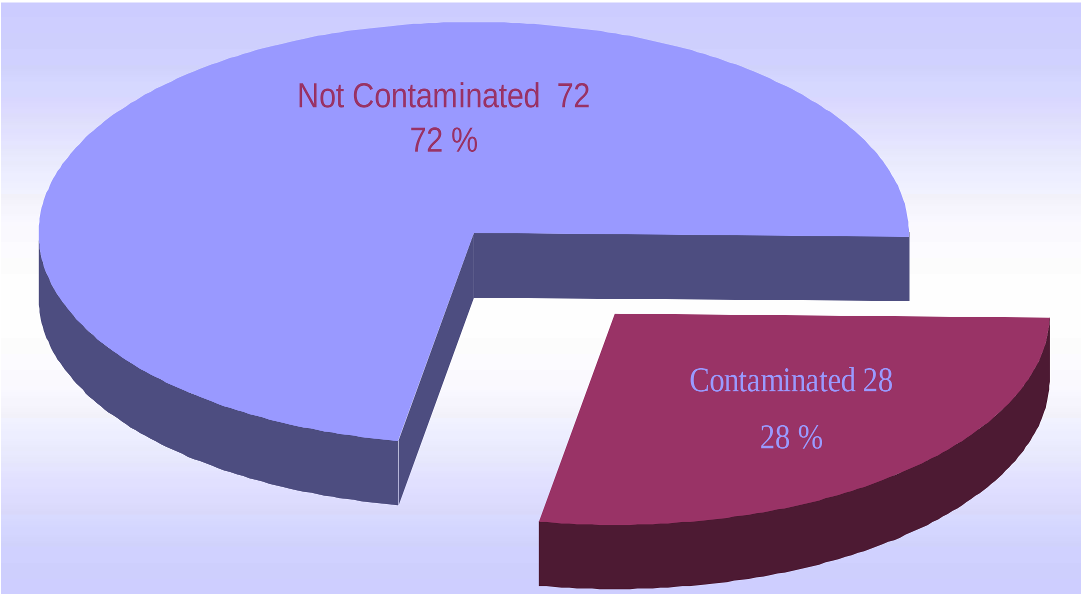


Figure (4.1) - Drinking Water Quality Testing for Total Coliform

The data of Echreachia coliform show that 22 out of 100 samples contained Echreachia coliform and 78 samples was free from Echreachia coliform. The Echreachia coliform colony counts revealed through the test of samples are presented in Table (4.4). This means that 22 % of the samples is contaminated by Echreachia coliform and did not meet WHO drinking water standards, and 78 % are not contaminated and meet WHO drinking water standard, (see Figure 4.2). Despite this finding it was still concluded that potentially water in general is safe and of good quality for drinking and domestic uses.

Table (4.4) - Escherichia Coliform Counts in 100 ml Samples for Drinking Water in the Hebron City

Esch. Coliform Counts in 100 ml	Escherichia Number of Samples	% Total Number of Samples
0	78	78
1 – 10	2	2
11 – 20	2	2
21 – 30	5	5
31 – 40	3	3
41 – 50	2	2
Total	8	8
>50	100	100 %

Figure (4.3) present the percentage water pollution in the Hebron city. The percentage of pollution in area A (40%) is more compare to others areas were the pollution ranges between 25-30%.

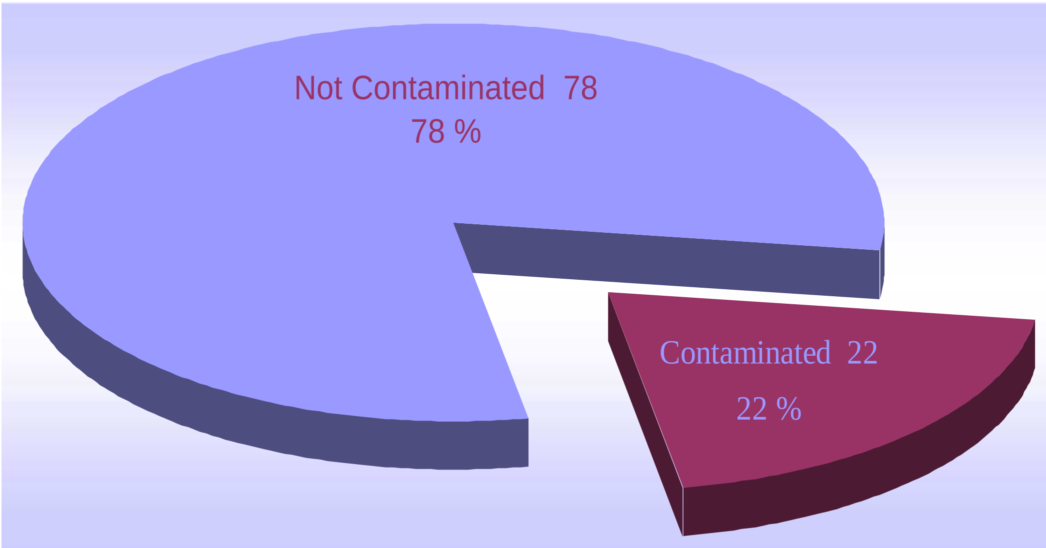


Figure (4.2) - Drinking Water Quality Testing for Escherichia Coliform

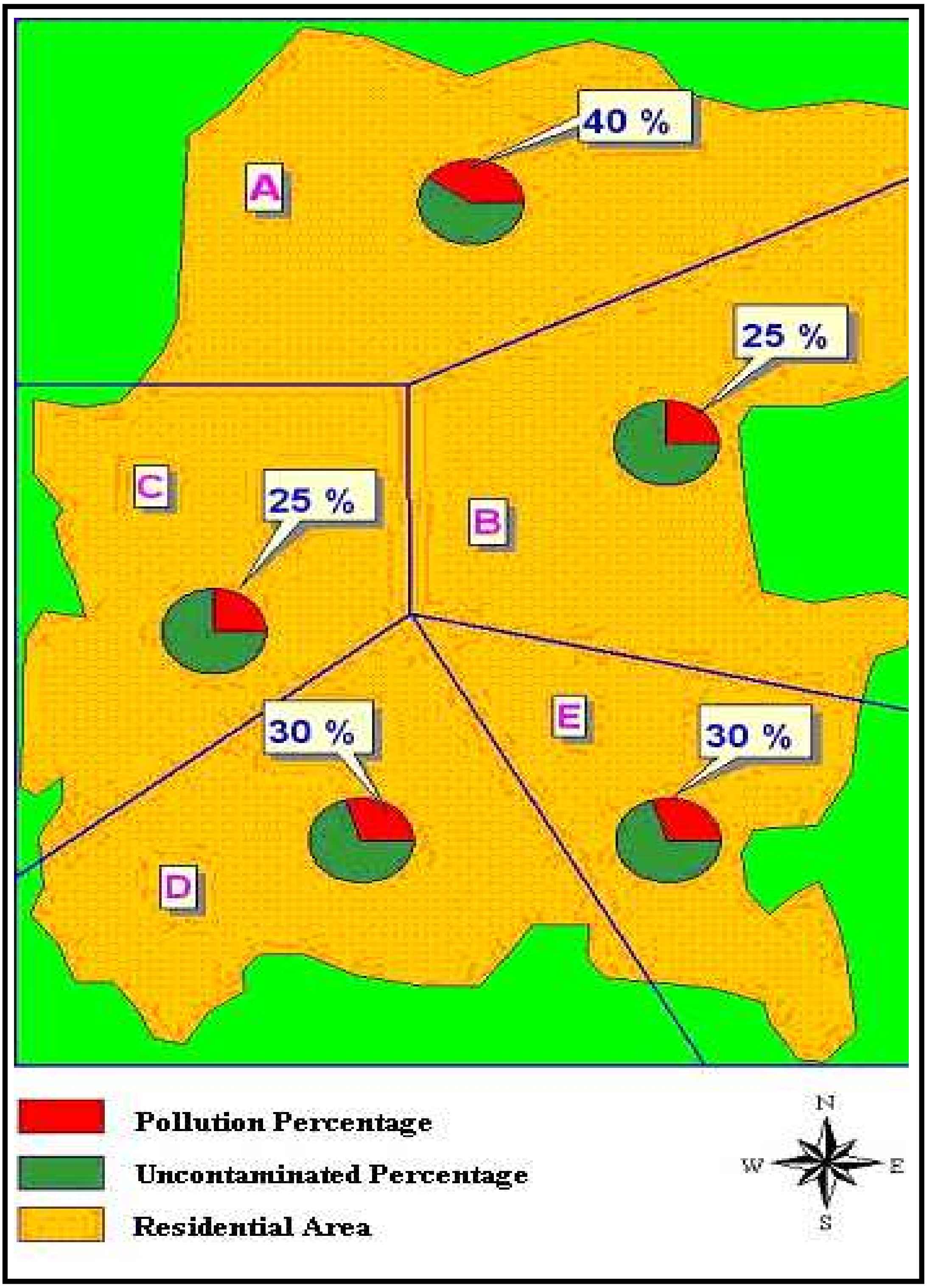


Figure (4.3) – Percentage Water Pollution in the Hebron City Areas

4.5 Factors Affecting Water Quality

1. Sewerage System:

As mentioned earlier, and according to the data obtained from the questionnaire, about 70% of the habitations in the Hebron city are connected to a sewerage system and the other 30% use septic tanks or cesspools without protective walls. No reliable data exist on the number of septic tanks even if in reality these are no great improvement; they often have cracks and holes. There is neither control nor maintenance. At the same time the distance between cesspits and water source in many house are very close which cause pollution to drinking water.

2. House Environment:

The environment of the house has big effect on bacteriological water quality. Table (4.5) present the results of total coliform contamination in rainwater collected from various cisterns in the Hebron city according to cistern environment, and method of collecting water to the cistern.

Table (4.5) – Analysis of Coliform in Cisterns Water

Information about the Cistern		Number of Samples	Contaminated Samples	% of Contamination
Cistern Environment	very good	2	0	0
	good	26	5	19
	intermediate	43	11	26
	bad	29	13	25
Collecting Water	roof	72	17	24
	roof & area	28	12	43

Cistern Environment:

- Very good: not availability of animals, insects, sewage, and general cleanliness is excellent.
- Good: the availability of animals, insects, sewage, and trees is very rare and general cleanliness is very good.
- Intermediate: availability of some pollution causes such as animals, insects, and sewage, and general cleanliness is good.
- Bad: availability of animals or insects or sewage or all of them, and the general cleanliness is very bad.

It may be noted from the table that the cistern environment has big effect in the contamination of water with total and Echreachia coliforms. In case of good environment, the contamination is less and vice versa, the contamination is more in bad environment. Percentage of coliforms contamination in good environments ranges between 0-20%, and in bad environment the percentage contamination reaches to a round 50%. So, to have safe and good quality of water to drink the cistern environment should be very clean.

The method of collecting water has less effect in the contamination of cistern water by coliforms. When the roof is the only catchments, the contamination is low (24.0%) and when the catchments include area around the cistern the percentage of contamination is slightly high (43.0%).

3. Roof Tanks

Using roof tanks of sizes from ١to 2 cubic meters is a common practice in all houses in the Hebron city without exception. Most of these tanks are not monitored. Some times these tanks are not covered and exposed to the open air and pollutants may enter. A regular maintenance and flushing or cleaning program is not common in most houses.

4. Effect of Storage

Water may be stored in either open or a covered reservoir. The former is seldom used for the storage of waters or of ground waters to be stored above ground.Some of the effects of the storage of water in an open reservoir may be as follows:

1. The temperature of the water may be changed to cool, if storage is deep; or warm, if water is near the surface in hot weather.
2. Turbidity is reduced.
3. Odor may be increased.

4. Bacteria may be reduced by sedimentation and other causes if pollution is not added to the reservoir.
5. Dissolved carbon dioxide and oxygen may be increased.
6. The water may become contaminated.
7. Microorganisms may grow in the water.

Growths of microorganisms in treated water or in ground water stored in an open reservoir may be due to the favorable environment, where food is available and predatory organisms are absent.

The covering of a reservoir used for the storage of treated water is desirable to prevent pollution from the air above the storage basin, but the absence of light caused by the cover may encourage the growth of fungi and other heliophobic organisms [6].

5. Other Factors:

There are also many factors effecting water quality such as pipe materials, roofing materials, method of obtaining water, tank materials, the cleaning of the roofs cisterns, and tanks.

4.6 Drinking Water Quality Evaluation

Water is used for many purposes such as drinking, domestic water supply, irrigation, and industrial. Water quality standards are not same for all uses. The suitability of water for irrigation is not same for domestic uses and vice versa, In order to evaluate the suitability of water for different purposes, the World Health Organization (WHO) has laid down international standards for different uses. Some countries put their national standards. The WHO standards of quality of water for domestic and drinking purposes and for constituents tested are given in Table (4.1).

Of course, water required for drinking and domestic uses must be colorless, odorless and tasteless. It should be of high quality biologically and chemically for protection against diseases. The questionnaire prepared for the purpose of the study has a question regarding water use in order to evaluate household water in the Hebron city. The discussion of the evaluation water quality in term of chemical and biological characteristics and for domestic and drinking use are given below.

The chemical constituents analyzed included pH value, electric conductance, total dissolved solid, total hardness, major cation, and major anions. The discussion of results is explained in the previous sections. The analysis revealed that none of these parameters exceeded WHO standards with the exception of some high values to some parameters such as total hardness due to different reasons. This means that the household water is of high quality and very suitable from chemical side for drinking and domestic purposes.

Biologically analysis revealed that only 28 % of 100 drinking water samples are contaminated by total coliform and did not meet WHO standards (Figure 4.1), and 22% of 100 drinking water sampled contaminated by Escherichia coliform and did not meet WHO standards (Figure 4.2). The availability of contaminated water samples that used for drinking purpose is dangerous matter because contaminated water by pathogens causes numerous water borne diseases such as typhoid, dysentery, etc. Even this it was still concluded that the water in the Hebron city in general, is of good quality. Since, generally the contamination was slight and the situation can be improved by taking care with the cleanliness of water source environment.

Chapter 5

CONCLUSIONS

CHAPTER FIVE
CONCLUSIONS

The present project deals with the study of physical, chemical, and biological characteristics of drinking water in the Hebron city. The biological and chemical tests for 100 samples collected from different houses were done during the phases of the project. The main conclusions drawn from the results are summarized below:

1. Generally speaking, the water in the Hebron city is of good quality, and meets with WHO standards for drinking and domestic uses.
2. The physical characteristics results show that most of the water samples are without color, odor or taste, but some samples have one or all of these features.
3. The study reveals that the concentration of major chemical constituents is well within the prescribed limits of WHO, except in few cases where the values of some parameters are comparatively high, and some values are very low.
4. The results show that 28% of the samples tested are contaminated by total coliform, and 22% of the samples are contaminated by Escherichia coliform. This means that around one thirty of samples collected and tested are contaminated by coliform.
5. The availability of contaminated water samples used for drinking purpose is dangerous matter because contaminated water by pathogens causes numerous water diseases such as typhoid, dysentery, etc. Even it was still concluded that the water in the Hebron city in general, is of good quality.
6. The contamination is comparatively low and the situation can be improved by taking care with the cleanliness, of water source environment.

LIST OF FIGURES

LIST OF TABLES

Table (A.1)

Questionnaire

"Evaluation of Water Quality in the Hebron City"

A) Water Sample (House):

1. Sample Number: ....
2. Area (Address): ....
3. Sample Point: ....
4. Sample Date: ....
5. Physical properties:

○ Color ○ Taste ○ Odor

○ Water Temperature: ....˚C.

B) Information about Each House:

1. Type of house:

○ Villa ○ Apartment

○ Traditional ○ Others

2. Method of obtaining water:

○ Connected to public network ○ Cisterns

○ By tankers ○ Other, specify ....

3. Disposal method of wastewater:

○ Connected to sewage system ○ Cesspits

○ Vacuum tankers ○ Other, specify ....

4. House Roofing materials:

○ Sheet metal ○ Cement / concrete

○ Clay tiles ○ Other, specify ....

5. House Environment:

○ Very Clean ○ Clean

○ Bad

C) Water Cistern:

1. Cistern Volume: ....m^3.
2. Cistern Age (Date of Construction): ....Year/s.
3. Type of Cistern Used in Your House:

○ Pear Shape Cistern Excavated in Rock.

○ Concrete Cistern Designed With Circular Plane.

○ Concrete Cistern Designed With Rectangular or Square Plane.

○ Other, Specify: ....

4. Cistern Place:

○ Inside ○ Outside

5. Source of Cistern Water:

○ Rain ○ Municipal

○ Spring ○ Mix (Rain &Municipal)

6. Method of Collecting Water:

○ Roof ○ Roof and Area Round the Cistern

7. Do You Clean The Roof Before The First Rainfall (First Flush Mechanism):

○ Yes ○ No

8. Cistern Water Use:

○ Domestic & Drinking ○ Domestic

○ Animal Watering ○ Irrigation

9. Cistern Environment (Availability of):

○ Animals ○ Insects

○ Sewage ○ Trees

○ Nothing

10. The Distance between Cistern and Cesspits: .... m.

11. All Cistern Should Include Different Features, Which of The Following is Include in Your Cistern?

○ A Solid Secure Cover.

○ A Coarse Inlet Filter.

○ An Over Flow Pipe.

○ An Extraction System (Tap, Pump, Bucket).

12. The Cleaning of Cistern is Done:

○ Once a Year. ○ Every Tow Years.

○ Every Three Years. ○ Every Four Years or More.

C) Water Reservoir:

1. Reservoir Volume: .... m^3.
2. Reservoir materials:

○ Sheet metal ○ Cement / concrete

○ PVC ○ Others

3. Is the Reservoir covered?

○ Yes ○ No

4. The cleaning of the Reservoir is done:

   ○ Once a year. ○ Every two years.

   ○ Every three years. ○ Four years or more.

   How ....

5. Reservoir Environment (Availability of):

   ○ Very Clean ○ Clean

   ○ Bad

D) General Question:

1. What is The Percentage of Rainwater from the Water Consumption? .... %.
2. Do you test The Quality of Cistern Rainwater?

   ○ Yes ○ No

3. Do you Disinfect the Collecting Rainwater?

   ○ Yes ○ No

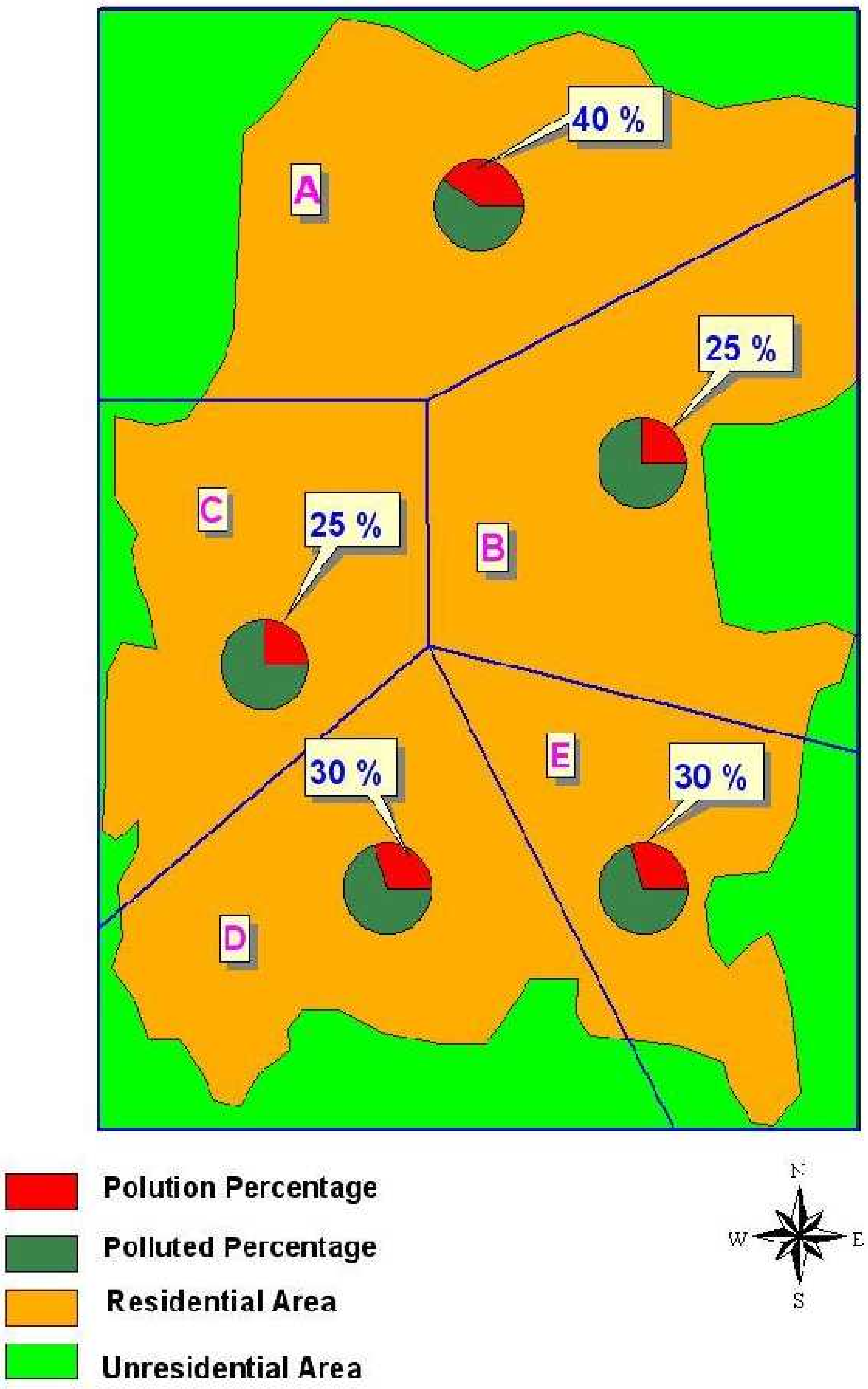
4. Disinfect Method? And How Many Done in the Year?

   .... , ...

REFERENCES

REFERENCES

Hebron Percentage Water Quality Pollution



بسم الله الرحمن الرحيم

آلية فحص المياه

اعـداد

م. مهـنـد نصـــار

جامعة بوليتكنك فلسطين

وحدة ابحاث الطاقة البديلة والبيئة

مشروع التوعية البيئية

آذار ٢٠٠٤

الادوات والمواد المستخدمة في المختبر(وحدة ابحاث الطاقة البديلة والبيئة).

المواد :

- ماء مقطر .
- ايثيل الكحول بنسبة تركيز **95**% (**Ethyl AL Cohol USP 95%**).
- صوديوم ثيو سلفييت (**$Na_2S_2O_3$**).
- مادة خاصة تنمو عليها البكتيريا وتتكاثر (**m Endo Agar LES**).

الأدوات :

- حاضنة ، يمكن معايرتها حسب درجة الحرارة اللازمة .
- مصدر لهب طبيعي .
- جهاز فاكيوم .
- وعاء زجاجي يتحمل حرارة عالية مع حامل.
- قمع بوخنر .
- حامل مع قاعدة.
- فلتر قطره (**47**) ملم ذو مسامات قطرها **0.45** ميكرو متر(**10^{-6}** متر) وهو مقسم الى اجزاء لتسهيل عملية قراءة عدد المستعمرات البكتيرية .
- ميزان الكتروني دقته **(0.1)**غم.

اولا: مرحلة تعقيم زجاجات الماء

١. جمع الزجاجات و تنظيفها وأغطيتها المعدنية في الماء .

٢. وضع الزجاجات والأغطية المعدنية داخل الفرن تحت درجة حرارة° **120** درجة مئوية لمدة **5** ساعات بحيث توضع بشكل عمودي وبدون غطاء (الأغطية على حدى).

٣. إطفاء الفرن وتبريد الزجاجات من أجل اضافة مادة ثيوكبريتات الصوديوم ($Na_2S_2O_3$) ومن ثم اغلاق الزجاجات بالاغطية المعدنية .

٤. وضع الزجاجات في الفرن وتشغيله مرة أخرى على درجة حرارة **°120** لمدة **5** ساعات .

٥. ايقاف الفرن عن التشغيل وتشغيل مروحه لتبريد الزجاجات حيث يتم وضع ملصق خاص على كل زجاجة وذلك لكتابة اسم صاحب العينة ومصدرها وتاريخها .

ثانيا: مرحلة جمع عينات الماء

١. فتح الزجاجات المعقمة فقط قبل ملئها بالماء مباشرة وفتح الحنفية لمدة **10** ثواني ومن ثم تعبئة الزجاجات بالماء .

٢. اغلاق الزجاجات ورجها لإذابة مادة ثيوكبريتات الصوديوم ($Na_2S_2O_3$) التي تعمل على اختزال الكلور الموجود في الماء والذي يقضي على البكتيريا وبالتالي تحويله الى ملح.

٣. احضار عينة الماء المراد فحصها إلى المختبر (**وحدة ابحاث الطاقة البديلة والبيئة) خلال** ساعتين من لحظة ملئها بالماء .

٤. اذا كانت المسافة طويلة وتحتاج العينة الى زمن اكثر من ساعتين قبل احضارها الى وحدة الطاقة يجب حفظها في حيز بارد لحين ايصالها.

ثالثا : **مرحلة تحضيير المادة الخاصة لزراعة البكتيريا**

خطوات تحضير الخليط (يحضر حسب الحاجه وبالنسب التالية)

١. نحضرالوعاء الزجاجي ونضع فيه(**51** غم) من مادة **(m Endo Agar lES)** ثم نضيف **(1** لتر) من الماء المقطر الذي يحتوي على **(20** مللتـــر) مـــن ايثيـــل الكحـــول (تركيزه **95%)** .

٢. نحرك الخليط باستمرار مع تسخينه حتى درجة الغليان بحيث تذوب جميع الماده في الماء ويصبح لونها بنفسجيا .

٣. نترك الخليط في وعاء التسخين (الوعاء الزجاجي) حتى تنخفض درجة حرارته قليلا .

٤. نسكب الخليط في أوعية بلاستيكية صغيرة حتى يتحول من سائل الى جل جامد .

رابعا : مرحلة الفلتره

تتم هذه العملية بوجود لهب في المنطقة بهدف التعقيم .

١. نضع الفلتر في قمع بوخنر.

٢. نرج الزجاجة التي تحتوي على الماء المراد فحصه .

٣. نفتح الزجاجة و نسكب ما مقداره **10** سم^{3} من الماء في قمع بوخنر.

٤. نشغل مضخة الفاكيوم لسحب الماء من خلال الفلتر واثناء مروره من خلال الفلتـــر تعلـــق البكتيريا والشوائب في مساماته.

٥. بواسطة حامل خاص (ملقط) معقم نمسك الفلتر ونضعه في الأوعيه البلاستيكيه فوق مـــادة الجل .

٦. نسجل اسم وتاريخ ومصدر العينة على العلبه البلاستيكية وليس على الغطاء .

٧. نغطي هذه الأوعية ونضعها في الحاضنة .

خامسا : مرحلة زراعة البكتيريا

١. للحصول على درجة الحراره المطلوبه يتم تشغيل الحاضنه قبل نصف ساعه على الأقل.

٢. لاجراء فحص لنوع معين من انواع البكتيريا نقوم بمعايرة الحاضنه على درجة الحـــراره التي يعيش عليها هذا النوع من البكتيريا .

فمثلا الكولونيات الكلية (البكتيريا الطبيعية) تعيش على درجة حراره **37 o** ولا تعيش على درجة حراره **42 o** اماالبكتيريا الاشريكية الكولونية(مصدرها من المجاري) فهي تعيش على**37 o** و على**42 o** وهكذا.

٣. تتكاثر البكتيريا الى الضعف في كل **(20)** دقيقة ولا تظهر الا بعد **(18 – 24)** ساعه مـــن زراعتها حيث تظهر على شكل نقط صغيره ملونه تسمى مستعمرات بكتيريه .

٤. كل لون من ألوان المستعمرات يدل على نوع البكتيريا الموجوده في الماء.

فمثلا اللون الأبيض أو الأبيض مع قليل من الزرقه يدل على الكولونيات الكلية (البكتيريا الطبيعية) أما اللون الفضي فيدل على البكتيريا الاشريكية الكولونيـــة (مصـــدرها مـــن المجاري).

سادسا :مرحلة عد المستعمرات البكتيرية

١. نخرج العينات من الحاضنة ونعد المستعمرات البكتيرية الموجودة على الفلتر ويتم تصنيفها حسب اللون كما ذكر سابقا.

٢. الماء الصالح للشرب يجب ان لايحتوي على اي نوع من انواع البكتيريـــا ولكـــن يســـمح عالميا بوجود **4** مستعمرات بكتيرية في العينة كحد اقصى.

سابعا :مرحلة المعالجة

أ- في حالة الكشف عن الكولونيات الكلية.

تتم عملية المعالجة عن طريق اضافة مادة الكلور الى المياه وذلك بعدة طرق:-

١. اضافة الكلور (السائل والغازي) : يتم في محطات خاصه في شبكة المياه من قبل البلديات وسلطة المياه.

٢. اضافة الكلور (الصلب) : يتم ذلك بعد طحنه واذابته في وعاء ماء، ثم يضاف الى الخزان او البئر ويحرك جيدا ويمنع الشرب منه الا بعد مرور **24** ساعة .

ب- اما الماءالذي يحتوي على الكولونيات الاشريكية، فيجب التخلص منه ومعالجة مصدر التلوث البكتيري.

APPENDIX – A

QUESTIONNAIRE AND DATA COLLECTION

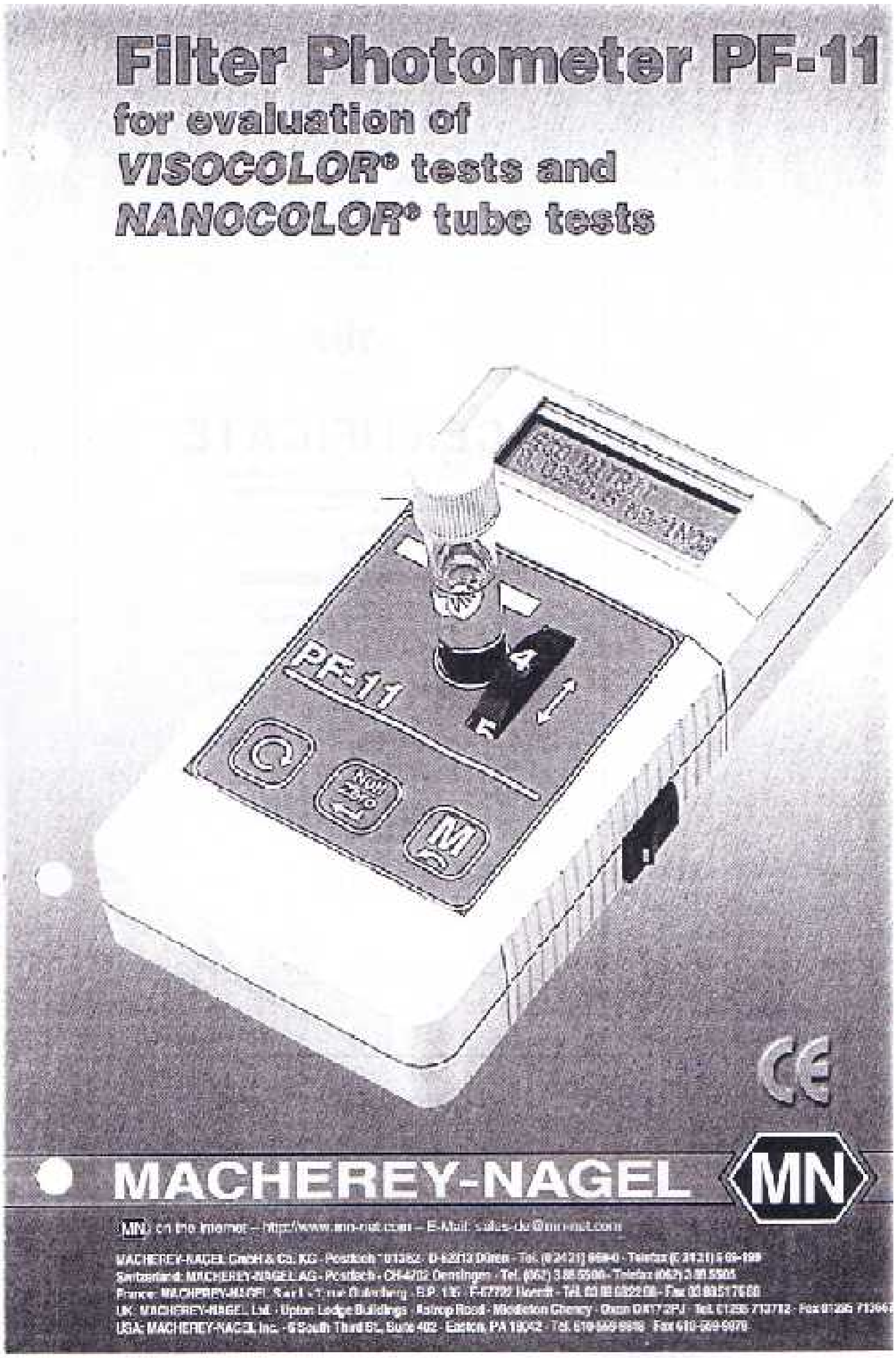
APPENDIX – B

CHEMICAL ANALYSIS

PROCEDURES

APPENDIX B

Chemical Analysis



1. **pH Value (4.0 – 10.0):**

A. **Method:**

Depending on the pH value, a mixture of indicator dyes shows characteristic colors.

B. **Procedure:**

a) Rinse test tube 14 mm ID several times with sample and fill up to the ring mark (10 ml).

b) Add **4 drops pH 4 -10**, close and shake test tube.

c) Compare the color of the sample with the corresponding color or the color scale, read off pH value. Intermediate values can be estimated.

2. **Oxygen:**

Procedure:

Dissolved oxygen in alkaline solution oxidizes manganese (ll) ions to higher-valent manganese hydroxides. Acidification leads to the release of manganese (IlI) ions which react with a special reagent forming a dark red dye.

Ranges: 1 —10 mg/l 02 ECO OXYGEN

Requisite accessory: oxygen baffle

Protect your workbench from spills.

1. Rinse oxygen bottle several times with the water to be analyzed, then fill the bottle to the brim (avoid air bubbles).

2. Add 5 drops O_2 - 1.

3. Add 5 drops O_2 – 2, close bottle with the tapered glass stopper (without any air bubble!) and mix.

4. After 1 mm, add 12 drops O_2 –3, close and shake the bottle, until the precipitate has dissolved.

5. Pour about 5 ml of the solution thus obtained into a test tube 4mm ID

Reaction time: -measure immediately

Measurement: Select method EGO OXYGEN

Perform measurement.

Interferences: Most oxidizing and reducing substances interfere, e.g. active chlorine, higher-valent mangenese compounds, ascorbic acid, iodide,

Nitrite, sulphide and sulphite. Organic compounds interfere, if the potassium permanganate consumption is above 60 mg/l.

3. **Potassium:**

Procedure:

Potassium ions react with sodium tetraphenylborate ($Na[B(C_6H_5)_4]$ To form a white precipitate, which allows a subsequent photometric determination of turbidiy.

Range: 2—15mg/I K ECO POTASSIUM

Procedure:

1. Rinse test tube 14 mm ID several times with sample and fill up to the ring mark (10 ml).

2. Add 15 drops Potassium -1 close and shake test tube.

3. Add 1 measuring spoon Potassium - 2, close test tube and shake evenly about 30 s until the powdered reagent is completely dissolved. The test mixture becomes more or less turbid.

Reaction time: measure immediately

Measurement: - Select method ECO POTASSIUM

Perform measurement.

Conversion factor: mg/I K x 1.2 = mg/I K_2O.

The method can not be applied for the analysis of sea water.

Interferences: Turbidities interfere; turbid test samples have to be filtered prior to the analysis (e.g. with the membrane filtration kit 0.45 µm.

4. **Chloride:**

Procedure:

Chloride ions react with mercuric thiocyanate to produce undissociated mercuric chloride and to liberate thiocyanate ions. In the presence of ferric salts these thiocyanate ions produce a characteristic orange colour.

Range: 1 – 40 mg/l Cl^- ECO CHLORIDE

Procedure:

1. Rinse test tube 14 mm ID several times with sample and fill with 5 ml sample.

2. Add 10 drops Cl-1 and mix.

3. Add 10 drops Cl-2 and mix.

Reaction time: 1 min

Measurement: Select method ECO CHLORIDE

Perform measurement

The method cannot be applied for the analysis of sea water.

Interferences: Bromide, cyanide, iodide, thiocyanate and thiosulphate all interfere since they react in the same way as chloride. Fluoride interferes in excess of 20 mg/I and causes false negative results.

Extinction table: The determination of chloride can be carried out by extinction measurement, if the method ECO CHLORIDE is not programmed.

E	mg/l Cl^-	E	mg/l Cl^-
0.045	1	0.201	9
0.069	2	0.215	10
0.092	3	0.273	11
0.113	4	0.314	12
0.132	5	0.342	13
0.151	6	0.365	14
0.169	7	0.387	15
0.185	8	0.414	16

5. **Chlorine:**

Procedure:

At a pH value between 5 and 6 free chlorine reacts with N, N-diethyl-1, 4 phenylene diamine (DPD) to form a red dye. In the presence of iodide ions also the total chlorine (sum of free and bound chlorine) can be determined.

Range: 0.1 —2.0 mg/l Cl_2 (free) ECO CHLORINE free

0.1 —2.0 mg/l Cl_2 (total) ECO CHLORINE total

Procedure:

Free Chlorine

1. Add 3 drops $C1_2$ -1 into a test tube 14mm ID.

2. Add 3 drops $C1_2$ -2.

3. Add 5 ml sample, close and shake test tube.

Reaction time: measure immediately

Measurement: Select method ECO CHLORINE free

Perform measurement

Total Chlorine

4. Open test tube again and add 3 drops $C1_2$ -3, close and shake test tube.

Reaction time: 2 min.

Measurement: Select method ECO CHLORINE total.

Perform measurement.

The bound chlorine is the difference between free and total chlorine.

Both methods can be applied for the analysis of seawater.

Interferences: Bromine, bromamines, iodine and to some extent chlorine dioxide contents are also included in the results of the determination of free - chlorine (1.0 mg/I Cl_2 = 2.3 mg/I Br_2 = 3.6 mg/I 1_2). Higher valency manganese compounds simulate free chlorine.

Chlorine concentrations above 10 mg/l may bleach the reaction colour and may cause lower results (false negative results).

Residues of reagent Cl_2 - 3 remaining in the test tube may cause higher results (false positive results). Rinse test tubes thoroughly with water after use.

6. **Nitrate:**

Procedure:

In acidic medium, nitrate ions are reduced to nitrite ions. These nitrite ions react with a suitable amine to form an orange-rod azo-dye.

4 – 120 mg/l NO_3^- ECO NITRATE

1 - 27 mg/l NO_3 - N

Procedure:

1. Rinse test tube 14mm ID several times with sample and fill with 5 ml sample.

2. Add 5 drops NO_3 - 1 and shake test tube.

3. Add 1 level measuring spoon NO_3 – 2,close test tube and shake vigorously for 1 mm.

Reaction time: 5 min

Measurement: Select method ECO NITRATE with range NO_3 or NO_3-N

Perform measurement.

The method can be applied for the analysis of sea water.

Interferences: Oxidising substances such as e.g. chlorine can cause low results or even completely inhibit the reaction depending on concentration.

7. **Nitrite:**

Procedure:

In acidic medium, nitrite ions react with sulfarilic acid and 1-naphthylamine to form a red azo-dye.

Ranges: 0.02 - 050 mg/l NO_2^- ECO NITRITE

0.01 - 015 mg/I NO_2 - N

Procedure:

1. Rinse test tube 14 mm ID several times with sample and fill with 5ml sample.

2. Add 4 drops NO_2 - 1 close test tube and rnix.

3. Add 1 level measuring spoon NO_2 – 2, close test tube and shake until the powder has dissolved.

Reaction time: 10 min

Measurement: Select method ECO NITRITE with range NO_2 or NO_2 -N

Perform measurement.

The method can be applied for the analysis of sea water.

Interferences: Chrornium (VI) and iron (III) ions in excess of 3 mg/l simulate higher nitrite results.

Chlorine interferes even in lowest concentrations.

8. **Ammonium:**

Procedure:

At an alkaline pH value ammonium ions react with chlorine to form monochloroamine. This forms a blue indophenol dye with thymol.

Ranges: 0.1 - 1.5 mg/l NH_4^+ ECO AMMONIUM

0.1 - 1.2 mg/I NH_4- N

0.1 - 1.5 mg/I NH_3

Procedure:

1. Rinse test tube 14 mm ID several times with sample and fill with 5 ml sample.

2. Add 10 drops NH_4 - 1 and mix.

3. Add 1 level measuring spoon NH_4 – 2, close and shake test tube, until the powder has dissolved. Wait for 5 minutes.

4. Add 4 drops NH_4 – 3, close and shake test tube.

Reaction time: 7 min.

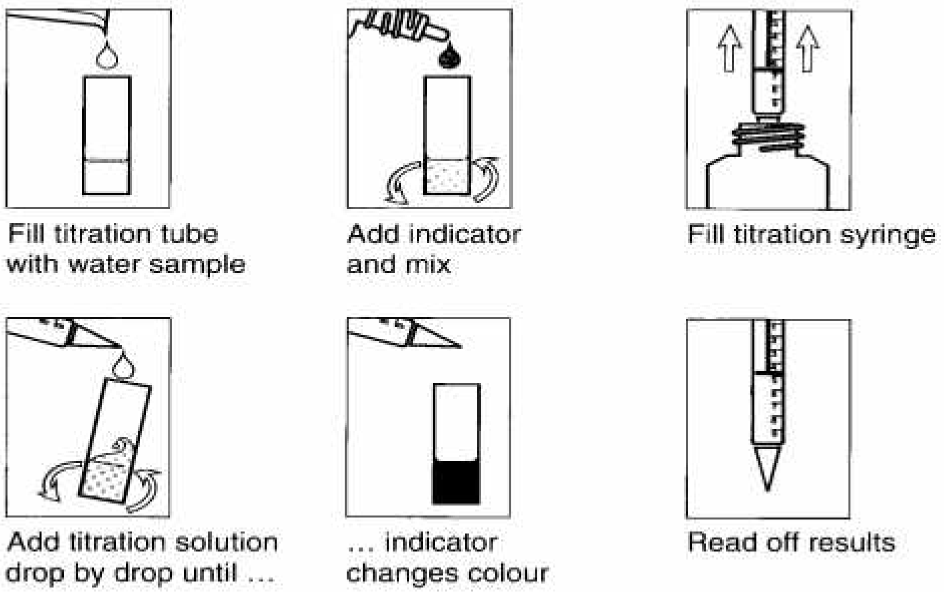
Measurement: Select method ECO AMMONIIJM with range NH4, NH4 -N or NH_3 Perform measurement.

The method can be applied also for the analysis of sea water after dilution (1:10).

Interferences: Primary amines react like ammonium ions and cause higher results.

Chlorine-consuming reagents cause lower ammonium values or even inhibit the reaction.

2. Titrimetric procedures



9. **Hardness:**

Procedure:

For the determination of total hardness of water:

a) Rinse test lube several times with the test sample and fill to ring mark.

b) Add **2 drops of indicator H 20/H 2** and shake. The test sample turns red. If sample turns green, no hardness is present (0 °d).

c) Put dropping tip onto the titration syringe (H 20: blue and black scale, H 2:orange and black scale), press down plunger, dip the tip into the titration solution TL H 20/H 2 and draw up plunger slowly, until the lower rim of the black plunger O-ring is lever with value 0 on the barrel scale. The small air pocket below the plunger tip doesn't disturb the determination.

d) Addition of the titration solution: We recommend taking the syringe in the left hand and the test tube in the right hand (see sketch) and adding titration solution dropwise while smoothly shaking the test tube. As soon as the red color turns lighter, drop more slowly until the solution turns completely green.

Read off total hardness in °d or mmol/l from the syringe barrel (lower rim of the plunger 0-ring). Color change is followed easily when holding test tube before a light background (e.g. sheet of white paper).

e) if the first syringe filling isn't enough to reach color change (hardness >20 (2) °d), fill syringe once more with solution TL H 20/H 2 and titrate to color change (as above). Read off total hardness as described before and add 20 (2) °d for each used syringe filling.

This method H 20 F can be applied so for the analysis of sea water after dilution (1:30).

10. **Calcium:**

For the determination of calcium hardness of water

1. Rinse test tube several times with the test sample and fill to ring mark.
2. Add **2 drops of sodium hydroxide solution 10 %** and shake. Test sample can get turbid.
3. Add **2 drops of indicator CA 20 and shake**. The test sample turns red. If sample turns blue, no calcium is present (0 °d).
4. Put dropping tip onto the titration syringe (blue and black scale), press down plunger, dip the tip into the titration solution TL CA 20 and draw up plunger slowly, until the lower rim of the black plunger 0-ring is level with value 0 on the barrel scale. The small air pocket below the plunger tip doesn't disturb the determination.
5. **Addition of the titration solution**: We recommend taking the syringe in the left hand and the test tube in the right hand (see page 47) and adding titration solution dropwise while gently shaking the test tube. As soon as the red colour turns lighter, drop more slowly until the solution turns completely **blue**.

   If the test solution turns grey after 15 - 30 s, add dropwise titration solution TL CA 20 until colour turns blue again.

   Read off calcium hardness in °d or mmol/l from the syringe barrel (lower rim of the black plunger 0-ring). Colour change is observed easily when holding test tube before a light background (e.g. sheet of white paper).
6. If the first syringe filling is not sufficient to reach colour change (calcium > 3.6 mmol/l), fill syringe once more with solution TL CA 20 and titrate to Colour

change (as above). Read off calcium hardness as described before and add 3.6 mmol/l for each used syringe filling.

This method can be applied also for the analysis of sea water after dilution (1: 5) and using 6 drops of sodium hydroxide solution 10%.

Note:

The magnesium content can be determined as the difference between total and calcium hardness.

11. **Carbonate:**

Prior to determination of carbonate alkalinity of a water sample the p and m value have to be determined. The determination of these values is made one after the other by titration.

1. Rinse test tube several times with the test sample and fill to ring mark.
2. **Determination of p value (p alkalinity):**

   Add **1 drop of indicator p** and distribute by shaking. If test sample remains colorless, the p value is 0. If test sample turns **red**, proceed as follows:
3. Put dropping tip onto the titration syringe (green and blue scale), press down plunger, dip the tip into the titration solution TL C 20 and draw up plunger slowly, until the lower rim of the black plunger 0-ring is level with value 0 on the barrel scale. The small air pocket below the plunger tip doesn't disturb the determination.
4. **Addition of the titration solution:** We recommend taking the syringe in the left hand and the test tube in the right hand (see page 47) and adding titration solution dropwise while gently shaking the test tube. As soon as the red colour vanishes completely, read off p value from the syringe barrel (lower rim of the black plunger 0-ring) and write down.
5. **Determination of m value (m alkalinity):**

   Add to the water sample in the test tube **1 drop of indicator** m and distribute by shaking. If the water turns **red**, the m value is identical with the p value. If the water turns **blue**, determine the m value as follows:

6. Continue titrating with the same syringe filling as used for determination of the p value (step 4), until the colour turns red. Read off the m value from the syringe barrel (lower rim of the black plunger 0-ring) and write down. After addition of a further drop titration solution the colour should not change.

   If the 1st syringe filling is not sufficient to reach colour change, fill up the syringe once more with solution TL C 20 and titrate to colour change as described before. Add the additional used syringe content to the value written down.

APPENDIX – C

BIOLOGICAL ANALYSIS PROCEDURES

APPENDIX – D

CHEMICAL RESULTS

APPENDIX – F

BIOLOGICAL RESULTS

APPENDIX – E

CHEMICAL RESULTS

APPENDIX – D

WATER TESTING PHOTOGRAPHS

APPENDIX D

Water Testing Photographs

هذه الصورة تبين الجهاز تم استخدامه في الفحص البيولوجي .

هذه الصورة تبين الاوعية البلاستيكية المعدة للفحص مع الفلاتر .

هاتان الصورتان تبينان عملية تحضير العينة لوضعها في الحاضنة.

نلاحظ من هاتان الصورتان كيفية وضع العينات في الحاضنة.

هذه الصورة تظهر العينات بعد إخراجها من الحاضنة حيث مكثت فيها ٢٤ ساعة.

هذه الصورة تظهر العينات الملوثة والغير ملوثة بالملوثات البيولوجية.

هذه الصورة تبين إحدى العينات التي لا تحتوي على أي ملوثات بيولوجية.

هذه الصورة تبين إحدى العينات التي تحتوي على بكتيريا القولونيات الكلية.

هذه الصورة تبين إحدى العينات التي تحتوي على بكتيريا الإشريكية القولونية.

REFERENCES

1. Abed Rabbo, Alfred and others, "Springs in the West Bank", Bethlehem University, PHG, UNUT, 1999.

2. Abu Sharkh, M. and Subuh, Y., "Cisterns Water Quality in South of the West Bank", Department of Research and Development, U.G.U, Hebron, West Bank, Palestine, 1994.

3. Ali,W., Hotzl, H., and Wolfer,J., "A Hydrogeological Study Along Wadi El Qilt Between Jerusalem and Jericho, West Bank", Water and Environment Scientific Journal, Palestinian Hydrology Group, West Bank, Palestine, Issues December, 1999.

4. American Water Works Association, Inc., "Water Quality and Treatment", Third Edition, Mcgraw-Hill, 1971.

5. Arabtech Jardaneh/Babel, "Master Plan Study for Hebron City Water Supply and Distribution" , Final Report , Hebron , West Bank , Palestine, 1999.

6. Babbitt, Harold E. and others, "Water Supply Engineering", Sixth Edition, McGraw-Hill Book Company, Inc., New York, U.S.A, 1962.

7. Ciaccio Leonard, "Water and Water Pollution Hand Book", Marcel Dekker, Inc, 1998.

8. El-Mahallawi, Khamis M., "Assessment and Improvement of Drinking Water Quality in the Gaza Strip", Water and Environment Scientific Journal, Palestinian Hydrology Group, West Bank, Palestine, Issues June, 2000.

9. Garg,S.K.," Hydrology and Water Resources Engineering", Seven Edition, Khanna Publishers,1987.

10. Garg,S.K., "Water Supply Engineering", Tenth Edition, Khanna Publishers, Delhi, India, 1998.

11. Hadad, M. and Al-Hamidi," Introduction to Water Quality", Nablus, West Bank, 1991.

12. Hammer, Mark J.,"Water and Waste-Water Technology", John Wiley and Sons, Inc., U.S.A, 1977.

13. Sharma, R.K., "Hydrology and Water Resources", Third Edition, Dhanpat Rai and Sons, Delhi, India, 1990.

14. Warren, Viessman Jr. and Hammer, Mark J.," Water Supply and Pollution Control", Fourth Edition, Harper and Row, Publishers, Inc., New York, U.S.A., 1985.

15. World Health Organization, "Guideline for Drinking Water Quality",Vol.3, 4WHO,Geneva,1985..