

ASSESSMENT OF GROUNDWATER QUALITY IN SIRTE CITY

Submitted By

Aisha Farag Rahel Amhamed

B.Sc. of Science (Biology), Faculty of Science, Sirte University, Libya, 2001

A thesis Submitted For Partial Fulfillment
Of
The Requirement for the the Master Degree
In
Environmental Science

Department of Environmental Basic Science
Institute of Environmental Studies& Research
Ain Shams University

2015

APPROVAL SHEET

ASSESSMENT OF GROUNDWATER QUALITY IN SIRTE CITY

Submitted By

Aisha Farag Rahel Amhamed

B.Sc. of Science (Biology), Faculty of Science, Sirte University, Libya, 2001

This Thesis Towards a Master Degree In Environmental
Science Has Been Approved by:

Name

signature

1. Prof. Dr. Salah Abd El-Ghany Abo El-Enein

Prof. of Physical Chemistry
Faculty of Science
AinShams University

2. Prof. Dr. Ezzat Aly Qorany

Prof. of Hydrogeology
Faculty of Science
AinShams University

3. Prof. Mohamed Ghareb El.Malky

Prof. of Environmental Geophysics Department of Environmental
Basic Sciences – Institute of Environmental Studies and Research
AinShamsUniversity

4. Prof. Maha Moustafa El- Shafei

Prof. of Sanitary and Environmental Engineering
Housing and Building National, Research Center.

2015

ASSESSMENT OF GROUNDWATER QUALITY IN SIRTE CITY

Submitted By
Aisha Farag Rahel Amhamed

B.Sc. of Science (Biology), Faculty of Science, Sirte University, Libya, 2001

A Thesis Submitted For Partial Fulfillment
Of
The Requirement for the The Master Degree
In
Environmental Sciences
Department of Environmental Basic Sciences

Under The Supervision of:

1. Prof. Mohamed Ghareb El.Malky

Prof. of Environmental Geophysics Department of Environmental
Basic Sciences – Institute of Environmental Studies and Research
AinShamsUniversity

2. D. Adeson Carabet Nezar

Assistant.Prof. of Chemistry, Head of Biochemistry Department,
Faculty of Medicine, Sirt University

3. Prof. Maha Moustafa El- Shafei

Prof. of Sanitary and Environmental Engineering
Housing and Building National, Research Center.

2015

ACKNOWLEDGEMENT

Thanks to Al-Mighty God for All the gracious graces including science he grants us.

All thanks and appreciation to my supervisors: ***Prof. Dr. Mohamed Ghareeb Al-Maleky***, Professor of Geophysics - Institute of Environmental Studies & Research, Ain Shams University for his sustenance and encouraging me, presenting me generously all scientific assistance.

Thanks also to ***Prof. Dr. Maha Moustafa El-Shafei***, Professor of Sanitary and Environmental Engineering Institute, Housing and Building National Research Center for her continuous helpful instruction, scientific support, and encouragement, particularly in theoretical and practical parts.

All thanks and appreciation to ***Dr. Hassan Garamoon***, Assistant Prof. of Hydrogeology, Department of Geology, Faculty of Science, Ain Shams University, to great support, important guidance, continuous encouragement, unlimited help and great efforts he presented to achieve this research project.

All thanks and appreciation to ***Prof. Dr. Mostafa Mohamed Hassan Khalil***, Professor of Inorganic Chemistry, Chemistry Dept., Faculty of Science, Ain Shams University, for all his help, encouragement, valuable discussions, constructive criticisms and helpful suggestions

I am also very much indebted to thank ***Dr. Ahmed Gad***, lecturer of geology, Department of Geology, Faculty of Science, Ain Shams University, for all his help, encouragement, valuable discussions, constructive criticisms and helpful suggestions.

.Finally, all great gratitude to my dear life companion, my beloved husband for all the support he gave me and the sweet and bitter moments he shared with me.

ABSTRACT

Sirte is a city that lies on the coast of the Mediterranean Sea being overwhelmed by the arid or the semi-arid climate. Across the extension of this city, there are several valleys descending from south to the north to be pouring into marshes across the long coast

The main aims of the present study are to conduct hydrochemical study of the Sirte area, assess the available water resources and to examine water quality and suitability for different uses.

Thirty groundwater samples were collected from Wadi Jarif. The collected samples are subjected to different analyses in order to conduct hydrochemical and bacteriological study of the study area, assess the available water resources and to examine water quality and suitability for different uses.

Chemical analyses have been conducted on those wells samples in terms of determining the concentration of main ions (Chloride Cl^- , potassium K^+ , sodium Na^+ , sulfate SO_4^{2-} , carbonate CO_3^{2-} , bicarbonate HCO_3^- , Silicon Si^{4+} , manganese Mn^{2+} , Barium Ba^{2+} , magnesium Mg^{2+} , calcium Ca^{2+} , nitrate NO_3^- , NH_4^+ , Alkalinity, electrical conductivity, acidity, pH and total dissolved solids TDS) and bacteriological analysis (The total count of coliforms bacteria, Faecal coliforms and Faecal Streptococcus)

Assessment of groundwater of Wadi Jarif for different uses indicates that the groundwater of Wadi Jarif area can be used in irrigation with availability of high permeable soil, good drainage conditions, in choosing a specific crops resist the saline water conditions, and applying modern irrigation techniques. This groundwater can't be used for domestic purposes for its high Total Dissolved Solids (TDS), Total Hardness (TH) and corrosivity ratio (CR).

For drinking, this groundwater are classified as very poor and unsuitable, also, all analyzed samples for bacteriological content classified as contaminated and classified as unsafe too. This groundwater can use for livestock drinking with limitation and can't used for any industrial purposes.

Key words: Libya, Sirte, Wadi Jarif, Hydrogeology, Groundwater quality, Groundwater assessment, chemical analysis, bacteriological analysis.

List of Contents

Title	Page No.
Acknowledgements	i
Abstract	ii
Table of content	iii
List of tables.....	vi
List of figures.....	ix
Chapter 1: Introduction and Literature Review	1
1.1 Preface.....	1
1.2 Location of Study Area	3
1.3 Aim and Objectives	4
1.4 Water Resources in Libya	5
1.4.1 Surface Water	5
1.4.2 Groundwater	5
1.4.3 Non-conventional water resources	7
1.5 Climate in Sirte	8
1.5.1 Temperature and Humidity	8
1.5.2 Precipitation and Evaporation	10
1.6 Geology.....	12
1.6.1 Stratigraphy.....	12
1.6.2 Structures and structural units	21
1.7 Hydrogeology.....	22
1.7.1 Aquifers	22
1.8 Review of previous studies	23
1.8.1 Previous Hydrogeological Studies.....	23
1.8.2 Previous Hydrogeochemical Studies.....	25
1.8.3 Previous Biological Characteristics Studies	28
1.8.4 Previous Seawater Intrusion Studies	29

List of Contents

Title	Page No.
Chapter 2: Materials and Methods	31
2.1 Field Sampling	31
2.2 Laboratory Analysis.....	34
2.2.1 Chemical Analysis.....	34
2.2.2 Bacteriological Analysis of Groundwater Samples	37
Chapter 3: Results & discussion Hydrochemistry	37
3.1 Physicochemical characteristion.....	37
3.1.1 Temperature	38
3.1.2 Hydrogen ion concentration(PH).....	40
3.1.3 Electrical conductivity (EC)	40
3.1.4 Total Dissolved Solids (TDS)	41
3.2 Chemical Composition	42
3.2.1 Major Cations	43
3.2.2 Major Anions	49
3.2.3 Trace Elements	54
3.3 Bacteriological Parameters.....	57
3.3.1. Faecal coliforms bacteria	57
3.3.2. The total count of coliforms bacteria.....	57
3.3.3. Faecal streptococcus bacteria	58
Chapter 4: Results & discussion hydrogeochemical facies and hydrochemical processes.....	59
4.1 Hydrogeochemical Facies	59
4.1.1 Groundwater Classification	59
4.1.2 Graphical Representation.....	61
4.2 Hydrochemical processes.....	68
4.2.1 Indicator of Seawater Intrusion (SWI)	68
4.2.2 Scatter Diagrams	69

List of Contents

Title	Page No.
Chapter 5: Results & Discussion Geoenviromental Assessment.....	75
5.1 Assessment of Water Quality	75
5.1.1 Groundwater quality for irrigation purposes.....	75
5.1.2 Groundwater quality for domestic purpose	85
5.1.3 Groundwater quality for drinking	89
5.1.4 Groundwater quality for Livestock (L.) and Poultry (P.)	94
5.1.5 Groundwater quality for industrial purposes	96
Summary and Conclusion	98
Recommendations.....	104
References	105
Arabic summary	

List of Tables

Table No.	Title	Page No.
Table (1.1):	Surface water in Libya.....	6
Table (1.2):	Groundwater in Libya.....	6
Table (1.3):	Lithostratigraphy of the study area.....	13
Table (2.1):	Inventory Data of Groundwater wells, wadi Jarif, Libya.....	33
Table (2.2):	Conditions of Flame atomic absorption spectrophotometer.....	36
Table (3.1):	Physicochemical parameters of the studied groundwater of Wadi Jarif	39
Table (3.2):	Percentage of the studied groundwater samples in each water mineralization.....	41
Table (3.3):	Percentages of the studied groundwater samples in each.....	42
Table (3.4):	Concentrations of major cations of the studied groundwater samples of Wadi Jarif.....	48
Table (3.5):	Concentrations of major anions of the studied groundwater samples of Wadi Jarif.....	53
Table (3.6):	Concentrations of toxic metals (ppm) of the studied groundwater of Wadi Jarif.....	56
Table (3.7):	The total count of coliforms bacteria, faecal coliforms and faecal streptococcus isolated from the studied groundwater samples of Wadi Jarif	58
Table (4.1):	Classification of groundwater.....	60
Table (4.2):	Chemical types of groundwater of Wadi Jarif samples.....	61
Table (4.3):	Classification of the studied groundwater samples of Wadi Jarif according to rectangular diagram proposed.....	66

List of Tables (Cont...)

Table No.	Title	Page No.
Table (4.4):	Classification of the studied groundwater samples of Wadi Jarif according to Simpson ratio (SR) proposed.....	69
Table (5.1):	Different parameter indices for rating of wadi Jarif groundwater sustainability for irrigation.....	77
Table (5.1):	Different parameter indices for rating of wadi Jarif groundwater sustainability for irrigation.....	78
Table (5.2):	Suitability of Wadi Jarif groundwater for irrigation based on EC	79
Table (5.3):	Suitability of Wadi Jarif groundwater for irrigation based on TDS	80
Table (5.4):	Suitability of Wadi Jarif groundwater for irrigation based on SSP	81
Table (5.5):	Suitability of Wadi Jarif groundwater for irrigation based on SAR	82
Table (5.6):	Suitability of Wadi Jarif groundwater for irrigation based on RSC	84
Table (5.7):	Suitability of Wadi Jarif groundwater for irrigation based on MAR.....	85
Table (5.8):	Different parameter indices for rating Wadi Jarif groundwater sustainability for domestic purposes.....	86
Table (5.9):	Suitability of Wadi Jarif groundwater for domestic purpose based on TDS.....	87
Table (5.10):	Suitability of Wadi Jarif groundwater for domestic purpose based on TH	88
Table (5.11):	Suitability of Wadi Jarif groundwater for domestic purpose based on CR	89
Table (5.12):	Suitability of Wadi Jarif groundwater for drinking based on NPI.....	90

List of Tables (Cont...)

Table No.	Title	Page No.
Table (5.13):	Suitability of Wadi Jarif groundwater for drinking based on WQI	93
Table (5.14):	Suitability of Wadi Jarif groundwater for drinking based on Total coliform, faecal coliform, and Faecal streptococcus	94
Table (5.15):	Suitability of Wadi Jarif groundwater for Livestock and Poultry based on EC	95
Table (5. 16):	Suitability of Wadi Jarif groundwater for industrial purposes	97

List of Figures

Fig. No.	Title	Page No.
Figure (1.1):	Location map of Sirte showing Wadi Jarif.....	3
Figure (1.2):	Distribution of the weather stations.....	9
Figure (1.3):	Temperatures variation in one year at Sirte and Abu Njayam stations	9
Figure (1.4):	Humidity variation in one year at Sirte and Abu Njayam Stations	10
Figure (1.5):	Distribution of average annual precipitation in the Study Area	11
Figure (1.6):	Variation of precipitation and evaporation at Sirte in One Year	11
Figure (1.7):	Distribution of the average annual evaporation in the Study Area	12
Figure (2.1):	Study area and location of water wells	32
Figure (2.2):	Atomic Absorption spectrophotometer.....	36
Figure (3.1):	Relation between Na ⁺ concentration and distance from coast.....	44
Figure (3.2):	Relation between K ⁺ concentration and distance from coast.....	45
Figure (3.3):	Relation between Ca ²⁺ concentration and distance from coast.....	46
Figure (3.4):	Relation between Mg ²⁺ concentration and distance from coast.....	47
Figure (3.5):	Boxplots of major cations concentrations in the studied groundwater of Wadi jarif.....	47
Figure (3.6):	Relation between Cl ⁻ concentration and distance from coast.....	49
Figure (3.7):	Relation between HCO ₃ ⁻ concentration and distance from coast.....	50

List of Figures (Cont...)

Fig. No.	Title	Page No.
Figure (3.8):	Relation between SO_4^{2-} concentration and distance from coast.....	51
Figure (3.9):	Relation between NO_3^- concentration and distance from coast.....	52
Figure (3.10):	Boxplots of major anions concentrations in the studied groundwater samples of Wadi Jarif	52
Figure (4.1):	Piper diagram of the studied Shallow groundwater samples of Wadi Jarif	62
Figure (4.2):	Piper diagram of the studied Deep groundwater samples of Wadi Jarif	63
Figure (4.3):	Parson's (1967) diagram of the studied groundwater samples of Wadi Jarif	64
Figure (4.4):	Plotting of the studied groundwater samples of Wadi Jarif on the rectangular diagram proposed.....	67
Figure (4.5):	Plotting of the studied groundwater samples on the TDS and $\text{Na}^+ / (\text{Na}^+ + \text{Ca}^{2+})$ relationships diagram.....	70
Figure (4.6):	Plotting of the studied groundwater samples on the TDS and $\text{Cl}^- / (\text{Cl}^- + \text{HCO}_3^-)$ relationships diagram	70
Figure (4.7):	Relation between Cl^- and Na^+ in the studied groundwater of Wadi Jarif.....	71
Figure (4.8):	Relation between Na^+ and Ca^{2+} in the studied groundwater of Wadi Jarif.....	72
Figure (4.9):	Relation between Ca^{2+} vs SO_4^{2-} and Ca^{2+} vs $\text{SO}_4^{2-} + \text{HCO}_3^-$ in the studied groundwater of Wadi Jarif	73
Figure (4.10):	Relation between $\text{Ca}^{2+} + \text{Mg}^{2+}$ and $\text{HCO}_3^- + \text{SO}_4^{2-}$ in the studied groundwater of Wadi Jarif.....	74

INTRODUCTION AND LITERATURE REVIEW

1.1 Preface

Water is an essential commodity to mankind, and the largest available source of fresh water lies underground. As the world's population increases, the demand for fresh water has stimulated for the development of underground water supplies. Inevitably, progresses in the form of modernization and urbanization have magnified the problem of the search for fresh water supplies. Efforts have increased to solve these problems; methods for investigating the occurrence, patterns, and movement of groundwater have been improved, better means for extracting groundwater have been developed, principles of conservation have been established, and research of several types has contributed to a better understanding of the subject (**Todd, 1963**).

Groundwater is an essential part of life; it is a vital source of water for domestic, irrigation and industrial uses in both urban and rural areas. The physicochemical and chemical properties of the groundwater determine its quality and suitability for irrigation and human consumption. The potential of groundwater is largely influenced by the specific geologic settings of the area (**Elango and Kannan, 2007; Manimaran, 2012; Parihar et al., 2012; Tmava et al., 2013**).

Groundwater is generally polluted; the pollution of groundwater regime is not only due to sub-surface waste disposal, but is also attributable to the seepage of contaminants from impoundment of toxic waste on

unlined surfaces such as indiscriminate spraying of insecticides, pesticides and excessive use of chemical fertilizers etc. (**Edmunds, 2003; Thangarajan, 2007; Abdul Jameel et al., 2012; Mumtazuddin et al., 2013**).

Arid regions have being featured with strong solar radiation, intensive evaporation, significant temperature variations and frequent sand storm, which result in vulnerable environment, particularly water environment due to the insufficiency and non-uniformity of precipitation. Therefore scientific and comprehensive insight into the water resources and environment in such a region is important for water sustainability (**Sen, 2008**).

The rate of population growth in Libya is considered a high rate and creates a demand for water at a great rate and one of the most important reasons that led to the emergence of the problem of water scarcity. This added to the great diversity in the water demand for the versatility that characterized recent decades, which covered all aspects of life (**Mohamed, 2014**).

Groundwater is an important water resource in both the urban and rural areas of Libya for domestic as well as for agriculture purposes (**Kumar et al., 2014**). Libya as many other regions under arid climates suffer from inadequate water resources to cover all the needs of this rapidly developing country (**Elgzeli, 2010**).

The Libyan coastal area, south of the Mediterranean Sea, is among one of the different types of water systems, which has a common and specific water characteristic (**El-Ghawi, 2005**). The intrusion of salt