

# LIST OF CONTENTS

| Subject                                                                                                                                            | Page No |
|----------------------------------------------------------------------------------------------------------------------------------------------------|---------|
| <b>CHAPTER I</b>                                                                                                                                   |         |
| <b>INTRODUCTION</b>                                                                                                                                |         |
| General outlines.....                                                                                                                              | 1       |
| I.1. Location .....                                                                                                                                | 1       |
| I.2. Climate .....                                                                                                                                 | 3       |
| I.3. Geomorphology .....                                                                                                                           | 3       |
| I.4. Geology.....                                                                                                                                  | 6       |
| I.5. Aquifer system.....                                                                                                                           | 7       |
| I.6. Scope of the present work.....                                                                                                                | 9       |
| I.7. Field work.....                                                                                                                               | 9       |
| I.8. Laboratory work.....                                                                                                                          | 9       |
| I.9. Office activities.....                                                                                                                        | 10      |
| I.10. Procedures and methods of water chemical analysis.....                                                                                       | 10      |
| I.10.1. Hydrogen ion concentration (pH).....                                                                                                       | 11      |
| I.10.2. Specific electrical conductance (EC).....                                                                                                  | 11      |
| I.10.3. Total dissolved solids (TDS).....                                                                                                          | 11      |
| I.10.4. Carbonate and bicarbonate constituents.....                                                                                                | 12      |
| I.10.5. Calcium and magnesium constituents.....                                                                                                    | 13      |
| I.10.6. Chloride constituent.....                                                                                                                  | 14      |
| I.10.7. Sodium and potassium constituents.....                                                                                                     | 15      |
| I.10.8. Sulfate constituent.....                                                                                                                   | 16      |
| I.10.9. Silica constituent.....                                                                                                                    | 17      |
| I.10.10. Boron constituent by carmine method.....                                                                                                  | 18      |
| I.10.11. Phosphate constituent.....                                                                                                                | 19      |
| I.10.12. Heavy metals analysis.....                                                                                                                | 20      |
| I.11. Materials and chemicals used in synthesis of (TiO <sub>2</sub> or ZnO) sodium alginate membrane.....                                         | 20      |
| I.11.1. Apparatus and methods used in synthesis and characterization of membrane.....                                                              | 21      |
| I.11.2. Swelling measurement of the grafted membranes.....                                                                                         | 22      |
| I.11.3. Fourier Infra-red spectrophotometer (FT-IR).....                                                                                           | 22      |
| I.11.4. X-ray diffraction.....                                                                                                                     | 23      |
| I.11.5. Atomic force microscopy (AFM).....                                                                                                         | 23      |
| <b>CHAPTER II</b>                                                                                                                                  |         |
| <b>REVIEW OF LITERATURE</b>                                                                                                                        |         |
| General outlines.....                                                                                                                              | 24      |
| II-1 Review of hydrochemistry of Fakous-El Hussania area .....                                                                                     | 24      |
| II-2 Review of synthesis and characterization of SA membrane.....                                                                                  | 26      |
| II-3 Review of Advanced oxidation processes (AOPs) [Photocatalytic oxidation] using Titanium dioxide (TiO <sub>2</sub> ) and Zinc oxide (ZnO)..... | 29      |

### CHAPTER III WATER CHEMISTRY IN FAKOUS-EL HUSSANIA AREA

|                                                                                        |     |
|----------------------------------------------------------------------------------------|-----|
| General outlines.....                                                                  | 36  |
| III.1. Frequency and areal distribution of water salinity.....                         | 38  |
| III.2. Frequency and areal distribution of hardness.....                               | 44  |
| III.2.1. Areal distribution of total hardness (TH).....                                | 47  |
| III.2.2. Areal distribution of non-carbonate (permanent) hardness (NCH).....           | 48  |
| III.2.3. Areal distribution of carbonate (temporary) hardness (CH).....                | 49  |
| III.3.1. Frequency and areal distribution of major ions.....                           | 51  |
| III.3.2. Areal distribution of major ions .....                                        | 58  |
| III.4. Hydrochemical coefficients (ion ratios).....                                    | 65  |
| III.5. Hypothetical salts combinations.....                                            | 73  |
| III.6. Water-Rock interaction in the groundwater of Pleistocene aquifer...             | 79  |
| III.7. Water pollution.....                                                            | 88  |
| III.7.A. Inorganic pollution.....                                                      | 88  |
| III.7.A.1. Distribution of iron.....                                                   | 89  |
| III.7.A.2. Distribution of manganese.....                                              | 90  |
| III.7.A.3. Distribution of lead.....                                                   | 91  |
| III.7.A.4. Distribution of cadmium.....                                                | 92  |
| III.7.A.5. Distribution of nickel.....                                                 | 92  |
| III.7.A.6. Distribution of copper.....                                                 | 93  |
| III.7.A.7. Distribution of zinc.....                                                   | 94  |
| III.7.A.8. Nitrogen compounds.....                                                     | 95  |
| III.7.A.9. Phosphate content.....                                                      | 99  |
| III.7.B. Organic pollution.....                                                        | 101 |
| III.7.B.1. Biochemical Oxygen Demand (BOD).....                                        | 101 |
| III.7.B.2. Chemical Oxygen Demand (COD).....                                           | 101 |
| III.7.B.3. Total organic carbon (TOC).....                                             | 103 |
| III.6. Geochemical classification of groundwater .....                                 | 104 |
| III.6.1.1. Geochemical classification based on Ions dominance.....                     | 105 |
| III.6.1.2. Geochemical classification based on trilinear diagram (Piper's, 1953).      | 107 |
| III.6.1.3. Geochemical classification based on modified Durov's diagram<br>(1948)..... | 109 |
| III.6.1.4. Geochemical classification based on Sulin's diagram (1948).....             | 111 |
| III.7. Geochemical evolution based on Burdon's system (1958).....                      | 115 |

### CHAPTER IV EVALUATION OF WATER QUALITY FOR DIFFERENT USES

|                                                                                               |     |
|-----------------------------------------------------------------------------------------------|-----|
| General outlines.....                                                                         | 117 |
| IV.1. Evaluation of groundwater quality for human drinking, domestic and<br>laundry uses..... | 117 |
| IV.1.1. Evaluation of groundwater quality for human drinking.....                             | 117 |

|                                                                                                                     |     |
|---------------------------------------------------------------------------------------------------------------------|-----|
| IV.1.1.1.TDS content.....                                                                                           | 118 |
| IV.1.1.2.Trace elements.....                                                                                        | 119 |
| IV.1.2. Evaluation of groundwater quality for domestic and laundry.....                                             | 121 |
| IV.2. Evaluation of groundwater quality for drinking of livestock and poultry...                                    | 122 |
| IV.3. Evaluation of groundwater quality for irrigation purposes.....                                                | 123 |
| IV.3.1. Evaluation of groundwater for irrigation according to TDS and the<br>effective salinity classification..... | 123 |
| IV.3.1.1.Total Dissolved Solids (TDS).....                                                                          | 123 |
| IV.3.1.2. The effective salinity.....                                                                               | 124 |
| IV.3.2.1 Guidelines for interpretation of water quality for irrigation (Ayers,<br>1977).....                        | 125 |
| IV.3.2.2 U.S. Laboratory classification of irrigation water (Richards, 1969<br>after Wilcox, 1955).....             | 129 |
| IV.3.2.3. Evaluation of groundwater for irrigation on basis of the crops and<br>their salt tolerance.....           | 131 |
| IV.3.2.4. Doneen's classification (1961).....                                                                       | 132 |
| IV.3.2.5. Evaluation of groundwater for irrigation according to Percentage<br>Sodium (Na %)......                   | 134 |
| IV.3.3. Evaluation of groundwater for irrigation according to Residual Sodium<br>Carbonate (RSC).....               | 136 |
| IV.3.4.Evaluation of groundwater for irrigation according to Boron contents<br>( $B^{3+}$ ).....                    | 137 |
| IV.3.5. Evaluation of groundwater for irrigation according to minor and trace<br>constituents.....                  | 138 |
| IV.4. Evaluation of groundwater for industrial purposes.....                                                        | 143 |

## CHAPTER V SYNTHESIS AND CHARACTERIZATION

|                                                                                  |     |
|----------------------------------------------------------------------------------|-----|
| General outline.....                                                             | 145 |
| V.1. Synthesis, SA/TiO <sub>2</sub> and SA/ZnO nanocomposite membrane.....       | 146 |
| V.1.1. Synthesis of sodium alginate membrane.....                                | 146 |
| V.1.2. Synthesis of SA/TiO <sub>2</sub> nanocomposite membrane.....              | 150 |
| V.1.3. Synthesis of ZnO nanoparticle.....                                        | 152 |
| V.1.4. Synthesis of SA/ZnO nanocomposite membrane.....                           | 152 |
| V.2. Characterization SA/TiO <sub>2</sub> and SA/ZnO nanocomposite membrane..... | 154 |
| V.2.1. FT-IR spectrum.....                                                       | 154 |
| V.2.2. X-Ray diffraction Patterns (XRD) Analysis.....                            | 157 |
| V.3.3. Atomic Force Microscopy (AFM).....                                        | 161 |

## CHAPTER VI PHOTOCATALYTIC NANOCOMPOSITE MEMBRANE

|                                                           |     |
|-----------------------------------------------------------|-----|
| General outline.....                                      | 164 |
| VI.1. Photocatalytic Activity.....                        | 165 |
| VI.1.1. Effect of time on the degradation of MO dye ..... | 167 |

|                                                                                  |     |
|----------------------------------------------------------------------------------|-----|
| VI.1.2. Effect of nanoparticle concentration .....                               | 169 |
| VI.1.3. Effect of initial dye concentrations.....                                | 170 |
| VI.1.3. Effect of pH values on the degradation.....                              | 171 |
| VI.1.4. Reuse of (SA/TiO <sub>2</sub> ) <sub>2</sub> nanocomposite membrane..... | 171 |
| VI.2. Kinetic study.....                                                         | 172 |
| VI.2.1. Photocatalytic degradation kinetics.....                                 | 173 |
| VI.3. Application of samples in the study area.....                              | 174 |
| VI.4. Conclusions.....                                                           | 175 |