**Faculty of Science**
**Chemistry Department**

# Hydrogeochemical Costal Hazard Assessment in North West Sinai, Egypt.

## A Dissertation

**Present to**

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By

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## " Hydrogeochemical Costal Hazard Assessment in North West Sinai, Egypt"

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# List of Symbols and Abbreviations

| | |
|---|---|
| amsl | above mean sea level |
| AI | Aggressiveness Index |
| DEM | Digital Elevation Model |
| Ec | Electrical conductivity |
| epm | Equivalent part per million |
| Ki | Kelley index |
| GIS | Geographic Information System |
| LI | Larson–Skold Index |
| mg/l | milligram per liter |
| MODFLOW | Software for simulating flow and contaminate transport behavior |
| MT3D | Engine in MODFLOW for simulating Contaminant transport behavior |
| HCA | hierarchical cluster analysis |
| PCA | Principal Component Analysis |
| PC | Principal Component |
| SAR | Sodium Adsorption Ratio |
| SI | Saturation Indices |
| TDS | Total Dissolved Solids |
| WQI | Water Quality Index |
| IDW | Inverse Distance Weighted |
| CVI | coastal vulnerability index |
| FFBI | flash flood potentiality index |
| SH | salinity hazard |
| GMWL | Global Meteoric Water Line |

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***Faten Attia Ali***

# Hydrochemical and multivariate analysis of groundwater quality in the northwest of Sinai, Egypt

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## ABSTRACT

The northwestern coast of Sinai is home to many economic activities and development programs, thus evaluation of the potentiality and vulnerability of water resources is important. The present work has been conducted on the groundwater resources of this area for describing the major features of groundwater quality and the principal factors that control salinity evolution. The major ionic content of 39 groundwater samples collected from the Quaternary aquifer shows high coefficients of variation reflecting asymmetry of aquifer recharge. The groundwater samples have been classified into four clusters (using hierarchical cluster analysis), these match the variety of total dissolvable solids, water types and ionic orders. The principal component analysis combined the ionic parameters of the studied groundwater samples into two principal components. The first represents about 56% of the whole sample variance reflecting a salinization due to evaporation, leaching, dissolution of marine salts and/or seawater intrusion. The second represents about 15.8% reflecting dilution with rain water and the El-Salam Canal. Most groundwater samples were not suitable for human consumption and about 41% are suitable for irrigation. However, all groundwater samples are suitable for cattle, about 69% and 15% are suitable for horses and poultry, respectively.

**Key words** | Egypt, groundwater quality, multivariate analysis, northwestern Sinai

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## INTRODUCTION

Coastal areas are highly sensitive to natural or anthropogenic effects. The northwestern coast of Sinai (site of the study area; Figure 1) is home to many economic activities: industry, agriculture, tourism, fisheries, trading and other development programs.

Securing water resources of appropriate quantity and quality is of prime importance for development programs in this important sector. This emphasises the importance of evaluation of the sustainability, potentiality and vulnerability of water resources from a development perspective.

The annual rainfall in the study area is limited; it varies between 26 and 54.8 mm and the total quantity of rainfall generally increases northward (El-Sheikh 2008). The national project of the El-Salam Canal has been started and River Nile water is being carried to Sinai. According to the Ministry of Water Resources and Irrigation (1991, 2009) and Hafez (2005), it is expected that the Nile water supply to this area will not fulfill the requirements of all the planned projects. Therefore, the demand for freshwater supplies has accordingly increased and attention is focused on groundwater utilization as an alternative or additive to rainfall.

The quality of groundwater resources in coastal zones is affected by many constraints (natural and/or anthropogenic). These include seawater intrusion, rock/water interaction, evaporation, irrigation return and drainage water effects, etc. Identifying the principal factors that control the salinity evolution and water quality aspects helps to achieve sustainable use of coastal resources.

This paper describes the prevailing groundwater conditions in the northwestern coastal zone of Sinai and

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# ABSTRACT

Coastal hazards are of high concern because of their adverse effects or even catastrophic impacts. These hazards, either natural or human induced, constrain development prospective and endanger lives, properties and resources in the coastal zones, such as the area under study in the northwest of Sinai. Analysis and evaluation of coastal hazards is a mandatory task for proper and secured development where necessary protective and controlling actions are proposed.

The basic objective of this thesis is to investigate, analyze, and evaluate some hydrogeochemical, hydrogeological and meteorological hazards at northwestern coast of Sinai. An approach has been applied that integrates system characterization into hazard evaluation which functions weighting / rating indices techniques, numerical modeling and empirical formulation.

The study is based on results of literature review, field and laboratory work (39 groundwater samples have been sampled and analyzed for major cations, major anions, $^{18}O$ and $^{2}H$ isotopic values), statistical treatment, numerical modeling, indices evaluation and categorization, GIS overlay and mapping.

The hydrogeological characteristics of the system ( including geomorphological, lithostratigraphic and groundwater conditions) and its hydrogeochemical ones (including ions distribution, ion dominance, water types , principle components, origin of salinity, its evolution and modification processes,...etc..) have been determined and isotopically insighted.

The results of characterization are fed into the hazard analysis processes conducted in this work, which include: hazard of groundwater consumption (drinking, irrigation, construction), soil salinization, sea water intrusion , contaminant transport in groundwater, sea water rise and coastal erosion, extreme rainfall and flash flood. The attributes of the different hazards are rated, weighed and mathematically interrelated in an overall hazard values which are mapped to locate the areas of high hazard potential, this is important for proposing protective and early preparedness measures to secure development processes in the study area.

The total salinity of the study groundwater varies in a wide range (from 692 ppm to 9384ppm). Two major hydrochemical facies exist , (a) the Cl-Na and $SO_4$- Na brackish water that dominates more than 90% of the samples reflecting a developed stage of salinity evolution under the effects of marine salts dissolution, surface evaporation before infiltration, cation exchange and Sabkha soil water contribution , (b) the $HCO_3$-Ca fresh water that dominates less than 10% of the samples reflecting an early stages of mineralization and are located close to El-Salam Canal where surface water from the canal seeps to dilute the saline water in the aquifer.

The $^{18}O$ and $^{2}H$ isotpic content revealed that the predominant recharging source of the groundwater under study is meteoric water. Rain water falls on the coastal and inland sand dunes and seeps to cover and bond Sabkha deposits in the depression between sand dunes. The bonding water leaks to the aquifer with salts concentrated through dissolution of marine salts from Sabkhas.

The high salinity and major ions concentration render about 90% of the collected groundwater samples posing health hazard for human drinking, about 31% and 85% posing hazard for horses and poultry,