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# *Assessment of Seawater Intrusion and Associated Environmental Impacts on the Al-Qarabulli Coastal Aquifer, Libya*

*Mjdi A. Mountaser [1], Abdalbaset M. Algish[2], Omaya J. Abujarir [3] Fathi I. Ashour[14].*

*majdialmuntssir@gmail.com,[1]*

*[14]Chemical and Petroleum Department, The Higher Institute for Science and Technology, Algaraboli , Libya.*

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**Abstract**

Seawater intrusion into groundwater aquifers is a natural phenomenon that commonly occurs in coastal regions due to the encroachment of seawater into freshwater reservoirs. This process leads to the degradation of groundwater quality, directly impacting the availability of potable water—particularly in populated areas that rely fully or partially on groundwater as a primary water source. As part of a scientific investigation conducted in the Al-Qarabulli region, water samples were collected from 12 wells located at varying distances from the coastline, ranging from 200 meters to 10 kilometers. The analysis involved measuring the concentrations of sodium, potassium, chloride, and magnesium ions. Additionally, the extent of seawater intrusion was assessed using the Jones Index and Base Exchange Index (BEX)

Keywords: Al-Qarabulli, Coastal aquifers, Groundwater quality, Hydrochemical indices, Seawater intrusion.

## 1. Introduction

The introduction of the paper titled “Analysis of the Interference of Seawater with Groundwater and Evaluation of the Resulting Environmental Impacts” aims to address the critical issue of seawater intrusion in coastal aquifers, a phenomenon that poses significant threats to freshwater resources and ecosystems. Seawater intrusion occurs when saline water encroaches into freshwater aquifers, primarily due to over-extraction of groundwater and rising sea levels, leading to detrimental effects on water quality and biodiversity. This paper will explore the mechanisms of seawater intrusion, its environmental impacts, and the implications for water management in coastal regions.

### 1.1 Seawater intrusion mechanisms

**Over extraction of Groundwater** Increased demand for freshwater for agricultural and domestic use leads to excessive groundwater withdrawal, facilitating seawater intrusion(Tharik & Saraswathi, 2024).

**Geological Factors**: Coastal geological structures can exacerbate the movement of seawater into aquifers, as observed in various studies(Tubalawony & Noya, 2023)(Arfah et al., 2022).

### 1.2 Environmental Impacts

**Water Quality Degradation**: High levels of salinity and contaminants in groundwater can render it unsuitable for drinking and irrigation, as evidenced by studies showing significant chloride concentrations in affected areas(Tubalawony & Noya, 2023)(Ismail, 2007).

**Biodiversity Loss**: Seawater intrusion disrupts local ecosystems, affecting flora and fauna dependent on freshwater sources(Tubalawony & Noya, 2023).

### 1.3 Implications for Water Management

**Need for Monitoring**: Regular assessment of groundwater quality and salinity levels is essential to manage and mitigate the impacts of seawater intrusion(Ismail, 2007).

**Sustainable Practices**: Implementing sustainable groundwater extraction practices can help preserve freshwater resources and reduce the risk of seawater intrusion(Tharik & Saraswathi, 2024).

While the focus is on the detrimental effects of seawater intrusion, it is also important to consider potential adaptive strategies that communities can employ to mitigate these impacts, such as rainwater harvesting and the use of alternative water sources.

### 1.3 Study area

The municipality of Qarabulli is located on the coastal strip east of the city of Tripoli, with an area of approximately 60 km.


The coast of the municipality of Karabuli extends about 20 km and its area is estimated at about 84,0000 m2. It is located between longitudes 32,45,00°N and latitudes 13,43,00°E. Its population is about 170,000 people.

## 2· Methodology

### 2.1 Samples and analyses used

Water samples were taken from 12 groundwater wells within the scope of Al-Qara Bulli Municipality. The coordinates of each sample (each well) were recorded, which was taken using a GPS device. The name of the well was written on each sample so that the coordinates of these wells are represented in the study area.

Table No. (1-1 shows the names of the samples and their distance from the sea, \

| Source age y | Source depth m | Distance from the sea m | Name of Source | no |
|---|---|---|---|---|
| 4 | **20** | **387.57** | **القويعة HT** | 1 |
| 40 | **20** | **585.65** | **فم الوادي** | 2 |
| 40 | **20** | **160.61** | **مصيف القره بوللي** | 3 |
| 1 | **20** | **648.36** | **الفنار** | 4 |
| 12 | **40** | **650** | **مركزتطوير المراة** | 5 |
| 45 | **50** | **4440** | **مركز مكافحة العطايا** | 6 |
| 35 | **25** | **4160** | **مصنع ثلج المصيف** | 7 |

| | | | | |
|---|---|---|---|---|
| 6 | **32** | **4490** | **طريق الاسماعلية 1** | 8 |
| 20 | **35** | **5430** | **صيدلة الحياة العطايا** | 9 |
| 30 | **60** | **7390** | **الساحة الشعبية** | 10 |
| 11 | **55** | **9000** | **الطريق الساحلي** | 11 |
| 18 | **42** | **4830** | **مشروع الابقار** | 12 |

Table No. (1-2) shows *the concentration of elements in groundwater obtained from laboratory analyses.*

| **Chloride mg/kg** | **Magnesium mg/kg** | **Calcium mg/kg** | **Potassium mg/kg** | **Sodium mg/kg** | **No** |
|---|---|---|---|---|---|
| 760 | 139 | 238 | 9.7 | 384 | 1 |
| 187 | 48 | 110 | 12 | 214 | 2 |
| 323 | 39 | 104 | 8.9 | 264 | 3 |
| 46 | 28 | 64 | 6 | 146 | 4 |
| 380 | 111 | 174 | 9.3 | 357 | 5 |
| 344 | 95 | 122 | 11 | 355 | 6 |
| 334 | 86 | 148 | 8.7 | 286 | 7 |
| 267 | 86 | 84 | 17 | 271 | 8 |
| 263 | 58 | 156 | 8.9 | 255 | 9 |
| 263 | 94 | 14 | 9.2 | 236 | 10 |
| 147 | 63 | 64 | 9 | 249 | 11 |
| 504 | 110 | 142 | 54 | 346 | 12 |

Figure (1-3) shows the latitude and longitude lines for all the samples that were taken..

| Distance from the sea m | Source depth m | latitude | Longitude | رقم البئر |
|---|---|---|---|---|
| 387.57 | 20 | $38.01113^0$ | $47.16332^0$ | 1 |
| 585.65 | 20 | $40.86113^0$ | $47.11832^0$ | 2 |
| 106.61 | 20 | $44.41932^0$ | $47.45932^0$ | 3 |
| 684.36 | 20 | $46.94313^0$ | $47.63332^0$ | 4 |

| | | | | |
|---|---|---|---|---|
| 4520 | 40 | $37.56113^0$ | $44.99132^0$ | 5 |
| 4440 | 45 | $41.44513^0$ | $45.06932^0$ | 6 |
| 4160 | 25 | $43.68413^0$ | $45.37232^0$ | 7 |
| 4480 | 32 | $47.15113^0$ | $45.58732^0$ | 8 |
| 5430 | 35 | $41.56913^0$ | $44.51632^0$ | 9 |
| 7390 | 60 | $44.55313^0$ | $43.57132^0$ | 10 |
| 9000 | 55 | $46.26113^0$ | $43.10432^0$ | 11 |
| 4830 | 42 | $37.67013^0$ | $44.79932^0$ | 12 |

## 3. Results and discussion

The sources of groundwater salinity in the study area were evaluated according to the Jones ratio (JR), base exchange (BEX), and calcium to magnesium (Ca/Mg) indicators. The study showed that groundwater reservoirs were salinized according to the Jones index in most of the study areas, except for the areas of Al-Ataya, Fum Al-Wadi, Al-Fanar, and the Control Center. The ice factory, agricultural land, Al-Hayat Pharmacy, the public square, and the coastal road, where readings were recorded less than 0.86 at a rate of 45%, the study showed the occurrence of salinization of groundwater reservoirs according to the basic exchange index (BEX) at a rate of 40% of the samples studied in most of the study areas. Except for the following areas: Bahr Fam El Wadi, Al Ataya, Al Fanar, the Women's Development Center, the Control Center, the Summer Ice Factory, the Agricultural Land, Ismailia Road, Al Hayat Pharmacy, the Popular Square, and the Qara Bulli Coastal Road, where positive readings were recorded.

The following table shows the results and indicators of salinity sources with well water for each region according to the results of the indicators.

Table (1-4) shows the results and indicators of salinity sources with well water for each region.

| BEX Index | Jones Index | **Chloride mg/kg** | **Magnesium mg/kg** | **Calcium mg/kg** | **Potassium mg/kg** | **Sodium mg/kg** | **No** |
|---|---|---|---|---|---|---|---|
| -282.7 | 051 | 760 | 139 | 238 | 9.7 | 384 | 1 |
| 75.754 | 1.16 | 187 | 48 | 110 | 12 | 214 | 2 |
| -34.23 | 0.82 | 323 | 39 | 104 | 8.9 | 264 | 3 |
| 136.7 | 3.17 | 46 | 28 | 64 | 6 | 146 | 4 |
| 70.1 | 0.49 | 380 | 111 | 174 | 9.3 | 357 | 5 |
| 72.37 | 0.97 | 344 | 95 | 122 | 11 | 355 | 6 |
| 22.79 | 0.86 | 334 | 86 | 148 | 8.7 | 286 | 7 |
| 87.88 | 1.01 | 267 | 86 | 84 | 17 | 271 | 8 |
| 40.07 | 0.97 | 263 | 58 | 156 | 8.9 | 255 | 9 |
| 57.37 | 0.897 | 263 | 94 | 14 | 9.2 | 236 | 10 |
| 163.47 | 1.69 | 147 | 63 | 64 | 9 | 249 | 11 |
| -30.1 | 0.69 | 504 | 110 | 142 | 54 | 346 | 12 |

## 4. Chemical and physical properties

### 1- Calcium Ca

Calcium is one of the most important positive ions found in groundwater. The source of these ions in groundwater is non-silicate minerals such as fluorite, anhydrite, gypsum, and dolomite. The increase in calcium concentration in groundwater changes its taste. The results of this study showed that sample 1 was higher than the permissible limit of 238 mg/L, and the permissible level is 200 mg/L. The remaining samples were within the permissible level of 200 mg/L.

**2- Magnesium Mg**

One of the most important ions found in groundwater is magnesium. The results of this study showed that all samples taken were within the permissible range of 200 mg/L.

**3- Potassium K**

Potassium is found in sedimentary rocks such as feldspar and is found in some igneous rocks, clay, sea sediments and some types of mica. It was found that the permissible limit for finding potassium in groundwater is 15 mg/L. Upon reviewing the samples, we found that all samples were within the permissible range, except for samples (8-12), which were higher than the average (17-54).

4- Chloride Cl

Chloride compounds are characterized by their solubility in water, with the exception of silver chloride. We note from studying the results of the previous samples that all samples show that some of the water is salty, some of which is caused by seawater, and others by the geological structure of the area.

## 5. Conclusion

The analysis results revealed strong evidence of significant interference between seawater and groundwater, leading to deteriorating groundwater quality and increased salinity levels, particularly in wells near the coast. The study showed that this water is no longer suitable for drinking or irrigation, except for agricultural crops that can tolerate high levels of salinity. These results highlight the urgent need for in-depth future studies to understand the dynamics of saltwater intrusion and propose effective solutions for addressing water salinity. Among the potential solutions, an integrated water resource management plan could be considered. In addition to recharging groundwater aquifers by pumping fresh water from nearby sources, this could help reduce the negative impacts of seawater intrusion and maintain the sustainability of these vital water resources.

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