

Effect of Climate, Soil Type and Distance from the Sea to the Seawater Intrusion and Water Quality In Azawia – Libya

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Accepted 11th July, 2014

ABSTRACT

Most coastal areas worldwide depend entirely on groundwater as their main source of fresh water. There are many sources of groundwater pollution due to human influence seawater intrusion is one of these sources. This problem is more acute in arid and semi-arid areas (including most of the Mediterranean coastline), since this groundwater is used as a source of fresh water, this is the case in most of the coastal regions of Libya. A mixture of seawater and freshwater in the coastal areas makes freshwater aquifers unsuitable for human consumption, as a 5% mixture of seawater causes most fresh water to become contaminated and makes aquifers highly vulnerable to pollution. This problem has caused the water framework directive to put forward renewed plans to define and to set the basis for understanding the phenomenon of seawater intrusion in the coastal regions, as it has a severe impact not only on the contamination of freshwater resources but also on natural systems of potential environmental interest. Survey was employed to show the significance of seawater intrusions phenomena in Azawia city, Libya that represented by comparison of chemical parameters in climate types, the length of distance from the sea, and the soil types. There are seawater intrusions in Azawia city, Libya. It is shown by the level of chloride and electrical conductivity in the points of sample collections. Chloride and TDS level conditions are influenced by climate types, the length of distance, and the soil types. Calcium and Magnesium are influenced by the climate types and the length of distance from the sea. And Sodium is influenced by difference in climate types. TDS level of all of the samples shows that there are only one well that fulfill WHO suitability standard.

KEYWORDS: seawater intrusions, az zawiya city, influence, climate, distance from the sea, soil types

INTRODUCTION

The impact of seawater intrusion (SWI), the landward movement of seawater in coastal aquifers, has long been recognized as a global issue (Adrian, 2013). Groundwater has been pumped excessively from coastal aquifers for various human activities as the population has grown throughout the world (Adrian, 2013). As a result, extensive coastal groundwater depletion and salinization have resulted from intensified seawater intrusion (SWI). Thus, the sustainability of coastal groundwater resources has become a significant issue in the coastal areas and even in the adjacent inland areas (Adrian, 2013). The degree of seawater intrusion in coastal aquifers depends on several natural and manmade parameters. Natural factors include, among other, geological aspects, aquifer geometry, depth at

the seaside, hydro geological and hydraulic parameters (such as porosity, permeability, storability, groundwater levels and slopes, and natural recharge), transport parameters (such as dispersivity, dispersion and diffusion coefficients), reaction processes, and boundary conditions (Sherif, 2012). Climate change effects are expected to substantially raise the average sea level. It is widely assumed that this raise will have a severe adverse impact on saltwater intrusion processes in coastal aquifers (Kouzana, 2009).

Soils in western Libya (from Tunisia to Misurata in the east) are: inceptisols and entisols (49.1 %), aridisols (11.5 %), salorthids (10.7 %) and sandy soils (3 %) (UNEP, 1996). Sandy soils bear more developed vegetation with a more regular and higher primary productivity than finer textured soils. Thus, profitably and commercials cultivated rainfed olive orchards are grown on deep sandy soils under as little precipitation as 200 mm/year in Tripoli area, but this is not possible without an additional runoff complement on silt soils (Le Houerou, 2001).

There are three types of climates in Libya (European Commission, 2009) that mentioned below :

- Type 1 : The Mediterranean coastal strip, with dry summers and relatively wet winters;
- Type 2 : The Jabal Nafusah and Jabal Akhdar highlands, experiencing a plateau climate with higher rainfall and low winter temperatures including snow on the hills;
- Type 3 : Moving south to the interior, pre-desert and desert climatic conditions prevail, with torrid temperatures and large daily thermal amplitudes. Rain is rare and irregular and diminishes progressively towards zero in the south.

Desertified lands have been categorized into four classes according to their degree of desertification (slight, moderate, severe, and very severe). Land categorized as slightly desertified shows little or no degradation (less than 10 % loss in potential yield), moderately desertified land shows 10-25 %, severely desertified land 25-50 %, and very severely desertified land over 50 % degradation (Nasr, 1999).

Table 1. Degree of water and wind erosions in western part of Libya

Degree of erosion	Water erosion	Wind erosion
Slight	165.5	180.0
Moderate	164.6	266.4
Severe	64.5	136.4
Total	394.7	582.8

Source: General Environmental authority, 2002: 210

An aqueous solutions ability to carry an electrical current by means of ionic motion is measured through conductivity. It has unit of reciprocal ohm- meter, denoted in the SI system as Siemens per meter (S/m). Pure liquid water has a very low electrical conductance, less than a tenth of a microsiemen at 25°C (Hem, 1970).

Conductivity is dependent on temperature. As mentioned before, the important chemical characteristic that indicates seawater intrusions are the overall situation based on

sodicity, salinity, and alkalinity.

These characters can be seen by measurement of chemical parameters in each of its amount comparison with the thresholds of fresh water quality.

This research later discussed also climate, distance from the sea, and soil types as causes of changing amounts of the chemical parameters by hydrogeological process and climate change.

Table 2. Standards of Drinking Water in Libya

Parameters Mg/l	Libyan	WHO
Na ⁺	50	30 – 60
K ⁺	40	40
Ca ²⁺	200	100
Fe ²⁺	0.3	0.3
Mn ²⁺	0.1	0.5
Mg ²⁺	150	150
Cl ⁻	250	250
SO ₄ ²⁻	400	250
NO ₃ ³⁻	45	50
pH	6.5-8.5	6.5-9.5
EC(μS/cm 25°C)	500	1400
TDS (mg/l)	Up to 1000	600

METHODOLOGY

This study was survey of water quality with point sampling consider the distance from the sea, soil type and climatic zone. Thus, the point samplings can be categorized as same soil type but different climatic zone, same zone but different distance, same distance but different soil type. Location of the Studied Area was Libya, Zawiya, is located in the northern part of the Gefara plain between the coordinates: 120 32` and 120 45` N , and 320 38` and 380 48` E.

Chemical analyse

Water samples from twenty four sampling point were immediately taken to the laboratory using standard methods

of analysis. Since the quality of the water can change throughout the year, collected samples were delivered of the drop-off locations within 24 hours.

During the previous studies of water points in the studied areas, chemical analyses of the water samples were collected from production wells at the time that steady rate pumping tests were compiled.

Chemical analyses were carried out in the water and soil laboratory of GWA in Tripoli. These results include: the main chemical properties including total dissolved solids (TDS), electrical conductivity (EC), hydrogen ion concentration (pH). In addition to water temperature (CO), as properties play an important role in the identification of water quality.



Point sampling area of water quality

Climate

There are three types of climates in Libya (European Commission, 2009) that mentioned below :

- Type 1 : The Mediterranean coastal strip, with dry summers and relatively wet winters;
- Type 2 : The Jabal Nafusah and Jabal Akhdar highlands, experiencing a plateau climate with higher rainfall and low winter temperatures including snow on the hills;
- Type 3 : Moving south to the interior, predesert and desert climatic conditions prevail, with torrid temperatures and large daily thermal amplitudes. Rain is rare and irregular and diminishes progressively towards zero in the south.

Distance from the Sea and Soil Type

This research classified the collected samples into 4 types of distance which later indirectly defines the soil types' basis of classification. There are 24 points of random samples from all area of Az Zawiya city which was taken from different length of distance. Distance of each sample has been measured and classified as below :

- Class 1 : 0 - 3,000 meters
- Class 2 : 3,000 - 10,000 meters
- Class 3 : 10,000 - 20,000 meters
- Class 4 : more than 20,000 meters

The types of soil classified into 4 groups as below:

Type 1: Coastal Strip (Soil 1)

Beach Sands, i.e. calcareous sands covering the coastal strip near the beach, which have sometimes been consolidated and converted into calcareous.

Type 2: Central Zone (Soil 2)

Characterized by coastal sand dunes and the brown silt, and its low topographic area is covered by sebkha sediments.

Type 3: Northern Zone (Soil 3)

Sobkha deposits, a mixture of clay and clay-like sands with gypsum and salts, found in the coastal western regions such as Massif Surman and Sidi Omar.

Type 4: Southern Zone (Soil 4)

Recent valleys Sediments, a mixture of sands claylike sands and gravels, distributed in a limited area south of the studied area. Chemical Analysis Sodium adsorption ratio (SAR), along with pH, characterize salt-affected soils. It was measured property that gives information by the comparative concentrations of Na^+ , Ca^{2+} , and Mg^{2+} in soil solutions. The equation used to calculate SAR is given as follows:

$$SAR = \frac{[Na^+]}{\sqrt{\frac{1}{2}([Ca^{2+}] + [Mg^{2+}])}}$$

where $[Na^+]$, $[Ca^{2+}]$ and $[Mg^{2+}]$ are the concentrations in meq/L of sodium, calcium, and magnesium ions in the soil solution. Concentrations of sodium, calcium, and magnesium are determined by first extracting the ions from the soil into solution. The solution is then analyzed to determine concentrations of the selected ions. Na^+ , Ca^{2+} , and Mg^{2+} concentrations are determined using atomic absorption spectrometry. The SAR of a soil extract takes into consideration that the adverse effect of sodium is moderated by the presence of calcium and magnesium ions. When the SAR rises above 12 to 15, serious physical soil problems arise and plants have difficulty absorbing water (Munshower, 1994).

RESULTS AND DISCUSSION

Correlation of Chemical Contents and Distance from the Sea

These samples are brought from varied distance to the sea. The nearest sample was brought from 110 m from the sea, and the furthest sample was brought from 24,288 m from the sea. The average distance of the sample from the sea is 8,128m. Distance from sea is an important condition to be obtained.

Levels of Chloride (Cl) and Electrical Conductivity (EC) are most simply indicative of seawater intrusion or salinization (Mercado 1985; El Moujabber et al. 2006).

EPA (2009) also has determined the threshold for EC and Cl which indicate seawater intrusion. EC threshold for seawater intrusion indication is 800 μ S/cm. For the case of Azawiya, minimum EC levels is 808 μ S/cm and maximum EC level is 9,180 μ S/cm. EC mean was 1,804 μ S/cm. Based

on EPA standard on EC threshold, the range of EC level indicates seawater intrusions happens in Azawia aquifer. Chloride (Cl) levels in Azawiya are varied between 116 mg/L and 882 mg/L. Chloride mean was 503 mg/L. The EPA threshold for seawater intrusion indication is 25 mg/L. Thus, the provided Chloride level in Azawiya shows seawater intrusion.

Figure 2 shows the relations between distance from sea and Chloride contain in water samples. As seen in the tables, the Chloride levels decreasing along with the increase of the distance from the sea.

The highest Chloride level was brought from the well is 481 meter from the sea. The nearest well from the sea also has 760 mg/L of Chlorides. The furthest well from the sea contains 403 mg/L Chloride its far 24288 meters from the sea. Figure 3 shows the relations between distance from the sea and Electrical Conductivity. These relations has the same pattern of distribution with Chloride contains. EC levels were found higher in the samples nearer to the sea.

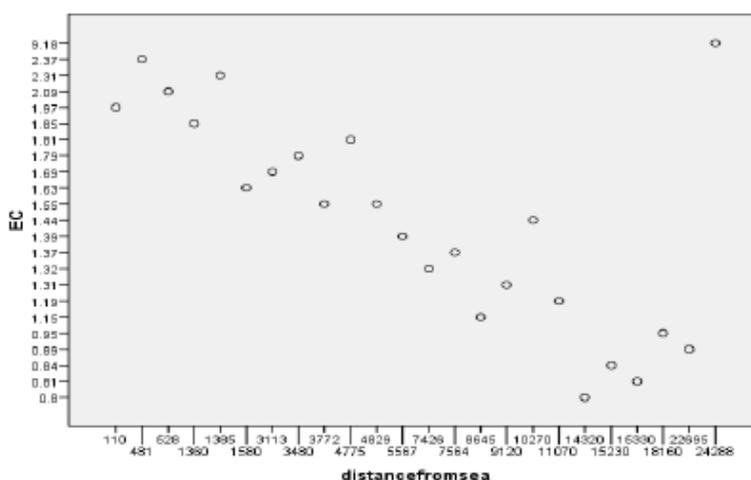


Figure 2. Correlation distribution of chloride and distance from the sea.

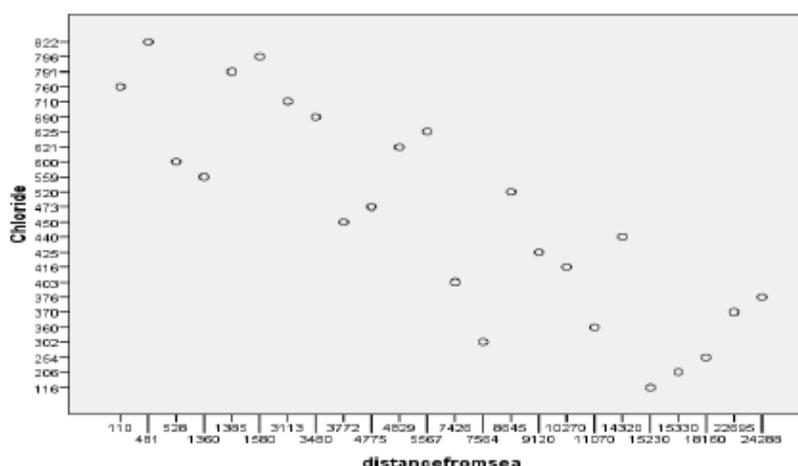


Figure 3. Correlation distribution of electrical conductivity and distance from the sea .

Relationship between Chemical Parameters and Climate

Analysis shows that different climates bring effects that showed by a significant difference (means within a column

followed by the same letter are not significantly different based on LSD (< 0.05)) in the Chloride, Magnesium, TDS, and Calcium level means.

Table 3. Correlation between climate and the main parameters.

Climate	Chloride (mg/l)	Natrium (Mg/l)	Natrium (Mg/l)	Calcium (Mg/l)	Th (Mg/l)	Temperature (CO)	pH	TDS (Mg/l)	EC (mmbos/cm)	SAR
Mediterranean Climate	707.375a	145.737a	69.0512a	165.825a	594.57a	23.88a	7.4 _a	1510a	21934.375a	2.342071a
Semi Mediterranean	492.125b	492.125b	55.9125a	148.325a	600.75a	24.08a	72. _a	1294ab	1457.625a	2.523814a
Semi desert climate	311.125c	110.075a	36.4012b	113.188b	453.75a	23.12a	7.2 _a	924b	2022.625a	2.264428a

Means within a column followed by the same letter are not significantly different based on LSD (0.05) .

In each of climate type based group, the groups of Chloride have significant in the difference of means of each of the group. Chloride in Climate Type 1; The Mediterranean coastal strip climate are highly significant ($p = 0,00$) with means of Chloride in Climate Type 2; a plateau climate with higher rainfall and low winter temperatures including snow on the hills and are also significant with Chloride in Climate Type 3 ($p = 0,01$); pre-desert and desert climatic conditions prevail, with torrid temperatures and large daily thermal amplitudes. Chloride in Climate Type 2 and means of Chloride in Type 3 also significant ($p = 0,03$).

The groups of TDS have significant in the difference of means of each of the group. TDS in Climate Type 1; The Mediterranean coastal strip climate are not significant ($p =$

0,099) with TDS in Climate Type 2; a plateau climate with higher rainfall and low winter temperatures including snow on the hills but significant with TDS in Climate Type 3 ($p = 0,008$); pre-desert and desert climatic conditions prevail, with torrid temperatures and large daily thermal amplitudes. Means of TDS in Climate Type 2 and TDS in Type 3 also significant ($p = 0,00$).

Relationship between Chemical Parameters and Distance from the Sea

Analysis shows that the difference in the distance bring effects that showed by a significant difference. LSD (< 0.05) in the Chloride, Magnesium, TDS, and Calcium level means.

Table 4. Correlation between distance and the main parameters

Distance	Chloride (mg/l)	Natrium (Mg/l)	Natrium (Mg/l)	Calcium (Mg/l)	Th (Mg/l)	Temperature (CO)	pH	TDS (Mg/l)	EC (mmbos/cm)	SAR
0-3,000 n	721a	138.86a	69.40a	154.583a	631a	24.0a	7.4 _a	1464a	2038a	2.21715a
3,000-10,000m	521b	145.45a	56.28a	162.785a	583a	23.5a	72. _a	1358a	1496a	2.46882a
>20,000 m	373 b	143.30a	54.55a	117.095a	517a	23.7a	7.3 _a	827.5b	1008a	2.23403a

Means within a column followed by the same letter are not significantly different based on LSD (0.05) .

From table, there were 3 parameters which have significant difference ($p < 0,05$) between all groups of parameter. result shows that different climate conditions has influence on the difference amount of Calcium ($p = 0,014$), Electrical Conductivity ($p = 0,010$) and Total Dissolved Solids ($p = 0,008$) and has no influence on the other parameters. This finding shows that Calcium as one of the components of salts when it's bounded with Chloride, Electrical Conductivity and Total Dissolved Solids that represent salinity and as also the indicators of seawater intrusions are influenced by different length of distance from the sea.

In each of distance length group, the groups of Chloride are significant with the difference of each group. Chloride in 0 – 3000 meters distance from the sea ($p = 0,052$) are not significant with Chloride in distance length 2; 3,000 – 10,000 meters. Chloride in 3,000 – 10,000 meters distance are significant with Chloride in distance length 3; 10,000 – 20,000 meters ($p = 0,00$); and also significant with Chloride in distance type 4; >20,000 meters. Chloride in 3,000 –

10,000 meters are significant with Chloride in 10,000 – 20,000 meters, and also significant with Chloride in >20,000 meters ($p = 0, 00$). TDS in 0 – 3,000 meters distance are significant with TDS in > 20,000 meters ($p = 0,04$). TDS in 3,000 – 10,000 meters and TDS in >20,000 meters are also significant different by ($p = 0,008$).

Relationship between Chemical Parameters and Soil Type

From table, there are 4 parameters which have significant difference ($p < 0,05$) between all groups of parameter. Result shows that different climate conditions has influence on the difference amount of Chloride ($p = 0,00$), Calcium ($p = 0,040$), and Total Dissolved Solids ($p = 0,015$) and has no influence on the other parameters. This finding shows that Chloride and Total Dissolved Solids that represent salinity as one of the indicators of seawater intrusions are influenced by different soil types.

Table 5. Correlation between soil and the main parameters

Soil	Chloride (mg/l)	Natrium (Mg/l)	Natrium (Mg/l)	Calcium (Mg/l)	Th (Mg/l)	Temperature (CO)	pH	TDS (Mg/l)	EC (mmhos/cm)	SAR
Mediterranean Climate	721.33a	138.8a	69.40a	154.58a	631a	24.0a	7.4a	1464a	2038a	2.27a
Semi Mediterranean	594.83a	159.3a	53.33a	168.63a	549a	23.2a	72.a	1404a	1633a	2.71a
Semi desert climate	404.33b	117.3a	55.51a	138.69ab	574a	24.4a	72.a	1179ab	1298a	2.07a
Semi desert climate	293.66b	117.4a	37.00b	107.87b	450a	23.1a	7.3a	922b	2249a	2.43a

Means within a column followed by the same letter are not significantly different based on LSD (0.05).

Chloride are significant in the difference of each of the group. Chloride in Soil Type 1; Coastal Strip ($p = 0,052$) are not significant with Chloride in Soil Type 2; Central Zone. Chloride in are significant with Chloride in Climate Type 3 ($p = 0,00$); Northern Zone and Chloride in Soil Type 4; Southern Zone. Chloride in Soil Type 2 and Chloride in Type 3 are also significant ($p = 0,03$).

The groups of TDS are significant in the difference of each of the group. TDS in Climate Type 1; The Mediterranean coastal strip climate are not significant ($p = 0,099$) with TDS in Climate Type 2; a plateau climate with higher rainfall and low winter temperatures including snow on the hills but significant with TDS in Climate Type 3 ($p = 0,008$); pre-desert and desert climatic conditions prevail, with torrid temperatures and large daily thermal amplitudes. TDS in Climate Type 2 and means of TDS in Type 3 are also significant ($p = 0,00$).

Analysis shows that different soil types bring effects that showed by a significant difference (means within a column followed by the same letter are not significantly different based on LSD (< 0.05)) in the Chloride, Magnesium, and Calcium level means.

CONCLUSION

Groundwater chemistries in coastal aquifers were evaluated to identify progress of seawater intrusion. From data analysis, this research concludes :

- Seawater intrusions that represented by occurring amount of chemical parameters compared to WHO of groundwater quality shows that chloride, calcium, electrical conductivity, Magnesium and total dissolved solids have been effected by three climate types also soil types has affected on groundwater in the studied area.
- Taking sampling and analyzed it, and make comparison between standard criteria the results this research found in the most well productions are not usable for drinking.
- This research found that the salt water inland even at the last well 24 km far from the sea has been affected by intrusion.
- There is not huge significant effect between Mediterranean and sim mediterrean climate on intrusion of sea water.

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