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Evaluation of the Ground Water Aquifers at the Area between Elarish and Rafah, North Eastern Sinai, Egypt

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ABSTRACT

This study aims to evaluate the quantity and quality of potential groundwater resources, their mode of occurrence in the different geologic formations and potential sustainable development. The evaluation of groundwater potentialities is done for the north eastern area of Sinai Peninsula. The study is mainly based on filed survey for groundwater wells, and interpretation of the measured hydrogeological data (i.e. Water level, well yield and analyzing groundwater quality). Three aquifers were recognized in the study area based on their lithostratigraphy, hydrogeological setting and water quality, these are : Quaternary aquifer, Fracture Limestone Aquifer, Lower Cretaceous Sandstone Aquifer. The Quaternary sediments cover most the area of study especially the central and northern parts where the thickness of the wadi deposits increase while they decrease in the southern part, generally the aquifer composed of sand, clay, silt and kurkar. The fracture limestone aquifer is considered one of the most important aquifer at the north east Sinai, generally the aquifer composed of dolomitic, chalky and fracture limestone with some strikes of shale and silt, this aquifer it is difficult to evaluate and led to more intensive studies. The lower cretaceous bearing formation is composed of ferruginous, vari-colored sandstone alternating with thin shale beds and common by Malaha formation, this aquifer is consider the promising aquifer in middle and north middle Sinai due to its highly production and good water quality.

I. INTRODUCTION

This study reflects the hydrogeological conditions for each area in north Sinai taking in our consideration the behavior and potentialities of the different types of aquifers in the area we still confirm that the areas which suffering from over pumping such as EL-Arish, Zuwyied, Rafah and Central Sinai all these areas have reached to the red line suffering from severe extraction leading to high salinity reach to over 5000 ppm in some locations.

The area of study lies between lat: 30° 40' & 31° 30' and long: 34° 00' & 34° 30' in the north eastern part of Sinai Peninsula as shown in Figure 1.

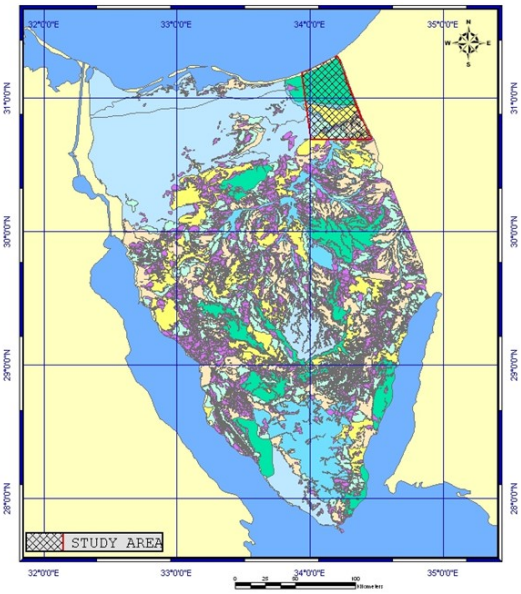

Figure 1. Location map shows the extension of the study area

The study area is covered by geomorphologic units; these are Sand dunes, Wad's, Gravel with Sands areas and Mountains. The main geologic units are dated back to Mesozoic and Cenozoic periods. These units are lithologically composed mainly of clastic (sand, sandstone, gravel, silt and clay) and non- clastic (limestone and dolomite) sediments. Figure 2.

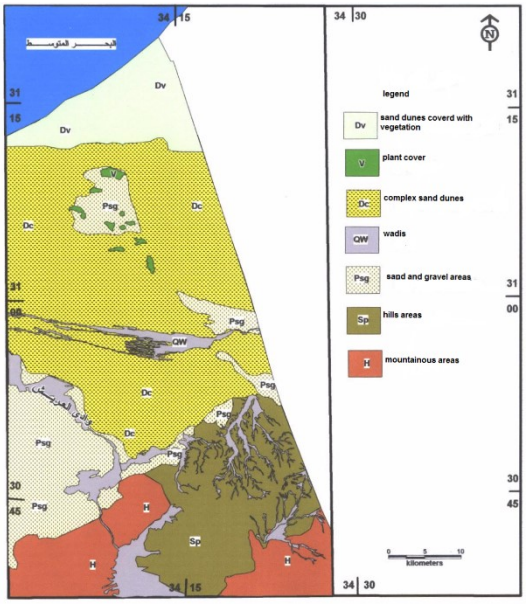

Figure 2. Geomorphological Units of the Study Area.

The sedimentary sequence in the study area subdivided into different rock units from younger to older: Cenozoic Sediments and Mesozoic sediments, this part includes many mountains, and wadis such as wadi El – Amr, W.Esram,W.El-Harab and Gebel – El-Sabha, G. Halal, G. Hamra and G. Qusima. Most of the Phanerozoic rocks represented in the area except the igneous rocks, Said (1962, 1971), Neev (1975), Bartov (1982), Moustafa (1989) Figure (3).

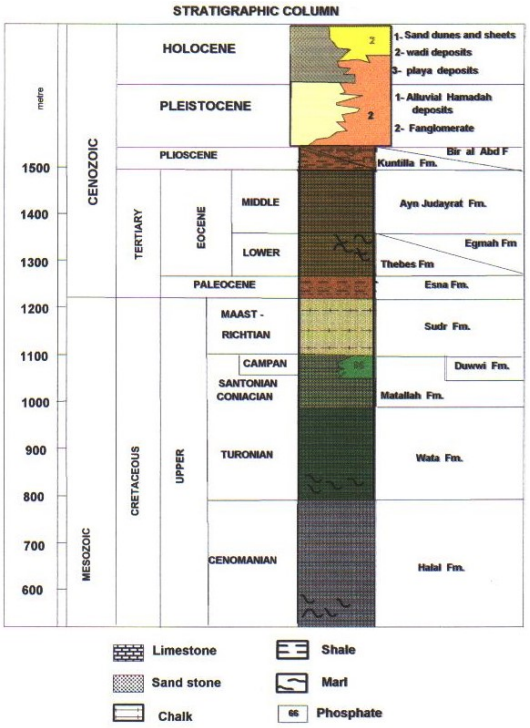

Figure 3. General Simplified Stratigraphic Column in the Study Area.

II. MATERIAL AND METHODS

The groundwater potentialities North Eastern Sinai was investigated based on a literature review and a regional survey, exploratory drillings and measuring water levels and sampling of groundwater samples from different depths. General geology, geomorphology, hydrology, hydrogeology, surface and groundwater quality, and aquifer hydraulic parameters were obtained from literature, the Ministry of Water Resources and Irrigation (MWRI) and from drilling companies' reports.

Wells were drilled for a 10 to 1025 m depths below ground surface. Aquifer sediments were collected and lithologically described. These data were also recorded in the drilling company well reports (RIGWA & DASCO). The well yield, depth to water level and transmissivity were measured. Water quality was monitored in production wells at 29 locations that are distributed on the study area and different aquifers. The sampling locations and distribution of wells are shown in figure 2. Water quality parameters included field parameters (pH,

Electric Conductivity EC/ total dissolved salts TDS) and major ions (Na, Ca, Mg, K, Cl, SO_4 and HCO_3). All analyses were done at the central laboratory of the Ministry of Water Resources and Irrigation.

III. RESULTS

Three aquifers were recognized in the study area based on their lithostrategraphy, hydrogeologic setting and water quality. These are: The Quaternary, Fracture Limestone and Lower Cretaceous Sandstone aquifers arranged respectively according to their importance. The distribution and characteristics of these aquifers is shown in figure 6 and the extraction rate (m3/day), number of wells changes in (El-Arish, Zewied, Rafah) are shown in Figure (7,8).

The Quaternary sediments cover most the area of study especially the central and northern parts where the thickness of the wadi deposits increase while they decrease in the southern part. The Quaternary aquifer in the area of study consists of three water bearing formations (zones); these are from top to bottom as follows:

Sand dunes Zone

It is coastal sand dunes parallel to the Mediterranean Sea and extends inland to a distance ranging from 2 to 10 km; it is detrital sand ranging in size from fine to medium grained sand. It extends along the coastal strip width increases toward the east, while it decreases toward the west. These sand dunes are considered the main source of recharge and at the same time the main passage of the surface runoff of the wadis main stream that originate from southern and eastern areas and move toward the north to feed the groundwater aquifer. The thickness of these sediments varying from 5 to 30m with total dissolved solids ranging from 500 to 1500 ppm, this aquifereous zone is considered the main source of drinking water in the area. It also used in irrigation especially during winter season by means of trenches.

Old Beach Aquiferous Zone

These deposits tapping the upper Pleistocene and composed of sand ranging in size from fine, medium to coarse grained intercalated with clay and silt in parts, the thickness of these deposits varying from 30 to 40 m, the water of this zone is more saline than the upper one which ranging from 1500 to 2500 ppm, these deposits extend underneath the sand dunes along the coastal plain and extends south ward some 7 to 10 km.

Calcareous Sandstone Aquiferous Zone

This zone is considered the main aquifer in the area of study it extends eastward to Ghaza and westward to El-Arish, it consists of calcareous sandstone containing shell fragments which is called kurkar and locally as El-Fajra. The thickness of this zone ranging from 5 to 25 m and reaches to about 60 m in some places, the thickness decreases toward the south to completely disappear at wadi El-Azariq area.

Generally, the Quaternary deposits decrease toward the south, where the Tertiary deposits began to appear which are represented by the carbonate rocks especially the limestone, consequently no Quaternary aquifer can be found between wadi El-Azariq in the north and El-Qusima in the south except at the main streams and tributaries of these wadis.

A number of sandy hills were found to the south of the old beach deposits, the elevation of these sandy hills reach to about 50-70 m above mean sea level, also salty sediments were found in the form of Sabkhas such as El-Sheikh Zuwyied Sabkha in the western part of the area of study it Takes an east-west direction with about 3 km long, 260 m wide and between 3-4 m above mean sea level, the salinity of these Sabkhas increases during summer season as a result of evaporation. Due to the field measurements a potentiometric surface map figure (2) and iso-salinity map figure (3) have been constructed, in addition to 25 water samples had been collected for chemical analysis.

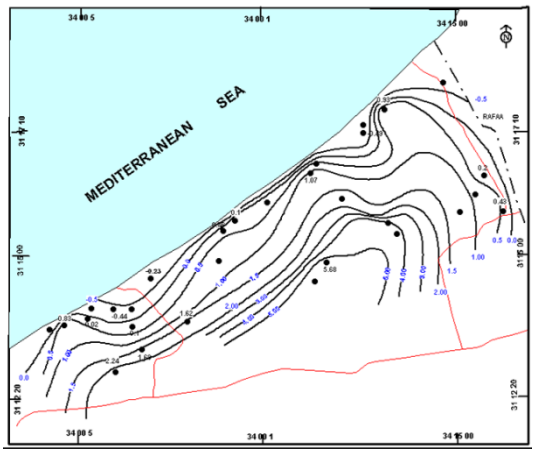

Figure 4. Potentiometric Map for the Quaternary Aquifer.

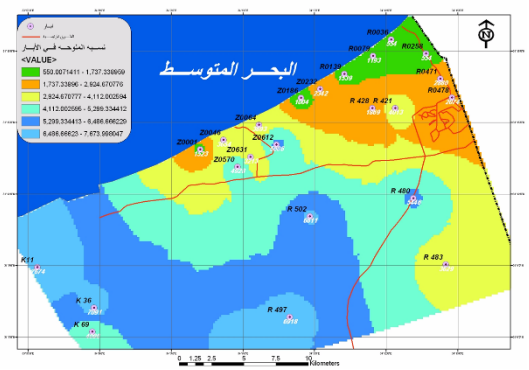

Figure 5. Salinity Map for the Quaternary Aquifer.

The Fracture Limestone Aquifer. This aquifer is considered one of the most important aquifer at the north east Sinai. It exists in the form of two zones. The first one is the lower Eocene age and the second is taped to the upper cretaceous. Generally the aquifer composed of dolomitic, chalky and fracture limestone with some stricks of shale and silt. The existence of the groundwater in this aquifer is highly affected by the geologic structures which control the direction, movement and quality. Therefore it is to difficult to evaluate the aquifer and led to more intensive studies.

Lower Eocene Limestone Aquifer

It represents the first zone of the fractured limestone which located at different locations and the following tested areas. El Qusaima, wadi El Amro, El Auga, Um Shihan, and Abu Awigela. The thickness of the aquifer attains about 300 m with total dissolved solids ranges between 3000 ppm at El Qusaima area and attains about 7000 ppm at the other areas as shown to table (1).

Table 1. Technical and Hydrogeological of some wells tapping the lower Eocene Aquifer

Well Name	Coordinates		Well depth (m)	Water Level (m) amsl	Q m3/hr	TDS ppm	T m2/day
	Lat	long					
ElQusima 1	30 41 15	34 20 10	90	272.45	12	5600	13.91
ElQusima 2	30 41 09	34 20 23	68	276	25	6000	-
ElQusima 3	30 40 15	34 20 15	78	268.89	7.5	6400	6.66
El Amro 2	30 52 39	34 21 50	62	-3	-	-	-

Upper Cretaceous Fractured Limestone Aquifer

The aquifer represented the second zone of the fractured limestone aquifer which is located at the following tested areas, El Auga, Um Shihan, and Abu Augila (1), (2). Its thickness attains about 900 m. from the different open hole tests carried out at the hole section we can differentiate the aquifer into two water bearing zones. The thickness of the upper zone attains about 600 m and contains saline water reaches more than 10.000 ppm while the lower zone is considered the most important one especially the area located south the investigated area. Table (2) shows the technical data obtained from the tested locations

Table 2. Wells Tapping Upper Cretaceous Aquifer

Well Name	Coordinates		Well depth	Water Level	Q m^3/hr	TDS ppm	T m^2/day
	Lat	long					

			(m)	(m) amsl			
Abu-Augila 1	30 50 51	33 06 56	1111	74	20	3966	1.2
Abu-Augila 1	30 10 00	34 07 00	1600	72	25	4396	1.2
Um Shihan	30 49 01	34 19 54	905	51.92	34	4750	579

The Lower Cretaceous Sandstone Aquifer. The lower cretaceous bearing formation is composed of ferruginous, vari-colored sandstone alternating with thin shale beds and common by Malaha formation.

This aquifer is considering the promising aquifer in middle and north middle Sinai due to its highly production and good water quality. The thickness range of about 200 to 250 m and increase gradually until reaches to more 400 m at Gebel El-Halal.

A Geophysical study have been carried out by Water Research Resources Institute (WRRI) at wadi Esram south the study area to test the lower cretaceous Aquifer and recommended to drill test hole with ±1100 m depth.

The water level ranges from 31 m (a.msl) at El-Grur, El-Sabha and Gaifi wells to 159 m at Arief El-Naqa well. Consequently the movement direction of the groundwater is from north east to north the study area.

From the analysis of the step drawdown and long duration pumping tests on the tested wells conducted by WRRI and general groundwater department (North Sinai) which shows a big variation at the transmissivity values ranges from 174 to 2046 m^3/day at El-Sabha and Gaifi wells respectively. The variation attributed to the facies changes and presence of some strikes of shale which decrease the transmissivity.

The salinity ranges from 2700 to 4000 ppm at El-Sabha well and reaches to 1500 ppm at El-Gaifi well south of the study area due to direct hydraulic connection between upper and lower cretaceous with direct rainfall recharge. Table (3) shows the Wells Tapping the Lower Cretaceous Aquifer.

Table 3. Wells Tapping the Lower Cretaceous Aquifer

Well Name	Coordinates		Well depth (m)	Water Level (m) amsl	Q m^3/hr	TDS ppm	T m^2/day
	Lat	Long					
Arif El-Naqa	34 27 40	30 18 38	902	159.5	50	3010	212
El-Grur	34 20 32	30 29 21	860	31.5	40	3969	1127
El-Gaifi	34 22 18	30 35 30	844	30.5	50	3461	2046
El-Sabha	34 25 17	30 43 37	900	32.5	45	2680	174

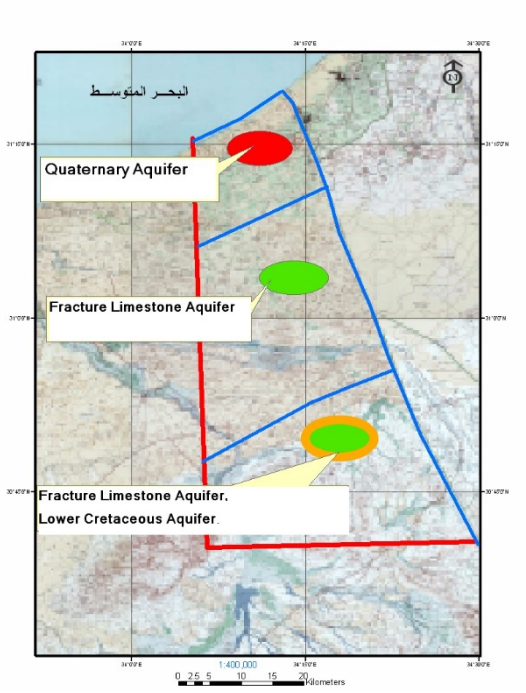

Figure 6. Distribution and characteristics of the different aquifers in the study area.

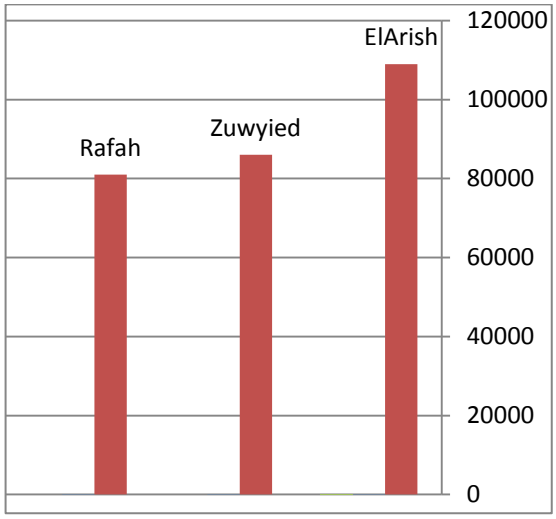

Figure 7. Extraction Rate Changes in (El-Arish, Zuwyied, Rafah) -2017

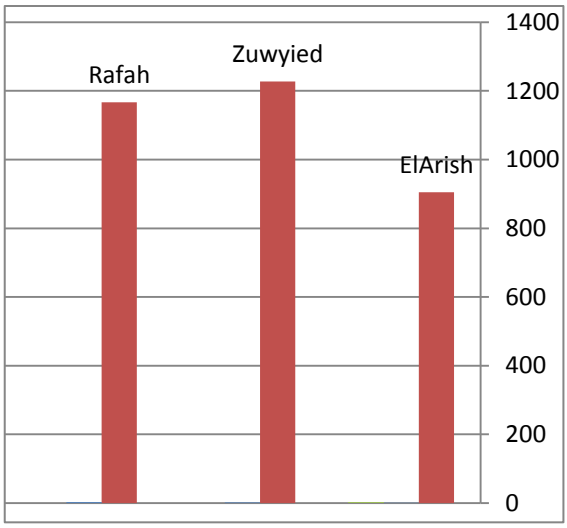

Figure 8. Number of Wells Changes in (El-Arish, Zuwyied, Rafah) – 2017

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