

The Hydrogeological conditions and characteristics of the groundwater occurrences in Ras Shukeir area, Suez Gulf, Egypt (Review)

Salah M. Ibrahim¹, Waheed M. Emam² and Wiame W.M. Emam³

1- Geology Department, Faculty of Science, An Shams Univ.

2,3- Zoology Department, Faculty of Science, Ain Shams Univ.

1- salaheldinmoussa@hotmail.com

2- Waheed.emam@yahoo.com

3- Dr_wiame2006@yahoo.com

Received: March 15, 2021

Accepted: April 20, 2021

ABSTRACT

Ras Shukeir area is one of the most important regions for petroleum activities in Egypt. It is south east Ras Gharib (30 km) and north to Hurghada (150 km). Its coastal area lies on the Suez Gulf from the east, while its western area is desert land. There are shortage of knowledge on the Hydrogeological conditions and characterless of the groundwater occurrences in Ras Shoukeir which are necessary for establishing new petroleum facilities there and to forecasting flash flood. Therefore this review is an attempt to collect the most available data to help decision makers for their future social and economic developmental projects in this area.

Climate of Ras Shukeir is a hot arid with dry and hot summer, whereas few sprinkles may occur in spring. The average annual temperature is 22.2°C, while the average precipitation is 5 mm. The foremost north-westerly winds are dominated.

No surface water supply is present at this region except that from wadis during rainfall which is very low. The freshwater supply is based mainly on the groundwater aquifer and desalination of sea water, where there are small salt marshes. The main characteristics of the groundwater known to exist in this area were discussed. Two main and distinctive types of groundwater according to its origin are found; the first is of purely meteoric origin and the other being formed during the different geological times (formation water). The latter is being highly saline and occurred on deep wells and mixed with minerals and sulphites. Water is good in winter after the rainfall in the ranges and unpleasantly salty in the summer or during rainless period. For normal drinking purposes, fresh water of salinity up to 1000 ppm can be used. Saline water, of salinity ranging from 1000 to 3000 ppm is used for limited irrigation in a sandy soil.

The courses of the hydrographic basins are filled with the Quaternary alluvial deposits which are formed of sand, gravel and boulder. Water depth in wells ranges between 0.5 and 3.2 m and the discharge ranges between 2 and 5 m³/day. Most deep hand-dug wells were established between 15 and 25 m in sand before reaching the water table, which is very close to or within the bed rock and obtaining a regular supply of between 10 and 50 m³ per day.

Keywords: Climate, groundwater, falsh flood, Ras Shukeir, Suez Gulf.

INTRODUCTION

Ras Shukeir is considered an important region for the oil production since 1966 (EGPC, 1996) in Egypt. It has many national, foreign, joint and private oil companies. It is a division belonging to Ras Gharib, Red sea governorate. Water is considered the chief environmental problem in Ras Shukeir area, where fresh water is a critical resource and is obtained through run-off after the scarce rainfall; however it is limited in quantity and non-existent in rainless years.

Run-off water from the mountains during winter rainy season resulted in some cases in some flash floods can reach the Suez gulf coast, causing damage in roads and constructions and contributed in recharging the groundwater aquifer system.

In the sandy floor of the wadis, water can be reached at depths of around 10 m, but in the fringes of coastal flats and sabkhas, the groundwater is usually brackish not suitable for human consumption, but some of it is drinkable for camels and other animals.

Currently, the supply of fresh water is based mainly on groundwater aquifer and desalination of sea water. With the increasing activities in oil industry and the consequent development projects in this area, there is an environmental threat of oil pollution to soil and groundwater as well as to the coastal and marine ecosystem. Most of the productivity of natural living systems is confined to the coastal strip, which is the area associated with human activities and environmental pressure.

METHODOLOGY

Data collection

Data used in this study was collected from the available published research articles especially on the nearby areas on the Suez gulf in addition to Hydrogeological Maps, reports, theses, Round Table Meeting, conferences, ..etc.

RESULTS AND DISCUSSION

1. Location

Ras Shukeir is at about 30 km south east Ras Gharib and about 130 km north Hurghada. It belongs to the governorate of the Red Sea. Its total area is about 11463.55 km². It has no local units (main and affiliated villages). There is an Oil and Gas Facility in Ras Shukeir belonging to the Egyptian General Petroleum Corporation (EGPC) with an airport. The coastal area of Ras Shukeir is located in the north Eastern Desert, Egypt, (28° 05' 56'' Lat., N and 33° 13' 26'' Long., E) on the western coast of the Gulf of Suez. The area can be reached by the coastal road extending from Suez to Halaib, where Ras Shukeir is located at 214 km south of Suez, and it is connected to the other towns on the Red Sea coast by the coastal main road (Fig. 1). Also, there are two new roads crossing the north Eastern Desert; one extends from Kattamiya, east of Cairo, to Ain Sukhna, and the other connects Sheikh Fadl in the Nile Valley to Ras Shukeir. With increasing oil fields, the area became one of the important oil producing provinces along the western coast of the Gulf of Suez.

The Hydrogeological conditions and characteristics of the groundwater occurrences in Ras Shukeir area, Suez Gulf, Egypt (Review)



Fig.1 : Location of Ras Shukeir area

2. Topography

The eastern sector of Ras Shukeir consists of relative flat areas with no significant hills. In the western part of the area the landscape becomes gradually hillier and consists of high and rugged igneous mountains which run parallel to, and at a short distance from the coast. These mountains are flanked to the north and west by an intensively dissected sedimentary plateau. The Red Sea hills do not form a continuous range, but rather a series of mountainous groups⁽¹⁾.

Ras Shukeir has the same characteristic features of the Eastern desert which are differ markedly from the rest of the Egyptian desert in that it is intensively dissected by valleys and ravines which all drain externally. Its wadis drain eastward to the Red Sea via numerous independent wadi systems. Yet, due to the arid climatic condition the extensive waterless tracts of land, it is far less inhospitable than any other area. Low precipitation caused dryness of land did not sustain soil development. The uppermost sediment in this area is characterized by depletion of fine material and hence enrichment in coarse materials due to wind erosion. The gravel and pebbles are often polished by wind. The gravel fraction is dominated by basalt and granite gravel with minor chert (flint). Since there is a lack of fine materials in the area for dune generation, the placement of the Aeolian deposits (wind derived) is in eroded ravines, at wadi beds and at vegetation. All placements have a low potential for growth and high potential for further erosion. The area is also covered by gypsum material with deposited thin sandstone beds and carbonate beds. Rock salt (halite) is not present.

3. Climate

Knowledge of the climatic conditions is important since they determine or affect the rainfall that represents a critical resource for fresh water or it may cause torrential flash floods. The terrestrial and marine climate influences many physical features which cause some impacts on the environment. Generally, the climate of Ras Shukeir area is semi-arid, characterized by hot dry summers, moderate winters and very little rainfall. The climatic data in this study was collected from the world meteorological weather organization and from Hurghada Weather Airport Station (the nearest weather station to Ras Shukeir). Ras Shukeir is considered to have a desert climate.

A- Temperature

The average maximum temperature in 30 years (1971-2000) is 46°C, while the average maximum temperature is 27.0°C. The mean minimum temperature is 18.74°C (Table 1).

Table 1. The average maximum and minimum temperatures, rainfall, relative humidity, and hours of sun roofs during the period 1971-2000 at Hurghada the nearest weather station to Ras Shukeir.

Month	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Av. Annual
Av. Highest Temp oC of	30 (86)	32 (90)	35 (95)	40 (104)	43 (109)	46 (115)	44 (111)	42 (108)	43 (109)	43 (109)	35 (95)	32 (90)	46 (115)
Av lowest Temp oC of	11 (52)	11.4 (52.5)	14 (57)	17.8 (64)	21.9 (71.4)	24.8 (76.6)	26.4 (79.5)	26.2 (79.2)	24.2 (75.6)	20.9 (69.6)	16.6 (61.9)	12.5 (54.5)	18.74 (65.73)
Av lowest low temp oC of	1 (34)	0 (32)	1 (34)	11 (52)	10 (50)	17 (63)	20 (68)	16 (61)	14 (57)	11 (52)	6 (43)	3 (37)	0 (32)
Av. Rain Fall mm inch	0.4 (0.016)	0.02 (0.0008)	0.3 (0.012)	1 (0.04)	0.04 (0.0016)	0 (0)	0 (0)	0 (0)	0 (0)	0.6 (0.024)	2 (0.08)	0.9 (0.035)	5.26 (0.2094)
Av RH%	48	46	46	43	42	41	45	46	48	53	51	51	46.67
Sun rise hours	279	290	310	300	341	360	403	372	330	310	270	279	3,844

Source: World Meteorological Organization (1971-2000)⁽²⁾.

The range of temperature was 7°C during January and 46°C in May 2016 and the mean monthly temperature was 26°C (Table 2, Fig. 2). The mean high temperatures reached 26 °C, while the average minimum temperatures was 21°C in 2016.

Table 2. The values of temperature, humidity, wind speed, rate of precipitation, visibility and pressure at sea level during the months of 2016 as recorded in the weather station in Hurghada International Airport⁽³⁾.

Parameter	Max	Avg	Min	Sum
Max Temperature	46°C	32 °C	17 °C	
Mean Temperature	32 °C	21 °C	7 °C	
Min Temperature	32 °C	21 °C	7 °C	
Heating Degree Days (Base 65)	10	1	0	199
Cooling Degree Days (Base 65)	60	15	0	5561
Growing Degree Days (Base 50)	75	30	5	10859
Dew Point	29 °C	11 °C	-22 °C	
Precipitation	40.9mm	0.1mm	0.0mm	40.89mm
Wind Speed	74km/h	19km/h	0km/h	

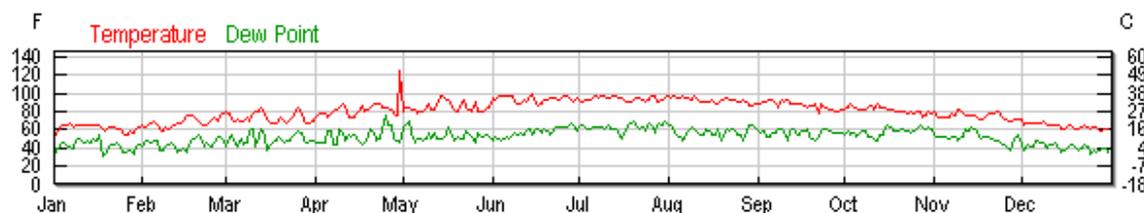


Fig. 2. Diagram of the monthly changes in temperatures for the year 2016 from the meteorological station measurements at Hurghada International Airport⁽³⁾.

The Hydrogeological conditions and characteristics of the groundwater occurrences in Ras Shukeir area, Suez Gulf, Egypt (Review)

On the other hand, the values of the maximum and minimum daily temperature Recorded at Ras Sh

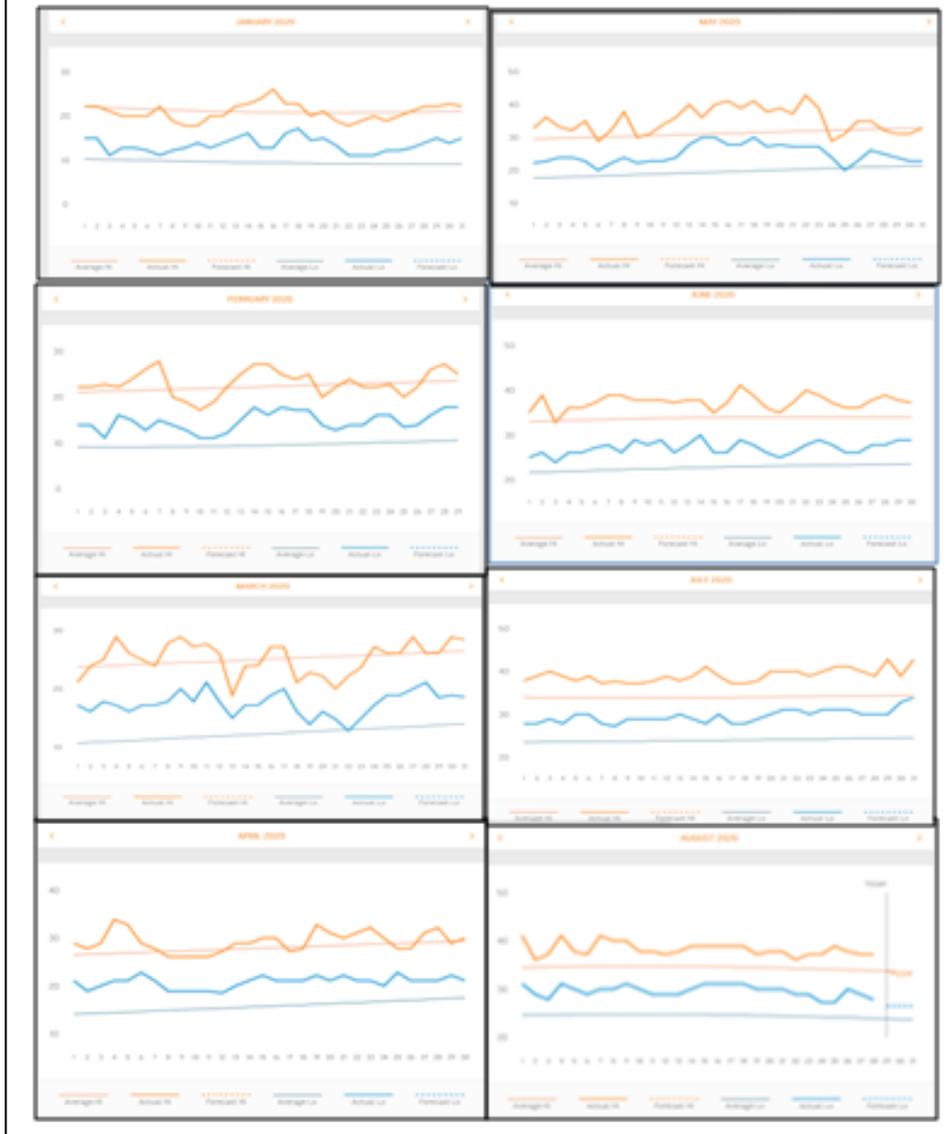


Fig. 3. The maximum and minimum daily temperature Recorded at Ras Shukeir during the period January–August 2020 . Source: ⁽³⁾

B-wind:

The highest wind speed recorded during 2016 at Hurghada weather station was 74 km/hr, with an average of 19 km/ hr (Table 2). From the study of the wind directions of Hurghada International Airport meteorological station, it is clear that the prevailing winds blowing on Ras Shukeir in the Red Sea Governorate are the northern or northeasterly winds in the summer and autumn or southwestern in winter (Figs. 4, 5,6).

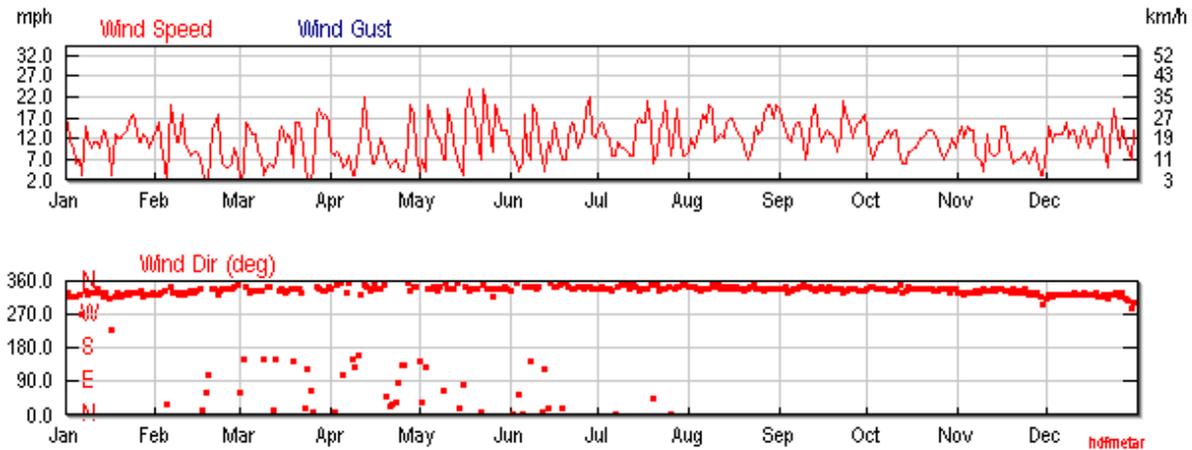


Fig. 4. Diagram showing the change in the average monthly wind speed and direction during 2016. (Source: Meteorological station measurements at Hurghada International Airport)⁽³⁾.



Fig. 5. Wind rose in Hurghada and some cities of the Red Sea Governorate Egypt (Source: GAENS)⁽⁴⁾.



Fig. 6. Wind direction in summer in the governorates of Egypt

C- The Relative Humidity:

The mean annual Relative Humidity % ranged from 41% to 51% with a total annual average equal 46.67% during the period 1971-2000 as shown in Table (1). The air humidity decreases sharply when the country is exposed to the Khamaseen winds during the period March and June which is hot, dry and dusty that leads to stirring fine sand with a degree that may obscure the vision, in addition to low humidity, and it is associated with depressions from the Mediterranean and North Africa, or associated with the occurrence of weather conditions that are accompanied by instability situations in spring.

The Hydrogeological conditions and characteristics of the groundwater occurrences in Ras Shukeir area, Suez Gulf, Egypt (Review)

C- Rainfall (Precipitation) and Evaporation:

Data taken from meteorological station at Hurghada International Airport indicated that the highest monthly total annual rain reached 40.89 mm during October 2016 and the mean lowest one was 0.1 mm in most months of the year (Table 2), while the total mean annual rainfall during the period 1971-2000 reached about 2 mm/year (Table 1). Meanwhile, the annual evaporation reaches 300 mm, and the maximum evaporation rate occurs in June and July reported during the period 1987-1996 at Suez Marine Meteorological Station (Hegazy and Effat)⁽⁵⁾.

D- Sea level pressure:

Figure (7) shows the monthly change in the atmospheric pressure in Hurghada. The average sea level pressure was 1012Pha during 2016.



Fig. 7. Diagram of sea level pressure distribution in different months of 2016 in Hurghada. (Source: Meteorological station measurements at Hurghada International Airport)⁽³⁾.

E- Sun shine:

Hegazy and Effat⁽⁵⁾ (2010) reported that the mean range of the monthly percent of sunshine hours was 65% to 70% in winter months and 80–85% in summer months as given by for the period 1987-1996 at Suez Marine Meteorological Station. Also, they mentioned that their investigated area including Ras Shukeir has a high solar radiation intensity ranging from 1.900 to 2.600 Wh/m²/year. The mean sun shine during the period 1971-2000 at Hurghada the nearest weather station to Ras Shukeir was 320.33hr/month (Table 1).

4. Geomorphologic and Geologic features:

4.1 The geomorphic features:

The eastern desert including the Red Sea region has specific geomorphologic units (Fig. 8). The major parts of them are structural plateau and ridges that underlain by rugged crystalline. The south eastern part of the eastern desert is characterized by structural plains, underlain mostly by sandstone. The north coastal plains of the eastern desert are mainly underlain by beach sand and lagoonal mud, while the southern part underlain by stony and reefal raised beaches. On the other hand, the basement ridge of the eastern desert underlain by fractured hard igneous and metamorphic rocks and has 1000m mean elevation above the mean sea level and is considered as the main watershed area in the direction of the Red Sea⁽⁶⁾.

The beach and shoreline of the Red Sea coastal plain in Egypt vary from place to place in width, sediments, and topography. Along the west side of Suez gulf the coastal plain is a narrow strip of land, only few tens meters in width except where the side western valleys (wadies) open into the Gulf and reach 30km in Ras Shukeir plain.

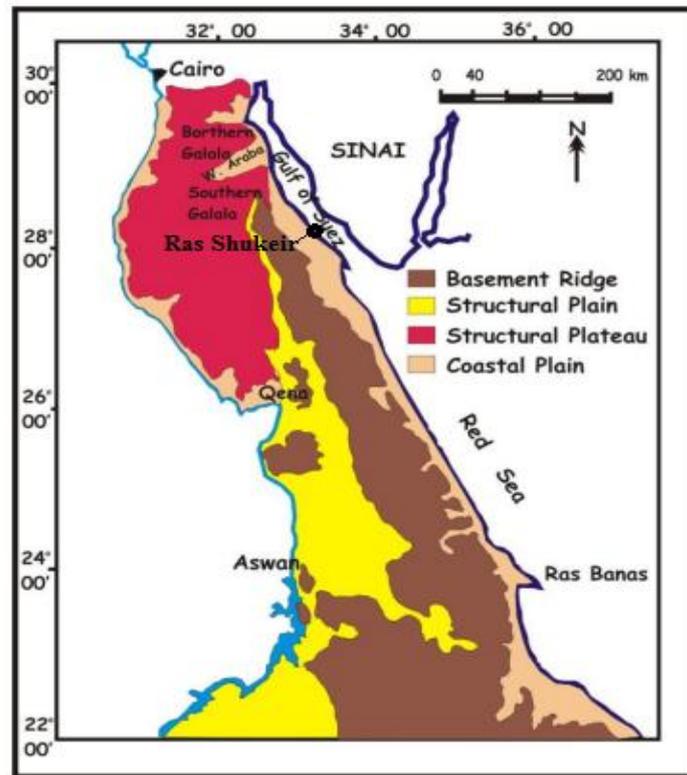


Fig. 8. Generalized geomorphological map of the Eastern desert. Extracted from Landsat TM image after Elewa)⁽⁶⁾.

4.1.1 Regional geomorphology

Ras Shukeir area as a part of Ras Gharib has three main geomorphologic units; mountainous terrain, pediment and coastal plain from, west to east^(5,7).

a- Mountainous terrain

This constitutes a part of the northern tip of the Red sea hills in the northern eastern desert. It is formed of high-altitude belt of basement rocks that extending parallel to the coast of Suez gulf with several prominent high peaks like Gebel Gharib (1745 m), Gebel Abu Khashaba (1455 m), Gebel Samr El-Abd (1068 m) and Gebel Samr El-Qaa (893 m). This mountainous terrain is cut by several deep and steep dendrite and reticulated drainage lines that are mostly controlled by faults and fractures.

b- Pediment plain

It includes the low-lying plain surface land near the feet of the terrain that gently sloping eastward, and is covered by cobbles, gravels and debris of rocks. Besides, there are small rocky hills that scattered within this pediment. There are shallow bifurcated drainage lines that passing through the pediment, with wide bottom and the flow of their water is under the influence of gravity and general slope eastwardly to the Suez gulf.

b- Coastal plain

Ras Shukeir area has a relatively wide coastal plain in comparison to other areas along the Suez gulf and Red Sea. Its flat surface is covered by sands and gravels, with some sabkha and saline flats in low areas. The drainage lines in this coastal plain is shallow wide with braided branches ended by deltas at the outlets of the main wadis like Wadi Abu Had; Wadi

The Hydrogeological conditions and characteristics of the groundwater occurrences in Ras Shukeir area, Suez Gulf, Egypt (Review)

El-Darb; Wadi El-Khariem; Wadi Abu Khashaba and Wadi Um Yusr. Water from these wadis is drained to the Suez Gulf away from the oil reserving tanks and facilities at Ras Gharib.

4.2. Geologic Outline

Ras Shukeir area as a part of Ras Garb is located within a highly tectonized structural zone, trending from Gebel El-Zeit ridge parallel to the western coast of the Suez Gulf and extending further to the north⁽⁸⁾. The exposed rock units in this area and its surroundings are represented by various lithological associations ranging in age from Quaternary to Precambrian.

At the eastern side of the project area, Pliocene marine beds of the Red sea are met. A detailed description of the exposed rock units will be addressed from old to young through the following description.

a- Carboniferous rocks

The exposed rocks belonging to the Upper Carboniferous age and they are essentially constituted of clastic sedimentary rocks (argillaceous and arenaceous sandstone) beds with some limestone- rich horizons.

b- Cretaceous Deposits

These deposits are well exposed just to the west and North West of the site location and constitute the lower part of the northern Galala plateau. Both the Lower Cretaceous clastic and the marine Upper Cretaceous rocks of the Cenomanian-Turonian are exposed in the studied section. Field investigation of the studied succession led to recognition of three rock units. They are the oldest deposits exposed in the location site where the Peleozoic and Carboniferous deposits are exposed completely outside the location to the south and southwest.

c- Upper Cretaceous Deposits

These are mainly composed of intercalating beds of shale, carbonate and chalk. These rocks are not recognized at site location where the lower Cretaceous clastics along the scarp of northern Galala plateau to the north west of the area can be found.

d- Quaternary Deposits

These cover almost all the area and are formed of sand, gravel, clay, sand dunes, aeolian sand and sand accumulation. These sediments cover the most considerable part of the area. They are mostly composed of clastic sediments of various textures ranging from silt to boulder. Wadi sediments comprise different particles of gravel, sand, and silt which are present in the main courses of the wadis. Ras Shuker area is dominated by Quaternary alluvial deposits derived from erosion within the Red Sea Crystalline Mountains towards the west. Materials are transported in flash floods and in wadis. The wadis are relative wide in most of the area but towards west they are confined and hence, in the western part, hills of gypsum and layers of weak sandstone protrude the cover of wadi sands and gravel. The gypsum is presumably of Miocene age and covered by Pliocene sandstone dipping east.

The mountainous terrain in the western side of Ras Shukeir area is built up of more or less coherently high ridges trending parallel to the Gulf coast and interrupted by a number of detached masses and peaks⁽⁵⁾. It is composed essentially of crystalline igneous and metamorphic basement rocks of Precambrian age, dominated by granitoid rocks and metavolcanics. Subordinate Upper Cretaceous sediments and Miocene evaporates are

recorded in some detached outcrops. In some places, Pliocene deposits unconformably overlie Upper Cretaceous sediments. They are composed mainly of gravel, sand, sandstone and shale with limestone intercalations. On the other hand, at the feet of these mountains, the low-lying terrain of pediment is gently sloping eastwardly and it is covered by scattered outcrops of low-lying beds of Upper Cretaceous, Miocene and Pliocene sediments. The coastal belt exhibits a sedimentary sequence of Quaternary deposits towards the east, which are mostly formed of sands and gravels, sabkhas and saline flats, and alluvial deposits in the wadis crossing the area.

The boundary between the low-lying terrain and the mountainous terrain is distinct and runs generally along NNW– SSE trending normal faults. Moreover, fractures are the dominant structures that crossing various rock formations in Ras Shukeir area. The density, persistence, extensions and directions of these fractures are variable. However, the dominant fracture sets are those striking mainly in the NE–SW (N 30–40 E), NNW–SSE (N 20–30W) and NNE–SSW (N 10–20 E) directions.

5. Groundwater aquifer systems and their potential

5.1 Precambrian Fractured Basement Complex

According to REGWA (1991) (Table 3), the fractured basement water bearing rocks are found in Wadi Gharib and Wadi Kharm Ayun. The water bearing rock is the fractured granite. In Wadi Abu Had, the water table is available at a depth ranging between 46 and 76 m from the ground surface⁽¹⁰⁾. The total salinity varies between 3186 and 3586 ppm. The recharge to Abu Had granites takes place through major NW-SE and NE-SW fractures dissecting the bounding granitic high lands.

The groundwater in the nearby region (Ras Gharib) is locally detected in the fractured Precambrian rocks of Gebel Gharib. The water salinity ranges from 736 to 2000 ppm. The discharge is very small and exhibits seasonal variations. The water is used by Bedouins for drinking. The recharge takes place through the fracture systems which strike NW-SE and NE-SW.

Table (3): Hydrogeological characteristics of the water points in fractured basement aquifers in Safaga-Ras Gharib area, (REGWA)⁽⁹⁾

Water-point No.	Waterpoint Name	Waterpoint Type	Water Bearing Fm.	Depth to Water (m)	Water Salinity (ppm)	Aquifer Type
3	Wadi Gharib G33	Hand dug	Weathered granite	-	736	Free Water Table
4	Wadi KharmAyun G34	Hand dug	Weathered granite	4.00	2000	Free Water Table

5.2 Clastic group of sediments (Nubia Sandstones) (Carboniferous-Upper Cretaceous?)

The Lower Cretaceous water bearing formation of Nubia Sandstone (90 m. thick) was tapped by a well in El-Sukhna locality at a depth of about 1230 m. The water bearing formations of Lower Cretaceous age are consisting of Nubia Sandstone and clays are tapped by many wells in the Gulf of Suez region. The Lower Cretaceous sandstone is recorded as water bearing formation in two main areas in the Gulf of Suez; Wadi Araba and Wadi Dara. In Dara area, the groundwater of the studied aquifer occurs under confined and unconfined conditions. The western high mountainous terrain and the exposed Nubia Sandstone to the west represent the watershed area. Dara Oasis is located on the downthrown side eastward of

The Hydrogeological conditions and characteristics of the groundwater occurrences in Ras Shukeir area, Suez Gulf, Egypt (Review)

a fault trending NNW-SSE. The confining conditions are developed, where a succession of 160 m of evaporates, shale and limestone of Cenomanian age overlies the Lower Cretaceous sandstone. The aquifer attains a maximum thickness of 321 m. The groundwater is of artesian flowing type and the unconfined conditions are recorded west of the above mentioned fault^(10,11). Due to the differences in local geologic conditions (structure and stratigraphic succession), the groundwater is encountered at variable depths (74-170 m). This depth increases southward due to the effect of a set of faults trending E-W and has its downthrown sides southward. Accordingly, the groundwater rises 1.42 and 2.75 m above the ground surface. The water salinities range between 2763.9 ppm and 3417.2 ppm revealing an increase eastward. The hydraulic parameters of the unconfined part (Dara Plain) indicate a transmissivity value⁽¹⁰⁾ reaching 293.97 m²/day and storativity of 8.78×10^{-3} (Nasr, 1990). In the oasis, the hydraulic parameters⁽¹²⁾ were calculated to be $T = 1600$ m²/day and $S = 0.004$.

5.3 Fractured carbonate group. (Cretaceous-Paleogene)

5.3.1 Upper Cretaceous shally formations

These formations may be considered globally impervious. They form an aquiclude, which confines the underlying Nubian aquifer. The latter may be tapped by deep boreholes only (300 to 700 m), and the water level will be relatively deep, given the relatively high relief of the Upper Cretaceous outcrops compared to that of the Nubian. Small water resources, probably drained from the overlying limestones, can however be tapped at shallow depths.

5.3.2 Upper Cretaceous limestones and sandstones formations

The Cretaceous rocks comprise the high groundwater potentiality in the Gulf of Suez area. The groundwater is available from non-clastics (carbonates) as well as clastics (sandstone). The Campanian limestone was detected as water bearing along the eastern scarp of the Southern Galala from which it receives its recharge (El-Dakhel Springs, no. 31). It yields from 3 to 5 m³/day. The water occurs under unconfined conditions. The water salinity is 1430 ppm reflecting its high elevation (+840 m). The Santonian chalky limestone aquifer is detected through gravity springs along the northern scarp of the Southern Galala (Saint Anthony Springs nos. 17 and 18). They are recharged from the rainfall through the connected open fractures⁽¹⁴⁾ (N60°E-S60W and NNE-SSW). They yield about 120 m³/day, reflecting a wide watershed area (15000 km²) and high fracture density.

The Turonian limestone is recorded as a water bearing formation along the scarps of El-Galala Plateau. The faults bounding Wadi Araba from its northern and southern sides control the hydrogeologic condition of the existing water points (no. 4, 5, 6, 8, 19, 20 and 30). These faults brought the impervious strata against the fractured limestone. These strata prevent the groundwater flow to Wadi Araba⁽¹³⁾. They are recharged from the rainfall through open connected fractures. The water salinity ranges from 1124 to 2369 ppm. This variation is mainly attributed to the difference in location with regard to replenishment area, altitude, and size of recharging area and the nature of dissecting fractures⁽¹¹⁾ (DRC, 2002).

The Cenomanian marl and limestone are recorded as water bearing formations in the area of St. Anthony Monastery along the eastern scarp of Southern Galala. They occur as gravity springs and free water table conditions⁽¹³⁾. The springs are of acceptable quality water (1600 ppm), yielding 100 m³/day, and are surrounded by small oases.

5.4 Neogene sediments (on coastal belt)

These are mainly represented by the Miocene succession on the Red Sea-Gulf of Suez coastal belt. They are variable in thickness. The evaporates faces predominate the upper part of the succession (South Gharib and Belayeim Formations) and clastic sediments predominate the lower portion (Kareem and Rudeis Formations). Therefore, saline groundwater is expected in the upper formations and fresh to brackish groundwater in the lower ones. Generally, these aquifers are of limited productivity and poor water quality. The Middle Miocene limestone and Lower Miocene sandstone represent the Miocene water bearing rocks. One spring and three wells represent these aquifers⁽¹⁴⁾. The Middle Miocene reefal limestone is recorded as water bearing formation at the southern part of the Gulf of Suez. It attains a thickness of 100 m (Abu Sha'ar Well, No. 31). This formation rests unconformably on the basement rocks. It is recharged laterally through the western nearby fractured basement rocks and also vertically along the fractures of the exposures of the water bearing limestone. The water occurs under confined conditions, where the shale and evaporites form the confining beds⁽¹⁴⁾. The water level is + 29 m and the water salinity reach 7123.95 ppm. The high salinity is attributed to the leaching of the intercalated shale and evaporites surrounding the water bearing rocks.

On the other hand, the Middle Miocene sandstone is detected as water bearing formation at the Northern Galala. The groundwater is issued from the undifferentiated Miocene sandstone along a NW-SE fault at the northeastern corner of the Northern Galala as spring (Ain Sukhna). The groundwater of this spring occurs under confined conditions and it has a high salinity⁽¹⁵⁾ (8173 ppm) (Abdel Samei and Elewa, 2005) and standard temperature (33°C). This reflects that the source of this water is paleowater from deep aquifers^(15,16).

The Lower Miocene white sandstone (Rudeis Formation) aquifer is considered as the main source of Ras Gharib and Ras Shukeir poultry water. It is composed of sand and sandstone, calcareous in some part. The thickness of the Rudeis Formation varies from 192 to 325 m in Shagar Field and from 36 m to 246.5 m in Shukeir Field. This aquifer has a maximum thickness of 185 m and the water occurs under confined conditions⁽¹⁰⁾. The water bearing formation is overlain by a thick section of impervious shale and evaporites (475 m thick). The recharge of this aquifer is mainly from the western main watershed area along the basement rocks (Gebel Gharib). The piezometric level varies from +17.5 to +55.7 m (Shagar Field) and from + 42.98 to +55.48 m (Ras Shukeir Field). The water salinity ranges between 1700 and 3400 ppm. The water salinity increases to the northwest in Shukeir Field and southeast directions in Shagar Field and the origin is meteoric.

5. Quaternary alluvial deposits. (*Pleistocene to Recent*)

These deposits are widely distributed in the area of Ras Shukeir. They cover most of the wadis floors, alluvial fans, structural depressions, and rugged depressions. Alluvial deposits may be subdivided into two groups:

A. Wadi fillings: They spread in the rugged depressions, in alluvial fans and in alluvial courses. They are extremely variable in thicknesses. They overlie both the sedimentary and crystalline rocks. In El-Sukhna area, they reach a thickness of 80 m and overlie the carbonate group of sediments (Eocene). They exhibit a greater thickness in the wadis debouching towards the Nile Valley and some major deltas of the Red Sea drainage basins.

B. Coral reefs and beach deposits:

Sometimes these reefs contain thin layers of perched fresh groundwater which is expected to be formed on account of infiltration of surface water from coastal wadis debouching to the Red Sea direction. The Quaternary aquifer is developed at the deltaic areas

The Hydrogeological conditions and characteristics of the groundwater occurrences in Ras Shukeir area, Suez Gulf, Egypt (Review)

of the main wadis which cross the coastal plains. The water exists under phreatic conditions, nearly at sea level. The Quaternary alluvial deposits are formed of sand, gravel and boulder filling the courses of the hydrographic basins. They have lateral and vertical variations in lithological composition according to the dominated rock exposures in the hydrographic basins. The alluvial deposits are detected as water bearing formation by three wells, two in Wadi Araba, and one in Abu Sunduq⁽¹³⁾. The recharge is mainly from direct infiltration and the underlying shales prevent its downward percolation. The wells have depth to water ranges between 0.5 and 3.21 m and the discharge ranges between 2 and 5 m³/day. The water salinity of Wadi Araba wells is remarkably high (16210 to 30082 ppm) due to the stagnancy, evaporation, leaching processes and salt-water intrusion. However, most deep hand-dug wells have had to be dug through between 15 and 25 m of sand before reaching the water table, which is very close to or within the bed rock and obtaining a regular supply of between 10 and 50 m³ per day.

The Quaternary groundwater aquifer system in Ain Sukhna area occurs under different conditions reflecting the remarkable structural, lithologic and topographic variations. Generally, the water levels vary from west and northwest to east and southwest. The groundwater level decreases gradually from more than 100 m (towards the upstream of wadis) to few centimetres above the sea level near to the shoreline. This low level of the groundwater is due to the high permeability in the coastal plain and low relief in the delta of the drainage basins. The water level at the area of the Miocene aquifer in the northern parts of Ain Sukhna area is higher than that of the Quaternary aquifer areas. Due to that, the Miocene aquifer is the source of recharge to the Quaternary aquifer. At the southern part of the study area, the water level is higher than the water level in the middle parts, which is due to the higher ground level beside El Galala El Baharyia Plateau. The water level map constructed for the Quaternary aquifer during March 2004 reveals that the water levels in the Quaternary aquifer are regionally decreasing from the west and northwest to the east and southeast. But, there are minor directions from south to north and from north to south at Wadi Ghweibba and Wadi Badaa, respectively⁽¹⁵⁾. Water harvesting is a very important and urgent need for the major wadis of the Gulf of Suez to develop the groundwater reserves in the Quaternary aquifer system.

6. Surface and ground water resources:

There is no surface water in Ras Shukeir. In absence of reliable statistics, surface runoff reaching up to this area is expected to be seldom. Heavy rains in the mountains can cause flash floods in the major Wadis. There is no statistical evidence on the occurrence interval of such rains. From inhabitants information received it is guessed that it should be of an order of once in 10 years.

Groundwater in that zone can be differentiated into Fissure water of the weathering zone, which is confined to igneous, metamorphic and sedimentary rocks (only little water that can be stored and collected during rainfall and that can travel over long distances through fissures). There are two origins of groundwater; purely meteoric origin and the other being formed during the different geological times, the so-called formation water. The formation is being highly saline and occurred on deep wells and mixed with minerals, sulphites. While, that of meteoric origin making its entry at the outcrops of permeable formations, percolated down faults and takes varying amounts of salts with solutions. The result is the formation of shallow and deep saline water accumulations.

Groundwater at the alluvial fill of the Wadis (recharged from occasional rainfalls in the mountains and draining fissure water). Water is pumped from deep zones, more than 100 m below the surface out of Nubian sandstone zones, which are recharged from the existing

watersheds in the region. Groundwater in the shallow alluvial aquifers of the Eastern Desert and in the karstified Eocene limestone aquifers underlying the alluvial aquifers could provide an alternative renewable water resource. In the Eastern Desert, rainfall is collected as surface runoff through networks of alluvial channels in the main valleys and as groundwater in the shallow alluvial and limestone fractured aquifers flooring the main valleys. Groundwater pumping takes place in Ras Shukeir by EGPC and GUPCO, both being petrol companies indicated that this groundwater is slightly saline and it is not suitable for drinking.

6.1 Occurrence and Distribution of Water Resources:

The extent of water supply depends largely on the direct rainfall, as much of the water occurs in rock-Poole in the upper mountain-valleys. Water-Poole are abundant and of long standing in the central hills. The valleys draining from them will have good underground water supplies at their heads, gradually diminishing in quantity and increasing in salinity as we pass eastwards to the Gulf of Suez. Generally, in this hilly regions composed of igneous and metamorphic and sedimentary rocks, wells in the valleys are frequent. Groundwater Nubian Sandstone is the main water bearing formation in the area, but information on its properties is scarce. The small number of drilled wells in the area shows a piezometric water level starting at 120 m up to 375 m below ground level with salinity range within 1,000-10,000 ppm.

6.2 Flash Flood:

Ras Shukeir area usually suffered and threatens by the main natural hazards; flash flood and earthquake. The climate of the Red Sea and Gulf of Suez is characterized by aridity typified by very low rainfall, high evaporation rate and high summer temperature. Nevertheless, the region is occasionally subjected to heavy rainstorms that commonly followed up by floods. These may cause disastrous impacts on life, roads and settlements. The system of natural drainage of the area is remarkably simple, but little rain, as is well known, falls in central and southern portions. The rain-channels are dry during the greater part of the year and vary in length according to the season.

Generally, the torrents of terrible floods were observed during November and December, 1932 and in December 1959, in the area from Safaga to Ras Banas, the discharge of rain was estimated at 500 cubic meters per second but the second torrent is least destructive action⁽¹⁷⁾.

The drainage network is well-developed; variable dense and high integrated. Gradient is commonly steep particularly in the upper reaches and tends to be gentler at the foot slopes of the mountains and pediment and gentle at the coastal plain where local fans are formed. According to Yehia *et al.*⁽¹⁸⁾ the main basins / catchment areas in Ras Garib and Hurghada including Ras Shukeir area from north to south include Wadi Abu-Had, Wadi Dara, Wadi El-Darb, Wadi El-Khreim, Wadi Abu Khashaba and Wadi Um Yusr. The hydrological parameters of the drainage in area of Ras Gharib including Ras Shukeir was given by NARSS⁽⁷⁾ and Hegazy and Effat⁽⁵⁾ as shown in Table (3).

Table 3. Some hydrological characteristics and flash flood hazard assessment of the man drainage basins in Ras Gharib area (after NARSS, 1977) ⁽⁷⁾.

No.	Drainage Basin Characteristic	Wadi Abu Had	Wadi El-Darb	Wadi El-Khreim	Wadi Abu Khashaba	Wadi Um Yusr
1	Area (Km ²)	1089.9	186.4	304	149.7	14.3
2	No. Of drainage lines (N)	5280	891	1553	448	66
3	Total length of drainage lines (Km)	3828.2	762.9	1290	385	134.3
4	Drainage density (K/Km ²)	4.9	4.78	5.11	3	4.6
5	Drainage frequency (N/Km ²)	3.98	3.8	4.2	3.25	3.88
6	Risk assessment	High	Moderate	Moderate	Moderate	Low

The Hydrogeological conditions and characteristics of the groundwater occurrences in Ras Shukeir area, Suez Gulf, Egypt (Review)

Surface Runoff Modeling:

The model construction involved extraction of geomorphologic and lithologic information from Landsat thematic mapper (TM) scenes and digital terrain elevation data (DTED) to enable estimates to be made for initial loss, recharge rate through transmission loss, and runoff at the watershed's outlets. No sign of surface water was observed in the project area except for some traces of wadi drains. Since there were no studies on the runoff depths at Ras Shukeir, the available data at Ras Gharib obtained by Hesham *et al.*⁽¹⁹⁾ by applying the SCS model is used. The runoff depths at Ras Gharib estimated were 19.86, 8.00, 2.32, and 0.06 mm for the return periods 100, 50, 25, and 10 years, respectively whereas the total surface runoff volumes reached the Ras Gharib area was estimated as 34.78, 14.02, 4.07, and 0.11 Mm³, respectively for the selected return periods. Also, the total groundwater recharge volumes for the selected return periods are 58.16, 31.34, 18.14, 3.18 million m³, respectively.

Floods:

In order to manage and sustain the current and future water resources, understanding of floods is required for water resources management⁽²⁰⁾. According to a recent report on soil by the REGWA⁽⁹⁾, Ras Shukeir area is classified as a high risk region of flood occurrence in 2011. However, based on subsequent investigations in 2012, the site of petroleum facilities layout is at a greater distance from flood prone area. Petroleum companies report high water pressure in wells drilled in the Nubian sandstone and recharged from the existing watersheds in this region. The wadi system occupies most of the Eastern Desert, consists mainly of alluvial gravels and sands, which normally have a high storage capacity. However, limited size and reliability of supplies cause variation of storage from season to season and year to year resulting in a relatively moderate storage capacity. In addition, there are also likely to be runoff losses to the Red Sea. However, this is considered an inexpensive water source and therefore very valuable for the nearby small communities. Some literature reviews⁽²¹⁾ indicated that the saturated thickness is 200-33 m below surface and the transmissivity is 209 m²/day.

The hydrology and drainage basins have been studied in Suez gulf area including Ras Gharib and Hurghada by NARSS⁽²²⁻²⁷⁾ where Ras Shukeir. Is located between them. The surface drainage network in this area forms some large drainage basins namely, from north to south: Wadi Abu Had; Wadi El-Darb; Wadi El-Khareim; Wadi Abu Khashaba and Wadi Um Yusr. All of these wadis are draining eastwardly to the Gulf of Suez. This is in addition to the areas in between the outlets of these main wadis, which include some small short wadis, especially between Wadi Abu Had and Wadi El-Darb. There are two small round hills of 50–60 m elevations, draining by some short wadis flowing towards Ras Gharib airport and the surrounding urban areas; however these are far from Ras Shukier. The drainage pattern in this region is greatly affected by the prevailing trends of geological structures, where many parts of wadi lines are controlled by faults and fractures particularly of the ENE and NNW trends. Also, bends in some wadis are mostly found at the intersection of major fractures.

At Ras Shukeir the Pre-Cambrian basement complex aquifer is predominated. Generally, this rock is impermeable; however, aquifers could occur where weathered rock and extensive fracturing systems exist. This aquifer is recharged mainly by small quantities of infiltrating rainwater and flash flood water. The higher aquifer transmissivity and yielding zones are characterized by highly fractured and hydraulically connected systems. Occasionally, alluvial deposits are found in shallow wadis above or adjacent to the basement rock and at the deltaic areas of the main wadis. However, wadi tributaries drain the watershed area of the basement rock. The alluvium deposits form a local aquifer, with shallow to

moderate depths of 0–30 m and 30–100 m, respectively. The shallow aquifers are located in the coastal areas and are replenished mostly by rainfall and surface water from flood.

Ground water in the shallow alluvial aquifers could provide an alternative renewable water resource. In Ras Shukeir, rainfall is collected as surface runoff through networks of alluvial channels in the main valleys and as ground water in the shallow alluvial and limestone fractured aquifers flooring the main valleys

5. Environmental hazards:

In 1966, the first oil discovery was made in Ras Shukeir area, followed by several others, and the area is considered one of the most prolific petroleum province in the Suez Gulf. Over the last three decades, the workers in petroleum field increased and reached more than 4000 and number and capacity of oil tanks and facilities increased in the same area. Also, the indirect activities related to Petroleum production also increased. Currently, there is a threat of pollution resulting from these activities, particularly oil pollution, in addition to the impacts of flash floods that occur after occasional heavy rain storm causing disastrous hazards on roads and settlements especially at Gharib city (30km north Ras Shukeir). Besides, there is a threat of oil pollution resulting from these activities.

Flash-flood hazards

In the eastern desert flash floods became more frequent and causing life losses and significant infrastructure damages during the last five decades⁽²⁸⁾. In this region the flash floods occur once or twice per year causing discharging of water in wadis (valleys) towards the Red Sea or the Nile River^(29,30). In Gulf of Suez area, there are five main hydrographic basins, namely Wadi Abu Had, Wadi El-Darb, wadi El-Khreim, Wadi Abu Khashaba and Wadi Um Yusr. From the analysis and interpretation of Landsat ETM+ false-color composite images (with 30 m resolution), SRTM DEM data and topographic maps (scale 1:50,000), the drainage networks and boundaries of drainage basins have been accurately delineated. Measurements and statistical analysis of the extracted drainage pattern lead to the determination of geomorphometric parameters of the drainage in Ras Shukeir area.

Wadi system and flash floods Wadis, representing water courses after rainfall, are important arteries for fresh water in the study area. However, during periods of torrential rainfall, wadis can lead to flash floods and result in major damage. Hefny⁽³¹⁾ determined the risk factors of wadis, as having the characteristics of high, medium and low risk areas. During floods, wadis also bring down sediments to low land and coastal areas. This can be damaging to the physical infrastructures and human settlements. Also, heavy sediment loads on coastal systems are harmful to coral reefs and other photosynthetic communities, such as coastal vegetation. These ecosystems stabilize shorelines and help prevent erosion. On the other hand, the nutrient input through wadis is beneficial for sea grasses and consequently to the production of fish associated with these ecosystems. Any future large scale management of wadi systems could have direct implications to human settlements and coastal systems.

The flash floods of November 1996 caused some damages in the coastal road, particularly at the Km 30 along Zaafarana – Ras Gharib Road⁽⁷⁾. It is worthy to notice that the main wadis, crossing the area eastwardly to the Gulf of Suez, have a direct influence on the roads, settlements and other human activities in the coastal zone. The hazard probability varies for the different basins according to their morphometric parameters, particularly the drainage frequency, density and bifurcation ratio. This is in addition to the basin area, slope, amount and velocity of runoff water flowing through the basin. The basins outlet delineated from the SRTM DEM revealed that three basins can affect the coastal road and the surrounding settlements located on the wadi mouth, whereas one of these basins is draining

The Hydrogeological conditions and characteristics of the groundwater occurrences in Ras Shukeir area, Suez Gulf, Egypt (Review)

into the main water body of the area (wet sabkha). This means that the water ponds are essential for reducing the risk of flash flood hazard threatening its outlet.

Generally the hazard effect of flash floods on Ras Shukeir are considered very low compared to Ras Gharib city and the nearby areas along the Egyptian Red Sea Coast^(28,32,33).

CONCLUSIONS

The supply of fresh water is based mainly on groundwater aquifer and desalination of sea water, where there are small salt marshes at Ras Shukeir. The main characteristics of the groundwater known to exist in the area under consideration are only pointed out. Two essential and distinctive types of groundwater are present, one type of purely meteoric origin and the other being formed during the different geological times, the so-called formation water. The formation is being highly saline and occurred on deep wells and mixed with minerals, sulphites.

The water of meteoric origin making its entry at the outcrops of permeable formations, percolated down faults and takes varying amounts of salts with solutions. The result is the formation of shallow and deep water accumulations.

Water is good in winter after the rainfall in the ranges and unpleasantly salty in the summer or during rainless period. For normal drinking purposes, fresh water of salinity up to 1000 ppm can satisfactorily be used, Saline water, of salinity ranging from 1000 to 3000 ppm is used for limited irrigation in a sandy soil. No sign of surface water was observed in the project area except for some traces of wadi drains.

The Quaternary alluvial deposits are formed of sand, gravel and boulder filling the courses of the hydrographic basins. They have lateral and vertical variations in lithological composition according to the dominated rock exposures in the hydrographic basins. The wells have depth to water ranges between 0.5 and 3.2 m and the discharge ranges between 2 and 5 m³/day. The water salinity in this area is remarkably high (16210 to 30082 ppm) due to the stagnancy, evaporation, leaching processes and salt-water intrusion. However, most deep hand-dug wells have had to be dug through between 15 and 25 m of sand before reaching the water table, which is very close to or within the bed rock and obtaining a regular supply of between 10 and 50 m³ per day.

REFERENCES

- 1- Said, R. (1990). The Geology of Egypt. A.A. Bulkema/Rotterdam. Brookfield, 734 p.
- 2- World Meteorological Organization (1971-2000). At: :<https://worldweather.wmo.int/en/city.html?cityId=1270>
- 3- Meteorological station measurements at Hurghada International Airport. www.accuweather.com/en/eg/ras-shu-kheir/126891/january-weather/126891?year=2020
- 4- GAENS, General Administration for Environmental and Natural Studies (2009). The environmental perspective of the urban development strategy at the level of the Republic. South Upper Egypt Region. Ministry of Housing and Urban Utilities - General Authority for Urban Planning (In Arabic).
- 5- Hegazy, M.N. and Effat, H.A. (2010). Monitoring some environmental impacts of oil industry on coastal zone using different remotely sensed data. *Egypt. J. Remote Sensing and Space Sciences*, 13(1):63-74.
- 6- Elewa, H.H. (2007). Groundwater in the Eastern Desert with Reference to Application of Remote Sensing and GIS. <https://hdl.handle.net/10535/10576>

- 7- NARSS (1997). (National Authority for Remote Sensing and Space Sciences). Hazard assessment and mitigative measures of flash flooding on the Red Sea towns, Egypt. Scientific Report presented to the Red Sea Governorate, 294 p.
- 8- EGPC (1996). Gulf of Suez Oil Fields – A Comprehensive Overview. The Egyptian General Petroleum Corporation, Cairo, Egypt, p. 136
- 9- REGWA (1991). Water resources for the area between Gharib and Quseir; Red Sea Development Organization. Submitted report to the Ministry of Housing, Development and New Communities. 271 p.
- 10- Nasr, I.M. (1990). Geological and geophysical studies on the groundwater potentialities in the area between RasGharib and RasGemsa, A.R.E. M.Sc. Thesis, Faculty of Science, Al-Azhar Univ. 218 p.
- 11- DRC (Desert Research Center) (2002). Mineral, petroleum and groundwater assessment program. DRC, Cairo, Egypt. Aid Project 2633-0105, Groundwater investigation in the Eastern Desert: Volume II: Groundwater supplies in selected mining and petroleum districts, A: WadiAraba (143 p), B: RasGharib-RasGemsa (194 p) and C: Quseir-MersaHimeira (256 p).
- 12- Sweidan, A.S. and Himida, I.H. (1991). Evaluation of hydraulic parameters for Dara area (Gulf of Suez), Egypt. Qatar Univ. Sci. J., 11: 307-330.
- 13- Aggour, T.A. (1990). Response of geomorphological and geological features on groundwater in Wadi Araba, Eastern Desert, Egypt. M.Sc. Thesis, Fac. Sci. Ain Shams Univ. 179 p.
- 14- Gomaa, M.A. and Aggour, T.A. (1999). Hydrogeological and hydrogeochemical conditions of carbonate aquifers in the Gulf of Suez region, Egypt. Assiut Sci. Bull., 28(2):191-214.
- 15- Abdel Samie, S.G. and Elewa, H.H. (2005). Hydrogeochemical and Environmental isotopic evaluation of groundwater of the area located to the northwest of the Gulf of Suez coast, Egypt. J. Geol., 49:109-131.
- 16- Aggour, T.A. and Sadek, M.A. (2001). The recharge mechanism of some cases of the different groundwater aquifers, Eastern Desert, Egypt. Mansoura Sci. Bull. (C- Nat. Sci. and Phys. Sci.): 28 (1).
- 17- Ganoub, A.F. (1969). Water Resources between Suez and Ras Banas, West Coast of Gulf of Suez and Red Sea District. The General Exploration Company of Egypt , Cairo pp. 109
- 18- Yehia, M.A; Ashmawy, M.H. and EI-Etr, H.A. (1999). Flash flooding threat to the Red Sea coastal towns of Ras Gharib and Hurghada, Egypt. Egypt. J. Remote Sensing and Space Sci., 2:87-106
- 19- Hesham, E.Z.Z.; Muhammad, G. and Mohamed, A. (2019). Watershed Delineation and Estimation of Groundwater Recharge for Ras Gharib region, Egypt. J. Geosci. Environ. Protection, 7(4):202-213.
- 20- Masoud, A.A. (2004). Flash Flood Potential, Mitigation, and Floodwater Resource Management: Integrating Remote Sensing and GIS Technologies in Safaga Area. J. Geosci., Osaka City Univ., 47:21-38
- 21- RIGW (1999). (Research Institute for Groundwater). Hydrogeological Map of Egypt, 2nd Edition Scale 1:2,000,000. Ministry of Public Works and Water Resources, Cairo, Egypt.
- 22- NARSS (1999). (National Authority for Remote Sensing and Space Sciences). Water resources in south east Aswan and WadiAllaqi areas. Internal un-published report, 25 p.
- 23- NARSS (2000). (National Authority for Remote Sensing and Space Sciences). Using remote sensing applications in studying the natural resources in Halaib-Shalatin area. Project submitted to the Academy of Scientific Research and Technology, 300 p.

The Hydrogeological conditions and characteristics of the groundwater occurrences in Ras Shukeir area, Suez Gulf, Egypt (Review)

- 24- NARSS (2001). (National Authority for Remote Sensing and Space Sciences). Intrusive dykes and its relation to the groundwater occurrence in the southeastern part of Egypt. Internal unpublished report.30 pp.
- 25- NARSS (2004). (National Authority for Remote Sensing and Space Sciences). Water resources assessment and future land use planning of the area located to the northwestern coast of the Gulf of Suez, Egypt, Internal unpublished final report of a research Project, 247 p.
- 26- NARSS (2005). (National Authority for Remote Sensing and Space Sciences). Water and land resources assessment for the Eastern fringes of Assiut district and its adjacent areas, Egypt, using geoinformation technologies. Internal unpublished final report, 253 p.
- 27- NARSS (2006). (National Authority for Remote Sensing and Space Sciences). Assessment of water and land resources in WadiQena basin for sustainable development. Unpublished internal report, 120 p.
- 28- Ezz, H. (2017). The Utilization of GIS in Revealing the Reasons behind Flooding Ras Gharib City, Egypt. *Int. J. Engineer. Res. Africa*, 31: 135-142.
- 29- Gomaa, M. A.; Mohallel, S.A. and Elsheikh, A.E. (2016). Estimation of Recharge Quantity of the Fractured Basement Aquifer in the Southern Portion of Eastern Desert, Egypt; Critical Importance of the Hydrological and Chemical Criteria. *Middle East J. Appl. Sci.*, 6:759-773.
- 30- Mahmoud, S.H. (2014). Investigation of Rainfall-Runoff Modeling for Egypt by Using Remote Sensing and GIS Integration. *Catena*, 120:111-121. <https://doi.org/10.1016/j.catena.2014.04.011>
- 31- Hefny, K.; Farid, S. and Hussein, M. (1991). Groundwater assessment in Egypt. Round Table Meeting (RTM-91) "Planning for groundwater development in arid and semi arid regions. pp. 93-103.
- 32- Youssef, A.M.; Pradhan, B.A.; Gaber, F.D. and Buchroithner, M.F. (2009). Geomorphological Hazard Analysis along the Egyptian Red Sea Coast between Safaga and Quseir. *Natural Hazards and Earth System Sciences*, 9: 751-766. <https://doi.org/10.5194/nhess-9-751-2009>.
- 33- Elnazer, A.A.; Salman, A.S. and Asmoay, A.S. (2017). Flash Flood Hazard Affected Ras Gharib City, Red Sea, Egypt: A Proposed Flash Flood Channel. *Natural Hazards*, 89, 1389-1400. <https://doi.org/10.1007/s11069-017-3030-0>
<https://doi.org/10.4028/www.scientific.net/JERA.31.135> .

الظروف الهيدروجيولوجية وخصائص تواجد المياه الجوفية بمنطقة رأس شقير ، خليج السويس ، مصر (مقالة مرجعية)

صلاح محمد إبراهيم¹ ، وحيد محمد إمام² ، ونام وحيد محمود³

1 - قسم الجيولوجيا ، كلية العلوم ، جامعة الشمس.

2،3- علم الحيوان بكلية العلوم جامعة عين شمس.

1 -salaheldinmoua@hotmail.com

2-Waheed.emam@yahoo.com

3-Dr_wiame2006@yahoo.com

المستخلص

تعتبر منطقة رأس شقير من أهم مناطق الأنشطة البترولية في مصر. تقع جنوب شرق رأس غارب (30 كم) وشمالاً إلى الغردقة (150 كم). تقع منطقتها الساحلية على خليج السويس من الشرق ، بينما منطقتها الغربية أرض صحراوية. هناك نقص في المعرفة حول الظروف الهيدروجيولوجية وخصائص المياه الجوفية في رأس شقير والتي تعتبر ضرورية لقامة منشآت بترولية جديدة هناك والتنبؤ بالفيضان المفاجئ. لذلك فإن هذه الدراسة المراجعة هي محاولة لجمع معظم البيانات المتاحة لمساعدة متخذي القرار في مشاريعهم التنموية الاجتماعية والاقتصادية المستقبلية في هذا المجال. مناخ رأس شقير حار جاف ، في حين أن القليل من تساقط الأمطار قد تحدث في الربيع. يبلغ متوسط درجة الحرارة السنوية 22.2 درجة مئوية ، بينما يبلغ متوسط هطول الأمطار 5 ملم. الرياح الشمالية الغربية هي السائدة. لا توجد إمدادات مياه سطحية في هذه المنطقة باستثناء تلك الآتية من الوديان أثناء هطول الأمطار التي تكون منخفضة للغاية. يعتمد إمداد المياه العذبة بشكل أساسي على طبقة المياه الجوفية وتحلية مياه البحر ، حيث توجد مستنقعات ملحية صغيرة. تمت مناقشة الخصائص الرئيسية للمياه الجوفية المعروفة بوجودها في هذه المنطقة ، حيث يوجد نوعان رئيسيان ومميزان من المياه الجوفية حسب مصدرها ؛ الأول ذو أصل نيزكي بحت والآخر يتشكل خلال فترات جيولوجية مختلفة (مياه التكوين). هذا الأخير شديد الملوحة ويحدث في آبار عميقة ويختلط بالمعادن والكبريتات. الماء المنحصر من تساقط الأمطار في الشتاء عذب ويمكن استخدامه حتى 1000 جزء في المليون ملوحة. تستخدم المياه ذات الملوحة التي تتراوح من 1000 إلى 3000 جزء في المليون للري المحدود في التربة الرملية. تمتلئ دورات الأحواض الهيدروغرافية بالترسبات الرسوبية الرباعية المكونة من الرمل والحصى والصخور. ويتراوح عمق المياه في الآبار بين 0.5 و 3.2 م ويتراوح التصريف بين 2 و 5 م³/يوم. يتم إنشاء معظم الآبار العميقة المحفورة يدوياً على مساحة تتراوح بين 15 و 25 متراً في الرمال قبل الوصول إلى منسوب المياه ، وهو قريب جداً من صخور قاع الحوض أو داخله ويحصل على إمداد منتظم يتراوح بين 10 و 50 متراً مكعباً في اليوم.