SUMMARY AND CONCLUSION

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The present thesis Introduce a comparison between the groundwater in the Miocene aquifers in some localities east of the Nile Delta from the hydrochemical and isotopical points of view. These localities are: Cairo-Suez desert road, Heliopolis basin and Inshas area.

The study involved geomorphological and geological survey depending mainly on the previous works while the hydrogeological, hydrochemical and environmental isotopes were studied depending on the field and laboratorial measurements.

This thesis includes the following chapters:

Chapter I: Methodology

This part includes the procedures used to determine hydrogen ion concentration (pH), electrical conductivity (EC), total dissolved solids (TDS), major constituents (Ca^{++}, Mg^{++}, Na^{+}, K^{+}, CO_3^{--}, HCO_3^{-}, SO_4^{--}, Cl^{-} and SiO_2), minor constituents (NO_3^{-}, PO_4^{---}, B^{+++} and Fe^{++}) as well as stable and radioactive isotopes (oxygen-18, deuterium, tritium and carbon-14). It also includes the chemicals and apparatus used in the analysis.

Chapter II: Geomorphological, geological and hydrogeological aspects

1-Geomorphology:

The area under investigation slopes generally northward and is classified into three geomorphologic units which could be described as follow

(i) Moqattam-Ataqa structural plateau.

This unit extends from Gebel El Mokattam westward to Gebel Ataqa eastward. It extends in an E-W direction for a distance of about 135 km and forms a series of highly elevated disconnected hills.

(ii) Structural ridges and depressions.

To the north of Moqattam-Ataqa plateau, a series of structural ridges and depressions are developed. They are represented by four subparallel structural ridges:

- Anqabiya-Nasuri.
- Dibba-Iweibied.
- Geniefa-Shubrawiet.
- Shubrawiet-Hamza.

These structural ridges are separated by two main shallow depressions:

-Heliopolis depression and

-El Dakruri depression.

The ground elevation of these depressions ranges between 15m and 240 m above sea level. They act as water-collecting basins during winter times.

(iii) Belbeis-El Tell El Kebeir-El Salhiya old deltaic plain.

This plain slopes northward (4m/km) and characterized by a moderately low relief. Inshas area lies within Umm Gidam gravelly plains, which are located within this old deltaic plain.

2- Geology

The area of study has a sedimentary cover ranging in age from Eocene up to Pliestocene-Holocene (Quaternary). Great attention is paid to the Miocene rocks.

(i) Quaternary deposits

The Quaternary deposits are mainly composed of sand sheets and recent deltaic silt with average thickness about 5 m, and the Pleistocene deposits which are dominated by sand and gravel with clay lenses with a thickness ranges from 50 m to about 200 m which is increasing toward El Ismailia canal

(ii) Miocene deposits

Miocene sediments cover a large area along Cairo-Suez desert road and at Heliopolis basin with a thickness reach about 250m, they overlie unconcformably the Oligocene. Lithologically, they are represented by sandstone and sandy limestone and are unconformably underlie the Pliocene, or sometimes, the Pleistocene sediments. They are divided into two units, the lower unit is made up of marine sediments and the upper is made up of non-marine fluviatile sediments. The Miocene sediments in Inshas area are unconformably underlying the Pleistocene sediments. These sediments are of marine origin and consist of dark grey clay and calcareous marl interbedded with gravel and sand bands.

3-Hydrogeology

Hydrogeologically, the investigated area includes two aquifers, the Quaternary aquifer and the Miocene aquifer.

(i) Quaternary aquifer:

This aquifer covers a great parts to the east of the Nile delta. Its thickness shows gradual increase towards the Nile Delta. The Quaternary aquifer is mostly under semiconfined conditions due to the presence of overlying clay. It is subjected to unconfined conditions in Inshas area due to the absence of the clay confining beds. It is mainly recharged from the main Nile Delta aquifer and seepage from surface water systems.

(ii) Miocene aquifer

The Miocene aquifer along Cairo-Suez desert road and at Heliopolis basin is mainly composed of sand and gravel with clay and limestones interbeds with an average thickness of about 250 m. The Miocene aquifer within this area is subjected to unconfined or semiconfined conditions with a depth to water ranges from 160 to 240 m.

The Miocene aquifer in Inshas area is mainly composed of grey clay and calcareous marl interbedded with gravel and sand bands. Its thickness reaches 65 m. The depth to water varies from 14 m to 36 m.

***Hydrogeological cross sections:**

The three hydrogeological cross sections constructed in the study area show that generally, the direction of groundwater flow is generally from SW to NE.

Chapter III: Hydrochemical aspects.

The main aim of this chapter is to know the water chemistry, water types and to asses the hydrogeochemical processes affecting water quality. Seventy eight water samples were collected from the study area. Fifty three of them represent the Miocene aquifer, sixteen represent Pleistocene aquifer, five represent mixed water and four represent surface water.

***Hydrochemistry of surface and Pleistocene groundwater**:

The total dissolved solids (TDS) in the surface water samples (El-Ismailia canal) ranges between 196 mg/l and 203 mg/l, reflecting fresh water type. On the other hand the total dissolved solids of the Pleistocene groundwater ranges between 499 mg/l and 3511 mg/l, reflecting fresh to brackish water type.

***Hydrochemistry of Miocene groundwater:**

The study of the chemistry of the Miocene groundwater is the main target of this thesis. The following topics are discussed:

(a) Total salinity:

Along Cairo-Suez desert road, the salinity ranges from 6194 mg/l to 7897 mg/l and from 3651 mg/l to 6802 mg/l at Heliopolis basin. In Inshas area, it ranges from 3433 mg/l to 10680 mg/l. Generally, the salinity in the above areas indicates brackish to saline water type.

(b) Alkalinity:

Along Cairo-Suez desert road , the alkalinity ranges between 96 mg/l and 177 mg/l as $CaCO_3$,where it ranges between 27 mg/l and 215 mg/l at Heliopolis basin. It has a relatively high value in Inshas area due to the influence of meteoric water rich in carbonate and bicarbonate. It ranges between 80 mg/l and 304 mg/l.

(c) Hardness:

Generally, all the Miocene groundwater samples are classified as a very hard water.

It ranges between 2659 mg/l as $CaCO_3$ and 4655 mg/l along Cairo-Suez desert road and ranges from 989 mg/l to 3664 mg/l at Heliopolis basin. It ranges between 639 mg/l and 3880 mg/l at Inshas area.

(d) Major ion relations:

The study revealed that, the Miocene groundwater samples have Cl-Na type and the combination between major anions and cations reveals three main groups of hypothetical salts. these are:

Group I : composed of NaCl, $MgCl_2$, $CaCl_2$, $CaSO_4$, and $Ca(HCO_3)_2$.

Group II : composed of NaCl, $MgCl_2$, $MgSO_4$, $CaSO_4$ and $Ca(HCO_3)_2$.

Group III: composed of NaCl, Na_2SO_4, $MgSO_4$, $CaSO_4$ and $Ca(HCO_3)_2$.

Two types of water are existed, namely Mg-Cl and Ca-Cl. The water of Ca-Cl reflects the old marine water with salt combination represented by group I.

This type is represented in most water samples along Cairo-Suez road and Heliopolis basin. In case of Mg-Cl type showing recent marine origin with salt assemblage represented by group II is exhibited in some samples in Heliopolis basin. The existence of Mg-Cl type refers to old marine water that was subjected to more developed stages of flushing by deep meteoric water percolation. Most of the samples in Inshas area reflects mixing water of $Na.SO_4$ type. Such water is characterized by salt combination represented by group II.

(f) Geochemical classification of groundwater:

By using the semi-logaritmic and the trilinear diagrams water analysis diagram, the Miocene groundwater of the study area shows the following:

Along Cairo-Suez road, the groundwater has the sequence: Ca(Mg) < Na < Cl > SO_4 > HCO_3 and occupies area (6) in the diamond shape reflecting the secondary salinity character. This could be attributed to the overpumping from these water wells.

At Heliopolis basin, the groundwater has the sequence: Ca > Mg < Na < Cl > SO_4 > HCO_3 and occupies area (6) and (7)) in the diamond shape, reflecting the secondary and primary salinity character. This reveals marine origin and ion exchange processes. In Inshas area, the sequence of groundwater samples is: Ca > Mg < Na > Cl(SO_4) > SO_4(Cl) > HCO3 and occupies area (7) in the diamond shape reflecting the primary salinity character. This reveals the effect of marine groundwater with meteoric water.

The evaluation of the Miocene groundwater in the study area shows that, it can not be used for domestic purposes, which it can be used for the consumption of some livestock. In the field of agriculture, it can be used for some limited crops under certain conditions.

***Final conclusion**

It can be concluded that the groundwater in the Miocene at Heliopolis basin is the less deteriorated water compared with the other two localitis. It may be attributed to the hydrogeological features in Heliopolis basin and the fluviomarine facies dominated. The overpumping in this area may also lead to the deterioration of water quality.

Chapter IV: Environmental isotopes aspects.

Twenty three samples (imply both Pleistocene and Miocene) were selected from the study area for isotopic analysis. The environmental stable isotopes content (O-18 and D) of the groundwater samples were plotted with the Global Meteoric Water Line (GMWL).

This indicates that, the groundwater in the Quaternary aquifer is isotopically more enriched than that in the Miocene aquifer. The tritium concentration is also significantly higher in the Quaternary than the Miocene aquifer.

The recharge for the Quaternary aquifer is mainly due to water from Nile system at present time or before construction of High Dam with some component from deep water or Miocene water in contact.

The Miocene aquifer on the other hand is less currently recharged than Quaternary and dominated with paleowater of pluvial time meteoric water cycle and shows some hydraulic connection with quaternary aquifer and Nile system in some localities.

The Miocene groundwater samples in Inshas area (Nos. 49, 50 and 51) and some samples in Heliopolis basin (Nos. 41, 43 and 44) are less depleted than the rest of the Miocene samples. These can mark a zone of mixing and interconnection with the Quaternery aquifer and the recent recharge. The Pleistocene water samples are not as enrich as the Nile water system.

This confirms the presence of zone of mixing and hydraulic connection between the present time recharge source and pluvial time water entrapped between the rock pores since Pleistocene-early Holocene. This zone is present in the northern boundary of the study area (El Adlia water wells).

The areal distribution of O-18, D and T are highly compatible together where O-18, D and T get the lowest concentration values in the central part of the study area at Heliopolis basin.

There seem present a structural break between Heliopolis basin and the other localities in the area of study, where the structural features resist the recent recharge to the basin while it reaches the northern and eastern portion of the area.