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Physicochemical Parameters, Grain Size Distribution and Mineralogical Composition of Recent Bottom Sediments and water of Qaroun Lake, Fayoum, Egypt

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THE PRESENT study aimed to study the physical and chemical properties of the recent bottom sediment and water of Qaroun lake. The water depth values varied in the Lake as 4.4, 5.1, and 5.7 m were at the eastern, western, and central regions, respectively, as well as water transparency values were 71.9, 73.5, and 92.2 mS/cm at the eastern, western, and middle zones, respectively. The transparency increased with increasing the depth. Water's (pH) was 8.05,7.85, and 8.13 while salinity values were 177.6, 191.4, and 191.6 mg/l in the east, central, and western regions, respectively. Electrical conductivity increases gradually from the east zone to the zone of west, passing through the central area. The average values of carbonates in the recent bottom sediment of Qaroun lake have fluctuated between 31.08, 37.05, and 34.24% in the eastern, central, and western regions, respectively. In contrast, the average values of organic matter in Qaroun lake have fluctuated between 17.33, 16.78, and 26.68% in the eastern, central, and western regions, respectively.

The silt and mud are highly accumulated in the eastern region, clay and gravel are high in the central part, and sand increased in the western area. The XRD showed the distribution of mineralogical composition over the lake was found in the ranges Montmorillonite, 2-15 %, Kaolinite, 2-7 %, Quartz, 30-40%, Halite, 8-55%, Anhydrite, 7-10, Calcite, 20-30%, Albite, 10 %, Anorthite, 5-8 %, and Cosite, 25-40%.

Keywords: Physic-chemical; water; grain size; minerals; sediments; Qaroun lake.

1.Introduction

The Fayoum depression is located west of Beni Suef City. It covers an area of approximately 2,580 square meters (Fig. 1). It is connected with the drinking water Canal (Bahr Youssef), which crosses the desert through the Hawara Canal (Mahmoud, 2008). Qaroun lake is a saline closed lake planned as a natural reserve in 1989 (El-Sayed et al., 2015). Qaroun lake is a natural inland saline lake and represents one of the main geomorphological features of the Egyptian Western Desert. It is a place for fisheries, salt production, tourism, and migratory birds in the Fall and Winter seasons and a natural drainage area for Al-Fayoum Governorate (El-Sayed et al., 2015; Attia et al., 2018 and El-Kady et al.,2019). The description and study of the ecosystem, climatic conditions, geochemistry, mineralogy of Qaroun lake have attracted many authors (e.g., El-Sayed et., 2022; Abdel Wahed et al.,2015; Abd El-Aal et al.,2020; Abdel-Satar et.,2010; Elwasify et al.,2019 and Abdelmageed et al.,2022) and biological diversity (e.g., Al-Afify et al.,2019; Mehanna, 2020), sedimentation rates (Imam and Salem, 2023) and integration of water pollution indices and assessment of ground water quality (Gad and El-Hattab, 2019; Khairy et al.,2022 and Elsayed et al.,2021).

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It is the third-largest lake in Egypt and represents the final stage in the development of the ancient Maurice Lake (Fathi & Flower, 2005).
The uptake, Adsorption, accumulation, and fate of minerals, including availability for organisms, are affected by sediment properties such as organic matter content, grain size, and oxidation state (Yao et al., 2015; El Azhari et al., 2016). Moreover, the mineralogical and geochemical properties of sediments reflect the source lithographic compositions and give a good idea of the tectonic setting and prevailing weathering conditions in the source region (Armstrong – altrin et al., 2004; Roy & Roser, 2012; Saydam et al., 2018; Massoud et al., 2009; Helaly & El-khafeef, 2011). The transportation of residues has derived from the nearby geological formations and soils by weathering and erosion processes to the aqueous sedimentation environment (Shah et al., 2020). The wastewater discharge into the lake should be increased to reduce its salinity and increase its organic matter content. The current study aims to study the physical and chemical properties, grain size distribution, and mineralogical composition of Qaroun lake's recent bottom sediments. Observing a lake's physical, chemical, and microbial characteristics allows temporal changes to be easily monitored and minimize hazardous impacts (Bhateria & Jain, 2016).

2. Geomorphology and Geological Setting

El Fayoum Governorate is composed of four significant depressions (Nile Valley, El-Fayoum, Hawara, and El-Raiyan) surrounded by the limestone plateau of Eocene age rock units exposed in El- Fayoum region ranging from Eocene to Quaternary Ages. The depositional environments and sequential succession of the limestone bedrock led to the accumulation of thick Quaternary sediments in this region (Massoud et al., 2009). Most of the cultivated soils in the Fayoum depression are deep alluvial loam or clayey, derived mainly from the Nile flood (Ali & Abdel Kawy, 2013). The Fayoum depression is excavated in Middle Eocene rocks, composed of gyps-ferrous, shale, white marls, limestone, and sand (Hammad et al., 1983; Said, 1993). The Quaternary deposits are widely distributed over the Fayoum area as Aeolian, Nilotic (alluvial sediments), and lacustrine deposits. The alluvial sediments are sands and gravel of variable sizes intercalated with calcareous silt and clay contents (Tamer, 1968). A complete description of the lithological units in the El Fayoum area, based on direct observation of the exposed rock units (well information was unavailable), the exposed outcrop of this region range in age from Eocene to Recent.

The Eocene rocks consist of limestone with some flints, mainly covering the southwest portion. The Miocene sediments are separated from the Eocene rocks by a narrow belt of Oligocene rocks outcropping north of Birket Qaroun and consist of cross-bedded sandstone and gravels with interbeds of shales and limestones. The Pleistocene - Recent sediments mainly cover the narrow strips of the Nile Valley, around cultivated lands, with local Pliocene outcrops covering the ancient rocks. The Basaltic flows and sheets that date back to the Late Oligocene-Early Miocene age are exposed in some areas in this region, e.g., Gabal Qatrani, south of Cairo and west of the Nile Valley. Gabal Qatrani is located to the north of the study area. (Helaly and El-khafeef, 2011).

3. Materials and Methods

The studied area was divided into three regions:
The eastern, middle, and western regions.

Forty-nine bottom sediment samples were collected from 49 stations using the Ekman grab sampling tool (Fig. 2) to cover the Qaroun lake (Fig. 1) from east to west. Nine samples were selected to cover the different bottom regions of the Lake for mineralogical investigation and (Table 1) and other parameters and grain size distribution. Mineralogical identification of the collected samples was performed using the XRD technique at Egyptian Mineral Resources Authority. The X-Ray Diffraction equipment is PANanalytical model X′Pert PRO with Secondary Monochromator, Cu-radiation (l=1.542Å) at 45 K.V., 35 M.A. and scanning speed 0.02^{o}/sec. The diffraction peaks between 2q =2° and 60°, corresponding spacing (d, Å), and relative intensities (I/Io) were obtained. The X-ray diffraction pattern of the bulk sample was used to identify the non-clay minerals. Clay minerals were determined by X-ray diffraction patterns of the oriented sample technique, as follows:

The samples were fractured and immersed in distilled water. Carbonate and organic-rich samples were treated using HCl and hydrogen peroxide (H_2O_2) to remove carbonates and organic matter contents.
Repeated stirring and centrifugal removal of the flocculation process were conducted for several days. The sample dispersed was stirred in a one-liter cylinder for a few minutes and then left for several hours to settle down. This process gives the clay fracture a chance to float.
Pipettes were made for the 2-micron particles (clay fraction) at a depth of about 5 cm. This fragment was deposited on a glass slide, thus,

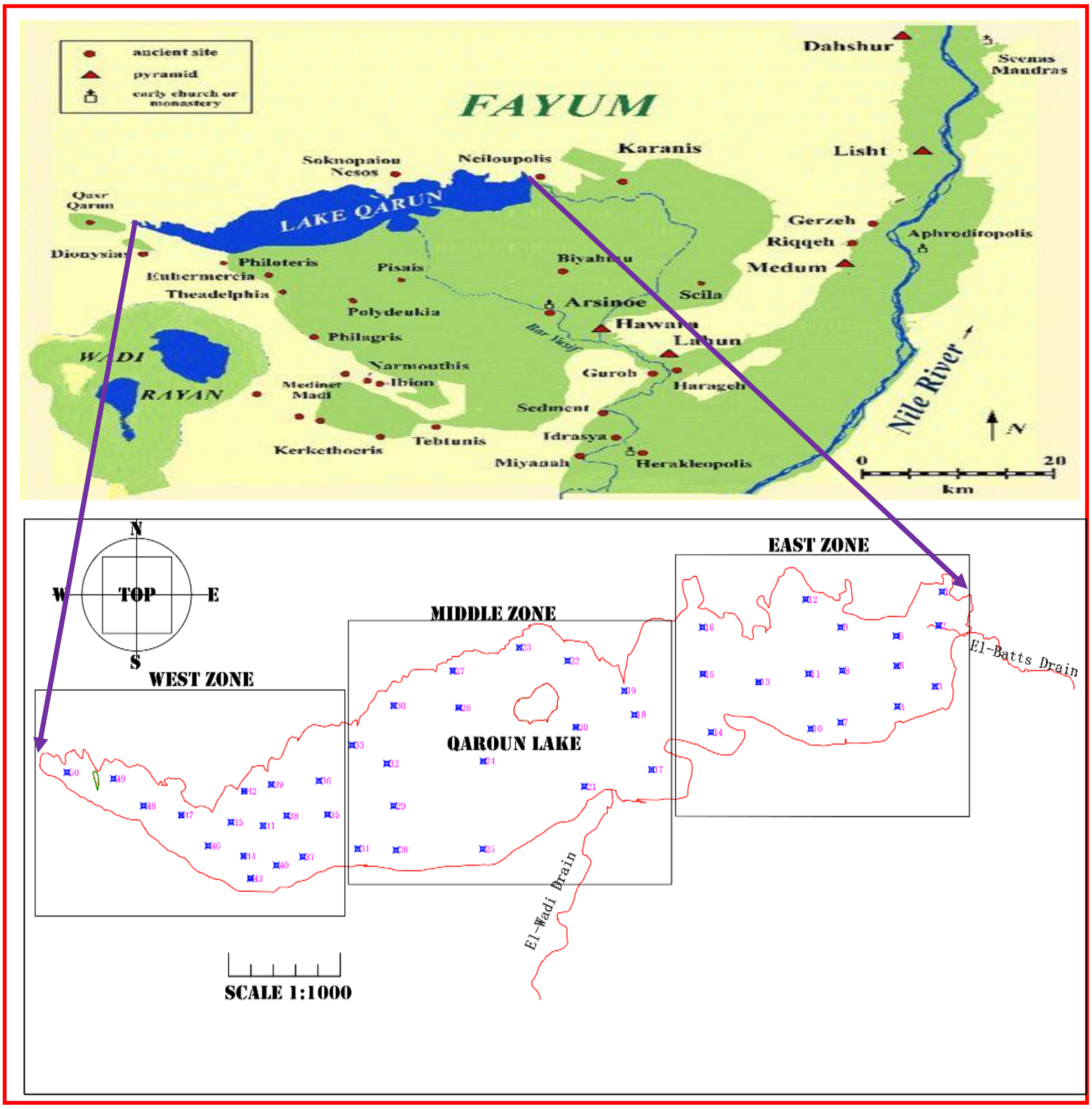

Fig. 1. Location map and sampling stations of all collected samples within Qaroun lake (east, middle, and west regions) (source, 2023 google, image Landsat / Copernicus).

we have the oriented basal flakes of the clay minerals.

The sediment samples were subjected to mechanical analysis by the method described by Folk (1968) and Jackson (1956), and the grain size parameters were determined. Gravity sedimentation was used to separate silt (63-50 µm) and clay size (< 4 µm). Experiments for the deflocculation of samples were carried out following the techniques proposed by Krumbein and Pettijohn (1938) and Folk (1968). About 40 gm of each sample was soaked in distilled water for one to three days. It was found necessary to wash the samples due to the relatively high salinity of the lake.

Thus, the samples were placed in the 500 ml beaker with dispersant (Sodium Hexametaphosphate), then decanted into a 1liter cylinder after using a mechanical stirrer for ten minutes then found to be most effective in ensuring complete dispersion. Then the pipette method was followed (Folk, 1968). The pipette sucked the suspension at different times and depths, then decanted it in a 50 ml beaker, dried and weighed it. The weight was calculated as a percentage of the total.

Transparency was measured using a white/black Secchi Disk (20 cm in diameter) (Fig. 3). Field measurements Parameters (water temperature, transparency, pH, TDS, and electrical conductivity) were measured immediately in the

field during sampling using a portable multi-probe meter (Crison-Spain MM40+).
The organic matter in sediment was estimated according to (Hanna, 1965). The carbonate content of sediments was determined by the method described (Alxjev, 1917; Vogel, 1982).

4. Results and discussion:

4.1 Physico-chemical parameters

Physico-chemical factors are essential for studying Qaroun lake water's properties as a sedimentary environment. These parameters are:

4.1.1 Water depth

The differences in depths in the lake are listed in Table 2 and Fig. 9. The results showed that the maximum and minimum water depth values in the eastern region were recorded at 9 m and 0.5 m at stations 12 and 1, respectively. On the other hand, in the western zone, the maximum value was 7.5 m and recorded at station 35, while the minimum value was recorded at 3.5 m at station 50. As for the central region, the maximum value was recorded at 8 m at stations 29, 30, 31, and 33, while it recorded the lowest value of 0.5 m at station 25. The eastern, western, and central zones recorded average water depths of 4.4, 5.1, and 5.7 m respectively.

4.1.2. Transparency

The transparency and depth were measured by using a white/black Secchi Disk (20 cm in diameter). The differences in the lake's transparency are given in Table 2 and Figs. 4 & 10. The results of the eastern region showed that the maximum and minimum values of transparency were recorded by 115 and 35 cm at stations 12 and 1, respectively.
The results of the eastern region showed that the maximum and minimum values of transparency were recorded by 115 and 35 cm at stations 12 and 1, respectively. On the other hand, in the western region, the highest value was recorded at 90 cm at station 39, while the lowest value was recorded at 59 cm at station 50. For the central region, the maximum value of transparency was found to be 134 cm at station 33, while the lowest value was recorded at 40 cm at station 25. The average transparency values were 71.9, 73.5, and 92.2 cm in the eastern, western, and central regions, respectively. The changes in water transparency values in the lake water range from 35 cm to 134 cm from east, middle, and west with an average value of 79.2 cm. The lowest value was found at station no.1 in the eastern region. The highest value was found at station no.33 in the central region, and this may be due to the discharge drainage water from the drains in the east (El-Batts drain) and central regions (El-Wadi drain) being full of suspended particles which led to decrease transparency compared with the western zone. Moreover, the lowest observed value of transparency can be attributed to the effect of fertilizers and feed used in fish farming and the disposal of untreated sewage and agricultural effluents into the two drains (Al-Afify et al., 2019). These results agreed with (Salem, 2005; Abdel – Satar et al., 2010; Al- Afify et al., 2019).

4.1.1.2. Chemical Parameters

Physical parameters may cause alternation or change in the chemical composition of precipitating compounds since the digenetic processes are achieved by solution, precipitation, crystallization, recrystallization, oxidation, reduction, acidity, and alkalinity (Pettijohn, 1975).

4.1.1.2.1 Hydrogen ion Concentration of water

The pH of Qaroun lake water is located on the alkaline side, between 7.85 in the eastern region and 8.13 in the western region, and is included in table 3, Figs. 4 & 11. These results are slight to those found in (Abd El-Aal et al.,2020) and are still within permissible limits. It has (6.5-9) for the aquatic organisms. Many organisms in alkaline conditions use calcium carbonate to build their shells. These organisms flourish in most significant numbers in water approximately saturated with calcium, where only a minor change in pH values is needed to cause precipitation of carbonate (Broecker et al., 1982; Mucci, 1983; Krauskopf& Bride, 1995). The average values of hydrogen ion concentration of Qaroun lake varied between 8.05, 7.85, and 8.13 in the eastern, central, and western regions, respectively.

4.1.1.2.2. Salinity (T.D.S)

Qaroun lake has many radical changes that affect its potential economic role as a location for living natural resources. The main reason came from the gradual salinity increase over the past century. The rise in salinity depends on the wastewater input (controlled by irrigation practices) and the lake's subtropical climate, resulting in a warming and seasonal variable in the rate of water evaporation (Anwar et al., 2001). The salinity of Qaroun lake was recorded in (Table 3) and Figs. 4 & 12. The results showed that high salinity values were recorded in the western region. The zonal

Fig. 2. shows Ekman dredge bottom sampler.

Fig. 3. Shows white/black Secchi Disk, water testing (20 cm in diameter).

Table 1. Direction of Stations of selected samples and its code for mineralogical composition from Qaroun lake.

Zone	Number of Stations	Station Code
Eastern part	3 Stations	1, 5 and 11
Middle part	3 Stations	20, 29 and 31
Western part	3 Stations	39, 46 and 50

distributions of salinity in the west of the zone showed that the maximum value (197.1 mg/l) was recorded at station 36, while the minimum value (159.3 mg/l) was recorded at station 37. On the other hand, in the eastern region, the maximum value of salinity (192 mg/l) was recorded at station 16, while the lowest value (54.2 g/l) was recorded at station 1 close to El – Batts drain. At the central region, the highest value (198.7 mg/l) was recorded at station 29, while the lowest value (141.6 mg/l) was recorded at station 25 in front of the El-Wadi drain. The average salinity values of Qaroun lake varied between 177.6, 191.4, and 191.6 mg/L in the eastern, central, and western regions, respectively. In general, the increase in TDS values during the summer can be attributed to the dilution and rising water levels in the lake through the discharge of drainage water by two drains during these seasons. These findings agree with (Salem, 2005; Authman& Abbas, 2007; Al-Afify et al., 2019; Abd Ellah, 2009; Goher et al.,2018; El-zeiny et al.,2019).

4.1.1.2.3. Electrical Conductivity (EC)

The results of the electrical conductivity of Qaroun lake are listed in (Table 3) and Figs. 4 & 13. The results showed that higher values of electrical conductivity were detected in the western region than in the other two areas. The highest value was observed in the west region, 44.8 mS/cm at station 36, while the lowest was found at 43.6 mS/cm at station 43. On the other hand, in the eastern region, the maximum value was recorded at 43.6 mS/cm at station 16, while the minimum value was recorded at 12.33mS/cm at station 1 close to El–Batts drain. The maximum value of 45.1 mS/cm in the central region was recorded at stations 28, 29, and 30. In contrast, the lowest value, 32.2 mS/cm, was found at station 25 in the front of the El-Wadi drain, so the electrical conductivity directly relates to salinity (TDS). The average electrical conductivities of 40.35, 43.52, and 44.05 mS/cm were found in the eastern, central, and western regions, respectively. The electrical conductivity increases gradually from the east region to the west of the area passing through the central part.

4.1.1.2.4. Carbonates and Organic Matter

Organic matter in sediment consists of carbon and nutrients. It is derived from autochthonous or allochthonous sources. The first is the organic matter (as residues of plants, plankton, and animals) formed inside the oceanic basin. The latter is derived from outside the basin due to natural sources and anthropogenic activities (Goher et al., 2021). The differences between carbonates and organic matter in the lake are listed in Table 4 and Fig. 4; the mean values of carbonates of Qaroun lake in recent bottom sediment fluctuated between 31.08, 37.05, and 34.24% in east, middle, and west regions, respectively.

In contrast, the average values of organic matter in Qaroun lake have fluctuated between 17.33, 16.78, and 26.68% in the eastern, central, and western regions, respectively. The significant contributors to carbonate fracture are biogenic shells and shell fragments (Lykousis et al., 1981). The critical environmental factors affecting the natural precipitation of $CaCO_3$ appeared to be water temperature, degree of $CaCO_3$ saturation, and pressure. Regarding carbonate content in the current study, it was more than that recorded in the Nile sediments obtained by (Goher et al., 2021). According to (Emeis et al., 2000), Carbon concentrations also increase with the decreasing grain size because organic matter adsorbs on mineral surfaces and has a high affinity for fine-grained sediments. On the other hand, the higher organic matter content in the surficial sediment may be due to stronger eutrophication, where the increasing nutrient concentrations in the water column led to higher primary and secondary production.

During the current study, the horizontal distribution of organic matter was shown in (Table 4). In the eastern region, the organic matter content ranged between 10.7 and 21.7%, with an average of 17.33 %, while in the central area, it ranged between 8.3 and 24.2%, with an average of 16.78 %. The western region ranged between 16.4 and 62.5%, averaging 25.68 %. In general, the part of the west has been shown to have the highest value of organic matter. The content of organic matter in recent bottom sediments of Qaroun lake is more than that recorded in the Nile sediments and Manzalah lake (Lotfy, 2001; El-Enany, 2004 &Lotfy, 2006; Salem, 2011; Goher et al., 2021).

In Qaroun lake, most organic matter is stored at the bottom of the central region. At depths> 3 m, high percentages of organic matter may occur, especially in fine-grained mud. This agrees with Postama (1981), who proved that most transient organic particles behave like fine-grained sediments.

4.3. Grain size distribution

The grain size analysis data were plotted on Folk's diagram, 1968 (Fig. 5). It was found that samples of the eastern region belong to one category (sandy silt), while it was found that the deposits of the central region belong to two classes: 29.4 % silty sand and 70.6 % sandy silt. Finally, the western region's sediment comprised 68.7 % sandy silt and 31.3 % silty sand. In general, the results of the mechanical analysis of recent bottom sediments for Qaroun lake showed that the average size of deposits towards the deeper region, the eastern, and western regions in general medium and very fine size (i.e., medium silt). However, those in the central area and toward the beach and the sediments were slightly coarse in size (i.e., fine sand). This means that a high accumulation of sediment occurs in the east and westwards and towards the deeper zone associated with increasing the fine grains of sediments coming from suspended solids at El-Batts and El-Wadi Drains (Lotfy, 2001). There is a clear trend of the horizontal distribution of different grade sizes among the bottom sediments of Qaroun lake (Figs. 6 and 7) and Table 5. The silt and mud are highly accumulated in the eastern region, clay and gravel are highly in the central part, and the sand is high in the western region.

From the above results, it can be concluded that there is a clear trend for the horizontal distribution of sediments of different grade sizes at the bottom of Qaroun lake. The sand-size deposits increase in the central region at station 17 due to the high erosion on El-Qarn Island. In contrast, silt size content increases in the eastern part at station 14, and finally, the clay size content increases in the central region at station 18.

4.4. Mineralogy of Qaroun lake

Data for the mineralogical composition of recent bottom sediments of Qaroun lake is divided into three zones as follows:

4.4.A. Mineralogical composition at Eastern Zone:

Three representative samples (nos. 1, 5, and 11) for this region are to be examined mineralogically by XRD, as shown in (Fig. 8) and (Table 6). The discussed the presence of different groups of minerals with different abundances characterizes recent bottom sediment samples.

Table 2. Shows the Depth (m) and transparency (cm) in East, Middle and West Zones of Qaroun lake.

Zone	Sample No.	Depth (m)	Transparency (Cm)
East Zone	1	0.5	35
	2	5	90
	3	5	88
	4	3.75	50
	5	7	86
	6	8	110
	7	2.5	65
	8	3.25	60
	9	7	90
	10	2	42
	11	5	80
	12	9	115
	13	2	44
	14	4.25	65
	15	4	67
	16	2.5	64
Average		**4.4**	**71.9**
Middle Zone	17	3	62
	18	6	78
	19	2	69
	20	6.5	113
	21	1.75	47
	22	7	84
	23	6	80
	24	5	75
	25	0.5	40
	26	6	110
	27	7	115
	28	7	120
	29	8	110
	30	8	124
	31	8	98
	32	7	109
	33	8	134
Average		**5.7**	**92.2**
West Zone	35	7.5	84
	36	7	72
	37	5	76
	38	5.5	83
	39	5.5	90
	40	6	71
	41	4.5	83
	42	4	74
	43	5	73
	44	5	66
	45	5.5	67
	46	4.5	72
	47	4	71
	48	4.5	69
	49	4.5	66
	50	3.5	59
Average		**5.1**	**73.5**

Table 3. Average values of some physical and chemical parameters in Qaroun lake.

Zone	P^H	Salinity (mg/l)	Electric Conductivity (mSlcm)
East Zone	8.05	177.6	40.35
Middle Zone	7.85	191.4	43.52
West Zone	8.13	191.6	44.05

4.4.A.1. Clay minerals (Montmorillonite and Kaolinite): Montmorillonite (Na (Al, Mg)$_2$Si$_4$O$_{10}$(OH)$_2$.4H$_2$O, Monoclinic system) and kaolinite ($Al_2Si_2O_5(OH)_4$, Triclinic system) are identified by using (Pdf card no.130135 and 896538, respectively). The results showed that the montmorillonite content varies from 2 - 15 % by volume, while the kaolinite content varies from 5 - 7 % by volume.

4.4.A.2. Quartz (SiO_2) (Trigonal System): Quartz is identified using (Pdf card no. 5-0490), and it is occurring as the main phase with variable content by 30 % to 40 % by volume.

4.4.A.3. Calcite $CaCO_3$ (Trigonal system): Calcite occurs as the main phase in the bottom sediments of Qaroun lake with clay minerals with variable content by 20 to 30 % by volume. It is identified using (Pdf card no. (5-0490).

4.4.A.4. Halite NaCl (Cubic system): Halite occurs as the primary phase, with clay minerals forming about 8 % to 30 % by the volume of the investigated samples. It is precipitated from hyper-saline water. The encountered halite is of clastic origin. It is identified using (pdf card no. 5-0628).

4.4.A.5. Albite $NaAlSi_3O_8$ (Triclinic): Albite is represented by 10 % of the volume of the investigated samples, and it is identified by using (Pdf card no. 840752).

4.4.A.6. Anorthite $CaAl_2SiO_8$ (Triclinic system): Anorthite occurred by 8% by volume in the investigated samples of the east region of Qaroun lake, which is identified using (Pdf card no.710788). It appeared only in sample no.11.

Table 4. The percentage of organic matter and carbonate at East, Middle and West zones of Qaroun lake.

Zone	Stations	O. M. %	CO_3 %
East	Q2	16	22.97
	Q4	10.7	38.5
	Q7	18.6	33.1
	Q11	19.1	27.4
	Q12	21.7	32.7
	Q13	16.33	27.4
	Q15	18.9	35.49
Average		**17.33**	**31.08**
Middle	Q18	20.2	31.92
	Q21	11.12	33.1
	Q24	14.95	39.1
	Q25	8.3	30.8
	Q26	24.2	54.73
	Q28	15.9	38.65
	Q32	21.6	40.8
	Q33	18.01	27.3
Average		**16.78**	**37.05**
West	Q35	62.5	38.2
	Q37	16.4	28.98
	Q38	17.4	25.97
	Q41	22.2	36.95
	Q42	21.3	29.32
	Q44	23.3	41.46
	Q45	24.1	40.76
	Q46	22.2	41.66
	Q48	21.6	31.6
	Q50	25.8	27.522
Average		**25.68**	**34.24**

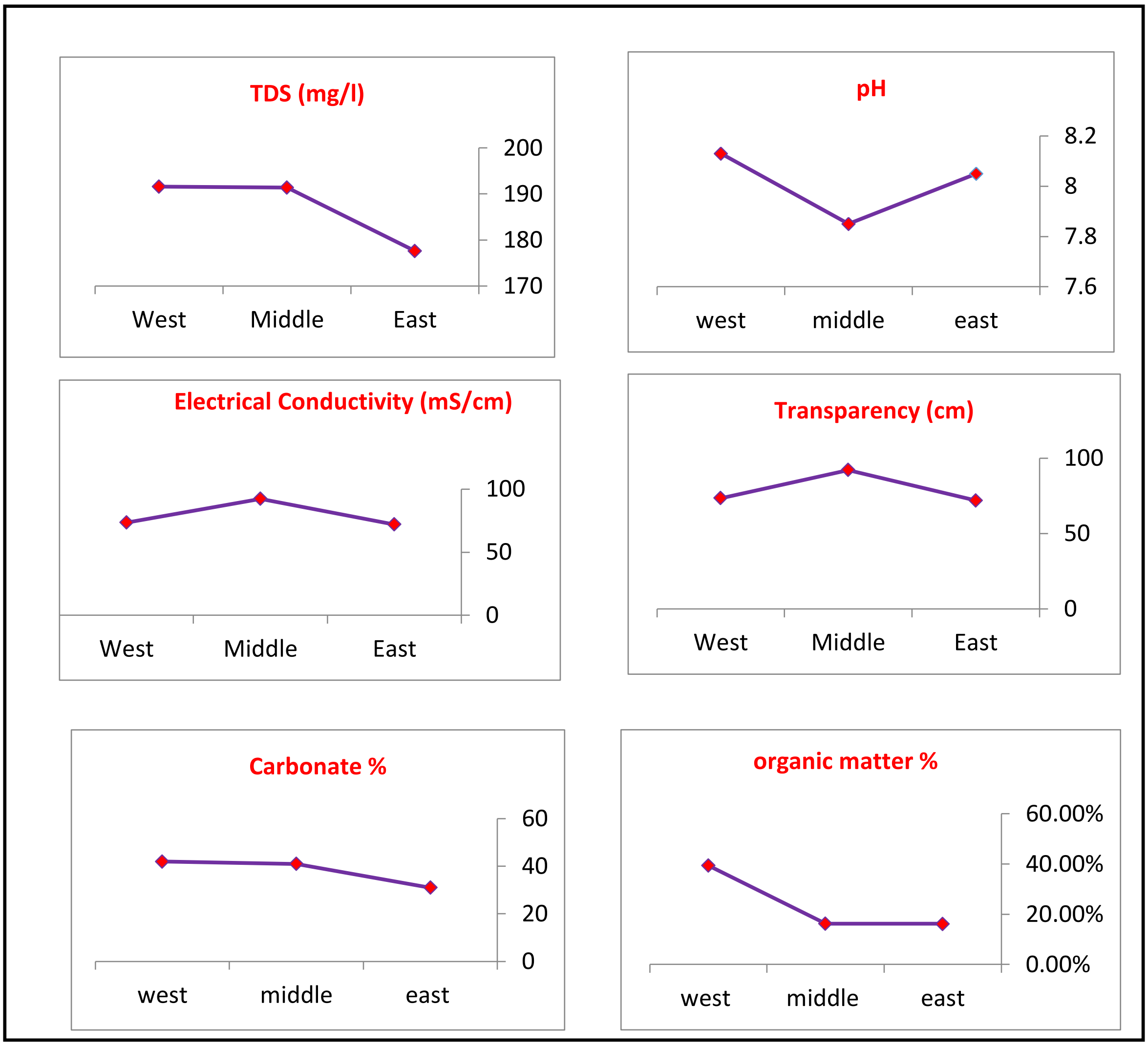

Fig. 4. Environmental parameters for water and recent bottom sediments of Qaroun lake.

Table 5. Average percent sediment types of Qaroun lake.

Zone	Silt%	Clay%	Mud%	Sand%	Gravel%	O.Matter
East	47.5	5.8	53.3	44.7	0.44	17.33
Middle	42.9	6.04	48.97	45.6	0.82	16.77
West	41.3	5.9	46.6	49.6	0.4	25.7

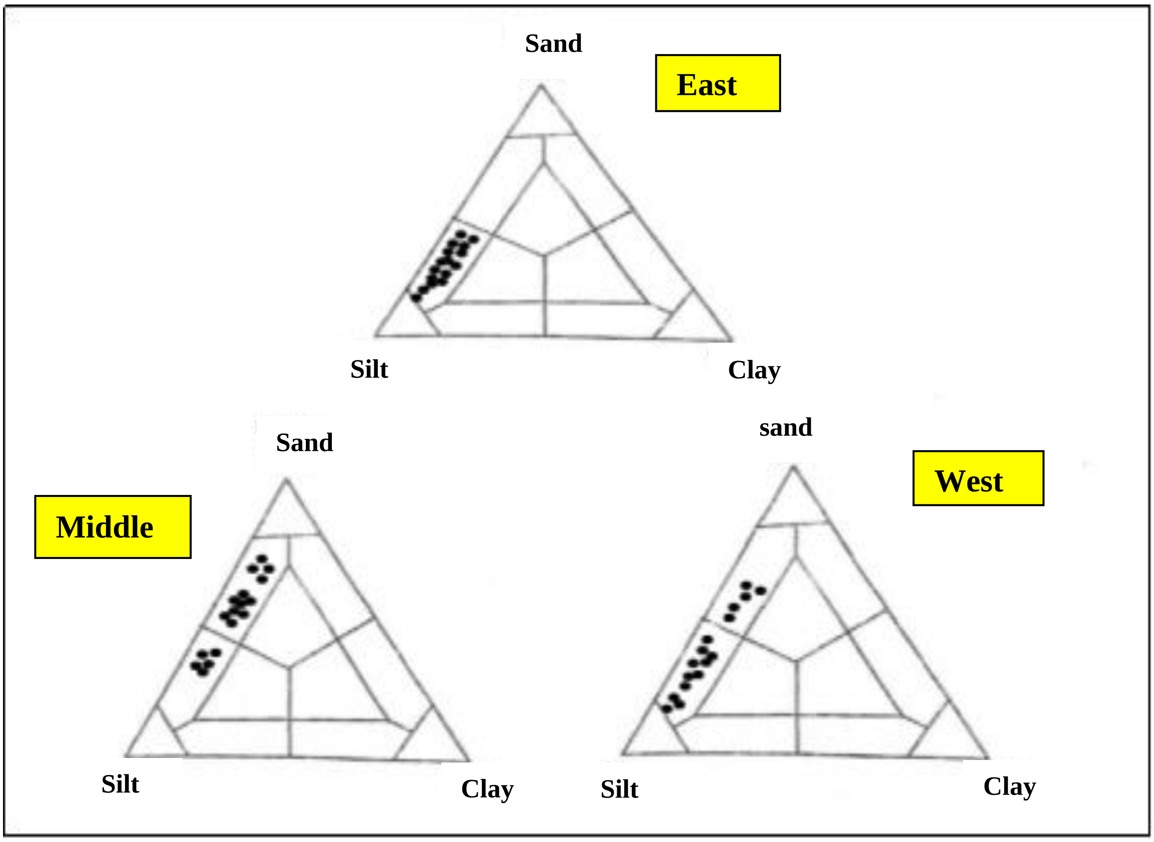

Fig. 5. Shows sediment types of the reconstructed sedimentary unit according to the ternary plots Folk (1968) in the recent bottom sediment of Qaroun lake (east, middle, and west zones).

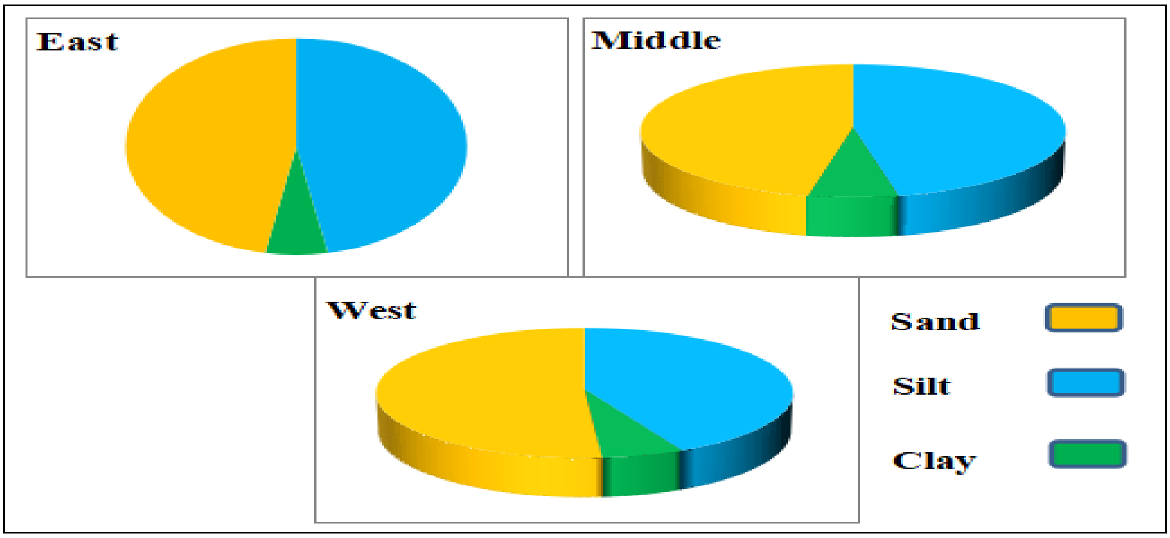

Fig. 6. Sand, Silt, and clay average percentages (%) in the recent bottom sediment of Qaroun lake (east, middle and west zones).

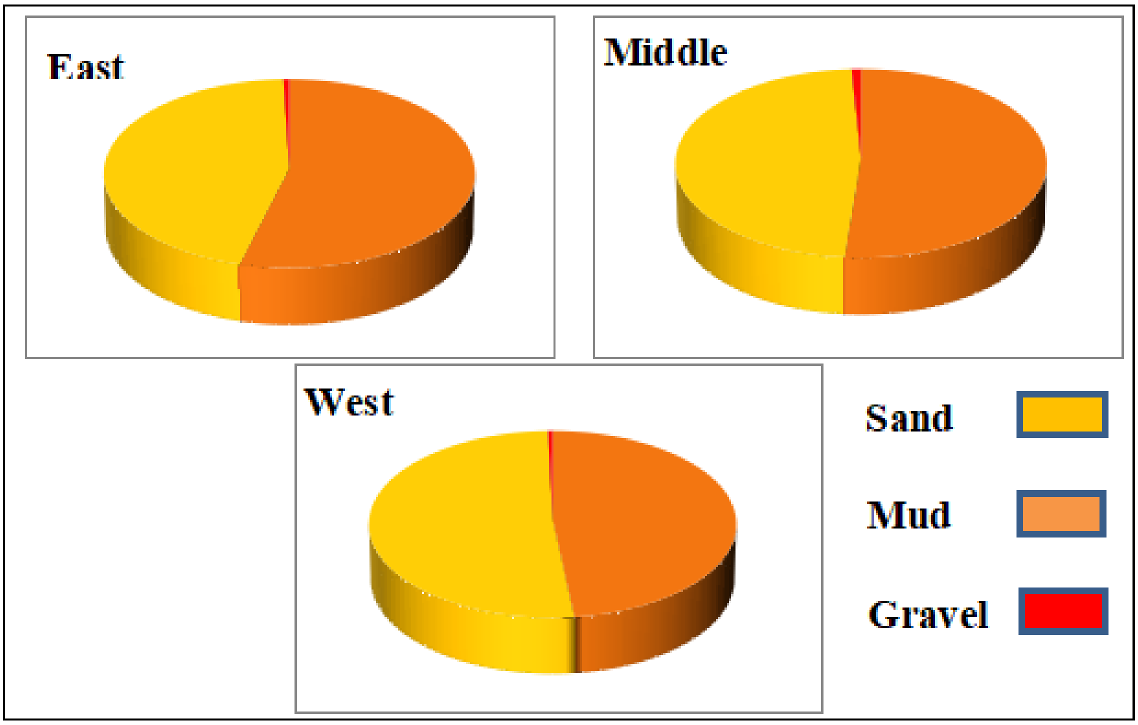

Fig. 7. Sand, Mud, and Gravel average percentages (%) in the recent bottom sediment of Qaroun lake (east, middle and west zones).

4.4.B. Mineralogical composition at Middle Zone:

Three representative samples (nos. 20, 29, and 31) for this region are to be examined mineralogically by XRD, as shown in (Fig. 8) and (Table 6). The analyzed recent bottom sediment samples are characterized by the presence of different groups of minerals with varying abundances as follows:

4.4.B.1. Clay minerals (Montmorillonite and Kaolinite): The results showed that the montmorillonite content is 15% by volume, while the kaolinite content is 5 % by volume.

4.4.B.2. Quartz (SiO_2) (Trigonal System): Quartz is the main phase, with a content reach of 40 % by volume.

4.4.B.3. Calcite $CaCO_3$ (Trigonal system): Calcite is a main phase in the bottom sediments of Qaroun lake with clay minerals, containing 30 % volume.

4.4.B.4. Halite NaCl (Cubic system): Halite is a main phase with clay minerals by 35 % to 55 % by volume. It is precipitated from hypersaline water. The encountered halite is of clastic origin.

4.4.B.5. Albite $NaAlSi_3O_8$ (Triclinic system): Albite is occurred by 10 % by volume in the bottom sediments of Qaroun lake.

4.4.B.6. Cosite SiO_2: Cosite is occurred as a main phase with variable content (25 – 40 %) by

4.4.B.7. Anhydrite $CaSO_4$ (Orthorhombic): Anhydrite has occurred as a minor phase with a content of 5% by volume, and it is identified by using (pdf card no.862270) in only one sample (sample no.31).

4.4.C. Mineralogical composition at Western Zone

Three representative samples (nos. 39, 48, and 50) for this region are to be examined mineralogically by XRD, as shown in (Fig. 8) and (Table 6). The analyzed recent bottom sediment samples are characterized by the presence of different groups of minerals with varying abundances as follows:

4.4.C.1. Clay minerals (Montmorillonite Kaolinite): In this zone, the montmorillonite content varies from 8% to 15% by volume, while the kaolinite content varies from 2% to 5 % by volume.

4.4.C.2. Quartz (SiO_2) (Trigonal System): Quartz occurs as a main phase with a variable content (30 - 40 %) by volume.

4.4.C.3. Calcite $CaCO_3$ (Trigonal system): Calcite occurs as main phase in the bottom sediments of Qaroun lake with clay minerals, and it has content that varies from 20 % to 30 % by volume.

4.4.C.4. Halite NaCl (Cubic system): Halite occurs as main phase with clay minerals from 30 % to 40 % by volume. It is precipitated from hypersaline water. The encountered halite is most probably of clastic origin.

4.4.C.5. Anhydrite $CaSO_4$ (Orthorhombic): Anhydrite has occurred as a minor phase with content varying from 7% to 10 % by volume. From the results above, quartz appears in all recent bottom sediments of Qaroun lake, ranging from 30 to 40 %. The highest abundance of quartz mineral in the sediments under study is likely due to weathering and erosion of agricultural soils and silico- clastic rocks outcropping around the lake basin, the sand dunes in the north and west, and the clastic sedimentary rock (sandstone) of El-Qarn Island in the central part of the lake (El-Sayed et al.,2022). The calcite is present in the range of 20 to 30 %. The presence of calcite in the sediment composition reflects the contribution from the geologic formation surrounding the lake and drains. The calcite mineral can be associated with the weathering and erosion of the exposed geological formation, such as the Ravine and Wadi Hof formations, which are rich in limestone deposits (El-Sayed et al.,2022). It can also be deposited in the lake due to reduced water flow and high evaporation rates (Abdel Wahed et al.,2015). Montmorillonite and Kaolinite occur in the range of 2 to 15 %. These minerals represent the weathering products of ancient clay-bearing deposits in the exposure areas, such as lacustrine deposits, Moghra Fm shale, and Qar El-Sagha Fm claystone (El-Sayed et al.,2022). The halite and anhydrite are present in samples between 8 to 55 % and 7 to 10 % for halite and anhydrite, respectively. The presence of halite indicates precipitation from supersaturated brine solution in the aqueous ecosystem of the lake, as reported by (Abdel Wahed et al.,2014). Anhydrite has occurred as a minor phase with content varying from 7% to 10 % by volume.

5. Conclusion:

In the current study, about Forty-nine samples were collected from 49 stations covering the Qaroun lake from east to west to study Physicochemical parameters and grain size distribution. Nine samples were selected from the total samples to check the mineralogical composition and coverage of the bottom zone of the lake to determine its content of mineralogical composition using XRD, and the main results are plotted as follows:

- Physical parameters, including average water depth for Qaroun lake, ranged between 4.42 m, 5.69 m, and 5.1 m for eastern, central, and western regions, respectively, and average transparency ranged between 71.94cm, 92.23cm, and 73.5 cm for eastern, central and western regions, respectively.

- Chemical factors, including the average hydrogen ion concentration (pH) of the water of Qaroun lake, ranges between 7.85,8.05 and 8.13 for central, eastern, and western regions, and this indicates that the lake belongs to an alkaline part, with average salinity for the lake ranges between 177.6, 191.4 and 191.6 mg/l for eastern, central and western regions, respectively, the average of electrical conductivity for lake ranges between 40.35, 43.52 and 44.05 mS/cm for eastern, central and western regions, respectively, the average organic matter ranges between 16.78,17.33 and 25.68% for central, eastern and western, respectively. The average carbonates range between 31.08, 34.24, and 37.05% for eastern, western, and central regions, respectively. The sand-size deposits increase in the central part due to the high erosion on El-Qarn Island. In contrast, silt size content increases in the eastern region, and clay size content increases in the central area. The silt and mud accumulate significantly in the region's east; clay and gravel are high in the central part, while the sand is high in the western region.

The distribution of mineralogical composition over the lake is found in the ranges (Montmorillonite, 2-15%), Kaolinite, 2-7 %; Quartz, 30-40%; Halite, 8-55%; Anhydrite, 7-10, Calcite, 20-30%, Albite, 10 %, Anorthite, 5-8 %, and Cosite, 25-40%.

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Table 6. Mineralogical composition (in %) of selected samples from recent bottom sediment of Qaroun lake in east, middle and west zones.

Zone	Sample No.	Montmorillonite	Kaolinite	Quartz	Halite	Anhydrite	Calcite	Albite	Anorthite	Cosite
East	1, 5, 11	2-15 %	7 %	30 – 40 %	8-30 %	ND	20-30 %	10 %	8 %	ND
Middle	20, 29, 31	15 %	5 %	40 %	33-55 %	ND	30 %	10 %	5 %	25-40 %
West	39, 48, 50	8-15 %	2-5%	30-40%	30 – 40 %	7 -10 %	20-30 %	ND	ND	ND

*** ND= Not Detected**

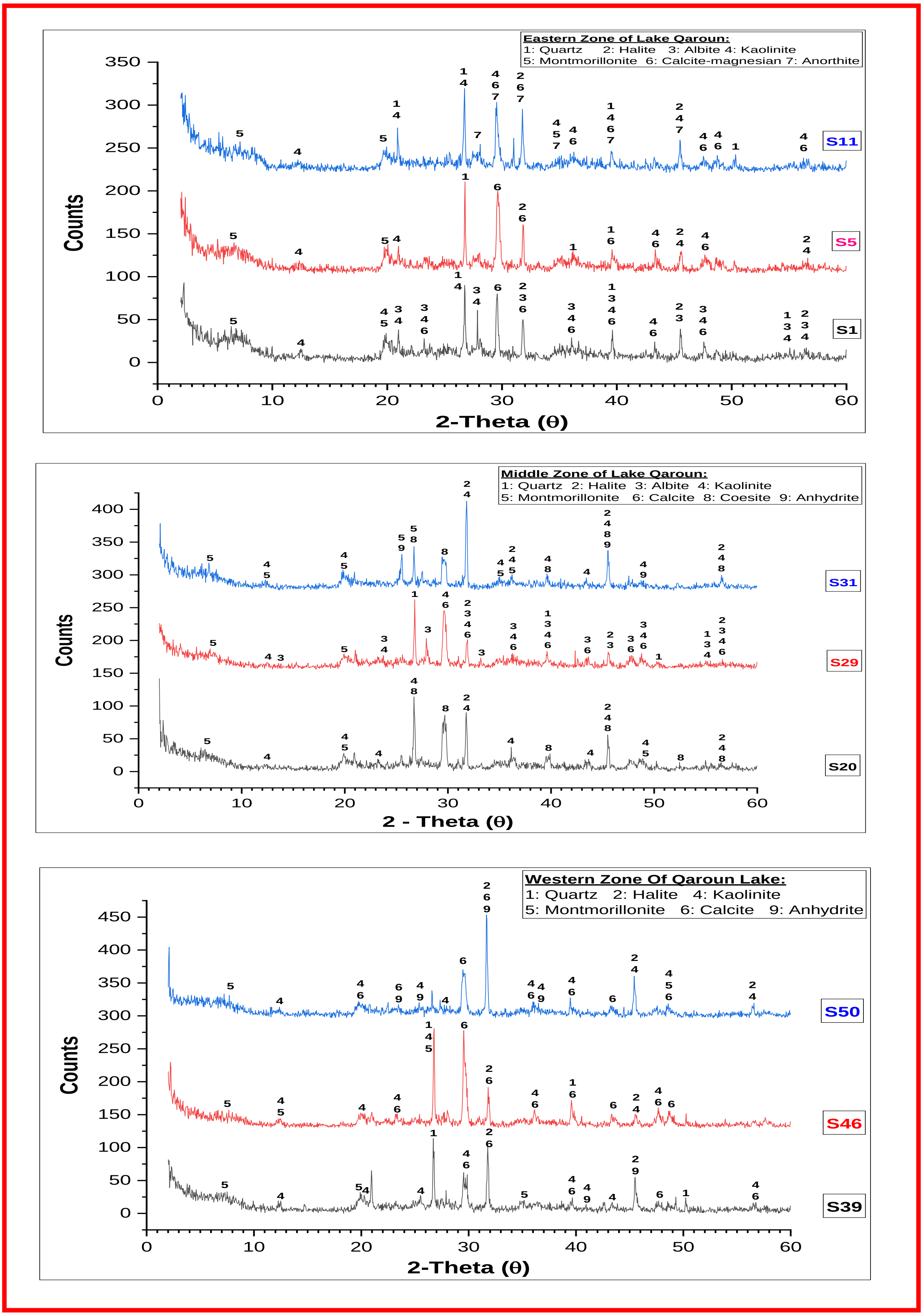


Fig. 8. Representative X-ray diffraction patterns of some recent bottom sediment samples form Qaroun lake.

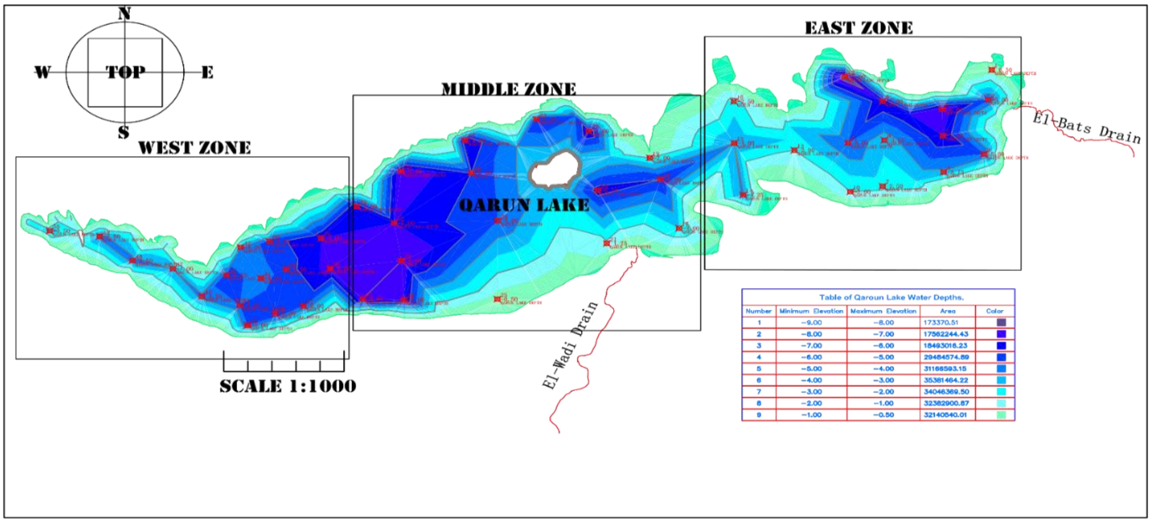


Table of Qaroun Lake Water Depths.

Number	Minimum Elevation	Maximum Elevation	Area	Color
1	−9.00	−8.00	173370.51	
2	−8.00	−7.00	17562244.43	
3	−7.00	−6.00	18493016.23	
4	−6.00	−5.00	29484574.89	
5	−5.00	−4.00	31168593.15	
6	−4.00	−3.00	35381464.22	
7	−3.00	−2.00	34046369.50	
8	−2.00	−1.00	32382900.87	
9	−1.00	−0.50	32140540.01	

Fig. 9. Shows distribution of water depths in east, middle, and west zones of Qaroun lake (Civil 3D Program).

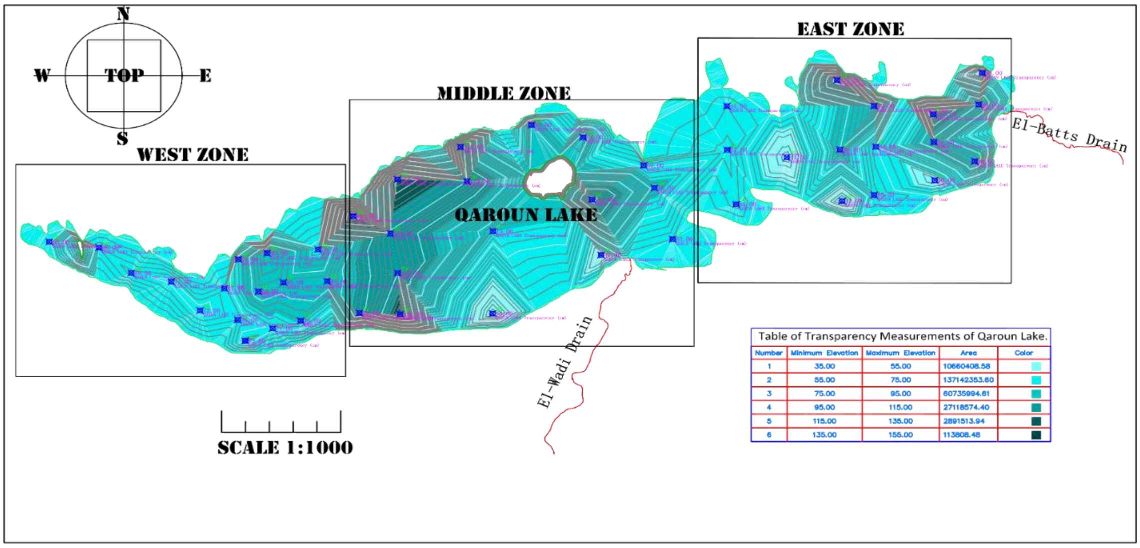
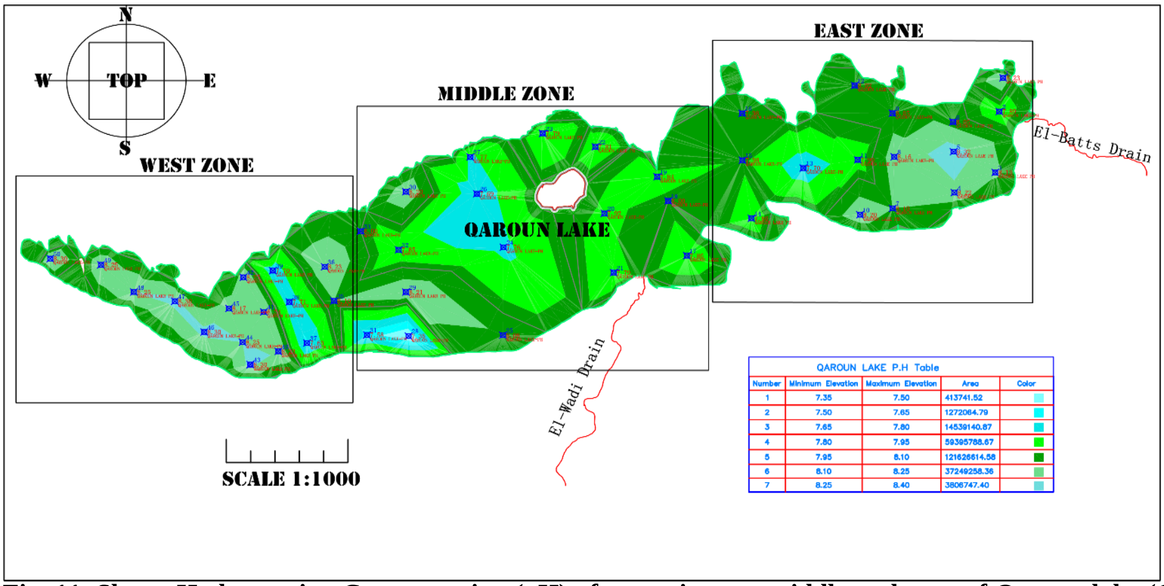


Table of Transparency Measurements of Qaroun Lake.

Number	Minimum Elevation	Maximum Elevation	Area	Color
1	35.00	55.00	10660408.58	
2	55.00	75.00	137142353.60	
3	75.00	95.00	60735994.61	
4	95.00	115.00	27118574.40	
5	115.00	135.00	2891513.94	
6	135.00	155.00	113808.48	

Fig. 10. Shows the transparency in east, middle and west zones of Qaroun lake (Civil 3D Program).



QAROUN LAKE P.H Table

Number	Minimum Elevation	Maximum Elevation	Area	Color
1	7.35	7.50	413741.52	
2	7.50	7.65	1272064.79	
3	7.65	7.80	14539140.87	
4	7.80	7.95	59395788.67	
5	7.95	8.10	121626614.58	
6	8.10	8.25	37249258.36	
7	8.25	8.40	3806747.40	

Fig. 11. Shows Hydrogen ion Concentration (pH) of water in east, middle and west of Qaroun lake (Civil 3D Program).

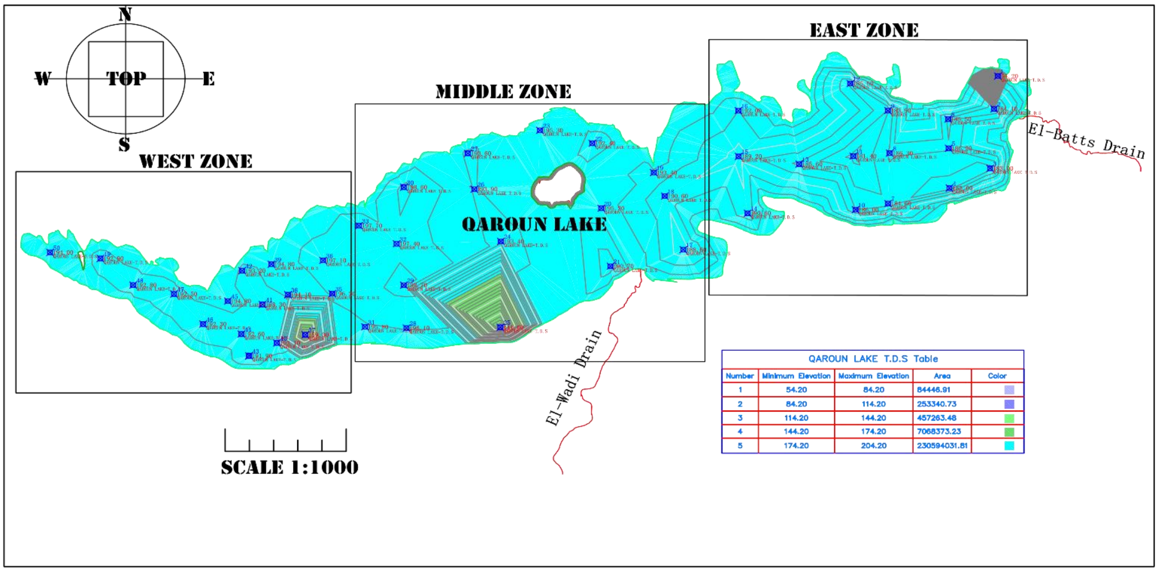


Fig. 12. Shows Total Dissolved Salt (T.D.S) of water in east, middle and west zones of Qaroun lake (Civil 3D Program).

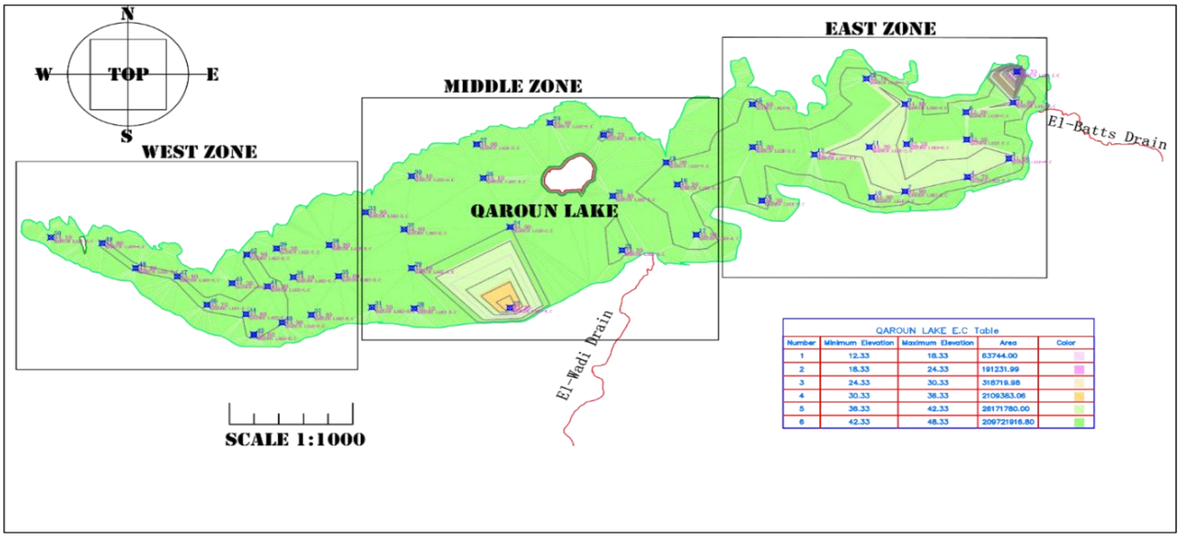


Fig. 13. Shows the Electrical conductivity of water in east, middle and west zones of Qaroun lake (Civil 3D Program).

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العوامل الطبيعية والكيميائية والتوزيع الحبيبي والتركيب المعدني للرواسب القاعية الحديثة ومياه بحيرة قارون، الفيوم، مصر

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هدفت الدراسة الحالية إلى دراسة الخصائص الفيزيائية والكيميائية وتوزيع حجم الحبيبات والتركيب المعدني لرواسب القاع الحديثة ومياه بحيرة قارون. تم تسجيل الخصائص الفيزيائية والكيميائية مثل قياس قيم أعماق المياه ٤,٤ و٥,١ و٥,٧ متر في المناطق الشرقية والغربية والوسطى على التوالي، وقياس قيم الشفافية ٧١,٩ و٧٣,٥ و٩٢,٢ مللي/سم في المناطق الشرقية والغربية والوسطى على التوالي.

تم قياس تركيز آيون الهيدروجين في الماء وكانت النتائج كالتالي: ٧,٨٥ و٨,٠٥ و٨,١٣ في المناطق الشرقية والوسطى والغربية على التوالي. كانت قيم الملوحه ١٧٧,٦ و١٩١,٤ و١٩١,٦ ملجم/لتر فى المناطق الشرقية والوسطى والغربية على التوالي. تزداد التوصلية الكهربائية تدريجيًا من المنطقة الشرقية إلى منطقة الغرب، مرورا بالمنطقة المركزية. تتراوح متوسط قيم الكربونات في الرواسب القاعية الحديثة لبحيرة قارون بين ٣١,٠٨ و٣٧,٠٥ و٣٤,٢٤% في المناطق الشرقية والوسطى والغربية على التوالي. في المقابل، تتراوح متوسط قيم المادة العضوية في بحيرة قارون ما بين ١٧,٣٣ و١٦,٧٨ و٢٦,٦٨% في المناطق الشرقية والوسطى والغربية على التوالي. يتراكم الطمي والطين بشكل كبير في المنطقة الشرقية والطين والحصى وبشكل مرتفع في الجزء الأوسط، ويزداد الرمل في المنطقة الغربية. علاوة على ذلك تم استخدام جهاز XRD لدراسة االتركيب المعدني، وقد أظهرت النتايج أن توزيع التركيب المعدني في البحيرة كالتالي: حيث وجدت نطاقات المونتموريالنيت من ٢ إلى ١٥%، كاولينيت من ٢ إلى ٧%، كوارتز من ٣٠ إلى ٤٠%، والهاليت من ٨ إلى ٥٥%، والأنهيدريت من ٧ إلى ١٠%، والكالسيت من ٢٠ إلى ٣٠%، والألبيت ١٠%، والأنورثيت من ٥ إلى ٨%، والكوسيت من ٢٥ إلى ٤٠%.