**Marine Science Center-University of Basrah**

**Mesopotamian Journal of Marine Sciences**
**Print ISSN: 2073-6428**
**E- ISSN: 2708-6097**
www.mjms.uobasrah.edu.iq/index.php/mms

# Mineralogy and sediment grain-size distributions as index of the modern sedimentary processes of Sawa Lake, Mothanna Governorate, Southwestern Iraq

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**Article info.**
✓ *Received: 26December 2018*
✓ *Accepted: 8 August 2019*
✓ *Published: 29December 2019*

**Key Words:**
Grain Size analysis.
Sand dunes,
Sawa,
Sedimentary structures,

**Abstract -** Sawa Lake is located in the southwest of Samawa city, it is of geological significance because it lies in the transitional zone between the sedimentary plain and the western plain, which is semi-desert and relies on the ground water as providing sources. It has a special case in sedimentation. The mineralogical composition of the lake sediments is characterized by Gypsum Calcite, Anhydrite, and Hematite, which is in turn builds different forms of sedimentary structures, including the tuberous, concretion, Nodule, and linear forms, as well as the deposition of calcium carbonate at the bottom of the lake in general. The cones were deposited by Chara algae (biological deposition), which collect sand grains from the atmosphere and connect them with calcium carbonate, these structures in the southern part of the lake are close to the sand dunes. The physical deposition in the lake was based mainly on wind and dust storms and the presence of sand dunes in the south and south-west and some areas in the north-west of the lake. The results of the grain size analyses showed the dominance of sand, more than 80%, and the silt does not exceed 20% while the clay is 1%. The north and south east of the lake, which is far from the movement of sand dunes does not exceed 70%, while the silt reaches 30% and the clay is still about 1%. This process detects the effect of sand dunes movement in the area.

# التوزيع الرسوبي والمعدني كدليل للعمليات الرسوبية الحديثة في بحيرة ساوة، محافظة المثنى، جنوب غرب العراق

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**المستخلص -** تقع بحيرة ساوه في الجنوب الغربي لمدينة السماوة وتحظى بأهمية جيولوجيا كونها تقع في المنطقة الانتقالية بين السهل الرسوبي والهضبة الغربية وهي منطقة شبه صحراوية وتعتمد على المصادر الجوفية في تجهيزها ولها وضع خاص في عملية الترسيب اذ يمتاز الترسيب الكيميائي للبحيرة بوجود المعادن الجبس والكالسايت والهماتايت والانهيدرايت والتي بدورها تبني تراكيب ترسيبيه مختلفة الاشكال منها الدرنية والخيطية والعقدية فضلاً عن ترسيب كربونات الكالسيوم في قاع البحيرة بشكل عام، يتم ترسيب المخاريط بواسطة طحالب الكارا (ترسب بيولوجي)، والتي تجمع حبيبات الرمل المنقولة بواسطة الرياح وتربطها بكربونات الكالسيوم، لذلك نرى أن هذه التراكيب تقع في الجزء الجنوبي من البحيرة بالقرب من الكثبان الرملية. أما الترسيب الفيزيائي والذي اعتمد بشكل رئيس على الرياح والعواصف الترابية ولوجود الكثبان الرملية في الجزء الجنوبي والجنوب الغربي وبعض المناطق في الجزء الشمالي الغربي من البحيرة وكما لوحظ من التحاليل الحجمية بسيادة الرمل بنسبة تفوق 80% ونسبة الغرين لا تتجاوز 20% اما الاطيان فلم تتعدى1%، بينما الجزء الشمالي والجنوب الشرقي من البحيرة والتي تكون الجهة البعيدة عن حركة الكثبان الرملية فلم تتجاوز نسبة الرمل 70% اما الغرين فقد وصل الى 30 % وبقى الطين بحدود 1% ومن هذه العملية يظهر تأثير حركة الكثبان الرملية الموجودة في المنطقة.

**الكلمات المفتاحية**: ساوة الكثبان الرملية، الهياكل الرسوبية ، تحليل حجم الحبوب

DOI: https://doi.org/10.58629/mjms.v34i2.31., ©Authors, Marine Science Centre, University of Basrah.

## Introduction

Sawa Lake has historical significance for being an ancient site in early times. It is located between latitudes (31° 17′ 43.10″ and 31° 19′ 49.79″) and longitudes (44° 59′ 29.01″ and 45° 01′46.61″). It lies about 25 km from the southwest Samawa Governorate. It occupies an area of about 12.5 km2 and 4.75 km long, and its width is 1.75 km (Fig. 1). Al-Atshan river waterway is far from the lake at about 4 km to the north and northeast side and the lake rises about 11 m (above sea level ASL) and above the level of the Al-Atshan river. The depths in the lake are more shallow being generally less than 2m, except at the three feeding holes, one of which is big and the other two are small (Al-Abadi, 2013). These holes are considered as cliffs formed by deposits accumulate in sand dunes (Jamil, 1977).

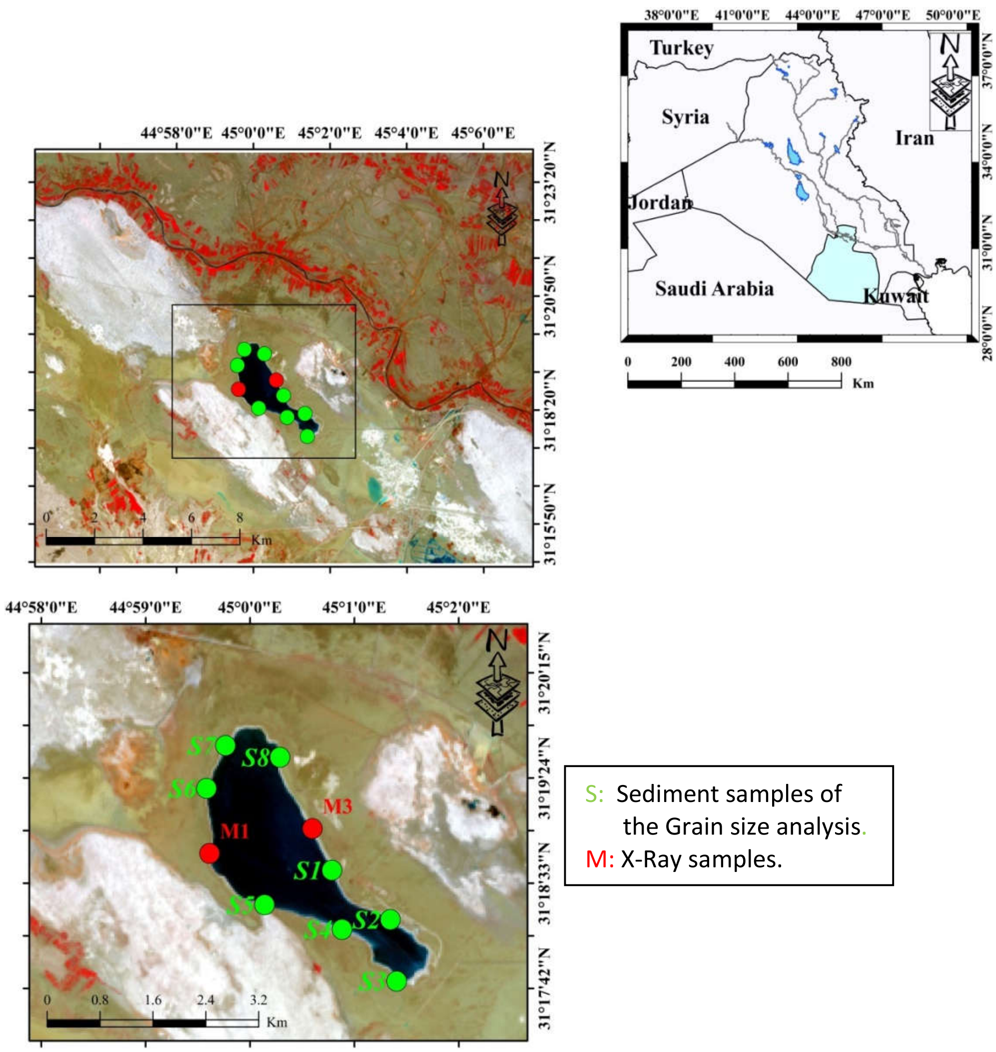


Figure 1. Location of the study area (Landsat 8 OLI Earth Explorer, 2018).

Sawa Lake waters is provided from the underground sources. There are some of discontinuous layers on the side of the hole due to the existence of a number of underground cavities extends to several meters with different dimensions and forms(Al-Mosawi *et al.*, 2015). The lake is characterized by having underground sources. It has no superficial feed sources except at the monsoon rains when only a few millimeters per year that discriminate the dry desert climate (Al-Quraishi, 2013). The area was described as desert conditions, because it is located in a dry area with high temperatures, sever dry heat long summer and low temperature, low rainfall short winter (Al-Khafaji, 2016). The deposition in this lake is generally a chemical type (Al-Naqash, 1977). The study of green algae in Sawa Lake, identified the following species; Chara sp., *Cladophora crispata* and *Cladophora fractavar* (Hassan *et al.,* 2006).

Geological Setting:

Generally, the study area is associated with the geological development of Iraq, which is part of the Arabian plate, which formed the general frame of the tectonic and geological events that affected the area in different degrees. Tectonically the study area is located at the transition zone between two tectonic Subzones; Southern Desert and Mesopotamia fore deep (Fig. 2).

The first is part of the Inner Platform (stable continental part), the latter is part of the Outer Platform (unstable continental part) (Fuoad, 2015). It is located between Salman subzone Stable Shelf and Samawa-Nasiriya Unstable Shelf subzones (Al-Kadhimi *et al.*, 1996). The Euphrates (Abu Jir) Fault Zone is located on the southwestern side of Sawa Lake. This fault has a tectonic behavior through the neotectonic movements evidenced by straight escarpment that forms the boundary between the Mesopotamian Plain and the Southern Desert (Sissakian and Deikran, 2009). The study area is characterized by Quaternary alluvial and flood plain deposits of the Euphrates River from the north to northeast side as well as the Aeolian sand dunes and sand sheet deposits distributed on the southwest side.

The recent layer represented by salting deposit lies beneath the area under studying. The determination of water quality is a magnificant factor for the area. The Quaternary sediments include the slope sediments, the gypecrete, sheet of salt, and Sabkha. The sediments of sand dunes and sand sheet are the Aeolian deposits. In fact. The Quaternary sediments are marked by many factors such as the nature of the inhomogeneity as well as the vertical and lateral behavior, particularly in the upper parts because of the availability of silt and clay layers found at depth of 20-25 meters (Jassim and Goff, 2006).

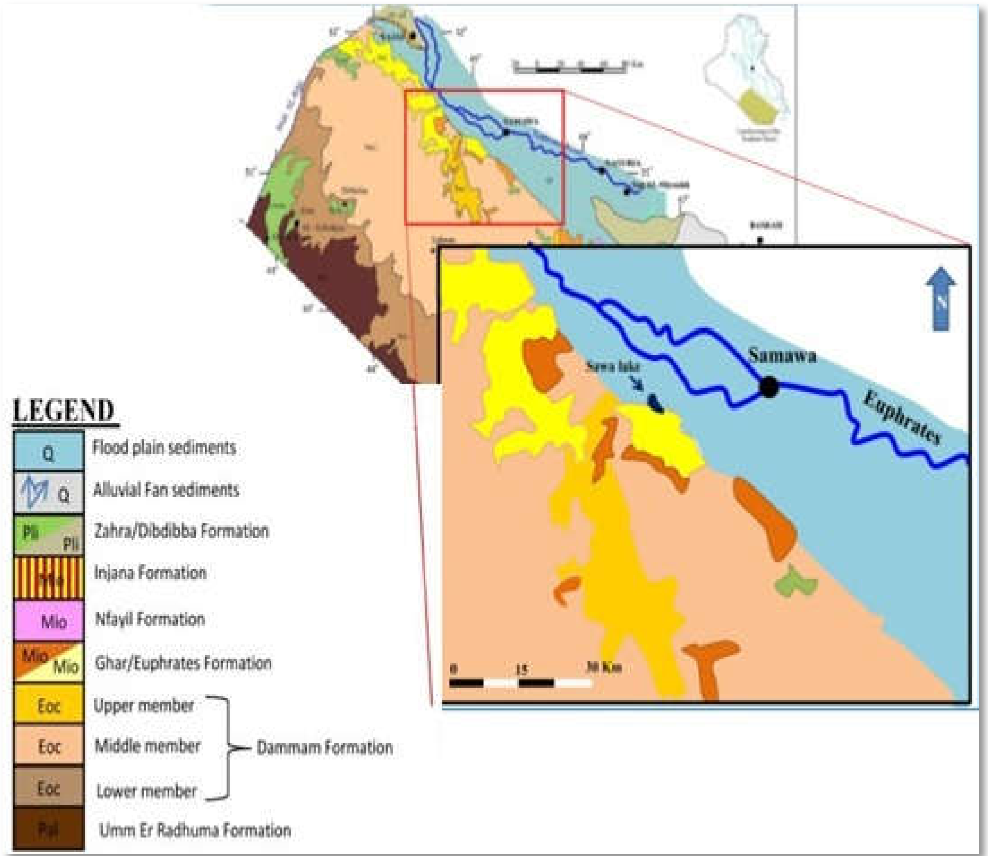


Figure 2. Geological map of the study area (after Sissakain, 2000)

## Materials and Methods

The methods carried out here were divided into two parts:

A. Field Work:

1. Eight sediment samples were collected on two field trips in April 2012 and February 2015 from the sediments near the lake at a depth of 50 cm. The samples were stored in plastic bags and the imposition (X, Y) were fixed (Fig. 3).
2. Twenty water samples were collected using water sampler.
3. In-situ measuring of the pH and EC of the samples using pH and EC WTW meter.
4. Measurement of Total dissolved Salts (TDS) by Multimeter Device WTW.
5. Reconnaissance field trip for observing the geological features around the lake and recording their occurrence by Digital camera.

B. Laboratory Work:

1. Performing a volume analysis of samples using the Master seizer instrument.
2. Measuring the volume of suspended load by the filtration method (Drake, 1974).
3. Mineralogical analysis of sediment by X-Ray diffraction techniques.

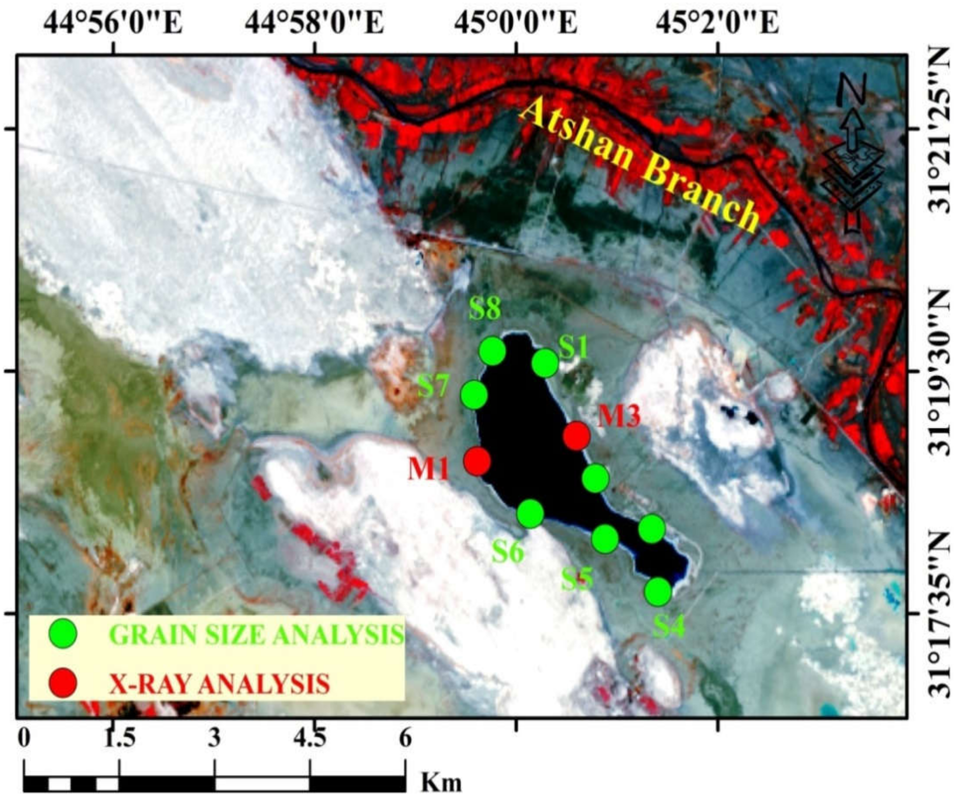


Figure 3. Surface sample of the Sawa Lake (Landsat8 OLI).

**Results and Discussion**

The results of the suspended load showed decreasing in the values at all samples tested in the laboratory, which reached 50 gm/l (Table 1). This is because of the lack of surficial feed sources.

The main source of suspended load in the lake is created by wind action. The sand dunes are characterized by relative evenness, and their sediments are approximately fine (Fig. 3).

The sand dunes are distributed from west-south of Sawa Lake and they moved from south to north. This movement was influenced by the sediment type as the bed sediments are carbonate beds contain sand particles at a ratio of 29%. The grain size analysis showed an increase in the sand ratio (Table 1, Fig. 4). This ratio doesn't increase consistently at all lake parts.

The ratio was about 90% in the southern direction of the lake when the site was nearest to the sand dunes location. Whereas in other parts of the lake it doesn't pass 70%.

The field measurements of pH, EC and TDS) showed that the dominant deposition process in the lake was chemical deposition (Table 1). The pH, EC and TDS values were 8.43, 34.6 µS and 24165 mg/l, respectively. The measurements indicate that the medium of Sawa Lake is a deposition not solution.

Gypsum increased in the south of the lake while Halite, Hematite, and Anhydrite, respectively are lower in the south than the north. Calcite is higher in the south of the lake (Fig. 5, Table 2).

Table 1. Some water parameters and sediment analysis of the Sawa lake.

| Sample | TSS mg/l | pH | E.C µS | TDS mg/l | Clay % | Silt % | Sand % |
|---|---|---|---|---|---|---|---|
| 1 | 52 | 8.5 | 34300 | 24100 | 1 | 37 | 62 |
| 2 | 50 | 8.21 | 34500 | 24190 | 1 | 31 | 68 |
| 3 | 53 | 8.33 | 34700 | 24200 | 1 | 17 | 84 |
| 4 | 47 | 8.59 | 34700 | 24180 | 1 | 13 | 86 |
| 5 | 51 | 8.5 | 34600 | 24100 | 1 | 10 | 89 |
| 6 | 51 | 8.55 | 34700 | 24185 | 1 | 15 | 84 |
| 7 | 46 | 8.22 | 34700 | 24190 | 1 | 32 | 67 |
| 8 | 50 | 8.36 | 34600 | 24165 | 1 | 32 | 67 |
| Average | 50 | 8.41 | 34600 | 24163.75 | 1 | 23.38 | 75.88 |

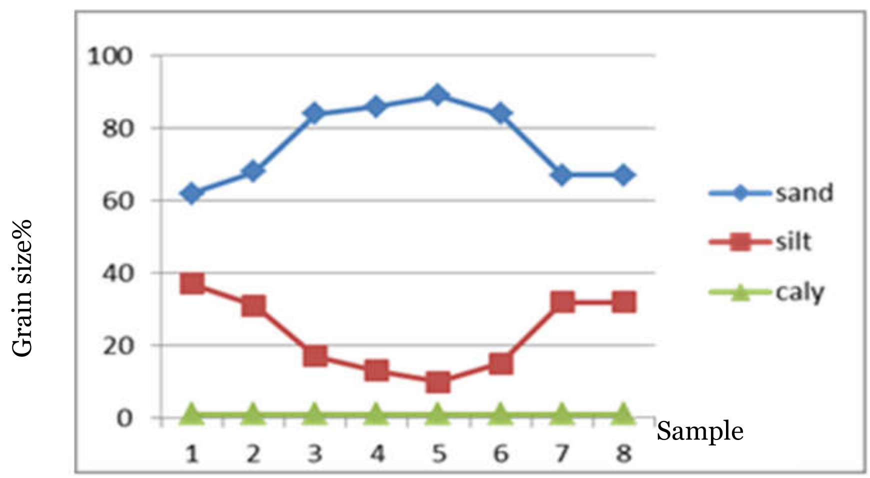


Figure 4. Grain size analysis (Sand, Silt and Clay) of the Sawa lake.

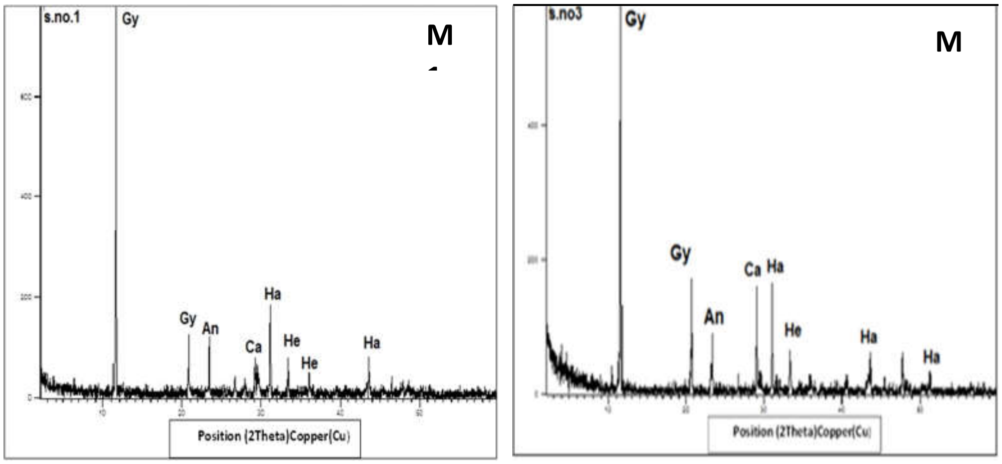


Figure 5. X-Ray M1, M3 of Sawa lake.

Table 2. X-Ray parameters of Saw lake.

| Sample No. | Gypsum % | Halite % | Hematite % | Calcite % | Anhydrite % |
|---|---|---|---|---|---|
| m1 | 64 | 4.0 | 15 | 7 | 6 |
| m3 | 54 | 11 | 17 | 6.0 | 16 |
| Average | 59 | 7.5 | 16 | 6.5 | 11 |
| Total | | | | | 100.00 |

Cone deposition processes are initiated by (Chara) algae, which combine sand, sedimentation of carbonate and calcium carbonate as a soluble form of the lake water. These results support this scenario because of the proportion of sand in these structures was more than 90%, and the proportion of carbonate was 78%, and these cones are in the part of the lake adjacent to sand dunes.

While the proportion of sand in the far side was up to 60% whereas the percentage of the silt reached more than 30% as well as fine sand (Table 1), which consist of structures of mud cracks.

The direct chemical deposition of minerals in the lake is based on the concentration of the soluble material in the lake water. The occurrence of sand like sheets surrounding the lake, especially in the west to northwest parts of the lake led to the predominance of sand deposits in the lake beds. These sediments deposited by wind forces and dust storms activated by the dryness summer seasons.

Sedimentary Structures Description:

Accumulative structures: These structures are associated with two phases:

Primary structures (biological):

Charophytes are a group of carbonate-precipitating, macroscopic green algae that forms an important floral element in the littoral zones of carbonate-rich freshwater or brackish lakes up to ~12 m deep (Garcia and Chivas, 2006; Détriché et al., 2008). The main factor determining the precipitation of CaCO3 in Sawa Lake, is the depressurization of carbonate-laden groundwater leads to a release of excessive CO2 and stimulates precipitation of CaCO3. (Merz, 1992; Riding, 2000).

It can thus be anticipated that both the super saturation of the incoming lake water with CaCO3 or dissolve rocks in the lake wall and the presence of Characean algae runs a major control on the effective production of CaCO3 (Khanaqa et al., 2013). As a result of common influences, white events occur during the summer, especially during strong wind times. The sediments of the newly formed lime sand facies exhibit very poor sorting and little rounding.

The Characean Algae gathers the grain of sand and calcium carbonates being as a cement material, subsequently the cones shapes were composited. The newly lime sand facies formed exhibiting very poor sorting and little rounding. The weathered lime sand facies characterized by well-sorted and rounded grains with smooth surfaces.

Most sedimentary structures have moderate roundness and high cone shapes reflecting the original elongate nature of the skeletal fragments of Chara species. Most sedimentary structures in Sawa lake area have moderate roundness and high cone shapes that reflect the original elongate nature of the skeletal fragments of Chara species.

A. Secondary structures:

These compositions are formed after the accumulation base from the Characean algae that formed above. The water starts to impact on the body of the structure to develop needle or node sheets forms composed from Halite (Fig. 6). When the connection is broken, the deposition of sulfur can be observed in the sedimentary structure (Fig. 7).

1. Nodule Structures:

It is a tiny knot with heterogeneous and cyclic shape, mass, of a mineral or mineral accumulate that has different composition, for example the Pyrite and Chert nodule in limestone, or a phosphorite nodule in marine shale.

The nodule structure in Sawa Lake found either on the wall of the lake building their structure out of wall, or above in the surface (Fig. 8). In general, nodules structures loss any internal structure excluding the protected remnants of the original bedding or fossils.

Nodules are closely depended on concretions and sometimes these terms are used interchangeably. Minerals that typically form nodules include Calcite, Chert, Apatite (phosphorite), Anhydrite, and Pyrite (Boggs, 2009). While the minerals that composed the nodule structure in Sawa Lake were Calcite and Chert, Anhydrite as it identified by the XRD analysis.

2. Concretion structures:

These Structures have spherical, ovoid irregular shapes. They composed by the compaction of sediments when the cementing materials are precipitated within the spaces of particles.

Concretion is formed in sedimentary strata that deposited in anticipation. It forms early in the buried sediments before the sediments are desiccated into rocks (Al Agha *et al.*, 1995).

It consists of carbonate minerals and represents with the calcite, silica microcrystalline such as Jasper, Flint and Chert, and hydroxide or iron oxide such as hematite and goethite (Boggs, 2009). We found that the Gypsum is a primary mineral that composed the concretion structure in Sawa Lake (Fig. 9).

3. Karst topography:

These structures occur in carbonate rocks like dolomite or limestone owning to liquefaction of dissolves layers in bedrock. The karst is formed with shape of three-dimensional landscapes. It shows a behavior of subsurface draining or little of surface drawing off (Ford and Williams, 2007). We found these features in Sawa Lake as in (Fig. 10).

4. Mud Cracks:
   This type of hexa shape sedimentary structures is established in muddy soils that exposed to wet and hard drying due to the decreasing in moisture content. These structures diffused in the north of Sawa Lake where the sediments and grain size particles, silt and clay are high in percentage (Table 2 as shown in Figure 11).

**Conclusion**

1. The study area has shown wide range of processes and factors influencing the deposition of sediments that varies according to different positions in the lake.
2. The availability of the sediment particles and minerals may help in the formation of exceptional sedimentary structures.
3. Sawa Lake provides an excellent insight into the occurrence and fossilization process of characean algae and the formation of sedimentary structures in some sites of the Lake.

**Acknowledgements**

We wish to thank Mrs. Najid Faisal Shareef for her help in reading the manuscript. Many thanks are due to Miss Layal Fadhel for providing suggestion on the X-Ray analysis and Identification of minerals. A special thanks goes to Mr. Hashim Jaafar for the photographs of the Sawa Lake.

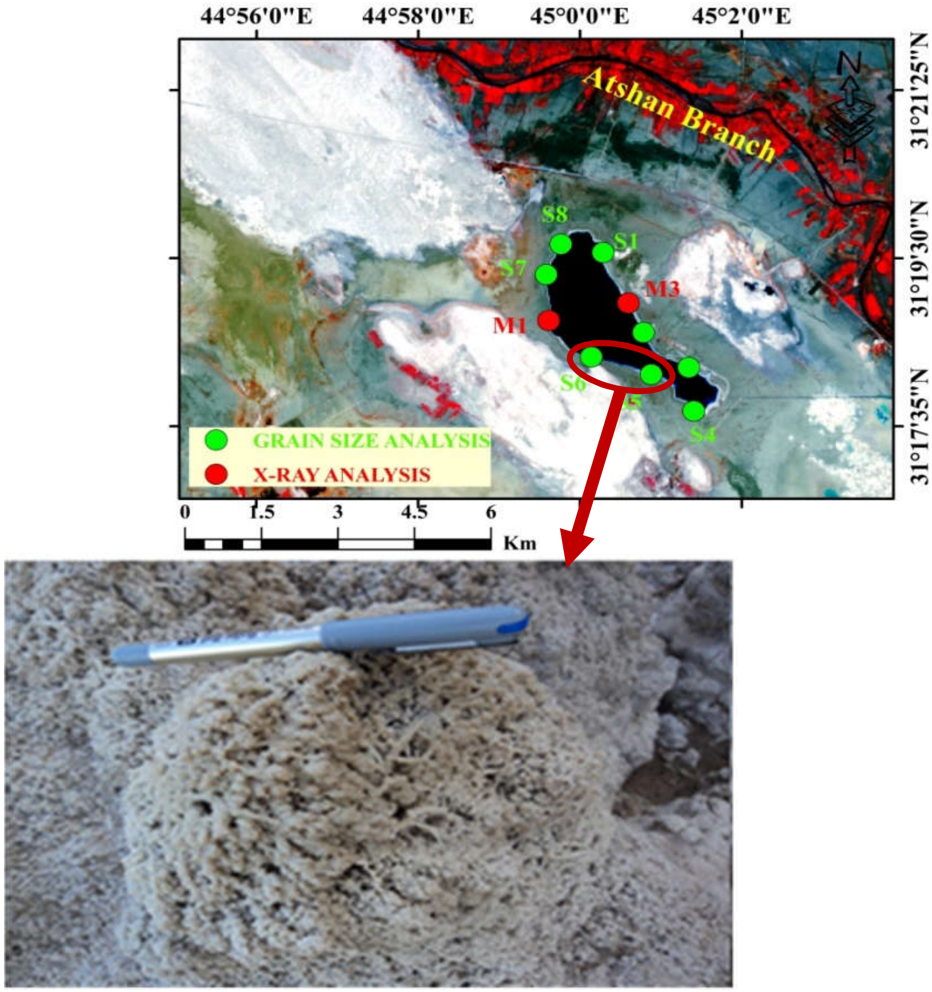


Figure 6. Secondary structures and Halite in Sawa Lake.

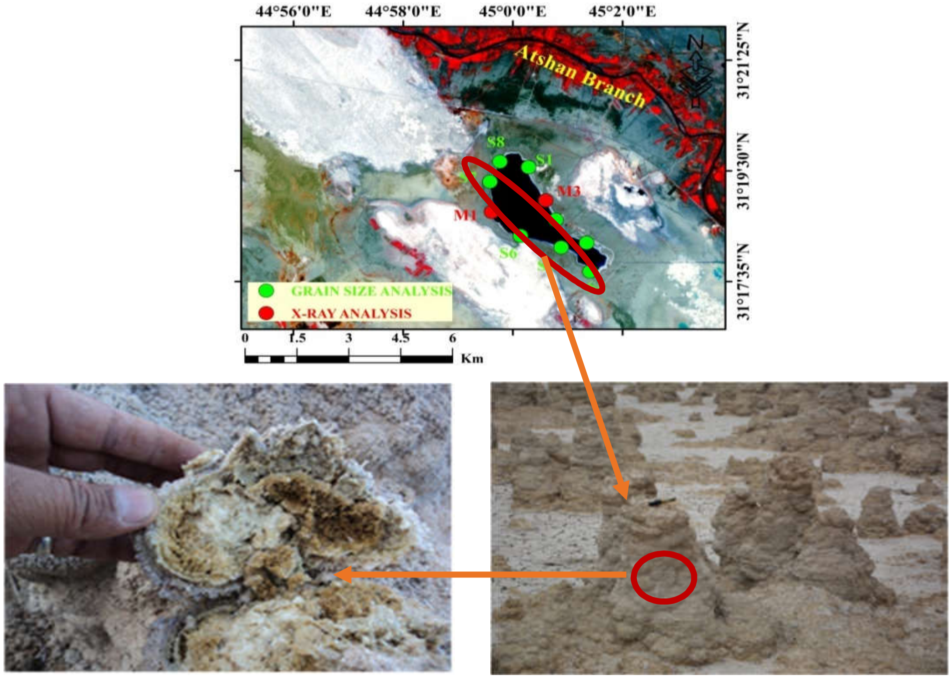


Figure 7. Nodule and Cones in Sawa Lake.

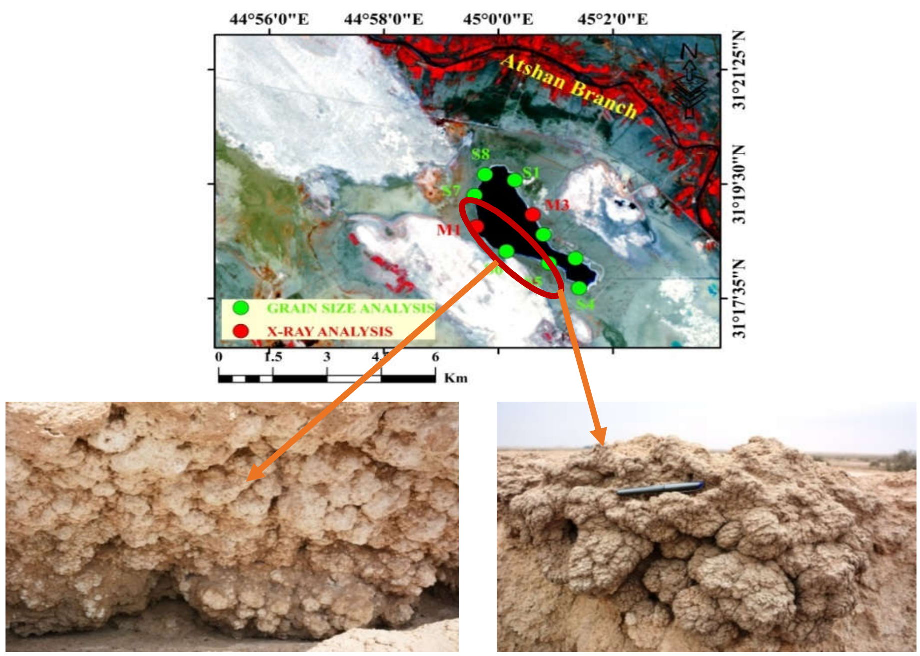


Figure 8. Nodule Structure from Sawa Lake.

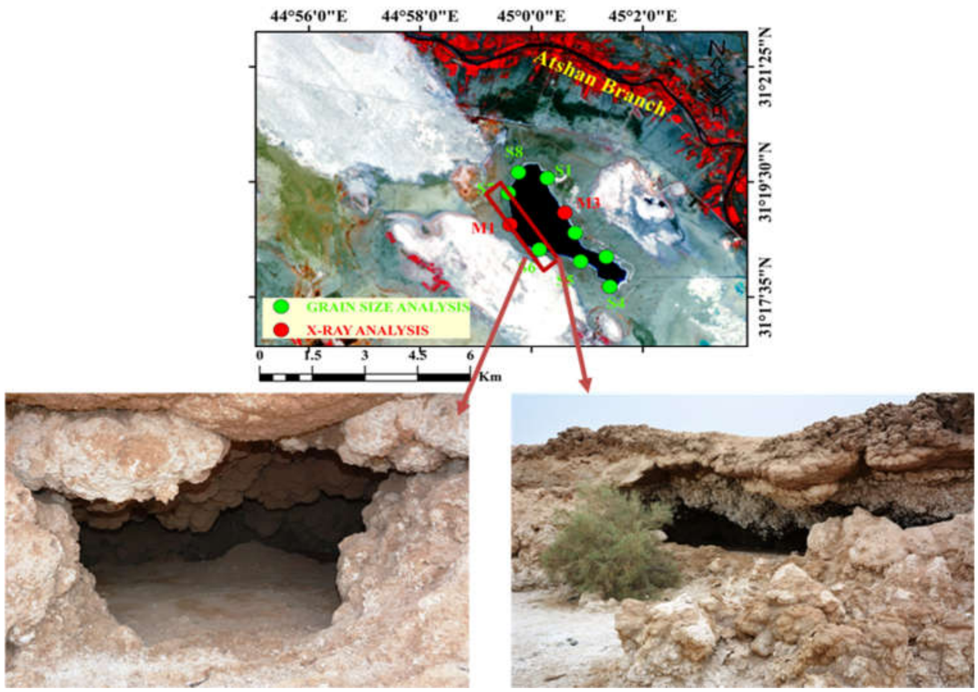


Figure 9. Karst topography of the Sawa Lake.

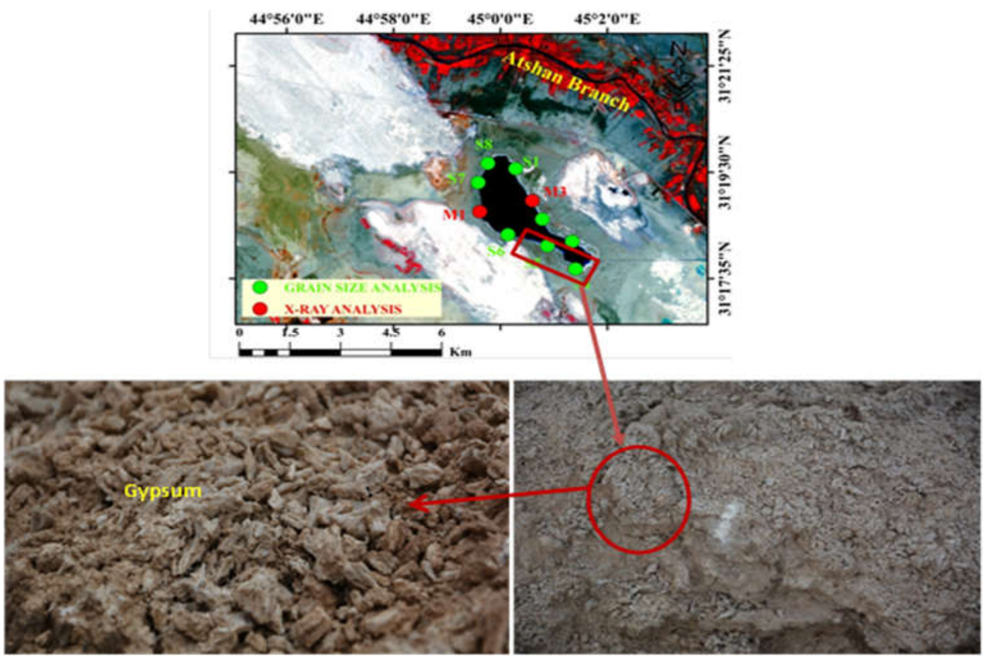


Figure 10. Concretion structure of the Sawa Lake.

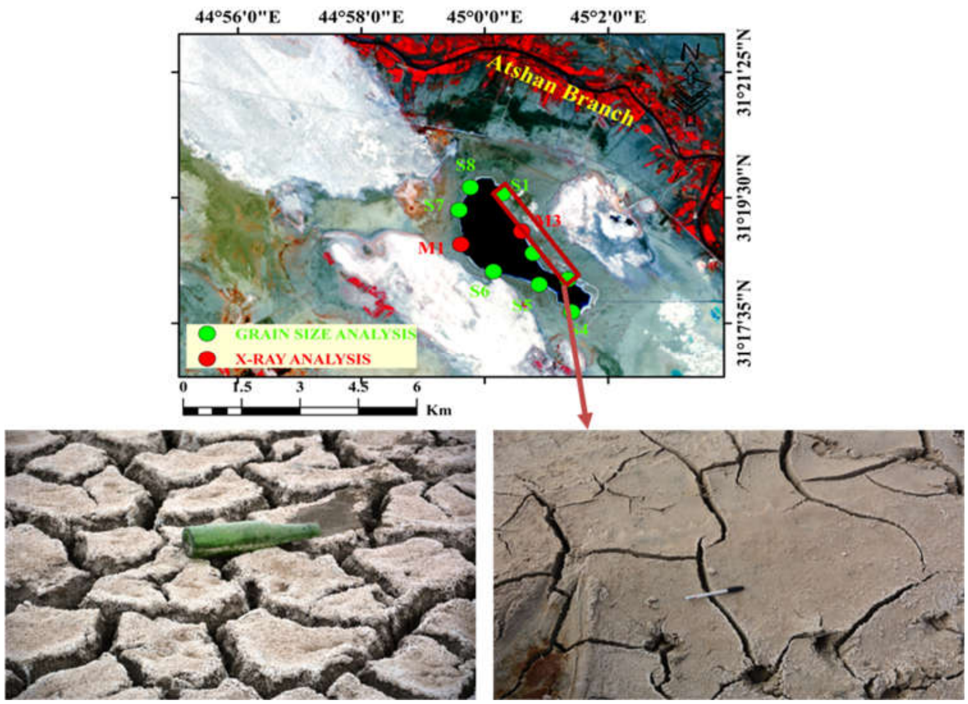


Figure 11. Mud Cracks at Sawa Lake.

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