**Original Research Article**

# The impact of some physico-chemical variables on hydrogen sulphide levels in Lake Burullus sediments, Egypt.


## Abstract

The present investigation was carried on Lake Burullus; nine stations were selected covering the whole area of the lake during April, 2015. The study includes the measurements of hydrogen sulphide concentrations as well as the variation of some related hydrochemical parameters in occurrence of sulphide. The results indicated that, the highest concentration of $H_2S$ in lake sediment was found at station 9 correlated within decrease of dissolved oxygen in water and the load of organic matter in sediment. The biological oxygen demand in water exhibited a strong correlation with organic matter in sediment and hydrogen sulphide as well as dissolved oxygen. on the other hand, pH values were alkaline in some stations, while it were acidic in other stations which were affected by the discharges in front of the drains as shown in station 6 & 9 with highest recorded values of $H_2S$. Generally, the data gave positive correlation between the levels of hydrogen sulphide in sediment, biological oxygen demand, dissolved oxygen, hydrogen ion concentration and organic matters in sediment. Spatial distribution for these metals approved the results of interrelationship.


**Keywords:** Lake Burullus, water, sediment, pollution, hydrogen sulphide

## Introduction

Lake Burullus represents one of the most important northern Delta lakes in Egypt. It is bordered from the north by Mediterranean Sea and from the south by agricultural land and fish farms between Long. $30^o$ 30\` $31^o$ 10\`E and Lat. $31^o$

20` 31° 35`N. It extends for a distance 41.8km. It covers now an area about 410km with average depth 100cm. The lake receives drainage water from several drains which were considered the main source of pollution in the lake (4 milliar $m^3/y^{-1}$). The maximum amount of drainage water discharge from drain 9 at the middle sector of the lake. The estuarine water of Rosetta mouth of the River Nile is mixed with the lake water through Brimbal canal. Sea water may also flow into the lake at Burullus outlet.

Monitoring of hydrogen sulphide concentration in water and sediment in many aquatic system represent good indicator for oxygen levels in the water and sediment to assess the suitability of lake water to survive the fish community and other biota. Sulphides are mainly produced in sediment of aquatic environment through the bacterial reduction of sulphate under anaerobic condition and the decomposition of organic sulphur compound (Nriagu, 1968). It is an extremely potent metabolic poison, lethal at low concentrations (<1 ppm) to most vertebrates alike (Evans, 1967, Smith *et al.,* 1976; Oscid and Smith 1974 a, b).

The toxicity of hydrogen sulphide for some fauna; namely *Tilapia gallilae*; Nauplii larvae of *Artemia salina* (*Ocenebra erinacea*) and *Idotea baltica* have been studied (Tayel and Shriadah, 1991). Oxidation of hydrogen sulphide in natural waters either produces or consumes hydrogen ions, depending on products and other conditions (Tayel and Shriadah 1991).

<u>Thus</u>

$$2HS^{-}+O_2 \rightarrow 2H_2O + 2S$$

$$2HS^{-} + 2O_2 \rightarrow H_2O + (S_2O_3)^{-2}$$

$$2HS^{-} + 4O_2 \rightarrow 2(SO_4)^{-2}+2H^{+}$$

In case of absence of biological activity, sulphide can be slowly oxidized to sulpher which then combines with remaining sulphide to form polysulphide.

## 2. Material and Methods

### 2.1.Selected and sampling stations

Surficial sediment samples were collected during April, 2015 from nine stations covered Lake Burullus, (Figure 1). Burullus Lake is one of the five Mediterranean Lakes of Egypt which used for many purposes including fishing, recreation and contains many organisms. Area is about 460 km$^2$. Lake Burullus is connected to the Mediterranean Sea through the El-Burullus outlet (Boughaz El-Burullus) which is about 250 m wide and 5 m deep. The depth of the Lake varies between 40 cm in its middle sector and near the shores and 200 cm near the outlet to the sea (Zahran and Willis, 2009). Descriptions of sampling locations were as shown in Table (1).

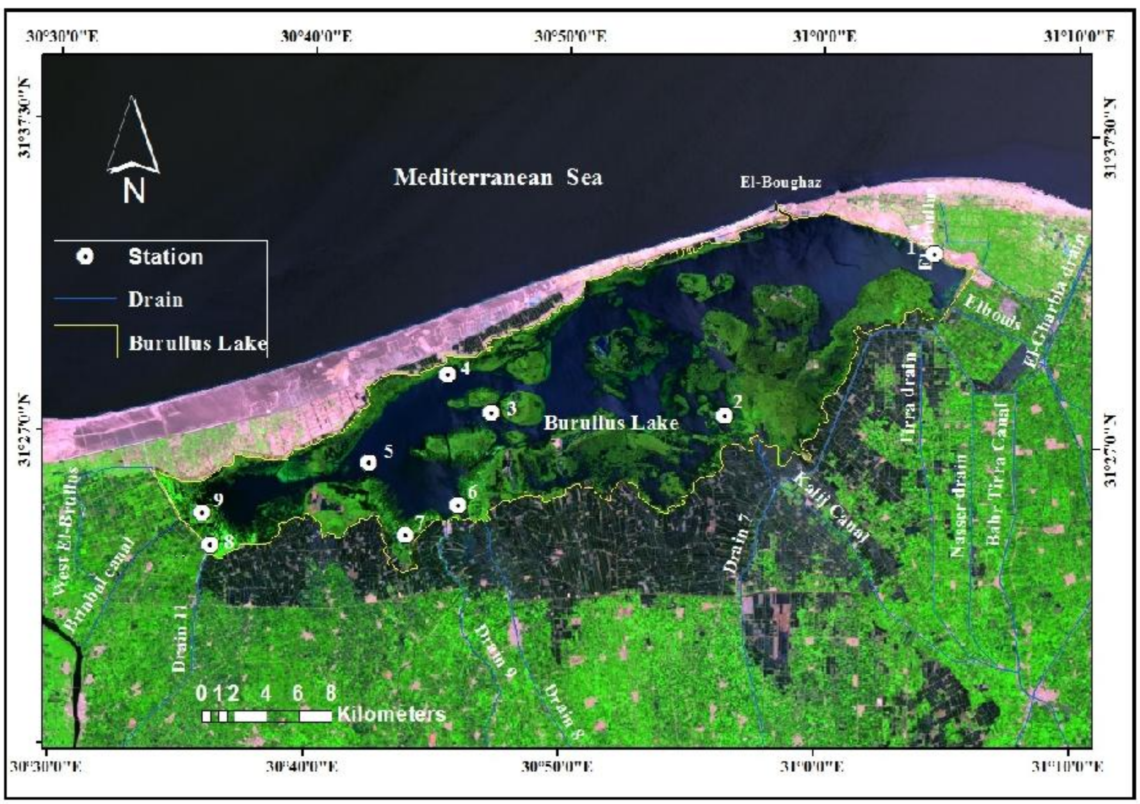



**Fig.1. Sampling stations at Lake Burullus**

**Table (1): Latitudes and longitudes of the sampling stations at Lake Burullus**

| St. NO | Station name | Latitude N | Longitude E |
|---|---|---|---|
| 1 | El-Burullus (east) | $31^{o}$ 33` 29.9`` | $31^{o}$ 04` 25.3`` |
| 2 | inf. of drain 7 | $31^{o}$ 27` 56.1`` | $30^{o}$ 56` 17.5`` |
| 3 | El-Zankah | $31^{o}$ 27` 53.3`` | $30^{o}$ 47` 10.0`` |
| 4 | Mastarouh | $31^{o}$ 29` 09.0`` | $30^{o}$ 45` 24.4`` |
| 5 | Abo-Amer | $31^{o}$ 26` 07.0`` | $30^{o}$ 42` 23.3`` |
| 6 | El-Tawelah | $31^{o}$ 23` 43.8`` | $30^{o}$ 43` 52.8`` |
| 7 | inf. of drain 8 & 9 (Shakhlobah) | $31^{o}$ 24` 46.9`` | $30^{o}$ 45` 54.9`` |
| 8 | inf. of drain 11 (El-Hoksa) | $31^{o}$ 23` 15.5`` | $30^{o}$ 36` 15.3`` |
| 9 | inf. of Brimbal Canal | $31^{o}$ 24` 06.0`` | $30^{o}$ 35` 00.4`` |

St= station inf= infront

## 2.2. Analytical methods

Geo-referenced water samples were collected from 9 locations. In the field, water temperature and DO were measured using the DO meter (Lutron YK-22 DO meter). pH is measured using pH-meter (Model Lutron YK-2001, pH meter). EC was determined using EC-meter (Thermo, Orion 150 A+ advanced conductivity).

## 2.3. Determination of $H_2S$

Concerning, estimation of hydrogen sulphide in sediment samples, 0.1 – 0.8gm wet acidified samples with $\simeq$ 5ml Conic $H_2SO_4$ in closed system, (Figure 2). The involved hydrogen sulphide gas was displaced with oxygen free nitrogen gas into zinc acetate traps. The recovery of sulphide in this manner in 99% efficient. Sulphide collected in the traps was measured calorimetrically using methylene blue method (Youssef, D.H. 1999). Results are expressed as mg/gm on wet weight basis *Eichhornia crassipes*.

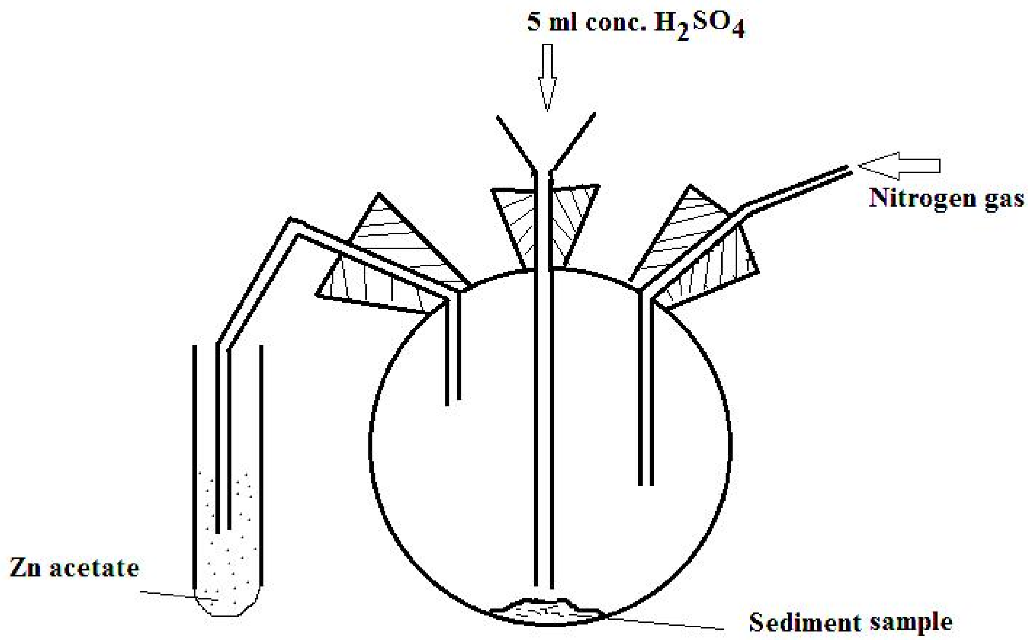



**Fig. 2. The apparatus used for estimation of hydrogen sulphide**

## 2.4. Statistical analysis:

The statistical analysis for the data were carried out to determine the correlation coefficient (r) using the formula

$$r = \frac{n(\sum xy) - (\sum x)(\sum y)}{\sqrt{\left[n\sum x^2 - (\sum x)^2\right]\left[n\sum y^2 - (\sum y)^2\right]}}$$

Where X the concentration of $H_2S$ and Y is the corresponding concentration of variant and n is the number of data.

## 2.5. Geo-statistical Analysis

Inverse distance weight (IDW) is a deterministic interpolation procedure that estimates values at prediction points (V) using the following equation

$$V = \frac{\sum_{i=1}^{n} v_i \quad (\frac{1}{d_i^p})}{\sum_{i=1}^{n} (1/d_i^p)}$$

Where d is the distance between prediction and measurement points, Vi is the measured parameter value, and p is a power parameter (Isaaks *et al.* 1989). The main factor affecting the accuracy of inverse distance interpolator is the value of the power parameter p, as well the size of the neighborhood and the number of neighbors are also relevant to the accuracy of the results (Burrough and McDonnell, 1998).

## 3. Results and discussion

Results of hydrogen sulphide concentrations in sediments as well as concentrations of some related parameters in the water (organic matter, dissolved oxygen, biological oxygen demand and hydrogen ion concentration can be shown in Table 2. The highest concentration of $H_2S$ in the lake sediment was found at station 9 in the western sector of the lake in front of Brimbal Canal, where the highest value of organic matter and biological oxygen demand were recorded.

It's obvious that the high values of $H_2S$ appeared in sediment samples with low values of DO and OM in the water. It is noticed that $H_2S$ not detected in lake water at all the selected stations.

Hydrogen sulphide was produced in the anoxic part of the sediment, with highest sulphate reduction. Sulphate reduction can account for up to 13% of the total organic matter in the acidic sediment, while to 50% in marine sediment (Kühl and Jorgesen, 1992). From Table 2 it’s  can be clear that, the OM content in the water was low at station 1 near to El Boughaz opening due to the large amount of sand poor in the organic matter content while the highest value recorded at station 9 infront of Brimbal Canal in the western sector where it composed mainly from finer sediment (clay and silt) enriched with organic matter in addition to this area was characterized by high density of hydrophytes especially *Eichhornia crassipes* where the contribution of plant detritus and from vegetation area. These results were agree well or consistent with Moussa *et al.* (1994) and Khalil *et al.* (2007) for lake Edku where the content of OM in sediment was controlled by the amount of clay and silt in addition to the plant detritus from nearby vegetation area.

Values of pH (Table 2): were all in, the alkaline side except for stations nearby the point of drain discharges, which were characterized by high density of hydrophytes and their debris. This observation coincided with results of Abbas *et al.* (2001) and Sayed (2003), who stated that, the lowest pH value is attributed to the effect of pollution due to liberation of $H_2S$ during the decompositions of OM as shown in our study where the highest recorded value of $H_2S$ (7.7 mg/g) was detected in station 6.

The excess of OM produced during photosynthesis process in the euphotic zone eventually sinks down through the water to the sediments where respiration processes dominate. The depth of the Lake does not exceed 1.5 meter, Thus, a significant difference often exists between the oxygen rich euphotic zone and underlying oxygen-poor aphotic zone. The presence or absence of oxygen has significant effect on the oxidation-reduction chemistry, also attributed to the anaerobic bacteria where the biological oxygen demand is an empirical test used to determine the relative oxygen requirements needed for the biochemical decomposition and oxidation of OM and inorganic material. The of BOD were recorded in stations close to the point of discharges, where huge amount of OM originated from drains led to heavy demand on DO by the bacterial activities which leads to oxygen depletion and rise in $H_2S$ level in the sediment.

**Table (2): Hydrogen sulphide concentration (mg/g) in sediment and concentration of some related hydrochemical parameters in water of Lake Burullus.**

| St. | $H_2S$ mg/gm | OM % | DO mg/l | BOD mg/l | pH | T.W C$^o$ |
|---|---|---|---|---|---|---|
| 1 | 6.9 | 1.8 | 8.5 | 3.8 | 8.67 | 22.7 |
| 2 | 7.2 | 3.1 | 5.8 | 6.5 | 8.78 | 23.0 |
| 3 | 7.2 | 2.4 | 9.1 | 5.7 | 8.55 | 23.0 |
| 4 | 6.8 | 2.9 | 8.1 | 11.4 | 8.78 | 22.8 |
| 5 | 4.3 | 1.6 | 10.6 | 7.3 | 8.83 | 22.1 |
| 6 | 7.7 | 3.6 | 5.9 | 13.5 | 8.0 | 25.0 |
| 7 | 6.8 | 2.9 | 5.1 | 18.3 | 7.86 | 24.0 |
| 8 | 5.9 | 2.1 | 7.4 | 10.6 | 6.88 | 25.0 |
| 9 | 7.7 | 4.4 | 6.0 | 21.4 | 6.37 | 25.7 |
| Av. | 6.7 | 2.7 | 7.4 | 11.0 | 8.1 | 23.7 |
| σn | 0.997 | 0.842 | 1.728 | 5.596 | 0.8518 | 1.1935 |
| σn.1 | 1.058 | 0.893 | 1.833 | 5.936 | 0.9035 | 1.2658 |
| X | 6.722 | 2.7525 | 7.38 | 10.944 | 8.08 | 23.700 |

Sedimentary production of hydrogen sulphide can increase the oxygen demand rate of sediment leading to a reduction in dissolved oxygen in the overlying water as shown in our investigation at stations 5 and 9.

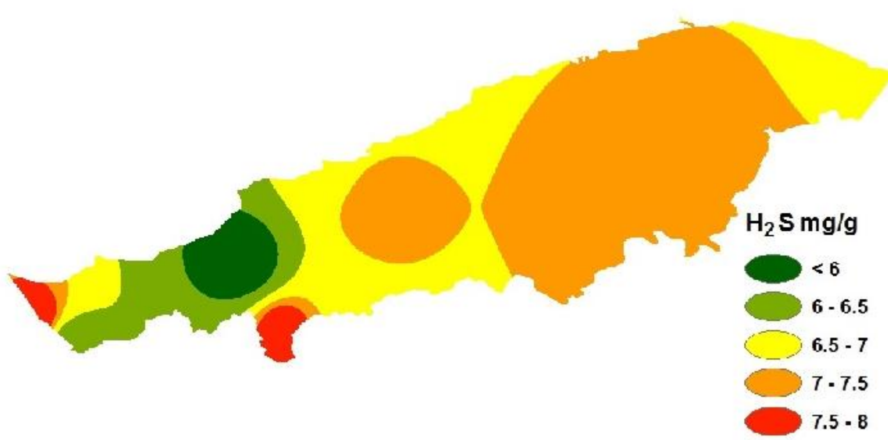
Utilize combined oxygen as sulphate, purification then occurs resulting from decomposition of OM to hydrogen sulphide as end product (Klein, 1962). From the results obtained in Table 2, its clear that, the whole water body of the lake is well aireated and oxygenated during the time of sampling with a minimum of 5.1mg$^{-1}$ at station 7 (infront of drain 8,9) a maximum of 10.6 mg$^{-1}$ at station 5 in the middle sector.

The increasing rates of drainage water discharge infront of the drains rich with O.M at south of the lake adjacent to outlet of drains led to decreasing DO due to oxidation of such OM. These observations were in agreement with El-Ghobashy (1990) in Lake Manzalah.

From the statistical analysis, it is obvious that, highly significant inversely proportional was observed between hydrogen sulphide and dissolved oxygen (r= 0.67) meanwhile, the relation was positive sign correlation (r= 0.74) with organic matter, on the other hand, the relation was insignificant between hydrogen sulphide, biological oxygen demand, (r= 0.32), pH (-0.24) and with water temp. (r= 0.47). Spatial distributions of these parameters are as shown in figure (3). The distribution proved the relation between the presences of different parameters within the $H_2S$, which highly attributed to drainage waters from different drains. El-Amier *et al*. (2016) and El-Alfy *et al*. (2017) used geostatistical and deterministic methods for creating spatial distribution maps for different pollutants in Burullus Lake.

## Conclusion

It's concluded that areas besides drainage water as drains recorded high levels of $H_2S$. Strong relation between drained water containing low concentrations of dissolved oxygen, high concentration of BOD and high levels of OM in sediments with the levels of $H_2S$. Areas with low pH values or characterized by acidic nature may be indication for high levels of $H_2S$ in sediments of lake.



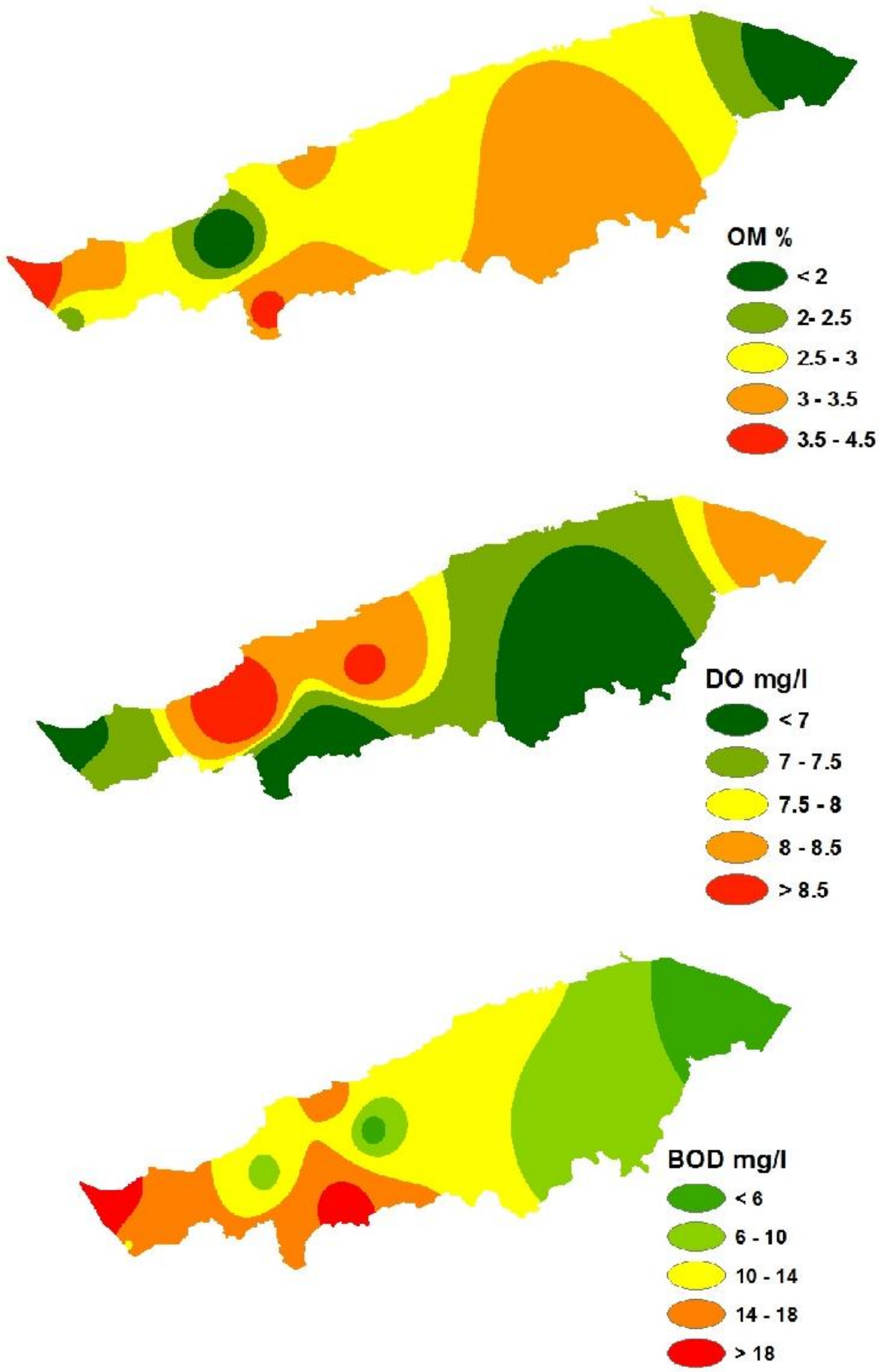

OM %
< 2
2- 2.5
2.5 - 3
3 - 3.5
3.5 - 4.5
DO mg/l
< 7
7 - 7.5
7.5 - 8
8 - 8.5
> 8.5
BOD mg/l
< 6
6 - 10
10 - 14
14 - 18
> 18


Fig. 3. Spatial distribution of $H_2S$, OM, DO, BOD and pH within Burullus Lake.

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