Original Research Article

Relation of some hydrochemical variables with hydrogen sulphide (H_2S) levels in Lake Burullus sediments, Egypt.

Abstract

The present investigation was carried on Lake Burullus; georeferenced 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 hydrochemical parameters related to the occurrence of sulphide. The results indicated that H_2S in lake sediment is increased with increasing water temperature, biological oxygen demand and the load of organic matter in water. On the other hand the presence of dissolved oxygen and pH of water inversely impacted the levels of H_2S. On the other hand, pH values were alkaline in some stations, while it was acidic in front of the drains as a result of agricultural and other discharge. Spatial distribution for these metals approved the results of interrelationship. The huge amount of different wastes increases the level of H_2S that affected on biota badly so it is highly recommended to treat wastewater to serve the biodiversity of the lake.

Keywords: Lake Burullus, Pollution, Hydrochemical Parameters, 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` $31^{o}$ 35`N. It extends for a distance 41.8km. The lake receives (4 milliar m^3/y^{-1}) drainage water from several drains which were considered the main source of pollution in the lake (El-Bayomi, 1999). The maximum amount of drainage water discharge from drain 9 at the middle sector of the lake (Fig. 1).
The lake receives drainage water from several drains which were considered the main source of pollution in the lake. 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 (Al-Sayes *et al*., 2007).

The bottom sediment of Lake Burullus is mainly derived from the suspended load (i.e. the total particulate matter suspend in water), clay and silt. These are carried annually into the lake through the drain water, sea water and wind. The bottom along the northern shores extending from the lake-sea connection westwards is mainly clayey-sand; silty sand with some patches formed molluscan shells. The eastern and western regions of the lake are silty clay. The southern shore sediments which receive directly the drain discharges which formed from clay and silt with small areas covered with molluscan shells (Med. Wet. Coast Project, 2005)

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 (Golterman, 1975). 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 (*Tilapia gallilae*; Nauplii larvae of *Artemia salina* (*Ocenebra erinacea*) and *Idotea baltica* have been recorded by 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).

Thus

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

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

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

In case of absence of biological activity, sulphide can be slowly oxidized to sulpher which then combines with remaining sulphide to form polysulphide. The aim of this search is to study the interrelationship between some hydrochemical parameters and H_2S level in the sediments of Lake Burullus.

2. Material and Methods

2.1. Selected and sampling stations

Surficial sediment samples were collected during April, 2015 from nine geo-referenced 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).

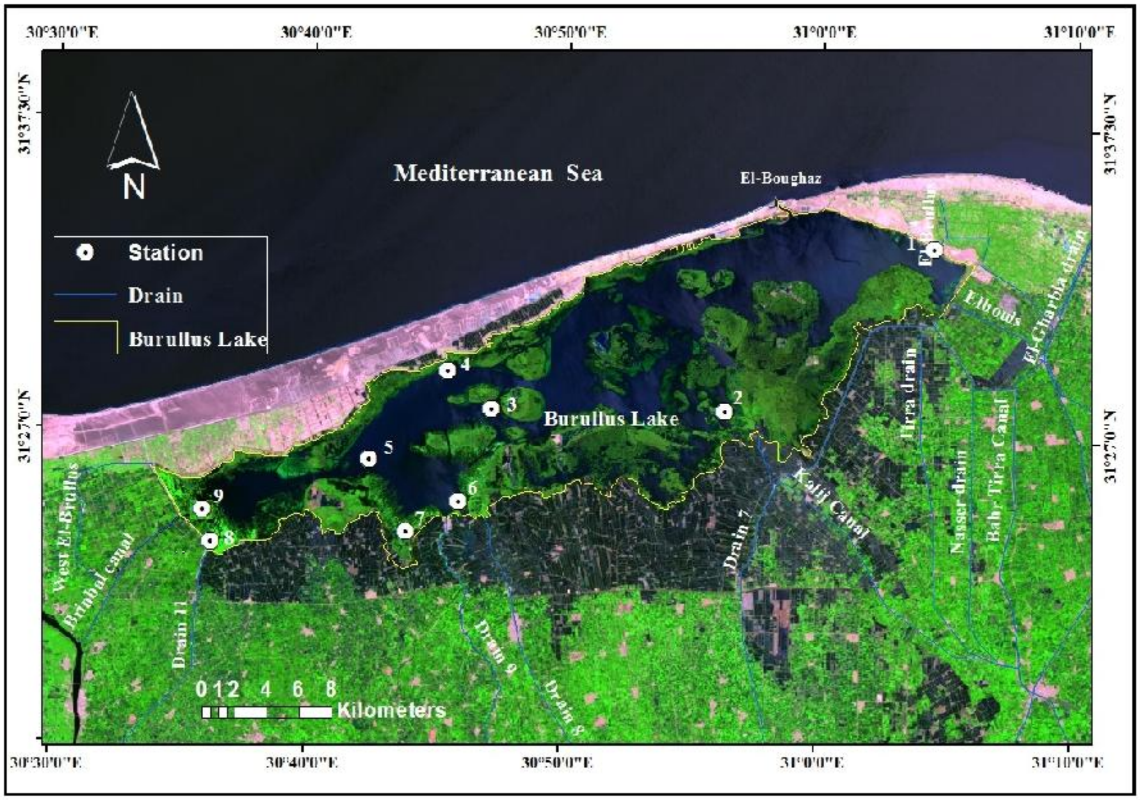


Fig.1. Sampling stations at Lake Burullus

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° 33` 29.9``	31° 04` 25.3``
2	inf. of drain 7	31° 27` 56.1``	30° 56` 17.5``
3	El-Zankah	31° 27` 53.3``	30° 47` 10.0``
4	Mastarouh	31° 29` 09.0``	30° 45` 24.4``
5	Abo-Amer	31° 26` 07.0``	30° 42` 23.3``
6	El-Tawelah	31° 23` 43.8``	30° 43` 52.8``
7	inf. of drain 8 & 9 (Shakhlobah)	31° 24` 46.9``	30° 45` 54.9``
8	inf. of drain 11 (El-Hoksa)	31° 23` 15.5``	30° 36` 15.3``
9	inf. of Brimbal Canal	31° 24` 06.0``	30° 35` 00.4``

St= station inf= infront

2.2. Analytical methods

Nine geo-referenced water samples were collected within Lake Burullus. 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). The BOD determination was carried out using the conventional Winkler method **(APHA, 1998).** OM is determined by Permanganate oxidation method (FAO, 1975).

Estimation of hydrogen sulphide in sediment samples occurred as follow: 0.1 –0.8gm wet acidified samples with nearly 5ml Conc 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 is 99% efficient. Sulphide collected in the traps was measured calorimetrically using methylene blue method (Youssef, D. H. 1999). Results are expressed as mg/gm.

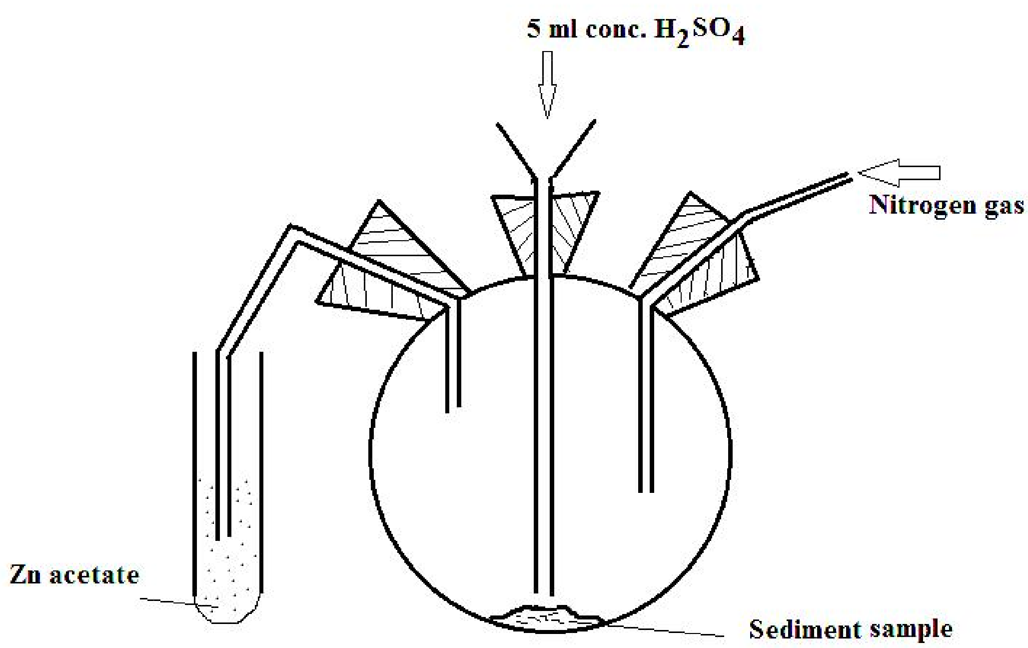


Fig. 2. The apparatus used for estimation of hydrogen sulphide

2.3. 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.

2.4. Geo-statistical Analysis

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

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

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 as 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 highest 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 (1.8%) near to El Boughaz opening due to the large amount of sand poor in the organic matter content while the highest value (4.4 %) 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 alkaline 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 highest concentrations of BOD were recorded in stations close to the point of discharges as pronounced at station 7 (drains 8&9), 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^oC	EC	Depth
1	6.9	1.8	8.5	3.8	8.67	22.7	30.8	70
2	7.2	3.1	5.8	6.5	8.78	23.0	9.11	60
3	7.2	2.4	9.1	5.7	8.55	23.0	10.1	90
4	6.8	2.9	8.1	11.4	8.78	22.8	9.29	110
5	4.3	1.6	10.6	7.3	8.83	22.1	9	120
6	7.7	3.6	5.9	13.5	8.0	25.0	8.61	100
7	6.8	2.9	5.1	18.3	7.86	24.0	4.52	70
8	5.9	2.1	7.4	10.6	6.88	25.0	4.1	80
9	7.7	4.4	6.0	21.4	6.37	25.7	3.9	90
σn	0.997	0.842	1.728	5.596	0.8518	1.1935	7.74	18.72
σn.1	1.058	0.893	1.833	5.936	0.9035	1.2658	8.21	19.61
X	6.722	2.7525	7.38	10.944	8.08	23.700	9.94	87.77

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 aerated and oxygenated during the time of sampling with a minimum of 5.1mg^{-1} at station 7 (in front of drain 8,9) a maximum of 10.6 mg^{-1} at station 5 in the middle sector.

The increase 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 Manzala.

From the statistical analysis (Table 3), it is obvious that highly inverse significant proportion was observed between hydrogen sulphide and dissolved oxygen (r= - 0.67). Meanwhile, the relation was positive significant correlation with organic matter (r= 0.74). On the other hand, the relation was insignificant between hydrogen sulphide, biological oxygen demand, (r= 0.32), pH (-0.24) and with water temperature (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.

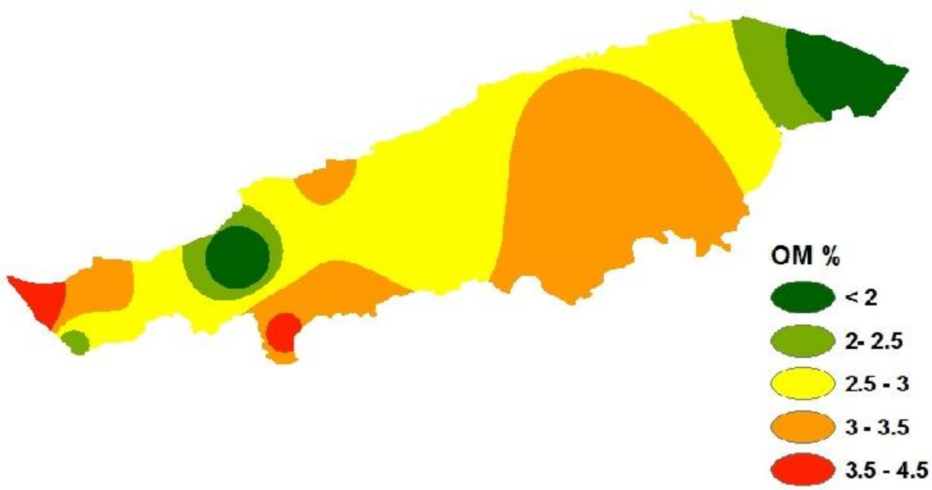
Conclusion

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.

Table (3): Pearson moment correlation matrix between some hydrochemical parameters and H_2S in sediments.

Variables	H_2S	OM	DO	BOD	pH	TºC
H_2S	1					
OM	0.743*	1				
DO	-0.675*	-0.741*	1			
BOD	0.329	0.756*	-0.648	1		
pH	-0.246	-0.524	0.471	-0.734*	1	
TºC	0.48	.692*	-0.666	0.754*	-0.917**	1

*. Correlation is significant at the 0.05 level (2-tailed).
**. Correlation is significant at the 0.01 level (2-tailed).



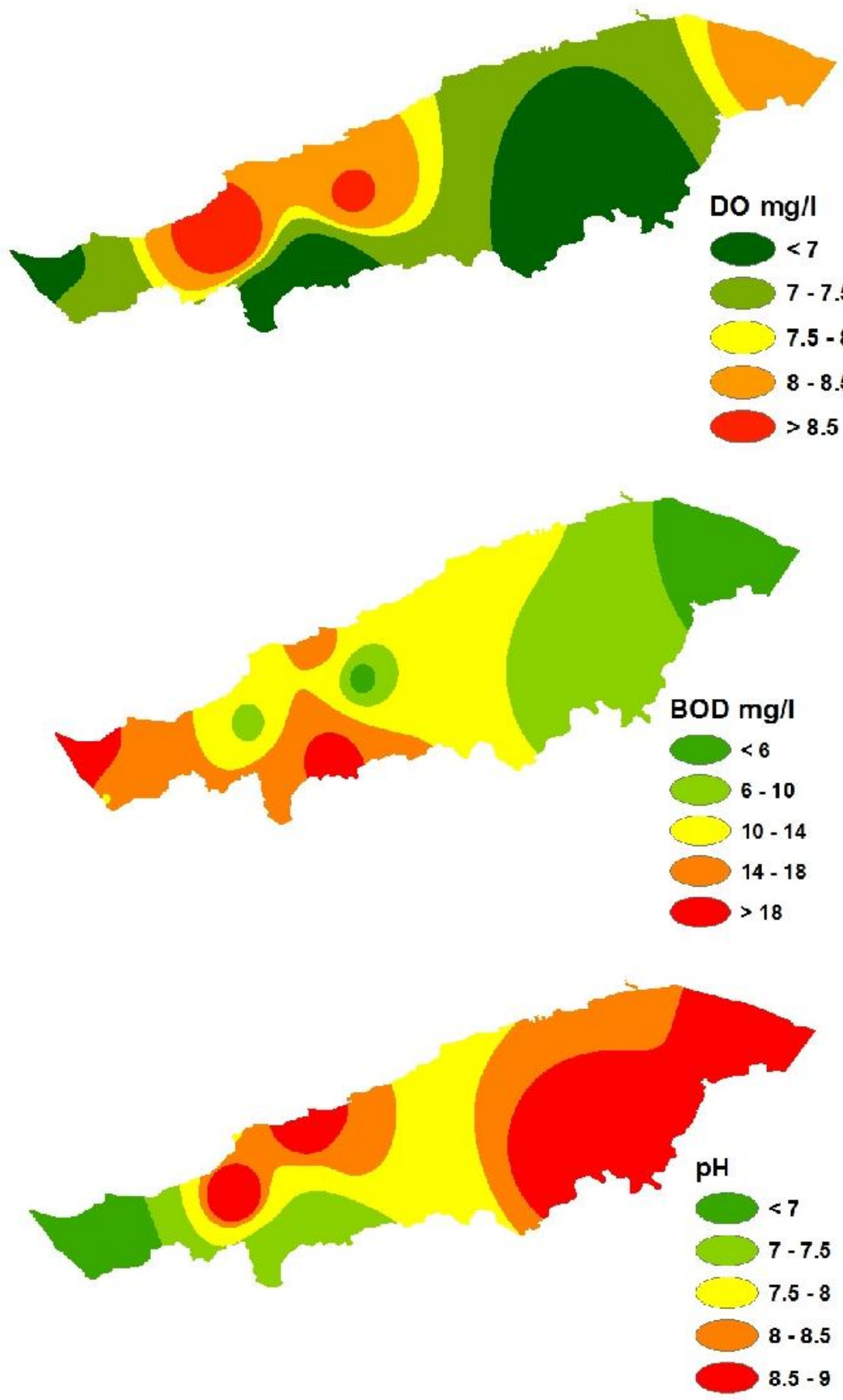


Fig. 3. Spatial distribution of H_2S, OM, DO, BOD and pH within Burullus Lake.

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