Geo-spatial variability assessment of water pollutants concentration in Mariut Lake, Egypt

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Abstract

In recent decades, the need to better understand the spatial and temporal variabilities of pollutants within aquatic systems was increased. Mariut Lake is one of the most heavily populated urban areas in Egypt and in the world. A total of 22 samples were collected and analyzed for determining the concentrations of chromium (Cr), manganese (Mn), iron (Fe), cobalt (Co), nickel (Ni), copper (Cu), zinc (Zn), cadmium (Cd) and lead (Pb) in winter time 2014. Inverse distance weighting analyst tools were used to explore, analyze the spatial distribution and mapping of the heavy metal concentrations.

The results revealed that all of heavy metals concentrations matched with the allowable limits to be discharged in marine environment as prescribed in Egyptian law except of Ni metal which exceeded the allowable limits. The results illustrated that the highest concentration of Mn and Fe were distributed in the upper north eastern parts of the studied stations, this may be due to human's activities and industrial area. While the eastern region has high concentrations of Pb, Ni, Cr and Co due to El-Kalaa drain discharges. However, the western part of the study area has high concentration of Zn and Cu due to El-Ommum drain discharges.

Keywords: Heavy metal, Mariut Lake, Geo-Spatial.

1. Introduction:

Heavy metals are common pollutants which are distributed in aquatic environment and have received considerable attention due to their toxicity (Mason, 1991). Metals generally enter the aquatic environment through atmospheric deposition, erosion of the geological matrix, or due to anthropogenic activities caused by industrial effluents, domestic sewage, and mining wastes (Stephen *et al.*, 2000; Kambole, 2002).

The spatial variability of heavy elements concentration in water can play an important role in understanding of possible pollution sources, identifying critical and contaminated areas and monitoring the impacts of human activities and natural sources (Yalcin *et al.*, 2007; Fang *et al.*, 2011). However, environmental protection in nature requires a good knowledge of the present conditions, and the spatial distribution of contaminants of concern. Geo-statistical and spatial analysis techniques can be used in the identification of contaminant sources (Oyarzun *et al.*, 2007; Choe *et al.*, 2008; Wang and Lu, 2011).

In this research, inverse distance weighting interpolation techniques was used to extract spatial distribution of heavy metal concentrations in the studied area of Mariut lake because it was detected in little specific locations.

2. Study area

Lake Mariut is a 90-150 cm deep brackish water lake located in the north of Egypt southeast to the Alexandria city, belonging to the Nile River Delta, and one of the most heavily populated urban areas in Egypt and in the world. By the end of the 19th Century, the development of irrigation systems of the adjacent fields made of Mariut lake an intermediate water body to receive the excess of water from the irrigation channels. Then the water was pumped out to the Alexandria Bay (Miguel, 2009).

3. Materials and methods

Water samples were collected from twenty two water stations in Lake Mariut in February 2014. The stations were selected on the basis of variation including all water bodies. Water samples were collected, routinely acid-treated with a solution (0.5 N HNO_3) and stored in bottles to prevent contamination. All samples collected for chemical analysis were kept at a temperature of about 4 °C by using cool boxes and cooling agents. The collected water samples were taken to laboratory for determining heavy metals concentration (Cr, Mn, Fe, Co, Ni, Cu, Zn, Cd and Pb), according to standard method (APHA, 1992).

4. Results and Discussion

4.1. Manganese (Mn) concentrations and its spatial distribution

The obtained data (table 1) illustrated that the manganese concentrations ranged from 0.097 to 0.245 mg/L with a mean average of 0.15 mg/L. The Mn concentrations are matching with the Egyptian law No. 4/1994 which is 1 mg/L as a maximum allowable limit for manganese. The maximum concentration value of manganese was 0.245 mg/L recorded at site 21, while the minimum concentration value was 0.097 mg/L observed at site 12. The average of Mn (0.15 mg/L) are more than that reported by (Kondrashin and Khalifa, 2013) (0.084 mg/L) in Mariut lake. The spatial distribution of Mn concentration level in water was given in Figure,1. As seen in the distribution map, the Mn concentration has high level on the north eastern part due to human's activities which has industrial wastes.

Table 1. Variation of heavy metal concentrations of studied area February 2014

Sample No.	Mn (mg/L)	Co (mg/L)	Cr (mg/L)	Ni (mg/L)	Cu (mg/L)	Cd (mg/L)	Pb (mg/L)	Fe (mg/L)	Zn (mg/L)
1	0.229	0.079	0.028	0.406	0.094	0.068	1.016	1.0893	1.160
2	0.171	0.069	0.029	0.407	0.060	0.015	0.980	0.576	0.085
3	0.179	0.087	0.034	0.395	0.028	0.009	1.027	0.698	0.089
4	0.191	0.086	0.038	0.398	0.077	0.0109	1.040	0.319	0.069
5	0.205	0.101	0.012	0.408	0.064	0.014	1.092	1.072	0.134
6	0.108	0.112	0.016	0.435	0.083	0.011	1.094	0.070	0.038
7	0.108	0.107	0.006	0.438	0.009	0.012	1.135	0.049	0.035
8	0.12	0.115	0.044	0.447	0.010	0.011	1.160	0.038	0.036
9	0.109	0.129	0.053	0.478	0.042	0.014	1.185	0.049	0.032
10	0.114	0.132	0.050	0.474	0.006	0.012	1.221	0.045	0.032
11	0.111	0.14	0.071	0.477	0.007	0.011	1.228	0.065	0.035
12	0.097	0.144	0.114	0.472	0.009	0.011	1.257	0.034	0.072
13	0.114	0.155	0.100	0.484	0.011	0.007	1.294	0.076	0.036
14	0.123	0.161	0.090	0.489	0.010	0.011	1.317	0.068	0.048
15	0.139	0.199	0.059	0.483	0.008	0.010	1.333	0.071	0.033
16	0.147	0.152	0.080	0.485	0.024	0.008	1.357	0.218	0.031
17	0.148	0.156	0.113	0.503	0.031	0.010	1.356	0.219	0.048
18	0.159	0.156	0.088	0.498	0.035	0.011	1.396	0.367	0.043
19	0.138	0.164	0.106	0.512	0.013	0.013	1.428	0.144	0.035
20	0.162	0.177	0.120	0.516	0.011	0.009	1.452	0.049	0.021
21	0.245	0.159	0.080	0.490	0.086	0.003	1.455	1.261	0.106
22	0.23	0.166	0.094	0.498	0.065	0.0109	1.464	0.648	0.075

4.2 Cobalt concentrations

The data indicated that (table 1) the cobalt concentrations ranged from 0.069 to 0.199 mg/L with a mean average of 0.133 mg/L, which is matching with the Egyptian law No. 4/1994 (2 mg/L) as a maximum allowable limit for cobalt. The maximum concentration of cobalt was 0.199 mg/L recorded at site 15, while the minimum concentrations value of cobalt was 0.069 observed at site 2. The present results of cobalt are higher than that reported by (Kondrashin and Khalifa, 2013) (Most of the cobalt concentration values fall below the instrument detection less than 0.005 mg/L) in Mariut lake which mean that the concentration increased from 0.005 to 0.133 mg/L in one year although it is under the permissible level, it is a serious call to observe the increase in heavy metal pollutant every year to try to control the water pollutant. The spatial distribution of Co, in water is shown in Figure, 1 , which illustrates that the increase of Co level in the eastern region due to El-Kalaa drain discharges.

4.3. Chromium concentrations

The results indicated that (table 1) the chromium concentrations ranged from 0.006 to 0.12 mg/L with a mean average of 0.065 mg/L. It is observed that chromium concentrations are matching with the Egyptian law No. 4/1994 which is 1 mg/L as a maximum allowable limit for chromium. The highest concentration value of chromium was 0.12 mg/L recorded at site 20, while the lowest concentrations value of chromium were 0.006 observed at site 7. The present average result of chromium (0.065 mg/L) is higher than that reported by (Kondrashin and Khalifa, 2013) (0.038 mg/L) in Mariut lake. The spatial distribution of Cr in water was given in Figure, 1 which demonstrated that the maximum value is distributed in the eastern region of the studied area. This is attributed to effect of El-Kalaa drain discharges.

4.4 Nickel concentrations

As seen from the data (table 1), that the nickel concentrations ranged from 0.395 to 0.516 mg/L with a mean average of 0.46 mg/L. It is observed that nickel concentrations are higher than the Egyptian law No. 4/1994 which is 0.1 mg/L as a maximum allowable limit for nickel. The highest concentration value of nickel was 0.516 mg/L recorded at site 20, while the lowest concentration value was 0.395 mg/L recorded at site 3. The present results of Nickel are higher than that reported by (Kondrashin and Khalifa, 2013) All nickel concentration values fall below the instrument detection limit (i.e. less than 0.001 mg/L) in Mariut lake. The high concentrations of nickel might be due to agricultural, domestic and industrial wastewaters discharged into these sites. The geographical distribution of Ni in the studied area is given in Figure, 1 which illustrates that the Mn concentration has high level on the eastern region due to El-Kalaa drain discharges.

4.5. Copper concentration

Data showed that the copper concentrations ranged from 0.006 to 0.094 mg/L with a mean average of 0.036 mg/L. The obtained values of copper are coinciding with the Egyptian law no. 4/ 1994 which is 1.5 mg/L. The present average result of copper (0.036 mg/L) is lower than that reported by (Kondrashin and Khalifa, 2013) (0.048 mg/L) in Mariut lake. As seen in Figure, 1 the geographical distribution of Cu concentrations in lake water, the levels increased on the western region due to El-Ommum drain.

4.6. Cadmium concentration

The obtained data (table 1) showed that the cadmium concentrations ranged from 0.003 to 0.068 mg/L with a mean average of 0.013 mg/L. It is stated that cadmium concentrations match with the Egyptian law No. 4/1994 stating 0.05 mg/L as a maximum allowable limit for cadmium. The highest concentration value of cadmium is 0.068 mg/L recorded at site 1, while the lowest concentrations value 0.009 mg/L is observed at site 20. The high concentrations of cadmium might be due to agricultural, domestic and industrial wastewater discharged into these sites. The present average result of cadmium (0.013 mg/L) is lower than that reported by (Kondrashin and Khalifa, 2013) (0.026 mg /L) in Mariut lake. The spatial distribution of cd is shown in Figure, 1.

4.7. Lead concentration

The obtained data indicated that the lead concentrations ranged from 0.98 to 1.527 mg/L with an average of 1.25 mg/L. The mean concentrations of lead are below the allowable limits (5 mg/L) to be discharged in marine environment as prescribed in Egyptian law No. 4/1994. The highest concentration level of lead 1.527, 1.464 and 1.396 mg/L reported at sites 12, 22 and 18, respectively (table 1). The high values of lead might be due to the high amounts of agricultural, domestic and industrial wastewater discharged into these waterways. The present average result of Pb (1.25 mg/L) is lower than that reported by (Kondrashin and Khalifa, 2013) (2.5 mg/L) in Mariut Lake. The geographical distribution of Pb in water is given in Figure, 1. This element has high levels on the eastern region due to El-Kalaa drain discharges.

4.8. Iron concentration

The obtained data (table 1) showed that the iron concentrations value ranged from 0.034 to 1.261 mg/L with an average of 0.33 mg/L. The obtained values of iron are coinciding with the Egyptian law No. 4/1994 which is 1.5 mg/L. The highest concentration of iron is 1.26 mg/L observed at site 21. High concentrations of iron might be attributed to agricultural, sewage and industrial wastewater discharged into these sites. Fluctuation of salinity is a prime factor in the coastal areas, which influences partitioning and bioavailability of metals (Mitra *et al*., 1998). The present average results of Fe (0.33 mg/L) are higher than that reported by (Kondrashin and Khalifa, 2013) (0.172 mg/L) in Mariut lake. The concentration and geographical distribution of Fe in water is given in Figure, 1 Fe element has high levels on the eastern north region because this region is near to industrial area.

4.9. Zinc concentration

Data showed that (table 1) zinc concentrations ranged from 0.021 to 1.160 mg/L with an average of 0.1 mg/L. The highest concentration value of zinc is 1.16 mg/L observed at site 1. The mean concentrations of zinc is in agreement with the allowable limits to be discharged in marine environment as prescribed in Egyptian law No. 4/1994 which is (5 mg/L). The mean concentration of Zn (0.1 mg/L) in the present study is coinciding with that reported by (Kondrashin and Khalifa, 2013) (0.1 to 0.15 mg/L) in Mariut lake. The geographical distribution of Zn concentration in water is given in Figure,1. This element has high levels on the western region due to El-Ommum drain.

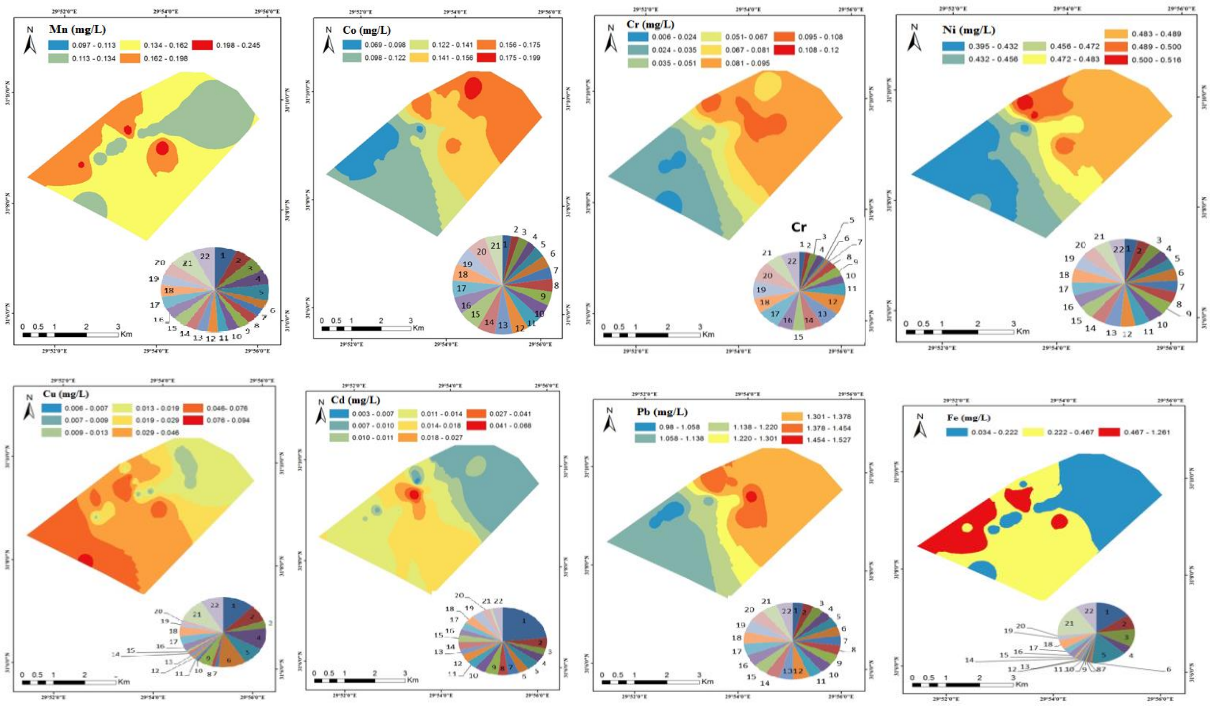

Figure 1 spatial distribution of the Heavy metals

Conclusion

Mariut Lake has a very important economic activity in Egypt for fish production. The results of the present study clearly demonstrate that the Lake Mariut is in risk of contamination with heavy metals due to the continuous discharge of different wastes. From this study it can be concluded that using inverse distance weighting for spatial interpolation, it is possible to determine and map the heavy metals concentrations in the studied area. The result revealed that all of heavy metals concentrations matched with the allowable limits to be discharged in marine environment as prescribed in Egyptian law except of Ni metal which exceeded the allowable limits. Also, the north eastern parts of the studied area have high concentration of Mn and Fe due to human's activities and industrial area while, eastern region has high concentration of Pb, Ni, Cr and Co due to El-Kalaa drain. While, the western part of the studied area has high concentrations of Zn and Cu due to El-Ommum drain discharges. These also, lead to conclude that the El-Qalaa canal manage to a great extent the contamination and concentration of heavy elements at Mariut lake water.

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