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Organics and Nutrients Loading to The 23rd of July Man-Made Lake in Benghazi City, NE Libya

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تقدير كميات المواد العضوية والمغذيات في مياه بحيرة 23 يوليو الصناعية بمدينة بنغازي، شمال شرق ليبيا.

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Abstract

The 23 of July lake in Benghazi City is a Man-made lake or lagoon. It was established in 1982. The lake has a surface area of about 93 hectares and the water depth ranges from 5 *m* near its landward edge to about 2.5 *m* in the seaward direction. The lake receives inputs from various outlets, however, the discharge of untreated sewage remains the major environmental problem for the neighboring residential area as well as the commercial and recreational places. The current study was carried out in order to estimate the organic and nutrient loading into the lake and determine the pollution status of the lake. The result obtained showed a very high concentration of almost all pollution indicators parameters and showed levels above those reported for the non-polluted body. For instance, the parameters for the water characteristics such as the total dissolved solutes were found to range from 18468.2-23233 *mg/l*. The level of dissolved oxygen was found to range from 1.97-3.07 *mg/l*, while the pH showed no significant differences ranging from 7.35-7.94. The results also indicated a massive enrichment of organics as the BOD values were found to range from 117.5–148.33 *mg/l* while the COD values ranged from 235.0-296.7 *mg/l* and the total suspended solids were 60.50-86.50 *mg/l*, all of which reflecting on an environment highly polluted by organic material. The ranges for the nutrient NO_3^- and PO_4^{-3} were found to be ranging from 1.68-3.43 *mg/l* for nitrate and 0.95-2.22 mg/l for phosphorus, revealing on the possibility of stimulating algal growth in the lake if the environmental condition needed exist. The levels of ammonia (NH_3 and nitrite (NO_2^-) were found to be in the range of 0.01-0.03 *mg/l* and 3.60-11.20 *mg/l* respectively. In general, the results showed large variations both between samples and among zones. This could be attributed to the variety of input sources. The exceptionally high level of BOD at zone (D) could be attributed to the initial entrance of the major sewage input point and low dilution.

Keywords: *Pollution Load, Organic nutrients, Phosphorus, Nitrogen, Hotspot.*

الملخص

أجريت هذه الدراسة على بحيرة 23 يوليو الواقعة في وسط مدينة بنغازي وذلك بهدف تحديد مستويات التلوث بها وحساب حمل التلوث (Load). النتائج المتحصل عليها اظهرت قيم عالية لمستويات كل المعاملات الدالة على التلوث التي تم دراستها على سبيل المثال قيمة الاملاح الذائبة الكلية كانت تتراوح ما بين 18468.2–23233 مجم/لتر. الأكسجين الذائب في الماء تراوح ما بين 1.97–3.07 مجم/لتر. الرقم الهيدروجيني (pH) تراوح ما بين 7.35–7.94. النتائج أظهرت أيضاً إغناء كبيراً (Massive enrichments) بالمواد العضوية في صورة طلب الاكسجين الحيوي (BOD) حيث تراوح ما بين 117.5–148.33 مجم/لتر، بينما قيم طلب الاكسجين الكيميائي (COD) كانت تتراوح ما بين 235.0 – 296.7 مجم/لتر. العوالق الصلبة الكلية وجدت تتراوح ما بين 60.50–86.50 مجم/لتر، وعناصر التغذية النترات والفوسفور (NO_3^- and PO_4^{-3})

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وجدت تتراوح ما بين 1.68-3.43 مجم/لتر للنترات و0.95-2.22 مجم/لتر للفوسفور، بالإضافة إلى قيمة المتوسط مجموع الأملاح الذائبة والملوحة والمواد العالقة الكلية وكذلك الأس الهيدروجيني والتوصيلة الكهربائية ودرجة الحرارة وبالإضافة إلى تقدير تركيز العناصر المعادن الثقيلة وتحديداً (Zn, Pb, Ca, Cr, Cd) حيث تم جمع العينات من مياه البحيرة خلال شهر 12 لسنة 2010م وخلال شهر1 لسنة 2011م، معظم النتائج المتحصل عليها كانت ضمن الحدود غير الطبيعية المسموح بها لكل المعاملات التي تم دراستها حيث تراوحت تركيز طلب الأكسجين الحيوي BOD ما بين (117.500-148.33) مجم/لتر وطلب الأكسجين الكيميائي COD ما بين (235-296.66) مجم/لتر والنترات ما بين (1.680-3.433) مجم/لتر والنتريت ما بين (0.0063-0.0280) مجم/لتر والامونيا ما بين (3.6083-11.1667) مجم/لتر والأكسجين الذائب في الماء ما بين (1.9667-3.0667) مجم/لتر والفوسفات ما بين (0.9550-2.2250) مجم/لتر والملوحة ما بين (28374-87060.67) مجم/لتر والمواد العالقة الكلية ما بين (60.500-86.500) مجم/لتر، ودرجة الحرارة ما بين (29-31.667) °م صيفاً وكان تركيز الزنك ما بين (0.7280-1.3700) مجم/لتر والكادميوم ما بين (0.4880-0.7060) مجم/لتر.

الكلمات الدالة: حمل التلوث، المواد العضوية، عناصر التغذية، الفوسفور، النيتروجين، النقاط الساخنة.

1. Introduction

Marine and costal environment provide essential services to society, including desalination of water for drinking, power generation and a recreation place for many people and resting for birds. Decaling water quality will impact the value of marine environment economically, ecologically, and socially. Many semi-closed bays and coastal areas specially in the Mediterranean are exposed to land based pollution sources, mainly from domestic and industrial effluents (Hamouda and Wilson, 1989; UNEP MAP, 1996a; UNEP/MAP, 1996b; Benoit and Comeau, 2005; UNEP, 2006; Mallin, 2007; Bettinetti *et al.*, 2010; Abdel-Halim and Aly-Eldeen, 2016). Recently there are reports of pollution in a number of beaches along the Libyan coastline and in particular Tripoli coastline were several beaches declared not suitable for bathing last summer of 2017 (Environment General Authority, 2017). High organics and nutrients levels from sewage, is the most widespread and possibly most serious marine pollution problem in many Mediterranean counties and in Libya (Hamouda and Wilson,1989; Gabutti *et al.*, 2004; Benoit and Comeau, 2005; UNEP, 2006; Bettinetti *et al.*, 2010; Abdel-Halim and Aly-Eldeen, 2016). Although eutrophication is not a common phenomenon along the Libyan coastal water, continuation of sewage discharge with excessive input of phosphorus and nitrogen, would contribute largely to the acceleration of the occurrence of this phenomenon particularly around the major cities (UNEP-IETC, 1999). Nutrient over-enrichment has a range of effects on coastal systems, but in general, it brings on ecological changes that decrease the biological diversity the variety of living organisms in the ecosystem (Howart *et al.*, 2000; and Abdel-Halim and Aly-Eldeen, 2016). It is well known also that, when additional nutrients or organic matter enters by rivers or effluents to a coastal area or confined sea, or lake like the current lake will disrupted the overall equilibrium and upset the system leading to initiation of the eutrophication process (UNEP-IETC, 1999; Howart *et al.*, 2000; Arhonditsis *et al.*, 2000; Gabutti *et al.*, 2004; 2007 ،الدويب; and Abdel-Halim and Aly-Eldeen, 2016). Discharges of high-BOD/COD water to the coastal environment should therefore be restricted unless a sufficiently high degree of dispersion is

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guaranteed by the outfall to avoid accumulation of particulate matters depletion of the oxygen.

2. Materials and Methods

The lake is located at the center of the city Figure (1). The lake was divided into four different zones as shown in Figure (2). Six water samples were collected from different sites of each zone twice in a period of six months during 2011, and analyzed in order to determine the water characteristics (pH, Dissolved Oxygen (DO), Total Dissolved Solids (TDS)). In order to determine the degree of pollution by organic materials and nutrients, the water samples were analyzed to Biological Oxygen Demand BOD, Chemical Oxygen Demand (COD), Total Suspended Solid (TSS), Nitrate (NO_3^-), Nitrite (NO_2^-), Ammonia (NH_3), and Phosphors (PO_4^{-3}) as pollution indicators .

All parameters were determined after conducting a careful water sampling procedures. The pH was measured using a pH meter-HANNA and the Total Dissolved Solids (TDS) were also determined using TDS meter. The Dissolved Oxygen (DO) was measured using a DO Meter-HANNA. All the measurements is completed after the reading had stabilized. Gravimetric Method was used to determine the Total Suspended Solids (TSS). A 100 *ml* water sample was filtered using a glass fiber filter paper. Then, the water sample was set to evaporate into dryness from 103 to 105^oC using a pre-weighed 100 *ml* beaker. After evaporation, the beakers, were placed in desiccators before weighing. The weighing was continued until a constant weight was obtained .

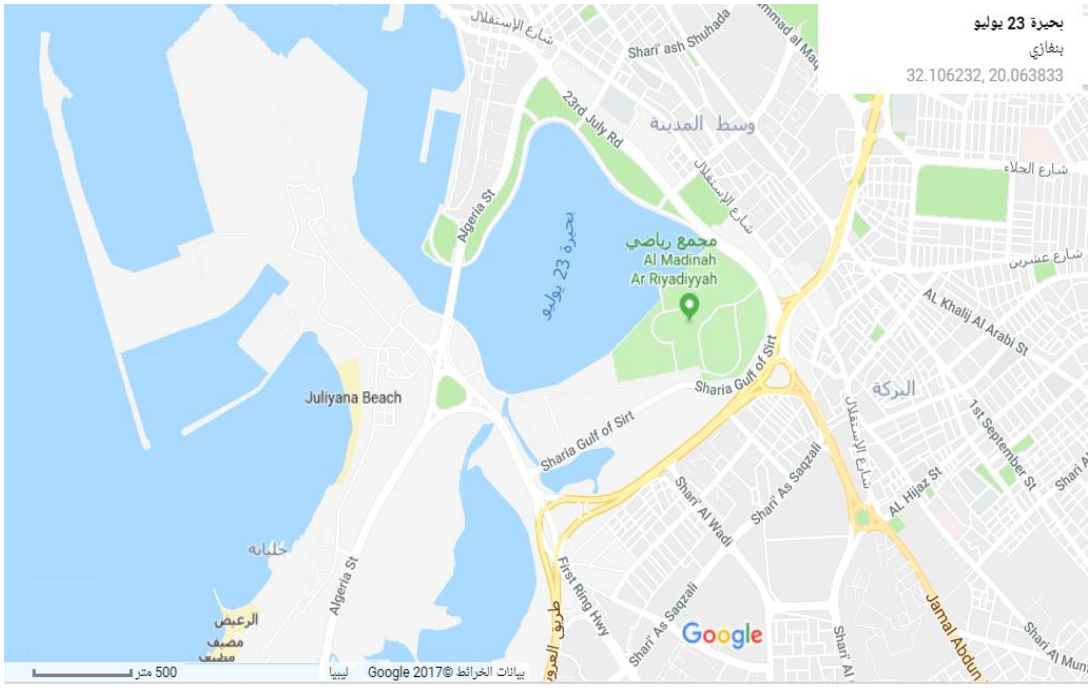

Figure 1. Location of the 23rd Lake (Google maps, 2017).

ISSN: 2413-5267

The Biochemical Oxygen Demand (BOD) involved in the 5-*day* incubation at 20 ^oC. A dilution technique was used accordance with the procedure of the Standard Methods for the examination of water and wastewater, and the same reference was used for COD determination (Clesceri *et al.*, 1998).

The procedure for determination of total phosphorus in seawater consists in the oxidation to phosphate, which is then determined by standard photometric technique. The pH of the sample was adjusted and the vanadate-molybdate reagent was added and after several minutes from the time of adding the vanadate-molybdate reagent, the absorbance of the sample versus the blank at a wavelength of 890 *nm* was measured. A calibration curve by using suitable volumes of standard phosphate solution was also prepared and read at the same wavelength. The Total N_2, NH_3, NO_2^-, and NO_3^- were determined by standard photometric technique using also a Model 2010 HACH Spectrophotometer also then each ions were measured at its specific wavelength according to ASTM (1990) procedures. It must be noted that the precision of these techniques is high; however, concentrations in surface waters is so often found to be near to the detection limits .

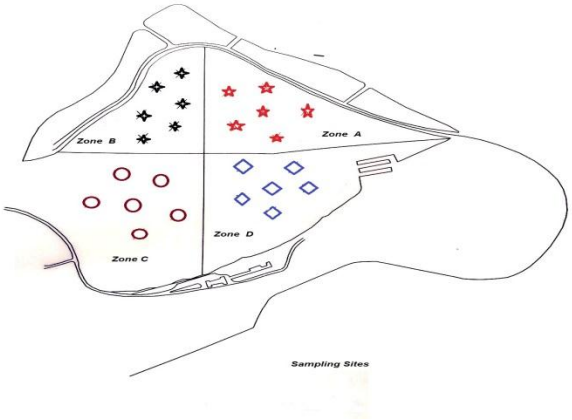

Figure 2. Sites of the collected samples

3. Results and Discussion

Tables (1-3) represent the mean concentrations of parameters of the water characteristics. It can be seen from Table (1), there were slight differences between the zones in pH values.

Table 1. Values of the pH, Standard deviation (SD), and the Confidence interval (CI) for all Zones.

CI	SD	Mean (pH)	Replicates	Location
7.10-7.50	0.16	7.35	6	A
6.93-8.34	0.54	7.94	6	B
7.50-8.00	0.21	7.71	6	C
7.40-7.77	0.12	7.60	6	D

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The highest 7.94 were found at zone B, while lowest 7.35 were found at zone A. With regard to the TDS (Table 2) there were a quite different distribution as the highest value 23233.0 *mg/l* was reported for zone D, and the lowest 18468.2 *mg/l* were for zone C.

Table 2. Concentration of the Total Dissolved Solutes (TDS), Standard deviation (SD), and the Confidence interval (CI) for all Zones.

CI	SD	Mean, (*mg/l*)	Replicates	Location
21691.2-23757.8	984.6	22724.5	6	A
22053.4-23866.6	863.9	22960.0	6	B
16984.3-20952.0	1890.4	18468.2	6	C
22687.9-23778.1	519.4	23233.0	6	D

The dissolved oxygen results in Table (3) show the unsaturated condition were the levels found to range between 1.46 *mg/l* at zone A to 3.06 *mg/l* at zone B.

Table 3. Concentration of Dissolved Oxygen (DO), Standard deviation (SD), and the Confidence interval (CI) for all Zones.

CI	SD	Mean, (*mg/l*)	Replicates	Location
-0.56-6.69	3.45	3.06	6	A
0.61-2.32	0.81	1.46	6	B
0.50-3.03	1.24	1.76	6	C
1.58-2.48	0.42	2.03	6	D

Tables (4-11) show the mean concentrations of the parameter of the pollution indicators of the water.

Table 4. Values of the Biological Oxygen Demand (BOD), Standard deviation (SD), and the Confidence interval (CI) for all Zones.

CI	SD	Mean, (*mg/l*)	Replicates	Location
80.7-154.3	14.3	117.5	6	A
77.8-167.2	17.4	122.5	6	B
77.4-162.8	16.6	120.0	6	C
101.9-194.8	18.1	148.3	6	D

It can be seen from Table (4) that there were differences between the zones in organic loads in terms of both BOD and COD. The highest 148.3 *mg/l* was reported at zone D, while the lowest 117.5 *mg/l* was found at zone A. These levels clearly attributed to a sewage input that enters the lake. The values for COD shown in Table (5), it can be seen that the high level 296.6 *mg/l* at zone A and lower 235 *mg/l* at zone D. The relatively high levels of BOD and COD reflecting on an environment rich in organic material while the differences between sites and zones reflect on the possibilities of the present of other several inputs from non-point sources.

ISSN: 2413-5267

Table 5. Values of the Chemical Oxygen Demand (COD), Standard deviation (SD), and the Confidence interval (CI) for all Zones.

CI	SD	Mean, (*mg/l*)	Replicates	Location
161.5-308.5	28.6	296.7	6	A
155.5-334.5	34.8	240.0	6	B
154.5-325.5	33.3	245.0	6	C
203.8-389.5	36.1	235.0	6	D

The results of the suspended solids shown in Table (6), differences between sites and zones as it ranges from 60.5 *mg/l* at site C to 88.7 *mg/l* at site A.

Table 6. Total Suspended Solids (TSS), Standard deviation (SD), and the Confidence interval (CI) for all Zones.

CI	SD	Mean, (*mg/l*)	Replicates	Location
70.89-90.43	9.30	88.70	6	A
21.65-105.67	40.03	63.70	6	B
43.08-86.91	25.16	60.50	6	C
79.29-93.70	6.86	86.50	6	D

The results of all the Total Nitrogen (TN) and its derivatives (NH_3, NO_2^-, and NO_3^-), shown in Tables (7-10). The concentrations of TN were found to range from 2.25 *mg/l* at zone B to 6.36 *mg/l* at zone A as shown in Table (7).

Table 7. Total Nitrogen (TN), Standard Deviation (SD), and the Confidence interval (CI) for all Zones.

CI	SD	Mean, (*mg/l*)	Replicates	Location
1.62-7.06	4.009	6.36	6	A
0.86-2.01	1.025	2.25	6	B
1.52-5.03	2.453	4.86	6	C
0.54-3.04	1.704	2.93	6	D

Table 8. Nitrate (NO_3^-), Standard deviation (SD), and the Confidence interval (CI) for all Zones.

CI	SD	Mean, (*mg/l*)	Replicates	Location
0.91-2. 98	0.40	1.95	6	A
0.23-3.13	0.56	1.68	6	B
4.23-2.63	0.31	3.43	6	C
0.16-3.63	0.67	1.90	6	D

Table 9. Concentration of Nitrite (NO_2^-), the Standard deviation (SD), and the Confidence interval (CI) for all Zones.

CI	SD	Mean, (*mg/l*)	Replicates	Location
0.013-0.023	0.005	0.018	6	A
0.006-0.026	0.009	0.016	6	B
0.005-0.026	0.005	0.006	6	C
0.034-0.021	0.003	0.028	6	D

ISSN: 2413-5267

Table 10. Concentration of Ammonia (NH_3), the Standard deviation (SD), and the Confidence interval (CI) for all Zones.

CI	SD	Mean, (*mg/l*)	Replicates	Location
4.20-18.13	6.63	11.16	6	A
1.05-6.16	2.43	3.60	6	B
4.41-11.58	3.41	8.00	6	C
-1.51-11.54	2.53	5.01	6	D

Tables (11 and12) presented the yearly load levels obtained were very high compared with other places along the Libyan coast as mentioned by (Hamouda and Wilson, 1989; الملاح؛ 2006 واخرون 2007 الدويب; 2007 قويدر; 2014؛ موسى 2015؛ عكاشة وأخرون 2012؛ تنتوش والصغير). The load obtained 8.5 *Ton* were very close to the level were the lake could be classified as a Hot Spot as the level set by MAP/UNEP for Hotspot Area is a 10 *Ton* BOD/*day*. The levels were very high in comparison with other sites and area along the Libyan coast but very low to what been reputed for El- Mex bay in Egypt in which the level were a load of 219.498 *Ton* BOD while the level at Abu-Qir Bay were 91.701 *Ton* BOD (UNEP/MAP, 1996b). Saronic bay in Greece receives an organic load of 56.386 Ton.

Table 11. Concentration of Total phosphorus (TP), the Standard deviation (SD), and the Confidence interval (CI) for all Zones.

CI	SD	Mean, (*mg/l*)	Replicates	Location
1.49-2.43	0.45	1.95	6	A
0. 51-1.39	0.17	0.95	6	B
1.67-1.67	0.04	2.22	6	C
2.33-2.33	0.15	1.28	6	D

Table 12. Concentration, Load of BOD, COD, Total suspended Solid (TSS), Total Nitrogen (TN), and Total phosphorus (TP) of the wastewater flow that enters to the lake.

Yearly Load (*Ton*)	Daily Load (*Ton*)	Concentration (g/m^3)	Mean Flow (m^3 /*day*)	Parameters
2971.47	8.141	195	41765	BOD
5456..75	14.95	358	41765	COD
1752	4.80	115	41765	TSS
65.7	0.18	4.40	41765	TN
25.55	0.07	1.73	41765	TP

A study were carried out by امجيديب (2006) to estimate the pollution loads from a number of industry in Benghazi city in which the lake and some parts of the city coastline exhibit a high level of organic load. UNEP Map (1996b) estimated the organic loads input into the Mediterranean by 804.298 *Ton* and also estimated the cost of treatment to around USD 417 million (UNEP Map, 1996a).

From the results obtained it appears that the discharge of untreated sewage should be restricted unless a sufficiently high degree of dispersion is guaranteed by the outfall in order to avoid accumulation of particulate organic matters in its surroundings and to assure that the DO is at saturation. It is well known that, when additional nutrients or organic matter enters by

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rivers or effluents to a coastal area or confined sea, or lake like the current lake the many processes well disrupted and the overall equilibrium will be upset leading to initiating the process of eutrophication. In addition to that an excessive load of dissolved or particulate organic matter may lead to the generation of hypoxic or anoxic environments shifting the system from being oxygen-controlled to be sulphur-controlled with the appearance of nasty smelling hydrogen sulphide and toxic sulphides for the biota. Hamouda and El Mabroke (2006) found a value of 0.3 for the Sequential Comparison Index (SCI) for the current lake indicating a very low population and diversity in the benthic community.

There were no clear correlation between the parameters studied shown in Table (13) the only linearly correlation were found between COD, DO, NH_3, BOD, TP, NO_2^-, and BOD. It very difficult to find a clear relationship and pattern in a situation there are several input of different types of pollutants.

Table 13. Spearman correlation coefficients

TP	NH_3	NO_2^-	NO_3^-	TN	TSS	COD	BOD	DO	TDS	pH	Parameters
										1.0	pH
									1.0	-.74	TDS
								1.0	0.25	-.83	DO
							1.0	-0.18	-0.11	-.05	BOD
						1.0	0.25	0.91	0.13	-.73	COD
					1.0	-0.54	-0.39	0.67	0.03	-.77	TSS
				1.0	- 54	0.50	0.53	-0.06	-0.82	-.05	TN
			1.0	0.714	-.51	-0.13	-0.30	-0.18	0.84	0.69	NO_3^-
		1.0	-0.77	0.29	-.32	-0.10	0.79	0.23	0.31	-.61	NO_2^-
	1.0	-0.29	0.32	-0.67	-.27	0.88	-0.51	0.47	0.44	0.03	NH_3
1.0	0.85	0.59	0.78	0.78	0.15	0.49	-0.46	0.85	0.26	0.80	TP

4. Conclusion

In conclusion the results obtained appeared not to exhibit a specific pattern, this could be due the existence of different points and non-points of input. In addition to that the differences between zones could be attributed to the differences in distance from the point source (the input point). It appears from the results obtained in this study that highly levels of BOD and COD obtained indicate that the influence of the marine in terms of dilution seems to be very limited. However, this has to investigated further in future study in order to find if there were sharp seasonal variation on the levels of pollution indicator, and find the extent and degree of lake transported materials to the sea were different from season to season.

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