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Assessment of some water quality characteristics as guide lines for the management of pond fish culture in Lake Manzala, Egypt

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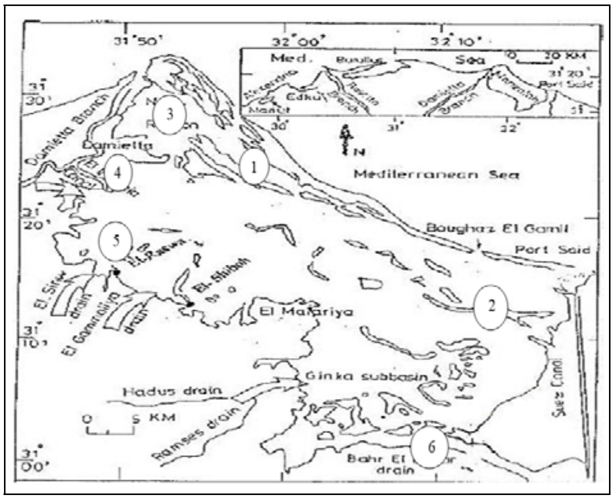
Abstract
The Optimum fish production is totally dependent on the physical, chemical and biological qualities of water to most of the extent. Hence, successful pond management requires an understanding of water quality. Water quality is determined by variables like temperature, transparency, turbidity, water colour, carbon dioxide, pH, alkalinity, hardness, unionised ammonia, nitrite, nitrate, primary productivity, The obtained results declared that, the agricultural and domestic sewage drained into the lake from urban and rural lands have an adverse effects of water quality characteristics of the lake. Nowadays, there are huge amount of treated sewage from Bahr El-Baqr drain discharged into the lake, but the water quality still undergoes a severe deterioration. The most studied parameters; especially nutrient salts and toxic gases varied in wide range, increased in the southern region and decreased towards north eastern part of the lake. This study demonstrates the usefulness of multivariate statistical approaches for analysis and interpretation of water quality data, identification of pollution sources and understanding of temporal variations in water quality for effective lake water quality management.

Keywords: physicochemical conditions, heavy metals, nutrient, salts, Lake Manzala.

1. Introduction
Water is the culture environment for fish where they perform all their bodily functions. They are totally dependent upon water to breathe, feed and grow, excrete wastes, maintain a salt balance, and reproduce [1]. Water quality focuses on the various aspects of the physicochemical parameters of water by which state of a water body can easily be observed. It is the first most important limiting factor in fish culture which is normally governed by a number of parameters including color, odor, temperature, pH, DO, BOD, TDS, EC, transparency, acidity, alkalinity and hardness [2]. Each of these parameters has a standard value for fish culture [3]. A guiding principle of fish culture is that water quality and hence efficient production are a direct consequence of good water chemistry [4]. Therefore, the maintenance of good water quality is essential for healthy fish culture. The majority of fish culture throughout the world is conducted in ponds. Pond habitats can easily be manipulated by controlling the water characteristics for an optimum environment yielding high level fish production [4]. The objective of the present study is to review and present a concise opinion regarding the optimum levels of water quality characteristics required for maximum fish production as well as enforcement of laws enacted to protect our environment are therefore advocated.

Materials and Methods
Study Area
Lake Manzala is the largest of the four brackish coastal lakes fringing the Nile Delta. It is bordered by Suez Canal from east, Damietta branch of Nile from west and Mediterranean Sea from north. The lake connected to the Mediterranean Sea via five outlets, permitting exchange the water and biota between the lake and the sea. These outlets are EL-Sofara, El-Boughdady at Damietta El-Gamil, the new El-Gamil and Canal EL-etesal with Suez Canal at Port Said. Lake Manzala can be divided into two main regions according to its salinities; the southern region of the lake which characterized by lower values of salinities and high concentration of nutrients and heavy metals as consequence of its receive high volumes of low salinity drainage water through different drains and the second region at the North Eastern area of the lake, near to the lake-sea connection (EL-Sofara and El-Gamil), which characterized by high salinity

values and low nutrient concentration as a result of seawater intrusion through the outlet openings [5]. The southern part of the lake water maintained the high heavy metals levels which exceed the allowable maximum concentration reported by Word Health Organization (WHO), which might cause a public health problem [6]. Lake Manzala attracts attention of many scientist because of its important economic aspects. Several investigations have been carried out concerning its ecosystem. These studies dealt with different environmental aspects of the lake including geological aspects, hydrological regime, physicochemical properties, bacterial indices, phytoplankton composition, benthic invertebrates and fishery status [7-9].



Map of Manzala Lake show the six study station

Sample Collection

Water samples were collected from the 6 stations for 4 seasons of Manzala Lake. Then, collected samples were kept in a 2 L polyethylene plastic bottles cleaned with metal free soap, rinsed many times with distilled water and finally soaked in 10% nitric acid for 24 h, finally rinsed with Di ionized water. All water samples were stored in insulated cooler containing ice and delivered on the same day to laboratory and all samples were kept at 4 °C until processing and analysis [10, 11].

Analytical Methods

In the present investigation, water samples were collected from 6 stations in four different seasons (winter, spring, summer and autumn of 2014). Sampling site selection criteria include natural conditions, as well as human activities. Stations 1 and 2(EL-Sofara and El-Gamil) represents natural condition where neither agricultural nor industrial activities can be found. Stations 3 and 4(EL-Ratama and EL-Heesha) are mostly affected by agricultural, as well as aquaculture activities. Stations 5and 6 (Moheeb drian and Bahr El-Baqr drain) are affected by almost all type of pollutant from residential, agricultural and to a lower extent industrial activities. The selected water quality parameters consist of dissolved oxygen (DO), pH, water temperature (T), nitrate (NO3), total phosphate (T-PO4) (using HACH DR2010 spectrophotometer), respectively. (APHA, 1998). The water quality parameters, their units and methods of analysis are summarized in Table (1&2). All mathematical and statistical calculations were implemented using STATISTICA 8 and Microsoft Office Excel 2007.

Results and Discussion

Salinity S%

Salinity is a major driving factor that affects the density and growth of aquatic organism's population [12]. Salinity values are distributed in Lake Manzala in a similar trend. Their values increased in the north eastern area near to boughaz EL-Sofara and El-Gamil recording the maximal values of (64 ppt and 63 ppt respectively) at station 1 and 2. The lowest values of (1ppt &1 ppt ‰ respectively) were recorded at station 5 and 6 (Table 1). Salinity is important to control growth and survival of crabs. Each and every aquatic organism requires particular salinity for normal growth and survival. The sudden drop in survival rates has been noticed from 87% to 45% in between (30 day to 45 day) when salinity has been decreased from 29.6 ppt to 10.4 ppt. at the same time the growth of the crabs were crippled at 0.97 g/day when the salinity has been dead fall [13].

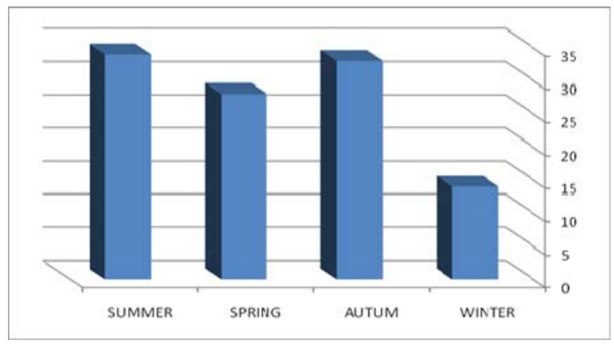


Fig 1: showed the con centration of salinty in ppt.a t the six study station

Dissolved Oxygen (DO)

Water of Lake Manzala is well oxygenated during different time intervals except the inlet of Moheeb and Bahr El-Baqr station (5 and 6) region which suffered from complete depletion of dissolved oxygen around the year especially during hot months. Station 6 had the lowest average value (0 – 5.3 mg /l) during the year as a result of decomposition of organic matter and detritus materials consumed the dissolved oxygen. The maximum value of DO (16 mg/l) was recorded at station 1 during December due to decreasing of temperature and to the prevailing winds which permit to increase the solubility of atmospheric oxygen [13]. According to [14]. and [15] DO level >5ppm is essential to support good fish production. [16] Recommended that fish can die if exposed to less than 0.3 mg /l of DO for a long period of time, minimum concentration of 1.0 mg /l DO is essential to sustain fish for long period and 5.0 mg /l are adequate in fish ponds.

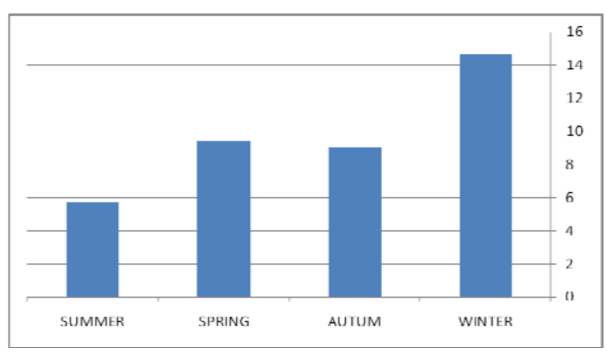


Fig 2: showed the con centration of Dissolved Oxygen in ppm. At the six study station

Temperature
Water of Lake Manzala temperature fluctuate during different time intervals from (17 - 30.5 °C) According to [17]. 30-35 °C is tolerable to fish, [15]. suggested the levels of temperature as 28 – 32 °C good for tropical major carps; < 12 °C –lethal but good for cold water species; 25-30 °C ideal for Penaeous monodon culture; < 20 °C –sub lethal for growth and survival for fishes and > 35 °C -lethal to maximum number of fish species and according to [18]. suitable water temperature for carp culture is between 24 and 30 °C.

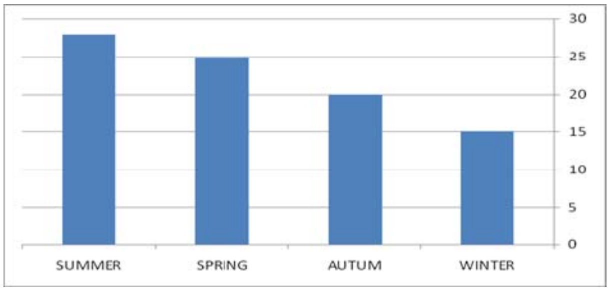


Fig 3: Showed the temperture in °C at the six study station

pH Values.
The pH values of Lake Manzala were fluctuated between 7.45 - 8.9 with slight regional and seasonal variations. The lowest pH values were mostly recorded in the southern region in front of Bahr El-Baqr Drain due to the fermentation of the organic matter and liberation of hydrogen sulphide and methane gases which lead to lowering pH values. However, in the western region of lake, the pH values lie in the alkaline side mostly above 8.0. These results in agreement with those obtained by [19]. Who reported that the change in pH value was always in the alkaline side and ranged between 7.7 to 9.0? The higher pH values observed suggests that carbon dioxide, carbonate -bicarbonate equilibrium is affected more due to change in physico-chemical condition [13].

Nitrate salts NO_3
Nitrate levels of Lake Manzala were fluctuated between 0.01 – 3.8 with slight regional and seasonal variations. The lowest Nitrate levels(0.01ppm) were mostly recorded in the northern region in front of (station 1&2) while the highest level(3.8ppm) were mostly recorded in the southern region station (6) in front Bahr El-Baqr Drain. Our result is in agreement to [18]. described the favorable range of 0.1 mg ⁄l to 4.0 mg ⁄l in fish culture water. However, [20]. recommends that nitrate levels in marine systems never exceed 100 mg ⁄l The distribution dynamic of dissolved nutrients in Lake Manzala is governed by several factors; the major of which are; 1) the heavily polluted water drained into the lake through Moheeh & elsyala Drains and Bahr El-Baqr Drains, and 2) its removal through uptake by macrophytes assimilation processes. Although, the construction of great treatment ponds to treat about 25,000 cubic meter per day of the organic sewage from Bahr El-Baqr, but the effect of this treatment not clearly obvious till now. The south and south eastern regions still undergoes a severe pollution case represented in high nutrients and heavy metals loading from different effluents inflow into the lake. Except this area, the distribution of nutrients in the rest of the lake showed irregular narrow variations.

Nitrite (NO2)
In the present study it is clear obviously that the concentration of nitrite at station 6 (facing Bahr El-Baqr Drain) exceeds much more than other parts in the lake which mainly attributed to different sewage effluents discharges into this area. Nitrite showed its minimum value (0.01 µg/l) during December at station 1, while the maximum value (0.6 µg/l) was recorded during July at station 6. It is clear that, the increase of nitrite concentration attributed to the oxidation of ammonia yielding nitrite especially in abundant of dissolved oxygen. According to [15]. 0.02-1.0 ppm is lethal to many fish species, >1.0 ppm is lethal for many warm water fishes and <0.02 ppm is acceptable [18]. Recommended nitrite concentration in water should not exceed 0.5 Bahr [20]. Recommended that it should not exceed 0.2 mg⁄ L in freshwater and 0.125 mg⁄l in seawater.

Ammonia (NH_3)
Ammonia (NH_3) concentration in Lake Manzala showed an abrupt increase at station (5 and 6) due to the direct impact of domestic sewage inflow from Moheeb & Elsyala Drain and Bahr EL-Baqr Drain into this region. Thus, the rate of ammonification process increases converting the organic matter to ammonia especially at high temperature, therefore the maximum ammonia value (0.42 mg/l) was recorded during summer. The other parts of the lake showed a homogeneous distribution with narrow horizontal fluctuations. The minimum value of 0.01 mg/l was recorded at station 1 during winter. Maximum limit of ammonia concentration for aquatic organisms is 0.1 mg ⁄L [18, 15]. suggested 0.01-0.5 ppm is desirable for shrimp; >0.4 ppm is lethal to many fishes & prawn species; 0.05-0.4 ppm has sub lethal effect and <0.05 ppm is safe for many tropical fish species and prawns. [14]. recommended the level of ammonia (<0.2 mg ⁄L) suitable for pond fishery.

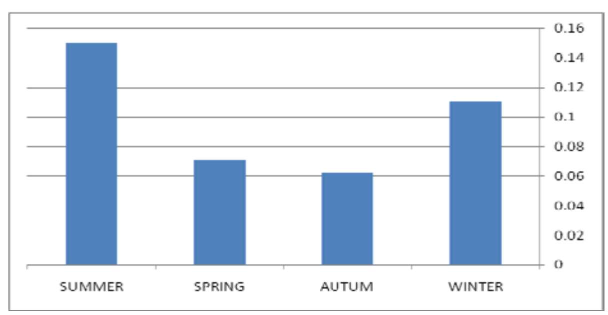


Fig 4: Showed the conc. of toxic ammonia (NH3) mg/l at the six study station

Table 1: Some variable parameters (S%, DO, Tenp, NO3, NO2, NH3, O-PO4 and T OP) determined at the six station.

Season	Station	S% ppt	DO mg/L	Tenp. (°C)	pH	NO_3	NO_2	NH_3
Spring Mean ±SD	1	45	14.3	30	8.3	0.03	0.01	0.02
	2	42	14	30	8.2	0.13	0.01	0.02
	3	40.	6.2	25.7	8.5	0.05	0.03	0.032
	4	37	8.2	24.7	9.1	0.04	0.02	0.045
	5	1.8	8.3	20.6	7.6	1.12	0.14	0.09
	6	1.7	5.3	20.7	8.0	2.2	0.25	0. 21

Total Mean ±SD	Mean ±SD	28±0. 013	9.45±0021	25.28±0.022	8.2±0.032	0.056±0.04	0.076±0.04	0.071±0.04
Summer Mean ±SD	1	64	16	28	8.6	0.05	0.01	0.032
	2	63	16	28	8.6	0. 18	0.01	0.021
	3	42	3.1	30	8.2	0.62	0.03	0.041
	4	37	3.4	30.5	8.2	0. 71	0.05	0.055
	5	3.4	3.1	26	7.6	1.9	0.40	0.35
	6	2.2	2.9	26	7.5	3.8	0.60	0.42
Total Mean ±SD	Mean±SD	34.2±0.020	5.7±0.015	28±0.015	8.1±0.015	1.2±0.015	0.18±0.015	015±0.015
Autumn Mean ±SD	1	56	8.5	19.6	8.5	0..05	0.01	0.030
	2	50	8.7	18.1	9.0	0.03	0.01	0.021
	3	44.4	8.3	21	7.8	0.08	0.02	0.043
	4	40.4	9.3	21.2	8.5	0.09	0.02	0.054
	5	6.3	10	23	8.3	1.7	0.04	0.230
	6	4.5	9	21	8.1	2.6	0.07	0.056
Total Mean ±SD	Mean±SD	33.6±0.015	9±0.015	20.6±0.002	8.3±0.0025	0.74±0..01	0.028=0.01	0.072±0.02
Winter Mean ±SD	1	37.3	9.2	17	8.8	0.04	0.01	0.01
	2	36.3	8.8	17.2	8.6	0.02	0.01	0.01
	3	1	7.3	20	7.8	0.75	0.02	0.02
	4	7.7	10.1	21	9.1	0. 86	0.04	0.14
	5	5	0	22	8.1	1.90	0.07	0.25
	6	1	0	22	7.9	2.50	0.09	0.25
Total Mean ±SD	Mean±SD	14.6±0.015	6±0.025	20±0.015	8.2±0.015	0.9±0.0025	0.04±0.015	0.11±0.015

Major Anions

Carbonates in Lake Manzala are almost depleted in most stations during cold months as a consequence of its precipitation as $CaCO_3$ onto the overlying sediment or its conversion to bicarbonate, then increased gradually during spring and summer and reached its maximum value of 56 mg/l due to the increase of the amount of dissolved carbon dioxide, which is converted to carbonate in the water environment [21]. Bicarbonate values fluctuated in wide range between 216 - 352 mg/l (Table 2), showing an obvious decrease during winter at station 3 in the middle region of the lake due to utilization of dissolved carbon dioxide that resulted from the chemical reaction of converting calcium bicarbonate to calcium carbonate. [22]. Then, they showed a remarkable increase during hot months at the southern region (stations 5 & 6) which may be attributed to direct impact of the agricultural effluents from Moheeb & Elsyala Drain and Bahr El-Baqr Drain. These results were in agreement with that obtained by [19]. who cited that the total alkalinity of Lake Manzala water reached its minimum in spring (200 mg/l), whereas the maximum value was recorded in summer (300 mg/l) at the southern region. The distribution pattern of chlorosity and sulphate exhibits an opposite manner to bicarbonate. Their maximum values were recorded in the north eastern area nearby the boughaze outlet as a result of sea water intrusion and then decreased obviously towards southern region. The highest values of chloride and sulphate (11.5 g/l and 1345 mg/l) were recorded at station 1 during August. The lowest chloride and sulphate values (0.47 g/l and 117 mg/l) were recorded at southern region at station (6) during winter.

Major Cations

Major cations showed their highest levels in the restricted area nearby the boughaz outlet as a result of seawater intrusion into the lake. While in the rest area of the lake the levels showed slight variation among the different stations and time intervals (Table 2).The lowest calcium value (13 mg/l) was recorded at station 6 during summer. There are relative variation in magnesium distribution pattern except at boughaz area, which was mainly attributed to high solubility characteristics of its salts, which keep a homogenous distribution and mass balance for magnesium [23]. The results showed a relative increase of magnesium during summer which is mainly attributed to increase of microbial activity and fermentation processes shared in the increase of magnesium concentration and the elevation of water temperature that enhances the dissolution of magnesium carbonate from underlying sediments or from the rocks containing magnesium salts Thus, the maximum value of 1244 mg/l was recorded during August at station 1. The minimum value (115 mg/l) was recorded at station 5 during winter, which attributed to receiving the freshwater effluents from Moheeb& Elsyala Drain. More or less, sodium and potassium showed the same behavior, where their minimum values (3. 48 and 28 mg/l) were recorded at station 6 during winter, while the highest values (8.6 g/l and 543 mg/l) were recorded at Station 1 during summer (Table 2).

Table 2: Some variable (Major Anions& Major cations) parameters determined at the six station

Season	Station	Ca++ (mg/l)	Mg++ (mg/l)	Na+ (g/l)	K+ (mg/l	HCO_3- (mg/l)	CO_3-- (mg/l)	Cl (mg/l)	SO_4-- (mg/l)
Spring Mean ±SD	1	63	1123	27	487	58	31	98	1238
	2	64	1112	26	475	67	32	85	1156
	3	40	1016	21	421	82	36	6.8	1012
	4	37	986	19	398	91	40	6.4	1002
	5	18	732	14	55	108	47	4.4	987
	6	17	586	13	52	145	50	4.1	912
Total Mean ±SD	Mean±SD	40±0.01	926±0.01	20±0.01	315±0.01	92±0.01	39.3±0.01	34±0.025	1051±0.015
Summer Mean±SD	1	27	1244	28	543	128	39	11.3	1345
	2	20	1231	26	521	130	36	10.2	1194

	3	19	1190	25	456	144	41	8.1	1102
	4	21	1076	24	432	134	44	6.8	1032
	5	15	765	22	65	213	49	5.9	1001
	6	13	641	19	47	235	56	5.7	997
Total Mean±SD	Mean±SD	19±0.025	1004.5±0.01	24±0.01	344±0.025	164±0.015	44±0.025	8±0.025	940±0.025
Autumn Mean±SD	1	56	825	19.6	368	89	33	0.51	131
	2	50	807	18.1	346	99	34	0.47	122
	3	54.4	764	21	332	102	40	0.41	120
	4	50.4	742	21.2	301	106	42	0.32	115
	5	20.3	453	16	54	135	47	0.30	102
	6	18.5	420	14	49	189	50	0.30	99
Total Mean±SD	Mean=SD	41.7±0.015	665.5±0.015	20±0.015	244.6±0.015	120±0.015	41±0.015	0.038±0.015	115±0.025
Winter Mean ±SD	1	34	192	27	293	74	30	0.47	117
	2	36	188	25	287	68	32	0.42	112
	3	25	173	20	264	56	41	0.39	104
	4	21	101	11	278	64	43	0.35	105
	5	18	115	8.4	33	122	48	0.29	97
	6	16	121	3.48	28	176	50	0.28	98
Total Mean ±SD	Mean=SD	25±0.015	148.3±0.015	15.7±0.015	197±0.025	93.3±0.025	40.6±0.015	0.36±0.015	105.5±0.025

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