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Assessment of Bacterial Biota and Heavy Metals Pollution of Lake Manzala

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ABSTRACT

Lake Manzala is Egypt's largest lagoon and one of most important fishing sources in the country. The lake faces numerous environmental challenges that have an impact on its water quality. This study was conducted to assess some characteristics lake’s water. Seasonal water samples were collected from three lake stations during the years 2020 (autumn, winter, spring, and summer). Water samples were collected and analyzed physicochemically as well as microbiologically. The findings revealed significant variations in water's physical and chemical properties, including : temperature (13.8°C in spring -34.3°C in autumn), pH (9.09 - 6.2), dissolved oxygen (1.01 -14.66 g), total dissolved solids (408-260 g), total suspended solids (288-72 g), ammonia (0.02 -6.15 g), nitrite (0.39 -0.013 g), nitrate (0.22 - 2.6 g), T.phosphate (2611-1395.5 g), Fe (214-35 g), Mn (7.3 -66.7 g) , Cu (1.02 -5.46 g), Pb(1.01 -9.9 g), Cd(1.01-9.9 g) and Zn (16.8 -45.4 g). The findings indicate that the lake's water quality is critical. The results also revealed a high density of total viable bacterial count and indicator organisms such as total viable bacteria, faecal coli forms, *Aeromonas spp*, and Total coliform bacteria. It is concluded that water in Lake Manzala is highly damaged and the phenomena need more attention in order to reduce the pollution load that reaches the Mediterranean Sea.

Key Words:
Heavymetal Accumulation, Lake Manzala, Microbial Pollution, physical and chemical properties, Wastewater, Water Quality.

1. INTRODUCTION

Lake Manzala is an extremely dynamic aquatic system that has undergone significant physical, chemical, and biological changes. The lake has gradually changed from a primarily marine or estuarine environment to a eutrophic nearly fresh water system, which can have serious ecological, health, social, and economic consequences for humans. This was the result of various human impacts, primarily wastewater discharge into the lake, as well as other human impacts such as strait closure and/or opening, continuous drying processes for human settlement, and lake silting [1].

1.2. Wastewater Discharge into Lake Manzala

Every year, millions of cubic metres of untreated domestic, industrial, and agricultural drainage water are dumped into the lake. These drains have an impact on the lake's size and quality, endangering human health and causing a serious pollution problem [2]. As a result of these findings, contaminants such as heavy metals accumulated and spread within the lagoon sediments. Heavy metal contamination of Lake Manzala has been predicted [3]. In addition to viable bacterial count and contaminant index organisms such as total coliforms, fecal coliforms, *Aeromonas spp*., *Staphylococcus spp*. and *Vibrio spp* was also reported in the lake [1].

2. MATERIALS AND METHODS

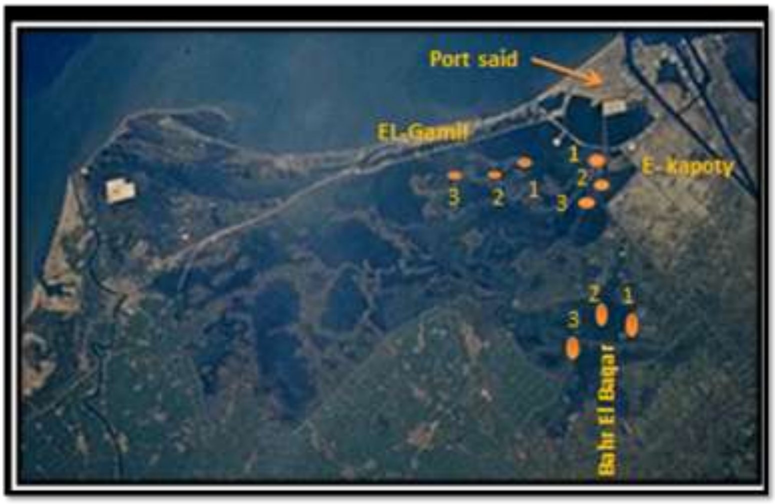


Fig 1. Lake Manzala geographical location

2.1 Study area

Manzala Lake is the largest shallow lake located in the Northern shoreline of the Nile delta of latitudes (31°10" to 31°40" N) and longitudes (31°50" to 32°25" E), [4]. It has a length of about 60 kilometers and an average water depth of about 1 meter. The Mediterranean Sea borders the lake to the north, and the Suez Canal borders it to the east. Furthermore, the lake is bounded on the south by Dakahlia and Sharkia provinces and on the west by Damietta governorate, [5, 6]. The lake is linked to the Mediterranean Sea via a three-outlet opening known as Boughaz, which includes El-Soffara, El-Gamil, and the new El-Gamil, [7]. The three Boughaz are in charge of exchanging water between the lake and the Mediterranean Sea, as well as replenishing the lakes' ecosystems. In addition, the lake is linked to the Suez Canal by a very narrow connecting channel known as the El-Qabuty channel. The Al-Enania and Al-Rotma canals are two other laterals that feed the lake with Nile freshwater from the Damietta branch. Three Boughaz are in charge of exchanging water between the lake and the Mediterranean Sea and of refreshing the lake's ecosystems. (The lake is also connected to the Suez Canal via a very narrow connecting channel called El-Qabuty channel Other laterals that enrich the lake with Nile freshwater from the Damietta branch are the Al-Enania and Al-Rotma canal., [8].

2.2 Sampling sites

Water samples were collected from three sites (composite sample from each), Bahr El-Bakar area (I)(30°23'06.0000''N latitude and 32°19'60.0000''E longitude) , El-Gamil area (II)(31°24'06.0000'' N latitude and 32°28'00.0000''E longitude) and El-Kapoty area (III)(31°25'06.0000''N latitude and 32°25'60.0000''E longitude) (Figure 1) quarterly during the year 2020 period from(Autumn , Winter, Spring and Summer). The selected sampling sites are representing the different conditions and human activates in the lake.

2.3 Sampling Methods

Water samples 1L were taken (15 cm under water surface) in clean sterile glass bottles and transported to the laboratory within six hours in ice bags and ice jackets for further investigation [9].

2.4 Physicochemical characteristics of water samples

Physicochemical characteristics of each water sample (Temperature, pH, DO, TDS, TSS, Ammonia, Nitrite, Nitrate and T. Phosphate) were measures immediately in the field. The temperature was determined by using a mercury thermometer. The pH value was determined using pH meter (Eill, Model 7030) or (Toledo,MB 125,Switzerland) . Dissolved oxygen was determined using Oxygen Meter model (YSI 58) [10].

The chemical analyses (pH, DO, TDS, TSS, Ammonia, Nitrite, Nitrate and T. Phosphate)) were determined according to the methods of [10] were done using the recommended standard methods of water analysis (mg/L).

2.4.1 Sample preparation and digestion for heavy metal procedures

After collection and filtration of the water samples, the metals in the filtrate were extracted using APDC-MIBK procedure [11]. The procedure consists of chelation with ammonium pyrrolidine dithiocarbamate (APDC) to form complex the heavy metals after shaking well, methyl isobutyl ketone (MIBK) was used for extraction. The particulates for each sample were digested in 3.0 mL of concentrated HNO_3 and 5.0 mL of H_2O_2 [12].

2.4.2 Bacterial Pollutants

Using isolation and identification bacterial contaminant taxa the dilution method and the pouring plate method, water samples were directly diluted with 0.8 percent saline distilled water for bacterial counting. Using nutrient agar medium, total viable bacterium was determined, Endo agar medium was used to estimate total coli forms and faecal coli forms [13]. *Aeromonas spp*., *Staphylococcus spp*., and *Vibrio spp*. were identified in that order using the *Aeromonas* differential medium, salt mannitol agar, and thiosulphate citrate bile salts sucrose agar [13]. Correlation analysis was used to test the significance of relationships between the bacterial count and Lake Manzala water characteristics [14].

2.5 Preparation of samples

2.5.1 Water

Water samples were directly diluted with 0.8% saline distilled water for bacterial counting using the dilution method and pour plates method [15].

2.6 Statistical analysis

Pearson correlation bivariate two-tailed test were used to evaluate the significant difference in water quality parameters of different study sites. A probability at level of 0.05 or less was considered significant.

3. RESULTS AND DISCUSSION

3.1 Physical and Chemical Analyses

The results in **Table (1)** displayed the temperature in the lake varied between 13.8°C in spring 34.3°C in autumn with an average of 24.05°C. The highest temperature was recorded in El-Boghaz (34.3°C) whereas the lowest was found in Bahr- El- Bakar (13.8°C). In Bahr El-Bakar, the temperature had the maximum value in autumn (31.2°C) and the lowest in spring (14.7°C) and an average of 23.0°C. In El-Boghaz, the temperature varied from the minimum of 19.1°C in spring to the maximum of 32.1°C in autumn. The average temperature in El-Boghaz was 25.6°C. Temperature in El- Kapoty the reached its maximum value in autumn where it was 32.6°C. On the other hand, the lowest temperature was found in spring (17.5 °C) while the average was 25.1°C. There was no discernible difference in temperature between the sites studied (Fig 2, (A)). Temperature is significant primarily because of its influence on the chemistry and biological activities of organisms in water. Temperature is primarily significant because of its effects on the chemistry and biological activities of organisms in water. It is also believed to affect the determination of other variables such as pH, conductivity, and dissolved oxygen [1].

The concentration of the hydrogen ion (pH) in the lake ranged between 9.09 and 6.2 with an average of 7.645. The highest pH was found in summer where (9.09) while the lowest pH was recorded in summer (6.2). The highest pH was recorded in El- Gamil (9.09) the high pH value at EL- Gamil is due to the lake's direct link to the Mediterranean Sea, allowing water to flow to and from Lake Manzala. El-kapoty (6.2) had the lowest (possibly due to organic matter fermentation and the release of hydrogen sulphide and methane gases, as well as effluent fresh water drains). In Bahr El-Bakar, pH had the maximum value in summer was (8.0) and the lowest in autumn was (7.5) average (7.8). In El-Gamil, pH had the maximum value in summer with 9.07 and the lowest in winter with 8.44 and an average of 8.7. The average value of pH in El- Kapota region was 6.88. The highest pH was recorded in winter (7.22) while the lowest value was recorded in summer (6.5) (Fig 2, (B)).

When organic matter in drain water degrades, it consumes oxygen and emits CO_2, causing the lake to become more acidic. This finding is consistent with the findings of Fathi [16] and Ahmed [17], who discovered that the pH change in Lake Manzala was always alkaline, ranging between 7.5 and 8.0. The findings also indicated (Fig 2,(C)) that the dissolved oxygen levels differed significantly between the sites studied. In general, the lake is well oxygenated as the average concentration of dissolved oxygen was 7.3 g. The oxygen concentration varied from the low-oxygenated to the oversaturated levels. Varied from the lowest in El-kapoty (1.01 g to the highest and the highly oxygenated waters in El- Gamil (14.66 g). The highest value (14.66 g) may be due to a decrease in temperature and the prevailing winds, which allow for an increase in the solubility of atmospheric oxygen [18]. This finding is noteworthy because dissolved oxygen concentrations typically increase as water temperature decreases. Seasonally, DO reach its maximum concentration in spring (14.66 g) and its minimum concentration was recorded in autumn (1.01 g). The observation of the opposite phenomenon suggests that something else, possibly the high microbial communities and the dominant effect of drainage effluents on this location and less anthropogenic activities, is acting to reduce dissolved oxygen. At the lake's southern end (El-kapoty), the dissolved oxygen concentration fell below the minimum acceptable value for aerobic life (1.01 g). Bruner [19] reported a similar result.

Bahr El-Bakar showed the lowest concentration over the lake where the concentration of oxygen varied from 0.02-0.34 g with a standard of 0.18 g. On the other hand, El- Gamil had the highest and the highly oxygenated water in the lake where DO concentration reached its maximum value in of 14.6 g in spring. The average concentration of DO in El-kapoty was 1.6 g. The highest DO concentration was found in spring (3.2 g) whereas the lowest concentration (0.02 g) was found in autumn. Fish and other aquatic organisms require dissolved oxygen for respiration, making it an important ecological parameter. Low oxygen contents do not directly impede uses such as drinking water production or recreation, but they can indicate pollution stresses and/or eutrophication phenomena, which may have a negative impact on these functions [20].

The total dissolved solids (TDS) values differed significantly between sampling sites. TDS in the lake varied between (408 g) and (260 g) with an average of 2174 g. The highest TDS was found in spring where the TDS was (4088 g) on the other hand the lowest TDS was recorded in autumn (260 g). The highest TDS was recorded in El-kapoty (4088 g) whereas the lowest was found in El-Gamil (260 g). In Bahr El-Bakar, TDS had the maximum value in winter (856.5 g) and the lowest in (summer (834.4 g) and the average was 845.5 g. In El-Gamil, TDS had the maximum value in summer (548.3 g/L) and the lowest in autumn (264.1 g) and the average was 406.2 g/L. In El- Kapoty TDS had the maximum value in spring (4085.3) and the lowest in summer (4048.3 g/L) (Fig 2, (D)). According to El-Gawady [21] and Shakweer [22], Lake Manzala can be divided into two main regions based on salinities: the southern region of the lake, which is characterised by lower salinity values and a high concentration of nutrients and heavy metals as a result of receiving high volumes of low salinity drainage water through different drains, and the second region in the lake's north eastern area, near the lake-sea connection (El-Ga Ramadan) [23] reported similar findings. Because of geogenic and other natural sources, major ions are present in all aquatic ecosystems. Of course, anthropogenic activities can increase salinity. Anthropogenic activities, of course, can contribute to increased salinity. The total suspended solids TSS was ranged from (288 g/L 8) and (72 g/L) with a standard of 180 g/L. The highest TSS was found in the summer (288 g/L), while the lowest TSS was found in the winter (72 g/L). The highest TSS was recorded in El-kapoty (288 g/L) whereas the lowest was found in Bahr El-Bakar (72 g/L). In Bahr El-Bakar, TSS had the maximum value in summer (80.8 g/L) and the lowest in winter (76.8 g/L) and the average was 78.8 g/L. In El-Gamil, TSS had the maximum value in summer (129.3 g/L) and the lowest in autumn (88.4 g/L) and the average was 108.8 g/L. TSS in El- Kapoty was highest in the summer (273.3 g/L) and lowest in the winter (124.5 g/L). (Fig 2, (E)) To the north, TSS is clearly increased. Bacteria adsorb to the surfaces of suspended particles, whether organic or mineral in nature, where they find a more favourable nutritional environment than in free water. The majority of microorganisms have been observed growing on the surface of suspended particles in water containing extremely low nutrient concentrations. Adsorption to debris particles also neutralises inhibitory and toxic substances. As a result, the suspended particles encourage the growth of bacteria.

There was a significant difference in ammonia concentrations between investigated sites. The ammonia in the lake varied between 0.02 g in winter 6.15 g in spring with an average of 3.085 g. The highest ammonia was recorded in Bahr El-Bakar 6.15 g whereas the lowest was found in El-Gamil 0.02 g. In Bahr El-Bakar, the ammonia had the maximum value in sprig 5.7 g and the lowest in summer 0.98 g and an average of 3.36 g. In El-Gamil, the ammonia varied from the minimum of 0.03 g in winter to the maximum of 1.62 g in summer. The average ammonia in El-Boghaz was 0.82g. The ammonia in El- Kapoty the reached its maximum value in spring where it was 1.38 g. Winter, on the other hand, had the lowest ammonia concentration (0.44 g, while the average was 0.91 g). (Fig 2, (F)) The presence of high levels of ammonia in the Bahr El-Bakar area indicates polluted water and abundant algal growth. Proteins, like many other biomolecules, contain nitrogen when they are metabolized; much of this nitrogen could end up as ammonia (NH_3). Furthermore, the NH_3 ratio has been shown to increase with temperature and pH. Other sources of ammonia pollution include the lake's low DO value (1.01 g) and the receipt of approximately 7500 million cubic meters of annual discharge of untreated industrial, domestic, and agricultural drainage water through several drains. The amounts of nitrite have shown to be the average in the lake was 0.20 g and the highest nitrite was recorded in winter (0.39 g) whereas the lowest was recorded in autumn (0.013 g). El-kapoty recorded the highest value of nitrite (0.39 g) whereas El-Gamil recorded the lowest value (0.013 g). In Bahr El-Bakar, nitrite had the maximum value in (winter) was (0.238 g) and the lowest in (summer) was (0.231 g) average (0.235g). In El-Gamil, nitrite had the maximum value in (summer) was (0.0144 g) and the lowest in (spring) was (0.0143 g) average (0.014 g). In El- Kapoty nitrite had the maximum value in (winter) was (0.36 g) and the lowest in (summer) was (0.32 g) average (0.34 g).) (Fig 2, (G)) This result can be observed by the fact that nitrite has a relatively short life in water due to the rapid conversion of nitrite to nitrate by bacteria. NO_2 pollution is primarily relevant to aquatic organisms due to its short lifetime.

Nitrate in the lake varied between 0.22 g in spring 2.6 gin summer with an average of 1.41 g. The highest nitrate was recorded in Bahr El-Bakar 2.6 g whereas the lowest was found in El- Kapoty 0.22 g. In Bahr El-Bakar, the nitrate had the maximum value in summer (2.3 g) and the lowest in winter (2.1 g) and an average of 2.2 g. In El-Gamil, the nitrate varied from the minimum of 0.04 g in winter to the maximum of 0.13 g in spring. The average nitrate in El-Gamil was 0.09 g. Nitrate in El- Kapoty the reached its maximum value in summer where it was 0.72 g. On the other hand, the lowest nitrate was found in spring (0.22 g) while the average was 0.47 g.) (Fig 2, (H)) Organic nitrogen degrades to ammonium (NH_4/NH_3). The high value (2.6 g) at the lake's Bahr El-Bakar indicates man-made pollution. Domestic and industrial discharges, as well as agricultural runoff containing fertilisers, are all man-made sources of nitrate in the environment.

The phosphate levels in the water collected from the two sites differed slightly. The average Phosphate in the lake was 180 g and the highest Phosphate was recorded in summer (2611 g) whereas the lowest was recorded in autumn (1395.5 g). El-Gamil recorded the highest value of Phosphate (2611 g) whereas Bahr El-Bakar recorded the lowest value (180 g). In Bahr El-Bakar, Phosphate had the maximum value in (summer) was (1077.5 g) and the lowest in (autumn) was (183.4 g) average (630.5 g). In El-Gamil, Phosphate had the maximum value in (summer) was (2606.4 g) and the lowest in (autumn) was (847 g) average (1726.7 g). In El- Kapoty Phosphate had the maximum value in (summer) was (1094.2 g) and the lowest in (autumn) was (194 g) average (644.1 g). (Fig 2, (I)) This demonstrates that the water in the southern reaches of Lake Manzala is slightly eutrophicated. Regardless, nitrate and phosphate concentrations in Lake water exceeded the permissible limits of 11.3 g and 1.0 – 2.0 g, respectively [20].

Water samples from each site were tested for Fe, Mn, Cu, Pb, Cd, and Zn levels. The following are the average heavy metal concentrations in water for the entire area:

Metal ions can enter food chains and become concentrated in aquatic organisms to the point where they affect their physiological state. Heavy metals, that also have a significant environmental impact on all organisms, are among the most effective pollutants. The current study's results **Table (2)** revealed that the concentration of Fe in the lake ranged between 35 g and 214 g, with an average of 124.5 g.

The highest Fe concentration was discovered in autumn where the Fe was 214g on the other hand the lowest Fe was recorded in summer 35 g. The highest Fe was recorded in El-Kapoty 214 g whereas the lowest was found in El-Gamil 35 g. In Bahr El-Bakar, Fe had the maximum value in autumn 172.85 g and the lowest in summer was 42.7 gand the average was 107.8111 g. In El-Gamil, Fe had the maximum value in spring 53.3 g and the lowest in winter 35.2 gand the average was 44.2 g. In El- Kapoty, Fe had the maximum value in autumn 212.5 g and the lowest in summer 72.5 g and the average was 142.5 g . This may be due to the massive amounts of raw sewage, agricultural and industrial wastewater dumped into the Lake. [24].

Mn in the lake varied between 7.3 g in autumn 66.7 g in spring with an average of 37 g. The highest Mn was recorded in El- Kapoty 66.7 g whereas the lowest was found in El-Gamil 7.3 g. In Bahr El-Bakar, Mn had the maximum value in spring 46.7 g and the lowest in winter 8.1 and an average **of** 27.233 g. **In** El-Gamil, Mn varied from the minimum of 7.3 g in autumn to the maximum of 23 g in spring. The average Mn in El-Gamil was 14.51 g. Mn in El- Kapoty the reached its maximum value in spring where it was 66.7g. On the other hand, the lowest Mn was found in winter 10.4 g while the average was 23.88 g. It is most likely the result of fertilizers containing agricultural drainage water that was dripped into the drain. Moreover, the fish farms surrounding to the drain feed fish with Mn-rich residuals from chicken farms. These findings are consistent with previous research on Lake Manzala [25, 26, 27].

Cu (Figure 4C) concentrations ranged from 1.02 g in summer to 9.9 g in autumn, with an average of 5.46 g. The highest Cu was recorded in El- Kapoty 9.9 g whereas the lowest was found in El-Gamil 1.02 g. In Bahr El-Bakar, Cu had the maximum value in spring 7.6 g and the lowest in summer 1.1 g and an average of 4.35 g. In El-Gamil, Cu varied from the minimum of 1.02 g in summer to the maximum of 3.71 g in spring. The average Cu in El-Gamil was 2.349 g. Cu in El- Kapoty the reached its maximum value in spring, autumn where it was 9.9 g. On the other hand, the lowest Cu was found in winter 5.1 g while the average was 7.361 g. Again, it is most likely the result of industrial waste that was spilled into the drain and settled at the bottom. Previous findings disagree with Adel-Hamid and El-Zareef [28], who found lower Cu concentrations in lake water (0.01-0.02 mg/l), but agree with Abdel-Bakey *et al*[26], Ali and Abdel-Satar [29], who found higher Cu concentrations in Lake Manzala water.

Pb in the lake varied between 1.01 g in autumn 9.9 g in spring with an average of 5.455 g. The highest Pb was recorded in El- Kapoty 9.9 g whereas the lowest was found in El-Gamil 1.01 g. **In Bahr El-Bakar**, Pb had the maximum value in spring 7.9 g and the lowest in summer 1.1 g and an average **of** 4.54 g. **In El-Gamil**, **Pb** varied from the minimum of 1.01 g in autumn to the maximum of 8.2 g in spring. The average Pb in El-Gamil was 4.57 g. Pb in **El- Kapoty** the reached its maximum value in spring, where it was 9.9 g. On the other hand, the lowest Pb was found in autumn 5.1 g while the average was 7.43 g. The high concentrations of Pb and other heavy metals discovered raise serious concerns about the disposal of nearby gas factories. It is most likely due to a long period of industrial waste deposition at the bottom of the drain. These findings agree with Ali and Abdel-Satar [29], who attributed the increase in heavy metal concentrations in the water to the release of heavy metals from the sediment to the overlying water as a result of both high temperature and a fermentation process caused by the decomposition of organic matter.

Beliles [30] mentioned that the major sources for manganese in air and water are iron and steel manufacturing and the burning of diesel fuel in the motor cars. So, the engine boats which are distributed in Lake could be a reason for increasing the Pb and Mn in the Lake water.

Cd in the lake varied between 1.01 g in winter 9.9 g in autumn with an average of 5.455 g. The highest Cd was recorded in El- Kapoty 9.9 g whereas the lowest was found in **Bahr El-Bakar** 1.01 g. **In Bahr El-Bakar**, Cd had the maximum value in autumn 7.9 g and the lowest in winter 1.01 g and an average **of** 4.316 g. **In El-Gamil**, Cd varied from the minimum of 1.1 g in summer to the maximum of 5.7 g in autumn. The average Cd in El-Gamil was 3.350 g. Cd in **El- Kapoty** the reached its maximum value in autumn, where it was 9.9 g. On the other hand, the lowest Cd was found in summer 3.26 while the average was 6.658 g. Water containing high levels of Cd and Pb can be attributed to industrial and agricultural discharge [31]. The high level of Pb in Lake Manzala's water could be attributed to industrial and agricultural discharge, as well as spills of leaded gasoline from fishing boats and dust that contains a large amount of lead from the combustion of gasoline in automobiles [32]. The heavily travelled roads that run alongside the northern delta Lakes can be blamed for the high Pb levels in the water. Higher levels of Pb are frequently found in water bodies near highways and large cities due to high gasoline combustion [33].

For **Zn** (Figure 4B) the concentrations were from 16.8 g in winter 45.4 g in spring with an average of 31.1 g. The highest Zn was recorded in El- Kapoty 45.4 g whereas the lowest was found in Bahr El-Bakar 16.8 g. In Bahr El-Bakar, Zn had the maximum value in spring 35.4 g and the lowest in winter 16.8 g and an average of 25.46 g. In El-Gamil, Zn varied from the minimum of 2.11 g in autumn to the maximum of 35.6 g in winter. The average Zn in El-Gamil was 28.80 g. Zn in El- Kapoty the reached its maximum value in spring, where it was 45.4. On the other hand, the lowest Zn was found in winter 17.3 g while the average was 31.29 g. The heavy level of Zn in Lake Manzala samples taken could be attributed to significant volumes of zinc leached from active zinc-containing protection plates on boats.

It is most likely due to the deposition of industrial waste spilled into the drain into the drain's bottom over time. The results agree with those of Ibrahim *et al* [27] and Bahnasawy *et al* [34].

3.2. Bacterial Pollutants

The results in Table (3) showed that total viable bacterial count varies seasonally in both studied areas, with the lowest record being 120 (CFU/ml) 10^3 in winter and the highest record being 1577 (CFU/ml) 10^3 in summer, with an average of 848.5 (CFU/ml) 10^3. The highest T.V.B. was recorded in El- Kapoty with 1577 (CFU/ml) 10^3 whereas the lowest was found in Bahr- El- Bakar with 120 (CFU/ml) 10^3. In Bahr El-Bakar, T.V.B. had the maximum value in summer (466 CFU/ml $\times 10^3$) and the lowest in winter (120 CFU/ml $\times 10^3$) and an average of 276.3 (CFU/ml) 10^3. In El-Gamil, T.V.B. varied from the minimum of 376 (CFU/ml) 10^3in winter to the maximum of 1156 (CFU/ml) 10^3 in summer. The average T.V.B in El-Gamil was 766.6 (CFU/ml) 10^3. T.V.B. in El-Kapoty reached its maximum value in summer where it was 1577(CFU/ml) 10^3. On the other hand, the lowest T.V.B. was found in autumn 500 (CFU/ml) 10^3while the average was 1054.2 (CFU/ml) 10^3. The **total viable bacterial** count was significantly correlated with salinity, dissolved oxygen, total suspended solid, total dissolved solid, and phosphate (r= 0.26, 0.36, 0.72, 0.441and 0.57; $P<0.05$) respectively.

The **fecal coli forms** recorded in the lake varied between 100 (CFU/ml) 10^3 in autumn 1055 (CFU/ml) 10^3 in summer with an average of 577.5 (CFU/ml) 10^3.The highest F.C. was recorded in El- Kapoty 1055 (CFU/ml) 10^3 whereas the lowest was found in Bahr- El- Bakar with 100 (CFU/ml) 10^3. In Bahr El-Bakar, F.C. had the maximum value in summer 590 (CFU/ml) 10^3 and the lowest in autumn 100(CFU/ml) 10^3 and an average of 345.8 (CFU/ml) 10^3. In El-Gamil, F.C. varied from the minimum of 110 (CFU/ml) $\times 10^3$in winter to the maximum of 226(CFU/ml) 10^3 in summer. The average F.C. in El-Gamil was 168.5 (CFU/ml) 10^3. F.C. in El- Kapoty the reached its maximum value in summer where it was 1055 (CFU/ml) 10^3. On the other hand, the lowest F.C. was found in winter 200(CFU/ml) ×103while the average was 628.05 (CFU/ml) 10^3. The **fecal coli forms** were significantly correlated with total suspended solids, and total dissolved solid (r= 0.453 and 0.323; $p<0.05$) respectively.

The total number of ***Aeromonas* spp**. was generally in the lake varied between 99 (CFU/ml) 10^3 in autumn 607 (CFU/ml) 10^3 in autumn with an average of 353 (CFU/ml) 10^3.The highest *Aeromonas* was recorded in El- Kapoty 607 (CFU/ml) 10^3 whereas the lowest was found in Bahr- El- Bakar 99 (CFU/ml) 10^3. In Bahr El-Bakar, *Aeromonas* had the maximum value in summer 605 (CFU/ml) 10^3 and the lowest in autumn 99 (CFU/ml) 10^3 and an average of 353.2 (CFU/ml) 10^3. In El-Gamil, *Aeromonas* varied from the minimum of 170 (CFU/ml) 10^3in winter to the maximum of 318 (CFU/ml) 10^3 in summer. The average *Aeromonas* in El-Gamil was 242.1 (CFU/ml) 10^3. F.C. in El- Kapoty the reached its maximum value in autumn where it was 607 (CFU/ml) 10^3. On the other hand, the lowest *Aeromonas* was found in winter 200 (CFU/ml) 10^3while the average was 393.05 (CFU/ml) 10^3.

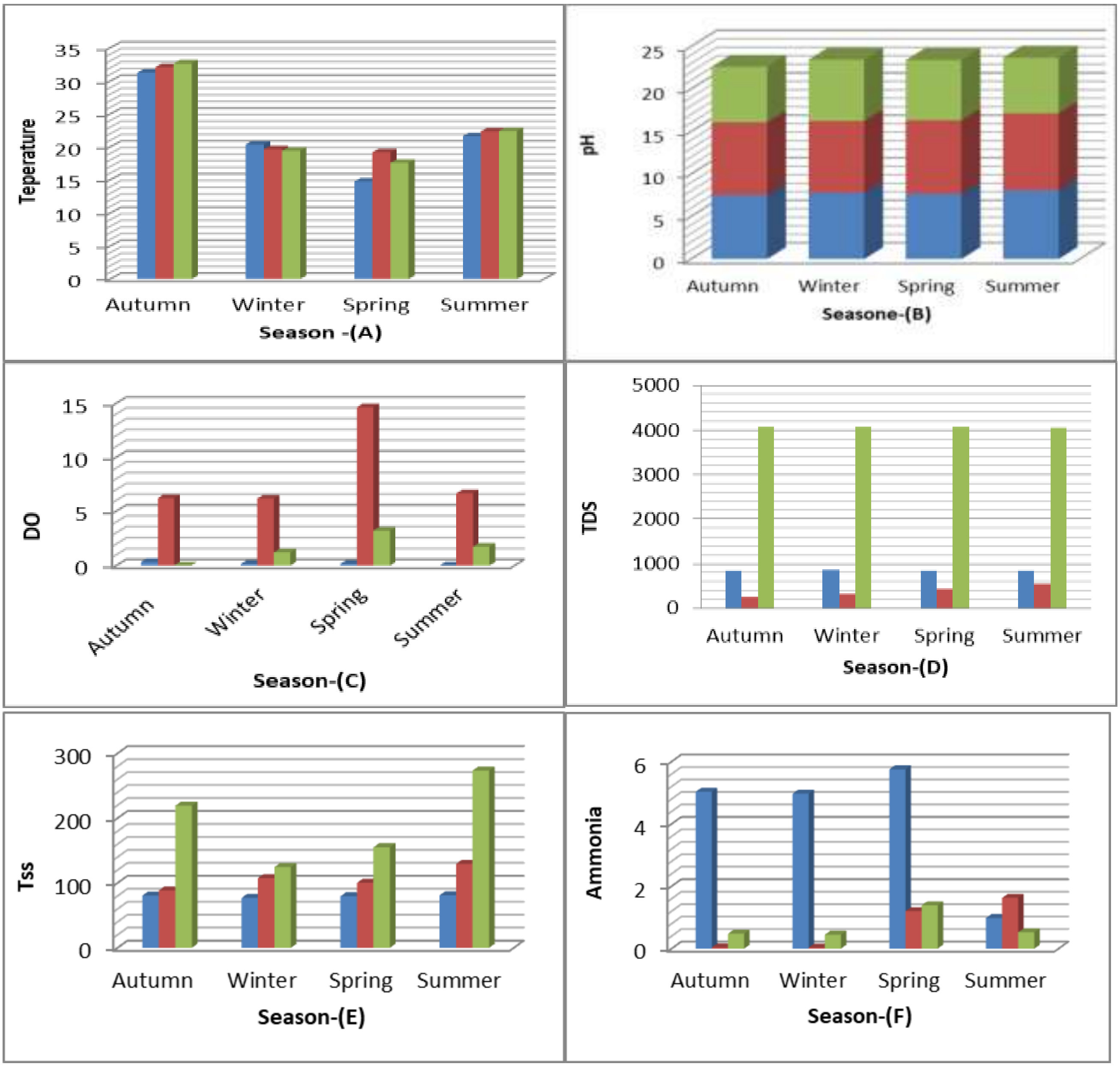
Aeromonas spp. and total suspended solids and dissolved oxygen were significantly correlated (r=0.453, and 0.32; $p<0.05$) respectively

Tcb. *Vibro* in the lake varied between 50 (CFU/ml) 10^3 in autumn 212 (CFU/ml) 10^3 in summer with an average of 131 (CFU/ml) 10^3.The highest **Tcb. *Vibro*** was recorded in **El- boghaz** 212 (CFU/ml) 10^3 whereas the lowest was found in Bahr- El- Bakar 50 (CFU/ml) 10^3. In Bahr El-Bakar, **Tcb. *Vibro*** had the maximum value in summer 211 (CFU/ml) 10^3 and the lowest in winter 50 (CFU/ml) 10^3 and an average **of** 130.6 (CFU/ml) 10^3. **In** El-Gamil, *Aeromonas* varied from the minimum of 50 (CFU/ml) 10^3in winter to the maximum of 212 (CFU/ml) 10^3 in summer. The average **Tcb. *Vibro*** in El-Gamil was 131.2 (CFU/ml) 10^3. **Tcb. *Vibro*** in El- Kapoty the reached its maximum value in summer where it was 200 (CFU/ml) 10^3. On the other hand, the lowest **Tcb. *Vibro*** was found in autumn 92 (CFU/ml) 10^3while the average was 142.8 (CFU/ml) 10^3.

Total and fecal coli forms bacterial counts proved extremely useful in classifying the lake's polluted conditions. With a nod to World Health Organization recommendations [35] . El- Kapoty is regarded as one of the most polluted areas in Manzala Lake. As many researchers routinely use these groups of bacteria, it appears that they are still a powerful tool and the most trusted indicators of water pollution [35]. According to the World Health Organization [35], this area is also the most polluted, with numerous health-hazardous bacterial counts, such as Vibrio spp. and Aeromonas spp.

4. CONCLUSION

Temperature, Dissolved oxygen, Ph, and Nitrite recorded values less than the minimum permissible limit, while Ammonia, T. Phosphate, Do, TDS, and TSS recorded values greater than the Egypt law's permissible limits. The findings revealed significant variations in water's physical and chemical properties, including : temperature (13.8°C in spring -34.3°C in autumn), pH (9.09 - 6.2), dissolved oxygen (1.01 -14.66 g), total dissolved solids (408-260 g), total suspended solids (288-72 g), ammonia (0.02 -6.15 g), nitrite (0.39 -0.013 g), nitrate (0.22 - 2.6 g), T.phosphate (2611-1395.5 g), Fe (214-35 g), Mn (7.3 -66.7 g) , Cu (1.02 -5.46 g), Pb(1.01 -9.9 g), Cd(1.01-9.9 g) and Zn (16.8 - 45.4 g). In addition, the lake had a greater density of total viable bacterial count and pollutant indicator organisms such as total Coli forms, fecal coli forms, *Aeromonas spp., and Vibrio spp.*



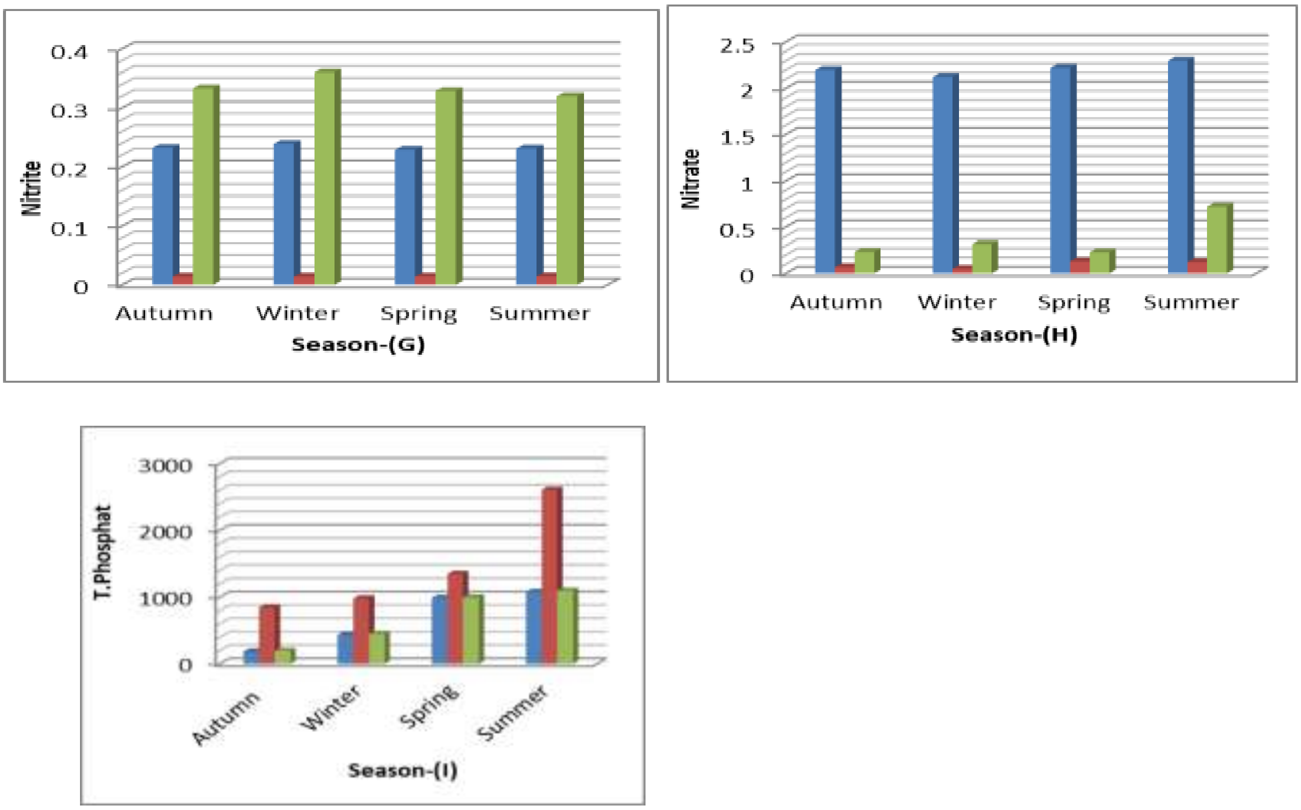


Fig (2): Physical and chemical properties of Lake Manzala water samples: (A) Temperature of the water (T), (B) pH, (C) Dissolved Oxygen (DO), (D) Total Dissolved Solids (TDS), (E) Total Suspended Solids (TSS), (F) Ammonia (Amm), (G) Nitrite, (H) Nitrate, and (I) T.Phosphate. Data is presented as a mean ±SE

Table 1 . Physical and chemical properties of Lake Manzala water samples.

Sites / Parameter	**Bahr El-Bakar**				**EL-Boghaz**				**EL-Kapoty**				**Permissile Limits***
	utumn	**inter**	**pring**	**ummer**	**utumn**	**inter**	**pring**	**ummer**	**utumn**	**Vinter**	**pring**	**ummer**	
Temperature °C	**31.2**	**20.3**	**14.7**	**21.6**	**32.1**	**19.6**	**19.1**	**22.3**	**32.6**	**19.4**	**17.5**	**22.4**	**<35**
pH	**7.5**	**7.8**	**7.6**	**8**	**8.5**	**8.4**	**8.6**	**9**	**6.5**	**7.2**	**7**	**6.5**	**6.0-9.0**
DO (g)	**0.3**	**0.1**	**0.1**	**0.02**	**6.2**	**6.1**	**14.6**	**6.6**	**0.02**	**1.2**	**3.2**	**1.7**	**> 4**
TDS (g)	**838**	**856**	**834**	**834**	**264**	**317**	**446**	**548**	**4084**	**4065**	**4085**	**4048**	**<2000**
TSS (g)	**80.5**	**76.8**	**79.4**	**80.8**	**88.4**	**107.3**	**100.2**	**129.3**	**219.2**	**124.5**	**155**	**273.3**	**< 60**
Ammonia (g)	**5.03**	**4.97**	**5.75**	**0.98**	**0.04**	**0.03**	**1.2**	**1.6**	**0.4**	**0.4**	**1.3**	**0.5**	**< 0.5**
Nitrite (g)	**0.2**	**0.23**	**0.22**	**0.23**	**0.0141**	**0.014**	**0.0143**	**0.014**	**0.33**	**0.36**	**0.32**	**0.32**	**< 0.3**

	3					**1**		**4**					
Nitrate (g)	**2.2**	**2.1**	**2.2**	**2.3**	**0.06**	**0.04**	**0.13**	**0.12**	**0.23**	**0.31**	**0.22**	**0.72**	**11.3-45**
T.Phosphate (g)	**183**	**433**	**988**	**1077**	**847**	**978**	**1345**	**2606**	**194**	**449**	**993**	**1094**	**1.0**

*Permissible Limits of Egypt legislation of the national law 48/1982.

Table 2. Heavy metal concentrations in water samples collected from Lake Manzala.

Sites / Parameter	**Bahr El-Bakar**				**EL-Gamil**				**EL-Kapoty**				**permissible Limits***
	Autumn	**winter**	**Spring**	**Summer**	**Autumn**	**winter**	**Spring**	**Summer**	**Autumn**	**Winter**	**Spring**	**Summer**	
Fe(g)	**172**	**63.1**	**102**	**42.7**	**50.6**	**35.2**	**53.3**	**37.5**	**212**	**83.2**	**123.4**	**72.5**	**< 1.0**
Mn(g)	**10.4**	**8.4**	**46**	**25.6**	**7.4**	**8.6**	**21.5**	**15.8**	**21.2**	**17.5**	**66**	**35.2**	**< 0.5**
Cu(g)	**4.2**	**2.3**	**7.2**	**1.4**	**2.3**	**3.2**	**3.6**	**1.04**	**9.2**	**8.3**	**9.1**	**5.4**	**< 1.0**
Pb(g)	**1.2**	**4.7**	**7.8**	**4.4**	**1.03**	**6.03**	**8.11**	**3.8**	**5.2**	**8.5**	**9.6**	**8.3**	**< 0.٠٥**
Cd(g)	**7.6**	**1.03**	**5.2**	**1.27**	**5.5**	**2.6**	**2.8**	**1.17**	**9.6**	**5.03**	**8.34**	**3.71**	**< 0.10**
Zn(g)	**20.07**	**17.24**	**33.6**	**32.2**	**22.14**	**35.47**	**25.8**	**32.2**	**25.4**	**18.9**	**43.6**	**42.2**	**< 1.0**

*Permissible Limits of Egypt legislation of the national law 48/1982.

Table 3: Total Bacteria count (cfu /ml) in Water Samples collected from Lake Manzala.

Sites / Bacterial count $\times 10^3$	**Bahr El-Bakar**				**EL-Gamil**				**EL-Kapoty**				**permissible Limits***
	Autumn	**winter**	**Spring**	**Summer**	**Autumn**	**winter**	**Spring**	**Summer**	**Autumn**	**Winter**	**Spring**	**Summer**	

T.V.B. (CFU/ml)	**155.3**	**123.4**	**214.4**	**429.3**	**465.7**	**382.4**	**916.7**	**1150.8**	**562.5**	**637**	**872.4**	**1546**	
F.C. (CFU/ml)	**104.7**	**228.3**	**347.7**	**586.8**	**124.7**	**113.5**	**151.8**	**223.4**	**345.3**	**244.2**	**758.6**	**1011.8**	
Aeromonas spp (CFU/ml)	**576**	**210.1**	**238.6**	**457**	**180.4**	**173.6**	**215.2**	**310.6**	**104.3**	**152.1**	**420.8**	**602.1**	
Tcb.Vibro (CFU/ml)	**84.5**	**54.3**	**111.2**	**207**	**113.2**	**54.8**	**152.8**	**208.1**	**94**	**104.4**	**136.4**	**191.6**	

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