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Abstract

The present study represents an attempt to classify and evaluate the surface water quality around Ras El-Bar Island by investigating the surface water physical and chemical parameters near Damietta Branch Outlet, Damietta Port Canal and Mediterranean Sea. The measured pH values show a tendency towards alkaline side aquatic system. The variations in the total dissolved solids and the electrical conductivity values show relatively high values in the Sea water compared with that in the Damietta Branch and the Damietta Port Canal. The observed increasing in the dissolved solids and electrical conductivity values seaward may be related to the effect of sea water intrusion. However, the observed lower values of the dissolved solids and electrical conductivity in Damietta Branch water may be related to the effect of receiving many waste-water resulted from domestic sewage, industrial activities and the extensive boating activities at Ezbt El-borg. The sodium and chloride values increase downward, through Damietta Branch toward its outlet to the Sea water and through the site of connection with the Damietta Port Canal toward the sea. The observed increasing in sodium and chloride values seaward may be related to the effect of sea water intrusion.The potassium, calcium and bicarbonate values decrease downward, through Damietta Branch toward its outlet to the sea water and through the site of connection with the Damietta Port Canal toward the sea. The observed decreasing in Potassium, Calcium and Bicarbonate values seaward may be related to the effect of sea water intrusion. The alkalis (Sodium and potassium) exceed alkaline earths (calcium and magnesium) and strong acids (Cl+SO4) exceed weak acids (C03+HCO3) indicating secondary salinity. High contents of Lead and Cadmium values are observed in the in the study surface water around Ras El-Bar Island. Cadmium and Lead fall in the category "high". The category "high" is usually observed near the main shipping routes to the ports.The studied surface water samples show non-permissible water quality for drinking, domestic and irrigation purposes.

1. Introduction

Egypt suffering from increasing deterioration of its water due to increasing discharges of polluted domestic and industrial effluents into its waterways. Deterioration in water quality occurs when the Nile divided into Damietta and Rosetta Branches due to the disposal of the municipal and industrial effluents and agricultural drainage with decreasing flows (World Bank, 2005).

River Nile water have been used in a variety of purposes including drinking (domestic) water supply, agricultural irrigation, industrial uses, fisheries, navigation, recreation and others. For sustainable utilization of the water resources, periodic examinations of the freshwater bodies are very much essential (Shah and Pandit, 2012).

Damietta Branch is the main source of drinking and irrigation waters for many of Governorates such as El-Qalubia, El-Gharbyia, El-Dakahlyia and Damietta (Abdo, 2004). Faraskour Dam about 20 km south of Mediterranean Sea cut off the flow of the Nile water to the Mediterranean Sea. The water characteristics after the dam (saline water) is completely different compared with the water before the dam (fresh water) (Al-Afify, 2006). Damietta Branch at Damietta Governorate has been suffered from intensive pollution. Damietta Nile Branch receives the water of a number of agricultural drains, which are heavily polluted by industrial and domestic sewage.

Many of villages on each banks of Damietta Nile branch without sanitation services, thus the river receive many wastewater resulted from industrial and domestic activities. Untreated sanitary waste-water with agricultural and industrial wastes is still released through a number of drainages channels along the study area. Damietta Branch receives several pollutant types. Talkha fertilizer factory is considered the main source of industrial pollution, cooling waters of Talkha and Kafr Saad electric power stations. Domestic and sewage effluents at El-Serw City represent another source of pollution (APRP, 2002).

Seawater intrusion is typical near the Damietta Nile Branch mouth, where two dissimilar aquatic ecosystems interact, including fluvial (fresh water) and marine (salt or brackish water) ecosystems. Water quality and heavy metals pollution near the Damietta Nile Branch Outlet, Damietta Port Canal and Mediterranean Sea around Ras EL-Bar Island were investigated in the current work.

1.1. Study Area

Ras El-Bar which translates to "head of land" is a resort city in the Damietta Governorate. It lies at the mouth of Damietta Branch in the Mediterranean Sea, where the Nile fresh water merges with the Mediterranean salt water. Damietta Sea Port was constructed in 1982, about 10 Km to the west of Damietta branch outlet. The port is connected with Damietta Branch through a canal 4.5 Km long, 90 m wide and 5 m deep. Therefore, Ras El-Bar is a peninsula with a triangle shape embraced by the Mediterranean Sea, Damietta Branch and is bordered in south by Damietta Sea Port Canal (Fig. 1). The Damietta Estuary receives discharges from wastewater treatment plant (Ras El-Bar Sewage Plant), agriculture runoff, industrial activities (such as Moboco Fertilizer Plant) as well as extensive boating activity at Ezbt Elborg.

1.2. Aim of Study

The present study aimed to investigate the surface water Physical and chemical parameters and concentrations of the heavy metals (Cadmium, Copper, Lead and Zinc) near the Damietta Nile Branch Outlet, Damietta Port Canal and Mediterranean Sea, to classify and evaluate surface water quality around Ras El-Bar Island.

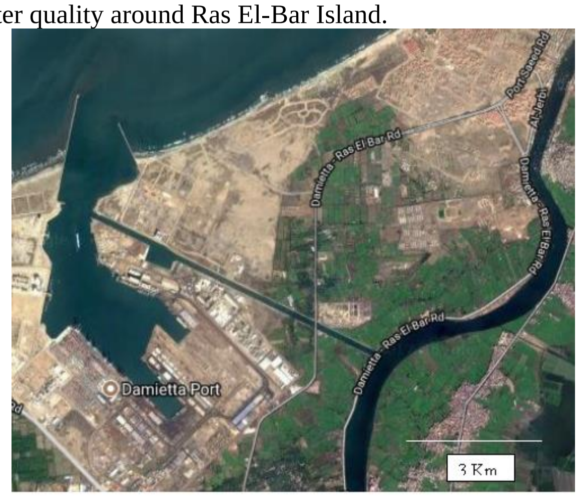

Fig. (1): Satellite view shows urban expansion (yellow) in Ras El-Bar Island and Damietta Sea Port.

2. Materials and Methods

2.1. Samples Collection

A total number of twenty-one surface seawater samples were collected from selected sampling sites around Ras EL-Bar area (Fig. 2). The water samples were collected from the central area of the Damietta Branch, from the site of Damietta Branch outlet to the site of the connection between Damietta Port Canal and Damietta Nile Branch (samples 1 to 10), from the Damietta Port Canal (samples 11 to 15) and from the Mediterranean Sea (samples 16 to 21). The water samples were collected from each site at depth of 10 – 30 cm in a one-liter polyethylene bottle thoroughly rinsed with surface water and stored in ice box to minimize biological degradation and filtered through 0.45 µm membrane filter papers prior chemical analysis in the laboratory.

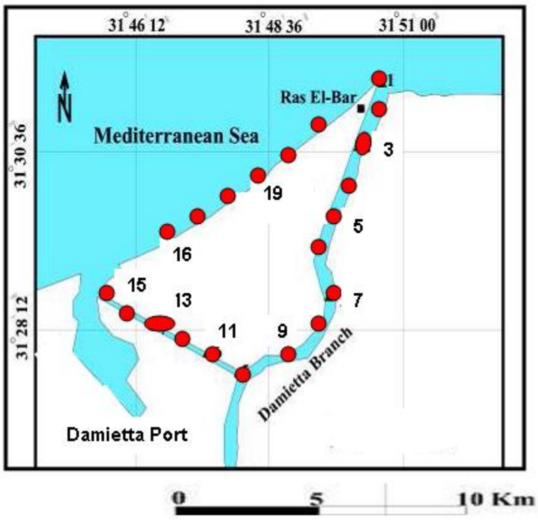

Fig. (2): Showing the study area and the sites of the collected water samples.

2. 2. Samples Analysis

The collected water samples were analyzed for various physico-chemical parameters such as pH, Electrical Conductivity (EC), Total Dissolved Solids (TDS), Calcium (Ca^{++}), Magnesium (Mg^{++}), Sodium (Na^{+}), Potassium (K^{+}), Chloride (Cl^{-}), Sulphate (SO_4^{--}), Carbonate and Bicarbonate.

Hydrogen ion concentration was measured in the field by using a pocket pH meter. Salinity was determined using an inductive salinometer. The other water parameters were measured according to the traditional manual methods of the American Public Health Association (Adams, 1990 and APHA, 2005).

Dissolved heavy metals (Pb, Cu, Zn, and Cd) were determined according to the standard methods (APHA, 1989). Metals contents of cadmium, lead, copper and zinc were determined using Perkin Elmer 2380 atomic absorption spectrophotometer.

3. Results and Discussion

3.1. Distribution of Water Parameters

3.1.1. Distribution of Physical Parameters

The physical and chemical parameters of the collected water samples were shown in Tables (1, 2 and 3).

3.1.1.1. Distribution of pH Values

The pH values used as indicators of alkalinity and acidity of water, where, the pH values may affects in many chemical and biological processes in the water. The measured pH values are ranging between 7.19 and 7.67 for the Damietta Branch water; between 7.30 and 7.70 for the Damietta Port Canal water and between 7.32 and 8.00 for the Mediterranean Sea water showing a tendency towards alkaline side aquatic system (Tables 1, 2 and 3).

3.1.1.2. Distribution of Electrical Conductivity Values

The measured EC values are ranging between 39 to 62 mmhos/cm, between 33.90 and 54.70 mmhos/cm and between 61.90 and 62.20 mmhos/cm for the Damietta Branch, the Damietta Port Canal and the Mediterranean Sea water respectively (Fig. 3 and Tables 1, 2 and 3).

3.1.1.3. Distribution of Total Dissolved Solids

The measured Total Dissolved Solids values are ranging between 23.80 and 40.10 g/L for the Damietta Branch water; between 33.70 and 34.80 g/L for the Damietta Port Canal water and between 40.10 and 40.50 g/L for the Mediterranean Sea water (Fig. 3 and Tables 1, 2 and 3).

Total Dissolved Solids (TDS) gives an indication about the dissolved substances content that is proportional to the conductivity measurements. Therefore, the total dissolved solids and the Electrical Conductivity values have nearly similar distribution patterns (Fig. 3).

The variation in the total dissolved solids and the Electrical Conductivity values (Fig. 3) shows that, relatively high values are observed in the Sea water compared with that in the Damietta Branch and the Damietta Port Canal. The measured values of the total dissolved solids and Electrical Conductivity increase downward, through Damietta Branch toward its outlet to the sea water and through the site of connection with the Damietta Port Canal toward the sea (Fig. 3). Along the study area, the observed decreasing in the Dissolved solids and Electrical Conductivity values landward may be related to the effect of sea water intrusion (Fig. 3). However, the observed lower value of the Dissolved solids and Electrical Conductivity in Damietta Branch water may be related to the effect of receiving many wastewater resulted from domestic sewage, industrial activities and the extensive boating activities at Ezbt El-borg.

TDS values showed slight variations throughout the sampling segment of the surface water around Ras El-Bar Island (Tables 1, 2 and 3). An obvious increase in TDS was however, recorded downward, through Damietta Branch toward its outlet to the sea water and through the site of connection with the Damietta Port Canal toward the sea. Similar pattern was recorded with regards to electrical conductivity (EC) with high values observed in the Sea water. As conductivity measures the water's ability to conduct an electrical current; it increased whenever water purity decreases. This describes the strong significant relationships between EC and TDS (Fig. 3).

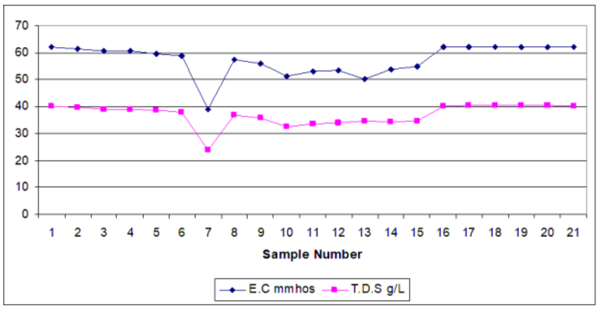

Fig. (3): Distribution of the measured E.C and T.D.S values.

3.1.2. Distribution of Chemical Parameters:

3.1.2.1. Distribution of the Major Cations

3.1.2.1.1. Distribution of Sodium

The sodium content is a very important factor about water suitability for agriculture. The excess of this cation may cause an increase of the soil hardness and affects its permeability (El- Bihery and Lachmar, 1994). Sodium content are ranging between 5.70 g/L to 11.00 g/L, for the Damietta Branch water; between 7.50 g/L and 10.00 g/L for the Damietta Port Canal water and between 10.60 g/L and 12.00 g/L for the Mediterranean Sea water (Fig. 4 and Tables 1, 2 and 3).

The variation in Sodium values (Fig. 4) shows that, relatively high values are observed in the Sea water compared with that in the Damietta Branch and the Damietta Port Canal. The Sodium values increase downward, through Damietta Branch toward its outlet to the sea water and through the site of connection with the Damietta Port Canal toward the sea (Fig. 4). Along the study area, the observed decreasing in Sodium values landward may be related to the effect of sea water intrusion.

3.1.2.1.2. Distribution of Potassium

Potassium content varies from 2.20 g/L and 0.40 g/L for the Damietta Branch water; from 0.12 g/L and 10.00 g/L for the Damietta Port Canal water and from 0.04 g/L and 0.20 g/L for the Mediterranean Sea water (Fig. 5 and Tables 1, 2 and 3).

The variation in Potassium content (Fig. 5) shows that, relatively high values are observed in Damietta Branch compared with that in the Damietta Port Canal and the Sea water. The Potassium values decrease downward, through Damietta Branch toward its outlet to the sea water and through the site of connection with the Damietta Port Canal toward the sea (Fig. 5). Along the study area, the observed decreasing in Potassium values seaward may be related to the effect of sea water intrusion.

3.1.2.1.3. Distribution of Magnesium

Magnesium content are ranging between 0.75 g/L to 2.21 g/L, for the Damietta Branch water; between 0.97 g/L and 1.26 g/L for the Damietta Port Canal water and between 0.89 g/L and 1.26 g/L for the Mediterranean Sea water (Fig. 6 and Tables 1, 2 and 3).

3.1.2.1.4. Distribution of Calcium

Calcium content varies from 0.83 g/L and 1.72 g/L for the Damietta Branch water; from 1.07 g/L and 1.92 g/L for the Damietta Port Canal water and from 0.99 g/L and 1.53 g/L for the Mediterranean Sea water (Fig. 7 and Tables 1, 2 and 3).

The variation in Calcium content (Fig. 7) shows that, relatively high values are observed in Damietta Branch compared with that in the Damietta Port Canal and the Sea water. The Calcium values decrease downward, through Damietta Branch toward its outlet to the sea water and through the site of connection with the Damietta Port Canal toward the sea (Fig. 7). Along the study area, the observed decreasing in Calcium values seaward may be related to the effect of sea water intrusion.

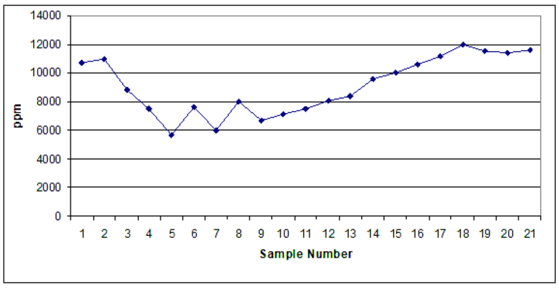

Fig. (4): Distribution of Sodium values.

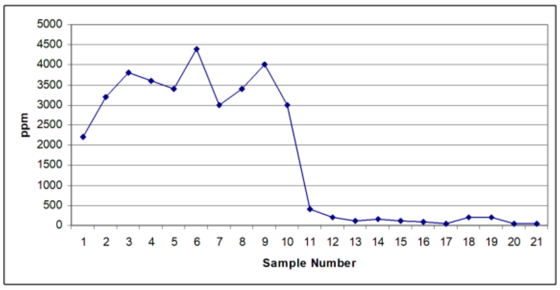

Fig. (5): Distribution of Potassium values.

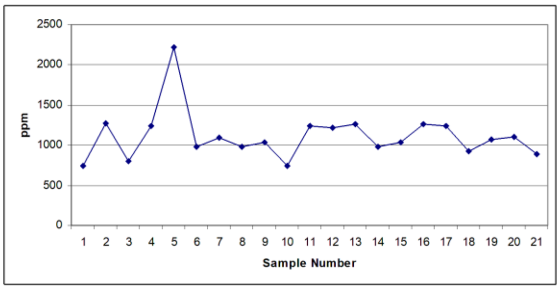

Fig. (6): Distribution of Magnesium values.

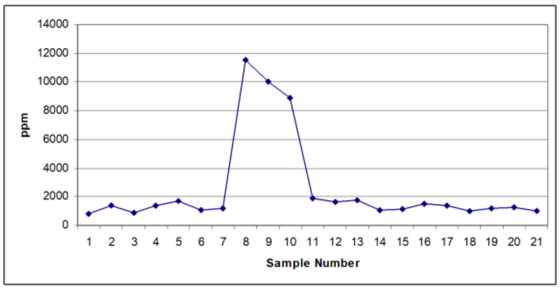

Fig. (7): Distribution of Calcium values.

The variations in potassium and calcium values show relatively high contents in Damietta Branch compared with that in the Damietta Port Canal and the Sea water. The potassium and calcium values decrease downward, through Damietta Branch toward its outlet to the sea water and through the site of connection with the Damietta Port Canal toward the sea. The observed decreasing in Potassium and Calcium values seaward may be related to the effect of sea water intrusion.

3.1.2.2 Distribution of the Major Anions

3.1.2.2.1. Distribution of Chloride

Chloride content are ranging between 0.99 g/L to 12.40 g/L, for the Damietta Branch water; between 9.43 g/L and 11.52 g/L for the Damietta Port Canal water and between 10.43 g/L and 13.85 g/L for the Mediterranean Sea water (Fig. 8 and Tables 1, 2 and 3).

The variation in Chloride values (Fig. 8) shows that, relatively high values are observed in the Sea water compared with that in the Damietta Branch and the Damietta Port Canal. The Chloride values increase downward, through Damietta Branch toward its outlet to the sea water and through the site of connection with the Damietta Port Canal toward the sea (Fig. 8). The observed decreasing in Sodium values landward may be related to the effect of sea water intrusion. However, increase in chloride concentration in Rivers is mainly attributed to the discharge of municipal and industrial wastes, domestic wastes discharged, Agriculture activity (mineral-rich fertilizers) and application of and extensive irrigation (Sadashivaiah et al., 2008).

3.1.2.2.2. Distribution of Sulphate

Sulphate constitutes the second predominant anion after chloride, and varies in content from 2.15 g/L to 14.35 g/L for the Damietta Branch water; between 1.22 g/L and 12.36 g/L for the Damietta Port Canal water and between 11.25 g/L and 15.44 g/L for the Mediterranean Sea water (Fig. 9 and Tables 1, 2 and 3).

3.1.2.2.3. Distribution of Bicarbonate

Bicarbonate distribution ranges between 0.34 g/L and 0.52 g/L for the Damietta Branch water; from 0.50 g/L and 0.64 g/L for the Damietta Port Canal water and from 0.43 g/L and 0.82 g/L for the Mediterranean Sea water (Fig. 10 and Tables 1, 2 and 3).

The variation in Bicarbonate content (Fig. 10) shows that, relatively high values are observed in Damietta Branch compared with that in the Damietta Port Canal and the Sea water. The Bicarbonate values decrease downward, through Damietta Branch toward its outlet to the sea water (Fig. 10).

Generally, the variations in sodium and chloride show relatively high values in the Sea water compared with that in the Damietta Branch and the Damietta Port Canal. The sodium and chloride values increase downward, through Damietta Branch toward its outlet to the Sea water and through the site of connection with the Damietta Port Canal toward the sea. The observed increasing in sodium and chloride values seaward may be related to the effect of sea water intrusion.

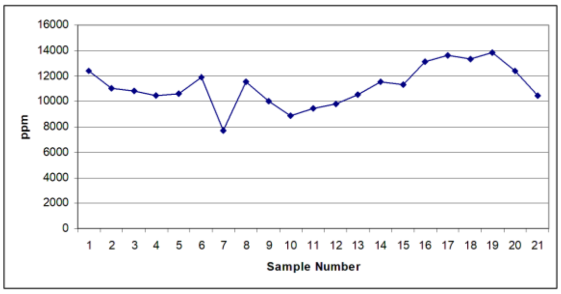

Fig. (8): Distribution of Chloride values.

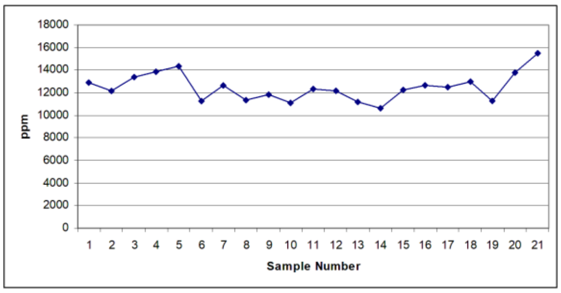

Fig. (9): Distribution of Sulphate values.

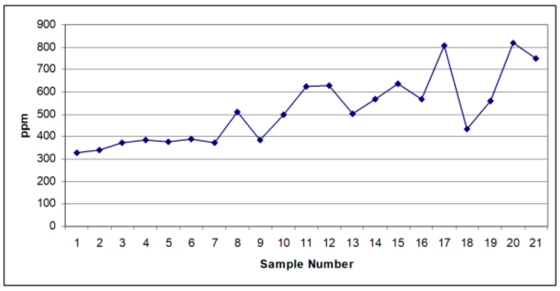

Fig. (10): Distribution of Bicarbonate values.

The variations in sodium and chloride show relatively high values in the Sea water compared with that in the Damietta Branch and the Damietta Port Canal. The sodium and chloride values increase downward, through Damietta Branch toward its outlet to the Sea water and through the site of connection with the Damietta Port Canal toward the sea (Figs 11 and 12). The observed increasing in sodium and chloride values seaward may be related to the effect of sea water intrusion.

The variations in potassium, calcium and bicarbonate values show relatively high contents in Damietta Branch compared with that in the Damietta Port Canal and the Sea water (Figs 11 and 12). The potassium, calcium and bicarbonate values decrease downward, through Damietta Branch toward its outlet to the sea water and through the site of connection with the Damietta Port Canal toward the sea. The observed decreasing in Potassium, Calcium and Bicarbonate values seaward may be related to the effect of sea water intrusion.

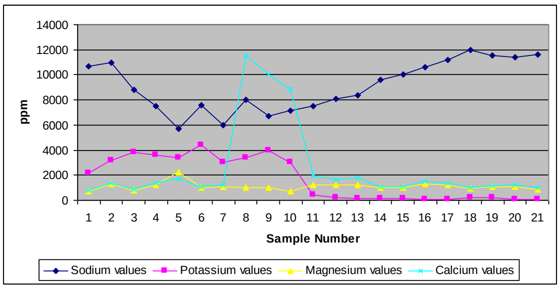

Fig. (11): Distribution of cations values.

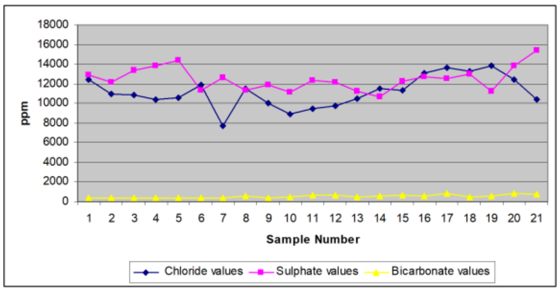

Fig. (12): Distribution of anions values.

3.1.3 Distribution of Heavy Metals

Heavy metals contamination is important due to their potential toxicity for the environment and human. Some of the metals such as Cu, Fe, Mn, Ni and Zn are essential as micronutrients for the life processes in animals and plants while many other metals such as Cd, Cr, Pb and Co have no known physiological activities (Hamed, 2004).

High metal concentrations primarily resulting from domestic, industrial and agricultural effluents loaded with metals (Abdel-Satar and Elewa, 2001; Abdel-Satar, 2005; El Bouraie et al., 2010; Shamrukh and Abdel-Wahab, 2011; Ezzat et al., 2012; Goher et al., 2014; Ali et al., 2014). The concentration of the heavy metal (Pb, Cd, Zn and Cu) were introduced into the Damietta Nile Branch in Damietta Governorate from agricultural drains, which are heavily polluted by industrial and domestic sewage, many of villages on each banks of Damietta Nile branch without sanitation services, Kafr Saad electric power stations, and Talkha fertilizer factory.

The concentrations of Cd, Cu, Pb and Zn were investigated for water quality assessment around Ras El-Bar Island. The values of cadmium, lead, copper and zinc in the study surface water around Ras El-Bar Island are given in Table (4). Lead and Cadmium were found at the sampling sites however, Zinc and Cupper were not detected (Table 4).

3.1.3.1 Distribution of Cadmium

Relatively high concentrations of cadmium are observed in the surface water of Damietta Port Canal, Mediterranean Sea compared with that of Damietta Nile Branch (with maximum values of 5.76, 4.98 and 2.61 µg/L respectively (Table 4 and Fig. 13).

3.1.3.3 Distribution of Lead

Relatively high concentrations of Lead are observed in the surface water of Damietta Nile Branch compared with that of Damietta Port Canal, Mediterranean Sea (with maximum values of 21.12, 17.86 and 13.44 µg/L respectively (Table 4 and Fig. 14).

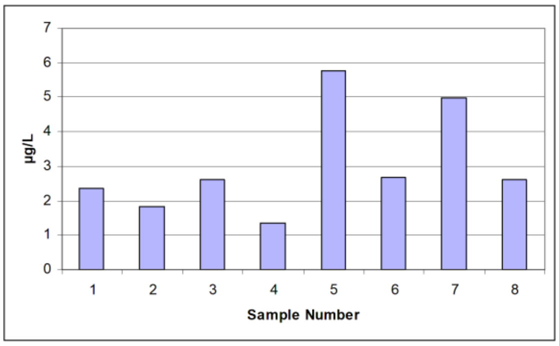

Fig. (13): Distribution of cadmium values.

Table (4): The values (in µg/L) of the dissolved toxic heavy metals in the study surface water around Ras El-Bar Island.

Area	Sample No.	Cadmium	Lead	Copper	Zinc
Damietta Nile Branch	1	2.36	4.31	ND	ND
	5	1.82	14.61	ND	ND
	9	2.61	21.12	ND	ND
Damietta Port Canal	11	1.36	5.7	ND	ND
	13	5.76	6.03	ND	ND
	15	2.69	13.44	ND	ND
Mediterranean Sea	17	4.98	10.92	ND	ND
	19	2.62	17.86	ND	ND

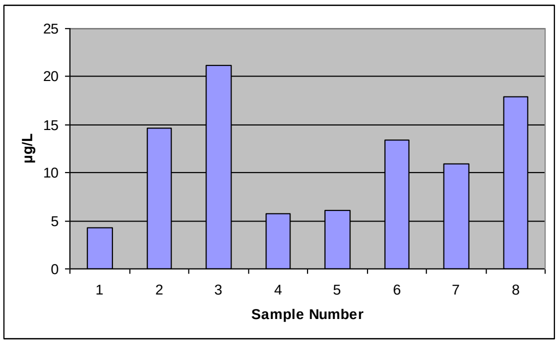

Fig. (14): Distribution of Lead values.

There is a relatively increase in lead in the surface water of Damietta Nile Branch compared with that of Damietta Port Canal and Sea water. The reverse is true for cadmium, where there is a relative increase in cadmium in the surface water of Damietta Port Canal and Sea water (Fig. 15).

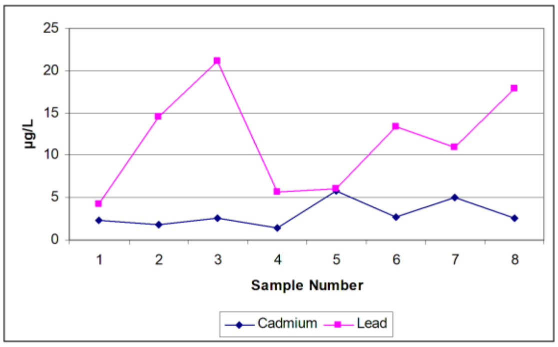

Fig. (15): Distribution of Lead and Cadmium values.

Generally, high contents of Lead and Cadmium values are observed in the in the study surface water around Ras El-Bar Island. When adopting the background levels (Table 5) assumed by Nurnberg (1977), Cadmium and Lead fall in the category "high" (Table 5). Wallace et al., (1977) reported that, cadmium and lead, falling in the category "elevated" are transported from regions of high source. Moreover, the present study favors that reported by Goldberg (1983), who reported that, the category "high" is usually observed near the main shipping routes to the ports.

Table (5): Levels of dissolved toxic heavy metals in seawater (Nurnberg, 1977); All values in µg/L.

Level	Cadmium	Lead
Low	0.005 - 0.009	0.018 – 0.09
Elevated	0.021 – 0.050	0.21 – 0.50
High	0.052 – 0.452	0.51 – 2.42

4. Hydrochemical Classification

The chemical parameters of water play a significant role in classifying and assessing water quality (Sadashivaiah et al., 2008). The concentrations of cations and anions are incorporated in Tables (1, 2 and 3).

4.1. Trilinear -Piper Diagram

Trilinear Piper diagram (Piper, 1953) used to compare surface water chemistry of the study water samples. This classification system shows the anion and cation facies in terms of major-ion percentages. To define composition class, Back and Hanshaw (1965), suggested subdivisions of the tri-linear diagram. The water types are designated according to the area in which they occur on the diagram segments.

The cations triangle distribution indicates that, all water samples are of sodium and potassium type. In the anions triangle most of the studied water samples plotted in the chloride corner indicating chloride type water. Samples number 2 and 7 (Damietta Branch water) and sample number 21 (Sea water) are plotted in the Sulphate corner indicating Sulphate type water. Only samples number 4 and 5 (Damietta Branch water) and sample number 11 (Damietta Port Canal water) indicating no dominant type water in the anions triangle (Figs 16, 17 and 18).

The diamond diagram shows that, the studied water samples fall in the area of Sodium, Potassium – Sulfate, Chloride. The alkalis (Sodium and Potassium) exceed alkaline earths (Calcium and Magnesium) and strong acids (Cl+SO4) exceed weak acids (C03+HCO3). Therefore, the studied water samples are dominated by alkalies (Sodium and potassium) and strong acids (Sulfate, Chloride) indicating secondary salinity.

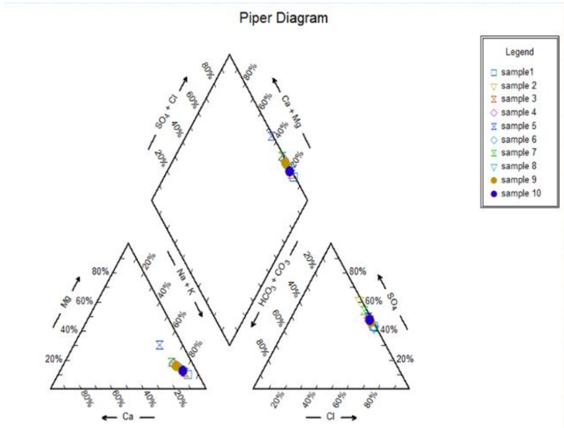

Fig. (16): Classification diagram for the Damietta Branch water types.

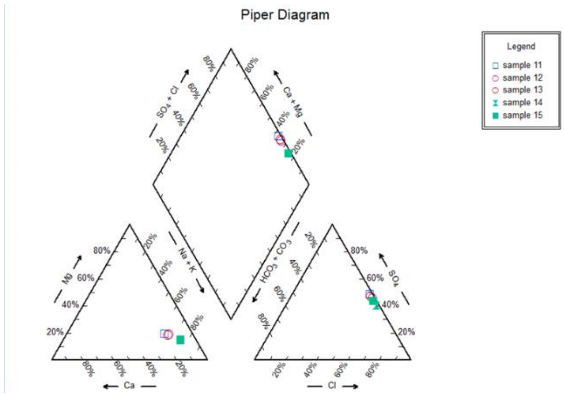

Fig. (17): Classification diagram for the Damietta Port Canal water types.

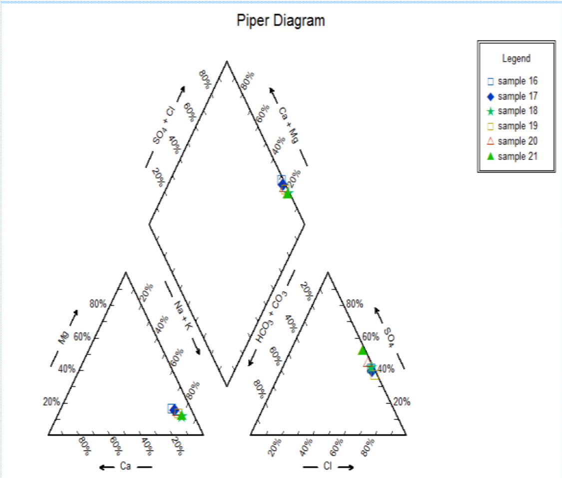

Fig. (18): Classification diagram for the Sea water types.

4.4. Hypothetical Salt Assemblage

The hypothetical salt assemblages of the analyzed water samples are determined and are given in Table (6).

It is observed that, sodium chloride is the dominant salt encountered in all the analyzed water samples (up to 59.70 %), sodium sulphate (up to 33.65%), magnesium sulphate (up to 30.25%), calcium bicarbonate (up to 15.44 %) and calcium sulphate (up to 14.45 %). However, in Damietta Branch water, the dominant salts are (K+Na)Cl, $MgSO_4$, Na_2SO_4, $Ca(HCO_3)_2$ and $CaSO_4$ respectively; compared with that in Damietta Port Canal water and in the Sea water are (K+ Na)Cl, Na_2SO_4, $MgSO_4$, Ca SO_4 and $Ca(HCO_3)_2$ respectively (Table 7).

Table (7): Ranges of the hypothetical salt assemblage in Damietta Branch water compared with that in the Damietta Port Canal and the Sea water.

Hypothetical salt assemblage	Damietta Branch	Damietta Port Canal	Sea water
(K+ Na)Cl	38.12 – 58.19	49.84 – 58.43	46.82 – 59.70
Na_2SO_4	5.45 – 27.95	12.73 – 20.47	14.49 – 33.65
$MgSO_4$	9.84 – 30.25	14.49 – 19.11	11.60 – 16.19
Ca SO_4	6.58 – 13.23	8.03 – 14.45	4.52 – 10.39
$Ca(HCO_3)_2$	1.11 – 15.44	1.46 – 1.91	1.08 – 4.45

5. Evaluation of Water

It is very essential and important to evaluate the water with different physico-chemical parameters before it is used for drinking, domestic, agricultural or industrial purpose. Evaluation and the suitability of surface water for human drinking, domestic, irrigation and industrial purposes have been evaluated according to World Health Organization Standards (1998) and the Egyptian Standards (Ministry of Health, 1995), World Health Organization (1998), U.S. Salinity Lab Staff (1954).

5.1. Suitability of water for human drinking and Domestic purposes

For drinking and domestic purposes, water should be colorless, tasteless and odorless and has a reasonable salinity. According to the permissible limits used for drinking and domestic purposes (WHO, 1998 and the Egyptian standards (Ministry of Health, 1995) it is clear that, the studied surface water samples show non-permissible water quality for drinking and/or domestic purposes.

5.2. Suitability of Water for Irrigation Purposes

The overall suitability of ground water for irrigation can be deduced from the relationship between the dissolved solids expressed in terms of electric conductivity and sodium adsorption ratio. The sodium adsorption ratio (SAR) is given by the equation:

SAR = Na / (Ca + Mg)/2)1/2

Where, Na, Ca and Mg are expressed in epm (U.S. Salinity Lab Staff, 1954). High values of SAR imply a hazard of sodium replacing adsorbed Ca and Mg, which consequently damages the soil structure.

The analyzed surface water samples fall beyond the partitions of the diagram and consequently are quite non-suitable for irrigation. The continual use of such waters is not recommended; Otherwise degradation by salinization, which eventually leads to desertification, may occur. However, EL-Bady and Metwally (2016) showed that, the water near the Damietta Nile Branch Outlet is unsuitable for drinking and irrigation, but the water in the south of study area suitable for all purposes.

CONCLUSIONS

The present study represents an attempt to classify and evaluate the surface water quality around Ras El-Bar Island by investigating the surface water physical and chemical parameters and concentration of the heavy metals (Cadmium, Copper, Lead and Zinc) near Damietta Branch Outlet, Damietta Port Canal and Mediterranean Sea.

The measured pH values show a tendency towards alkaline side aquatic system. The variations in the total dissolved solids and the electrical conductivity show relatively high values in the water of Damietta Branch and the Damietta Port Canal. The total dissolved solids and electrical conductivity values increase downward through Damietta Branch toward its outlet to the sea water and through the site of connection with the Damietta Port Canal toward the sea.

The observed increasing in the dissolved solids and electrical conductivity values seaward may be related to the effect of sea water intrusion. However, the observed sites of lower dissolved solids and electrical conductivity in Damietta Branch water may be related to the effect of receiving many wastewater resulted from domestic sewage, industrial activities and the extensive boating activities at Ezbt El-borg.

The variations in sodium and chloride show relatively high values in the Sea water compared with that in the Damietta Branch and the Damietta Port Canal. The sodium and chloride values increase downward, through Damietta Branch toward its outlet to the Sea water and through the site of connection with the Damietta Port Canal toward the sea. The observed increasing in sodium and chloride values seaward may be related to the effect of sea water intrusion.

The variations in potassium, calcium and bicarbonate values show relatively high contents in Damietta Branch compared with that in the Damietta Port Canal and the Sea water. The potassium, calcium and bicarbonate values decrease downward, through Damietta Branch toward its outlet to the sea water and through the site of connection with the Damietta Port Canal toward the sea. The observed decreasing in Potassium, Calcium and Bicarbonate values seaward may be related to the effect of sea water intrusion.

High contents of Lead and Cadmium values are observed in the in the study surface water around Ras El-Bar Island. Cadmium and Lead fall in the category “high”. The present study favors Goldberg (1983), who reported that, the category “high” is usually observed near the main shipping routes to the ports.

The plotted surface water samples on the diamond diagram show alkalis (Sodium and potassium) exceed alkaline earths (calcium and magnesium) and strong acids (Cl+SO4) exceed weak acids (CO3+HCO3). The studied water samples fall in the area of sodium, potassium – sulfate, chloride indicating secondary salinity. The studied surface water samples show non-permissible water quality for drinking, domestic and irrigation purposes.

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