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Geochemistry And Quality Assessment of River Nile Water, Northern Part of Damietta Branch, Egypt

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Abstract: *Detailed chemical examinations were conducted for 55 water samples, collected from 29 sampling profile along the northern part of Damietta Branch, River Nile, Egypt to assess the nature of water quality. The assessment of the water quality made herein indicates that most of the running-water of the examined river branch (31%) fall in the category of excellent water quality distributed along the 29profiles. On the other hand, about 24% of the examined water profiles are of good water quality, 20% represents fair water quality, 17% represents marginal water quality and 6 % represents poor water quality which is not suitable for drinking purposes.*

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I. Introduction

River Nile has long been acted as the main source of life-necessary water for millions of Egyptians. Therefore, the Nile water was dealt since the Pharaonic times with much care, and so many instructions and constructions were established to control and adjust the water quantity and quality. The river distributaries of any given river-system are commonly the final terminations of that drainage net. They represent the remote receivers that keep all wastes and pollutants derived into the drainage net both within bottom-sediments and water body. Recently, the uncontrolled discharge of undesired waste disposalscommonly poured into the River Nile in huge quantities, especially along the areas of heavy-population, factories and power stations, constitutes a direct threat on the water and bottom sediments qualities[1].The behavior and fluxes of Cu and Pb in the River Nile and found that about 110 tones Cu and 50 tones Pb are transported annually through the River Nile to the Mediterranean water [2], constituting more than 50% of both metals reaching the basin from different sources. documented that The Rosetta Branch is impacted by several industrial companies in the surrounding areas that potentially affect and deteriorate the branch's water quality [3]. found that the heavy metals in the northern Lakes include Fe, Zn, Cu, Cd and Pb recording high levels exceeding the international permissible limits in drinking water were found [4]. Egypt is the most populous, agricultural and industrial country in the River Nile Basin [5]. Therefore, most sewage release to the river takes place in Lower Egypt, and the Nile pollutants are derived from sources such as industrial wastewater, oil pollution, municipal wastewater, agricultural drainage. The River Nile sediments are the major source of persistent bio-accumulative toxic chemicals which may threat the ecological and human health, even after contaminants are no longer released from sources [6].

The present study is concerned with the northern part of Damietta Branch as a major River Nile distributary in the northern part of Egypt. Along this branch, cities of huge populations and crowded villages drain their wastes into the river water. Thousands of cultivated acres usually discharge their returnedirrigation water into the river branch. Many industrial factories and power plants established along the river sides discharge their industrial wastes into the river branchwater[1].

The present work aims to detail the chemical characteristics of Damietta Branch River water, and assessesthe geochemical status and quality natureof such water for drinking purposes.

II. The Study Area

The study area focuses on the northern part of the major Damietta distributary flowing over the northern part of Egypt (Fig.1). The area extends between Latitudes 31^{o} 00' &31^{o} 20'N and Longitudes 31^{o}30' & 31^{o} 50'E. The river course in the study area displays so many meanders, the most acute of which lies at Cities of Sherbin and Damietta (Fig. 1). The examined segment has a total length of 102 km, passing through a large number of villages and cities. It extends from the southern reaches of El-Mansoura City, to the northeastern-most outlet at Ras El-Barr, where the distributary debouches into the Mediterranean Sea (Fig. 1).

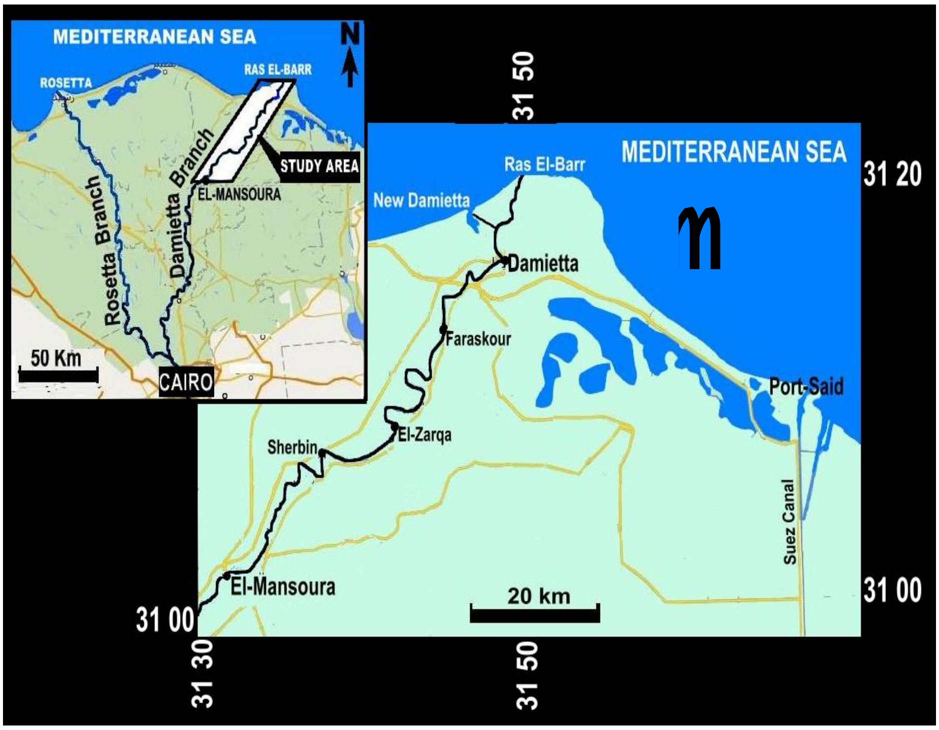


Fig. (1): Location map of the examined sector of the Damietta Distributary along the Nile Delta.

III. Materials And Techniques

The different aims of this work were accomplished through a series of field and laboratory techniques. The field work was carried out during the time interval from the 30th of October, 2015 to the 30th of November, 2015. The sampling period was done after annual seasonal discharge usually done by the Ministry of Irrigation along the River Nile course in Egypt, little after the main annual period of the river flood (Mid-August). During this period, the best healthy state of the running-water and the bottom-sediments will be achieved, where much of the suspended and settled contaminants are being removed away into the Mediterranean Sea. During this period, six successive one-day field trips were carried-out, along the northern parts of Damietta river branch to sample the running-water and the bottom-sediments.

The examined segment of the Damietta Branch (102 km) was subdivided into twenty-nine (29) sampling profiles along El-Dakahliya and Damietta Governorates (Fig. 2). The sampling profiles were chosen along an almost equal distance of about 3.5 km, as far as the river nature permits, each profile extends from the eastern bank to the western bank. A special interest was paid to collect samples from the areas with specific concerns and those having negative environmental impacts. Table (1) provides the numbers, locations and names of the sampling profilesandsome site remarks characterizing their environments.

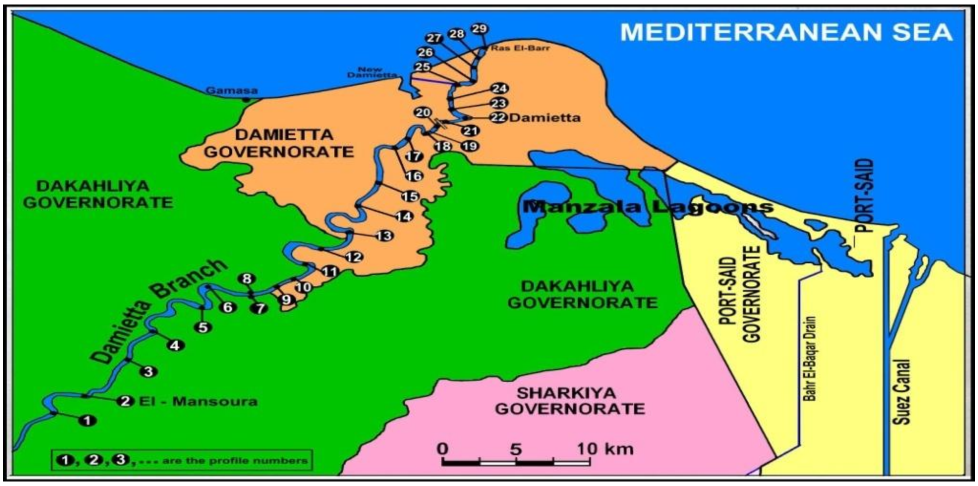


Fig. (2): The distribution and numbers of the examined profiles along the Damietta Branch, River Nile.

Generally, two representative water samples were collected from each sampling profile across the river-branch using normal or steam boats. The water bodies close to the western and eastern banks of the river branch were the essential points of sampling process, since the expected chemical pollutants are normally settled within the less-energetic water bodies lying close to the river bank.The water samples were collected at 5.0 m – 15.0 m away from each river bank. Accordingly, the total sum of the collected water samples from the 29 profiles is (55) fifty-five water samples (Table 1). It is worth of mentioning that the sampling process was differentiated into two techniques according to the purposes of the aimed forthcoming chemical analyses as follows:

(a) For major ions determination, one-liter dry, clean plastic bottle was immersed into the branch's water body at an appropriate depth to be completely filled. As soon as the sample was collected, it was filtered in the boat using filter-paper. Then the sample is numbered, labeled, and prepared for the storage immediately.

(b)For determining the heavy metals, a 250 ml dry, clean plastic bottle was immersed into the branch's water body at an appropriate depth to be completely filled. Then, 2.5 ml of 10% pure analarnitric acid were directly added to the filtered water sample. The sample is then numbered, labeled, and prepared for the storage immediately. Table (1) provides the sample numbers of the collected running-water at the examined profiles along Damietta Branch.

The chemical analyses were applied upon **55** water samples collected from **29** sampling profiles (Table 2). The chemical analyses of water samples include the followings:

(1) Determination of total water hardness of the extracted solute in order to determine the Ca hardness, Mg hardness, Ca content and Mg content according to Eaton [7]..

(2) Determination of major cations and anions as well as the heavy metals (Table 2)were done as follows:

a- Potassium (K) and sodium (Na) were estimated using the flame photometer type 410e, model 850 CORING UK.

b- Bicarbonates (HCO_3) and Chloride (Cl) were determined by titration following the technique of Eaton et al. (2013).

c- Sulphates (SO_4) was determined using Spectrophotometer instrument, type NANOCOLOUR, model NUV 0741 MACHEREY-NAGEL MN GERMANY.

e- Heavy metals including Cu, Cd, Pb, Zn, Cr, and Co were determined using digital atomic absorption instrument model AVANTA-E, GBC AUSTRALIA.

Table (1): The numbers of the surface water samples taken along the examined profiles of the northern part of Damietta Branch, River Nile**.**

Profile Nos.	Profile name	Water sample Nos. and site remarks	
		Western Bank	Eastern Bank
1	MitBadrKhamis – El-Mansoura	1A	1C
2	El-Mansoura: (Talkha Electric Power Station	2A	2C
3	El-Khiyariya - Sheremsah	3A	3C
4	El-Baramon – El-Tawila	4A	4C
5	Ezbet El-Qabbani – Taranis El-Bahr	5A	5C
6	Shirbin	6A	6C
7	Bosat Karim El-Din	7A	7C
8	Bosat Kareem El-Din Drinking Water Station	8 taken from the intake-outlet of the Drinking Water Station	
9	Sheremsah – El-Sheikh Attia	9A	9C
10	El-Zaatra – El-Ahmadi	10A	10C
11	El-Zarqa	11A	11C
12	El-Serw-Ras El Khaleeg	12A	12C Ras El-Khaleeg Drinking Water Station
13	El-Berashiya – El-Sawalem	13A	13C
14	Kafr El-Arab – Mit Abu Ghaleb	14A	14C
15	Faraskour	15A	15C
16	Al-Horani – El- Tawfiqiya	16A outlet of El-Horani Electric Power Station	16C
17	El-Bostan Station for Drinking water	17 taken from the intake-outlet of El-Bostan Station for Drinking Water	
18	El-Adliya – Taranis El-Arab	18A	18C
19	Ezab El-Nahda Drinking Water Station (Adliya)	19 taken from the intake-outlet of Ezab El Nahda Drinking Water Station	
20	DAMIETTA:(South El-Hawiss)	20A	20C

21	DAMIETTA:(North El-Hawiss)	20A	20C
22	DAMIETTA: (City-El-Sa'a Square)	22A	22C
23	DAMIETTA:(Al-Senaniya)	23A	23C
24	DAMIETTA:(El-Khayyata)	24A	24C
25	DAMIETTA: (New Damietta Navigation Canal)	25C	25A
26	DAMIETTA:(Ezbet El-Ratama – El-Gerbi)	26A	26C
27	DAMIETTA: (El Sheikh Dorgham – El-Gerbi)	27A	27C
28	DAMIETTA:(Ezbet El- Borg – El-Gerbi)	28A	28C
29	DAMIETTA:(Ras El- Barr outlet)	29A	29C
Total Sampled Profiles are 29 profiles		Total Running-Water Samples is 55 samples	

Table (2): The chemical parameters contentand Water Quality Index (WQI) of the examined waterprofiles along Damietta branch,River Nile.

Profile	Profile Name	TH (mg/l)	Ca Hardness (mg/l)	Mg Hardness (mg/l)	Ca (mg/l)	Mg (mg/l)	Na (mg/l)	K (mg/l)	HCO_3 (mg/l)	SO_4 (mg/l)	Cl (mg/l)	Balance Error(%)	WQI
1	MitBadr Khamis-El Mans	96.0	76.0	20.0	32.0	13.0	48.0	1.0	195.2	22.0	40.0	0.1	712.99
2	Talkha Electric Station	98.2	78.7	19.6	33.6	13.0	36.0	1.0	180.6	19.0	36.0	0.4	591.03
3	Al Khiyariya – Sheremsah	96.4	76.0	20.4	30.4	15.0	38.0	1.0	190.3	20.0	32.0	0.1	0.081
4	El Baramoon – El Tawila	96.9	76.0	20.9	30.4	16.0	34.0	1.0	185.4	21.0	32.0	0.5	614.72
5	Ezbet El-Qabbani-Taranis	152.0	128.0	24.0	51.2	17.0	497.0	7.0	195.2	125.0	708.0	0.0	824.44
6	Sherbin	136.7	118.0	18.7	46.4	15.0	512.0	4.0	190.3	131.0	712.0	0.0	758.82
7	Bosat-Karim El Din	166.0	140.0	26.0	60.8	22.0	592.0	8.0	224.8	165.0	840.0	0.0	982.19
8	Bosat-Karim Water	136.0	120.0	16.0	48.0	12.0	459.0	5.0	190.3	123.0	632.0	0.1	684.30
9	Sheremsah – El-Sheikh	134.0	116.0	18.0	46.4	13.0	527.0	6.0	195.2	142.0	720.0	0.0	594.41
10	EL Zaatra - El Ahmadi	140.0	120.0	20.0	44.8	14.0	505.0	4.0	185.4	118.0	708.0	0.0	363.53
11	El Zarqa	144.0	124.0	20.0	51.2	14.0	520.0	6.0	205.0	140.0	716.0	0.0	635.87
12	El Srew - Ras El Khaleeg	124.0	112.0	12.7	43.2	12.0	345.0	5.0	161.4	68.0	504.0	0.0	0.004
13	El Berashiya - El Sawalem	115.0	104.0	11.3	46.4	4.0	356.0	4.0	161.0	73.0	500.0	0.1	709.23
14	Kafr El Arab-Mit Abu Ghal	99.0	88.0	11.3	36.8	7.0	366.0	4.0	170.8	62.0	510.0	0.1	0.004
15	Faraskour	118.0	108.0	10.7	33.6	13.0	351.0	4.0	165.9	64.0	500.0	0.1	808.81
16	El Horani - El Tawfiqiya	120.0	104.0	16.0	36.8	12.0	356.0	6.0	175.7	74.0	498.0	0.0	295.48
17	El Bostan Water Station	136.0	120.0	16.0	44.1	12.0	349.0	6.0	170.8	68.0	508.0	0.1	917.90
18	El Adliya - Tranis El Arab	123.3	112.0	11.3	48.0	8.0	356.0	5.0	170.8	70.0	512.0	0.1	704.12
19	Ezab El Nahda Water	114.7	104.0	10.7	41.6	8.0	362.0	7.0	175.7	70.0	508.0	0.0	796.45
20	Damietta: South El Hawiss	110.0	98.0	12.0	41.6	11.0	350.0	5.0	170.8	70.0	500.0	0.1	367.15
21	Damietta: North El	130.0	116.0	14.0	44.8	8.0	348.0	7.0	161.0	69.0	502.0	0.1	366.59
22	Damietta: (El Sa'a	117.3	106.0	11.3	43.2	10.0	345.0	6.0	165.9	58.0	504.0	0.0	960.77
23	Damietta: (ElSenaniya)	124.0	114.0	10.0	46.4	8.0	352.0	5.0	180.6	65.0	500.0	0.0	595.74
24	Damietta: (El Khayata)	121.3	106.0	15.3	41.6	12.0	356.0	6.0	180.6	67.0	510.0	0.1	520.71
25	New Damietta Navig.	124.7	112.0	12.7	41.6	12.0	362.0	6.0	201.3	70.0	504.0	0.0	0.004
26	Damietta: (Ezbet El	125.3	112.0	13.3	46.4	10.0	348.0	4.0	165.9	64.0	508.0	0.0	476.86
27	Damietta: (El-Sheikh	126.0	114.0	12.0	44.8	10.0	360.0	5.0	201.3	67.0	502.0	0.0	817.00
28	Damietta: (Ezbet El Borg -	1146.7	1000.0	147.7	400.0	107.5	10866.0	10.0	341.6	120.0	17500.0	0.0	268.41
29	Damietta: (Ras El Barr	1166.7	1000.0	166.7	400.0	142.5	11784.0	10.0	331.8	152.0	19000.0	0.0	725.82

Water Quality Index (WQI)is a mathematicallyestimated index which converts large number of water quality data into a single number. It is expressed as a score that reveals the combined influence of different water quality parameters.The water quality index (WQI) is estimated by using the Egyptian drinking water quality standards [8]. WQI is computed through three steps:

First,the estimated concentrations (Ci) in mg/l of each of the 11 parameters (TDS, Chloride, Sulphate, Calcium, Magnesium, Sodium, Cupper, Cadmium, Lead, Zinc and Chromium) is divided by standard values (Si) in mg/l of each parameter in [8]multiplied by 100 to obtain the Individual Quality Rating (qi) by the following formula:

qi= (Ci/Si) *100

Second, unit weight of each parameter (Wi) is assigned by the following formula:

Wi=1/Si

Thrid, the sum of all the (qi) multiplied by (Wi) and divided by the sum of all values of unit weights (ΣWi) will gives the overall WQI of different water samples as expressed by the following formula

WQI=Σqi Wi/ ΣWi

The water quality classeswere assigned based on WQI values following the [9] classification categories. The classification of WQI scores was illustrated by 5 categories of water quality as excellent (<450), good (450–649), fair (650–789), marginal (790–949) and poor (>950).

IV. Results And Dscussions

4.1. Major Elements Geochemistry

The results of chemical analyses of the examined water profiles are given in Table (2). The following is a brief description of the obtained results.

The Calcium content along the examined water profiles in the northern part of the Damietta river branch almost display little variations, except for the northern-most profiles toward the Mediterranean Sea (Table 2).

The minimum concentrations of 28.8 mg/l are recorded at the southern reaches of the study area (Profiles Nos. 1- 4, Table: 2). The maximum Ca content along the examined profiles range between the fifties and sixties of mg/l, especially at the southern profiles (Nos. 5 – 11, Table 2). On the other hand, the maximum and minimum Ca contents along the northern half of the examined area oscillate around the forties and fifties of mg/l (Table: 2). However, an abnormal increase in Ca content of 400 mg/l is suddenly recorded at the profiles Nos. 28 (Ezbet El-Borg) and 29 (Ras El-Barr Outlet) near the connection with the Mediterranean Sea (Fig. 2). In general the overall Calcium content in the first twenty-seven profiles falls within the allowed category of Calcium permissible limit (200 mg/l) as permitted by the Egyptian Ministry of Health [8]. The generally low Ca content encountered in the examined segment of the Damietta river branch could be attributed to the lack of Ca-rich bottom sediments that can yield free Ca. Also, the weak role of photosynthesizing organisms usually enriches Ca in river waters could be an additional cause of Ca poverty. Possibly, the unsuitable habitat necessary for flourishing such organisms in the branch water prohibited or diminished their role. However, the abnormal increase in the Ca content near the connection with the Mediterranean Sea could be attributed to advancing sea-saline water front, commonly releases Calcium due exchange process by the Sodium brought by the advancing saltwater.

The Magnesium content along the examined water profiles in the northern part of the Damietta river branch display low variation-trends similar to those of Calcium. The overall average magnesium trend can be categorized into three main segments:

(i) A southern segment with relatively high Mg content, extending to the profile No.12 (El Srew - Ras El Khaleeg). The lowest average Mg-content in this area is 12.0 mg/l at Bosat Karim El-Din Drinking Water Station (Profile-8) and El Srew - Ras El Khaleeg (Profile 12), whereas a maximum content of 22.0 mg/l is recorded at Bosat Karim El-Din (Profile-7), (Table 2and Fig. 2). The role of water filtration in Bosat Karim El-Din Drinking Water Station (Profile-8) might results in the observed reduction in Mg content although it located at the same area of Bost Karim El-Din, (Profile-7).

(ii) A northern segment with relatively lower Mg-content, extending from the profile No. 12 (El Serw –Ras El Khaleeg) to the profile No.27 (El-Sheikh Dorgham – El-Gerbi). Here, the Mg displays poor concentrations reaching down to 4.0, 7.0 and 8.0 mg/l (six profiles, Table 2), whereas the maximum concentrations of 13.0 mg/l are recorded (Table 2 and Fig. 2).

(iii) A northernmost segment including the two profiles No. 28 (Ezbet El-Borg – El-Gerbi) and the profile No. 29 at the Ras El-Barr Outlet. This segment possesses Mg contents with an abnormal increase, ranging between 107 to 143 mg/l (Table 2 and Fig. 2). Near to the safe limit of the Egyptian Ministry of Health for Mg of 150 mg/l[8].

The generally low Mg-concentrations encountered in the northern part of the Damietta river branch could be attributed to the absence of Mg-rich rock substrates and to the lack of marine water as a significant source of magnesium. The abnormal increase in the Mg content near the connection with the Mediterranean Sea is attributed to the mixing with the Mg-rich saline sea-water encroached the river water. In general, the overall Magnesium concentration over all the examined profiles fall in the allowed category of Magnesium level (150 mg/l) as permitted by the Egyptian Ministry of Health[8].

The Sodium content along the examined water profiles of the northern part of the Damietta river branch fall in the ranges between 34 and 11784 mg/l; however, it does not exceed 530 mg/l in about 93% of the examined profiles (Table 2). The concentration almost displays little variations in most of the examined profiles except for the northern-most profiles toward the Mediterranean Sea (Profiles: 28 & 29, Fig 2). However, the detailed examination of the regional Na content trend along the studied profiles reveals that it can be differentiated into the following segments:

(i) Segment (1) includes the southernmost three profiles Nos. 1, 2, 3 and 4 displaying low Na-contents around fifties (Table 2 and Fig. 2). This segment contains Na levels below the allowed permissible limit for drinking water (200 mg/l) according to the Egyptian Ministry of Health [8].

(ii) Segment (2) includes the southern profiles Nos. 5 to 11, having average Na content ranging between 459 and 592 mg/l (e.g.: Taranis El Bahr – Ezbet El-Qabbani, profile No. 5, recording 497 mg/l, and Sherbin, profile No. 6, recording 512 mg/l). This segment is ended toward a relatively moderate concentration of 520 mg/l recorded at the southern reaches of the study area profiles No. 11 (EL Zarqa), (Fig. 2 and Table 2).

(iii) Segment (3) encompasses the majority of the examined profiles Nos. 12 to 27. The Na concentrations range between 345 and 366 mg/l (Table 2).

(iv) Segment (4) toward the connection with the Mediterranean Sea, a sudden and abnormal increase in Na-concentration reaching up to 11784 mg/l (Table 2) is recorded at the profiles Nos. 28 and 29 (Fig. 2). The extremely high Na records of these profiles may attributed to the mixing of Nile Water with the saline Sea Water.

The generally low Na–concentrations over most of the study area, although more than the safe healthy limit proposed by the Egyptian Ministry of Health [8], could be attributed to the lack of Na-rich bottom sediments that can yield Na. However, the abnormal increase in the Na content near the connection with the Mediterranean Sea is attributed to the encroachment of the advancing saline sea water front.

The Potassium average content along the examined water profiles in the northern part of the Damietta river branch almost display no remarkable variations, only varying between 1.0 up to 10 mg/l (Table: 2 and Fig. 2), in other words, the concentrations fall in the range of dilute natural water [10]; [11]. Along the first four examined profiles (Nos. 1 – 4), the concentration equals to 1.0 mg/l (Table 2). Northwards, the Potassium concentrations fluctuate between 5.0 and 8.0 mg/l, with maximum average concentrations of 7.0 mg/l at the profiles Nos. 5, 7, 19, and 21, whereas the minimum concentrations of 5.0 mg/l were recorded at the profiles 8, 12, 18, 20, 23 and 27. Toward the northernmost profiles Nos. 28 and 29 (Ezbet El-Borg and Ras El-Barr) close to the outlet with the Mediterranean Sea, an abnormal increase in K concentration of 10 mg/l is recorded. This increase may be attributed to the K-derivation from the supratidal shallow marine areas rich in evaporite minerals scattered around the river outlet and to the salt-water encroachment into the river branch from the Mediterranean Sea. Decomposition of the K-rich clay minerals could contribute additional source of the present K-concentrations.

Bicarbonate content of water profiles situated at the southern parts of the study area, up to the profile No. 27 slightly varies around 161 and 224 mg/l, whereas at the northward, from the profile No. 28 (Ezbet El-Borg) up to the profile No. 29 (Ras El-Barr Outlet) just with the connection with the Mediterranean Sea, an abnormal increase in bicarbonates concentration is suddenly recorded displayinghigher bicarbonate contentsvary between 331 and 341 mg/l (Table2 and Fig. 2). The marine water rich in soluble carbonate salts could be the cause of such local increase at these two profiles.

The Sulphate content along the examined profiles in the northern part of the Damietta river branch ranges between19.0 and 165 mg/l, however the concentration behavior can be categorized in four distinctive segments:

i) Segment (1): with the low SO_4content of almost 20 mg/l along the southern-most profiles Nos. 1-4 (Table 2 and Fig. 2).
ii) Segment (2): with the high SO_4content ranging between 123–165 mg/l along the southern profiles Nos. 5 - 11, (Table 2 and Fig. 2.).
iii) Segment (3): with the moderate SO_4content ranging between 58 – 74 mg/l prevailing most of the study area along the profiles Nos. 12 – 27(Table 2 and Fig. 2).
iv) Segment (4): with high SO_4level similar to that of the Segment (2), ranging between 120 – 152 mg/l along the northern-most profiles Nos. 28 -29 (Table 2 and Fig. 2).

The overall SO_4content along the examined sector of the Damietta Branch falls within the safe permissible limit for drinking purposes (250 mg/l) proposed by the Egyptian Ministry of Health [8].Generally, the aerial trend of the SO_4 concentration is quiet similar to those of Potassium (K) and Sodium (Na) suggesting similar sources, mostly leached from the surrounding soils and clay-rich bottom sediments, as well as the SO_4-rich fertilizers application to the surrounding cultivated fields.

Detailed investigation of the Chloride variations along the study area has revealed distinctive four segments:

i) Segment (1): includes the average chloride concentrations along the southernmost four profiles. The concentrations almost display very little variations and show the most minimum concentrations ever recorded in the study area. The concentrations range between 32.00 mg/l(profiles No. 3 & 4) and 40.00 mg/l (profile No. 1, Table 2 and Fig. 2). This segment is characterized by Cl concentration within the allowed healthy limit (250 mg/l) stated by the Egyptian Ministry of Health [8].
ii) Segment (2): includes the next seven southern profiles (Nos. 5, 6, 7, 8, 9, 10, and 11) having high average Cl-concentrations, ranging between 632.0 mg/l (Bosat Karim El-Din Water Station, profile No 8) and 840.0 mg/l (Bosat Karim El-Dinprofile No.10, profile No. 7).This segment records Cl-concentrations strongly exceeds the allowed healthy limit (250 mg/l) stated by the Egyptian Ministry of Health [8].
iii) Segment (3): includes moderate average Cl-concentrations fluctuating around 500.0 mg/l (502.0 to 512.0 mg/l, Table 2 and Fig. 2). This concentration segment encompasses the majority of the examined profiles (fifteen profiles Nos. 12 – 27). Also, this segment show Cl-concentrations markedly exceeds the allowed healthy limit (250 mg/l) stated by the Egyptian Ministry of Health [8].
iv) Segment (4): includes the northernmost two profiles Nos. 28 (Ezbet El-Borg) and 29 (Ras El-Barr Outlet) near the connection with the Mediterranean Sea (Fig. 2). These two locations display an abnormal sudden increase in average Cl-concentration of 17500 mg/l and 19000 mg/l, very strongly exceeds the allowed healthy limit (250 mg/l) stated by the Egyptian Ministry of Health [8].

Generally, the aerial trend of the water Cl-concentration over the study area is quiet similar to those of water Potassium (K), water Sodium (Na) and water Sulphates (SO_4) assuming possible similar sources. These sources are mostly xenogeneic due to long-term leaching of the surrounding irrigated lands with the Cl-rich fertilizers and pesticides used in cultivation of the surrounding fields, from the surrounding saline-rich ponds, lakes and marches (especially at the northern parts), and possibly from the decomposed clay-rich bottom sediments. These xenogeneic Cl-sources added huge amounts of Cl-rich salts giving rise to the remarkable Cl-concentrations in the river-branch water.

4.2.Water Type and Ion Relativity

A water type is determined on the basis of the most important cation and anion contents. The water type helps in easier identification of hydrogeochemical processes, like cation exchange, acidification, mixing of natural waters, pollution, leaching of manure to the water body and other related hydrochemical problems [12]&[13].Schoeller plots [14], which illustrate the Ca,Mg, Na + K, Cl, SO_4 and HCO_3 contents, have been made for each water profile (Fig. 3 a&b). The shape of each plot is a "fingerprint" for that water. From this diagram, a number of two principal hydrochemical types are identified (Table 3), which are (1) Na-chloride type (Fig. 3a), and (2) Ca (mixed cations)-bicarbonate type (Fig. 3b). Each of the principal type characterizes a definite chemical or physical process dominating the river water. The Na- chloride type characterizes the evaporation process acting on the Lake Nasser water before releasing to the River course. Additionally, the irrigation return flows to the river course usually are at concentrations much higher than those in waters applied to the land because evapotranspiration removed about 50 percent of the water producing Na-Cl type of the remaining that returned into the river course.

Table (3): Chemical types of the studied water from Damietta Branch, River Nile**.**

Profile Name	Profile NO	Water type
Taranis El Bahr	5	Na - Cl
Sherbin	6	
Bosatkarim El Din	7	
Bosatkarim El Din drinking water station	8	
Sheremsah - El sheikh Attia	9	
El Zarqa	11	
El Srew - Ras El Khaleeg	12	
El Berashiya - El sawalem	13	
Faraskour	15	
El Horani - El Tawfiqiya	16	
El Adliya - Tranis El Arab	18	
Ezab El Nahda Station for Drinking Water(El Adliya)	19	
Damietta South El Hawiss	20	
Damietta North El Hawiss	21	
Damietta (El Sa'a Square)	22	
Damietta (El Senaniya)	23	
Damietta (El Khayata)	24	
New Damietta Navigation Canal	25	
Damietta (Ezbet El Ratama – El Gerbi)	26	
Damietta (El-Sheikh Dorgham – El Gerbi)	27	
Damietta (Ezbet El Borg - El Gerbi)	28	
Ras El Barr outlet	29	
Kafr El Arab - Mit Abu Ghaleb	14	
EL Zaatra - El Ahmadi	10	
Talkha electric power station	2	Ca-Na-Mg-HCO3
Al Khiyariya – Sheremsah	3	Na-Ca-Mg-HCO3
El Baramoon – El Tawila	4	Ca-Na-Mg-HCO3
MitBadr Khamis -El Mansoura	1	Na-Ca-Mg-HCO3

The (mixed cations)-bicarbonate type reflects the mixing process between the original river water with the municipal waste water discharged into the river course. The resulted water type has interference of cationic contents (Ca-Mg-Na) with HCO_3 anion predominance (Fig. 3b).

The river water of Damietta Branch has Cl>HCO_3>SO_4 anion pattern associated with Na as a dominant cation (Fig. 3a) which represents the chemical pattern of the river water. This anionic pattern is associated mainly with Na>Ca>Mg and Ca>Mg>Na cationic relativities (Table 4) confirming the Cl-Na type of the river water. Another anionic relativity of HCO_3>Cl>SO_4 associated with Ca>Na>Mg and Ca>Mg>Na as dominant cation (Table 4) with high salinity which represents waters of a long flow path. The relatively lower salinity level may attributed to the mixing of river water with the municipal waste water discharges into the river course. The relatively mixed cations may be attributed to the variability of cationic contents of the municipal waste water.

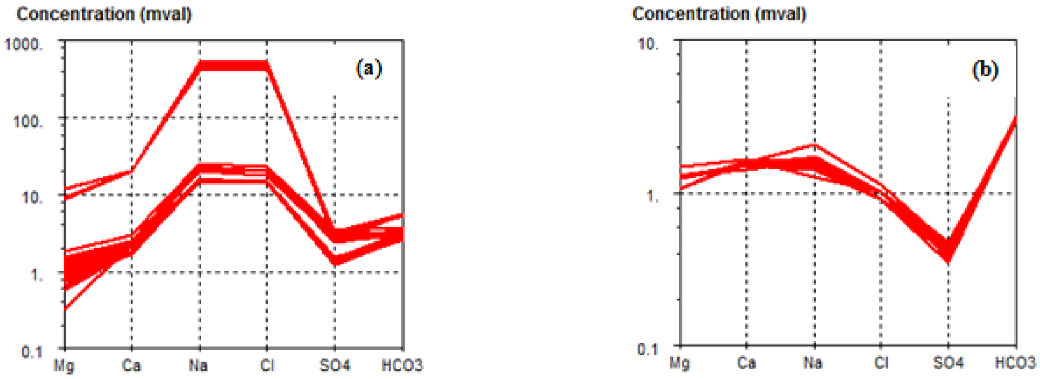


Fig. (3): Schoeller plot of the studied water profiles from Damietta Branch, River Nile

Table (4): Ion relativities of the studied water from Damietta Branch, River Nile.

Anion relativity	**Cation relativity**
Cl>HCO_3>SO_4	Na>Ca>Mg
	Ca>Mg>Na
HCO_3>Cl>SO_4	Ca>Na>Mg
	Ca>Mg>Na

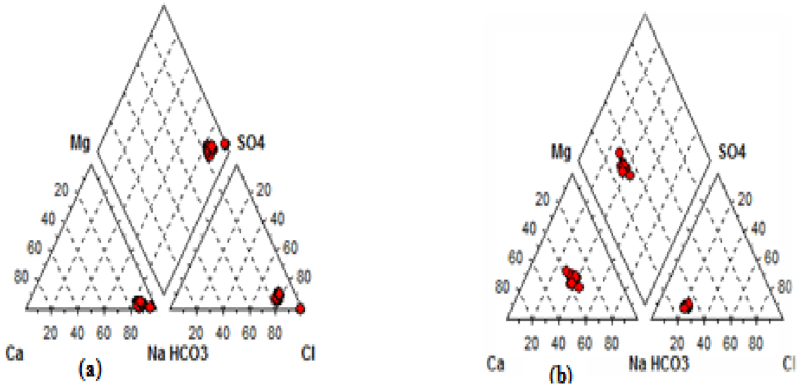
4.3. Chemical Facies of Water

In the Piper diagram, the milliequivalent percentage of the major cations and anions are plotted in each triangle and the type of water is determined on the basis of position of the data in the respective cationic and anionic triangular fields [15]. The plotting from triangular fields is extended further into the central diamond field, which provides the overall character of the water.

As water flows through the river course, it assumes a diagnostic chemical composition as a result of mixing with wastewater discharges and irrigation return flows from the surrounding watersheds. The influences of humans, stream pollution and waste disposal by all kinds of activities within the river watershed. Irrigation return flows may contain high concentrations of many chemicals leached from the soil, nutrients, and suspended solids.

The term hydrochemical facies is used to describe the water bodies that differ in their chemical composition. The facies are a function of solution kinetics and flow patterns of the water body [16], [17]. Hydrochemical facies can be classified on the basis of dominant ions in the facies by means of the Piper diagram (Fig. 4).

The plotting of the studied samples shows a change in cation chemistry from sodium facies in river water influenced by returned irrigation flows (Fig. 4a) to calcium-magnesium-sodium mixed facies in river water mixed with sewage water (Fig. 4b).The anionic chemistry of the studied water profiles shows the change from chloride facies in river water influenced by returned irrigation flows (Fig. 4a) to bicarbonate facies in river water mixed with sewage water (Fig. 4b).



The main facies dominating the river water is the Cl-Na facies (Fig. 4a) which reflects the influence of huge quantities of irrigation return flows to the river water. The irrigation return flows usually are at concentrations much higher than those

Fig. (4): Hydrochemical classification of the studied river water using Piper Diagram**.**

in waters applied to the land because evapotranspiration removed about 50 percent of the water. That roughly doubles concentrations of chemicals in irrigation raw water, in addition to constituents added during flow over and through the soil. The resulted chemical facies of the mixture is Cl-Na which dominates the majority of the river water profiles. The Piper plotting shows the effect of mixing of the original river water with the untreated sewage-water discharged into the Damietta Branch, at Mit-Badr Khamis Village and other similar villages widely extended along the river course. The mixture of these waters are plotted on the center of the diamond shape at the mixed facies field expressing (HCO_3-no dominant cation) facies (Fig. 4b)

4.4. Trace ElementsGeochemistry

The Damietta Branch, River Nile were analyzed for their content of the trace elements; Copper (Cu), Cadmium (Cd), Lead (Pb), Zinc (Zn), Chromium (Cr), and Cobalt (Co) to investigate their relative abundance and distribution in the study area. The average concentration of each encountered trace elements in each sampling profile is given in Table (5). The following are the main remarks on the examined metals:

Generally, the overall average Cu-concentrations along the examined profiles in the northern part of the Damietta river branch fall in the safe limit of the Cu-concentration of 2.0 mg/l allowed by the Egyptian Ministry of Health[8]. The Copper (Cu) is recorded, however, in only ten (10) profiles (Table 5). The Copper concentrations in the other seventeen (17) profiles are either below thedetection limits of the used atomic absorption instrument, or having a very negligible amounts not exceed 0.01 µg/l (0.00001 mg/l) as recorded along Sheremsah-El sheikh Attia (profile No . 9) and El- Zaatra-El Ahmadi (profile No.10).

Table (5): The average concentrations of the heavy metals content of the river water samples along the examined profiles**.**

Profile No.	Profile Name	The Average Concentrations of Heavy Metals in (mg/l).					
		Cu	Cd	Pb	Zn	Cr	Co
1	MitBadr Khamis -El Mansoura	0.005	BDL	0.0002	0.25	8.09	5.80
2	Talkha Electric Power Station	0.009	0.0001	0.0004	0.25	6.70	4.17
3	Al Khiyariya – Sheremsah	0.00013	0.0001	BDL	0.30	8.28	5.66
4	El Baramoon –El Tawila	0.0011	BDL	BDL	0.03	6.98	6.52
5	Ezbet El-Qabbani-Taranis ElBahr	BDL	BDL	0.0013	BDL	9.33	19.13
6	Sherbin	BDL	0.0001	BDL	BDL	8.61	14.37
7	Bosat Karim El Din	BDL	BDL	0.005	BDL	11.04	17.41
8	Bosat Karim El Din Drinking Sta	BDL	BDL	0.0004	BDL	7.76	18.93
9	Sheremsa-El sheikh Attia	0.00001	0.0002	0.0004	0.03	6.69	12.77
10	EL Zaatra-El Ahmadi	0.00002	0.0001	BDL	BDL	4.10	13.51
11	El Zarqa	BDL	BDL	0.0010	0.32	7.20	14.47
13	El Berashiya-El Sawalem	BDL	0.0001	0.0001	0.32	8.05	10.88
15	Faraskour	0.001	BDL	0.0002	BDL	9.18	12.32
16	El Horani - El Tawfiqiya	0.002	BDL	0.0006	0.21	3.34	14.95

17	El Bostan Station for Drinking W	BDL	BDL	0.0030	BDL	10.35	15.74
18	El Adliya-Tranis El Arab	BDL	BDL	BDL	0.13	7.99	12.42
19	Ezab El Nahda Station for Drinki	BDL	BDL	0.0005	BDL	9.03	15.03
20	Damietta: South El Hawiss	BDL	BDL	0.0004	0.32	4.16	18.85
21	Damietta: North El Hawiss	BDL	BDL	0.0040	BDL	4.07	13.92
22	Damietta: (El Sa'a Square)	0.0032	0.0003	0.0020	BDL	10.79	13.17
23	Damietta: (El Senaniya)	0.0011	0.0007	0.0230	BDL	5.99	17.67
24	Damietta: (El Khayata)	BDL	0.0002	0.0120	BDL	5.58	16.33
25	New Damietta Navigation Canal	BDL	0.0016	0.0070	BDL	4.23	9.76
26	Damietta: (Ezbet El Ratama–El	BDL	0.0008	0.0130	BDL	4.89	14.99
27	Damietta: (El-Sheikh Dorgham –	BDL	0.0022	0.0071	BDL	8.50	12.19
28	Damietta: (Ezbet El Borg - El Ge	BDL	BDL	0.0015	0.15	3.01	16.14
29	Ras El Barr outlet	BDL	BDL	0.0030	0.35	8.17	12.43

BDL*: *Below Detection Limit

The maximum concentrations were recorded along the profile No. 2 (Talkha Electric Power Station, El-Mansoura) of 0.009 mg/l, followed by a concentration of 0.005 mg/l along the profile No. 2 (MitBadr Khamis-El-Mansoura). Minor concentrations were recorded along the profiles No. 15 (Faraskour, 0.005 mg/l) and No. 16 (El-Horani, 0.002 mg/l). Another moderate concentrations were recorded along the northern parts at Profile No. 22 (Damietta, El-Sa'a Square, >0.003 mg/l), and profile No. 23 (Damietta, El-Senanyia, 0.001 mg/l). It is of worth mentioning that the profiles displaying rather enrichment in the Copper concentrations generally fall within and/or beside areas of big city-centers with noticeable population, very heavy traffic and industrial establishments (e.g.: electric power stations, factories, etc.). This is noticed within the big and crowded cities of El-Mansoura and Damietta, and to less extent in Faraskour and El-Horani as big country-side centers. The Copper contaminations could be generated in the air over these area due mass-combustion of fuels used in the heavy traffics factories, power stations, and industrial factories. As mentioned above, this air-copper will remain until it settles with rain over the water course and river-bank soils resulting in local enrichment in such areas.

The overall average Cadmium (Cd) concentrations along the examined profiles in the northern part of the Damietta river branch (Table 5) fall in the safe limit of Cd-concentration of 0.003 mg/l allowed by the decision of the Egyptian Ministry of Health[8]. The Cadmium (Cd) is recorded, however, in only twelve (12) profiles (Table 5).The Cd concentrations in the other fifteen (15) profiles are either below the detection limits of the used atomic absorption instrument, or having a very negligible amounts ranging between 0.000003 mg/l and 0.00001 mg/l as recorded along (profile No. 2), (profile No.3) and (profile No.13) along the southern half of the study area (Table 5). However, this half shows Cd-concentrations of 0.00004 mg/l and 0.0002 mg/l at the profiles No. 6 (Sherbin) and No. 9 (Sheremsah - El-Sheikh Attia) respectively, (Table 5, Fig. 2). The maximum Cd-concentrations were recorded at the northern-most profiles at the end of the examined river branch. A Cd-concentrations ranging between 0.0003 mg/l and 0.0022 mg/l were recorded along the northern profiles Nos. 22 – 27 belonging to the northern territories of Damietta Governorate. The localized enrichment of the Cd-concentrations along the northern-most territories of the examined river branch, although within the allowed limit of the Egyptian Ministry of Health[8], could be attributed to:

(i) The long exposure to fuel combustion, especially that the examined river branch cut-through big cities having very heavy traffics of different kinds (e.g.: El-Mansoura, Sherbin, Faraskour, Damietta, Ras-El Barr).
(ii) The extensive and unwise use of Cd-rich phosphate fertilizers and other animal-dung fertilizers in the cultivated lands around the examined river branch.
(iii) The massive municipal solid wastes distributed along the river banks that commonly yield dangerous secondary product leached by time into the river water course.

The long leaching and continuous water removal of the secondary contaminants yielded due to the above-mentioned factors through the long northward trip of the river branch resulted in the obvious presence of localized Cd-concentrations at the northern territories of Damietta Governorate. In this concern,it was concluded that the long exposure to fossil fuel combustion, phosphate fertilizers, and municipal solid waste result in Cadmium environmental hazards for human beings[18]and [19]. It was documented that most plants bio-accumulate Cd as a metal toxin, and when manufactured to form organic fertilizers, after animal-dung, yield a product containing high amounts (up to 0.5mg/kilo fertilizer) of metal toxins that can contain amounts of Cadmium[20].

The average Lead (Pb) concentrations along the majority of the examined profiles (24 profiles) in the northern part of the Damietta river branch (Table 5) fall in the safe limit of Cd-concentration of (0.01 mg/l) allowed by the Egyptian Ministry of Health [8], whereas the other three (3) (profiles Nos. 23, 24, and 26) transgress this safe limit (Table 5). However, the Lead (Pb) concentrations was found below the detection limits of the used atomic absorption instrument at Al Khiyariya–Sheremsah (profile No. 3), El Baramoon–El Tawila (profile No. 4) ,Sherbin (profile No. 6) , EL Zaatra-El Ahmadi (profile No. 10), El Adliya-Tranis El-Arab (profile No. 18) , (Table 5). On the other hand, very negligible concentrations of Lead (Pb) ranging between 0.00001 mg/l and 0.0013 mg/l were recorded along the profiles Nos. 1, 2, 5, 8, 9, 11, 13, 15, 16, 19, and 20 (Table 5). Some observed Lead (Pb) concentrations were, however, recorded along the profiles Nos.; 7, 17, 21, 22, 25, 27, 28, and 29 (Table 5) ranging between 0.0015 mg/l and 0.007 mg/l. The maximum Pb-concentrations over the study area were recorded at the northern-most profiles at the end of the examined river branch (the northern parts of Damietta Governorate). At these areas, Pb-concentrations were found transgressing the safe limit stated by the Egyptian Ministry of Health (0.01 mg/l) at three profiles; Damietta, El-Khayata, profile No. 24 (0.012 mg/l), Damietta (Ezbet El-Ratama-ElGerbi), profile No. 26 (0.13 mg/l), and Damietta, El-Senaniya, profile No. 23, (0.023 mg/l), (Table 5). Possibly, the localized high Lead (Pb) concentrations along the northern-most territories of the examined river branch beyond the allowed limit of the Egyptian Ministry of Health[8] could be related to long-term exposure to the Lead-polluted air derived from the gasoline after the heavy traffic around the examined river branch. The heavily polluted smoke emitted from the many industrial factories, either along the study area or at the southern segment of the river branch passing through big industrial cities (El-Kalyoubyia and Cairo Governorates). Moreover, the many primitive factories (for wood-painting, metal-industry, work-shops of used electrical lead-batteries, etc.), widely distributed along the river segment, and debouching their wastes directly onto the river water, could be an extra Lead sources. In addition, the long-term usage of lead-pipes in sewage-water connections could be a further Lead source, especially that the sewage water was recorded discharged directly into the river segment in a number of areas. The local enrichment of the Lead-concentration encountered at the northern parts of Damietta Governorate could be related to the fact that this part lies at the end of the river branch, receiving long-term leaching and continuous water removal of the secondary contaminants across the river.

The average Zinc concentrations (Zn) along the examined profiles of Damietta River Branch are generally ranging between 0.03 and 0.35 mg/l. They are too little than the allowed safe Zinc limit (3.0 mg/l) stated by the Egyptian Ministry of Health [8]. The Zinc was recorded in only 12 profiles whereas it was not detected in 15 profiles (Table 5) either due to the element absence or that its concentration lies below the detection limit of the used Atomic Absorption Instrument. The overall variations of the Zinc's average concentrations throughout the study area display irregular trends with disordered maxima and minima. The minimum average concentrations were recorded at Sheremsah-El-Sheikh Attia profile No. 9 (0.025 mg/l) and El-Baramoon–El Tawila profile No. 4 (0.033 mg/l). Both profiles are situated at the southern part of the study area. Moderate average Zn-concentrations were recorded at profile No. 16 (El-Horani-El-Tawfiqiya, 0.205 mg/l) and profile No. 18 (El Adliya-Tranis El Arab, 0.13 mg/l) in the middle parts of the study area (Table 5). On the other hand, the maximum average Zn concentrations were recorded as 0.297 mg/l at Al Khiyariya – Sheremsah (profile No. 3), 0.32 mg/l at El-Zarqa (profile No. 11) and at Damietta-South El-Hawiss (profile No. 20). The highest average concentration was recorded at Ras EL-Barr outlet (profile No. 29) of 0.35 mg/l at the end of the examined river branch. The observed low Zn-concentrations are most probably related to the different fertilizers and pesticides widely used along the cultivated lands besides the river banks. The discharges of the waste irrigation water through many drainage canals directly into the river branch carry such metals to be accumulated in water.

Generally, the average chromium (Cr) concentrations along the examined part of the Damietta river branch display remarkable variations from one profile to the other (Table 5). However, the concentration values obviously exceed the safe limit of Chromium concentration (0.05 mg/l) according to the Egyptian Ministry of Health [8].The Chromium was not recorded in three profiles Nos. 12, 13, and 14 (Table 5) either due to the element absence or that its concentration lies below the detection limit of the used Atomic Absorption Instrument.The lowest average Cr-concentration was encountered at the profile No. 28 (Damietta, Ezbet El-Borg – El-Gerbi) recording 3.01 mg/l. Relatively low average Cr-concentrations of 3.34 mg/l (El-Horani – El-Tawfiqiya, profile No. 16), 4.06 mg/l (Damietta, North of El-Hawiss, profile No. 21), and 4.10 mg/l (El-Zaatra – El-Ahmadi, profile No. 15) were also recorded. On the other hand, the maximum Cr-concentrations are non-rhythmically distributed between the low and moderate ones. The maximum average Cr-concentrations of 11.04 mg/l was recorded at the Profile No. 7 (Bosat Karim El-Din). It is of worth mentioning that the value of Cr-concentration at Bosat Karim El Din Drinking Water Station (profile No. 8), situated close to the profile No.7 above, recorded 7.76 mg/l indicating good influence of the filtration process within the drinking-water station, however still more than the safe limit of Cr-concentration (0.05 mg/l) of the Egyptian Ministry of Health[8], . Other average maxima of Cr-concentrations are also recorded as 10.79 mg/l at Damietta: El-Sa'a Square (profile No. 22), 10.35 mg/l at El-BostanDrinking Water Station (profile No. 17), and 9.18 mg/l at Faraskour (profile No. 16).

The average Cobalt (Co) concentrations along the examined profiles in the northern parts of the Damietta river branch show wide variations from one profile to the other, and display non-rhythmic behavior (Table 5). The overall average concentrations vary between 4.17 mg/l and 19.13 mg/l. However, the Cobalt was not recorded in three profiles Nos. 12, 13, and 14 (Table 5) either due to the element absence or that its concentration lies below the detection limit of the used Atomic Absorption Instrument. The minimum average Co-concentrations were recorded in the southernmost profiles No. 1 (MitBadr Khamis – El Mansoura; 5.8 mg/l), profile No. 2 (Talkha Electric Power Station-El-Mansoura; 4.17 mg/l), profile No. 3 (Al Khiyariya – Sheremsah; 5.76 mg/l) and profile No. 4 (El Baramoon–El Tawila; 6.52 mg/l). The maximum average Co-concentrationof 19.13 mg/l was recorded at the southern parts of the study area, profile No. 5 (Taranis El-Bahr – Ezbet El-Qabbani). However, other maxima were recorded at some other profiles such as profile No. 8 (Bosat Karim El Din drinking water station; 18.93 mg/l), profile No. 20 (Damietta South El Hawiss; 18.85 mg/l) and profile No. 23 (Damietta, El Senaniya; 17.67 mg/l), (Table 5). On the other hand, moderate Co-concentrations were also recorded without definite trend varying between 9.0 – 16.0 mg/l along the other profiles (Table 5). Generally, the overall trend of the average Co-concentrations are quiet similar to that of Cr-concentrations, indicating that both elements could have similar sources in the study area. The Co-rich-waste products and secondary-materials arrived to the river branch from surrounding local factories and small work-shops, especially those of dye pigments, wood-preservatives, wood-paintings, tobacco-industry, the many distributed brick-kilns, and leather tanning commonly distributed in big cities and villages around the river course, could be sources of the encountered Co-Concentrations. The increasing biological threat of the water-Cobalt is related to that it will accumulate in plants grown upon soils and sediments of the surrounding cultivated fields. The bodies of humans as well as animals that eat these plants will thus contain Cobalt [21]. When plants grow on contaminated soils they accumulate very small particles of Cobalt, especially in the parts of the eatable plant, such as fruits and seeds [21].

4.5. Water Quality Assessment

Rapid urbanization has affectedthe availability and quality of ground and surfacewater due to its overexploitation and improperwaste disposal, especially in urban areas [22]).Therefore, it is necessary to frequently test thequality of surface to protect thedrinking water sources. In the last few decades,there has been a tremendous increase in thedemand for fresh water due to rapid growth ofpopulation and the establishment ofindustrialization. Due to agricultural developmentactivities particularly in relation to excessiveapplication of fertilizers and unsanitaryconditions, human health is at very big risk [23].According to World Health Organization [24], about 80% of all the diseases in human beingsare caused by water. Once the surface water iscontaminated, its quality cannot be restored bystopping the pollutants from the source. For thisreason, continuous examining and assessment ofwater quality helps to develop managementstrategies to control surface waterpollution and to protect it. Water Quality Index (WQI) is an importanttechnique for determining groundwater qualityand its suitability for drinking purposes. WQI is defined as a technique of rating that provides the composite influence of individual water quality parameters on the overall quality of water for human consumption. It is simple and easy method for decision makers to understand about quality and possible uses of any water body [25] (. Therefore, the present work has been carried out to evaluate water quality of Damietta Branch, River Nile water by analyzing chemical parameters and estimating WQI. WQI is a mathematical equation which converts large number of water quality data into a single number. It is expressed as a score that reveals the combined influence of different water quality parameters. The water quality index (WQI) is estimated by using the standards of drinking water quality recommended by the Egyptian drinking water quality standards [8]. The computed WQI values ranges from 0.004 for the minimum value to 982.2 for the maximum value (Table 2). The classification of WQI scores was illustrated by 5 categories of water quality as excellent (<450), good (450–649), fair (650–789), marginal (790–949) and poor (>950) (Table 6, Fig. 5).

The analysis of water quality of Damietta Branch, River Nile water founds that there are different water profiles have different Water Quality Index values (Table 6). The results of WQI show that profiles numbers (7, 22) have WQI values 982 and 961 respectively indicating the **poor quality** of these waters (Table 6). Water of profiles Nos. (5, 15, 17, 19, 27) have WQI values of 842, 809, 918, 797, and 817 respectively falling them within the **marginal class**of water quality (Table 6, Fig. 5).

Samples of water profiles Nos. (1, 6, 8, 13, 18, 29) have WQI values of 713, 759, 684, 709, 704 and 726 respectively indicating the **fair quality class** of these water (Table 6, Fig. 5).Profiles numbers (2, 4, 9, 11, 23, 24, 26) have WQI values of 591, 615, 594, 636, 596, 521 and 477 respectively indicating the **good quality** of these waters (Table 6, Fig. 5).

Table (6): Classification of WQI categories of the Nile River, Damietta branch water.

WQI Categories	Water Quality Class (CCME, 2001)	Profiles Included	Total
<450	Excellent water	3, 10, 12, 14, 16, 20, 21, 25, 28	9
450-649	Good water	2, 4, 9, 11, 23, 24, 26	7
650-789	Fair water	1, 6, 8, 13, 18, 29	6
790-949	Marginal water	5, 15, 17, 19, 27	5
>950	Poor water unsuitable for drinking purposes	7, 22	2

The best water quality found along the study area were water of profiles Nos. (3, 10, 12, 14, 16, 20, 21, 25, 28) have WQI values of 0.08, 364, 0.004, 0.004, 296, 367, 367, 0.004 and 268 respectively falling them within the **excellent class**of water quality (Table 6, Fig. 5). These profiles are located along Damietta Branch at El Khiariya- Sheremsah (3), El-Za'atra-El Ahmadi(10), El Srew-Ras El Khaleeg (12), Kafr El Arab-Mit Abo Ghaleb (14), El Horani-El Tawfiqia (16), Damietta South El Hawiss (20), Damietta North El Hawiss (21), New Damietta Navigation Canal (25) and Damietta (Ezbet El Borg- El Gerbi) (28).

So it is concluded that waters of excellent and good quality classes do not requires any kind of treatments before the usage as drinking water sources, while water profiles falling into poor, marginal and fair categories which indicating unsuitable water for direct consumption and requires pre-usage treatments. After treatment practices, this water could be used for drinking and domestic purposes. The continuous monitoring of river water is required along Damietta Branch to protect water in future against any possible contamination due to growing urbanization, industrialization and agricultural practices.

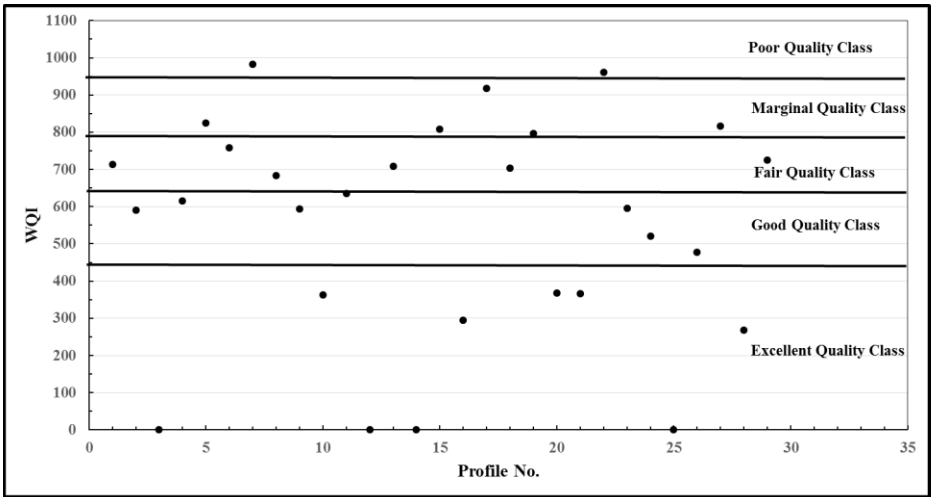


Fig. (5): Water quality class distributions along Damietta Branch water profiles.

V. Conclusion And recommendations

The present study is concerning with the most important source of life of millions of Egyptians. The study proved the presence of some dangerous quality deterioration influencing the water of the Damietta branch river. Therefore, it is assumed here to state some recommendations that may act to improve the quality the concerned water:

5.1.People

General populations should stop the bad habits and prevent sources of pollution derived from throwing rubbish materials, washing animals, releasing domestic sewage water, releasing solid municipal andindustrial wastesfrom primitive factories and local workshops.

5.2. Media

News-papers, magazines, TV-programs and broadcasting-programs must focus their efforts to change the unsafe traditions and habits of publics. Media must propose the safe and right treatment with the river branch to the public in different places at any civil standard. Media must propose the safe alternatives to the people to treat with the river. The suspected diseases and health damages that may take place must be continuously announced in different media.

5.3. Ministry of Irrigation

The Ministry of Irrigation must apply the different laws ensuring the right treatment with the river. The different factories, power plants and local industries must be held pre-chemical treatment to their wastes before releasing into the river to prevent pollutants releases into the river water. Drainage canals carrying wastes must be widened, cleaned and directed to safe reservoirs far from the river.

5.4. Ministry of Health

The Ministry of Health must prepare the medicines, vaccines and equipment necessary for treating with suspected diseases take place by various pollutants recorded. Medical-trips must visit villages and cities to let the public aware with health-circumstances due to bad treatment with river.

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