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Water Quality Index and Environmental Assessment of Rosetta Branch Aquatic System, Nile River, Egypt

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Abstract

This study was carried out on Rosetta branch water and 3 drains (El-Rahawy, El-Soble and El-Gezira) that discharging wastewater into it, to assess the Water Quality Index (WQI) of their waters. This investigation was performed during the period starting from winter 2017 to summer 2018. The mean annual averages of WQI values of Rosetta branch water were good to poor for irrigation (up to 55) and from poor to very poor for aquatic life (up to 97) at stations exposed to wastewater discharged from drains into water branch. The obtained values of physical and chemical variables of Rosetta branch and drains water were matched with the standard values set by FAO (1994) for irrigation, Canadian Water Quality Guidelines (2011) for aquatic life and WHO (2007) for drinking water. The obtained results indicated that the values of examined variables were higher than the recommended standards which affects the environmental live in this area and producing healthy problems. The concentrations of physical and chemical parameter were higher during winter than summer.

Keywords: Rosetta branch; Nile River; Water Quality Index; El-Rahawy; El-Soble; EL-Gezira drains

1- Introduction

Egypt is unique among other countries in its reliance on its extremely limited share of the surface water of the Nile River. The Nile Water Agreement conducted in 1959 with Sudan allocated 55.5 billion cubic meters per year to Egypt [1]. The Nile water has been used for various purposes such as drinking (domestic) water supply, agricultural irrigation, industrial uses, fisheries and navigation, among others. Water needs in Egypt are constantly increasing due to population growth, increased urbanization, industrialization and rapid agricultural growth. Demand for the agricultural sector represents the largest component (around 80%) of total water demand in Egypt. Water requirements were estimated to be increased in 2020 by 20% (15 billion cubic meters per year). Moreover, all water uses require that the water quality to be within acceptable value [2].

The Nile River flow rate is depends on the available water stored in Lake Nasser that meet the needs within Egypt's annual water budget [3]. The Nile River enters Egypt from its southern border with Sudan and passes through a narrow valley (1000 km long) ranging in width from 450 m to 2.8 km. Thereafter, it bifurcates at a distance of 25 km (north of Cairo) into the Rosetta and Damietta branches and forms a delta with its base on the shore of the Mediterranean [4].

The Rosetta branch flows as part of this system, downstream of the Delta to the northwest for about 239 km and ends with the Idfina barrage that regulates the branch's overflow. It is considered the main source of fresh water for the western side of the Nile Delta, with an average width of 180 m and an average depth between 2-16 m. The Rosetta branch

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extends between five governorates (Giza, Menoufia, Gharbia, Beheira, Kafr El-Sheikh). There are five main drains along the Rosetta branch with an amount of 8.9 million m^3 / day that are discharged from industrial, agricultural and sewage water. These drains are: El-Rahawy, Soble, El-Tahreer, Zawiet El-Bahr and Tala, and they receive various types of pollutants that affect water quality and lead to its deterioration. El-Rahawy drain receives all the sewage of Giza Governorate in addition to the agricultural and domestic wastes of the village of El-Rahawy and the disposal of these wastes (400,000 m^3/day) directly without treatment in the branch. In addition to the Kafr El-Zayat industrial zone, which includes liquid industrial waste from superphosphate and sulfur factories, the oil and soap industries and pesticide factories [5,6] .

Many reported work were performed to assess the water quality of Rosetta branch as example; Ghodeif, et. al., (2017) examined the water quality of Rosetta branch and found an increase in electrical conductivity (EC), ammonium (NH_4), nitrite (NO_2^-), and phosphate (PO_4^{3-}) ions [7]. The statistical evaluation revealed the association of NH_4, EC and PO_4^{3-} are indicators of wastewater load. High ammonium often indicates a bad location respect to oxygen whereas high nitrite indicates initial oxidation of wastewater by microbiological processes. The effect of low flow periods has a serious impact on the drinking water source. Other reported work recommended and made biological and /or chemical treatment for municipal waste water prior discharging onto river or their for using in agriculture purpose [8,9]

Regular water quality assessment of water resources is essential to evaluate water quality for ecosystem health, industrial, agricultural usage and domestic use. Water quality assessment can be a complex exercise in complex standards, which causes many concerns. It is hard to evaluate water quality for large samples compromising different concentrations of several parameters. Conventional methods for assessing water quality are based on comparing values of the tested determined variable with current guidelines. So, water quality indicators are such methods that greatly reduce the volume of data and simplify the expression of water quality status. The calculation of the water quality index is based on the number of physical, chemical and bacteriological parameters. The advantage of the number of water quality indicators developed is that they efficiently give the total water quality for a given area. An example of different water quality indicators developed around the world is the American National Sanitation International Journal of Advances in Chemistry (IJAC) Water Quality Index (NSFWQI), these indicators give water quality in a single value by comparing different parameters according to the criteria [10]. The present study aims to asses and calculate the concentrations of physical and chemical parameters of Rosetta branch water and drains waste water were matched with the standard values established by FAO (1994) for irrigation and Canadian Council of Ministers of the Environment (CCME) (2011) for aquatic life as well as calculate the WQI of Rosetta branch water.

1. Experimental

1.1. Area under investigation

We The Rosetta branch covers 239 km in the northwestern border of Egypt. Its depth ranges from 2 to 16 m, and its width averages 180 m [11]. There are five main drains along Rosetta branch with a quantity of 8.9 million m^3/day discharged from industrial, agricultural and waste water. These drains are El-Rahawy, Sabal, El-Tahreer, Zawiet El-Bahr and Tala [12]. The area under investigation extended from El-Kanater El-Khayria (at Galatma) to Kafr El Zayat cities, (approximately 120 km). Along this area there are three drains are directly discharging into branch water (El-Rahawy, Soble and EL-Gezira drains) at El Giza, El Monufia Governments and Kafr El- Zayat city.

1.2. Sampling

Water samples were collected during the studied period (winter2017 – summer 2018) and taken from the subsurface water (about 30 cm) at 10 stations were selected along the branch (up and down streams) of the main drains (El-Rahawy, Soble, and El-Gezira) that directly discharging into the branch water. Also 3 samples were directly collected from drains along the branch. The locations and names of collected water samples are represented in Table (1) and represented in Fig. (1). Sampling, preservation and experimental procedure of the water samples were carried out according to the standard methods for examination of water and waste water; American Public Health Association (APHA 2017) [13].

Table (1). The Names of the selected stations along the Rosetta branch

Stations	Name
I	El Galatma
II	ElRahawy drain upstream
III	El Rahawy drain outlet
IV	El Rahawy drain downstream
V	Soble drain upstream
VI	Soble drain outlet
VII	Soble drain downstream
VIII	Kafr El Zayat upstream
IX	Kafr El Zayat outlet
X	Kafr El Zayat downstream
XI	El Rahawy drain
XII	Soble drain
XIII	El-Gezira Kafr El Zayat drain

1.3. Physical and chemical analyses

Physical and chemical investigation of water samples were performed rendering to the procedures described in American Public Health Association (APHA, 2017). Water temperature (T, in $^{\circ}C$), pH and electrical conductivity (EC, mS/cm) were in- situ assessed *via* Hydrolab model Multi Set 430i WTW. Transparency was evaluated by a white/black Secchi Disc (20 cm in diameter). Total solids (TS) were measured by evaporating a known weight of well mixed sample at 105°C. A total dissolved solid (TDS) was assessed by passing a volume of sample through a glass fiber filter (GF/C), and a known weight of filtrate was evaporated at 105°C. Total suspended solids (TSS) is the difference between TS and TDS. Dissolved oxygen (DO, mg/L) was determined by using a modified Winkler technique. Biological oxygen demand (BOD) was assessed *via* using the 5 days incubation procedure. Chemical oxygen demand (COD) was performed *via* potassium permanganate technique. Water alkalinity was assessed immediately after collection of water samples usnig phenolphthalein and methyl orange indicators. Chlorinity and Sulfate were assessed *via* Mohr's and turbidimetric techniques, respectivily. Calcium and magnesium were determined using a complexemetry technique *via* direct titration using EDTA solution. Sodium and potassium were assessed using Flame photometer (Model JENWAY PFP.7 U.K). Ammonia was determined by the phenate method. Nitrite was detected using a colorimetric procedure by formation of a reddish purple azo-dye. Nitrate was determined as nitrite after cadmium reduction. Orthophosphate and total phosphorus (TP) were assessed *via* using the ascorbic acid-molybdate procedure. Reactive silicate was estimated *via* the molybdate method.

Fig. (1). Monitoring locations on Rosetta Branch at the area under investigation

2. Results and Discussion

2.1. Water Quality Monitoring

Naturally, Water quality monitoring refers to obtaining quantitative and qualitative description on the chemical, physical and biological properties of a water system over time and space. The effect and behavior of pollutants in an aquatic ecosystem is complex and may include adsorption - adsorption, sedimentation, dissolution, filtration, biological uptake, excretion, and precipitation - suspension. Besides natural processes that affect water quality, there are also anthropogenic influences, such as man-made and non-aspect sources, exotic vitality, alteration of water quality due to imprudent use of water and river engineering projects (for example, irrigation, damming,.. etc) [14] .

The obtained results of physico- chemical variables of Rosetta branch water and waste water of drains during winter (2017) and summer (2018) are presented in Tables (2 & 3) respectively.

2.2. Physical variables

2.2.1. Temperature

The water temperature of The Rosetta branch increased during summer season and was found to be 30.6 °C and the lowest temperature recorded was 14.30 °C during winter season and the general average was 18.01 ^{o}C. The drains water temperature ranged between 18.01 – 30.6 °C. There is no obvious thermal stratification recorded in the Rosetta branch due to the shallowness of the branch (~4 m depth on average) and it is considered homogeneous in nature. The water temperature values showed the expected seasonal pattern with no differences between the sampling stations, this result coinciding with that has been reported Mousad et al [15].

2.2.2. Transparency

The changes in water transparency values ranged between (15 to 85 cm) with a year average of 48.5 cm in the water branch. The highest value was found at site I during the summer and the lowest value was found in the out let of the drains during the winter. This may be due to waste water discharged from drains in the eastern and central sections was loaded with suspended particles which resulted in lower transparency compared to the western part. Transparency in water ranged between 10.00 -100.00 cm. The observed decrease in transparency can be attributed to the effect of untreated sewage and agricultural effluents into the three drains. These results are in agreement with those reported by Abdelsater et al [16].

2.2.3. Electrical conductivity (EC)

EC in the water branch fluctuated between 360 - 840 and 480 - 1300 µs/cm, with an overall mean value of 800 µs /cm, but the EC in the wastewater fluctuated between 1005-1600µs /cm, with a mean value of 1300 µs/cm. The lowest EC value was recorded at site I corresponding to the drains. While the maximum values were found in site V. The increase in the electrical conductivity values of the Rosetta branch water during the winter season may be attributed to the decrease in the water level due to the high concentration rate and the increase in the amount of waste water flowing into the Rosetta branch. On the other hand, the lower values were recorded during the summer and this may be due to the direct effect of dilution by Nile river [15].

2.2.4. Solids (TS, TDS and TSS)

TS, TDS and TSS values were found in the ranges of 420-1065, 158- 683 and 196- 462 mg/l, and the mean values were 739, 400 and 341 mg/l, respectively in water branch. For El-Rahawy, Soble and El-Gezira drains they ranged between 996- 1235, 531- 798 and 380- 493 mg/l, respectively. The increasing in (TS, TDS and TSS) values during winter season. This may be attributed to the high concentration rate and decreased in water level. While their decrease during summer season may be attributed to the dilution effect and raising of the water level in the Rosetta branch water through the drainage water discharging by the three drains during these seasons. These results are agree with that reported by Authman and Abbas [17] .

2.2.5. The pH Values

The favorable pH range is 6.5 - 9.0 which is the most suitable for fish production. The water pH values are quite variable throughout the seasons, and pH >7 values indicates that alkaline water conditions predominate in the branch. The pH values were found within the permissible limits and ranged between 7.69 -8.4. The highest value was recorded during the summer season at site I, while the lowest value was recorded during the winter season at site IX with an overall mean value of 7.67. For drains it ranged between 7.34 -8.84. The pH values for the three drains were found in the lower ranges of 7.19 - 7.4 that lower than the Rosetta branch water. The lower PH values of waste water drains than the Rosetta branch water. this may be attributed to the decay and decomposition of organic pollutants constituents in waste water of the drains [18] .

2.3. Chemical variables

2.3.1. Major Anions (CO_3^{-2} , HCO_3^- ,Cl^- and SO_4^{-2})

The carbonate and bicarbonate are the major components of alkalinity of surface water. CO_3^{-2} and HCO_3^- concentrations were found in the ranges of 10 - 50 and 165 - 340 mg/l respectively. While in the drains waste water were 20 -35 and 190 - 345 mg/l, respectively. The decrease in bicarbonate during winter may be attributed to the decline of water and air temperatures that resulted in precipitation of calcium bicarbonate. On the other side, the high concentration values during summer with maximum annual average of 363 mg/l may be related to the decomposition of organic matter and/or increasing

Table (2). Physical and chemical variables of the Rosetta branch water at the area under investigation during winter (2017).

Parameters	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	Mean
Water temp. ^{o}C	17.3	19.9	18.6	18.6	18.9	18.6	19.3	17.1	15.7	16.5	18.7	18.5	16.5	18.02
TS (mg/l)	436	496	710	551	700	1065	782	700	755	729	1143	1235	1225	809.7
TDS (mg/l)	196	242	350	274	322	583	405	324	416	337	650	798	748	434.2
TSS (mg/l)	240	254	360	277	378	482	377	376	339	392	493	437	417	370.9
Trans. (cm)	80.0	60	30	50	60	50	40	60	35	55	15	20	20	44.23
EC (µS/cm)	481.0	488	701	555	757	1363	953	848	888	874	1300	1601	1521	948.4
pH	7.8	7.94	7.67	7.95	7.57	7.6	7.65	7.95	7.27	7.81	7.38	7.23	7.25	7.62
DO (mg/l)	13.0	12.9	10	10.6	9.92	7.4	9.4	10.4	8.6	10	6.2	4.6	4.6	9.05
BOD (mg/l)	5.2	5.17	4	5.85	4.78	4	4.19	4.96	4	5.59	0.76	1.13	1.26	3.91
COD (mg/l)	8.6	19.5	27.08	13.92	18.56	29.08	18.7	33.68	28.72	29.12	63.72	33.32	23.32	26.72
CO_3^{--} (mg/l)	10.0	10	40	10	10	15	10	20	50	50	20	20	25	22.31
HCO_3^- (mg/l)	170.0	180	165	170	170	190	225	340	250	200	240	190	220	208.4
T-Alkalinity	180	190	215	180	180	205	235	360	300	250	260	210	245	231.5
Cl^- (mg/l)	34.74	34.17	39.70	49.63	35.02	40.55	45.38	41.12	41.97	41.69	197.1	146.7	161.7	69.97
SO_4^{2-} (mg/l)	38.0	37.9	65.58	41.63	95.71	148.3	85.4	74.99	76.80	74.91	135.8	152.3	145.3	90.22
Ca^{2+} (mg/l)	36.4	38.1	39.75	37.03	43.76	52.04	53.0	45.04	48.57	46.49	38.63	58.35	53.45	45.44
Mg^{2+} (mg/l)	29.9	21.2	30.25	20.81	30.54	25.10	33.1	34.24	34.82	35.31	45.72	76.36	66.46	37.21
T-Hardness (mg/l)	214	183	224	178	235	233	269	253	265	261	285	460	406	266.6
Na^+ (mg/l)	48.5	49.6	79	60.83	88.78	133.5	102.	97.73	101.1	99.97	136.8	153.6	117.1	97.61
K^+ (mg/l)	5.7	5.85	8	6	8.45	15.55	11.1	8.96	9.48	9.31	16.24	18.15	15.9	10.67
NO_2^- (µg/l)	15.3	25.1	35.39	24.85	13.39	29.12	20.3	28.24	68.89	51.09	56.63	32.86	31.86	33.31
NO_3^- (µg/l)	264	247.6	189.6	274.8	96.37	61.11	107.9	38.94	578.5	347.2	110.0	75.89	79.89	190.2
NH_3^- (µg/l)	476	593.3	6253.2	3004.6	4675.6	6253.2	5532	3732.1	5976.4	5682.8	4751.6	4928.6	4637.1	4345.9
PO_4^{3-} (µg/l)	10.5	47.82	392.87	162.24	310.15	1065.22	720.38	394.64	286.06	565.74	1346.35	1456.17	1156.17	608.79
TP (µg/l)	101.5	158.3	784.15	389.51	821.87	1222.92	754.21	563.44	585.05	664.76	1419.59	1582.89	1222.89	790.08
SiO_3^- (mg/l)	2.1	2.4	7.4	3.869	4.126	14.55	4.88	6.27	5.71	5.54	16.73	19.78	16.78	8.47

Table (3). Physical and chemical variables of the Rosetta branch water at the area under investigation during summer (2018).

Parameters	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	Mean
Water temp. ^{o}C	31.8	31.2	30.7	30.5	31.1	30.5	30.4	28.7	31.2	32.3	31	29.7	28.8	30.6
TS (mg/l)	420	480	540	470	459	884	897	430	510	431	996	1090	1090	669
TDS (mg/l)	158	188	175	175	205	470	435	203	212	208	531	600	710	328.5
TSS (mg/l)	262	413	365	295	254	414	462	227	298	223	465	490	380	349.85
Trans. (cm)	85	75	50	55	70	30.5	50	55	40	45	15	35	25	48.50
EC (µS/cm)	361	331	450	450	409	740	846	408	425	412	1047	1202	1397	652.15
pH	8.36	8.26	7.88	7.89	8.02	7.78	7.8	7.65	7.16	7.66	7.35	7.19	7.56	7.74
DO (mg/l)	11.76	9.88	9.68	9.68	11.36	7.44	7.76	8.29	7.48	8.4	6.4	4.84	5.16	8.32
BOD (mg/l)	5.04	5.015	3.346	4.82	5	3.68	4.215	4.45	3.325	4.6	1.37	1.145	1.405	3.65
COD (mg/l)	6.64	6.24	7.04	6.08	6.64	11.84	10.2	11.04	9.16	8.64	16.88	14.04	5.76	9.25
CO_3^{--} (mg/l)	14	11	40	12	15	18	11	27	29	28	20	35	20	21.54
HCO_3^- (mg/l)	147	148	155.5	141	147	251.5	299	220	184	177	265	345	329	216.08
T-Alkalinity	251	258	195.5	153	163	269.5	309	247	209	198	285	380	349	251.3
Cl^- (mg/l)	25.52	26.94	29.77	28.36	52.466	112.022	97.84	43.95	45.37	48.12	184.34	141.8	181.5	78.31
SO_4^{2-} (mg/l)	32	33.89	63.53	36.7	71.12	114.57	69.69	62.88	64.14	74.91	112.86	112.79	126.56	75.05
Ca^{2+} (mg/l)	28.85	30.46	33.66	28.8	30.46	48.096	44.88	25.65	35.27	32.06	43.28	54.5	22.44	35.26
Mg^{2+} (mg/l)	12.64	12.64	11.18	15.5	12.64	35.9936	35.99	17.51	12.64	12.64	27.23	55.44	92.41	27.27
T-Hardness (mg/l)	140	128	130	140	128	268	260	136	140	132	220	364	436	201.69
Na^+ (mg/l)	36.54	36.55	54	43.11	64.1	117.47	130.42	68.92	77.1	157.94	154.7	193.548	73.77	92.94
K^+ (mg/l)	7.4	9.74	12	11	7.847	11.11	12.74	9.84	10.85	17.63	15.99	14.37	13.5	11.85
NO_2^- (µg/l)	26.43	32.14	43.26	34.37	35.15	42.95	36.31	59.76	71.74	62.15	65.76	57.83	53.34	47.78
NO_3^- (µg/l)	272.50	248.85	201.45	324.74	116.52	83.54	139.48	64.64	724.57	418.36	127.51	134.25	94.71	227.01
NH_3^- (mg/l)	235.4	209.3	3472.3	1944.8	3279.5	4869.3	4135.6	3193.9	5286.6	5099.8	4151.4	4271.2	4394.7	3426.5
PO_4^{3-} (µg/l)	33.99	34.93	322.83	122.38	239.76	876.72	576.49	336.56	306.17	498.99	1116.38	1126.78	1359.76	534.75
TP (µg/l)	87.56	121.45	599.19	319.6	674.7	988.6	603.5	513.7	598.1	613.6	1294.8	1242.9	1120.4	675.2
SiO_3^- (mg/l)	1.99	2.2	5.99	3.26	3.82	11.66	4.37	5.88	3.299	3.162	12.36	14.24	14.89	6.70

Table (4). The comparison between the mean values Physical and chemical parameters of Rosetta branch water with Irrigation (FAO, 1994)[19] **, Aquatic life (CEQG 2011)**[20] **and Drinking Water (WHO 2008)** [21,22]

Parameters	Winter	Summer	Mean	Sd	Irrigation (FAO, 1994)	Aquatic life (CEQG, 2011)	Drinking water (WHO, 2008)
Water temp. ^oC	18.02	30.61	24.31	8.91		8 - 28	25
TS (mg/l)	809.77	669	739.38	99.53			
TDS (mg/l)	434.23	328.46	381.34	74.79	2000	500	
TSS (mg/l)	370.92	349.84	360.38	14.90		+ 250	
Trans. (cm)	44.23	48.5	46.36	3.02			
EC (µS/cm)	948.46	652.15	800.31	209.52	3000		1500
pH	7.62	7.73	7.67	0.08	8.5	6.5 – 9.0	6.5 – 8.5
DO (mg/l)	9.05	8.31	8.68	0.52		5.5	8
BOD (mg/l)	3.91	3.64	3.77	0.19		5	4
COD (mg/l)	26.72	9.24	17.98	12.36		7	25
CO_3^{--} (mg/l)	22.31	21.53	21.92	0.54	3		
HCO_3^- (mg/l)	208.46	216.07	212.26	5.38	610		
T-Alkalinity	231.53	251.31	241.42	13.98			120
Cl^- (mg/l)	69.97	78.31	74.14	5.89	1063	120	
SO_4^{2-} (mg/l)	90.21	75.05	82.63	10.73	960		
Ca^{2+} (mg/l)	45.43	35.26	40.35	7.19	400		
Mg^{2+} (mg/l)	37.21	27.26	32.23	7.03	60		
T- Hardness (mg	266.61	201.69	234.15	45.91		500	
Na^+ (mg/l)	97.61	85.97	91.79	8.23	919		
K^+ (mg/l)	10.67	11.85	11.25	0.83	20		
NO_2^- (µg/l)	33.31	47.78	40.55	10.23		60	1000
NO_3^- (µg/l)	190.22	227.01	208.62	26.01	10	2930	5000
NH_3^-(µg/l)	4345.9	3426.5	3886.2	6501	5000	1370	200
PO_4^{3-} (µg/l)	608.79	534.75	571.77	52.36	2000		
TP (µg/l)	790.08	675.26	732.67	81.18			
SiO_3^- (mg/l)	8.471	6.70	7.58	1.21			

the anaerobic processes which augment carbon dioxide in the water system [23]. The highest value of Cl^- 112 mg/l was recorded during winter season while the lowest value of 25 mg/l was recorded during summer season. This may be related to the effects of salt marches adjacent to the Rosetta branch, the leakage of salts from the neighbor cultivated lands and underground water. Furthermore, the high rate of concentration during cold season (winter) and low water level of the Rosetta branch water; as well as, the increase in the discharged waste water; regard the main reason for increase in the Cl^- content. On other side the decrease in the Cl^- and SO_4^{--} concentrations during summer may be related to the dilution effect by increase in water level in the Rosetta branch. These results agree with that reported by (Ali and Fishar, 2005; Authman and Abbas, 2007) for drains waste water 141 – 197 mg/l [17,24].The SO_4^{2-} values were fluctuated in the ranges of 32 – 148 mg/l for the Rosetta branch water, while drainage El-Rahawy, Soble and El-Gezira were in the range 112 – 152 mg/l. As whole, the distribution of major anions (Cl^- and SO_4^{2-}) in the Rosetta branch water may be governed mainly by the concentration rate, the intrusion of drainage water of the different drains along the Rosetta branch. These results are matches with that reported by Abdelsattar et al [16] .

2.3.2. Major Cations (Na^+, K^+, Ca^{2+} and Mg^{2+})

Na^+, K^+, Ca^{2+} and Mg^{2+} concentrations of the Rosetta branch water were found in the ranges of 36-157, 5.6–12, 28–53 and 12–35 mg/l respectively, and in the drains waste water were 73–193, 12– 18, 22-58 and 27–92 mg/l respectively. In the Rosetta branch water, the predominant cation trend was in the order of $Na^+ > Ca^{2+} > Mg^{2+} > K^+$ with sodium being dominant cation and the predominant anion trend was in the order of $HCO^- > Cl^- > SO^{-2} > CO^{-2}$, with bicarbonate being the dominant anion. These results are in agreement with that reported by Abdel-Satar et al.; Abou El-Gheit and Abdo [16,25].

2.3.3. Oxygen forms (DO, COD and BOD)

The DO and COD concentration values are found in the ranges of 6.2 -13 and 4 - 11.84 mg/l and the general annual average of concentrations 8.6 and 17 mg/l, in water branch respectively. While the drains recorded 4.6 – 6.4 and 5.76 - 63.72 mg/l, respectively. The highest BOD value in the Rosetta branch was 5.88 mg/l at site IV at El- Rahawy downstream indicating a significant entry in the organic contamination loaded into the Rosetta branch.

The highest value of DO 12.80 mg/l was recorded during the winter season, which can be mainly attributed to the lower temperature, and the action of the prevailing winds that allow for an increase in the solubility of oxygen gas in the atmosphere. The dissolved oxygen values showed a relative decrease during the summer, reaching 4.8 mg/l which was mainly attributed to the high water temperature which led to a lower solubility of oxygen gas. In addition to the oxidation of organic matter by microorganisms that consume part of the dissolved oxygen. These results are in agreement with those reported by Al-Afifi et al [26]. In general, higher values of DO, BOD, and COD are indicators of higher microbial activities. This was reflected in the high values of NH_4^+, NO_2^- and NO_3^- [15].

2.3.4. COD / BOD ratio

Concerning the biodegradability condition of the aquatic ecosystem of the water in the area under study. The COD / BOD ratio was taken into account. The ratio of the order of 1:1 is characteristic of pure water according to the national standard and the ratio 2:1 to 4:1 is the specified raw domestic waste water. Also, a high COD / BOD ratio refers to the excess amount of organic matter that is not degraded by microorganisms. COD/ BOD ratios of the Rosetta branch water ranged between 1.07 – 5.32 and its annual average 2.40, while in the drains waste water was 0.59 - 13.51, and its annual average was 4.21. These closer values also show that the structures of organic matter entering to the Rosetta branch water were similar approximately in all station(in front of El-Rahawy, Soble and El-Gezira drains) except the sites I and IX [15,26] .

2.3.5. Nutrient salts

Nutrient salts (NO_2^-, NO_3^-, NH_3, PO_4^{-3}, TP and SiO_3^-) are essential in the productivity of the aquatic ecosystems providing the food chain for phyto and zooplanktons as well as fish [5]. Nitrite is an intermediate product of the aerobic nitrification bacterial practice, formed by the autotrophic Nitrosomonas bacteria merging oxygen and ammonia. Nitrate (NO_3^-) can get into water directly as the result of runoff of fertilizers.

The concentration levels of NO_2^-, NO_3^- and NH_3^- were found in the ranges of 4.64 - 416.14, 4.56 - 635.99 and 53.06-766.52 µg/l, and in the drains waste water were 9.90 - 723.09, 47.44 - 441.75 and 179.84 - 4579.96 µg/l; respectively. These nutrient salts concentration increase with runoff from agricultural lands particularly intensively cultivated lands with high inputs of synthetic fertilizers and urban wastewater, creating eutrophication [5,26].

Phosphorus that come in the aquatic system *via* anthropogenic sources, e.g. fertilizer-runoff, can be include an organic or inorganic component. Once phosphorous increased within a Rosetta branch, it can circulate through the water system and enhance unlimited algal blooms.[2].

The concentrations levels of PO_4^{-3} and TP were found to be in the ranges of 6.02 – 454.09 and 50.30 – 968.44 µg/l and in the drains waste water were 262.35-627.74 and 302.18-1097.42 µg/l, respectively. The high ortho and total phosphates concentration levels can be explained on the basis of the high amount of agricultural runoff and domestic sewage inflow from the drains. The ranges of SiO_3^- in the Rosetta branch was found between 1.99 - 14.6 mg/l and in the drains waste water was 12.4 -19.8 mg/l. The high value of silicates is also may relate to the different effluents that discharged into Rosetta branch from (El-Rahawy, Soble and Kafr El Zayat) drains. Generally, the most probably the contamination delivered by the relevant drains containing sewage and domestic waste water (El-Rahawy drain), agricultural drainage water (Soble drain) and industrial wastes (Kafr El Zayat drain) discharged into the branch water [5]. This agreed with that reporting by El-Sayed et al [27].

2.4. Water quality index (WQI)

Water quality index (WQI) can be recognized as a technique of rating that affords the combined effect of distinct water quality parameters on the whole quality of water at certain location and time [28] . The determination process of WQI was established by Brown et al [29], that has been extensively used by numerous reported work [30–32]. The equation formula of WQI method can be written as:

$$\mathrm{WQI} = \frac{\sum_{i=1}^{n} QiWi}{\sum_{i=1}^{n} Wi}$$

Where Qi is the quality rating scale of each parameter, Wi is the weight unit of each parameter, n is the number of all parameters.

Qi value can be estimated as following:

$$\mathrm{Qi} = \frac{(Vi - Vo)}{(Si - Vo)}$$

Vi is the measured value of ith parameter, Si is the standard allowable value of ith parameter, Vo is the ideal value of ith parameter in clean water, Vo equal zero for all variables except for pH =7.0 and DO = 14.6 mg/l [33].

The weight unit (Wi) for different water quality variable is inversely proportional to the endorsed standards for the corresponding parameters.

$$\mathrm{Wi} \propto \frac{1}{\mathrm{Si}} \quad \text{Or} \quad \mathrm{Wi} = \frac{\mathrm{K}}{\mathrm{Si}}$$

Whereas K is the proportionality constant of the ‘‘Weights’’ for various water quality properties.

$$\mathrm{K} = \frac{1}{\sum_{i=1}^{n} \frac{1}{\mathrm{Si}}}$$

WQI has been categorized into 5 categories, the water quality can be valued as excellent, good, poor, very poor and unfit when the value of the QWI lies between 0.00-25, 26- 50, 51-75, 76-100 and >100, respectively, as shown on Table(5).

Table (5). Water Quality Rating (WQR) as weight arithmetic WQI method

WQI value	Water Quality Rating (WQR)	Grading
0-25	Excellent	A
26-50	Good	B
51-75	Poor	C
76-100	Very Poor	D
Above 100	Unsuitable for drinking purpose	E

WQR= Water Quality Rating, WQI = Water Quality Index

Water quality index of Rosetta branch water at different selected stations and drains are present in Table (6) and illustrate in Fig. (2). The WQI score for irrigation water was computed using guidelines of (FAO, 1994) [19]. Protection of aquatic life was determined according guidelines of (CEQG, 2007) [20]. Different parameters were used for the determination of WQI regarding to both irrigation and aquatic life standard. The selected variables for irrigation water include, TDS, pH, HCO_3^-, NO_2^-, NH_3, PO_4^{-3}, Cl^-, SO_4^{-2}, Na^+, K^+, Ca^{+2} & Mg^{+2}. On the other side the aquatic life include TDS, pH, DO, BOD, COD, NO_3^- [26].

The present results show that the WQI values of Rosetta branch water were ranged between 32.71–68.57 and 33.33 – 95.62 regarding to the irrigation and protection of aquatic life guidelines, respectively.

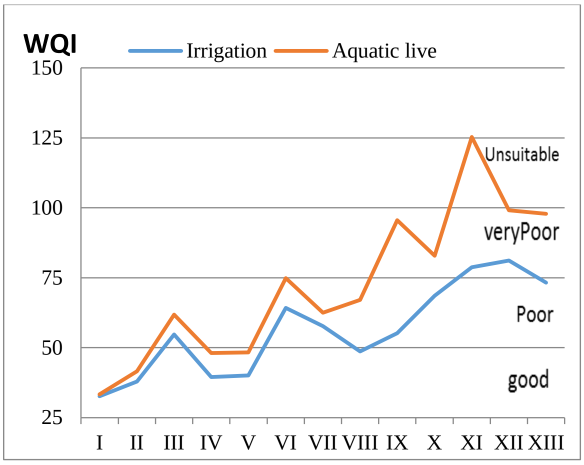

Fig. (2) Shows high pollutions rate at out let of drains in the branch water.

As it can be seen from Fig (2) the quality of water located at in front of drains (points discharged) e.g. III, VI, VII, IX and X are poor and XI, XII and XIII are very poor but stations far from the points discharged e.g. I, II, V and VII are good. The higher the value of contamination with WQI of poor or very poor are mainly resulted from the discharging of one or more drained without any convenient treatment before discharging. The various drains as sewage, domestic waste water, agricultural drainage water and industrial wastes that discharged into the branch water are recommended to be treated before discharging and should be a firm policy for forcing such treatment.

2. Conclusion

From previous results we can conclude that municipal and agricultural, domestic sewage and industrial wastes discharged into Rosetta branch causes serious problem of its water quality. The WQI values revealed that the Rosetta branch water poor and very poor for irrigation and aquatic life guidelines respectively at station point discharged of drains and good life at clear zone stations. The Rosetta branch water is contaminated by biological sewage and domestic waste water (El-Rahawy drain), agricultural drainage water (Soble drain) and industrial wastes (Kafr El Zayat drain) discharged into the branch water. The decrease in water level (winter season) and dilution rate increases in water level during (summer season) of the branch water and climatic conditions are the most important factors affecting the physical and chemical characteristics of the water of branch. Due to the high Ammonium ion concentration in Nile River > 0.2 mg/l and other nutrient salts it should be to make treatment before used as drinking water. Therefore, we recommend changing of the pathway of drains discharging and/or treatment of the wastewater before discharging into water branch.

Conflict of interest: None

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