Physico- Chemeical Studies on the Pollutants Effect in the Aquatic Environment of Rosetta Branch River Nile, Egypt

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Abstract: Rosetta branch is receiving several and different pollution types from different sources; sewage and domestic effluents from El-Rahaway drains (more than 5×10^8 m^3 daily effluents). Agricultural wastes at Soble drain as well as industrial effluents produced from El-Malya and Soda Companies at Kafr El-Zyat City. All these pollutants prominent affect on the aquatic environment of the Rosetta branch. To study the impact of these effluents on the Rosetta branch aquatic environment, 40 water samples were collected during four successive seasons from 10 stations along the branch. Physical and chemical parameters were included air and water temperatures, transparency, EC, salinity, TS, pH, DO, BOD, COD, CO_3^-, HCO_3^-, Cl^-, SO_4^{2-}, Ca^{2+}, Mg^{2+}, NO_2^-, NO_3^-, NH_3, PO_4^{3-}, TP and SiO_3^-. The obtained results declared that, the high concentration values of EC, TS, Cl^-, SO_4^{2-}, NO_2^-, NO_3^-, NH_3, PO_4^{3-} and TP were recorded at point's discharge of these drains with water branch. However, the salinity, EC, TS, Cl^-, SO_4^{2-}, Ca^{2+} and Mg^{2+} were found very increased at sites affected by saline water of Mediterranean Sea e.g. Edifina, Rosetta cities and estuary.

1. Introduction

River Nile is regarding as the life artery of Egypt through the known Egyptian history. The River Nile constitutes over 98 % of the fresh water resources available to Egypt represent 55.5 million m^3 per year coming from the south according to the international agreement for the distribution of water resources of the River Nile between countries of Nile basin (El-Dib, 2004).

At the north area of Cairo at El-Kanater El-Khyria, the River Nile bifurcates into two branches namely Damietta and Rosetta and four Rayahs (Canals) namely El-Nassery, El-Behery, El-Menofy and El-Toufeky (Abdel Aziz, 2005).

Concerning the Rosetta branch, it is about 220 km in length with average width 180 m and with an average depth varies between 1.5 – 16.0 m. Rosetta branch receives different types of pollution. El-Rahawy drain is the main source of pollution discharged 400,000 m^3/day of sewage, domestic and agricultural effluents. Soble drain, which directly discharge a great amount of agricultural wastes which potentially affect and deteriorate the water quality of the branch (Elewa et al., 2009). On the other hand, in the north at Kafr El-Zyat City the most of industrial plants e.g. El-Malyia Company for pesticides production in addition to Soda and Salt company for Soap and chemical salts productions are directly pour their effluents into the branch without any treatment.

The estimated flow of industrial waste water discharge to the Rosetta branch is about 0.05 million m^3/day (Daifullah *et al.,* 2003). The metal industry represents almost 50 % of the total waste water discharge. Besides, about 88 of drains are located on both sides along the River Nile.

Abdo (2002) pointed out that the main pollutant sources along Rosetta branch from El-Kanater El-Khyria Barrage to Kafr El-Zyat City are; El-Rhawy and Soble drains. At Kafr El-Zyat City El-Malyia and Soda companies are directly discharged their effluents into the branch without any treatment which severe changes in the distribution and concentrations of water quality parameters. Abdel-Satar and Elewa (2001) studied the quality of the Rosetta branch water and reported that, the high concentration levels of physical and chemical parameters were recorded at discharge points of El-Rahawy, Soble and Kafr El-zyat Companies drain. Also, Elewa *et al.* (2009) concluded that Rosetta branch remains threatened by the increasing of human activities on the long term which affect the water quality characteristics. El-Rahawy drain is the main source of pollution at the area of investigation due to the huge amount of domestic and agricultural wastes discharged into Rosetta branch.

The aim of the present study is to pay attention and follow up the changes in the River Nile water quality and impact pollution on the t aquatic environment at Rosetta branch.

2. Material and Methods

The present study was conducted through the research project of freshwater and lakes division which belongs to the National Institute of Oceanography and Fisheries in order to identify the

environmental status of the River Nile at Damietta and Rosetta branches during 2005 – 2006.

1. Sampling stations:-

Ten stations were selected along the Rosetta branch from El-Kanater El- Khyria to Rosetta estuary

in order to cover the different environmental conditions of the water branch. The locations and features of these stations are representing in Table (1). And these stations are representative in Fig. (1).

Table (1): Locations and features of sampling stations

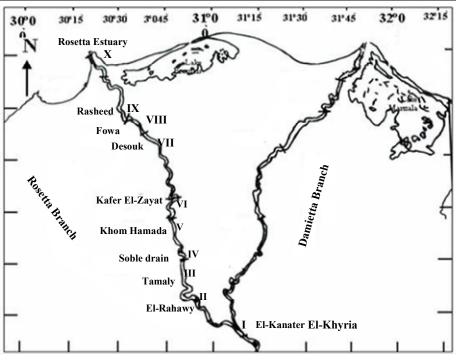| Stations	Code	Latitute	Longitute	Features
Station 1	I	30º 09'.73	31º 08'.99	25 km north of Cairo after El-Kanater El-Khyria Barrage
Station 2	II	30º 12'.44	31º 01'.99	35 km north of Cairo and infront of El-Rahawy drain (domestic and sewage wastes).
Station 3	III	30º 30'.46	30º 50'.03	45 km north of Cairo and down stream of El-Rahawy drain under Tamalay bridg.
Station 4	IV	30º 32'.22	30º 51'.12	60 km north of Cairo and infront of Soble drain (agricultural and sewage wastes).
Station 5	V	30º 42'.89	30º 45'.69	80 km north of Cairo at Khom Hamad City.
Station 6	VI	30º 49'.56	30º 48'.43	125 km north of Cairo and infront of Kafr El-Zyat companies at Kafr El-Zyat City.
Station 7	VII	31º 08'.16	30º 38'.16	142 km north of Cairo at Desouk City.
Station 8	VIII	31º 12'.00	30º 33'.17	170 km north of Cairo at Fowa City.
Station 9	IX	31º 23'.86	30º 25'.43	216 km north of Cairo at Rasheed City.
Station 10	X	31º 27'.55	30º 22'.03	220 km north of Cairo at Rasheed estuary.

Fig. (1) The sampling locations of Rosetta branch

2. Water collection and analysis:-

Subsurface water samples (at depth 60 cm) were collected from ten cross sections at the main channel and two banks of the branch by using poly vinyl Van Dorn plastic bottle (2L). The samples were collected during four successive seasons starting from autumn and winter (2005), spring and summer (2006). Salinity, electrical conductivity (EC), air and water temperatures, as well as pH values were measured in

the field using Hydro-Lab., Model "Multi 340 I/SET". The transparency of the water was measured in the field, using Secchi-disc (diameter - 25 cm). Total solid (TS), dissolved oxygen (DO), chemical oxygen demand (COD), biological oxygen demand (BOD), carbonate (CO_3^{2-}), bicarbonate (HCO_3^-), chloride (Cl^-), sulphate (SO_4^{2-}) calcium and magnesium, nutrient salts (nitrite, nitrate, ammonia,

phosphates and silicates) and total phosphorus were measured using Standard Methods APHA (2002).

Standard deviations (SD), coefficient of variations (V) were calculated for fresh water stations (I and VIII) and correlation coefficients "r" were assigned by computing, using Microsoft Office Excel (2003).

3. Results and Discussion

During recent decades a considerable increase in pollution has taken in the rate of disposal of agricultural and domestic sewage into River Nile and its branches. In addition, the industry is expanding in the river banks and producing large volumes of liquid wastes which find their way into the River Nile and its branches (Abdel-Satar and Elewa, 2001). So, the physical and chemical analysis of Rosetta water branch were measured to achieved the impact pollutants discharged into Rosetta branch on the water quality and aquatic environment of this branch.

1. Physical observations:-

1.1. Air and water temperatures:-

Temperature was water quality indicator that exhibited little variance between the sites and declare seasonal variations. The mean values of air and water temperatures (18.16, 16.5, 26.89 and 30.20^0C) and (18.94, 17.14, 25.03 and 28.73^0C) during autumn, winter, spring and summer seasons respectively, where the highest values were recorded in summer (28.5 – 31.9 and 27.2 – 29.7 ^{0}C) and the lowest in winter (15 – 17.5 and 15.6 – 18.3 ^{0}C) for air and water respectively at different selected stations.

Air and water temperatures were correlated with each other (r = 0.61, 0.98, 0.5 and 0.71) during autumn, winter, spring and summer seasons respectively.

1.2. Transparency:-

The mean values of transparency (91.25, 83.80, 86.83 and 73.75cm) during autumn, winter, spring and summer seasons respectively. However, the lower values of the water transparency were recorded at stations receiving effluents discharged e.g. stations number II, III, IV, VI and IX as showed in Tables (2 – 5). This may be related to the abundance of planktonic organisms and other suspended organic and inorganic particles constituents in their effluents (Fathi and Abdel-Zahar, 2003). On the other side, the high values of visibility were recorded at clear area sites with increased in depths e.g. stations number I, VII, VIII and X.

Table (2). Physico-chemical variations, mean ± standard deviation (SD) and coefficient variation (V) at Rosetta branch water during autumn 2005.

Stations Parameters	I	II	III	IV	V	VI	VII	VIII	IX	X	Mean ± SD	"V"
Air. Temp. ^{0}C	18	18	18.5	18.5	17.8	18	18.5	18	17.9	17.5	18.16 ± 0.29	1.58
Wat. Temp. ^{0}C	18.9	19.8	19	19.1	18.2	18.5	19.1	18.9	18.4	18	18.94 ± 0.47	2.48
Depth m	8	2	2	1.5	2.5	6	3	15	5	3	5.00 ± 4.64	92.74
Trans. cm	70	60	50	80	90	120	110	150	40	70	91.25 ± 33.57	36.79
Salinity	ND	ND	ND	ND	ND	ND	ND	0.1	9.6	18	0.01 ± 0.04	0.00
EC µS/cm	363	772	509	523	549	540	620	635	16370	29400	563.9 ± 117.9	20.91
TS mg/l	488	632	460	372	376	324	328	352	30560	40012	416.5 ± 105.3	25.28
pH	7.95	7.7	7.26	7.55	7.35	7.48	7.57	7.56	8.07	8.05	7.55 ± 0.21	2.80
DO mg/l	8	2.5	5.2	5.2	7.2	4.8	6.6	8	6	9.6	5.94 ±1.88	31.66
BOD mg/l	3.5	30	2.5	2.5	3	3.5	1	1	2.5	3	2.50 ± 1.00	40.00
COD mg/l	4.8	19.6	5.6	6	4	3	2.5	2.5	6.4	32	6.00 ± 5.66	94.29
BOD/COD	0.73	1.53	0.45	0.42	0.75	1.16	0.4	0.4	0.39	0.093	0.73 ± 0.42	57.13
CO_3^{2-} mg/l	ND	ND	ND	ND	ND	ND	ND	ND	9.68	4.84	0.00 ± 0.00	0.00
HCO_3^- mg/l	157	181	203	165	149	173	188	227.4	204	227	180.4 ± 25.6	14.21
Cl^- mg/l	40	160	60	80	80	100	120	84	20000	25000	90.50 ±36.91	40.78
SO_4^{2-} mg/l	28.2	62	45	42	44	48	57	58	274	308	48.03 ±10.89	22.67
Ca^{2+} mg/l	29	40	39	47	44	37	47	45	180	261	41.00 ± 6.12	14.92
Mg^{2+} mg/l	12	24	27	24	12	27	12	29	499	754	20.88 ± 7.53	36.07
NO_2^- µg/l	2.83	8.5	13.5	15	38	49	66	70	44	65	32.9 ± 26.6	80.97
NO_3^- µg/l	6.2	10.6	20	20	43	72	140	130	376	241	55.23 ± 53.57	97.00
NH_3 mg/l	0.69	11.2	4.9	4.5	4	4.5	4	4.1	2	2	4.74 ± 2.92	61.70
PO_4^{3-} µg/l	82	967	319	355	288	281	434	438	314	158	395.5 ± 256.4	64.84
TP µg/l	372	1476	953	735	1246	541	966	744	704	587	879.1 ± 361.4	41.11
SiO_3^- mg/l	1.74	4	2.7	4.8	1.86	3.23	2.4	4.14	4.7	46	3.11 ±1.12	36.14

ND: Not Detected

Table (3). Physico-chemical variations, mean ± standard deviation (SD) and coefficient variation (V) at Rosetta branch water during winter 2006.

Stations Parameters	I	II	III	IV	V	VI	VII	VIII	IX	X	Mean ± SD	"V"
Air.Temp. ^{0}C	16.5	16	17.3	17.5	17.9	16.8	15	15	16	17.5	16.5 ± 1.1	6.65
Wat.Temp. ^{0}C	17	16.9	18	18.4	18.3	17.2	15.6	15.7	16.7	18.3	17.14 ± 1.08	6.32
Depth m	7.5	1.25	0.9	1.25	2	7	6	18	5	2	5.49 ± 5.76	104.97
Trans. cm	125	60	80	40	60	125	100	80	35	200	83.8 ± 31.0	37.04
Salinity	ND	ND	ND	ND	ND	ND	ND	ND	10.1	17.5	0.0 ± 0.0	0.00
EC µS/cm	330	660	476	506	549	594	704	650	17380	245000	558.6±121.3	21.71
TS mg/l	488	492	300	371	460	316	434	460	17100	20440	415.1 ± 76.2	18.35
pH	7.56	7.32	7.11	7.22	7.42	7.49	7.27	7.40	7.81	7.88	7.35 ± 0.15	2.01
DO mg/l	10	3	11	6.8	5.2	6.4	6.4	8.8	10.4	12	7.20 ± 2.62	36.34
BOD mg/l	3.2	28	5.6	3	4	3.3	4.4	4	4.5	4.8	6.94 ± 8.55	123.26
COD mg/l	6	18	10	10	9.2	12	8	12	12	10	10.65 ± 3.57	33.53
BOD/COD	0.53	1.55	0.56	0.3	0.43	0.28	0.55	0.33	0.37	0.48	0.57 ± 0.41	73.02
CO_3^{2-} mg/l	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.00 ± 0.00	0.00
HCO_3^- mg/l	156	266	227	156	251	220	212	227	243	274	214.4 ± 40.0	18.64
Cl^- mg/l	42	85	56	50	61	67	88	71	8095	8253	65.0 ± 16.1	24.81
SO_4^{2-} mg/l	29	72	46	43	52	58	67	60	573	2148	53.4 ± 13.9	26.07
Ca^{2+} mg/l	51.3	59.3	55.3	57.3	58.9	59	67	58	201	220	58.26 ± 4.42	7.58
Mg^{2+} mg/l	11	10	10	10	10	10	9	21	310	1220	11.38 ± 3.93	34.51
NO_2^- µg/l	10	14	15	10	32	38	44	54	73	60	27.1 ± 17.1	63.16
NO_3^- µg/l	15	20	24	80	40	41	50	60	99	70	41.3 ± 21.9	53.19
NH_3 mg/l	0.21	8.4	4.38	7.61	7.26	6.82	7.65	5.5	1.15	0.04	5.98 ± 2.67	44.58
PO_4^{3-} µg/l	27	1350	608	584	632	549	742	682	177	103	646.8±359.4	55.57
TP µg/l	565	2130	1034	1110	1055	1297	1233	1124	2430	681	1194 ± 438	36.67
SiO_3^- mg/l	0.84	4	1.6	1.4	2.45	2	4	2.9	1.8	1.2	2.40 ± 1.17	48.84

ND: Not Detected

Table (4). Physico-chemical variations, mean ± standard deviation (SD) and coefficient variation (V) at Rosetta branch water during spring 2006.

Stations Parameters	I	II	III	IV	V	VI	VII	VIII	IX	X	Mean ± SD	"V"
Air.Temp. ^{0}C	25.3	23.5	27.3	30.1	31.1	29.1	23	25.7	27.3	27.3	26.89 ± 3.02	11.21
Wat. Temp. ^{0}C	24.3	24.1	25	25.3	25.8	25.6	24.7	25.4	26.8	27.4	25.03 ± 0.61	2.45
Depth m	8	1.5	1	1.5	2	3	5	8	4.5	3	3.75 ± 2.90	77.42
Trans. cm	150	60	50	70	60	80	100	120	25	150	86.25 ± 34.62	40.13
Salinity	ND	ND	ND	ND	ND	ND	ND	ND	4.6	5.4	0.00 ± 0.00	0.00
EC µS/cm	332	346	433	438	460	518	470	483	12800	13400	435.0 ± 65.0	14.95
TS mg/l	264	408	292	264	260	320	336	332	10680	12048	309.5 ± 50.6	16.35
pH	8.15	7.38	7.37	7.47	7.49	7.58	7.41	7.44	8.43	8.47	7.54 ± 0.26	3.41
DO mg/l	12	10	10.9	11	10.4	11.4	11	10.4	13	14	10.89 ± 0.63	5.80
BOD mg/l	6	8	6.8	7.6	7.20	9.2	5.8	5.6	5.8	8.8	7.03 ±1.23	17.58
COD mg/l	20	28	26	26	14	16.8	18	20	21	24	21.10 ± 5.02	23.80
BOD/COD	0.3	0.28	0.26	0.29	0.51	0.55	0.32	0.28	0.42	0.37	0.35 ± 0.11	32.60
CO_3^{2-} mg/l	4.84	ND	ND	ND	4.84	ND	ND	4.84	19.7	19.7	1.82 ± 2.50	138.01
HCO_3^- mg/l	156	172	180	188	156	219	196	180	120	115	180.9 ± 20.9	11.54
Cl^- mg/l	40	42	43	43.5	56.7	57	49.6	49.63	6678	7000	47.68 ±6.62	13.87
SO_4^{2-} mg/l	19	21	27	27.1	31	36	30	28	288	320	27.4 ± 1.45	6.16
Ca^{2+} mg/l	25.7	28.8	27.3	28.8	25.7	30.5	28.9	25.7	40.1	56	27.68 ± 1.85	6.67
Mg^{2+} mg/l	15.6	16.6	18.5	20.8	23.4	20.5	21.5	23.4	312	405	20.04 ± 2.91	14.54
NO_2^- µg/l	1.7	1.72	17.4	17	119	179	82	84	8.7	6.1	62.73 ± 64.48	102.79
NO_3^- µg/l	29.6	24.1	32.6	25.6	125	188	88	86	23	26	74.86 ± 59.10	78.94
NH_3 mg/l	0.05	3	2.01	2.02	1.33	1.18	1.41	1.27	1.82	1.6	1.53 ± 0.85	55.47
PO_4^{3-} µg/l	27	47	22	24	264	306	262	273	79	71	153.1 ± 132.5	86.54
TP µg/l	242	984	572	530	689	675	533	510	480	322	591.9 ± 209.4	35.38
SiO_3^- mg/l	1	1.49	1.07	0.9	1.21	1.38	2.03	1.88	2.73	1.6	1.37 ± 0.41	30.01

ND: Not Detected

Table (5). Physico-chemical variations, mean ± standard deviation (SD) and coefficient variation (V) at Rosetta branch water during summer 2006.

Stations Parameters	I	II	III	IV	V	VI	VII	VIII	IX	X	Mean ± SD	"V"
Air. Temp. ^{0}C	29	29	29.2	33.3	31.9	30.7	30	28.5	29.1	29.1	30.20 ± 1.67	5.54
Wat. Temp. ^{0}C	27.7	28.9	28.7	29.3	29.3	29.7	29	27.2	28	28.4	28.73 ± 0.85	2.97
Depth m	8	1.5	2	1.5	1.5	6	4	16	4.5	3.5	5.06 ± 5.04	99.53
Trans. cm	150	60	70	40	60	50	80	80	60	90	73.75 ± 33.78	45.80
Salinity	ND	ND	ND	ND	ND	ND	ND	ND	9	17	0.00 ± 0.00	0.00
EC μS/cm	361	435	403	422	455	482	530	511	15800	28400	449.9 ± 56.5	12.55
TS mg/l	256	588	384	392	520	428	380	392	10868	23040	417.5 ± 99.7	23.88
pH	8.14	7.43	8.24	8.2	7.86	7.88	7.88	7.24	7.86	8.1	7.86 ± 0.36	4.58
DO mg/l	9.2	5	7.2	7.2	9.5	8.8	8.4	7.2	8	9	7.81 ± 1.47	18.82
BOD mg/l	3	14	6.4	4.4	6.4	4.4	4	1.2	4	6	5.48 ± 3.84	70.16
COD mg/l	8	12.8	16	16	12.8	16	8	14.4	17.6	19.2	13.00 ± 3.36	25.85
BOD/COD	0.37	1.09	0.4	0.28	0.5	0.8	0.5	0.08	0.23	0.31	0.50 ± 0.31	62.47
CO_3^{2-} mg/l	14.9	ND	29	24	4.9	4.9	4.9	ND	4.9	5.9	10.33 ± 11.07	107.24
HCO_3^- mg/l	156	196	112	100	142	180	196	196	275	361	159.8 ± 38.8	24.28
Cl^- mg/l	28.4	38.9	36.9	39.7	42.6	45.4	45.7	42.5	5743	13117	40.01 ± 5.61	14.02
SO_4^{2-} mg/l	21.8	37.9	32.8	33.4	36.4	40.9	39.4	38.8	81.2	89.3	35.18 ± 6.10	17.34
Ca^{2+} mg/l	27.3	29	24	32.1	32.1	32.1	32.1	32.1	80.2	121	30.10 ± 3.08	10.22
Mg^{2+} mg/l	13	17	15	15	15	15	15	15	488	903	15.00 ± 1.07	7.13
NO_2^- μg/l	2	6.1	13.5	20	22	79	129	119	31	12	48.83 ± 52.21	106.93
NO_3^- μg/l	37	8	40	29	41	87	136	141	43	18	64.88 ± 50.47	77.80
NH_3 mg/l	0.48	4.5	0.69	1.22	0.56	0.69	1.75	1.69	1.06	0.43	1.45 ± 1.33	91.92
PO_4^{3-} μg/l	21.5	202	120	148	89	124	189	186	46	70.5	134.9 ± 60.4	44.75
TP μg/l	45	407	379	383	188	388	328	311	271	223	303.6 ± 125.8	41.42
SiO_3^- mg/l	3.12	3.18	3.46	3.86	3.88	1.24	2.25	4.73	4.1	4.18	3.22 ± 1.07	33.37

ND: Not Detected

1.2.3. Salinity, Electrical Conductivity (EC) and Total Solids (TS):-

Both of salinity, EC and TS are dependence variations in fresh and saline ecosystem. At Edfina City, Edfina barrage cut off Rosetta branch into two different ecosystems (fresh water before and saline water after the barrage). The barrage used in control of the fresh water release from Rosetta to Mediterranean Sea and vice versa. So, salinity values were not detected at fresh water stations (I – VIII) and ranged between (4.6 – 18.0) at stations IX and X after barrage during different seasons. Therefore the values of salinity depended on the time length of the inlet remained open.

EC values were ranged between 363 – 635, 330 – 704, 332 – 518 and 361 – 530 μS/cm at fresh water stations before barrage. After barrage, were found to be (16370 – 29400, 17380 – 24500, 12800 – 13400 and 15800 – 2840 μS/cm) during autumn, winter, spring and summer seasons respectively. The increase in EC values at stations I – VI mainly attributed to the sewage, domestic, agricultural and industrial effluents discharged from El-Rahawy, Soble and Kafr El-Zyat company drains respectively at this area. These results coincident with that finding by Elewa and Ghallab (2000) and Abdel-Satar and Elewa (2001) on the same studied area. For other stations VII, VIII, IV and X the main factor effecting on the EC values the saline water release at Edfina barrage opening.

In the same manner of EC, the TS were found increased at station affected by effluents discharged e.g. II, IV and VI. The maxim values of TS at these stations reached to 632, 392 and 428 mg/l during different seasons. On the other hand, the relative increase in TS values at stations (VII and VIII) and the maximum values at stations (IX and X) could be attributed to the saline water of Mediterranean Sea mixing with Rosetta branch freshwater at these stations and ranged between (328 – 460 and 10680 – 40012 mg/l) respectively.

The increase in EC and TS values were recorded during cold seasons are mainly attributed to the increase in cations and anions concentrations of the water, as result of low water level and discharge (Abdo *et al.,* 2010). But, the decrease in EC and TS during hot seasons may be due to the sedimentation of suspended solid with organic salts causing decrease in chemical elements concentration.

The obtained results of correlations coefficient "r" at (n = 10, $p < 0.5$), they revealed that a strong positive correlations between EC and TS (r = 1.00, 0.89, 1.00 and 1.00). Also salinity with EC (r = 1.00, 0.89, 1.00 and 1.00) during autumn, winter, spring and summer seasons respectively. Therefore both of EC, TS and salinity are depend on each other.

2. Chemical analysis:-
2.1. Hydrogen ion concentration "pH":-

The pH values were ranged between: 7.26 – 8.05, 7.11 – 7.88, 7.37 – 8.47 and 7.24 – 8.24 during

autumn, winter, spring and summer seasons respectively. The relative decrease in pH values at stations affected by effluents discharged from El-Rahawy, Soble and Kafr El-Zyat Companies e.g. stations II, IV and VI respectively. This could be attributed to the lower activity of phytoplankton as well as, to the bacterial and fungal action in the sediment. These activities give rise to methane and hydrogen sulphide release as, the formation of organic acids and other break down products (Elewa and Ghallab, 2000). Also, the decrease in pH values during cold season as shown in Tables (2 and 3) are mainly related to the high bicarbonate content, where the CO_2 uptake by phytoplankton is decreased in cold seasons (Ueda *et al.,* 2000). These results agreed with that reported by Abdo (2002) on the same area and Abdel-Satar (2005) on the River Nile.

2.2. Dissolved oxygen:-

Concerning the dissolved oxygen (DO), the values varied between 2.5 – 9.6, 3.0 – 12.0, 10.0 – 14.0 and 5.0 – 9.5 mg/l during autumn, winter, spring and summer seasons respectively. The lower values of DO were recorded at station II in front of El-Rahawy drain (sewage and domestic wastes). This is due to its consumption by the oxidation of nitrogenous compounds this finding was fully confirmed with the increase in ammonia at station II, where the nitrogenous compounds played an important role in the depletion of DO (Deai *et al.,* 1991).

On the other hand, the increase in DO values at station X, could be attributed to the strong mixing and winds prevailed at Rosetta estuary with Mediterranean Sea. The high concentration values of DO during spring Table (4) corresponding to the flourishing of phytoplankton (Abdel-Satar, 2008). Generally the DO values at most selected stations of Rosetta branch are within the guideline values cited by USEPA (1999) except for stations II, III, IV and VI during different seasons. For the protection of aquatic life stage 5.5 – 6.0 mg/l for worm water biota, other life stages 6.5 – 9.0 mg/l for cold water biota.

2.3. BOD, COD and BOD/COD ratio:-

The analysis of Rosetta water branch declared that, the Biochemical Oxygen Demand BOD varied between 1.0 – 28.0 mg/l and Chemical Oxygen Demand COD ranged between 2.5 – 32.0 mg/l. The increase in BOD and COD values at most investigation stations especially II, III. IV, V, VI, IX and X reflect the high load of organic matter discharged into Rosetta branch which receive high amounts of sewage, domestic, agricultural and industrial wastes via El-Rahawy, Soble, Kafr El-Zyat company drains.

BOD was positively correlated with COD (r = 0.55, 0.81, 0.53 and 0.80) showed that BOD and

COD are depend on each other and take the same behavior.

Concerning the biodegradability condition of Rosetta branch aquatic body; the BOD/COD ratio in the present study was taken into consideration. This ratio in the order 1 : 1 is the characteristic of the purified water according to the national standard and the ratio 2 : 1 to 4 : 1 is specified crud domestic sewage (WHO, 1992 and Abdo, 2005). Therefore, the present results revealed that, the most stations during different seasons were found in the ranges of 0.1 - 0.7. This indicates that water of Rosetta branch did not reach the degradation level and were not also biodegradable. The ratios at station II were found to be 1.5, 1.6 and 1.1 during autumn, winter and summer seasons respectively. Also, at station IV was found to be 1.2 during autumn. This means that these stations near reached to the degradation level and the water of Rosetta branch at station II in front of El-Rahawy drain and station IV opposite to Kafr El-Zyate factories may be near to the biodegradable levels. These results are accordance with that reported by (Elewa *et al.,* 2009) on the same branch.

2.4. Carbonate and bicarbonate alkalinity:-

Carbonate showed a wide range of variations ND – 19.70 mg/l with interrupted seasonal trends. The bicarbonate values fluctuated between (149 – 227.4, 156 – 274, 115 – 219 and 100 – 361 mg/l) during autumn, winter, spring and summer seasons respectively. The high values of bicarbonate values from up-to down stream (I – X) stations during all seasons as shown in Tables (2-5). This might be attributed to the presence of high amount of organic matter accessible to bacterial decomposition by increasing sewage, domestic, agricultural and industrial effluent drains direct discharging into the branch, where, bicarbonate is the final product of the decomposition (Abdo *et al.,* 2010).

The negative correlation between CO_3^{2-} and HCO_3^- (r= -0.90 and -0.56) declared that the inverse relationship between tow anions and working as buffer system.

2.5. Chloride and sulphate:-

The chloride concentrations were varied in the ranges of 40 – 160, 42 – 188, 40 – 57.0, 28.4 – 45.7 mg/l, 20000 – 25000, 8095 – 8253, 6678 – 7000 and 5743 – 13117 mg/l before and after Edfina barrage during autumn, winter, spring and summer seasons respectively. Also, sulphate concentrations were fluctuated between 28.23 – 62.0, 29 – 72.0, 19.0 – 28.0, 21.8 – 40.9, 274 – 308, 573 – 2148, 288 – 320 and 81.16 – 89.26 mg/l before and after Edfina barrage respectively during the same seasons. The increase in Cl^- and SO_4^{2-} from up to down stream of Rosetta branch especially at stations II, V and VI could be attributed to the domestic, sewage,

agricultural and industrial effluents discharged at these stations. On the other side, the high values of two anions at stations VII, VIII, IX and X mainly related to the intrusion of sea water at these stations which characterized by high concentration values of Cl^- and SO_4^{2-} respectively. The present results agreed with the findings of Abdel-Satar and Elewa (2001) and Sayed (2003) on the same area.

Cl^- and SO_4^{2-} were taken the same manner in Rosetta aquatic ecosystem (r = 0.99, 0.89 and 0.84) during different seasons.

2.6. Calcium and magnesium:-

The present results revealed that the low calcium and magnesium concentrations in fresh water of Rosetta branch before Edfina barrage (25.7 – 67.0 and 9.0 – 29.0 mg/l) for Ca^{2+} and Mg^{2+} respectively during different seasons. The high concentration values of two cations were recorded at stations affected by intrusion of saline water of Mediterranean Sea especially stations IX and X after Edfina barrage. The ranges of Ca^{2+} and Mg^{2+} in saline water after Edfina barrage of Rosetta branch were found to be (40.1 – 261 and 310 – 1220 mg/l respectively) during different seasons. Therefore, Ca^{2+} concentrations in freshwater were more than Mg^{2+} and vice-versa in saline water whereas, Ca^{2+} is a preponderance over Mg^{2+} in sedimentary rocks (Abdel-Halim, 1993). In addition, the preferential behavior of dissolved CO_2 may affect the concentration of Mg^{2+} in solution, when CO_2 present in appreciable concentration it reacts with salts than with Mg^{2+} thus converting large quantities of Ca^{2+} into soluble bicarbonates (Abdel-Halim, 1993).

In the same manner of Cl^- and SO_4^{2-}, the Ca^{2+} and Mg^{2+} were also strongly positive correlated (r = 1.00, 0.86, 0.95 and 1.00). Therefore, Ca^{2+} and Mg^{2+} may be present in sulphate and chloride salts in Rosetta aquatic ecosystem.

2.7. Nitrite and nitrate:-

The results of nitrite showed low level concentrations during the whole period of investigation (2.83 – 70, 10 – 73, 1.70 – 179 and 2.0 – 129.0 μg/l) during autumn, winter, spring and summer seasons respectively. The random distribution of nitrite concentrations at stations III-X during different seasons may be attributed to one of the following factors controlling the nitrite level in aquatic ecosystem as mentioned by Abdel-Satar and Elewa (2001) are: uptake by phytoplankton, bacterial activity and oxidation-reduction processes. On the other side, the low concentration levels of nitrite at station II during whole period of investigation could be explained the high reduction rate of nitrate to ammonia forming nitrite as intermediate stage by the action of anaerobic denitrifying bacteria. The rate of oxidation is minimized due to the removal of

dissolved oxygen during the decomposition of organic matter (Abdo, 2002).

The nitrate concentrations were found to be higher than nitrite at all stations due to the fact that NO_3^- is the final stable form of nitrogen. The ranges of NO_3^- were varied between 6.2 – 376, 15 – 99, 23 – 188 and 8.0 – 141 μg/l during the above mentioned seasons. The increase in NO_3^- during autumn and winter might be attributed to low consumption by phytoplankton as well as the oxidation of ammonia by nitrifying bacteria and biological nitrification (Sayed, 2003).

Generally, natural water have small concentrations of nitrates and increase with runoff from agricultural lands (especially intensively cultivated lands with large inputs of synthetic fertilizers) and urban waste water, creating eutrophication (Yang et al., 2003; Liu et al., 2009).

NO_2^- and NO_3^- were significant (r = 1.00, 0.68, 0.98 and 0.98) which means that NO_2^- and NO_3^- are dependent on each other, when nitrite decrease leading to nitrate increase due to the oxidation of NO_2^- into NO_3^-.

2.8. Ammonia:-

NH_3-N accounted for the major proportion of total soluble inorganic nitrogen. It fluctuated in wide range and showed high concentrations at stations affected by effluents discharge. The ranges of NH_3 were found to be 0.69 – 11.2, 0.04 – 8.4, 0.048 – 3.0 and 0.43 – 4.50 mg/l during autumn, winter, spring and summer seasons respectively. The highest concentration values were recorded during cold seasons this may be related to the low water levels and the leaching of fertilizer residues used on the agriculture into the aquatic environment of the branch via drains. This result is coincident with that reported by Abdel-Satar (2008) on Lake Manzalah. The lowest concentration of ammonia were recorded at clear water stations e.g. I & X at El-Kanater El-Khyria and Rosetta estuary respectively. On the other side the concentration levels were increased at all stations along the branch especially II opposite to El-Rahawy drain that discharging more than 400,000 m^3/daily of sewage, domestic and agricultural wastes into the Rosetta branch without any treatment, this leading to the increase in the concentration levels of NH_3 at all downstream stations especially II as shown in Tables (2-5) during four successive seasons. However, the effect of sewage discharge from El-Rahawy drain reached to next station III at Tamalay along 10 km of El-Rahawy drain. Also, the Soble drain discharging the agricultural and sewage effluents into Rosetta branch at station IV and effected on station V. At Kafr El-Zyate city, the industrial effluents of El-Malyia Company discharging into the aquatic environment of the branch at station VI and its effect

on the stations VII and VIII. These effluents leading to increase in ammonia concentration levels at these stations Tables (2 – 5).

Generally the average values of ammonia concentrations at these stations showed higher levels than the chronic guidelines (1.46 mg/l) recommended by USEPA (1999) for the protection of aquatic life. This result agreed with that finding by Abdo (2002) and Elewa *et al.* (2009) on the same area.

2.9. Ortho and total phosphorus:-

The ortho and total phosphorus concentrations were fluctuated between 82 – 967, 27 – 1350, 27 – 306, 21.5 – 202, 372 – 1476, 565 – 2130, 242 – 984 and 45 – 407 µg/l during autumn, winter, spring and summer seasons respectively. In the same trends of ammonia the PO_4^{3-} and TP concentrations were increased at stations received and affected by organic pollution resulting from sewage, domestic, agricultural and industrial effluents of different drains along Rosetta branch. However, phosphorus enters the aquatic system through anthropogenic sources, such as fertilizer-runoff, potentially could be incorporated into either inorganic or organic fractions (Eduards and Withers, 2008). Also, the high concentration values of PO_4^{3-} and TP at stations II-VII during four successive seasons Tables (2 – 5). This reflecting the effect of drainage water, sewage and agriculture is a major contributor of phosphorus to receiving waters (Dougherty *et al.,* 2004).

PO_4^{3-} and TP were positive correlated (r= 0.79 and 0.76) which indicated that the PO_4^{3-} and TP were also dependent on each other.

2.10. Reactive silicate:-

The present results declared that, silicate showed high significant seasonal variations but didn't show any variations depended on effluents discharging into the branch, Tables (2 – 5). The ranges of SiO_3^- were ranged between 1.74 – 4.80, 0.84 – 4.00, 0.9 – 2.73 and 1.24 – 4.73 mg/l during the same seasons. The lowest values of SiO_3^- were recorded during winter and spring seasons. This may be attributed to the silicate needed by diatoms which typically bloom water low-temperature conditions (i.e. late winter/early spring) (Wetzel, 2001).

In fact the waste water discharged (400,000 m³/day) from El-Rahawy (sewage and domestic wastes), agricultural wastes of Soble drain, in addition to industrial effluents of El-Malyia Company at Kafr El-Zyate City even today. The aquatic environment of the Rosetta branch at these drains still has very poor water quality and the aquatic life there in has been threatened to a devastating point, where there is no detectable change recorded in the concentrations of the key dissolved nutrient parameters N and P, both of which are generally high in the previously published e.g. Elewa and Ghallab

(2000); Abdel-Satar and Elewa (2001); Abdo (2002); Sayed (2003); Abdel-Satar (2005); Abdel-Aziz (2005) and Elewa *et al.*(2009), and the present data.

3. Statistical analysis:-

For the purpose of comparison between the degree of variability through whole year each component separately, coefficient variation "V" was calculated for the studied physical and chemical parameters of water samples.

In the same manner of "SD", the "V" values were increased in the physical and chemical parameters characterized by high concentration variations and vice-versa, Tables (2-5). Due to this observation, the variation orders of the studied parameters were found to be:

$NO_2^- > NO_3^- > NH_3 > PO_4^{3-} > BOD > CO_3^{2-} > SO_4^{2-} > COD > Trans > TP > SiO_3^- > Cl^- > DO > Mg^{2+} > TS > EC > HCO_3^- > Ca^{2+} > A\ ^0C > W\ ^0C > pH.$

88.41 > 72.73 > 63.41 > 62.92 > 62.73 > 61.31 > 54.31 > 44.36 > 39.9 > 38.65 > 38.65 > 23.37 > 23.15 > 23.06 > 20.82 > 17.53 > 17.16 > 9.84 > 6.24 > 3.55 > 3.2 respectively. These interpretations are agreement with that finding by Abdo (2006).

Generally, the comparison between the obtained results of physico-chemical parameters of the River Nile at Rosetta branch with other world rivers. Such as Osun River, southwestern, Nigeria (Olajire and Imeokparia, 2001), the concentration values of electrical conductivity, phosphate, nitrate, ammonia and chloride in Rosetta branch water less than Osun River. While were found in the same ranges of Turag River, Bangladesh (Zakir *et al.,* 2006).

Conclusion

1 – The River Nile at Rosetta branch remains threaded by the increasing of human activities in the long term which affect the aquatic environment and water quality characteristics of the branch. El-Rahawy, Soble and Kafr El-Zyate company drains are the main pollution sources along Rosetta branch due to huge amount of sewage domestic, agricultural and industrial wastes inflow into the branch.

2 – Statistical analysis "SD", "V" and "r" revealed that the strong relationships among the studied physical and chemical parameters in aquatic environment of the Rosetta branch.

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