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Assessment the Physico-Chemical Characteristics of Water and Sediment in Rosetta Branch, Egypt

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Abstract

Water quality of Rosetta Branch may be changed by several factors in the last decades as a result of anthropogenic activities. So, it's important to study the physicochemical characteristics of both water and sediment in the Rosetta Branch. Two identified sources are the main origin of most pollutants in this branch, namely: El-Rahawy drain and industrial activities in Kafr El-Zayat city. From the data of water quality index (WQI) based on six important parameters (pH, T ˚C, DO, BOD, COD and TP), it indicates that site 2 (from Kom Hamada to Edfina) is more polluted than the other two sites (from El-Qanater El-Khairia to Kom Hamada and from Edfina to Rosetta). The concentrations of heavy metals increase in sites that are more affected by drainage water from different drains. Great efforts are needed and wastewater must be treated before draining it into the River Nile water.

Keywords

Rosetta Branch, Physicochemical Characteristics, Pollution, WQI

1. Introduction

The River Nile is the major regular and voluminous supply of water secured in Egypt [1] [2]. In a survey of world freshwater, it has been reported that Egypt is one among the top first ten countries to be scare of water by the year 2025 due to the rapidly increasing population [3]. The agricultural activities and domestic wastes are the main sources of water pollutants in the River Nile.

The Rosetta Branch runs for about 220 km in length with average width 180 m and with an average depth varies between 1.5 - 16.0 m. It flows downstream Delta Barrage to the NW where it ends with Edfina Barrage which

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releases excess water to the Mediterranean Sea. Unfortunately, it receives polluted waters from different sources including industrial, agricultural and urban sewage that are causing serious environmental impacts on its freshwater [4]. It is affected by the agricultural drains located along the branch and by the industrial companies at Kafr El-Zayat city. The drains are EL-Rahawy, Sabal, El Tahrir, Zaweit El-Bahr and Tala. These agricultural drains also receive domestic water from 55 towns and villages distributed along this branch. The industrial effluents are from El-Maliya, Mobidat and Salt and Soda companies which are discharging directly at the east bank of the branch. These two sources of pollution potentially affect and deteriorate its quality of water [5].

Pollution can be defined as the change of physical, chemical and biological properties of water, restricting or preventing its use in the various applications [6]. Important physical and chemical parameters influencing the aquatic environment are temperature, rainfall, pH, salinity, dissolved oxygen. Others are total suspended and dissolved solids, total alkalinity and acidity and heavy metal contaminants. These parameters are the limiting factors for the survival of aquatic organisms (flora and fauna). Poor water qualities may be caused by low water flow, municipal effluents and industrial discharges [7].

The cost of the environmental degradation due to water pollution is relatively high with serious health and quality of life consequences; as well as increasing the severity of water scarcity problems. Hence, increasing water pollution causes not only the deterioration of water quality but also threatens human health and the balance of aquatic ecosystems, economic development and social prosperity [8]. The closed water system of Egypt makes it more vulnerable to quality deterioration in a northward direction toward the Nile Delta [9].

The water quality index (WQI) is a mathematical model used to integrate complex data to generate a score that describes the status of water quality to the public as well as decision and policy makers [10] [11]. WQI may also be used for comparing the quality of different water sources and monitoring the temporal changes in water quality [12]. The aim of this study was to analyze the river water quality of Rosetta Branch, Nile Delta, Egypt. Therefore, the physical and chemical parameters of water as well as those of sediment were determined.

2. Materials and Methods

2.1. Study Area

Rosetta Branch, as shown in **Figure 1**, located at the western part of the Nile Delta. Its length is about 220 km, average width 180 m with an average depth varies between 1.5 - 16.0 m. It serves five governorates of the Nile Delta: Qaliubiah, Kafr El-Sheikh, El-Gharbia, El-Menofyia and El-Behira. The study area divided into three sites as follows: site 1 (from El-Qanater El-Khairia to Kom Hamada), site 2 (from Kom Hamada to Edfina) and site 3 (from Edfina to Rosetta).

Figure 1. Map of the Nile Delta showing different ecological sites of the study area.

According to the map of the world distribution of the arid regions [13], the climatic conditions of the Nile Delta are similar to those of the northern part of Egypt, it is rather arid to semiarid, where the rate of evaporation exceeds many times the rate of precipitation. The mean minimum air temperature varies from 6.2˚C in February to 23.6˚C in August. The mean maximum air temperature ranges between 17.4˚C in January to 34.2˚C in July. The relative humidity ranges from 51% in May to 76% in December. The total annual rainfall ranged between 38.1 - 190.8 mm along the Branch from south at Shebin El-Kome city to the north at Rosetta city. The evaporation attains the highest annual mean value (6.8 mm/day) at Tanta and the lowest value (4.2 mm/day) at Rosetta.

2.2. Analytical Methods

2.2.1. Sediment Analysis

Sediment samples were collected from the 50 stands of the ecological sites for soil analysis. The texture of sediment samples, water-holding capacity, oxidizable organic carbon and chlorides was determined according to Piper [14]. Calcium carbonate content was determined according to Jackson [15]. Electric pH-meter was used to determine the soil reaction. Electrical conductivity was measured by YSI Incorporated Model 33 conductivity meter. Carbonates and bicarbonates were determined according to Pierce *et al.* [16]. Suphates were estimated gravimetrically and the total dissolved phosphorus was determined by direct stannous chloride method [17], while the total nitrogen was determined by the micro-Kjeldahl method according to Allen *et al.* [18] and heavy metals (Fe, Mn, Zn, Pb, Cu, Ni, Cd and Co) were carried out according to Allen *et al.* [19].

2.2.2. Water Analysis

Water temperature was measured using YSI model 33 S.C.T. meter, electrical conductivity was measured directly using conductivity meter (Model Corning, NY 14831 USA), The pH value of surface water was measured in situ by using Electrical-pH meter (Model Lutron YK-2001pH meter). Dissolved oxygen was measured directly using dissolved oxygen meter (Lutron YK-22 DO meter). The BOD, COD, chloride and total phosphorus according to APHA [17]. Calcium carbonate content was determined according to Welch (1948). Sulphate content was estimated gravimetrically according to Jackson [15]. Water-soluble carbonates and bicarbonates were determined according to Baruah and Barthakur [20]. The total nitrogen was determined by the micro-Kjeldahl method according to Allen *et al.* [18] and heavy metals (Fe, Mn, Zn, Pb, Cu, Ni, Cd and Co) were carried out according to Allen *et al.* [19].

2.3. Statistical Analysis

The data of the different ecological sites were compared by one-way ANOVA. The one-way ANOVA and correlation analyses were conducted using SPSS 16 for Windows.

2.4. Water Quality Index (WQI)

WQI is 100 points scale that was used to summarize results from different physicochemical measurements using computer program created by the National Sanitation Foundation, USA. The used parameters are: pH, T ˚C, DO, BOD, COD and TP. This index reduces huge amounts of data to a single number thus ranking water into one of five categories: very bad water (0 - 25), bad (25 - 50), medium (50 - 70), good (70 - 90) and excellent quality of the sampled water (90 - 100). It can be calculated as the following equation:

$$WQI = K \frac{\sum_i C_i W_i}{\sum_i W_i} \quad (1)$$

where: K is a subjective constant representing the visual impression of river water quality. WQI ranges from 0.25 (highly polluted water) to a maximum value of 1.0 (good quality water). C_i is the value assigned to each measured parameter after normalization on a scale from 0 to 100, where; Zero indicates water that is not suitable for the intended use without further treatment and 100 represents perfect water quality. W_i is the relative weight assigned to each parameter. A maximum weight of 4 was assigned to parameters of relevant importance for aquatic life such as DO, while the minimum value (unity) was assigned to parameters with minor relevance such as temperature and pH.

Full details about the index with a free calculating program are available at the following website http://www.water-research.net/watrqualindex/waterqualityindex.htm.

3. Results

3.1. Sediment Characteristics

The physical and chemical characteristics of the sediments collected from three ecological sites of the Rosetta Branch of the River Nile are shown in **Table 1**. Chloride, bicarbonate, total nitrogen, sodium and SAR showed highest significant correlations ($P < 0.05$) among three ecological sites. Chlorides and Na^+ showed high mean concentrations (1.40% and 147.86 mg/100g, respectively) in site 3 and bicarbonate (1.05%) in site 2, while the lowest mean value was recorded in site 1 (0.21%, 50.02 mg/100g and 0.82%, respectively). Total nitrogen showed high mean concentrations (3.96 mg/100g) in site 1, while the lowest mean values of TN was observed in site 3 (2.36 mg/100g). On the other hand, electrical conductivity, pH, K^+ and SAR exhibited low significant correlations ($P < 0.05$) among three ecological sites. The pH- values ranged between neutral to alkaline along this branch. Electrical conductivity, SAR and K^+ exhibited the highest mean value (1833.40 µmhos/cm, 22.32 and 41.54 mg/100g) were recorded in site 3, while the lowest mean value of EC and SAR (494.31 µmhos/cm and 11.94) were recorded in site 2, except K (12.13 mg/100g) in site 1.

Table 1. Means and standard errors of sediment characteristics collected from three ecological sites of Rosetta Branch of River Nile. WHC = Water holding capacity, OC = Organic carbon, EC = Electrical conductivity, TP = Total phosphorus, TN = Total nitrogen, PAR = Potassium adsorption ratio, SAR = Sodium adsorption ratio, ns = non-significant, *: Values are significant at P < 0.05, **: values are significant at P < 0.01, ***: values are significant at P < 0.01. Different superscript letters indicate a significant difference between different sites.

Sediment variables		Ecological sites			Mean (n =50)	F-Value	$LSD_{0.05}$
		Site 1 (n = 20)	Site 2 (n = 20)	Site 3 (n = 10)			
Sand	%	$89.64^{ab} \pm 1.05$	$85.18^{b} \pm 0.77$	$90.87^{a} \pm 28.74$	88.56 ± 10.19	3.29	4.32^{ns}
Clay	%	$8.56^{a} \pm 0.97$	$12.77^{a} \pm 0.71$	$7.23^{a} \pm 2.29$	9.52 ± 1.32	0.44	0.72^{ns}
Silt	%	$1.80^{ab} \pm 0.15$	$2.06^{a} \pm 0.16$	$1.90^{b} \pm 0.60$	1.92 ± 0.30	3.79	3.90^{*}
EC (µmhos/cm)		$522.85^{b} \pm 66.86$	$494.31^{b} \pm 58.33$	$1833.40^{a} \pm 579.77$	950.19 ± 234.99	5.03	1061.50^{*}
pH		$8.23^{a} \pm 0.09$	$8.14^{ab} \pm 0.08$	$7.84^{b} \pm 2.48$	8.07 ± 0.88	7.68	0.30^{**}
WHC	%	$48.43^{b} \pm 2.08$	$57.17^{a} \pm 3.52$	$46.59^{b} \pm 14.73$	50.73 ± 6.78	3.66	10.45^{*}
$CaCO_3$	%	$4.76^{a} \pm 0.66$	$4.55^{a} \pm 0.57$	$4.76^{a} \pm 1.51$	4.69 ± 0.91	0.11	2.35
OC	%	$0.99^{a} \pm 0.13$	$0.92^{a} \pm 0.19$	$1.29^{a} \pm 0.41$	1.06 ± 0.24	1.45	0.62^{ns}
Cl^-	%	$0.21^{b} \pm 0.02$	$1.33^{a} \pm 0.04$	$1.40^{a} \pm 0.44$	0.98	56.71	0.25^{***}
SO_4^-	%	$1.11^{a} \pm 0.06$	$1.06^{a} \pm 0.02$	$1.30^{a} \pm 0.41$	1.16 ± 0.16	1.53	0.31^{ns}
HCO_3^-	%	$0.82^{c} \pm 0.01$	$1.05^{a} \pm 0.02$	$0.98^{b} \pm 0.31$	0.95 ± 0.16	35.98	0.06^{***}
TN	mg/100g dry soil	$3.96^{b} \pm 0.36$	$3.15^{a} \pm 0.54$	$2.36^{c} \pm 0.75$	3.16 ± 0.55	26.19	0.16^{***}
TP	mg/100g dry soil	$0.74^{a} \pm 0.04$	$1.00^{a} \pm 0.04$	$0.48^{a} \pm 0.15$	0.74 ± 0.08	1.14	1.78^{ns}
Na^+	mg/100g dry soil	$50.02^{b} \pm 5.72$	$59.52^{b} \pm 5.39$	$147.86^{a} \pm 46.76$	85.8 ± 19.29	14.65	43.80^{***}
K^+	mg/100g dry soil	$12.13^{b} \pm 1.72$	$17.12^{ab} \pm 3.87$	$41.54^{a} \pm 13.14$	23.59 ± 6.24	3.44	22.71^{*}
Ca^{++}	mg/100g dry soil	$24.77^{b} \pm 2.23$	$28.35^{ab} \pm 5.47$	$63.89^{a} \pm 20.21$	39.00 ± 9.30	3.27	34.30^{ns}
Mg^{++}	mg/100g dry soil	$16.56^{a} \pm 2.60$	$29.38^{a} \pm 8.23$	$35.78^{a} \pm 11.31$	27.24 ± 7.38	1.77	26.89^{ns}
SAR		$13.54^{b} \pm 1.14$	$11.94^{b} \pm 1.67$	$22.32^{a} \pm 7.06$	15.93 ± 3.29	8.97	6.67^{**}
PAR		$2.59^{a} \pm 0.28$	$3.28^{a} \pm 0.66$	$5.80^{a} \pm 1.83$	3.89 ± 0.92	1.78	3.20^{ns}

3.2. Water Characteristics

The physical and chemical proprieties of water samples from three ecological sites of the Rosetta Branch of the River Nile are shown in **Table 2**. Water variables showed highest significant correlations ($P < 0.05$) among three ecological sites, except pH and sulphates. pH values in water were varied from neutral to slightly alkaline. EC increases from site 1 to site 3 and ranged between 323.63 to 18663.20 µmhos/cm. Organic Matter indicators (BOD and COD) exhibited the highest mean value (23.29 and 69.87 mg/l) in site 2, while the lowest mean value was obtained in site 3 (9.78 and 13.20 mg/l).

For anions, the highest mean values were recorded in site 3 except for SO_4, in site 2 and their values are (6526.58, 4075.33 and 4142.68 mg/l) for Cl, SO_4 and HCO_3, respectively. While, the lowest mean value of these was recorded in site 1 (664.58, 2557.80 and 244.18 mg/l) for Cl, SO_4 and HCO_3. TN and TP in water samples take the same distribution as their lowest mean values were recorded in site 3 (0.72 and 1.33) and the highest mean values were (3.14 and 2.16) which were recorded in site 2 for TN and TP, respectively. The lowest mean values of cations were recorded in site 1 and their highest mean values were recorded in site 3 as they ranged between (245.46 - 4405.43; 34.28 - 519.94; 32.19 - 1135.50 and 28.42 - 445.72) for Na, K, Ca and Mg, respectively. For the calculated SAR and PAR, the lowest mean values were recorded in site 1 (27.52 and 3.89) and the highest mean values were recorded in site 3 (155.91 and 18.17) for SAR and PAR, respectively.

Table 2. Means and standard errors of water sample characteristics collected from three ecological sites of Rosetta Branch of River Nile. EC = Electrical conductivity, DO = Dissolved oxygen, BOD = Biological oxygen demand, COD = Chemical oxygen demand, TP = Total phosphorus, TN = Total nitrogen, PAR = Potassium adsorption ratio, SAR = Sodium adsorption ratio, WQI: water quality index, ns = non-significant, *: Values are significant at P < 0.05, **: values are significant at P < 0.01, ***: values are significant at P < 0.01. Different superscript letters indicate a significant difference between different sites.

Water Variables		Ecological sites			Mean (n =50)	F-Value	$LSD_{0.05}$	*Egyptian law No. 48/1982
		Site 1 (n = 20)	Site 2 (n = 20)	Site 3 (n = 10)				
Depth (cm)		5.69^{b} ± 184.39	b176.98^{b} ± 7.07	218.79^{a} ± 12.88	133.82 ± 68.11	6.18	29.49**	-
Temp. (˚C)		30.25^{a} ± 0.38	30.26^{a} ± 0.34	22.86^{a} ± 0.32	27.79 ± 0.35	90.40	1.37***	-
pH		7.76^{a} ± 0.08	7.93^{a} ± 0.06	7.96a ± 0.03	7.88 ± 0.06	1.36	0.25ns	7 - 8.5
EC (µmhos/cm)		323.63^{a} ± 18.72	626.05^{b} ± 17.66	18663.20^{a}±382.01	938.63 ± 139.46	2241.93	643.38***	-
DO		10.40^{b} ± 0.52	10.82^{b} ± 0.34	13.32^{a} ± 0.42	11.51 ± 0.43	5.92	1.98**	≥5 mg/l
BOD		9.78^{b} ± 1.48	23.29^{a} ± 1.95	12.86^{b} ± 1.92	15.31 ± 1.78	10.03	6.89***	≤6 mg/l
COD		26.37^{b} ± 3.93	69.87^{a} ± 6.36	13.20^{b} ± 0.70	36.48 ± 3.66	31.91	16.93***	≤10 mg/l
Cl^{-}		664.58^{c} ± 151.56	1403.81^{b} ± 184.33	6526.58^{a} ± 385.88	2864.99 ± 240.59	111.80	870.19***	-
SO_4^{-}		2557.80^{b} ± 604.79	4075.33^{a} ± 1118.28	3582.24^{ab} ± 305.0	3405.12 ± 676.02	2.72	3526.76ns	≤200
HCO_3^{-}		244.18^{c} ± 19.70	759.95^{b} ± 116.01	4142.68^{a} ± 275.47	1715.60 ± 137.06	125.49	537.70***	<200 mg/l
$CaCO_3$	mg/l	105.44^{b} ± 3.81	164.99^{a} ± 4.60	161.05^{a} ± 7.54	143.83 ± 5.32	37.24	16.64***	50 - 200 mg/l
T.N		2.68^{b} ± 0.10	3.14^{a} ± 0.11	0.72^{c} ± 0.10	2.18 ± 0.1	129.01	0.35***	-
T.P		1.46^{b} ± 0.05	2.16^{a} ± 0.06	1.33^{b} ± 0.05	1.65 ± 0.05	32.87	0.24***	-
Na^{+}		245.46^{b} ± 55.82	491.05^{b} ± 72.45	4405.43^{a} ± 302.76	1713.98 ± 143.68	151.11	560.16***	-
K^{+}		34.28^{b} ± 5.02	59.49^{b} ± 7.53	519.94^{a} ± 35.35	204.57 ± 15.97	159.02	63.79***	-
Ca^{2+}		32.19^{b} ± 8.92	63.50^{b} ± 18.94	1135.50^{a} ± 78.29	410.40 ± 35.38	167.57	141.17***	-
Mg^{2+}		28.42^{b} ± 4.43	57.34^{b}± 8.02	445.72^{a} ± 41.53	177.16 ± 17.99	85.68	74.0***	-
SAR		27.52^{b} ± 5.15	45.90^{b} ± 5.17	155.91^{a} ± 4.82	76.44 ± 5.05	106.16	20.35***	-
PAR		3.89^{b} ± 0.58	5.46^{b} ± 0.61	18.17^{a} ± 0.55	9.17 ± 0.58	102.81	2.30***	-
WQI		**59.28**	**44.28**	**60**	-	-	-	-

*Egyptian standard regularities of article 60-law No. 48/1982 regarding minimum standards for the water quality of the Nile River.

Moreover, The WQI values indicated some variations in water quality between the different samples in all ecological sites. With highest quality at site 1 (from El-Qanater El-Khairia to Kom Hamada), while lowest quality at site 2 (from Kom Hamada to Edfina). The water quality during these sites fluctuated from good to bad water (**Figure 2**).

3.3. Heavy Metals Concentrations in Sediment and Water Samples

The cited results in **Table 3** show the concentrations of the heavy metals of the sediment and water samples collected from Rosetta Branch of the River Nile (3 sites, 50 stands). Heavy metals (Fe, Mn, Zn, Cu, Pb, Ni, Cd and Co) of the sediment and water variables showed highest significant correlations ($P < 0.05$) among three ecological sites, except Mn, Cd and Co in sediment and Cu and Ni in water. It is obvious that the iron ion concentrations in the sediment (28.61, 28.63 and 26.25 mg/kg) and water (0.44, 0.33 and 0.47 mg/l) samples were high compared to the other elements, in site 1, 2 and 3, respectively.

Zinc, copper, lead, nickel ions exhibited the highest concentration (5.45, 5.10, 5.47 and 2.79 mg/kg, respectively) in site 2, while, the lowest mean value (2.90, 2.89, 3.35 and 1.68 mg/kg, respectively) were recorded in sediment of site 3. In water samples, the highest concentration of manganese (0.27 mg/l), lead (0.10 mg/l), cadmium (0.04 mg/l) and cobalt (0.07 mg/l) recorded in site 3, while the lowest concentration (10.0, 0.06, 0.03 and 0.03 mg/l) estimated in site 1 and 2.

Table 3. Means and standard errors of heavy metals in sediment and water samples collected from three ecological sites of Rosetta Branch of River Nile. ns = non-significant, *: Values are significant at $P < 0.05$, **: values are significant at $P < 0.01$, ***: values are significant at $P < 0.01$. Different superscript letters indicate a significant difference between different sites.

Heavy metals	Ecological sites			Mean (n = 50)	F-Value	$LSD_{0.05}$	*Egyptian law No. 48/1982
	Site 1 (n = 20)	Site 2 (n = 20)	Site 3 (n = 10)				
Sediments (mg/kg)							
Fe	$28.61^a \pm 0.43$	$28.63^a \pm 0.53$	$26.25^b \pm 0.50$	27.83 ± 0.49	14.26	1.45^{***}	-
Mn	$17.40^a \pm 0.24$	$16.94^a \pm 0.24$	$16.99^a \pm 0.33$	17.11 ± 0.27	1.18	0.83^{ns}	-
Zn	$4.79^b \pm 0.14$	$5.45^a \pm 0.14$	$2.901^c \pm 0.24$	4.38 ± 0.17	52.64	0.55^{***}	-
Cu	$4.31^b \pm 0.15$	$5.10^a \pm 0.14$	$2.89^c \pm 0.21$	4.1 ± 0.17	39.46	0.55^{***}	-
Pb	$4.77^b \pm 0.13$	$5.47^a \pm 0.12$	$3.35^c \pm 0.26$	4.53 ± 0.17	35.43	0.56^{***}	-
Ni	$2.68^a \pm 0.10$	$2.79^a \pm 0.08$	$1.68^b \pm 0.14$	2.38 ± 0.11	22.69	0.37^{***}	-
Cd	$0.49^a \pm 0.08$	$0.40^a \pm 0.05$	$0.47^a \pm 0.15$	0.45 ± 0.09	0.033	0.32^{ns}	-
Co	$0.67^a \pm 0.06$	$0.47^a \pm 0.05$	$0.69^a \pm 0.12$	0.61 ± 0.08	1.95	0.27^{ns}	-
Water (mg/l)							
Fe	$0.44^a \pm 0.02$	$0.33^b \pm 0.01$	$0.47^a \pm 0.01$	0.41 ± 0.01	11.25	0.07^{***}	≤1.0
Mn	$0.10^b \pm 0.01$	$0.10^b \pm 0.01$	$0.27^a \pm 0.01$	0.16 ± 0.01	53.59	0.04^{***}	≤0.5
Zn	$0.09^b \pm 0.00$	$0.07^a \pm 0.01$	$0.03^c \pm 0.00$	0.06 ± 0.00	47.88	0.013^{***}	≤1.0
Cu	$0.04^a \pm 0.00$	$0.05^a \pm 0.00$	$0.06^a \pm 0.00$	0.05 ± 0.00	1.43	0.015^{ns}	≤1.0
Pb	$0.06^b \pm 0.00$	$0.06^b \pm 0.00$	$0.10^a \pm 0.01$	0.07 ± 0.00	20.30	0.013^{***}	≤0.05
Ni	$0.03^a \pm 0.00$	$0.03^a \pm 0.00$	$0.03^a \pm 0.00$	0.03 ± 0.00	3.2	0.009^{ns}	-
Cd	$0.03^b \pm 0.00$	$0.03^b \pm 0.00$	$0.04^a \pm 0.01$	0.03 ± 0.00	4.19	0.014^{*}	≤0.01
Co	$0.03^b \pm 0.00$	$0.04^b \pm 0.00$	$0.07^a \pm 0.00$	0.41 ± 0.01	19.21	0.011^{***}	-

*Egyptian standard regularities of article 60-law No. 48/1982 regarding minimum standards for the water quality of the Nile River.

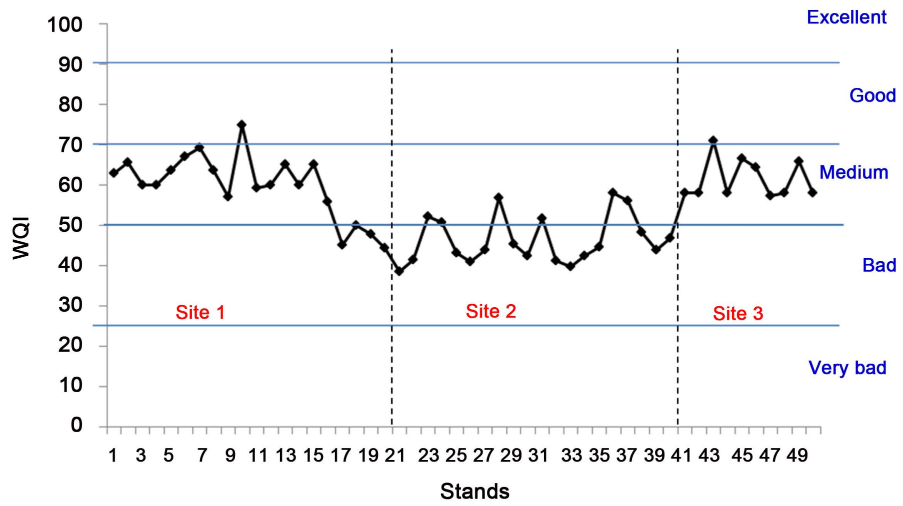

Figure 2. Variations in water quality index at the different sampling stands within the study area.

4. Discussion

4.1. Sediment

Soil is a precious natural resource, but its quality is deteriorated due to several anthropogenic activities [21]. The majority of grain size of the Rosetta sediments is fine sand especially nearby shoreline, this agrees with Abo Zed and Shereet [22]. Electrical conductivity ranged between 494.31 at site 2, while the highest mean value of EC in sediments samples was recorded in site 3 (Edfina-Rosetta) as a result of sea water intrusion. Overall, we can say that Edfina dam acts as artificial barrier which prevents natural equilibrium between Rosetta Branch and the Mediterranean Sea, this is agrees with El-Amier *et al.* [23] on environmental changes along Damietta Branch.

The highest mean value of organic carbon was recorded in site 3, this may attributed to the transformation, the rate of precipitation and deposition of dead aquatic plants and different wastes in this site (the end of Rosetta Branch), this agrees with Venkatramanan *et al*. [24].

The highest mean value of total nitrogen in soil was recorded in site 1; this could be attributed to El-Rahawy drain, an agricultural drain which also receives sewage water [5]. While the highest mean value of TP in sediment was observed in site 2 as a result of different drainage water sources from Zawiet El-Bahr drain and Kafr El-Zayat City.

All the sediment samples after Edfina dam (site 3) are characterized by the domination of HCO_3^- anion followed by Cl^- and SO_4^-. The cationic order of the sediment samples is: $Na^+ > Ca^{2+} > Mg^{2+} > K^+$ in all sites. The highest values were recorded in site 3 and lowest ones were at sites 1 and 2. This could be attributed to the seawater intrusion, which agrees with Elkhatat *et al*. [25] and El-Amier *et al*. [23].

4.2. Water

Water pollution is one of the most principal environmental and public health problems in River Nile [23]. The highest mean value of EC in water was recorded in site 3, this could be attributed to drainage water in this area from land runoff which contains large amounts of cations and anions, this agrees with Ezzat *et al.* [26]. The values of pH increases also in site 3 may due to the flourishing and the photosynthesis process of aquatic plants also the water seems to be alkaline because of sea water intrusion according to Patra *et al*. [27], El Bouraie *et al.* [28] and Ibrahiem *et al*. [29]. The values of pH are within the Egyptian law [30].

The high concentrations of dissolved oxygen are very vital and important for aquatic organisms as it is required for the metabolism of aerobic organisms and organic matter decomposition [26]. The lowest mean value of dissolved oxygen was observed in site 1 (10.40 mg/l), this could be attributed to the drainage water from El-Rahawy drain which characterized by high load of organic wastes and the microbial activity that degraded the organic matter led to the oxygen consumption. While the highest mean value of DO (13.32 mg/l) was recorded in site 3 far away from drains. The values of DO are within the Egyptian law [30].

It's noticeable that BOD is very high especially in site 2, opposite to Kafr El-Zayat city, as there are many companies and drains and increasing of the organic load, while the lowest mean value was recorded in site 1, this agrees with Zyadah [8] and El-Alfy [31], the values of BOD is higher than value of Egyptian law [30].

Chemical oxygen demand defines as a measure of capacity of water to consume oxygen in decomposition of organic and inorganic matters [32]. The lowest mean value of COD (26.37 mg/l) was recorded in site 1, while the highest mean value was observed in site 2 (69.87), this could be attributed to the industrial companies and agricultural activities in these areas, so huge amounts of sewage and domestic wastes concentrated in this site, also from the industrial effluents of El-Malyia Company discharging into the aquatic environment of the branch and this value is higher than (32) recorded by Abdo [33]. The values of COD are higher than the standard limits of Egyptian law [30].

The use of phosphate fertilizers tends to increase the phosphor content in water. Phosphate plays a role in plant and animal metabolism and thus occurs in their waste products. Domestic detergent and industrial sewage effluents represent important sources of phosphor in natural water. High concentrations of nutrients (i.e. T.P and T.N) can cause many problems to the river water quality such as; acidification, eutrophication and impairing the aquatic organisms to survive or grow [6] [34]. The lowest mean values of TP and TN were recorded in site 3, while the highest mean value of both were recorded in site 2 opposite to different drains that discharging huge amounts of sewage, domestic and agricultural wastes into the Rosetta Branch without any treatment, this leading to the increase in the concentration levels of nutrients. High values of TP and TN are related to agricultural wastes this agrees with the findings of Dougherty *et al*. [35] and Abdo [33].

Alkalinity is related to pH, alkalinity of water may be caused due to OH, CO_3, HCO_3 ions [36]. The lowest mean value of alkalinity (105.44 mg/l) was recorded at site 1, while the highest mean value was recorded at site 2 (164, 99 mg/l), this could be attributed to the decomposition of organic matter in this site.

Chlorides were higher in site 3, this due to sea water intrusion in site 3 [33], while sulphates is higher in site 2 may due to the effect of different drains distributed in Kafr El-Zayat City and different drains which increase sulphates in this area. Chloride concentrations higher than 200 mg/L are considered to be a risk for human health and may cause unpleasant taste of water [37]. However, Sulphates in high levels cause water hardening. Sulphates in these sites exceed the WHO permissible limit which is 200 mg/l [38].

Cations in water take the following sequence; $Na^+ > Ca^{++} > K^+ > Mg^{++}$. Na^+ is the most abundant between other cations; this could be attributed to the drainage water from different agricultural and cultivated lands [39]. Abdel-Halim [40] stated that 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.

From the calculations of WQI, it's noticeable that water quality index ranged from medium in site 1 (59.28) and site 3 (60) and bad in site 2 (44.28); this due to the drainage water from different drains in site 2 that effect on the water quality of Rosetta Branch.

4.3. Heavy Metals

Sediments are the main origin and source of heavy metals in the aquatic environment and play an important role in the transport and storage of potentially hazardous metals [41]. The concentrations of heavy metals in the sediments of different sites in Rosetta Branch take the following accumulation order: Fe > Mn > Zn > Cu > Pb > Ni > Co > Cd. This indicated that Fe was the most accumulated element in sediment, whereas Cd was found to be the least concentration. This is agreeing with Yehia and Sebaee [42].

The highest concentrations of Fe and Zn were recorded in site 2 as a result of the drainage water from the industrial compound at Kafr El-Zayat City; this is agreeing with Masoud *et al*. [43] and El-Alfy [31]. Also, the increase of organic matter facilitates the deposition of Fe in sediment [44].

Manganese (Mn) is an essential trace nutrient in all forms of life. The highest mean value of Mn was recorded at site 1; this could be attributed to drainage water from El-Rahawy drain which is an agricultural drainage water source. Copper was high in site 2 that characterized by high clay percentage content, where there is significant correlation between copper and clay minerals as Fine-grained clay particles with more surface area contained more metals than coarse grained sand [45] [46]. Also this could be attributed to the industrial disposal in this site [47].

According to Waite [48], Pb normally exists in an un-dissolved form and in low concentration, except when water is polluted by exogenous inputs. The concentration of lead increases in site 2 than other sites may due to the agricultural drainage water or the deposition of dead plankton that increase its amount in the sediments, this is agree with Nafea [49] who found the same. Cd in the sediments of Rosetta Branch showed low high concentrations especially at site 1 as it is mostly correlated to agricultural activity especially the phosphatic fertilizers [31].

The highest mean value of Ni in the sediments was recorded at site 2; this could be attributed to sewage disposal from different drains. The highest mean value of cobalt was recorded at site 3, may due to sea water intrusion or from urban runoff as concluded by [50].

Heavy metal pollution in water is generally associated with agricultural, industrial and municipal discharges into water resources [51]. The concentrations of heavy metals in water take the following sequence: Fe > Mn > Cu > Pb > Zn > Cd > Co > Ni. The concentrations of Fe and Cu were found to be very high in water samples collected from site 3, mainly due to the inflow of surface run off from agricultural wastes (agricultural and rocks) [39]. The relatively high Zn level is suggestive of the influence of refuse dump and domestic sewage sources. It could also be attributed to industrial effluents [52]. High concentrations of zinc were recorded in site 1, attributed to domestic wastes especially stands nearby El-Rahawy drain.

Cadmium is widely distributed in the aquatic environment. Cadmium and Lead are non-essential elements and higher concentrations can occur in aquatic organisms close to anthropogenic sources. These metals are toxic even at low concentrations and have no known function in biochemical processes [53]. The highest concentration of cadmium was recorded in site 1 nearby drainage wastewater especially industrial wastes. These results are in agreement with those obtained by Bahnasawy *et al.* [54] and Hamed *et al*. [47] who reported that the higher concentrations of Cd were due to the waste waters from different industrial activities without treatment directly to the aquatic systems. Manganese occurs in surface waters that are low in oxygen and often does so with Fe. So the highest concentration of Mn was observed in site 3, where the iron showed high values in the same site. While, there is no difference between the concentrations of Ni in water between these sites. The values of Co was high at site 3, this could be attributed to urban runoff or sea water intrusion.

5. Conclusion

It's concluded that the drains along Rosetta Branch affect the water quality and may have an effect on the aquatic life. Huge amounts of pollutants are observed nearby El-Rahawy drain and close to the industrial compound in Kafr El-Zayat City. Trace metals with serious impacts are concentrated in wastewater especially as a result of industrial activities. Water quality index indicates that site two is more polluted and water quality is bad. The wastewater from point and non-point sources must be treated before being drained into the River water, which is a source of drinking and municipal uses in Egypt.

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