Microbiological and physicochemical evaluation of River Nile (Rosetta branch)

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ABSTRACT

This study was carried out during period extended from January 2013 to December 2013 to evaluate the microbiological and physicochemical characteristics of Rosetta branch water, River Nile. The examination includes eight locations along Rosetta branch. Temperature values were ranged between 17.6 to 31.0ºC while, pH values ranged between 7.16 to 7.98 during four seasons. Moreover, turbidity values were ranged between 1.90 to 33.7 NTU during all seasons. Regarding dissolved oxygen (DO) value, the lowest (3.1 mg/l) and the highest (8.0 mg/l) values were recorded during autumn and winter, respectively. Moreover, the highest (26.6 mg/l) and the lowest (3.30 mg/l) values of biological oxygen demand (BOD) were recorded during winter and autumn, respectively. Chemical oxygen demand (COD) values were ranged between 7.4 to 42.6 mg/l which recorded during winter season. Additionally, ammonia values were ranged between 0.22 to 7.70 mg/l during all four seasons. Nitrite values ranged between 0.002 to 0.071 mg/l during all four seasons. The lowest nitrate value (0.10 mg/l) and the highest value (1.02 mg/l) were recorded during summer and winter, respectively. Respecting the monthly changes in microbial counts of Rosetta branch, average log no. of total coliform was ranged between 1.84 to 6.88 CFU/100ml, the highest log no. in most locations were recorded during July. While, average log no. of fecal coliform was ranged between 1.30 to 6.5 CFU/100ml during all months. Moreover, the highest counts of log no. was (5.96 CFU/100ml) and the lowest log no. was (0.30 CFU/100ml) of *E. coli* were recorded during August. Additionally, the highest log no. of fecal streptococci (4.85 CFU/100ml) was recorded during July.

Key words: Rosetta branch, microbiological, physicochemical, River Nile

Introduction

River Nile is the longest river in the world, located in the north-east of the continent of Africa, and stems specifically from Lake Victoria and ends in the Mediterranean Sea, a length of 6695 kilometers, and covers the Nile basin more than three million kilometers, it passes through 10 countries: the upstream States, Uganda, Ethiopia, Eritrea, Congo, Burundi, Tanzania, Rwanda, Kenya and the downstream states, Sudan and Egypt **(Encyclopedia Britannica, 2017)**. The River Nile in Egypt splits into two branches, the first is Rosetta Branch located in Lower Egypt, the western limit of the Delta before the river pours into the Mediterranean Sea. Whereas, the second is the Damietta branch to the east **(Salvini *et al*., 2015).** It also has four Rayahs (Canals) namely El-Nassery, El-Behery, El-Menofy and El-Toufeky **(Abdel-Aziz, 2005)**. Concerning the Rosetta branch, it is about 230 km in length with average width 180 m and average depth between 2-4 m. The Rosetta branch extends from Al-Qanatir Charity to the Mediterranean Sea at a length of 169 km and runs between five governorates (Giza, Menoufia, Gharbia, Beheira, Kafr El-Sheikh). 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 Al-Rahawy, Sabal, El-Tahreer, Zawiet El-Bahr and Tala **(Ibrahim *et al*., 2017 a).** Rosetta branch receives different types of pollution that affects and deteriorates its water quality through Al-Rahawy drain that receives all sewage of Giza Governorate in addition to agricultural and domestic wastes of Al-Rahway village and discharge these wastes (400,000 m^3/day) directly without treatment into the branch **(Tayel *et a1*., 2008)**. Moreover, Kafr El-Zayat industrial area, which include the industrial effluents from the factories of super phosphate and sulfur compounds, oil and soap industries and pesticides factories **(Daboor, 2006)**. Additionally, several small agricultural drains that discharge their water into the branch in addition to sewage discharged from several cities and its neighboring villages that are distributed along the two banks of the Rosetta branch **(El-Sayed, 2011)**. Nile River system receives a large quantity of industrial, agriculture and domestic wastewater. According to **Rifaat and Mohamed (2004)**, Rosetta branch as part of this system, flows downstream Delta Barrage to the north-west about 225 km and ends with Idfina barrage which regulates the excess flow of the branch. It is considered the main source of fresh water for the western side of the Nile Delta. Idfina barrage regularly releases water to the Mediterranean Sea during winter closure period. **Elewa *et a1*. (2009)** concluded that Rosetta branch remains threatened by the increasing of human activities on the long term which affect the water quality characteristics. A1-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. Water quality is a relative term that is defined as the characteristics of water that influence its suitability for a specific use through its physical, chemical, and biological nature. This nature could be altered through several contamination sources including: domestic, industrial, and agricultural wastes **(FAO, 1997)**. The physiochemical parameters are considered as the most important principles in the identification of the nature, quality and type of the water (fresh, brackish or saline) for any aquatic ecosystem. These parameters included water temperature, pH value and transparency (turbidity) **(Moustafa *et a1*., 2010)** moreover, BOD **(Abdo *et a1*., 2010)** and COD **(Garg *et a1*., 2010)**. Microbiological indicators for water pollution contains total coliforms, faecal coliforms, faecal streptococci and *Escherichia coli* **(Ezzat *et al*., 2012).** This study was carried out during period extended from January 2013 to December 2013 to evaluate the microbiological and physicochemical characteristics of Rosetta branch water, River Nile compared to **Law No. 48. (1982).**

Materials and Methods

1.1. Locations of the study sites at Rosetta branch, River Nile

The examination includes eight locations along Rosetta branch. The cods of sampling location with full of each site were described as follows in **Table (1).**

Table 1. Locations of the study sites at Rosetta branch, River Nile.

Location site	Distance from Delta Barrage (Km)	Description
N1	5.0	Downstream Delta barrage-upstream El-Rahawy drain
N2	15.0	Downstream El-Rahawy drain-upstream Sabal drain
N3	74.0	Downstream Sabal drain-upstream El-Tahreer drain
N4	89.0	Downstream El-Tahreer drain-upstream Zawiet El-Bahr drain
N5	103.0	Downstream Zawiet El-Bahr drain-upstream Tala drain
N6	135.0	Downstream Tala drain-downstream Abeg Village
N7	180.0	Rosetta branch at Foua city
N8	203.0	Rosetta branch upstream Idfina barrage

1.2. Physicochemical examination

Physicochemical analyses were performed according to the standard methods for examination of water and wastewater suggested by American Public Health Association **(APHA, 2005)**. Temperature (ºC) was estimated using thermal thermometer. PH values were determined using portable pH meter with electrode (WTW Model pH 197). Turbidity values were determined using HACH-RATIO/XR-turbidimeter gelex secondary turbidity standards (1800, 180, 18, 1.8 NTU). Dissolved oxygen (DO) was estimated using portable temperature/dissolved oxygen meter with oxygen and temperature probes (WTW Model Oxi 197) and expressed as mg/l at the same place and time of sampling. COD and BOD were measured gravimetrically determined according to **Stirling (1985).** Additionally, ammonia and nitrite and nitrate were determined according to **Gloterman *et al.* (1978).**

1.3. Bacteriological analysis

Total coliform count was determined using membrane filter technique according to standard method No.9222B **(APHA, 2005)** on M-Endo Agar LES medium (DIFCO, USA) and were recorded as CFU/100 ml. Fecal coliforms count were determined using membrane filter technique on M-FC agar medium (DIFCO, USA) according to standard method No. 9222D and No. 9230C **(APHA, 2005).** Whereas, *E. coli* detection was done according to the method described by **Pettibone (1992)** using multiple tube fermentation technique. Additionally, Fecal streptococci density was determined using membrane filter technique according to standard method No.9230 C **(APHA, 2005)** on M-Enterococcus agar medium (DIFCO, USA).

Results and Discussion

1.4. Physiochemical characteristics of River Nile, Rosetta branch

Physiochemical characteristics of Rosetta branch water were analyzed during the four seasons (Summer, Autumn, Winter and Spring) in 2013 at different sites.

1.4.1. Temperature, pH values and turbidity of River Nile water, Rosetta branch

Data in **Table (2)** showed the changes of temperature, pH and turbidity values in Nile's Rosetta branch water. Temperature values were ranged between 17.6-31.0ºC. The highest temperature (31.0ºC) was recorded during autumn in location No.8 (Rosetta branch upstream Idfina barrage) but the lowest value (17.6ºC) was recorded during winter in location No.1 (downstream Delta barrage upstream Al-Rahawy drain). Moreover, lower temperatures were recorded during winter followed by spring in all locations. Also, the lowest temperature during summer, autumn and spring were recorded in locations No. 1, 4 and 3, respectively. These results were in harmony with **Ezzat *et al*. (2012)** who reported that temperature changes ranged from 25.5°C to 27.7°C in drains outlets and between 25°C to 28.3°C along Rosetta branch sites during summer 2010 and winter 2011. Also, he said that temperature change depends mainly on the climatic conditions. In addition, **El Gammal and El Shazely (2008)** recorded that the temperature along Rosetta branch ranged from 20 to 30ºC at various seasons. Similarly, results by **Abdel-Satar *et a*l. (2017)** showed that temperature ranged between 17.8 to 18.9ºC during winter and between 18.7 to 27.9 ºC during spring. While, during summer and autumn the temperature ranged between 24.5 to 30.7ºC and 20.5 to 26.8ºC, respectively.

Regarding the seasonally changes of pH at Nile's Rosetta branch, data presented in **Table (2)** indicated that pH values ranged between 7.16 to 7.98. The highest value was recorded during winter in location No.1 (downstream Delta barrage-upstream Al-Rahawy drain) whereas, the lowest value was recorded during autumn in location No.7 (Rosetta branch at Foua city). Additionally, pH values were ranged between 7.86 to 7.42 during summer and between 7.16 to 7.94 during autumn. While, during summer and winter the pH values ranged between 7.68 to 7.98 and 7.35 to 7.92, respectively. Also, data showed that the highest pH during summer and winter were recorded in location No.1 (downstream Delta barrage-upstream Al-Rahawy drain). While, the highest recorded pH during autumn and spring were in location No.8 (Rosetta branch upstream Idfina barrage) and No.5 (downstream Zawiet El-Bahr drain-upstream Tala drain), respectively. Generally, the highest pH values in most under investigation sites were recorded during winter compared to other seasons. In this respect, **El Gammal and El Shazely (2008)** reported that pH values of 24 sites along the Nile from Aswan to Cairo ranged between 7.3 to 8.5 during winter and between 7.6 to 8.3 during spring. While, during summer and autumn pH values were ranged between 7.7 to 8.6 and 7.7 to 9.0, respectively. Also, **Ezzat *et al.* (2012)** showed that pH values water samples collected from Rosetta branch in summer and winter seasons were ranged from 7.45 to 7.9. Moreover, **Abdel-Satar *et al.* (2017)** reported that pH in the Nile River was generally on the alkaline side.

Table 2. Seasonally changes in temperature, pH values and turbidity in various locations at Rosetta branch, River Nile

Locations	Temperature (ºC)				Mean	pH				Mean	Turbidity (NTU)				Mean
	Su.	Au.	Wi.	Sp.		Su.	Au.	Wi.	Sp.		Su.	Au.	Wi.	Sp.	
No.1	28.0	27.0	17.6	23.0	23.9	7.86	7.70	7.98	7.35	7.72	4.00	4.00	4.20	5.00	4.30
No.2	28.7	28.3	18.0	25.0	25.0	7.42	7.43	7.78	7.73	7.59	15.9	29.5	8.40	33.5	21.83
No.3	29.0	26.0	18.5	21.0	23.6	7.65	7.21	7.84	7.44	7.54	21.7	27.2	14.0	27.5	22.60
No.4	29.6	25.5	19.0	24.0	24.0	7.72	7.65	7.80	7.66	7.71	16.0	26.1	8.80	23.0	18.48
No.5	29.7	29.5	19.0	22.0	25.1	7.76	7.42	7.80	7.92	7.73	17.0	25.3	9.40	19.0	17.68
No.6	30.0	30.3	19.8	26.0	26.5	7.58	7.53	7.70	7.41	7.56	33.7	31.7	10.5	34.5	27.60
No.7	29.5	27.9	19.7	24.5	25.4	7.64	7.16	7.68	7.51	7.50	8.30	17.5	2.80	17.5	11.53
No.8	29.2	31.0	19.9	22.7	25.7	7.68	7.94	7.75	7.73	7.78	4.60	15.0	1.90	19.5	10.25
Mean	29.2	28.2	18.9	23.5		7.66	7.51	7.79	7.59		15.2	22.03	7.5	22.4	
Standard	-					6.5-8.5					-				

Su.: summer Au.: Autumn Wi.: winter Sp.: spring

Locations description was presented in Table (1)

Turbidity is the measure of fine suspended matter in water, mostly caused by colloidal particles such as clay, silt, living and non-living organisms. In this respect, results in **Table (2)** clearly indicated that the highest value of turbidity was observed during spring in location No.6 (downstream Tala drain-downstream Abeg Village) at 34.5 NTU followed by the same location in summer at (33.7 NTU)). Whereas, the lowest value was in observed in winter in location No.8 (Rosetta branch upstream Idfina barrage) at 1.9 NTU. Moreover, site No (1) gave the lowest turbidity values during all seasons except during winter. Increasing values from up-stream to down-stream along the branch may be attributed to drains discharge **(Abdel-Satar *et al*., 2017)**. Also, among of all water samples from different sites the detected values of turbidity were greater in site No.6 (downstream Tala drain-downstream Abeg Village) than other sites. This may be due to the sewage effluent. Also, obtained results showed that the turbidity values were ranged between 4.33 to 7, 4.31 to 7, 1.9 to 10.5 and 5 to 34.5 during summer, autumn, winter and spring, respectively. In additions lower values were observed during winter than other three seasons. This trend of results was true in most under study sites. These results were reversible to results by **Abdel-Satar *et al.* (2017)** who reported that transparency values were lower (turbidity was higher) during winter. Similar results were observed by **Ezzat *et al.* (2012)** who found that turbidity values ranged between 8-26.5 NTU in Rosetta branch during summer and winter seasons. They also reported that turbidity values were negatively correlated with pH.

1.4.2. Dissolved oxygen (DO), chemical oxygen demand (COD) and biological oxygen demand (BOD_5) values in Rosetta branch, River Nile water

DO is required for the metabolism of aerobic organisms and it influences organic decomposition. Is also often used as an indicator of water quality. Regarding DO concentration in understudying sites along Rosetta branch, data presented in **Table (3)** showed that the lowest and the highest DO values were recorded in site No.3 (downstream Sabal drain-upstream El-Tahreer drain) during autumn at 3.1 mg/l and site No.1 (downstream Delta barrage-upstream Al-Rahawy drain) during winter at 8.0 mg/l, respectively. During summer, DO values were higher than other three seasons in sites No.3,4,5,6 and 7. In addition, the highest DO values during summer was recorded in site No.7 (Rosetta branch at Foua city) whereas, the lowest values were recorded in site No.2 (downstream Al-Rahawy drain-upstream Sabal drain). The highest DO values during autumn, winter and spring were recorded in site No.1 (downstream Delta barrage-upstream El-Rahawy drain). While, the lowest DO values during autumn and spring were in site No.3 (downstream Sabal drain- upstream El-Tahreer drain). Similar results were demonstrated by **Abdel-Satar *et al*. (2017)** who showed that DO values in all water samples from Rosetta branch were ranged between 4.1 to 13.2 mg/l, 5.4 to 9.8 mg/l, 3.0 to 9.8 mg/l and 4.1 to 10.8 mg/l during winter, spring, summer and autumn, respectively. Also, **El-Bouraie *et al*. (2011)** indicated that DO values were ranged between 0.38 to 5.16 mg/l, 0.52 to 5.12 mg/l, 0.50 to 5.31 mg/l and 0.63 to 5.57 mg/l) during winter, autumn, summer and spring, respectively. Moreover, **Ezzat *et al*. (2012)** stated that DO values in water samples collected from Rosetta branch were ranged from 1.7 mg/l to 6.8 mg/l. They also found that the amount of DO depends highly on temperature that increase with decrease in temperature. And the depletion of DO could be anticipated to microbial decomposition of the excessive organic matter discharged directly from the drains.

Respecting the biological oxygen demand, BOD is a measure of the amount of dissolved oxygen removed from water by aerobic microorganisms for their metabolic requirements during the breakdown of organic matter. It also used to determine the level of organic pollution of water. Data presented in **Table (3)** showed that the lowest BOD values (3.30 mg/l) was recorded in site No.1 (downstream Delta barrage-upstream Al-Rahawy drain) during autumn. While, the highest BOD value (26.6 mg/l) was recorded in site No.2 (downstream Al-Rahawy drain-upstream Sabal drain) during winter. Generally, the lowest BOD values were recorded in site No.1 (downstream Delta barrage-upstream Al-Rahawy drain) during all four seasons. On contrary, the highest BOD values during spring were recorded in site No.6 (downstream Tala drain-downstream Abeg Village) and during autumn and spring were recorded Generally, during autumn and spring the BOD values were higher than summer and winter in most sites. These results were in harmony with **Ezzat *et al*. (2012)** who reported that BOD in Rosetta branch were ranged from 5.5-52.0 mg/l. Also, **Abdel-Satar *et al*. (2017)** stated that BOD values were ranged between (1.2-8.0 mg/l), (1.8-8.0 mg/l), (1.2-5.9 mg/l) and (1.8-6.5 mg/l) during winter, spring, summer and autumn, respectively. Additionally, **El-Bouraie *et al*. (2011)** indicated that BDO values were ranged between (1.0-130 mg/l), (2.0-110.0 mg/l), (1.0-80.0 mg/l) and (1.0-75.0 mg/l) during winter, autumn, summer and spring, respectively.

Table 3. Seasonally changes in dissolved oxygen, biological oxygen demand and chemical oxygen demand values in various locations at Rosetta branch, River Nile.

Locations	Dissolved oxygen DO (mg/l)				Mean	Biological oxygen demand BOD (mg/l)				Mean	Chemical oxygen demand COD (mg/l)				Mean
	Su.	Au.	Wi.	Sp.		Su.	Au.	Wi.	Sp.		Su.	Au.	Wi.	Sp.	
No.1	6.1	7.8	8.0	7.5	7.4	5.70	3.30	4.40	4.50	4.5	9.10	8.43	7.40	7.70	8.15
No.2	4.2	4.2	3.3	3.5	3.8	14.9	21.1	26.6	19.5	20.5	28.1	33.6	42.6	27.7	33.0
No.3	4.5	3.1	3.9	3.4	3.7	10.3	19.9	13.9	17.5	15.4	16.0	29.7	18.7	33.3	24.4
No.4	5.0	3.8	4.3	4.3	4.4	7.30	17.4	9.00	13.9	11.9	10.1	23.2	12.8	27.2	18.3
No.5	5.8	4.9	4.9	4.1	4.9	7.70	15.3	8.90	14.5	11.6	11.6	22.2	12.0	25.1	17.7
No.6	7.0	5.3	4.0	3.7	5.0	10.1	21.2	12.8	21.3	16.4	17.1	27.9	20.2	34.2	24.9
No.7	7.6	6.4	5.7	4.9	6.2	9.90	14.2	10.5	11.2	11.5	12.9	23.1	13.2	19.2	17.1
No.8	5.1	6.1	5.6	5.1	5.5	9.80	13.2	9.10	12.7	11.2	16.5	17.9	15.4	21.2	17.8
Mean	5.7	5.2	4.9	4.6		9.5	15.7	11.9	14.4		15.2	23.3	17.8	24.5	
Standard	6					6					10				

Su: summer Au: Autumn Wi: winter Sp: spring

Locations description was presented in Table (1)

Concerning the chemical oxygen demand (COD) values, data presented in **Table (3)** indicated that the lowest values were recorded in site No.1 (downstream Delta barrage-upstream Al-Rahawy drain) during all seasons. Whereas, the highest values were recorded in site No.2 (downstream Al-Rahawy drain-upstream Sabal drain) during all seasons except during spring. The highest COD during spring was in site No.6 (downstream Tala drain-downstream Abeg Village) with 34.21 mg/l followed by site No.3 (downstream Sabal drain- upstream El-Tahreer drain) with 33.34 mg/l. Generally, higher COD values where recorded in sites No.3,4,5,7 and 8 during spring than other seasons. Moreover, COD values recorded during autumn and springs were higher than winter and summer. This trend of result was true in most sites. COD values were ranged between (2.9-111.0 mg/l), (3.7-65.4 mg/l), (3.4-78.5 mg/l) and (3.6-81.3 mg/l) during winter, spring, summer and autumn, respectively **(Abdel-Satar *et al*., 2017)**. Also, **El-Bouraie *et al*. (2011)** indicated that CDO values were ranged between (16.0-198.0 mg/l), (4.0-179.0 mg/l), (5.0-189.0 mg/l) and (4.0-141.0 mg/l) during winter, autumn, summer and spring, respectively.

1.4.3. Ammonia, nitrite and nitrate values in River Nile, Rosetta branch water

Ammonia is a form of the nitrogenous compounds present in nature and is essential for the growth and reproduction of living organisms. The ammonia ion is either released from proteinaceous organic matter and urea or is synthesized by industrial processes. In this respect, data presented in **Table (4)** showed the comparison between the results of Ammonia, Nitrite and Nitrate in River Nile-Rosetta branch during 2013.

Ammonia values ranged from 0.22 to 7.70 mg/l during winter in all sites. Additionally, Ammonia concentration in site No.1 (downstream Delta barrage-upstream Al-Rahawy drain) was lower than other sites. While, the highest values of ammonia were recorded in site No.2 (downstream Al-Rahawy drain-upstream Sabal drain) than other sites. This trend of results was observed during all four seasons. Also, data indicated that the ammonia concentration was lower in summer than other seasons. Similar trend of results was observed by **Ezzat *et al*. (2012)** who reported that NH_3 concentrations ranged from 1.25-8.35 mg/l in Rosetta branch. Additionally, **Abdel-Satar *et al*. (2017)** reported that NH_3 values were ranged between (21-3403 µg/l), (33-17928 µg/l), (29-2237 µg/l) and (33-11409 µg/l) during winter, spring, summer and autumn, respectively.

Regarding the nitrite (NO_2) concentration in Rosetta branch, data in **Table (4)** showed that NO_2 values ranged between (0.004-0.035 mg/l), (0.002-0.045 mg/l), (0.010-0.050 mg/l) and (0.010-0.071 mg/l) during summer, autumn, winter and spring, respectively. The highest NO_2 values in different seasons were recorded in site No.8 (Rosetta branch upstream Idfina barrage) during summer, in site No.5 downstream Zawiet El-Bahr drain-upstream Tala drain) during autumn and winter. Whereas, the highest NO_2 value during winter was recorded in site No.7 (Rosetta branch at Foua city). Generally, the lowest NO_2 values during all seasons were recorded in site No.1 (downstream Delta barrage-upstream Al-Rahawy drain). These results were in harmony with those obtained by **Abdel-Satar *et al.* (2017)** who reported that NO_2 values were ranged between (4.4-86.4 µg/l), (0.5-167.3µg/l), (4.6-694.3µg/l) and (5.0-1282µg/l) during winter, spring, summer and autumn, respectively. On contrast, **Ezzat *et al*. (2012)** showed that the NO_2 values in all water samples from Rosetta branch during summer and winter were constant and no changes were observed.

Table 4. Seasonally changes in ammonia, nitrite and nitrate values in various locations at Rosetta branch, River Nile.

Locations	Ammonia (NH_4^+) (mg/l)				Mean	Nitrite (NO^{-2}) (mg/l)				Mean	Nitrate (NO^{+3}) (mg/l)				Mean
	Su.	Au.	Wi.	Sp.		Su.	Au.	Wi.	Sp.		Su.	Au.	Wi.	Sp.	
No.1	0.48	0.31	0.22	0.33	0.34	0.004	0.002	0.010	0.010	0.007	0.10	0.11	0.16	0.03	0.10
No.2	3.00	5.52	7.70	6.72	5.74	0.030	0.017	0.040	0.041	0.032	0.65	0.77	1.02	0.92	0.84
No.3	2.10	4.31	6.30	5.35	4.52	0.026	0.031	0.032	0.023	0.028	0.35	0.62	0.75	0.71	0.61
No.4	0.80	3.21	3.20	5.13	3.09	0.018	0.007	0.020	0.017	0.016	0.50	0.61	0.78	0.42	0.58
No.5	1.80	3.44	4.00	4.31	3.39	0.020	0.045	0.030	0.071	0.042	0.40	0.51	0.62	0.55	0.52
No.6	1.50	3.56	6.90	4.71	4.17	0.025	0.034	0.035	0.013	0.027	0.56	0.43	0.50	0.56	0.51
No.7	0.80	2.71	5.80	2.11	2.86	0.030	0.024	0.050	0.011	0.029	0.48	0.44	0.39	0.41	0.43
No.8	0.90	0.93	5.40	1.95	2.30	0.035	0.032	0.025	0.021	0.28	0.40	0.31	0.32	0.34	0.34
Mean	1.42	3.00	4.94	3.83		0.024	0.024	0.030	0.026		0.43	0.48	0.57	0.49	
Standard law48/1982			0.5					-					2		

Su: summer Au: Autumn Wi: winter Sp: spring

Locations description was presented in Table (1)

Respecting the nitrate concentration in under investigation sites along Rosetta branch, data in **Table (4)** showed that the lowest and the highest values were recorded in site No.1 (downstream Delta barrage-upstream Al-Rahawy drain) during summer and in site No.2 (downstream Al-Rahawy drain-upstream Sabal drain) during winter, respectively. This trend of results was true during all four seasons. Nitrate concentration recorded in sites No.6 (downstream Tala drain-downstream Abeg Village), No.7 (Rosetta branch at Foua city) and No.8 (Rosetta branch upstream Idfina barrage) were higher during summer than other seasons. While, in sites No.3 (downstream Sabal drain-upstream El-Tahreer drain), No.4 (downstream El-Tahreer drain-upstream Zawiet El-Bahr drain) and No.5 (downstream Zawiet El-Bahr drain-upstream Tala drain) were higher during winter than other seasons. Generally, the highest concentrations of all determined compounds were recorded in winter. These results were in agreement with **Ezzat *et al*. (2012)** who showed that high positive correlations between ammonia and nitrate concentration in all water samples collected from Rosetta branch. This was attributed to the oxidation of ammonia to nitrate by aerobic bacteria. also, they reported that normal NO_3 values were recorded in all sites along Rosetta branch. Moreover, **Abdel-Satar *et al*. (2017)** recorded the nitrate concentration in River Nile during all four seasons. They found that NO_3 values were ranged between (8-550 µg/l), (19-1878 µg/l), (3-1864 µg/l) and (10-1087 µg/l) during winter, spring, summer and autumn, respectively.

1.5. Bacteriological examination of Rosetta branch, River Nile water

1.5.1. Total coliform counts (TC)

Data presented in **Table (5)** clearly indicated that higher T.C during all months were recorded in site No.2 (downstream Al-Rahawy drain-upstream Sabal drain) and the highest T.C was recorded during August (6.88. CFU/ml). In addition, the highest coliform counts in all locations except No.2 and No.8 were recorded during July and the highest counts in location No.8 was observed during June. Whereas, the lowest log. were observed in site No.8 (Rosetta branch upstream Idfina barrage). In general, location No.2 (downstream El-Rahawy drain-upstream Sabal drain) was more polluted than other locations, while, site No.8 (Rosetta branch upstream Idfina barrage) was the lower polluted site.

Table 5. Monthly changes in average log no. of total coliform in various locations at Rosetta branch, River Nile.

Months	Locations								
	No.1	No.2	No.3	No.4	No.5	No.6	No.7	No.8	Mean
January	3.69	6.44	4.34	3.23	3.27	3.11	2.84	1.84	3.59
February	3.77	6.53	4.41	3.36	3.32	3.14	2.77	1.95	3.65
March	3.84	6.60	4.47	3.38	3.44	3.23	3.00	2.00	3.74
April	3.90	6.67	4.53	3.50	3.46	3.27	3.07	2.00	3.8
May	4.00	6.79	4.68	3.57	3.63	3.41	3.17	2.20	3.93
June	4.11	6.83	4.77	3.72	3.69	3.49	3.32	2.27	4.03
July	4.14	6.87	4.86	3.90	3.71	3.62	3.34	2.23	4.08
August	4.11	6.88	4.83	3.88	3.68	3.49	3.27	2.25	4.05
September	3.95	6.76	4.65	3.59	3.61	3.38	3.17	2.17	3.91
October	3.95	6.69	4.57	3.54	3.49	3.32	3.14	2.11	3.85
November	3.95	6.71	4.60	3.54	3.47	3.34	3.17	2.14	3.87
December	3.84	6.60	4.46	3.44	3.44	3.23	3.04	1.95	3.75
Mean	3.94	6.69	4.59	3.55	3.51	3.33	3.10	2.09	

Locations description was presented in Table (1)

Abo-State *et al*. (2014) reported that the microbial water quality along the River Nile varies with location and depends on flow rate, water use, population density, sanitation systems, domestic and industrial discharges**.** Also, Rosetta branch is polluted at the discharge of Al-Rahway drain, where most probable number of TC reach 90x10^6 CFU/100ml.This drain discharges 28x10^4 m^3/day, of which 193x10^2 m^3 to Rosetta Nile. At Cairo 120 km downstream from the Delta barrage the Rosetta branch receives polluted in flows from three drains (Al-Rahawy, Sabal and Tala) and from industry at Kafr El-Zayat **(Rabeh, 2009).** Also, **Ezzat *et al*., (2012)** reported that the mean values of TBC were ranged between (1.8 x 10^{2} - 87 x 10^4 CFU/100 ml) and (1.3 x 10^2 - 71 x 10^4 CFU/100ml) in water samples collected from Rosetta branch during winter and summer, respectively. While, the mean counts. of total coliform (TC) were ranged between (51 x 10^2 - 27 x 10^4 CFU/100 ml) in water samples collected from Rosetta branch during winter and summer. Additionally, **Ali *et al*. (2011)** reported that populations of total coliforms, faecal coliforms and faecal streptococci ranged from 25 to 1800, 9 to 1800 and 8 to 1800 MPN/100 ml, respectively in upstream and middle stream collected water samples on River Nile.

1.5.2. Fecal coliform counts in various locations at Rosetta branch, River Nile

The monthly changes in fecal coliform log. (CFU/ml) in various locations along Rosetta branch, River Nile water were showed in **Table (6)**. The highest log. no of fecal coliform (6.51 CFU/100 ml) was recorded in site No.2 (downstream Al-Rahawy drain-upstream Sabal drain) during July and August. Whereas, the lowest log. (1.30 CFU/100 ml) was recorded in site No.8 (Rosetta branch upstream Idfina barrage) during February. Moreover, this was the only location complying with the international standard limits of **Ibrahim *et al*. (2017 b),** in which FC count didn't exceed 2 CFU/100 ml in drinking water. Meanwhile, about 87.5% of the under-investigation sites along Rosetta branch don't achieve these international standards. Generally, data indicated that the site No.2 was the highest polluted site, while, site No.8 was the lowest polluted one. This trend was true during all months. Also, data showed that the summer months (June, July and August) were polluted more than other year months. This trend was true in all under study sites. Moreover, the lowest fecal coliforms were counted during February in all sites. The use of indicator bacteria such as faecal coliforms (FC) for assessment of faecal pollution and possible water quality deterioration in fresh water sources is widely used **(Sabae and Rabeh, 2007).** Also, **Ezzat *et al*. (2014)** reported that fecal coliforms count in Rosetta branch ranged between 650 and 14 x 10^5 CFU/100 ml. **Abo-State *et al*. (2014)** showed that the most probable number of faecal coliforms (FC) reach 25x10^5 CFU/100ml.During February 2001 "winter season" Faecal coliform ranged from 1.7x10^2 CFU/100ml to 1.3x10^3 CFU/100ml at Kafr El-Zayat after factories. FC was 11-3.3×10^3 MPN 100/ml/, with annual average 7.6×10^2 MPN/100 ml during the period from summer 1994 to spring 1996 **(Rabeh, 2009).** Also, **Ezzat *et al*. (2002)** indicated that during February 2001, FC ranged from 1.7×10^2 100/ml (upstream of Edfina Barrage) to 1.3×10^3 100/ml at Kafr El-Zayat. The highest counts were at Kafr El-Zayat, after which the water complied with WHO Guidelines for irrigation.

Table 6. Monthly changes in average log no. of fecal coliform in various locations at Rosetta branch, River Nile.

Months	Locations								
	No.1	No.2	No.3	No.4	No.5	No.6	No.7	No.8	Mean
January	3.30	6.14	3.90	2.77	2.69	2.60	2.36	1.49	3.15
February	3.07	5.95	3.60	2.60	2.60	2.47	2.25	1.30	2.98
March	3.44	6.23	3.95	2.95	2.95	2.69	2.51	1.69	3.30
April	3.46	6.39	4.11	3.0	3.07	2.95	2.59	1.76	3.41
May	3.57	6.39	4.20	3.07	3.07	3.0	2.69	1.82	3.47
June	3.64	6.47	4.27	3.14	3.17	3.07	2.70	1.91	3.54
July	3.81	6.51	4.39	3.30	3.11	3.0	2.90	1.90	3.16
August	3.69	6.51	4.27	3.14	3.17	3.07	2.74	1.89	3.56
September	3.54	6.41	4.14	3.0	3.07	2.95	2.64	1.79	3.44
October	3.47	6.34	4.11	2.95	2.95	2.90	2.56	1.73	3.37
November	3.30	6.17	3.95	2.90	2.84	2.69	2.32	1.60	3.22
December	3.23	6.07	3.69	2.69	2.77	2.60	2.34	1.39	3.09
Mean	3.46	6.29	4.05	2.95	2.95	2.83	2.55	1.68	

Locations description was presented in Table (1)

1.5.3. Fecal streptococci counts in various locations at Rosetta branch, River Nile water.

Data presented in **Table (7)** indicated the monthly changes in average log no. of fecal streptococci (CFU/ml) in various locations along Rosetta branch, River Nile. The highest fecal streptococci log. (4.85 CFU/100ml) was recorded in site No.2 (downstream Al-Rahawy drain-upstream Sabal drain) during July. Whereas, the lowest count (0.77 CFU/100ml) was recorded in site No.8 (Rosetta branch upstream Idfina barrage) during Winter (January and February). Also, data showed that the lowest log no. in all sites were observed during February. Generally, sites in Rosetta branch exceeding 1000 CFU/100 ml were reported out of international standard limits by **Ibrahim *et al.* (2017 b).** Moreover, fecal streptococci log. were lower in site No.8 than other sites. This was true during all months. While, the log. was higher in site No.2 than other sites during all months of year. In addition, Fecal streptococci log. were lower and higher during February and July, respectively. This trend was true in most sites.

Table 7. Monthly changes in average log no. of fecal streptococci in various locations at Rosetta branch, River Nile.

Months	Locations								
	No.1	No.2	No.3	No.4	No.5	No.6	No.7	No.8	Mean
January	1.23	3.99	2.44	1.57	1.46	1.36	1.0	0.77	1.73
February	1.04	3.82	2.25	1.32	1.23	1.20	0.90	0.77	1.57
March	1.47	4.23	2.70	2.77	1.69	1.55	1.38	1.14	2.11
April	1.62	4.49	2.84	1.91	1.80	1.83	1.51	1.38	2.17
May	1.75	4.55	2.94	2.0	1.92	1.88	1.62	1.47	2.27
June	1.83	4.63	2.98	2.04	1.96	1.93	1.65	1.41	2.30
July	1.04	4.85	3.07	2.20	2.25	2.07	1.95	1.59	2.38
August	1.90	4.72	3.0	2.11	2.04	2.0	1.72	1.47	2.37
September	1.72	4.53	2.91	1.97	1.90	1.87	1.62	1.39	2.24
October	1.65	4.46	2.88	1.98	1.91	1.84	1.54	1.38	2.21
November	1.53	4.32	2.75	1.84	1.74	1.72	1.39	1.14	2.05
December	1.30	4.17	2.62	1.69	1.61	1.57	1.30	1.0	1.91
Mean	1.51	4.39	2.78	1.95	1.79	1.74	1.46	1.24	

Locations description was presented in Table (1)

It is noticeable that a gradual increase in bacterial indicators counts (TC, FC& FS) from upstream to downstream, which might be attributed to the drains discharge into the branch, this agrees with the results of **Abdo (2002)** and **Ezzat (2008).** This finding agrees with **Ezzat *et al.* (2014)** who found that fecal streptococci counts in Rosetta branch ranged between (8-11)10^4 CFU/100 ml.

Also, **Abo-State *et al.* (2014)** revealed that 99% of 116 fecal streptococci samples collected from 11 locations at Rosetta branch ranged between ($1.0x10^1$ - $7.0x10^4$ CFU/ml) during the year seasons. Generally, sites in Rosetta branch exceeding 1000 CFU/100 ml were reported out of international standard limits **(Abdo, 2013)**. The data revealed that there is a gradual increase in bacterial indicators counts from upstream to downstream, which might be attributed to the drains discharge into the branch, this agrees with the results of **Ezzat (2008).** The use of indicator bacteria such as faecal streptococci (FS) for assessment of faecal pollution and possible water quality deterioration in fresh water sources is widely used **(Sabae and Rabeh, 2007).**

Fecal streptococci also belong to the traditional indicators of fecal pollution. Fecal streptococci are Gram-positive, catalase-negative, non-spore forming cocci that grow at 35°C **(George *et al*., 2004). Ali *et al*. (2015)** reported that microbiological analysis of the water samples collected from two sites in River Nile; after and before El-Sail drain showed an increase in total bacterial counts in site II than Site I, while there was no difference between the two sites in the spore-forming bacterial count. Coliform bacteria were detected in the two sites with four-fold increases in site II than site I, similarly the fecal coliform increased to about five folds in site II than site I. On the other hand, there was no significant difference in fecal Streptococcus count in both sites. The FC: FS ratio was 0.5 in site I and 2.5 for site II.

1.5.4. *Escherichia coli* counts in various locations at Rosetta branch, River Nile

The monthly changes in *coli* counts (CFU/ml) in various locations at Rosetta branch, River Nile water were presented in **Table (8)**. The highest (5.96 CFU/100ml) and the lowest (0.30 CFU/100ml) *E. coli* log. were recorded in sites No.2 (downstream El-Rahawy drain-upstream Sabal drain) and No.8 (Rosetta branch up stream Idfina barrage) during August, respectively. Concerning the microbiological studies conducted earlier have reported high *coli* with the range between $1.0x10^1$ and $1.3x10^5$ CFU/ml during spring, summer, autumn and winter **(Abo-State *et al*., 2014)**. They recorded maximum count during summer and autumn. This study was incomplete accordance with that observed by **Sabae *et al*. (2006)** the seasonal runoff was the main cause affecting the coliform level within Rosetta water system especially in summer and autumn, while domestic discharges and agricultural wastes were the main cause of microbiological water quality deterioration Rosetta water.

Table 8. Monthly changes in average log no. of *Escherichia coli* in various locations at Rosetta branch, River Nile.

Months	Locations								
	No.1	No.2	No.3	No.4	No.5	No.6	No.7	No.8	Mean
January	2.84	5.54	3.32	2.32	2.11	2.14	2.0	0.90	2.65
February	2.69	5.41	3.20	2.17	1.96	1.95	1.84	0.84	2.51
March	2.95	5.59	3.38	2.38	2.17	2.20	2.11	1.07	2.73
April	2.90	5.69	3.44	2.43	2.25	2.20	2.11	1.11	2.77
May	3.07	5.83	3.61	2.60	2.38	2.39	2.30	1.27	2.93
June	3.17	5.25	3.75	2.67	2.46	2.46	2.36	1.30	2.93
July	3.30	5.94	3.89	2.86	2.59	2.59	2.46	1.44	3.13
August	3.23	5.96	3.68	2.74	2.54	2.54	2.38	0.30	2.92
September	3.14	5.85	3.61	2.60	2.38	2.36	2.30	1.07	2.91
October	3.04	5.77	3.53	2.53	2.30	2.25	2.20	1.0	2.83
November	3.07	5.79	3.56	2.50	2.38	2.36	2.20	1.0	2.86
December	2.95	5.62	3.36	2.38	2.11	2.14	2.04	1.07	2.71
Mean	3.03	5.69	3.53	2.52	2.30	2.29	2.19	1.03	

Locations description was presented in Table (1)

Also, data clearly indicated that the lowest *E. coli* log. were observed in February. This was true in all under studying sites. Whereas, the highest log. were recorded during July in all sites except site No.2. Moreover, the site No.2 was polluted more than other sites during all months. While, the site No (8) was less polluted than other sites. Generally, summer months showed higher log. than winter months. Also, sites No.1, 2, 3 and 4 were more polluted than the others. This trend was during all months. Currently, coliforms and *E. coli* are a great importance among bacterial indicators used in water quality definition and health risk **(Giannoulis *et al*., 2005)**. *E. coli* strains are a natural and essential part of the bacterial flora in the gut of humans and animals. Most *E. coli* strains are non-pathogenic and reside harmlessly in the colon. However, certain serotypes play a role in intestinal and extra-intestinal diseases such as urinary tract infections **(Gordon and Fitzgibbon, 1999)**.

Conclusion

The water quality along the studied locations in Rosetta branch is remarkably influenced by wastewater discharge from drains located on its sides regarding physicochemical and bacteriological characteristics. The study reflects strong evidence for bacterial contamination in Rosetta branch resulting from the impact of drains which was remarkable from Al-Rahawy drain. In addition to the untreated domestic wastes from villages distributed along the drain discharging directly their wastes, Al-Rahawy drain collects significant domestic wastes and sewage from greater Cairo represented by Zenain and Abu Rawash sewage treatment stations. In Rosetta branch, the bacterial contamination was maximum directly downstream the drains and decrease gradually far downstream. The self-purification and dilution effect could interpret the decreased gradual improvement recognized at the end of the Rosetta branch.

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التقييم الميكروبيولوجي والفيزيوكيميائي لنهر النيل (فرع رشيد)

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قد أجريت هذه الدراسة خلال الفترة الممتدة من يناير ٢٠١٣ إلى ديسمبر ٢٠١٣ لتقييم الخصائص الميكروبيولوجية والفيزيائية لمياه نهر النيل (فرع رشيد). ولقد شمل الفحص ثمانية مواقع على طول فرع رشيد. ولقد أوضحت النتائج قيم درجة الحرارة تراوحت بين ١٧.٦ م° إلى ٣١.٠ م° درجة مئوية بينما تراوحت قيم الرقم الهيدروجيني بين ٧.١٦ إلى ٧.٩٨ خلال أربعة مواسم. وعلاوة على ذلك، تراوحت قيم العكارة بين ١.٩٠ إلى ٣٣.٧ NTU خلال جميع الفصول. أما فيما يتعلق بقيمة الأكسجين المذاب، فقد سجلت أدنى قيمة (٣.١ ملليجرام / لتر) وأعلى قيمة (٨.٠ ملليجرام / لتر) خلال الخريف والشتاء على التوالي. وعلاوة على ذلك سجلت أعلى قيم (٢٦.٦ ملليجرام / لتر) وأدنى قيم (٣.٣٠ ملليجرام / لتر) من الأكسجين الحيوي الممتص خلال الشتاء والخريف على التوالي. وتراوحت قيم الأكسجين الكيميائي بين ٧.٤ إلى ٤٢.٦ ملليجرام / لتر والتي سجلت خلال فصل الشتاء. بالإضافة إلى ذلك، تراوحت قيم الأمونيا بين ٠.٢٢ إلى ٧.٧٠ ملليجرام / لتر خلال جميع الفصول الأربعة. ولقد تراوحت قيم النيتريت بين (٠.٠٠٤–٠.٠٧١ ملليجرام / لتر) خلال جميع الفصول الأربعة. ولقد سجلت أقل قيمة للنترات (٠.١٠ ملليجرام / لتر) وأعلى قيمة (١.٠٢ ملليجرام / لتر) خلال الصيف والشتاء على التوالي. وفيما يتعلق بالتغيرات الشهرية الميكروبيولوجية لفرع رشيد تراوحت قيم Total coliform bacteria بين (١.٨٤ إلى ٦.٨٨ CFU/100ml) وسجلت أعلى نسبة في معظم المواقع خلال شهر يوليو. في حين تراوحت أعداد Fecal coliform bacteria بين (١.٣٠الى ٦.٥ CFU/100ml) خلال جميع الأشهر. وعلاوة على ذلك سجلت أعلى قيمة (٥.٩٦CFU/100ml) وأدنى قيمة (٠.٣٠) CFU/100ml. تم تسجيل أعلي الأعداد لبكتريا *E. coli* خلال شهر أغسطس بالإضافة إلى ذلك، تم تسجيل أعلى عدد Fecal streptococci (٤.٨٥ CFU/100ml) أيضاً خلال شهر يوليو. وعموماً وفي ضوء النتائج المتحصل عليها يمكن القول بأن أعلي مستويات التلوث مياه نهر النيل (فرع رشيد) قد لوحظت خلال أشهر الصيف وهذا يرجع إلي ارتفاع درجة الحرارة والتي تزيد من الأنشطة الميكروبية المختلفة، في حين أوضحت النتائج أن أقل مستويات التلوث لمياه نهر النيل (فرع رشيد) قد لوحظت خلال أشهر الشتاء وهذا يرجع إلي انخفاض درجة الحرارة والتي تقلل من الأنشطة الميكروبية المختلفة.