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Physico chemical studies for water at Rosetta branch of river Nile, Egypt

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Abstract. This work was carried out to study the quality of water of Rosetta branch. Five sites were chosen for sampling during the period of January 2013 to December 2013. Physical parameters (Temperature, electrical conductivity (EC), turbidity and pH) and chemical parameters (concentration of Cl⁻, Ca⁺², Mg⁺², NH⁴⁺, SO⁴⁻², NO²⁻, and some of trace metals, alkalinity, total hardness, Dissolved Oxygen(DO), Chemical Oxygen Demand(COD) and Biological Oxygen Demand(BOD) were discussed. These results were compared with the results of another study that were carried out at Rosita Branch at 2018. Statistical analysis of data was computed to show the correlation between some parameters through the whole sampling sites during the period of the study, using simple correlation coefficient.

Keywords: Rosetta branch - Physical and chemical parameters – Water Quality Index - Correlation Coefficients

1. Introduction

Egypt faces severe water scarcity in recent years. Population increase leads to higher water demand and rapid economic growth leads to ecosystem degradation. Ineffective irrigation methods combined with poor water use degrade water quality. The Nile River is the main source of fresh water in Egypt [1], which suffers from an annual water shortage of about 8 billion cubic meters (BCM). The Nile River has two ending branches, Rosetta and Damietta. The Rosetta branch is about 210 km long and about 190 meters wide [2].

Identifying the source (s) of pollution and developing appropriate management strategies is essential to minimize potential public health risks [3]. Surface water quality in an area can be affected by point and unspecified point pollution [4].

Point source (PS) pollution occurs from a single specific source such as impacts from industries and wastewater treatment plants [5], while non-specific sources include runoff associated with a specific land use pattern such as urban areas (for example, water Rain, wastewater over flows), agriculture (such as fertilizers, pesticides, animal manure), or forest land uses [6]. The ingress of these sources into the water can represent improper drainage of toxic chemicals and pathogenic microorganisms; therefore, monitoring water quality and identifying health risks is essential to protect the population from water-borne diseases and to develop appropriate preventive measures. Since ecosystems such as rivers and lakes are affected by multiple sources, it is important to understand the spatial and temporal differences



in the physical-chemical and microbiological parameters for assessment and management [7]. Nevertheless, the evaluation of several water quality parameters generates large and complex data sets and multivariate statistical techniques that are required to interpret the results [8-10]. Multivariate technologies such as cluster analysis (CA) and principle component analysis (PCA) have been successfully applied to better understand the water quality and environmental state of the studied systems [11, 12]. In addition to assessing water quality, multivariate technologies have many applications such as determining potential factors / sources affecting water systems [13, 14], reduction of data [15, 16], spatial and temporal changes [13], and aggregation sampling sites [17].

Most of the resource quality uses several indicators of water quality, the most important of which are the Water Quality Index (WQI), the Water Pollution Index (WPI), and the River Habitat Survey (RHS) [18, 19].

In the Rosetta branch, a mathematical model will be constructed that integrates data as input parameters. This model will create a degree that describes the spatial distribution. In addition, the timing of the water quality status will be determined. This template will be presented to the public as well as to decision and policy makers [3, 4]. There are several previous studies that used models and methods of water quality indicators to assess the state of water quality [5,20].

2. Materials and methods

2.1. Materials

All chemicals used were of appropriate purity grade. They were obtained from "Hach, Panreac, Merck, BDH, Chem-lab, VWR, Fluka, Fisher Scientific and Sigma-Aldrich. All reagents utilized for chemical analysis were prepared according to "Standard Methods for the examination of Water and Wastewater", 21st ED [21].

2.2. Analytical Methods

2.2.1. Sampling.

As a result of the health survey conducted on the Rosetta branch, during the period from January 2013 to December 2013, five sites along the branch were selected for regular sampling, including the intakes of the four treatment plants. Sample sites of Rosetta branch are shown in table 1.

Table 1. Sample sites along Rosetta branch

Site no.	Site name	latitude	longitude	Site position (Km)
1	Mahallet Diyay	31°1'47.13''E	30°43'21.13''E	159 after El-Kanater El-Khyria
2	Mahallet Abu Ali	31°5'55.93''N	30°41'8.66''E	168 after El-Kanater El-Khyria
3	Desouq	31°7'50.64''N	30°38'14.85''E	174 after El-Kanater El-Khyria
4	Fuwwah	31°12'4.32''N	30°34'1.82''E	185 after El-Kanater El-Khyria
5	Mutubas	31°16'54.97''N	30°31'17.75''E	202 after El-Kanater El-Khyria

2.2.2. *Physical Parameters.*

2.2.2.1. *pH and Temperature.*

The pH values were measured using an analytical pH meter fitted with a glass electrode and a temperature probe. By using standard buffer solutions of pH values 4, 7 and 10, the instruments were calibrated daily and to ensure a slope of more than 0.95 [21].

2.2.2.2. *Turbidity.*

It was measured by a nephelometric method (NTU) using turbidimeter (HACH, 2100N, IS, HACH Co., USA). The turbidity standards used to calibration of the instruments, it measured weekly [21].

2.2.2.3. *Electrical Conductivity.*

It was measured by a Laboratory method using Conductivity meter (WTW, Cond 720, WTW Co., USA). This instrument was calibrated daily using a standard of 1413 $\mu\text{s}/\text{cm}$ at 25°C to ensure over 95% efficiency [21].

2.2.3. *Chemical Parameters.*

2.2.3.1. *Chloride.*

The chloride contents were determined by using the familiar Mohr's method [21].

2.2.3.2. *Alkalinity.*

Total alkalinity (measured at pH 4) was determined by using bromocresol green and methyl red indicator [21].

2.2.3.3. *Total hardness.*

EDTA and its sodium salts form a chelated soluble complex when added to a solution of certain metal cations. If a small amount of a dye such as Eriochrome Black T is added to an aqueous solution containing Ca and Mg ions at pH of 10.0 ± 0.1 , the solution becomes wine red. If EDTA is added as a titrant, the Ca and Mg will be complexed and when all of the Ca and Mg have been complexed the solution turns from wine red to blue [21]. Total hardness was determined as recorded by titrating against EDTA using Eriochrome Black T as an indicator [21].

2.2.3.4. *Calcium.*

Calcium can be determined directly, with EDTA, when the pH is made sufficiently high that the magnesium is largely precipitated as the hydroxide and an indicator is used that combines with calcium only. Several indicators give a color change when all of the calcium has been complexed by the EDTA at a pH of 12 to 13 [20]. Calcium was determined by titration against EDTA standard using murexide as an indicator [21].

2.2.3.5. *Magnesium.*

Magnesium may be estimated as the difference between hardness and calcium as CaCO_3 , "Calculation method" [20]. Mg Hardness mg/l [total hardness (as mg CaCO_3/l) - calcium hardness (as mg CaCO_3/l)]

2.2.3.6. *Ammonia.*

It was determined by "Nesslerization method" according to SMWW. Color was measured spectro-photo-metrically using spectrophotometer (Cecil CE7400, USA) at 420 nm [21].

2.2.3.7. Nitrites.

These were determined through formation of a reddish purple azo dye produced at pH 2.0 to 2.5 by coupling diazotized sulfanilamide with N-(1-naphthyl-ethylenediamine dihydro-chloride (NED dihydro-chloride) [90].

These were determined by measuring the UV absorption using spectrophotometer (CecilCE7400, USA) at 543 nm [21].

2.2.3.8. Dissolved oxygen.

DO meter (WTW, Oxi 730, USA) with a membrane electrode was used for measuring DO [21].

2.2.3.9. Chemical Oxygen Demand (COD).

Most types of organic matter are oxidized by a boiling mixture of chromic and sulfuric acids. A suitable volume of sample and the reagents ($K_2Cr_2O_7$, H_2SO_4 and $HgSO_4$) was putted into digestion tubes [21]. The samples tubes were placed in COD digester (WTW CR3200, Germany) $150^\circ C$ for 2 hours. After digestion the samples were slowly cooled to room temperature, the samples absorbance measured using (Thermo, Orion AQ2040, USA).

2.2.3.10. Biological Oxygen Demand (BOD).

BOD bottles were filled with the samples at $20^\circ C$ and neutralized to pH 6.5 to 7.5. Bottles were closed with stopper and incubated in incubator (VELP FOC 225E., Italy) at $20^\circ C$ for 5 days in a BOD Track (VELP BMS., Italy) that gave the reading directly as mg/l [21].

2.2.3.11. Sulfate.

Sulfate ions react with barium chloride solution to form insoluble barium sulfate, which is kept in suspension, by the buffer solution added [21]. The absorbance was recorded using spectrophotometer (Cecil CE7400, USA) at 420 nm.

2.2.3.12. Iron.

Iron is brought into solution, reduced to the ferrous state by boiling with acid and hydroxyl amine, using 1,10-phenanthroline indicator at pH 3.2 to 3.3 [21]. The absorbance was measured using spectrophotometer (Cecil, CE7400, USA) at 510 nm [17].

2.2.3.13. Manganese.

Persulfate oxidation of soluble manganous compound to form permanganate is carried out in the presence of silver nitrate. The absorbance was recorded using spectrophotometer (Cecil, CE7400, USA) at 525 nm [21].

2.2.4. Water Quality Index.

Statistical Water Quality Index (SWQI)

The weighted arithmetic index method has been used for the calculation of WQI of water body. The quality rating or sub index (q_n) was calculated using the following expression:

$$q_n = 100 \left[\frac{V_n - V_i}{S_n - V_i} \right] \quad (1)$$

Let there be n water quality parameters and quality rating or sub index (q_n) corresponding to n^{th} parameter is a number reflecting the relative value of this parameter in the polluted water with respect to its standard permissible value.

q_n : quality rating for the n water quality parameter

V_n : estimated value of the n parameter at a given sampling station.

S_n : standard permissible value of the n parameter.

V_i : ideal value of n parameter in pure water (i.e. 0 for all other parameters except the parameter pH and dissolved oxygen 7.0 and 14.6 mg/l respectively).

Assigned Unit Weight for various parameters is inversely proportional to the recommended standard (S_n) for the corresponding parameter.

$$W_n = \frac{K}{S_n} \quad (2)$$

W_n : unit weight for the n parameter.

S_n : standard value for n parameter

K : constant for proportionality.

The overall water quality index was calculated by aggregating the quality rating with unit weight linearity. [22-24]

$$SWQI = \sum q_n \frac{W_n}{\sum W_n} \quad (3)$$

2.2.5. Software.

2.2.5.1. MS Office 2007.

MS Excel 2007 software was used for calculation of standard deviation and average levels of water parameters in the present study, also used for generating graphs that summarize data. (Microsoft Co, USA)

2.2.5.2. Statistical Package for the Social Science (SPSS15) and (Minitab 14).

These two software statistical packages were employed for statistical treatment of data and predicting mathematical modeling, Minitab 14 was used to establish the model equation and to calculate the correlation between the water parameter and SPSS 15 software. It was used for conducting statistical analysis and generating tables and graphs that summarizes the data.

3. Results and Discussion

Rosetta branch is receiving several and different pollution types from different sources sewage and household effluents from El-Rahaway drains (more than 5×10^8 m³ daily effluents). Agricultural waste at Soble drain as well as liquid industrial waste generated by El-Malya and Soda Companies at Kafr El-Zyat City. All these pollutants have a prominent impact on the water environment of the Rosetta branch [25].

Water pollution is any chemical, physical or biological changes in water quality that have a harmful effect on any organism that drinks, uses, or lives in it. When humans drink contaminated water, it often has dangerous effects on their health. Water pollution can also make the water unsuitable for its intended use. In general, the use primary and secondary treatment systems are ineffective to remove pesticides residues and chlorinated organic

pollutants as well as parasites, viruses, and other non-parasites microorganisms. As a result, these remnants of chemical and biological contamination may remain permanently in drinking water and still unable to obtain safe clean water, moreover, increased levels of chlorine usually added to filtered or raw water increase the concentration of chlorinated organic compounds that are known as carcinogenic and mutagenic [26-30].

3.1. Physical parameters

The mean values of seasonal and annual variation of the physical parameters in Rosetta branch during the period of the study are given in table 2, and represented example figure 1. The results show that:

1. The temperature values in different sites were ranged between 17.37-18.47, 25.37-25.87, 27.77-28.83 and 24.77-25.20 °C during winter, spring, summer and autumn, respectively. Water temperature varies with season, elevation, geographic location, climatic conditions, stream flow, streamside vegetation, ground water inputs, and water effluent from industrial activities. Water temperature rise when streamside vegetation is removed. This small variation of temperature would indicate a physically protected water supply, with closed underground reservoirs, connected with a source of underground origin or deep surface reservoir [31, 32]. The water temperature depends on latitude, altitude and means daily number of sunshine hours, and also affected by specific characteristic such as turbidity, wind force, plant cover, climatic condition and humidity [33].
2. The Turbidity values in different sites were ranged between 2.33-4.57, 1.68-5.04, 2.59-4.44 and 1.79-3.87 NTU (Nephelometric turbidity unit) during winter, spring, summer and autumn, respectively. The turbidity in water is the reduction of transparency due to the presence of particulate such as clay or silt, finely divided organic matter, plankton or other microscopic organisms. These cause light to be scattered and absorbed rather than transmitted in straight lines through the sample [33-36]. Erosion, waste discharge, and urban runoff can add suspended solids to a body of water. Agricultural runoff, in addition to directly increasing suspended solids, can also contribute to the growth of algae. After a storm or flooding, turbidity in surface water generally increases rapidly due to the increase in runoff. Bottom sediment may be stirred up by such actions as waves or currents, bottom-feeding fish, people swimming, wading, or storm runoff [29, 30].
3. The pH results show that, the values in different sites were ranged between 7.73-7.78, 7.65-7.71, 7.7-7.86 and 7.59-7.76 during winter, spring, summer and autumn, respectively. The pH values are within standard range set by the Egyptian Ministry of Water Resources and Irrigation (law 48/1982) [31]. The pH of water is a measure of the acid-base equilibrium and, in most natural water, is controlled by the carbon dioxide-bicarbonate-carbonate equilibrium system. An increased carbon dioxide concentration will therefore lower pH. The role of pH in water chemistry is also associated with corrosivity, alkalinity, acidity, chlorination, coagulation, CO stability [33-35].
4. The Electrical Conductivity results show that, the values in different sites were ranged between 610-631, 435-487, 405-414 and 546-553 $\mu\text{s}/\text{cm}$ during winter, spring, summer and autumn, respectively. The increase in EC values were recorded during cold seasons is mainly attributed to the increase in cations and anions concentrations of the water, as result of low water level and discharge. But, the decrease in EC during hot seasons may be due to the sedimentation of suspended solid with organic salts causing decrease in chemical elements concentration [36].

Table 2. Seasonal and Annual variation of the water samples from Rosetta branch

T°C					
Season Site	Winter Average \pm SD	Spring Average \pm SD	Summer Average \pm SD	Autumn Average \pm SD	Annual Average \pm SD
1	17.360 \pm 2.183	25.867 \pm 1.270	27.767 \pm 0.681	24.767 \pm 2.589	23.942 \pm 4.409
2	17.500 \pm 2.193	25.433 \pm 1.210	28.033 \pm 0.833	24.800 \pm 2.762	23.942 \pm 4.398
3	17.833 \pm 2.610	25.567 \pm 1.172	28.367 \pm 0.850	24.900 \pm 3.027	24.167 \pm 4.440
4	18.233 \pm 2.335	25.367 \pm 1.589	28.567 \pm 1.012	24.067 \pm 2.706	24.308 \pm 4.294
5	18.467 \pm 2.290	25.700 \pm 1.277	28.833 \pm 1.387	25.200 \pm 2.381	24.550 \pm 4.266
Regional average	17.880 \pm 2.322	25.587 \pm 1.303	28.313 \pm 0.952	24.947 \pm 2.693	24.182 \pm 4.362

pH					
Season Site	Winter Average \pm SD	Spring Average \pm SD	Summer Average \pm SD	Autumn Average \pm SD	Annual Average \pm SD
1	7.730 \pm 0.072	7.690 \pm 0.104	7.697 \pm 0.029	7.763 \pm 0.058	7.720 \pm 0.068
2	7.757 \pm 0.058	7.710 \pm 0.090	7.700 \pm 0.026	7.743 \pm 0.067	7.728 \pm 0.060
3	7.770 \pm 0.036	7.693 \pm 0.085	7.707 \pm 0.072	7.627 \pm 0.112	7.699 \pm 0.087
4	7.783 \pm 0.067	7.693 \pm 0.074	7.717 \pm 0.086	7.587 \pm 0.118	7.695 \pm 0.106
5	7.780 \pm 0.070	7.653 \pm 0.064	7.863 \pm 0.292	7.663 \pm 0.040	7.740 \pm 0.160
Regional average	7.764 \pm 0.060	7.688 \pm 0.083	7.737 \pm 0.101	7.677 \pm 0.079	7.716 \pm 0.096

Turbidity					
Season Site	Winter Average \pm SD	Spring Average \pm SD	Summer Average \pm SD	Autumn Average \pm SD	Annual Average \pm SD
1	4.567 \pm 0.482	5.043 \pm 0.387	4.437 \pm 0.592	3.873 \pm 0.878	4.480 \pm 0.680
2	4.480 \pm 0.151	4.350 \pm 1.421	4.183 \pm 0.535	3.767 \pm 0.725	4.195 \pm 0.773
3	4.290 \pm 0.451	4.247 \pm 1.556	3.363 \pm 0.911	3.083 \pm 0.132	3.746 \pm 0.970
4	3.393 \pm 0.300	4.307 \pm 1.741	3.000 \pm 0.646	3.033 \pm 0.696	3.433 \pm 1.017
5	2.327 \pm 0.241	1.677 \pm 0.137	2.590 \pm 0.792	1.793 \pm 0.369	2.097 \pm 0.554
Regional average	3.811 \pm 0.325	3.925 \pm 1.048	3.515 \pm 0.695	3.110 \pm 0.560	3.590 \pm 0.799

Electrical conductivity					
Season Site	Winter Average \pm SD	Spring Average \pm SD	Summer Average \pm SD	Autumn Average \pm SD	Annual Average \pm SD
1	610.000 \pm 40.000	435.000 \pm 109.119	414.000 \pm 30.199	552.000 \pm 61.490	502.750 \pm 102.507
2	612.667 \pm 35.642	473.000 \pm 86.238	412.000 \pm 25.000	553.000 \pm 60.622	512.667 \pm 93.428
3	613.667 \pm 34.530	475.667 \pm 78.137	411.333 \pm 28.729	550.000 \pm 65.506	512.667 \pm 92.699
4	620.000 \pm 36.346	442.333 \pm 52.205	411.000 \pm 19.925	545.667 \pm 72.280	504.750 \pm 96.418
5	630.667 \pm 55.012	486.667 \pm 50.856	405.333 \pm 5.774	547.000 \pm 65.871	517.417 \pm 96.105
Regional average	617.400 \pm 40.306	462.533 \pm 75.311	410.733 \pm 21.925	549.533 \pm 65.154	510.050 \pm 96.231

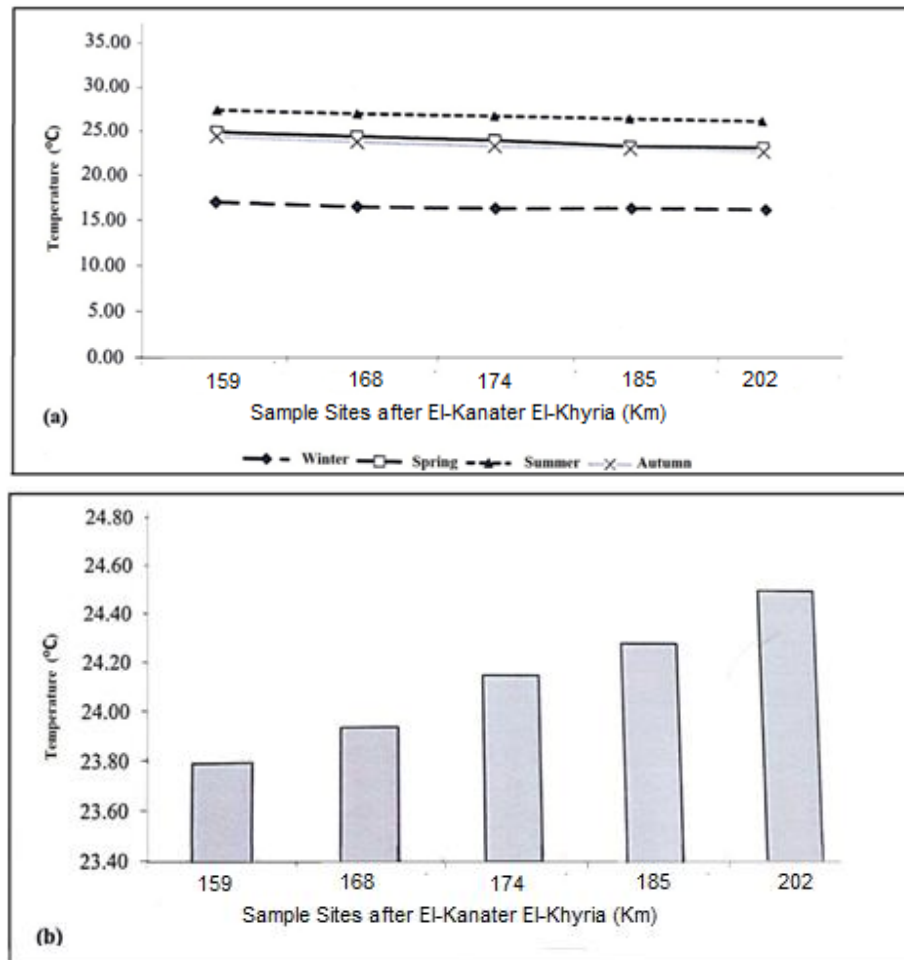


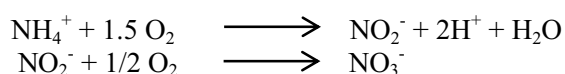
Figure 1. a Seasonal and (b) Annual variation of temperature (°C) from January 2013 to December 2013

3.2. Chemical parameters

tables 3-5, show the mean values of seasonal and annual variation of the Chemical parameters concentrations in Rosetta branch during the period of the study. The results show that:

1. The Chloride values in different sites were ranged between 68.00-78.67, 52.33-67.00, 41.33-44.33 and 64.67-69.00 mg/l during winter, spring, summer and autumn, respectively. The chloride values are within standard range set by Egyptian Ministry of Water Resources and Irrigation (law 48/1982) [32]. Chloride in surface and ground water from both natural and anthropogenic sources, such as run of containing road de-icing salts, the use of inorganic fertilizers, landfill leachates, septic tank effluents, animal feeds, industrial effluents, irrigation drainage, and seawater intrusion in coastal areas [38].
2. The alkalinity values (ranged between 208.00-238.00, 164.67-170.67, 164.00-164.67 and 180.00-184.00 mg/l during winter, spring, summer and autumn, respectively) are within stander range set by Egyptian Resources and Irrigation (law 48/1982) [32]. Alkalinity is buffering capacity of water body. Without this buffering capacity, any acid added to lake would immediately change its pH Alkalinity comes from rocks and soil, salts, certain plant activities, and certain industrial wastewater discharges (detergents and soup based products

- are alkaline). If an area's geology contains large quantities of calcium carbonate (CaCO_3), limestone, water bodies tend to be more alkaline [37-39].
3. The total hardness values ranged between 208.00-220.67, 156.67-160.67, 144.00-148.00 and 169.33-172.67 mg/l during winter, spring, summer and autumn, respectively. The results declared that, the high values of total hardness content recorded during autumn and winter, this may be attributed to the low water level. Hardness may be considered as a physical or chemical parameter of water, it represents the total concentration of Ca and Mg ions, which reported as calcium carbonate. Surface raw water thought to be softer than ground water (more rain, less contact with soil minerals [40].
 4. The calcium values ranged between 44.53-47.73, 36.00-39.20, 35.20-36.53 and 41.33-42.40 mg/l during winter, spring, summer and autumn, respectively. The results stated that, the high values of Ca^{+2} contents at different stations were recorded during winter, this may be attributed to the low water level through the brought period, or to the decaying and decomposing of phytoplankton and other microorganisms and liberated Ca^{+2} in different forms, or it is due to some re-dissolution of organisms and calcium compounds in the presence of CO_2 [41,42]. While the low Ca^{+2} contents recorded during summer attributed to the decrease of CaCO_3 solubility as a result of increase temperature and loss of CO_2 , or due to its uptake by microorganisms and fishes living in the water branch, photosynthesis and carbohydrate metabolism [43].
 5. The magnesium values ranged between 23.17-24.62, 16.04-16.69, 13.61-13.77 and 16.04-16.20 mg/l during winter, spring, summer and autumn, respectively. The high values of Mg^{+2} contents at different sites were recorded during winter, this may be attributed to the low water level through the brought period, or to the decaying and decomposing of phytoplankton and other microorganisms [41,42]. Magnesium is important element and needed by all biological cells for phosphate transfer involving adenosine tri-phosphate ATP and adenosine di-phosphate ADP [44].
 6. The Ammonia values in different sites were ranged between 5.831-8.111, 0.961-1.812, 0.101-0.419 and 0.785-2.136 mg/l during winter, spring, summer and autumn, respectively. The highest concentration values of ammonia were recorded during cold season in winter this may be attributed to the low water levels during drought period and leached of fertilizers residues used on the agriculture into the aquatic environment of the branch via drains [46]. The lowest concentration of NH_3 were recorded during summer may be attributed to the dilution effect by the flood period, and to oxidation of NH_3 into NO_2^- and NO_3^- through nitrification process by the action of nitrosomonas bacteria genus according to the following equations [47,48]:



Ammonia is an important parameter used to evaluate surface water quality. Small amount of ammonia occurs naturally, but a sudden increase in concentration may indicate sewage or industrial pollution. A rise in ammonia may be closely followed by an algae bloom with association taste and odor problems [49].

Table 3. Seasonal and Annual variation of the water samples from Rosetta branch

Season Site	Cl ⁻ (mg/l)				
	Winter Average±SD	Spring Average±SD	Summer Average±SD	Autumn Average±SD	Annual Average±SD
1	68.000±12.490	52.333±31.754	41.333±11.372	66.667±5.033	57.083±19.266
2	69.333±15.275	63.000±25.632	42.333±9.713	66.000±5.292	60.167±17.471
3	71.667±17.786	63.000±24.249	43.667±9.609	65.667±5.859	61.000±17.534
4	74.333±19.009	53.000±14.107	44.333±8.083	64.667±7.095	59.083±16.256
5	78.667±26.102	67.000±13.077	44.333±2.082	69.000±15.716	64.750±19.326
Regional average	72.400±18.132	59.667±21.764	43.200±8.172	66.400±7.799	60.417±17.971

Season Site	NO ₂ ⁻ (mg/l)				
	Winter Average ±SD	Spring Average ±SD	Summer Average ±SD	Autumn Average ±SD	Annual Average ±SD
1	0.117±0.077	0.659±0.218	0.750±0.230	1.104±0.611	0.657±0.473
2	0.136±0.090	0.652±0.143	0.722±0.176	1.108±0.497	0.654±0.432
3	0.214±0.190	0.762±0.120	0.676±0.142	1.274±0.593	0.732±0.481
4	0.170±0.098	0.793±0.246	0.680±0.023	1.321±0.187	0.741±0.449
5	0.421±0.204	0.980±0.447	0.286±0.255	0.751±0.393	0.609±0.406
Regional average	0.211±0.132	0.769±0.235	0.623±0.165	1.112±0.456	0.679±0.448

Season Site	SO ₄ ⁻² (mg/l)				
	Winter Average ±SD	Spring Average ±SD	Summer Average ±SD	Autumn Average ±SD	Annual Average ±SD
1	68.453±1.872	45.827±6.108	37.733±3.946	49.173±0.873	50.297±12.212
2	69.123±2.595	46.487±6.031	36.000±4.045	50.730±0.435	50.585±12.930
3	69.770±6.226	45.203±7.005	34.733±3.668	51.523±0.676	50.308±13.981
4	68.440±4.525	43.340±7.216	32.867±3.121	53.580±0.505	49.557±14.254
5	67.257±3.805	44.130±10.895	31.000±3.464	51.910±5.396	48.574±14.817
Regional average	68.609±3.805	44.997±7.451	34.467±3.649	51.383±1.577	49.864±13.639

Season Site	Alkalinity (mg/l)				
	Winter Average ±SD	Spring Average ±SD	Summer Average ±SD	Autumn Average ±SD	Annual Average ±SD
1	208.000±9.165	166.667±25.403	164.000±19.079	184.000±11.136	180.667±23.608
2	215.333±14.189	167.333±21.939	164.000±16.371	182.667±11.372	182.333±25.425
3	222.667±15.535	166.667±24.194	164.667±13.614	180.000±12.000	183.500±28.389
4	232.000±20.785	164.667±25.716	164.667±11.547	183.333±16.773	186.167±33.188
5	238.000±27.785	170.667±18.903	164.000±12.166	181.333±13.317	188.500±34.600
Regional average	223.200±17.492	167.200±23.231	164.267±14.555	182.267±12.920	184.233±29.042

Table 4. Seasonal and Annual variation of the water samples from Rosetta branch

Ca ²⁺ (mg/l)					
Season Site	Winter Average \pm SD	Spring Average \pm SD	Summer Average \pm SD	Autumn Average \pm SD	Annual Average \pm SD
1	44.533 \pm 3.946	36.000 \pm 4.157	35.200 \pm 2.117	42.400 \pm 2.117	39.533 \pm 5.019
2	44.533 \pm 3.946	37.333 \pm 3.946	35.467 \pm 2.013	42.133 \pm 1.848	39.867 \pm 4.625
3	45.067 \pm 2.444	37.333 \pm 3.946	35.733 \pm 2.444	41.333 \pm 1.222	39.867 \pm 4.432
4	45.600 \pm 2.117	36.267 \pm 3.695	36.000 \pm 2.117	41.600 \pm 2.400	39.867 \pm 4.749
5	47.733 \pm 5.787	39.200 \pm 2.884	36.533 \pm 2.444	41.333 \pm 2.013	41.200 \pm 5.301
Regional average	45.493 \pm 3.648	37.227 \pm 3.726	35.787 \pm 2.227	41.760 \pm 1.920	40.067 \pm 4.825
Mg ²⁺ (mg/l)					
Season Site	Winter Average \pm SD	Spring Average \pm SD	Summer Average \pm SD	Autumn Average \pm SD	Annual Average \pm SD
1	23.490 \pm 1.403	16.686 \pm 1.964	13.608 \pm 2.430	16.200 \pm 1.964	17.496 \pm 4.170
2	23.490 \pm 1.403	16.362 \pm 2.297	13.608 \pm 2.430	16.200 \pm 1.964	17.415 \pm 4.221
3	23.490 \pm 1.012	16.362 \pm 2.297	13.770 \pm 2.191	16.038 \pm 1.752	17.415 \pm 4.133
4	23.166 \pm 1.223	16.038 \pm 2.227	13.770 \pm 2.023	16.200 \pm 1.840	17.294 \pm 4.010
5	24.624 \pm 3.958	16.524 \pm 1.752	13.770 \pm 1.562	16.038 \pm 1.752	17.739 \pm 4.778
Regional average	23.652 \pm 1.800	16.394 \pm 2.107	13.705 \pm 2.127	16.135 \pm 1.855	17.472 \pm 4.262
Mn ²⁺ (mg/l)					
Season Site	Winter Average \pm SD	Spring Average \pm SD	Summer Average \pm SD	Autumn Average \pm SD	Annual Average \pm SD
1	0.097 \pm 0.005	0.070 \pm 0.014	0.053 \pm 0.007	0.073 \pm 0.007	0.073 \pm 0.018
2	0.089 \pm 0.006	0.063 \pm 0.010	0.041 \pm 0.007	0.069 \pm 0.009	0.066 \pm 0.019
3	0.076 \pm 0.006	0.056 \pm 0.004	0.036 \pm 0.006	0.063 \pm 0.005	0.058 \pm 0.016
4	0.075 \pm 0.015	0.054 \pm 0.012	0.032 \pm 0.010	0.059 \pm 0.009	0.055 \pm 0.019
5	0.066 \pm 0.015	0.048 \pm 0.019	0.026 \pm 0.009	0.053 \pm 0.006	0.048 \pm 0.019
Regional average	0.081 \pm 0.009	0.058 \pm 0.012	0.037 \pm 0.008	0.063 \pm 0.007	0.060 \pm 0.018
Iron (mg/l)					
Season Site	Winter Average \pm SD	Spring Average \pm SD	Summer Average \pm SD	Autumn Average \pm SD	Annual Average \pm SD
1	0.374 \pm 0.075	0.263 \pm 0.020	0.253 \pm 0.040	0.263 \pm 0.017	0.288 \pm 0.064
2	0.363 \pm 0.079	0.257 \pm 0.014	0.248 \pm 0.032	0.252 \pm 0.014	0.280 \pm 0.063
3	0.346 \pm 0.086	0.250 \pm 0.009	0.242 \pm 0.028	0.246 \pm 0.010	0.271 \pm 0.060
4	0.342 \pm 0.099	0.241 \pm 0.012	0.239 \pm 0.034	0.236 \pm 0.012	0.264 \pm 0.065
5	0.330 \pm 0.105	0.241 \pm 0.019	0.226 \pm 0.035	0.229 \pm 0.011	0.256 \pm 0.065
Regional average	0.351 \pm 0.089	0.250 \pm 0.015	0.241 \pm 0.034	0.245 \pm 0.013	0.272 \pm 0.063
NH ₄ ⁺ (mg/l)					
Season Site	Winter Average \pm SD	Spring Average \pm SD	Summer Average \pm SD	Autumn Average \pm SD	Annual Average \pm SD
1	8.111 \pm 1.178	1.812 \pm 1.548	0.419 \pm 0.276	2.132 \pm 1.671	3.119 \pm 3.278
2	7.952 \pm 1.547	1.775 \pm 1.376	0.398 \pm 0.230	2.097 \pm 1.566	3.056 \pm 3.225
3	7.601 \pm 1.529	1.400 \pm 0.744	0.301 \pm 0.128	2.136 \pm 1.375	2.860 \pm 3.084
4	7.429 \pm 2.951	1.595 \pm 1.277	0.299 \pm 0.113	1.697 \pm 1.414	2.755 \pm 3.244
5	5.831 \pm 2.404	0.961 \pm 0.698	0.101 \pm 0.062	0.785 \pm 0.193	1.920 \pm 2.612
Regional average	7.385 \pm 1.922	1.509 \pm 1.136	0.304 \pm 0.162	1.769 \pm 1.244	2.742 \pm 3.089

Table 5. Seasonal and Annual variation of the water samples from Rosetta branch

Total Hardness (mg/l)					
Season Site	Winter Average \pm SD	Spring Average \pm SD	Summer Average \pm SD	Autumn Average \pm SD	Annual Average \pm SD
1	208.000 \pm 15.620	158.667 \pm 18.475	144.000 \pm 10.392	172.667 \pm 4.163	170.833 \pm 27.269
2	208.000 \pm 15.620	160.667 \pm 16.166	144.667 \pm 8.083	172.000 \pm 5.292	171.333 \pm 26.469
3	209.333 \pm 10.263	160.667 \pm 16.166	146.000 \pm 7.211	169.333 \pm 4.619	171.333 \pm 26.095
4	209.333 \pm 10.066	156.667 \pm 14.189	146.667 \pm 5.033	170.667 \pm 9.018	170.833 \pm 26.319
5	220.667 \pm 30.746	166.000 \pm 12.490	148.000 \pm 3.464	169.333 \pm 7.024	176.000 \pm 31.760
Regional average	211.067 \pm 16.463	160.533 \pm 15.497	145.867 \pm 6.837	170.800 \pm 6.023	172.067 \pm 27.583

DO (mg/l)					
Season Site	Winter Average \pm SD	Spring Average \pm SD	Summer Average \pm SD	Autumn Average \pm SD	Annual Average \pm SD
1	4.410 \pm 0.698	4.393 \pm 0.525	3.240 \pm 0.867	4.943 \pm 1.823	4.247 \pm 1.141
2	4.467 \pm 0.666	4.847 \pm 0.389	3.170 \pm 1.100	4.660 \pm 1.693	4.286 \pm 1.150
3	4.650 \pm 0.685	5.107 \pm 0.463	2.587 \pm 0.905	3.303 \pm 1.381	3.912 \pm 1.318
4	4.807 \pm 0.704	4.993 \pm 0.696	2.747 \pm 1.416	2.920 \pm 1.287	3.867 \pm 1.420
5	4.803 \pm 0.208	5.917 \pm 0.772	2.767 \pm 1.663	2.643 \pm 1.380	4.033 \pm 1.749
Regional average	4.627 \pm 0.592	5.051 \pm 0.569	2.902 \pm 1.190	3.694 \pm 1.512	4.069 \pm 1.356

BOD (mg/l)					
Season Site	Winter Average \pm SD	Spring Average \pm SD	Summer Average \pm SD	Autumn Average \pm SD	Annual Average \pm SD
1	2.700 \pm 0.557	4.467 \pm 0.577	3.567 \pm 0.551	3.400 \pm 1.311	3.533 \pm 0.958
2	2.733 \pm 0.503	4.600 \pm 0.917	3.667 \pm 0.635	3.600 \pm 1.311	3.650 \pm 1.030
3	2.667 \pm 0.577	4.800 \pm 1.039	4.233 \pm 0.945	3.900 \pm 1.473	3.900 \pm 1.217
4	2.667 \pm 0.577	4.867 \pm 0.379	4.700 \pm 0.872	4.000 \pm 1.400	4.058 \pm 1.184
5	2.867 \pm 0.404	5.167 \pm 0.404	5.033 \pm 0.551	4.267 \pm 1.617	4.333 \pm 1.225
Regional average	2.727 \pm 0.524	4.780 \pm 0.663	4.240 \pm 0.711	3.833 \pm 1.423	3.895 \pm 1.123

COD (mg/l)					
Season Site	Winter Average \pm SD	Spring Average \pm SD	Summer Average \pm SD	Autumn Average \pm SD	Annual Average \pm SD
1	4.500 \pm 0.928	13.535 \pm 1.750	6.859 \pm 1.059	9.524 \pm 1.905	8.605 \pm 3.723
2	4.970 \pm 0.915	13.939 \pm 2.777	7.051 \pm 1.221	8.571 \pm 3.123	8.633 \pm 3.952
3	4.848 \pm 1.050	15.000 \pm 3.248	8.467 \pm 1.890	9.750 \pm 3.683	9.516 \pm 4.438
4	8.081 \pm 1.750	17.381 \pm 1.352	10.930 \pm 2.027	10.000 \pm 3.500	11.598 \pm 4.144
5	8.687 \pm 1.225	17.816 \pm 1.394	11.439 \pm 1.252	10.159 \pm 3.849	12.025 \pm 4.103
Regional average	6.217 \pm 1.173	15.534 \pm 2.104	8.949 \pm 1.490	9.601 \pm 3.212	10.075 \pm 4.072

7. The Nitrite values in different sites were ranged between 0.117-0.421, 0.652-0.980, 0.286-0.750 and 0.751-1.321 mg/l during winter, spring, summer and autumn, respectively. The results obtained of NO_2^- concentrations Show that, the nitrite were increased during autumn and decreased during winter. The sharp decrease of nitrite content during winter, might be due to principally the increase of oxidation rate of nitrite which converts nitrite into nitrate and as a result of denitrification biological reduction of nitrite which converts nitrite into cellular amino acids by the photosynthetic plankton algae and by transaminase enzyme which ultimately provide the fats, fatty acids, amino acids, nucleic acids, protein, organic acids and other organic compounds necessary for growth and reproduction of these organisms. This occurs during drought period [50].
8. The results of Dissolving Oxygen (DO) shows that, the values in different sites were ranged between 4.41-4.81, 4.39-5.92, 2.59-3.24 and 2.64-4.94 mg/l during winter, spring, summer and autumn, respectively. The highest values of DO were recorded during spring may be attributed to, the increase of photosynthesis activity, which liberate a significance amount of oxygen to surrounding water ecosystem, as well as related to the abundance of phytoplankton during this season in which the photosynthetic process regarded a main source of oxygen [51,52]. However, the lowest DO values were recorded during summer season, this may be due to the elevation in temperature during summer leading to the decrease the solubility of atmospheric oxygen surrounding to water [52, 53].
9. Biochemical Oxygen Demand (BOD) results shows that, the values in different sites were ranged between 2.67-2.87, 4.47-5.17 357.5.03 and 3.40-4.27 mg/during winter, spring, summer and autumn, respectively. The minimum values of BOD were recorded during winter this explained basically due to the drought period during this season. This agreed with that reported [54]. The higher BOD values recorded during spring may attribute to the photosynthetic activity and abundance of phytoplankton leading to an increase of DO there for BOD will increase [42]. High levels of BOD measurement refer to the wastewater contain organic materials that can be degradable by different organisms. This decomposition of organic materials can deplete dissolved oxygen supplies in receiving water body of aquatic life resulting in axoic or anaerobic conditions Methane, amines, and sulfide are produced in anaerobic water, causing the water to acquire an unpleasant odor, taste, appearance and less oxygen is available for higher animals such as fishes [54].
10. Chemical Oxygen Demand (COD) results shows that, the values in different sites were ranged between 4.50-8.69, 13.54-17.82, 6.86-11.44 and 8.57-10.16 mg/l during winter, spring, summer and autumn, respectively. This parameter is not requested for monitoring water supplies but used sometimes for evaluation of polluted raw water. Extremely useful in the determination of domestic waste and polluted waters, COD determination provides a measure of oxygen equivalent of the portion of the organic matter in a sample that is susceptible to oxidation by strong chemical oxidant. The high COD during the one year monitoring period may be due to loaded variety of samples with organic matter [55].
11. The Sulfate values in different sites were ranged between 67.257-69.770, 43.340-46.487, 31.00-37.733 and 49.173-53.580 mg/l during winter, spring, summer and autumn, respectively. The observed results of SO_4^{-2} concentration represented that, the higher values of SO_4^{-2} content during winter, may be due to, the death of microorganisms during drought period and to the decomposition of aquatic plants. This may also due to oxidation of S^{-2} into SO_4^{-2} which depends on the high concentration of dissolved oxygen during this season. This result agreed with that reported [55]. On the other hand, the lower SO_4^{-2} values were recorded during summer may be attributed to the elevation of temperature during this season leading to, two processes take place, Sulfate will be reduced directly by the action of sulfate reducing active bacteria into sulfide, and deposition of SO_4^{-2} to the sediment as sulfate salts. The above mentioned conclusion coincided with that reported [56].

12. The Iron values in different sites were ranged tween 0.330-0.374, 0.241-0.263, 0.226-0.253 and 0.229-0.263 mg/l during winter, spring, summer and autumn, respectively. The minimum values of iron were recorded during summer, may be attributed to that iron adsorbed by clay minerals, suspended matter, surface microorganisms and metals oxide as iron oxide under high temperature [57]. Generally, the distributions dynamics of iron in water ecosystem depends on the dissolved oxygen and present as insoluble $\text{Fe}(\text{OH})_3$ or ferric oxide. The ferrous form can only exist in the absence of oxygen and the ferric forms are almost completely insoluble, in other words, in oxygenated water, iron is precipitated as ferric salts [58,59].
13. The Manganese values in different sites were ranged between 0.066-0.097, 0.048-0.07, 0.026-0.053 and 0.053-0.073 mg/l during winter, spring, summer and autumn, respectively, figure 2. The results of manganese concentration revealed that, the high values were recorded during winter and autumn seasons; this may be attributed to the effect of the drought period. However, the low water level and the slow motion of water current would facilitate in the excretion of manganese from this aquatic plants in addition to dissolution of sediment manganese and release to water during spring [41]. The low values of manganese during summer and spring may be attributed to the removal of manganese from aqueous phase to solid phase during precipitation of Mn^{+2} as MnO_2 or by adsorption of suspended particles during summer and spring. Also, the dilution effect of the flood period during autumn can add more explanation [60].

3.3. Correlation Coefficients

The most familiar measure of dependence between two quantities is the Pearson product-moment correlation coefficient, or "Pearson's correlation". If we have a series of n measurements of X and Y written as x_i and y_i where $i = 1, 2, n$, The correlation coefficient is Written as:

$$r_{xy} = \frac{n \sum x_i y_i - \sum x_i \sum y_i}{\sqrt{n \sum x_i^2 - (\sum x_i)^2} \sqrt{n \sum y_i^2 - (\sum y_i)^2}} \quad (4)$$

The Pearson correlation coefficient ranges from -1 to +1. It is +1 in the case of a perfect positive (increasing) linear relationship (correlation), -1 in the case of a perfect decreasing (negative) linear relationship (anti-correlation), and some value between in all other cases, indicating the degree of linear dependence between the variables. As it approaches zero there is less of a relationship (closer to uncorrelated). The closer the coefficient is to either -1 or +1, the stronger the correlation between the variables [61].

Statistical analysis of data was computed to show the correlation between some parameters through the whole sampling sites during the period of the study, using simple correlation coefficient, table 6.

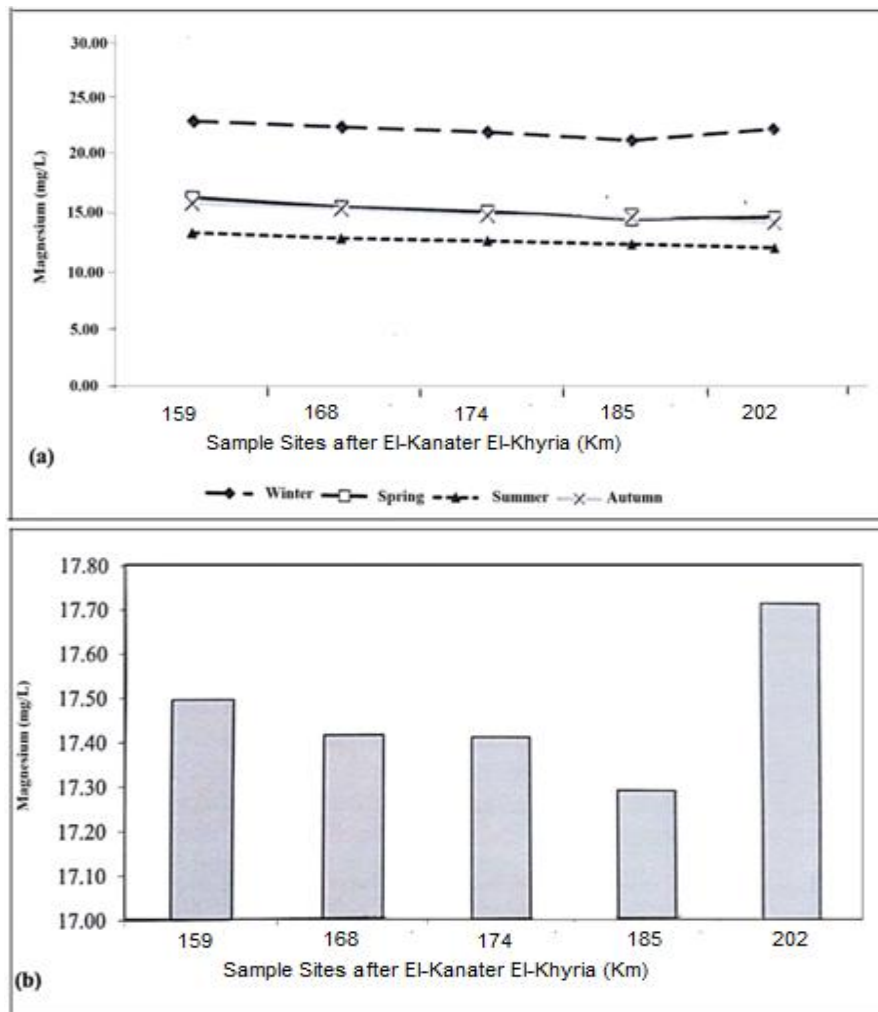


Figure 2. a) Seasonal and (b) Annual variation of magnesium (mg/l) from January 2013 to December 2013

Table 6. Person correlation coefficient for different parameters of Rosetta branch

	parameters	r	parameters	r	parameters	r		
	Temperature	E.C.	-0.877	NH ₄ ⁺	NO ₂ ⁻	-0.529	total hardness	Ca ⁺²
alkalinity		-0.864	BOD		-0.622	Mg ⁺²		0.955
Cl ⁻		-0.667	COD		-0.427	SO ₄ ⁻²		0.890
NH ₄ ⁺		-0.924	BOD	COD	0.788	Cl ⁻		0.743
NO ₂ ⁻		0.515		NO ₂ ⁻	0.521	total hardness	0.923	
total hardness		-0.936	Ca ⁺²	Mg ⁺²	0.728	alkalinity	Ca ⁺²	0.864
Ca ⁺²		-0.766	Fe ⁺³	Mn ⁺²	0.730		Mg ⁺²	0.858
Mg ⁺²		-0.945	E.C.	Cl ⁻	0.780	Ca ⁺²	Cl ⁻	0.728
SO ₄ ⁻²		-0.877		NH ₄ ⁺	0.782		SO ₄ ⁻²	0.770
DO		-0.420		Ca ⁺²	0.827	Mg ⁺²	Cl ⁻	0.668
Fe ⁺³		-0.821		Mg ⁺²	0.854		SO ₄ ⁻²	0.869
Mn ⁺²		-0.769		SO ₄ ⁻²	0.861		Cl ⁻	SO ₄ ⁻²
					Fe ⁺³	0.635		
				Mn ⁺²	0.727			

Positive correlations have been obtained between:

- Electrical conductivity and each of anions and cations parameters. This indicates that the increasing in ions concentration leading to increase of EC.
- Calcium and each of chloride and sulfate, this indicates that calcium may be found as calcium chloride or a calcium sulfate.
- Magnesium and each of chloride and sulfate, this indicates that magnesium may be found as magnesium chloride or magnesium sulfate.
- Total alkalinity and each of calcium and magnesium may be due to their association to form calcium and magnesium carbonates or bicarbonates.
- Total hardness and total alkalinity indicating that total hardness is mostly temporary hardness (carbonate hardness).
- Total hardness and each of calcium, magnesium, chloride, and sulfate as expected.
- Both calcium and magnesium were taken the same behavior with different parameters in the correlation matrix analysis, also iron and manganese found to have the same behavior with different parameters in the correlation matrix.
- BOD was positively correlated with nitrogen compounds (nitrite) as expected because nitrogen compounds is essential to growth of organisms where the nutrient limits the primary productivity of the living bodies

Negative correlations have been obtained between:

- Dissolved oxygen was negatively correlated with temperature in Rosetta branch as expected.
- Ammonia and nitrite indicate that strong opposite relationship between the two parameters and the inter conversion between them.
- Ammonia and BOD and COD as expected.
- Temperature and ammonia attributed to during hot season the oxidation of ammonia into NO_2^- and NO_3^- through nitrification process by the action of nitrosomonas bacteria takes place.

3.4. Analysis of variance

To estimate the amount of variation due to certain causes (temporal and/or spatial reason); using analysis of variance (ANOVA) examination the different (usually called source of variations) operating simultaneously on a response to decide which effect are statistically significant and to estimate their contribution to the variability of response. For these reasons, a two way ANOVA of independent variable used in the present study showed the existence of seasonal and/or spatial difference of Rosetta branch.

ANOVA tests were calculated for all parameters of Rosetta branch. The results indicate that the effect of seasons were significant (there were significant difference between seasons) for all parameters except temperature and pH are not significant. The effect of sites was significant (there were significant difference between sites) for temperature, turbidity, ammonia, BOD, COD, iron and manganese. However, the effect was not significant (there were no significant difference between sites) for pH, electrical conductivity, chloride, alkalinity, total hardness, calcium, magnesium, nitrite, dissolved oxygen and sulfate.

3.5. Statistical Water Quality Index (SWQI)

The calculation of statistical water quality index, eleven important Parameters were chosen. The SWQI has been calculated by using the Law 48/1982 amended in 2013, Decree NO. 49, "Quality of fresh water". The weighted arithmetic index method has been used for the calculation of WQI of water body, table 7. Water quality index and status of water quality was presented in table 8 and figure 3.

WQI was calculated for five sites along Rosetta branch during the period of the study figure 3, it shows that:

- Quality of water in summer ranged from 26.268 at site (5) to 46.64 at site (1) (good water quality).
- Water in spring in site (5) show (poor water quality) and in site (3,4) show (very poor water quality)
- In autumn and winter the water is (unsuitable for drinking) for all sites except site (5) show (poor water quality) as indicates

Table 7. Calculated Assigned unit weight for each and status of parameter with their Egyptian standard limits "Law 48/1982 amended in 2013, Decree NO. 4"

Sr. No.	Parameters	Standard	Unit Weight
1	pH	6.5-8.5	0.118
2	TDS	<500	0.002
3	Ammonia	<0.5	2.000
4	DO	>5.0	0.167
5	COD	<6.0	0.167
6	BOD	<10.0	0.100
7	Sulfate	<200	0.005
8	Iron	<0.5	2.000
9	Manganese	<0.2	5.000

Table 8. Water quality index water quality

Index level	Quality
0-25	Excellent water quality
26-50	Good water quality
51-75	Poor water quality
76-100	Very poor water quality
>100	Unsuitable for drinking

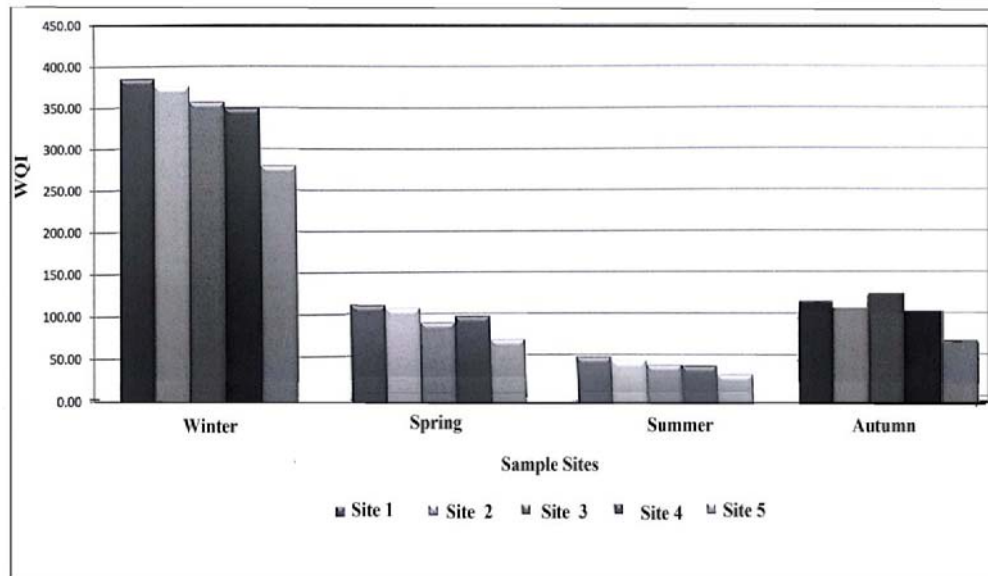


Figure 3. SWQI of Rosetta Branch at 5 sites

4. Conclusions and Recommendations:

The results show that:

- The pollution appears in the fresh water of the Rosetta branch with sewage and domestic wastes of El-Rahawy drain and agricultural wastes.
- Most of physical and chemical parameters are changeable and affected by seasonal variation.
- The degree of pollution of the branch is visible in the gradually increasing of the following parameters: electrical conductivity, chlorides, alkalinity, BOD, COD, hardness, sulfate, ammonia, iron, and manganese along the branch.
- Increasing of ammonia is the most indication of agricultural pollution.
- Increasing of electrical conductivity, chloride, COD and BOD indicates the sewage pollution.
- BOD and COD indicate the activation of microorganisms and presence of organic compounds where microorganisms use dissolved oxygen during oxidation process of it.
- WQI was calculated for the five sites along Rosetta branch during the period of the studies where:
 1. Good water quality in summer is in all sites.
 2. Poor water quality in spring in site (5) and very poor quality in sites (3,4).
 3. Unsuitable water for drinking in autumn and winter in all sites except site (5) show poor water quality.

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