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RESEARCH ARTICLE

PHYSICAL, CHEMICAL, AND HEAVY METAL CONCENTRATIONS IN WATERS OF KAFR EL-ZAYAT AREA, ROSETTA BRANCH, RIVER NILE, EGYPT.

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Abstract

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Five sites in the water of Rosetta Branch were selected to investigate the physical, chemical, and heavy metal concentrations. In this study there are great variations in the studied parameters according to the distance from the source of pollution. Heavy metal concentrations are strongly affected by the industrial effluents produced from each of El-Mobidat, El-Malyia and Salt and Soda companies which directly discharge industrial effluents at this area without any treatments.

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Introduction:-

In Egypt, River Nile plays an important role in the life of Egyptians. It is the main water source and represents the artery of life in Egypt **(Cavas, 2008)**. It is exposed to many types of pollutants whether biological or chemical in nature. Water quality of River Nile has been affected by the discharges of agricultural drains, industrial and municipal effluents **(El-Sherbini, 1996)**.

The aquatic environment makes up the major part of our environment and resources. Therefore, its safety is directly related to human health **(Ali et al., 2008)**. Pollution, loss of biodiversity, and habitat destruction are probably the main environmental threats for aquatic ecosystems. Moreover, the excessive contamination of aquatic ecosystems has evoked major environmental and health concerns worldwide **(McNeil and Fredberg, 2011),** as the aquatic environment is the ultimate recipient of pollutants produced by the natural and anthropogenic sources

The agricultural run-offs have cumulatively negative effects on the environmental quality of water in which decreased biodiversity and accidental fish die-offs have occurred. Water quality of the aquatic ecosystem is considered as the main factor controlling the state of health and disease in both cultured and wild fish (**Fathi and Flower, 2005).** Water quality cannot be measured directly and can only be described on a comparative basis **(Adams, 2002)**. Among the various toxic pollutants, heavy metals represent a very interesting group of elements due to their strong impact on stability of aquatic ecosystems **(Mikhail et al., 2018)**, bioaccumulation in living organisms **(Mansouri and Baramaki, 2011)** toxicity persistence and tendency to accumulate in water and sediments. The aim of the present investigation is to evaluate the quality of Nile water at Kafr El-Zayat area, Rosetta Branch.

Material and Methods:-

Study sites:-

This study was conducted at Kafr El- Zayat town. It located on Rosetta branch of the River Nile. Five sites in the study area were selected.

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1. Tala drainage: drain sewage water directly in Nile water.
2. The second site is located by about 200 m away from the first site.
3. This site is in-between sites 2 and 3 in middle of Rosetta branch water.
4. The area of industrial companies which drain their waste water into Nile water. These companies change it drain outlet from this area into Ganag drain which drains directly into Borolos Lake.
5. This site after site 4 by about 150-200m.

Water sampling:-
Water samples were taken with a water sampler from each site seasonally. Duplicates of water samples were taken from each of the five studied sites, between 10:00 and 12:00 a.m. at a depth of 30cm below the water surface and stored at 4˚c in clean1000 ml sampling glass bottles according to **Boyd (1990)**.

Water analysis:-
Water temperature, pH and electrical conductivity were immediately measured at site using Corning Checkmate II multi-parameter meter, chloride concentration was determined by argentometric method, sulphate concentration was determined by turbidimetric method, bicarbonate concentration was determined using titration method, sodium and potassium concentration were determined by flame emission photometric method, and calcium and magnesium were determined volumetrically using EDTA titrimetric method. These methods were done according to the American Public Health Association standard methods **(APHA, 2005)**. On the other hand, water heavy metals concentration (Fe, Mn, Cu, Cr, Co, Cd, Ni) were determined by a Perkin-Elmer 2380 atomic absorption spectrophotometer (AAS) according to **APHA (2005)**.

Results and Discussion:-

Temperature (^{0}C):-
Water temperature is one of most influencing aquatic environments **(Weatherley and Gill, 1987; Boyd, 1990). Boyd (1990)** mentioned that, water temperature is a factor affecting water dynamics as well as metabolism and growth of fish is greatly related to solar radiation and air temperature.

The variation in temperature between different sites in this study may be due to different sampling times. The increase of water temperature during the summer season is due to the increase of air temperature which affect the health, survival of aquatic organisms, while the sub lethal effects by altering the physiology of aquatic organisms, and thus affecting their ability grow, reproduce and compete for habitats (**Alaa, 2010; Mohamed and Hossam, 2004)**.

Water temperature values at different sites showed logical seasonal fluctuation with significant seasonal differences among the study period for all sites (Table 1) The highest temperature, 30 ^{0}C, was recorded in site 4, the area of industrial companies which drain their waste water into Nile water, while the lowest one, 16.5^{0}C, during autumn in site 2, located by about 200 m away from Tala drainage.

pH:-
pH values of the studied water samples showed significant seasonal differences among the study period. Values of pH in water samples collected during the study period ranged from 7.32 to 8.36 indicating slightly alkaline medium (Table 1).

The highest pH value (8.36) was recorded in winter in site 4, and may be attributed to the increasing of photosynthetic activity which reduces the CO_2 amount in water and the lowest pH value 7.32 was recorded during summer and autumn in site 3 This site is in between sites 2 and 3 in middle of Rosetta Branch water. Water with pH values ranging from 6.5-9.0 is optimum for fish growth and production **(Boyd, 1990)**. pH level of 11 may be lethal to fish (**Chaudhari, 2003).**

EC (ms/cm^{-1}):-
The highest recorded values of electrical conductivity may be due to the disposal of domestic and industrial effluent in water and implicate industrial and sewage sources and this is of a linear function of the concentration dissolved ions and its increases indicate that there is a source of dissolved ion in the vicinity (**Alaa, 2010)**. The highest value of water EC was recorded in winter in site 4 (820ms/m^{-1}) and the lowest value was recorded in site 2 (523ms/m^{-1})

Table 1:- Seasonal variations of water temperature, pH, electric conductivity in the sites of the sampling region.

Character	Site	Summer	Autumn	Winter	Spring
Temp, ^{0}C	1	28.37^{c}	17.17^{kl}	19.90^{h}	25.27^{f}
	2	28.10^{c}	16.50^{m}	18.03^{j}	26.27^{e}
	3	29.07^{b}	17.03^{i}	20.10^{h}	24.53^{g}
	4	30.27^{a}	16.57^{m}	18.90^{i}	26.23^{e}
	5	29.27^{b}	17.33^{k}	18.73^{i}	26.57^{d}
pH	1	7.66^{c}	7.67^{c}	8.33^{a}	7.38^{gh}
	2	7.61^{cd}	7.62^{cd}	8.28^{a}	7.36^{ghi}
	3	7.32^{i}	7.32^{hi}	8.13^{b}	7.43^{fg}
	4	7.51^{e}	7.55^{de}	8.36^{a}	7.48^{ef}
	5	7.32^{i}	7.33^{hi}	8.14^{b}	7.64^{c}
EC, ms/cm^{-1}	1	542e^{fg}	550^{e}	774^{b}	633^{c}
	2	542e^{fg}	533^{ghi}	776^{b}	523^{i}
	3	548e^{f}	576^{d}	780^{b}	528^{hi}
	4	533^{ghi}	527^{hi}	820^{a}	536^{fgh}
	5	554^{e}	554^{e}	781^{b}	530^{ghi}

Means with different superscript letters for each metal are statistically significant at $p \leq 0.05$

during spring season (Table 1). The highest recorded values of electrical conductivity during winter and autumn seasons may indicate the high amount of organic residues in water bodied and the increase in rates of degradation of organic pollutants which consequently increase the conductivity values in water bodies (**Sarwar and Wazir, 1988)**.

Water chemical characteristics:-

Water cations (calcium, magnesium, sodium and potassium):-

Calcium; the highest calcium concentration (4.34 mg/l) was recorded in site 1, Tala drainage which drain sewage water directly in the Nile water during winter while the lowest one 3.03 mg/l during summer in site 4. (Table 2). **Magnesium;** the highest magnesium concentration (2.82 mg/l) was recorded in winter in site 2 and lowest concentration (1.85 mg/l) during winter in site 1 (Table 2). **Sodium;** sodium highest concentration (2.59 mg/l) in site 2 during the spring season while the lowest concentration was recorded during summer in site 5 this site after the area of industrial companies, which drain their waste water into Nile water away, by about 150-200m (Table 2). **Potassium;** the highest value of potassium (0.52 mg/l) was recorded during autumn in site 5 while the lowest concentration (0.14 mg/l) in site 4 during summer season (Table 2).

Table 2:- Seasonal variations of water cations in the sites of the sampling region.

Character	Site	Summer	Autumn	Winter	Spring
Ca^{++}, mg l^{-1}	1	4.22^{b}	3.66^{f}	4.34^{a}	3.55^{g}
	2	3.12^{k}	3.42^{i}	3.11^{k}	3.41^{i}
	3	3.51^{h}	4.10^{c}	3.81^{e}	4.09^{c}
	4	3.03^{m}	3.32^{j}	3.05^{l}	3.81^{e}
	5	4.00^{d}	3.82^{e}	4.01^{d}	3.81^{e}
Mg^{++}, mg l^{-1}	1	1.85^{p}	2.12^{l}	1.88^{o}	2.14^{k}
	2	2.66^{c}	2.06^{m}	2.82^{a}	2.06^{m}
	3	1.87^{o}	2.64^{d}	1.95^{n}	2.52^{g}
	4	2.25^{j}	2.58^{f}	2.37^{i}	2.38^{i}
	5	2.61^{e}	2.38^{i}	2.79^{b}	2.41^{h}
Na^{+}, mg l^{-1}	1	1.41^{m}	2.45^{c}	1.63^{k}	2.52^{b}
	2	1.23^{o}	2.59^{a}	1.06^{p}	2.59^{a}
	3	1.40^{m}	1.69^{i}	1.54^{l}	1.78^{h}
	4	2.00^{f}	2.10^{e}	2.33^{d}	2.09^{e}
	5	1.06^{p}	1.89^{g}	1.33^{n}	1.67^{j}
K^{+}, mg l^{-1}	1	0.21^{j}	0.24^{hi}	0.27^{g}	0.25^{h}
	2	0.38^{c}	0.24^{hi}	0.38^{c}	0.23^{i}
	3	0.23^{i}	0.37^{c}	0.31^{e}	0.36^{d}
	4	0.14^{k}	0.20^{j}	0.41^{b}	0.23^{i}
	5	0.30^{e}	0.52^{a}	0.38^{c}	0.28^{f}

Means with different superscript letters for each metal are statistically significant at $p \leq 0.05$

Water anions (chloride, bicarbonate and sulfate):-

Chlorideion:-

In Table (3) the highest Cl^- ion concentration (5.30 mg/l) was recorded in site 4 during winter, while the lowest one (3.65 mg/l) recorded during summer season in site2. The high chloride may indicate the pollution by sewage or industrial wastes (**Alaa**, **2010**). The increase in Cl^- and EC points out that the agricultural activity such as runoff, soil erosion and salts in domestic wastewater **(Gupta and Zidan, 2003)**. **Bicarbonate;** the highest value of HCO_3^- concentration (0.53 mg/l) was recorded in winter in site 4 it may be attributed to decrease in water and air temperature lead to precipitation of calcium bicarbonate **(Elewa, 1993)**, while the lowest value (0.43 mg/l) was recorded in site 5 during autumn and winter seasons (Table 3). **Sulfate (SO_4^{2-})**; the highest SO_4^{2-} concentration (3.32 mg/l) in site 1 during autumn while the lowest value (2.32 mg/l) in summer in site 3 (Table 3).

Table 3:- Seasonal variations of water anions in the sites of the sampling region.

Character	Site	Summer	Autumn	Winter	Spring
Cl^-, mg l^{-1}	1	4.24^{m}	4.86^{h}	4.98^{f}	4.99^{ef}
	2	3.65^{r}	5.11^{c}	4.77^{i}	5.00^{e}
	3	3.88^{q}	5.04^{d}	3.89^{p}	4.32^{l}
	4	3.96^{o}	4.91^{g}	5.30^{a}	4.59^{j}
	5	4.76^{i}	5.25^{b}	4.18^{n}	4.45^{k}
HCO_3^-, mg l^{-1}	1	0.49^{de}	0.50^{cd}	0.50^{cd}	0.52^{ab}
	2	0.48^{ef}	0.50^{cd}	0.51^{bc}	0.51^{bc}
	3	0.51^{cd}	0.47^{fg}	0.46^{gh}	0.44^{ij}
	4	0.51^{cd}	0.51^{bc}	0.53^{a}	0.47^{fg}
	5	0.49^{de}	0.43^{ij}	0.43^{ij}	0.45^{hi}
SO_4^{2-}mg l^{-1}	1	2.69^{fg}	3.32^{a}	3.00^{c}	2.84^{e}
	2	2.51^{hi}	2.64^{g}	2.83^{e}	2.68^{g}
	3	2.32^{l}	3.20^{b}	2.34^{l}	2.33^{l}
	4	2.52^{hi}	2.74^{f}	2.98^{c}	2.45^{j}
	5	2.53^{h}	2.92^{d}	2.47^{ij}	2.39^{k}

Means with different superscript letters for each metal are statistically significant at $p \leq 0.05$

Water heavy metals (Fe, Mn, Cu, Cd, Cr, Co and Ni):-

The presence of metals in environment is partially due to natural process such as erosion but it is mostly the result of industrial wastes **(Dave and Xiu, 1991)**. Heavy metal pollution in water is generally associated with industrial and municipal dischargers **(Salah El-Deen *et al*., 1999; Zaghloul, 2000).** Once metals are in water column, they may be taken by living organisms, deposited in the sediments or remain for some period in the water itself **(Salah El-Deen *et al*., 1999).** The studied heavy metals in the present work are: Iron, Manganese, Copper, Cadmium, Chromium, Cobalt and Nickel. The detected values of these metals in water are illustrated in Table (4).

Iron concentration in water samples showed no significant difference in sites as well as seasons. The highest value of Fe (5.463 mg/l) was recorded in spring in site 1 and the lowest value (1.040 mg/l) was recorded in site 2 during summer. **Manganese** concentration in the studied water samples showed significant differences among sites and seasons. The highest value was recorded in summer in site 5 (1.356 mg/l) while the lowest one recorded (0.120 mg/l) in site 2 during autumn. **Copper** concentration in Nile water samples collected during the study period showed significant difference among sites and seasons. The highest concentration of Cu (0.360 mg/l) was recorded in the spring in site 1 and the lowest one (0.035 mg/l) in site 3 during winter. **Cadmium** concentration in the studied water showed significant difference among the study period for all sites. The highest value of Cd (0.164 mg/l) was recorded in spring in site 5 and the lowest value (0.008 mg/l) was recorded in site 5 during summer. **Chromium** concentration in water samples showed significant difference among most sites and seasons. The highest value of Cr (0.412 mg/l) was recorded during winter in site 1 while the lowest value (0.032 mg/l) was recorded in site 4 in the summer season. Cobalt concentration in the studied water samples showed significant difference among sites and seasons. The highest value of Co (0.060 mg/l) was recorded in winter in site 1and the lowest one (0.024 mg/l) was recorded in site 5 during summer. **Nickel** the highest concentration of Ni (0.270 mg/l) was recorded in site one in winter, while the lowest value (0.134 mg/l)in site 5 during winter.

Table 4:- Seasonal variations of water heavy metals in the sites of the sampling region.

Metal	Site	Summer2015	Autumn	Winter2016	Spring
Fe	**1**	2.331^{a}	5.000^{a}	4.953^{a}	5.463^{a}
	2	1.040^{a}	4.140^{a}	4.077^{a}	5.030^{a}
	3	3.416^{a}	4.750^{a}	3.647^{a}	4.637^{a}
	4	2.334^{a}	5.010^{a}	4.332^{a}	5.003^{a}
	5	1.111^{a}	4.620a	3.667a	4.253^{a}
Mn	**1**	1.341^{a}	0.170^{c}	0.994^{bc}	1.028^{bc}
	2	0.943^{bcd}	**0.120^{g}**	0.471^{ef}	0.868^{cd}
	3	0.874^{cd}	0.160^{g}	0.166^{g}	0.504^{e}
	4	1.200^{ab}	0.140^{g}	0.242^{fg}	0.701^{de}
	5	**1.356^{a}**	0.200^{g}	0.131^{g}	0.139^{g}
Cu	**1**	0.141^{g}	0.210^{de}	0.279^{b}	**0.360^{a}**
	2	0.134^{g}	0.220^{d}	0.146^{c}	0.149^{g}
	3	0.145^{g}	0.200^{ef}	**0.035^{k}**	0.140^{g}
	4	0.187^{f}	0.240^{c}	0.112^{h}	0.195^{ef}
	5	0.200^{ef}	0.210^{de}	0.050^{j}	0.078^{i}
Cd	**1**	0.059^{f}	0.140^{b}	0.133^{b}	**0.164^{a}**
	2	0.012^{h}	0.110^{c}	0.104^{cd}	0.144^{b}
	3	0.009^{h}	0.070^{f}	0.063^{f}	0.058^{f}
	4	0.036^{g}	0.100^{cde}	0.144^{b}	0.110^{c}
	5	**0.008^{h}**	0.090^{de}	0.087^{e}	0.066^{f}
Cr	**1**	0.049^{l}	0.080^{ghi}	**0.412^{a}**	0.167^{b}
	2	0.093^{fg}	0.070^{ij}	0.157^{b}	0.096^{efg}
	3	0.059^{jkl}	0.110^{de}	0.097^{def}	0.052^{kl}
	4	**0.032^{m}**	0.113^{d}	0.13^{c}	0.093^{fg}
	5	0.074^{hi}j	0.090^{fgh}	0.068^{ijk}	0.061^{jkl}
Co	**1**	0.041^{bcde}	0.040^{bcdef}	**0.060^{a}**	0.056^{ab}
	2	0.044^{abcd}	0.030^{def}	0.042^{bcde}	0.044^{abcd}
	3	0.035^{cdef}	0.030^{def}	0.027^{ef}	0.030^{def}
	4	0.037^{cdef}	0.040 ^{bcdef}	0.041^{bcde}	0.050^{abc}
	5	**0.024^{f}**	0.040^{bcdef}	0.033^{def}	0.031^{def}
Ni	**1**	0.214^{d}	0.210^{d}	**0.270^{a}**	0.224^{cd}
	2	0.235^{bc}	0.170^{gh}	0.193^{ef}	0.180^{fg}
	3	0.208^{de}	0.170^{gh}	0.14^{ijk}	**0.139^{jk}**
	4	0.213^{d}	0.150^{ijk}	0.162^{h}i	0.162^{hi}
	5	0.246^{b}	0.177^{fgh}	**0.134^{k}**	0.15^{1ij}

Means with different superscript letters for each metal are statistically significant at $p \leq 0.05$

The Nile River has been subjected to different sources of pollution and contamination through several and complicated routes. Industrial effluents constitute the real threat to the Nile River. Recently, the risk of water pollution with toxic chemicals not limited to the public health and veterinary public health only but extended and jointed as toxic chemicals causing zoonotic diseases as reported by (**El-Tras *et al*., 2011).** The Nile River at Kafr El-Zayat, is impacted by several industrial outfalls from oil and soap, fertilizers pesticides and sulfur industry (El-Malh and Soda, El-Malyia and El-Mobidat factories). There were other sources of pollution and contamination as agricultural drains, laying carcasses and sewage which discharged from several villages distributed along the two banks of the Rosetta Branch. **Mikhail *et al*. (2018)** found that the results the present investigation demonstrate that the Nile River at Kafr El- Zayat industrial area is heavily polluted and consequently harmful effects to the aquatic environment and to the quality of the water are established. So, pretreatment of different wastes through chemical and microbiological unit before discharging to the River Nile stream is recommended.

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