Research Journal of Environmental and Earth Sciences 6(3): 174-181, 2014
DOI:10.19026/rjees.6.5757
ISSN: 2041-0484; e-ISSN: 2041-0492

Submitted: December 19, 2013 Accepted: December 27, 2013 Published: March 20, 2014

**Research Article**

# Seasonal Variations in Physicochemical Parameters and Heavy Metals in Water of El-Bahr El-Pharaony Drain, El-Menoufia Governorate, Egypt

[1]Hala E. Ghannam, [1]Abdelrahman S. Talab, [2]Hossam S. Jahin and [2]Seleem E. Gaber
[1]Pollution Laboratory, Inland Water and Aquaculture Branch, El-Kanater El-Khiria, National Institute of Oceanography and Fisheries (NIOF), Cairo,
[2]National Water Research Center, El-Kanater El-Khairia, Egypt

**Abstract:** The aim of this study was to assess and monitor the seasonal variations of physicochemical parameters (temperature, EC, TS, TDS, TSS, pH, DO, BOD, COD, $CO_3$, $HCO_3$, Cl, $SO_4$, $NO_2$, $NO_3$, $NH_3$) and heavy metals (Al, Sb, As, Ba, Cd, Cr, Co, Cu, Fe, Pb, Mn, Ni, Se, Sn, V, Zn) concentrations in the water samples collected seasonally from El-Bahr El-Pharaony drain, El-Menoufia Governorate, Egypt from summer 2012 to spring 2013. Physicochemical characteristics of water varied significantly season to season and the most parameters values were significantly higher during summer at station I. All physicochemical parameters were below the permissible limits except TDS, BOD, COD and NH3 were higher in summer season at all stations. In case of heavy metals, As, Cd, Co, Sb, Se, Sn and V were not detectable (below the detection limits with ICP -OES <0.001 and <0.005) in water samples. On the other hand, Cu, Pb and Zn exceeded the permissible limits of Egyptian law. Heavy metal concentrations in El-Bahr El-Pharaony drain water were found in the following order: Fe>Cu>Al> Zn>Ni>Pb>Cr>Ba and the highest concentrations of heavy metals were recorded in summer at Station I. The water of El-Bahr El-Pharaony drain is partially polluted with heavy metals so, it is recommended that strict vigilance and constant monitoring are needed to maintain water quality of the drain, which considered a major source of fisheries in El-Menoufia Governorate.

**Keywords:** El-Bahr El-Pharaony drain, ICP-OES, water pollution

## INTRODUCTION

Water pollution is considered to be one of the most dangerous hazards affecting both developing and developed countries. The large-scale industrialization and production of variety of chemical compounds has led to global deterioration of the environmental quality (Chakravarty *et al*., 2010).

The River Nile is the second longest river in the world with about 6,825 km. Its basin is about 3.1 million $m^2$, extending by 1,530 km length inside Egyptian lands. It is the main source of freshwater in Egypt and more than 95% of Egyptian people depend on it. The water quality of River Nile is affected by agricultural drainage water containing salts, nutrients, pesticides, herbicides and industrial and municipal effluents from all towns and villages of Egypt that drain either directly or indirectly into the River (FAO, 2012). In Egypt, the pollution of River Nile system (main stem Nile, drains and canals) has increased in the past few decades because of increases in population; several new irrigated agriculture projects and other activities along the Nile (APRP, 2002).

El-Bahr El-Pharaony drain is one of the largest drains in El-Menoufia Governorate, Egypt, which extends for more 20 km long, 100-300 m width, 3-7 m depth and a total area of 2,000 feddans and pours into Damietta Branch of the River Nile, at Kattamiya Village. It receives untreated domestic sewage from numerous towns and villages in addition to the agricultural wastes (salts, nutrient and pesticides) which had a significant impact on ambient water quality and the lack of fisheries (GAFRD, 2011). The annual fish production of El-Bahr El-Pharaony drain is 2675 ton and the common fish species are carp (ESIAF, 2010).

The drain is very important economically in fishing and agriculture, so, special attention should be given to mitigate pollution from this drain. This study therefore serves to provide baseline data on the effect of seasonal changes on some physicochemical parameters as well as heavy metals concentrations (Al, Sb, As, Ba, Cd, Cr, Co, Cu, Fe, Pb, Mn, Ni, Se, Sn, V and Zn) in the water, which are essential for determining the water quality status of the El-Bahr El-Pharaony drain and providing the base line data on surface water quality to policy makers to manage and protect water bodies from water pollution for maintaining environmental ecological balance.

**Corresponding Author:** Hala E. Ghannam, Pollution Laboratory, Inland Water and Aquaculture Branch, El-Kanater El-Khiria, National Institute of Oceanography and Fisheries, 101 El-Kasr El-Eini, Cairo, Egypt

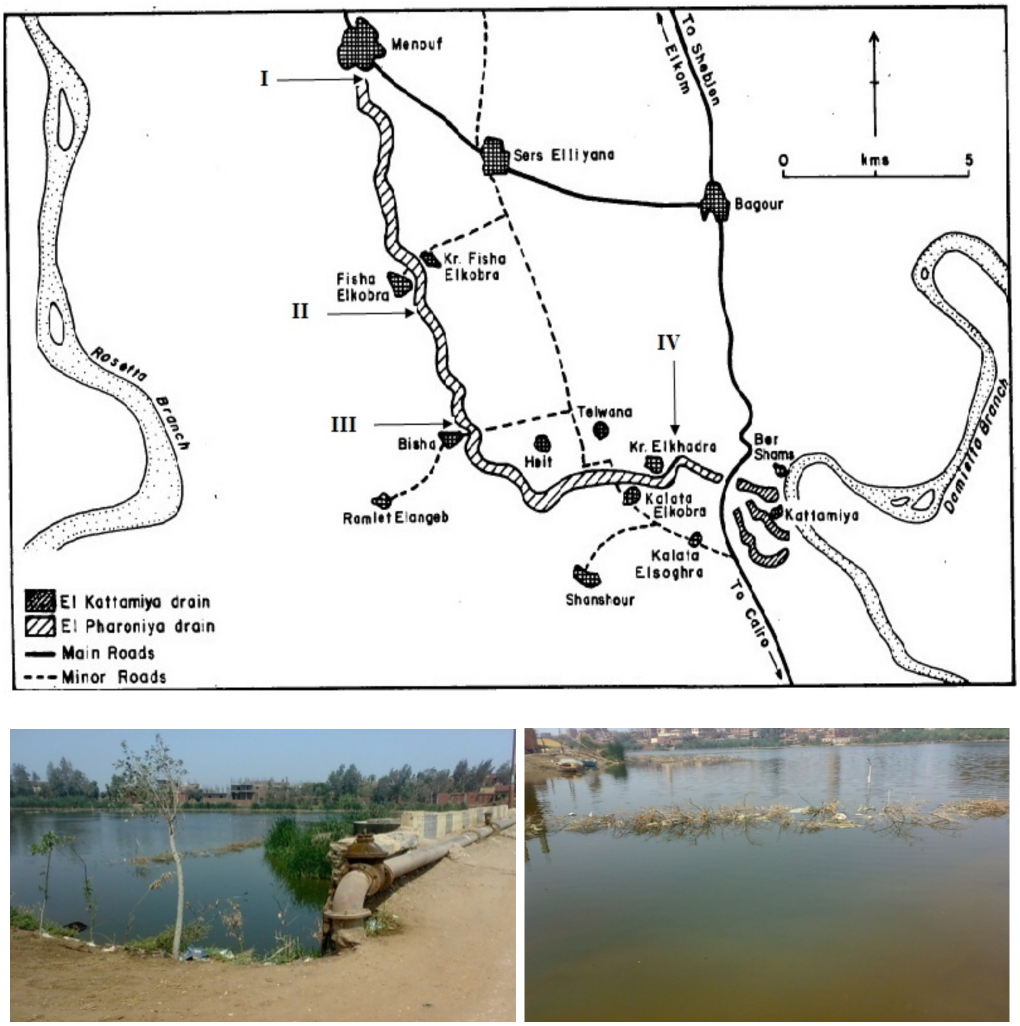


Fig. 1: Map of El-Bahr El-pharaony drain indicating the sampling stations I-IV

## MATERIALS AND METHODS

**Study area and monitoring sites:** El-Bahr El-Pharaony drain (Fig. 1) is divided into three parts, the first part extended from the Damietta branch to El-Rayyah El-Menofy (tanks Kettamiah); the second extends from the El-Rayyah El-Menofy to the bridge, which connects the village of Kafr Fisha with Fisha El-Kobra village and the third from Fisha El-Kobra bridge to Menouf City (GAFRD, 2011).

**Water sampling program and analysis:** Water samples were collected seasonally from summer 2012 to spring 2013 during four successive seasons. The samples were collected from different four stations at Menouf city (station I), Fisha El-Kobra Village (station II), Bisha Village (station III) and Kafr El-Khadra Village (station IV) of El-Bahr El-Pharaony drain (Fig. 1).

Water samples were collected at 60 cm depth using polyethylene bottles (one liter capacity). For heavy metals analysis water samples were collected in one-liter plastic bottles and preserved with 5 mL concentrated nitric acid (APHA, 1998). The samples were preserved in an icebox and returned immediately to the laboratory. Electrical conductivity, pH value and temperature were measured using instrument CRISON Multimeter MM 40. The chemical parameters and trace metals (Al, Sb, As, Ba, Cd, Cr, Co, Cu, Fe, Pb, Mn, Ni, Se, Sn, V and Zn) were determined in water samples according to the methods described in APHA (1998). The concentrations of heavy metals were measured using Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES) Model PERKIN ELMER Optima 3000.

## RESULTS AND DISCUSSION

**Physicochemical analysis of water:** In order to understand the environmental chemistry of metals, it is necessary to include the physicochemical parameters, especially the amount of free metal ions and very labile

Table 1: The seasonal variations in physicochemical parameters of El-Bahr El-Pharaony drain water from summer 2012 to spring 2013

| | Summer 2012 | | | | Autumn 2012 | | | |
|---|---|---|---|---|---|---|---|---|
| Parameters | I | II | III | IV | I | II | III | IV |
| Air temp. °C | 32.40 | 32.20 | 31.90 | 31.80 | 26.50 | 26.30 | 26.10 | 26.70 |
| Water temp. °C | 31.20 | 30.50 | 31.10 | 30.20 | 24.20 | 24.00 | 24.70 | 24.30 |
| EC µmhos/cm | 1122.00 | 935.10 | 962.20 | 941.30 | 742.00 | 732.00 | 452.00 | 801.00 |
| TS mg/L | 757.00 | 658.00 | 670.00 | 667.00 | 543.00 | 524.00 | 550.00 | 622.00 |
| TDS mg/L | 725.00 | 618.00 | 642.00 | 625.00 | 423.00 | 511.11 | 533.00 | 590.00 |
| TSS mg/L | 32.00 | 40.00 | 28.00 | 42.00 | 20.00 | 13.00 | 17.00 | 32.00 |
| pH | 8.36 | 8.37 | 8.34 | 8.36 | 8.33 | 8.34 | 8.31 | 8.22 |
| DO mg/L | 6.10 | 6.80 | 5.20 | 4.70 | 6.30 | 7.10 | 5.70 | 5.30 |
| BOD mg/L | 10.10 | 10.20 | 10.10 | 10.30 | 7.10 | 7.20 | 7.70 | 7.50 |
| COD mg/L | 19.80 | 19.90 | 20.30 | 20.80 | 15.30 | 15.20 | 15.80 | 15.80 |
| $CO_3$ mg/L | 4.20 | 4.60 | 4.10 | 4.50 | 2.50 | 2.20 | 1.20 | ND |
| $HCO_3$ mg/L | 222.00 | 215.00 | 291.00 | 293.00 | 307.00 | 315.00 | 392.00 | 389.00 |
| Cl mg/L | 142.00 | 152.00 | 212.00 | 174.00 | 60.00 | 61.00 | 65.00 | 71.00 |
| $SO_4$ mg/L | 113.00 | 92.00 | 108.00 | 106.00 | 49.00 | 53.00 | 44.00 | 75.00 |
| $NO_2$ µg/L | 9.00 | 9.00 | 10.00 | 11.00 | 18.00 | 17.00 | 20.00 | 20.00 |
| $NO_3$ µg/L | 27.00 | 28.00 | 30.00 | 30.00 | 36.00 | 38.00 | 40.00 | 38.00 |
| $NH_3$ mg/L | 1.10 | 1.00 | 1.10 | 1.20 | 0.77 | 0.72 | 0.74 | 0.75 |
| | Winter 2013 | | | | Spring 2013 | | | |
| Parameters | I | II | III | IV | I | II | III | IV |
| Air temp. °C | 19.70 | 19.50 | 19.30 | 19.70 | 27.70 | 27.30 | 27.20 | 27.40 |
| Water temp. °C | 17.30 | 17.50 | 17.60 | 17.70 | 26.50 | 26.40 | 26.70 | 26.10 |
| EC µmhos/cm | 516.00 | 510.00 | 632.00 | 680.00 | 622.00 | 610.00 | 652.00 | 692.00 |
| TS mg/L | 336.00 | 335.00 | 428.00 | 547.00 | 417.00 | 415.00 | 448.00 | 468.00 |
| TDS mg/L | 332.00 | 328.00 | 417.00 | 522.00 | 412.00 | 402.00 | 431.00 | 443.00 |
| TSS mg/L | 4.00 | 7.00 | 11.00 | 25.00 | 5.00 | 13.00 | 17.00 | 25.00 |
| pH | 7.86 | 7.91 | 8.12 | 8.03 | 8.26 | 8.25 | 8.33 | 8.34 |
| DO mg/L | 6.50 | 7.10 | 6.20 | 5.70 | 6.10 | 6.30 | 5.90 | 5.10 |
| BOD mg/L | 6.10 | 6.0.00 | 6.20 | 6.20 | 7.20 | 7.40 | 7.60 | 6.50 |
| COD mg/L | 10.10 | 10.10 | 10.80 | 10.70 | 13.30 | 13.10 | 13.00 | 12.10 |
| $CO_3$ mg/L | ND | ND | ND | ND | 1.70 | 2.10 | 2.50 | 2.70 |
| $HCO_3$ mg/L | 305.00 | 313.00 | 426.00 | 422.00 | 277.00 | 250.00 | 309.00 | 307.00 |
| Cl mg/L | 39.00 | 44.00 | 54.00 | 56.00 | 88.00 | 85.00 | 77.00 | 67.00 |
| $SO_4$ mg/L | 40.00 | 33.00 | 37.00 | 36.00 | 50.00 | 72.00 | 61.00 | 53.00 |
| $NO_2$ µg/L | 21.00 | 20.00 | 22.00 | 24.00 | 6.00 | 7.00 | 9.00 | 9.00 |
| $NO_3$ µg/L | 40.00 | 42.00 | 45.00 | 45.00 | 33.00 | 30.00 | 32.00 | 31.00 |
| $NH_3$ mg/L | 0.51 | 0.51 | 0.50 | 0.50 | 0.60 | 0.61 | 0.61 | 0.60 |

EC: Electrical conductivity, TS: Total solids, TDS: Total Dissolved Solids, TSS: Total soluble solids, pH: Hydrogen ion concentration, DO: Dissolved Oxygen, BOD: Biological Oxygen Demand, COD: Chemical Oxygen Demand

complexes under the diverse range of conditions possible in natural systems (Okonkwo and Mothiba, 2005). The seasonal variations in physicochemical parameters of El-Bahr El-Pharaony drain water from summer 2012 to spring 2013 are given in the Table 1.

Temperature plays an important role in aquatic ecosystem health and affects the speed of chemical reactions, the metabolic rate of organisms, as well as how pollutants, parasites and other pathogens interact with aquatic residents. Temperature change depends mainly on the climatic conditions, sampling times and the number of sunshine hours (Ezzat *et al*., 2012). Air temperatures ranged between (19.3 and 32.4), while, water temperatures ranged between (17.3 and 31.2). It followed climatic variation with lower values in winter and highest ones in summer.

Electrical conductivity of natural fresh waters varies greatly and may range from less than (20 µmhos/cm) in dilute waters to over several hundred or more in waters influenced by limestone or salt deposits (WWB, 2009). Electrical conductivity ranged from 510-1122 µmohs/cm during different seasons and stations. The highest values of electrical conductivity were recorded during summer and spring, while the lowest values were recorded during autumn and winter. The highest values of electrical conductivity might indicate that drains are receiving large quantities of land run off and/or intensity industrial pollution and suggest potential irrigation problems in case of illegal and unofficial drainage use due to salinity hazards (EC should be <700 µmhos/cm) as adopted from (WWB, 2009; Ezzat *et al*., 2012).

Solids refer to suspended and dissolved matter in water. In water, total dissolved solids are composed mainly of carbonates, bicarbonates, chlorides, phosphates and nitrates of calcium, magnesium, sodium, potassium and manganese, organic matter, salt and other particles (Mahananda, 2010). TS, TDS and TSS values were found in the same trend of the EC. However, the higher values of TS, TDS and TSS were recorded during summer 757, 725 and 32 mg/l, respectively in station I. On the other side, the lower values were recorded during winter and recorded 335, 328 and 4 mg/L in stations II, II and I, respectively (Table 1). TDS values are exceeded the limits of Egyptian Governmental Law No. 48 (1982) in summer and autumn and this increase may probably be due to stagnation (Campos *et al*., 1992), concentration of salts due to increased evaporation and shortage of water. A maximum of 500 mg/L of total dissolved solids is permissible for diverse fish population but present findings in indicated high total dissolved solids which may have adversely affected the fish growth.

pH value of water is important because many biological activities can occur only within a narrow range. Thus any variation beyond acceptable range could be fatal to a particular organism (Slingsby and Cook, 1986). The favorable range of pH is 6.5-9.0 at daybreak, are most suitable for fish production (Lloyd, 1992). pH values for all collected water samples are within the permissible limits and ranged from (7.86-8.37). The highest desirable levels for pH are within the limits of Egyptian Governmental Law No. 48 (1982). pH values range in the present study indicates that water is suitable for fish production. The increase in pH in the rivers could be related to photosynthesis and growth of aquatic plants, where photosynthesis consumes $CO_2$ leading to arise in the pH values (Yousry *et al*., 2009; Ezzat *et al*., 2012).

Dissolved Oxygen (DO) in water affects the oxidation-reduction state of many of the chemical compounds such as nitrate and ammonia, sulphate and sulphite and ferrous and ferric ions. It is extremely useful in self-purification of water bodies (Technical Report 115, 2006). The results showed that, the dissolved oxygen recorded (4.7-6.8), (5.3-7.1), (5.7-7.1) and (5.1-6.3) mg/L during summer, autumn, winter and spring, respectively. DO concentrations within the permissible limits of Egyptian Governmental Law No. 48 (1982) (not less than 5 mg/L) except station IV in summer and this decrease in DO value may be due to biological respiration and decomposition processes which reduce the concentration of DO in water bodies (Cunningham and Saigo, 1995).

Biochemical Oxygen Demand (BOD) is a measure of the amount of dissolved oxygen removed from water by aerobic bacteria for their metabolic requirements during the breakdown of organic matter (Chapman, 1996). The highest values of biochemical oxygen demand were recorded during summer and spring, seasons (10.2-7.6 mg/L) while the lowest values (6.1-6.2 mg/L) were recorded during winter and autumn. Maximum value of BOD was observed during summer and this may due to higher rate of decomposition of organic matter at higher temperature and less water current (Sanap *et al*., 2006).

Chemical Oxygen Demand (COD) is a measure of the total quantity of oxygen required to oxidize all organic material into carbon dioxide and water. COD values are always greater than BOD values (Vaishali and Punita, 2013). In the same manner of BOD, the COD values increased during hot period and ranged from 7.50-15.40 mg/L. The decrease in COD values were recorded during cold period (6.10-10.50 mg/L). COD values were exceeded the permissible limits of Egyptian Governmental Law No. 48 (1982) (not exceed 10 mg/L) in all seasons at all stations.

The carbonate system is the sum of all inorganic forms of carbon, which represents the most important component of the total budget and turnover of carbon i.e., one of the main cycles of the turnover of substances in nature (Soni *et al*., 2013). The carbonates and bicarbonates are the major components of alkalinity of surface water (Muhammad *et al*., 2000). Carbonates showed significant variations with the seasonal variation during the entire study period and not detected in winter at all stations, while the maximum 4.5 mg/L in summer at station IV (Table 1). The lower values of $CO_3^{--}$ may be attributed to the decomposition in the dead phytoplankton leading to liberation of $CO_2$ which dissolves in water and increase in the formation of $HCO_3^-$ according to the following equation:- $CO_2+CO_3^{--}+H_2O \rightarrow HCO_3^-$ (Goldman and Horne, 1983). The maximum bicarbonates 426 mg/l was observed in winter at station I and minimum value 215 mg/L in summer at station II.

Chlorides occur naturally in all types of waters. In natural freshwaters, however, its concentration remains quite low and is generally less than that of sulphates and bicarbonates. Therefore, the chloride concentration serves as an indicator of pollution (Hasalam, 1991). Seasonal data shows that, during the study period the chloride content was high in summer (212 mg/L) at station III which was probably due to the sewage waste. While the minimum value 39 mg/L observed in the winter at station I. Chlorides showed fluctuations in all stations and seasons (Table 1).

Dissolved Sulphates $SO_4^{2-}$ can be derived from the dissolution of $SO_4$ minerals; oxidation of pyrite and other forms of reduced S; oxidation of organic sulfides in natural soil processes; and anthropogenic inputs, i.e., fertilizers (Grasby *et al*., 1997). Discharge of domestic sewage in waters tends to increase its concentration (Trivedi and Goel, 1984). Higher values of $SO_4^{2-}$ are observed in summer and spring and lower values in autumn and winter. The maximum $SO_4^{2-}$ (113 mg/L) was observed in summer at station I and minimum value 33 mg/L in the winter at station II (Table 1). Sulphates concentrations in all seasons at all stations were within the permissible limits of Egyptian Governmental Law No. 48 (1982) (not exceed 200 mg/L).

Nitrite is an intermediate product of the aerobic nitrification bacterial process, produced by the autotrophic Nitrosomonas bacteria combining oxygen and ammonia. Nitrite can be termed as an invisible killer of fish because it oxidizes haemoglobin to methemoglobin in the blood, turning the blood and gills brown and hindering respiration also damage for nervous system, liver, spleen and kidneys of the fish (Bhatnagar and Devi, 2013). Higher values of nitrite are observed in autumn and winter and lower values in summer and spring. The maximum nitrite value (24 µg/L) was observed in winter at station IV and minimum value 6 µg/L in the spring at station I (Table 1). The increase attributed to the oxidation of existing ammonia, yielding nitrite as intermediate state especially in abundant oxygen during winter (Wetzel, 2000).

The average value of nitrate ranged between 27-45 µg/L. The maximum nitrate value 45 µg/L was observed in winter at station IV and minimum value 27 µg/L in the summer at station I (Table 1). The presence of nitrate and nitrite in water may result from the excessive application of fertilizers or from leaching of wastewater or other organic waste into surface water and ground water (WHO, 1997). Nitrate concentrations in all seasons at all stations were within the permissible limits of Egyptian Governmental Law No. 48 (1982) (not exceed 45µg/L).

Ammonia is the by-product from protein metabolism excreted by fish and bacterial decomposition of organic matter such as wasted food, dead planktons, sewage etc. The unionized form of ammonia ($NH_3$) is extremely toxic while the ionized form ($NH_4^+$) is not and both the forms are grouped together as total ammonia (Bhatnagar and Devi, 2013). The maximum ammonia (1.2 mg/L) was observed in summer at station IV and minimum value 0.5 mg/L in the winter at station III and IV. The relative decrease in the ammonia concentrations during cold seasons were related to the oxidation of the ammonia by oxygen rich rather than uptake of ammonia by the phytoplankton cells (Shabana, 1999). Ammonia concentrations in all seasons at all stations were exceeded the permissible limits of Egyptian Governmental Law No. 48 (1982) (not exceed 0.5 mg/L) except station III and IV in winter. Increasing in ammonia concentrations could be attributed to organic pollution resulting from domestic sewage and fertilizers runoff (Chapman, 1992). The occurrence of ammonia in the water source is often associated with pollution due to sewage infiltration, use of nitrogen-fertilizers or livestock wastes (Prasath *et al*., 2013).

The study clearly showed that during the investigation period some of the physicochemical parameters undertaken to assess the water quality of El-Bahr El-Pharaony drain were found above permissible limits, while some were found below permissible limits. All the physicochemical parameters of water collected from El-Bahr El-Pharaony drain were varied significantly season to season. The highest concentrations of EC, TS, TDS, pH, TSS, $CO_3$, $SO_4$ and $NO_3$ were observed in the summer season at station I. All physicochemical parameters showed higher concentrations at Station I and II than at Station III and IV. Seasonal variation is because of lean period and substantial evaporation due to extreme hot condition of the environment while the lowest concentration was observed either during monsoon or post monsoon season. It might be due to the heavy rain fall and dilution of the pollutants (Sahu *et al*., 2007). The present study showed seasonal variations throughout the study period, in all the physicochemical parameters like temperature, dissolved oxygen, chlorides and all other parameters. These different parameters remained in favorable ranges for the production of fish.

**Heavy metals concentrations in water:** Heavy metals occur in the environment both as a result of natural processes and as pollutants through various pollution sources from human activities (Franca *et al*., 2005). Heavy metals concentrations (mg/L) of El-Bahr El-Pharaony drain water from summer 2012 to spring 2013 are illustrated in Table 2.

The results showed that, there are some heavy metals not detectable (below the detection limits with ICP-OES <0.001 and <0.005) and this metals are As, Cd, Co, Sb, Se, Sn and V. On the other hand, most of the detectable heavy metal (Cr, Cu, Pb and Zn) were exceeded the permissible limits of Egyptian Governmental Law No. 48 (1982) and this may be attributed to the huge amounts of raw sewage and agriculture wastewater discharged into the drain (FAO, 1985).

As can be seen, the maximum Al concentration 2.26 mg/L was observed in summer at station II and minimum value 1.14 mg/L in the winter at station IV. The maximum Ba concentration 0.255 mg/L was observed in summer at station IV and minimum value 0.170 mg/L in the winter at station II. The maximum Cr concentration 0.380 mg/L was observed in summer at station III and minimum value 0.110 mg/L in the winter at station IV. The maximum Fe concentration 1.354 mg/L was observed in summer at station I and minimum value 0.205 mg/L in the winter at station III. The maximum Mn concentration 0.426 mg/L was observed in summer at station I and minimum value 0.027 mg/L in the winter at station II. The maximum Ni concentration 1.909 mg/L was observed in spring at station III and minimum value 0.115 mg/L in the autumn at station II. The maximum Pb concentration 0.521 mg/L was observed in summer at station I and minimum value 0.113 mg/L in the winter at station I. The maximum Zn concentration 1.388 mg/L was observed in summer at station I and minimum value 0.611 mg/L in the winter at station IV (Table 2). Heavy metal concentrations in El-Bahr El-Pharaony drain water were found in the following order: Fe>Cu>Al> Zn>Ni>Pb>Cr>Ba.

The obtained results revealed that, the concentrations of the measured heavy metals in the water samples varied with seasons and the highest levels of heavy metals in water were found during

Table 2: Heavy metals concentrations (mg/l) of El-Bahr El-Pharaony drain water from summer 2012 to spring 2013

| | Summer 2012 | | | | Autumn 2012 | | | |
|---|---|---|---|---|---|---|---|---|
| Heavy metals | I | II | III | IV | I | II | III | IV |
| Al | 2.2100 | 2.2600 | 2.1400 | 2.1300 | 1.1600 | 1.1700 | 1.1700 | 1.1900 |
| As | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 |
| Ba | 0.2410 | 0.2450 | 0.2460 | 0.2550 | 0.1780 | 0.1790 | 0.1890 | 0.1790 |
| Cd | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 |
| Co | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 |
| Cr | 0.3200 | 0.3400 | 0.3800 | 0.3500 | 0.2400 | 0.2000 | 0.2300 | 0.2000 |
| Cu | 2.3110 | 2.3240 | 2.2700 | 2.2290 | 1.1780 | 1.1710 | 1.1750 | 1.1730 |
| Fe | 2.3540 | 2.3500 | 2.3250 | 2.3270 | 0.7920 | 0.7020 | 0.7540 | 0.7190 |
| Mn | 0.4260 | 0.4150 | 0.4200 | 0.4110 | 0.1610 | 0.1550 | 0.1650 | 0.1620 |
| Ni | 1.0220 | 1.0150 | 1.0170 | 1.0100 | 0.1790 | 0.1150 | 0.9160 | 0.9580 |
| Pb | 0.5210 | 0.5150 | 0.5110 | 0.5170 | 0.2350 | 0.2150 | 0.2190 | 0.2170 |
| Sb | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 |
| Se | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 |
| Sn | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 |
| V | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 |
| Zn | 1.3880 | 1.3500 | 1.3680 | 1.3450 | 0.8550 | 0.8510 | 0.8330 | 0.8250 |
| | Winter 2013 | | | | Spring 2013 | | | |
| Heavy metals | I | II | III | IV | I | II | III | IV |
| Al | 1.1500 | 1.1600 | 1.1600 | 1.1400 | 2.1900 | 2.1100 | 2.1200 | 2.1100 |
| As | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 |
| Ba | 0.1750 | 0.1700 | 0.1710 | 0.1720 | 0.2150 | 0.2190 | 0.2150 | 0.2170 |
| Cd | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 |
| Co | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 |
| Cr | 0.1900 | 0.1800 | 0.1500 | 0.1100 | 0.2500 | 0.2900 | 0.2700 | 0.2600 |
| Cu | 1.1150 | 1.1170 | 1.1180 | 1.1130 | 2.2150 | 2.2140 | 2.2170 | 2.2180 |
| Fe | 0.2130 | 0.2950 | 0.2050 | 0.2180 | 2.1160 | 2.1050 | 2.0550 | 2.1200 |
| Mn | 0.0310 | 0.0270 | 0.0350 | 0.0450 | 0.6730 | 0.6500 | 0.6660 | 0.6700 |
| Ni | 0.5680 | 0.5500 | 0.5960 | 0.5450 | 1.9160 | 1.8590 | 19090 | 1.7560 |
| Pb | 0.1130 | 0.1190 | 0.1450 | 0.1500 | 0.4550 | 0.4480 | 0.3970 | 0.4150 |
| Sb | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 |
| Se | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 |
| Sn | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 |
| V | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 |
| Zn | 0.6130 | 0.6520 | 0.6210 | 0.6110 | 1.2490 | 1.2140 | 1.2240 | 1.2010 |

summer, while the lowest values occurred during winter. Similar results were obtained by Zyadah (1995) who reported that, the seasonal variations may be due to the fluctuation of the amount of agricultural drainage water, sewage effluents and industrial wastes discharged into the drain. Also, Abdel-Moati and El-Sammak (1997) explained the higher concentrations of heavy metals in the water samples during the dry seasons is due to the fact that water levels decrease in the drain, results in increase in concentration of the metals. Alne-na-ei (2003) stated that, the contamination of water bodies in the Egyptian Nile Delta by metals is caused by the discharge of massive amounts of domestic sewage as well as agricultural and industrial effluents. Also, Ali and Abdel-Satar (2005) attributed the increase of metal concentrations in the water during hot seasons (spring and summer) to their lease of heavy metals from the sediment to the overlying water under the effect of both high temperature and a fermentation process resulting from the decomposition of organic matter.

These seasonal variations may be due to the fluctuation of the amount of agricultural drainage water, illegal untreated domestic sewage and industrial wastes discharged into the canal (Authman, 2008; Authman *et al*., 2008). The concentration of the metals could be attributable to the reduced volume associated with higher evaporation rate induced by the higher water temperature during dry hot seasons (Obasohan and Eguavoen, 2008). Domestic wastewaters can contain fairly high concentrations of metals, such as Al, Ni, Cu, Fe, Pb and Zn, which are derived from a wide variety of household products, such as cleaning materials, toothpaste and cosmetics (Maceda-Veiga *et al*., 2012). Because of the dense agricultural activities in the surroundings of Sabal drain canal, El-Menoufia Governorate have been done and a lot of fertilizers and pesticides has been used, heavily contamination by domestic sewage and other wastes; it was determined that the canal water is contaminated by different kinds of metals, which were obviously high and appeared to be harmful to fishes (Authman *et al*., 2013). Ibrahim and Omar (2013) found that the accumulation and bioaccumulation factor of heavy metals especially Zn, Fe and Cu were higher in summer season due to increase of temperature. Saeed (2013) concluded that, environmental factors as climate (seasonal variations and temperature) and drainage wastewater affect the physical and chemical characteristics of water as well as fish condition and quality.

The study clearly indicated some of physicochemical and heavy metals parameters undertaken to assess the water quality of El-Bahr El-Pharaony drain were found below the permissible limits, while some were found above the permissible limits during investigation period from summer 2012 to spring 2013. All physicochemical parameters were below the permissible limits except TDS, BOD, COD and $NH_3$ were higher in summer season at all stations. It is also found that, water is contaminated by various kinds of heavy metals, because of the extreme agricultural activities and a lot of fertilizers and pesticides have been used in the surroundings village along the drain. Three heavy metals Cu, Pb and Zn with different concentrations were exceeded the permissible limits have been found in water samples and this pollution level has its bad effect on both of fauna and flora at the area and it can be explains the poor quality of the drain fish species, so it is strongly recommended that strict vigilance and constant monitoring are needed to maintain water quality of the drain.

## CONCLUSION

This study was carried out to evaluate seasonal variations of physicochemical parameters and heavy metals in the water samples of El-Bahr El-Pharaony drain. The present baseline information of the physicochemical properties and heavy metals concentrations in water would form a useful tool for water users (public), planners, policy makers and scientists reporting on the state of the environment, for further ecological assessment and monitoring in El-Bahr El-Pharaony drain water.

## REFERENCES

Abdel-Moati, M.A. and A.A. El-Sammak, 1997. Man-made impact on the geochemistry of the Nile Delta Lakes: A study of metals concentrations in sediments. Water Air Soil Poll., 97: 413-429.

Ali, M. and A. Abdel-Satar, 2005. Studies of some heavy metals in water, sediment, fish and fish diets in some fish farms in El-Fayoum province. Egypt J. Aquat. Res., 31(2): 261-273.

Alne-na-ei, A.A., 2003. Contamination of irrigation and drainage canals and ponds in the Nile delta by heavy metals and its association with human health risks. Egypt. J. Zoology, 41: 47-60.

APHA (American Public Health Association), 1998. Standard Methods for the Examination of Water and Wastewater. 20th Edn., Washington, DC.

APRP (Agricultural Policy Reform Program), 2002. Survey of nile system pollution sources. Report No. 64, United States Agency for International Development, Egypt.

Authman, M.M.N., 2008. *Oreochromis niloticus* as a biomonitor of heavy metal pollution with emphasis on potential risk and relation to some biological aspects. Global Vet., 2(3): 104-109.

Authman, M.M.N., E.M. Bayoumy and A.M. Kenawy, 2008. Heavy metal concentrations and liver histopathology of *Oreochromis niloticus* in relation to aquatic pollution. Global Vet., 2(3): 110-116.

Authman, M.M.N., H.H. Abbas and W.T. Abbas, 2013. Assessment of metal status in drainage canal water and their bioaccumulation in *Oreochromis niloticus* fish in relation to human health. Environ. Monit. Assess., 185: 891-907.

Bhatnagar, A. and P. Devi, 2013. Water quality guidelines for the management of pond fish culture. Int. J. Environ. Sci., 3(6): 1980-1997.

Campos, H., W. Steffen, G. Agnuero, O. Parra and L. Zuniga, 1992. Limnological studies of Lake Rupanco (Chile). Morphometry physics, chemistry, plankton and primary productivity. Arch. Hydrobiol./Suppl., 90(1): 85-113.

Chakravarty, P., N. SenSarma and H.P. Sarma, 2010. Biosorption of cadmium (II) from aqueous solution using heartwood powder of Areca catechu. Chem. Eng. J., 162: 949-955.

Chapman, D., 1992. Water Quality Assessments. 1st Edn., Dam Reservoir and River Nile Water at Aswan, Egypt. Chapman and Hall, London and New York.

Chapman, D., 1996. Water Quality Assessments: A Guide to the Use of Biota, Sediments and Water in Environmental Monitoring, 2nd Edn., UNESCO, WHO and UNEP. E & FN Spon, London, UK.

Cunningham, W.P. and B.W. Saigo, 1995. Environmental Science: A Global Concern. 3rd Edn., WNC Brown Publishers, Country.

Egyptian Governmental Law No. 48, 1982. The Implementer Regulations for law 48/1982 regarding the protection of the River Nile and water ways from pollution. Map. Periodical Bull., 3-4: 12-35.

ESIAF (Environmental and Social Impact Assessment Framework) 2010. ISSIP 2, Project Framework for the Delta Governorates. Ain Shams University, Institute of Environmental Studies and Research, pp: 181.

Ezzat, S.M., M. Hesham, M.A. Mahdy, E. Abo-State, H. Abd El-Shakour and M.A. El-Bahnasawy, 2012. Water quality assessment of river Nile at Rosetta branch: Impact of drains discharge. Middle-East J. Sci. Res., 12(4): 413-423.

FAO, 1985. Water quality guidelines for agriculture, surface irrigation and drainage. Food Agric. Organ. Rev., 1: 29.

FAO, 2012. Status and new developments on the use of brackish water for agricultural production in the near east. Egypt Country Report. United Nations Food and Agriculture Organization Regional Office for the Near East (RNE), Cairo, Egypt, pp: 99.

Franca, S., C. Vinagra, I. Cacada and H.N. Cabral, 2005. Heavy metal concentrations in sediment, benthic invertebrates and fish in these salt marsh areas subjected to different pollution loads in the Tagus Estuary (Portugal). Mar. Pollut. Bull., 50: 997-1003.

GAFRD (General Authority for Fish Resources Development), 2011. Retrieved form: http://www.gafrd.org/tags/11861/posts#http://www.gafrd.org/posts/ 326990.2011.

Goldman, C.R. and A.J. Horne, 1983. Limnology. International Student Edn., McGrow-Hill International Book Co., London, pp: 197-220.

Grasby, S.E., I. Hutcheon and H.R. Krouse, 1997. Application of the stable isotope composition of $SO_4^{2-}$ to tracing anomalous TDS in Nose Creek, southern Alberta, Canada. Appl. Geochem., 12(5): 567-575.

Hasalam, S.M., 1991. River Pollution-an Ecological Perspective. Belhaven Press, Great Britain.

Ibrahim, A. and H. Omar, 2013. Heavy metal accumulation in muscles of *Clarias gariepinus* and in River Nile water and sediments at Assiut Governorate, Egypt. J. Biol. Earth Sci., 3(2): B236-B248.

Lloyd, R., 1992. Pollution and Freshwater Fish. Fishing News Books, Oxford.

Maceda-Veiga, A., M. Monroy and A. de Sostoa, 2012. Metal bioaccumulation in the Mediterranean barbel (*Barbus meridionalis*) in a Mediterranean River receiving effluents from urban and industrial wastewater treatment plants. Ecotox. Environ. Safe., 76: 93-101.

Mahananda, M.R., 2010. Physico-chemical analysis of surface water and ground water of Bargarh District, Orissa, India. Int. J. Res. Rev. Appl. Sci., 2(3): 284-295.

Muhammad, A., A. Salam, A. Azeem, M. Shafiq and B.A. Khan, 2000. Studies on the effect of seasonal variations on physical and chemical characteristics of mixed water from rivers Ravi and Chenab at union site in Pakistan. J. Res. Sci., 11(1): 11-17.

Obasohan, E.E. and O.I. Eguavoen, 2008. Seasonal variations of bioaccumulation of heavy metals in a freshwater fish (*Erpetoichthys calabaricus*) from Ogba River, Benin City, Nigeria. Afr. J. General Agric., 4(3):153-163.

Okonkwo, J.O. and M. Mothiba, 2005. Physico-chemical characteristics and pollution levels of heavy metals in the rivers in Thohoyandou, South Africa. J. Hydrol., 308: 122-127.

Prasath, B.B., R. Nandakumar and S. Dinesh Kumar, 2013. Seasonal variations in physico-chemical characteristics of pond and ground water of Tiruchirappalli. India J. Environ. Biol., 34(2): 529-537.

Saeed, S.M., 2013. Impact of environmental parameters on fish condition and quality in Lake Edku, Egypt. Egypt. J. Aquat. Biol. Fish., 17(1): 101-112.

Sahu, R.K., S. Katiyar, T. Jaya and G.C. Kisku, 2007. Assessment of drain water receiving effluent from tanneries and its impact on soil and plants with particular emphasis on bioaccumulation of heavy metals. J. Environ. Biol., 28(3): 685-690.

Sanap, R.R., A.K. Mohite, S.D. Pingle and V.R. Gunale, 2006. Evaluation of water qualities of Godawari River with reference to physico-chemical parameters, District Nasik (M.S.), India. Pollut. Res., 25(4): 775-778.

Shabana, E.E., 1999. Limnological studies on Lake Bardawil. M.Sc. Thesis, Faculty Science, Suez Canal University, Egypt, pp: 135.

Slingsby, D. and C. Cook, 1986. Practical Ecology. Macmillan Education Ltd., London.

Soni, H.B., M. Dabhi and S. Thomas, 2013. Surface water quality assessment and conservation measures of two pond ecosystems of central Gujarat. Int. Res. J. Chem., 3(3): 69-81.

Technical Report 115, 2006. Physicochemical Analysis: The Ministry of Science and Technology India. Retrieved form: http://www.ces.iisc.ernet.in/energy/water/paper/Tr-115/chapter5.htm# 5.1.

Trivedi, R.K. and P.K. Goel, 1984. Chemical and Biological Methods for Water Pollution Studies. Environmental Publications, Karad.

Vaishali, P. and P. Punita, 2013. Assessment of seasonal variation in water quality of River Mini, at Sindhrot, Vadodara. Int. J. Environ. Sci., 3(5): 1424-1436.

Wetzel, R.G., 2000. Fresh water ecology: Changes, requirements and future demands. Liminology, 1: 3-9.

WHO, 1997. Guidelines for Drinking Water Quality: Surveillance and Control of Community Supplies. World Health Organization, Geneva, Vol. 3.

WWB (Water and Wastewater Branch Nova Scotia Environment), 2009. Water Quality Survey of Nine Lakes in the Carleton River Watershed Area Yarmouth County, Nova Scotia. Retrieved from: https://www.novascotia.ca/nse/surface.water/docs/Yarmouth.Area.Lakes.Report.with.Appendices.pdf. pp: 48.

Yousry, M., A. El-Sherbini, M. Heikal and T. Salem, 2009. Suitability of water quality status of Rosetta branch for west Delta water conservation and 22 irrigation rehabilitation project. Water Sci., 46: 47-60.

Zyadah, M.A., 1995. Environmental impact assessment of pollution in Lake Manzalah and its effect on fishes. Ph.D. Thesis, Faculty of Science, El-Mansoura University, Egypt, pp: 127.