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Assessment of Mahmoudia Canal and Drinking Water Nitrogen Forms Following Some Corrective Actions

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Abstract: The Nile is the main source of drinking water in Egypt. Alexandria water Company (AWCO) depends on the surface water only as canals fed by the Nile River. AWCO has 8 water treatment plants (WTP), 6 of which are located on Mahmoudia canal. AWCO has a monthly comprehensive program to survey canals supplying water to Alexandria water treatment plants (WTP), where all parameters of Mahmoudia canal and drain discharges are measured. This study was carried out during the period from March 2008 to Jan. 2010 and the program is still implemented until now. AWCO regularly monitors the water quality in the canals in the Rosetta branch of the Nile, all the way up to the Delta Barrage near Cairo. The water quality in Mahmoudia canal is stable at a manageable level. The raw water of WTPs has faced serious problems that are affected by the increasing free ammonia and nitrite in winter season. Many corrective steps (hourly free ammonia detection, break point of chlorination and prefiltration powdered activated carbon installation) were taken to overcome these problems. The main objective of this study was to identify long term feasible solutions for the drinking water quality problems on the basis of physical and chemical water parameters. The which are corrective actions had reduced the free ammonia values by more than 75% for WTPs distributed drinking water all over the years.

Key words: Canal water, Drinking water, nitrogen forms treatment.

INTRODUCTION

The Nile is the main source of drinking water in Egypt. Alexandria Water Company (AWCO) depends on surface water only as canals fed by the Nile River. Alexandria City is supplied by raw water from 2 canals (Mahmoudia canal branches from Rosetta branch and Noubaria canal branches from El-Rayah El-Behery). The Ministry of Public Works and Water Resources (MPWWR) is responsible for the management of these canals. AWCO has 8 water treatment plants (WTP), 6 of which are located on Mahmoudia canal and 2 treatment plants abstract their water from Noubaria canal. AWCO's service area covers the entire Governorate of Alexandria and part of Beheira Governorate about 100 kilometers

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to the south. In addition, it supplies water to industry, tourism and shipping in Alexandria.[1]

Drainage water from irrigation is a source of increased pollutants in raw water in addition to other sources along the Nile River. Water quality can have a major impact on both individuals and communities health. The quality of drinking-water is significant for health in both developing and developed countries worldwide. A reliable supply of clean drinking-water is essential to protect the health of individuals and communities. Both the quantity and the quality of supply are important. A secondary problem after microbiological pollution is the presence of natural or man-made contaminants such as arsenic, selenium, uranium, fluoride, nitrate or boron, which often result in crippling health effects or death due to chronic Exposure.[2] Nitrate and nitrite levels in the natural waters are important indicators of water quality. The increasing nitrate and nitrite concentrations become an important problem for public health. Hence, widespread and frequent monitoring surveys should be carried out.[3] Inorganic fertilizers and human and animal wastes (from livestock operations and septic tanks) are the primary sources of nitrate and nitrite contamination of drinking water. Nitrate released to soil as a result of human or animal activities can enter groundwater or surface water as a result of leaching or runoff. Some nitrate and nitrite exposure also originates in endogenous production of nitric oxide by many activities. Its uptake by humans is via drinking water and food. Nitrate toxicity to humans is manifested by increased levels of methemoglobin and formation of carcinogenic compounds.[4] Those compounds require advanced treatment technologies for reliable continuous removal as opposed to conventional methods such as sand filtration.

The main objective of the study is to identify long term feasible solutions for the drinking water nitrogen forms problems and the relationship with water characters in the supply areas of Alexandria. These areas are supplied with drinking water which is produced at six water treatment plants. The water quality problem has been assessed by application of a comprehensive monitoring program. After assessing various data, many feasible corrective actions were applied.

MATERIALS AND METHODS:

Assessment of water quality of Mahmoudia canal was implemented to evaluate surface water of the canal on A monthly basis according to the Standard Methods for examination of water and wastewater.(5) AWCO has a monthly comprehensive program to survey canals supplying water to Alexandria water treatment plants (WTP), where all parameters of Mahmoudia canal sampling points are measured. This study was carried out during the period from March 2008 to January 2010 and the program is still implemented until now. Sampling program points were designed to express the water quality along the canal.

Sampling sites:

Mahmoudia canal gets its water from the Nile River at two points. Seven sampling points were selected to represent the Mahmoudia canal before Alexandria city for 55km along and two sampling points represented the water sources for two water treatment plants (intake of Siouf WTP and intake of Manshia WTP). Table (1) and Figure (1) show the sampling sites and symbols along Mahmoudia canal and the distances from starting point.

Physical and chemical analyses of water samples:

For physico-chemical analyses, water samples were collected in sufficient amount about (2 liters) in polypropylene bottles and stored under cooling conditions.

Table (1) Sampling sites along Mahmoudia canal, their distance from starting point and sampling symbol for each point.

Sampling site	Mahmodia Canal	Zarkon Village	End of Khandak Canal	Zawyt Ghazal Village	Town Abou Hommos	Town of Kafer El Daware	Khorshid Village	Intake of Siouf WTP	Intake of Manshia WTP
Distance	00 km	9 km	15 km	15.8 km	26 km	42 km	55 km	61.3 km	73 km
Sampling Symbol	MC 0.0	MC 9.0	KC 15.0	MC 15.8	MC 26.0	MC 42.0	MC 55.0	MC 61.3	PC 73.0

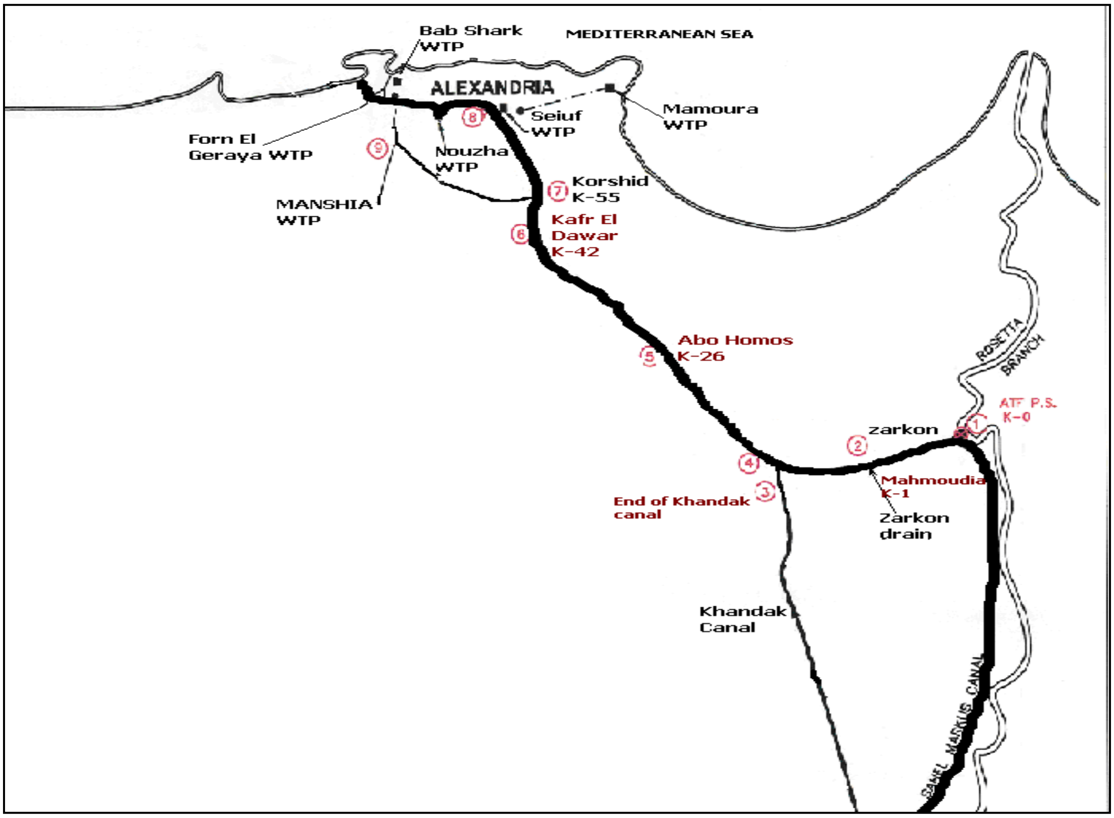

Figure (1): Mahmoudia canal (Northern Egypt) and location of sampling points (Red)

All the physical and chemical analyses were determined by the procedures recommended in the Standard Methods for the examination of Water and Wastewater[5]. The methods and its APHA reference code were Temperature, pH (2510 Platinum electrode), Electrical Conductivity (4500/B), Dissolved oxygen (45000 Membrane Electrode Method), Total dissolved solids (2540/B), Turbidity (2130 Nephelometric method), Chemical Oxygen Demand (5220 B Open Reflux Method), Biochemical Oxygen Demand (5210 B 5 Days BOD Test) and Total Suspended solids (2540/D). For nitrogen forms free Ammonia (4500/B selective electrode), Nitrate (4500/B UV Spectrophotometer) and Nitrite (4500/B Colorimetric method) were measured.

RESULTS AND DISCUSSION:

In general, the values of all parameters slightly decreased after mixing of Mahmoudia canal and End of Khandak Canal. Before the point # 3, the records were significantly higher than the points after. The impact of drain water is limited. Water discharged from drains up stream has a slight effect on water quality. Drains have the highest free ammonia, nitrate, nitrite, COD and BOD_5 values, however the results showed a significant increase in both sampling points #1 & 2 comparing to the water coming from Khandak canal as shown in Table (2). Starting from point # 4 that recorded the net mixing of two water sources, the change in water quality was insignificant throughout the sampling period. One of the major factors affecting nitrification in drinking water treatment is temperature. Low temperatures have generally a drastic effect on bacterial process rates, a phenomenon characteristic of all biochemical systems

Table (2): Water quality of Mahmoudia Canal – raw water from nine sampling sites for studying period (2008-2010)

Sampling site	Mahmodia Canal	Zarkon Village	End of Khandak Canal	Zawyt Ghazal Village	Town Abou Hommos	Town of Kafer El Daware	Khorshid Village	Intake of Siouf WTP	Intake of Manshia WTP
free ammonia	1.52±0.61	1.75±0.75	0.27±0.08	0.95±0.35	0.94±0.37	0.86±0.34	0.67±0.34	0.73±0.39	0.60±0.34
Nitrate	1.84±0.35	2.08±0.47	0.90±0.21	1.50±0.38	1.63±0.51	1.70±0.49	1.85±0.45	1.93±0.33	1.84±0.39
Nitrite	0.23±0.08	0.26±0.09	0.06±0.03	0.17±0.05	0.18±0.04	0.22±0.06	0.23±0.06	0.21±0.07	0.17±0.07
BOD_5	14.7±2.00	17.3±2.26	6.7±1.46	12.3±1.25	14.4±1.46	16.0±1.39	15.1±1.66	13.5±1.34	10.6±1.27
COD	36.0±3.0	38.9±3.2	20.0±2.2	31.4±3.7	33.7±3.3	36.0±3.0	35.6±2.8	33.6±3.2	29.8±3.3
TSS	3.45±0.86	4.51±1.45	4.71±1.79	4.50±1.37	5.9±1.59	5.87±2.19	8.19±4.18	5.56±2.07	6.05±3.12
Turbidity	8.7±2.6	10.2±3.0	11.8±3.9	10.6±2.9	11.7±3.3	13.6±5.8	18.8±8.6	14.4±5.2	13.6±5.5

However, this is especially important when nitrification processes are of concern. From Figure (2) the raw water is taken from along of 73 Km, where the temperature of the water is ranged between 30.7 °C (summer) to 20°C (winter) with average 23.4, 22.8 and 22.7°C at starting point of Canal, intake of Siouf WTP and intake of Manshia WTP, respectively throughout the sampling period.

Bouillot *et al.* (1992) worked on Parisian waters with temperatures ranging from 5 to 25°C.[6] Niquette *et al.* (1998) worked on colder waters (below 5°C) and showed a strong temperature impact on Biological Active Carbon filtration for the removal of both biodegradable organic carbon and ammonia. Since the main purpose of their work was not the study of ammonia removal, only few results concerning temperature effect on biological nitrification were available.[7] However, Rittmann and Snoeyink (1984) mentioned that nitrification processes have potential to achieve a good ammonia removal even at low temperatures.[8] The critical aspect seems to be the growth and maintenance of slow-growing nitrifying bacteria on the filtration medium. In a biological filter, biomass detachment that occurs during filtration and backwashing was identified as an important contribution to biomass losses, especially when the filters are backwashed with chlorinated water.[9,10]

The Canal water is of such a good quality that it can easily be treated to obtain drinking water by different plants. Both pH and Dissolved oxygen recorded highly stable values along Mahmoudia canal throughout the sampling period with low variances. The average values with standard error for pH were 7.90±0.12, 7.93±0.14 and 7.92±0.14 for MC 0.0, MC 61.3 and PC 73.0 sampling points, respectively. The average values with standard error for Dissolved oxygen were 5.57±0.15, 5.66±0.0.9 and 5.88±0.12 mg/l for MC 0.0, MC 61.3 and PC 73.0 sampling points, respectively. The average difference percent between different sampling sites were 0.5% and 4.2% for pH and dissolved oxygen, respectively as shown in Figure (2). The choice of a suitable colonization medium to support fixed biomass in biological filter is important, particularly when external conditions are unfavorable (low ammonia concentrations and low temperatures). The use of different filter media on nitrification has been investigated by several authors. The structure of the medium seems to impact directly on the number of attachment sites available to bacteria and the level of shear stress to which the bacteria are exposed during filtration and backwashing.(11)

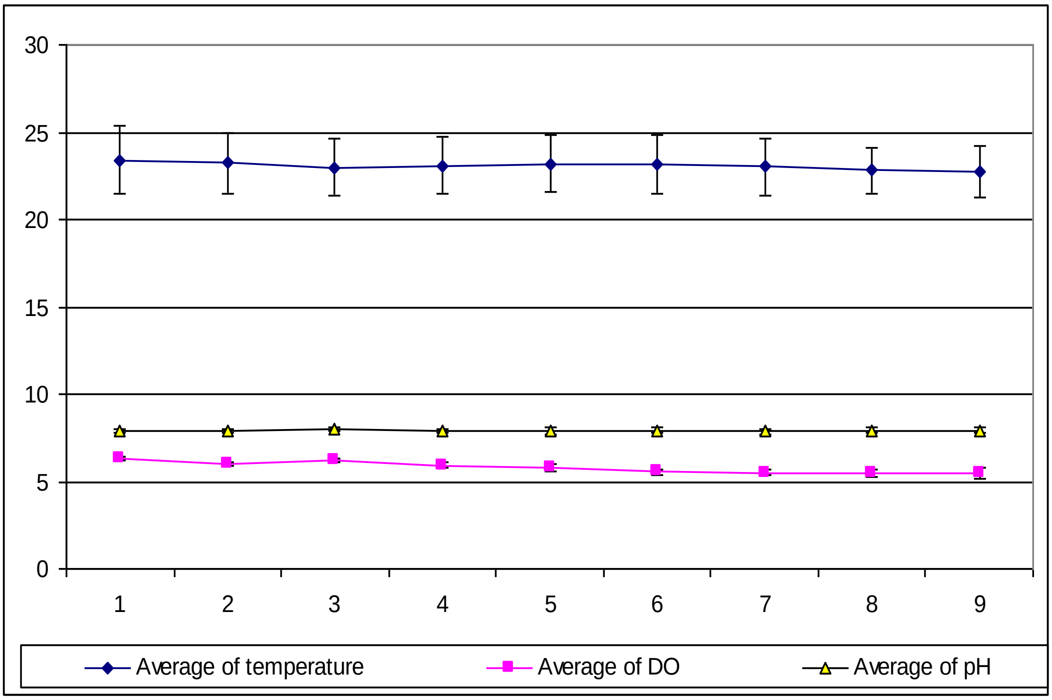

Figure (2): Average with standard error of Temperature (ºC), pH values and Dissolved Oxygen (D.O.) in mg/l along Mahmoudia canal during the period from March 2008 to Jan. 2010.

As shown from data, the concentrations of water quality as respect to major water parameters were suitable as WTP sources. According to the mixing actions that took place at point # 4, a reduction in different water parameters was noticed along Mahmoudia Canal from the starting point at km 0.0 up to Manshia water treatment plant (km 73). Figure (3) illustrates the Chemical Oxygen demand (COD), Biochemical Oxygen demand (BOD_5) and Total Suspended Solids (TSS) in mg/l which are indicators of pollution. The results of different sampling points located at Mahmoudia canal showed high values of COD and BOD_5.The lowest values were for point # 3 (End of Khandak Canal). However, they have little effect on water site located downstream at point # 4.

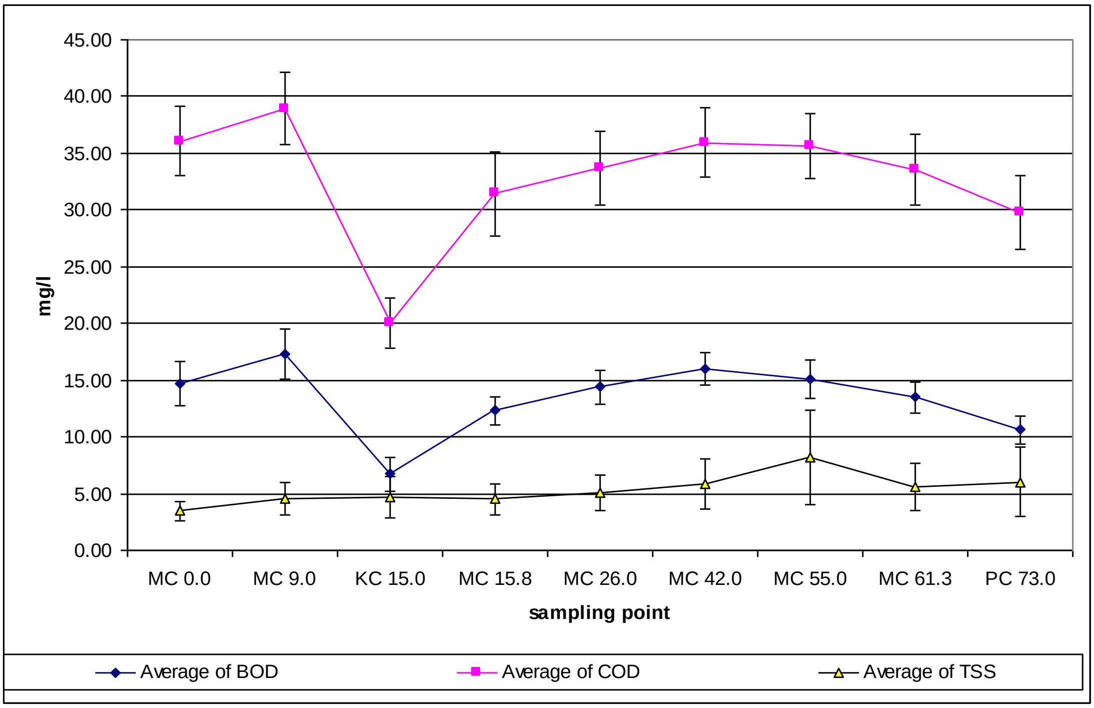

Figure (3): Average with standard error in mg/l of Biochemical Oxygen Demand (BOD_5), Chemical Oxygen Demand (COD) and Total Suspended Solids (TSS) along Mahmoudia canal during the study period from March 2008 to Jan. 2010

The identification of the different components in a water course is required to individualize and assess the actual contribution of irrigated agriculture to the pollution of the water course.[12] The effectiveness of activated carbon for removal of contaminants can be impacted by the water quality of the contaminated water and particularly the presence of dissolved organic carbon (DOC).[13] Coupling with chemical additives such as coagulants or powdered activated carbon if smaller contaminants such as natural organic matter or micropollutants are to be removed.[14]

From Figures 4 (a, b and c), it is clearly obvious that the free ammonia content of water in Mahmoudia canal has been slightly reduced throughout the period from 2008 to 2010, where the minimum values were recorded in summer period and the high values recorded in winter months. The free ammonia of ending point of Mahmoudia canal recorded high values and most of these records were above the level recommended by MPWWR. Water coming from Khandak Canal water source has a good water quality but the net result of mixing both sources has a slight change on Mahmoudia canal water ammonia. Also, the averages of free Ammonia were 0.72 and 0.60 mg/l for Siouf WTP and Manshia WTP, respectively. The results show a slight decrease in average of free Ammonia for both Siouf and Manshia WTP intakes due to self degradation of organic maters and denitrification a result of high temperature.

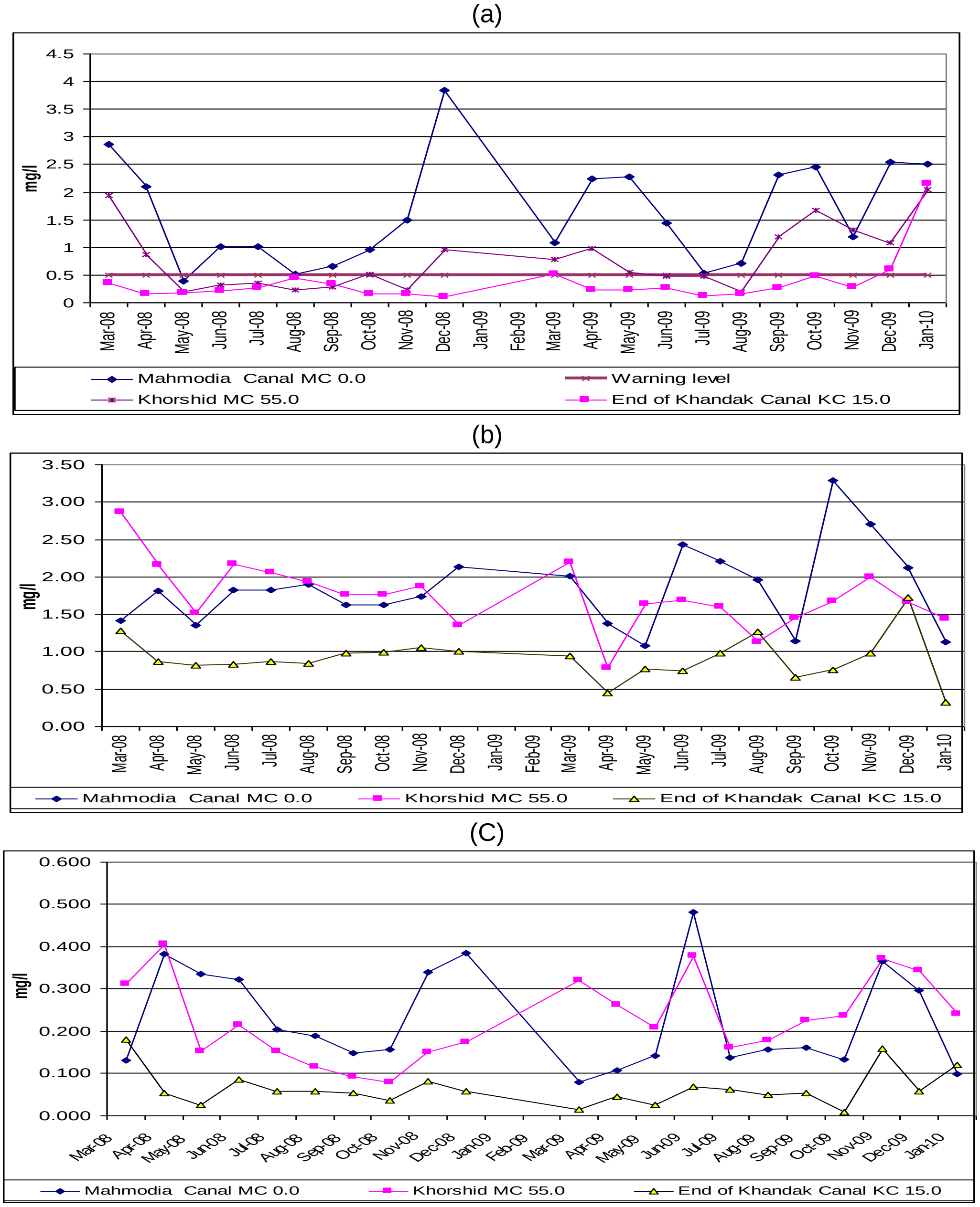

Figure (4): Average in mg/l of free Ammonia (a), Nitrarte (b) and Nitrite (c) for Mahmoudia canal (MC 0.0K), Khorshid (MC 55K) and Khandak canal (KC 15.0K) during the period from March 2008 to Jan. 2010

Nitrogen occurs in raw surface water used for drinking water production under the form of nitrogen such as free ammonia, nitrite, and nitrate, all of which are undesirable in drinking water. In winter seasons, the values of different nitrogen forms were recorded higher than other seasons. The European Community has regulated some of these substances in the EC standards for nitrogen compounds in potable water: 25 mg/L of nitrate (NO_3^-), 0.1 mg/L of nitrite (NO_2^-), and 0.05 mg/L of ammonia (NH_4^+). Increasing concentrations of ammonia in raw water and the possible future restriction of legislation underline the emergency to look for processes capable of producing better quality of drinking water.(15 Gopina, (1994) mentioned that uncontrolled fertilizer application resulted in steady accumulation of nitrate in soil worldwide; the pollutant then easily passes through the soil into water.(16) The literature lacks information on formation of organic chloramines produced from chlorination or chloramination of naturally occurring nitrogenous material (i.e., Dissolved Organic Nitrogen), and is only available for a limited range of model nitrogenous organic compounds (e.g., amino acids, heterocyclic N compounds, peptides, proteins.(17)

From Figures 5 (a, b and c), it is clearly obvious that the free Ammonia, Nitrate and Nitrite contents of water in six WTPs had been dramatically reduced comparing to the water sources that came from Mahmoudia Canal throughout the period from 2008 to 2010, where the most values were recorded less than 0.2 mg/l all over the year and the high values recorded in winter months (January to March). In winter seasons, the values of different nitrogen forms were recorded higher than other seasons. The averages of free Ammonia were 0.15, 0.15, 0.06, 0.06, 0.14 and 0.10 mg/l for Manshia WTP, Sharky WTP, Nozha WTP, Karmoze WTP, Seiouf WTP and Maamoura WTP, respectively.

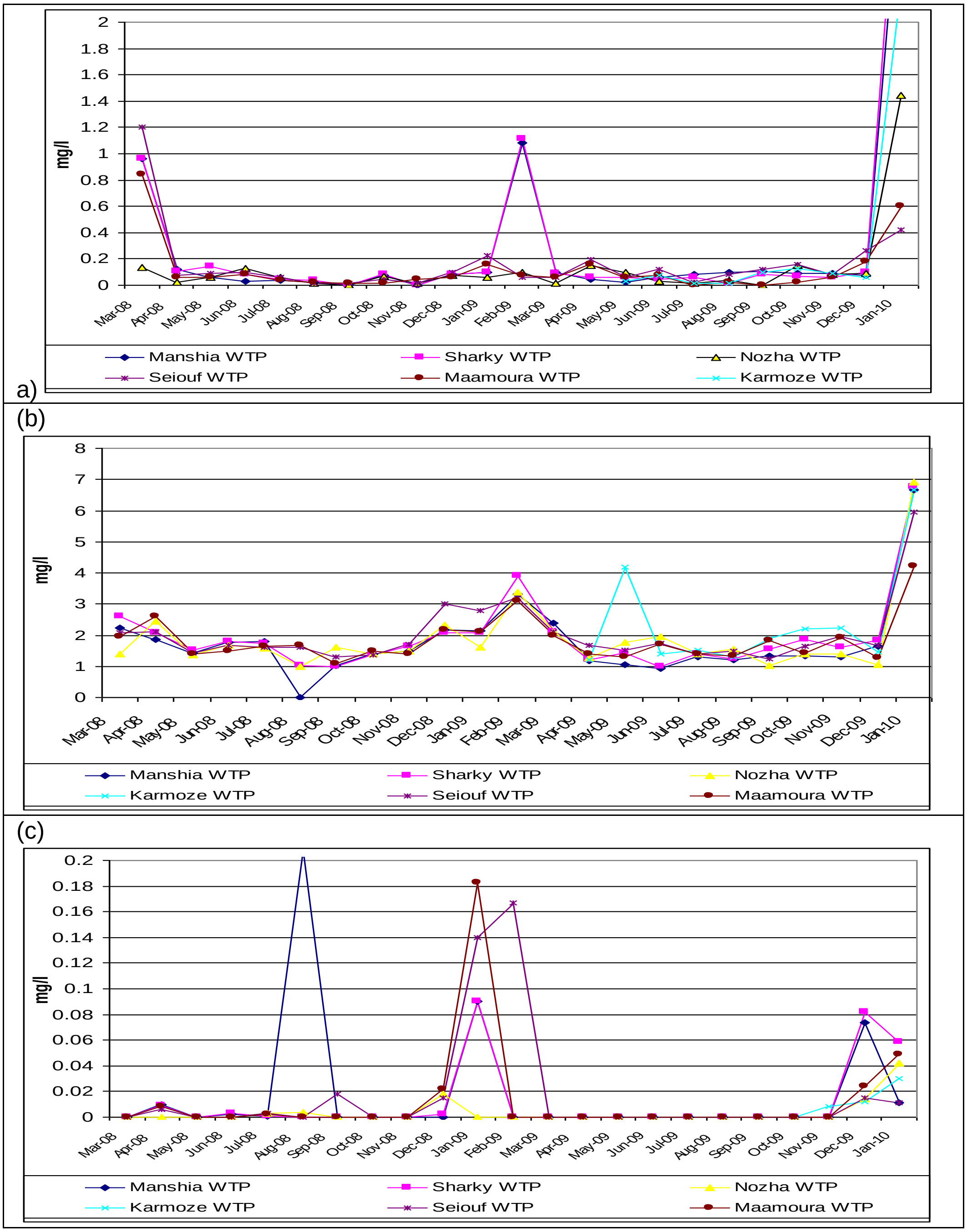

Figure (5): Average in mg/l of Free Ammonia (a), Nitrate (b) and Nitrite (c) for six AWCO WTPs effluent during the study period from March. 2008 to Jan. 2010

According to the corrective actions (hourly free ammonia detection, break point of chlorination and prefiltration powdered activated carbon installation) that took place, a reduction in different water parameters was noticed comparing to records for same points from 2000 to 2008.

It is clearly obvious that the free ammonia content of tap water in different WTPs had been greatly reduced throughout the period from 2008 to 2010 where minimum values were recorded and were found to comply with Egyptian guidelines. The Mahmoudia canal water free ammonia decrease gradually after mixing the canal water with the water that came from Khandak canal and became slightly affected but still higher than 0.5 mg/l in almost different seasons before applying the corrective actions. The results showed a slight increase in different nitrogen forms content in winter seasons comparing to summer seasons along the sampling points from AWCO WTPs tap water. Rao and Mamatha (2004) mentioned that Quality of water is assuming great importance with the rising pressure on industries and agriculture and the rise in standard of living.(18)

CONCLUSIONS

The identification of the different components in a water course is required to individualize and assess the actual contribution of irrigated agriculture to the pollution of the water course.(12) These discharges of agricultural wastewater are the major problem. Another potential source of pollution concerns the naval activities on the canal. Domestic waste as well as nitrogenous components may pollute the surface water, e.g. in case of agricultural activities. Consequently, the water quality of Mahmoudia canal deteriorates strongly. It then reaches a level that AWCO cannot meet the standards for drinking water with the conventional treatment processes

Although water quality of Mahmoudia Canal is affected by drains discharge, all parameters of raw water still comply with Egyptian Standards and WHO guidelines except the free ammonia and Nitrite in winter season. There is good correlation between the quality of raw water and the net result effluent. For preventing the pollution, it should be in the interest of all cities along the Nile River to secure and improve the water quality of the Mahmoudia by decreasing the amount of pollution. This will ensure a reliable and steady supply of clean fresh water in the outflow of Mahmoudia canal. The corrective actions had reduced the free ammonia values to under 0.5 mg/l as recommended by Egyptian guidelines.

The results after Instillation of powdered activated carbon (PAC) showed great difference between influent and effluent water. Application of activated carbon before Filtration step led to great reduction in nitrogenous compounds adsorption as a part of treatment system. PAC as pre-filtration consistently achieved higher free ammonia removal than the treatment system without PAC over the entire period of the study. Drikas (2009) results supported these work. Activated carbon can be applied as a powder in the early stages of the conventional treatment process when algal episodes are infrequent or, if algal blooms are a regular occurrence; it is more economical to include granular activated carbon (GAC) filters following the rapid filtration step in the conventional treatment process.(19) The effectiveness of activated carbon for removal of contaminants can be impacted by the water quality of the contaminated water and particularly the presence of dissolved organic carbon (DOC).(13) The difference in DOC concentrations pre and post GAC diminished with time over this period indicating reduced GAC adsorption capacity. This reduction can likely be attributed to both filling of pores of sizes suitable for adsorption of DOC and/or blocking of access to these pores by adsorption of larger DOC in larger transport pores.[20]

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