ENVIRONMENTAL IMPACT OF WATER REUSE OF BAHR EL-BAQAR DRAIN State of the Art Report

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ENVIRONMENTAL IMPACT OF WATER REUSE OF BAHR EL-BAQAR DRAIN

State of the Art Report

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Egypt

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31° 30'
32° 00'
MEDITERRANEAN SEA
N
31° 30'
El- Manzala Lake
Damietta Branch
31° 00'
SUEZ CANAL
Abu Talb Drain
Bahr El-Baqar Drain
30° 30'
Abu El-Akderi Drain
El-Horomy Drain
El-Qalubiya Drain
Sandhor Drain
Belbies Drain
Shebeen Drain
Gebel El-Asfer Drain
Belbies South Drain
30° 30'
CAIRO
10 km
Main Drainage System
Tributary Drain

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Abstract

Water pollution is one of the most severe problems faced by administrators. The principal causes of water pollution and quality regression are well known: untreated or inadequately treated domestic and industrial wastewater, improper use of fertilizers and pesticides, solid waste disposal and unplanned urban and rural development. Polluted drains are considered one of the most important dangerous elements for the surrounded environment. Bahr El-Baqar drain locates in northeastern Egypt and is considered as one of the most polluted drains in Egypt. The use of polluted water from the drain in fish farms and agricultural lands has a very dangerous environmental effect on soil and groundwater. Besides, seepage from the drain may contain different kinds of pollutants out of which heavy metals may be the most dangerous ones. Using polluted water for irrigation makes the problem more complicated. This article attempts to identify and analyze the findings of most recent studies regarding Bahr El-Baqar drain and effects of its polluted water on surrounding environment. The article recommends that future research should clearly be oriented towards development of a fully integrated water quality monitoring for the Bahr El-Baqar drain system. Continuous standardized monitoring of the most polluted location through a national integrated project for the whole area of the Bahr El-Baqar drain system.

1 - Introduction

For now, decaying water quality is a serious threat in countries with a scarcity of water resources. It does not only diminish the country's chance to sustainable development but it also threatens public health with spreading infectious diseases. Water-related diseases are the most common causes of infants' mortality in the developing countries.

Due to this fact and the steady increase of population in addition to limited water resources, the importance of the optimal use of available fresh water resources and conservation of each drop obligates applying of modern technologies to safely reuse drainage water instead of wasting them to seas, oceans or the surrounding environment without treatment. Pollution and irrational consumption of water are the main two problems, negatively affect water resources. Water pollution is one of the main issues concerns scientists and experts in the environmental protection field. Due to the necessity of water for all biological and industrial processes, it is not surprising the studies conducted to address this issue are more than those addressing other environmental branches. Biochemistry proved that water is necessary for all reactions and transformations that occur within bodies of living organisms. Water forms about 60-70% of the higher organisms including humans and 90% of the lower organisms; so that water pollution can cause serious damage and threat the living organism and disturb the ecological balance which would be meaningless and invaluable if the properties of its main component (water) are spoiled. Irrational consumption of water, leads to waste clean fresh water instead of its consumption in different usages, which negatively impact economic and environmental development, taking into account the unequal distributions of potable water all over the world.

This article attempts to identify and analyze the findings of most recent studies regarding Bahr El-Baqar drain and effects of its polluted water on surrounding environment. Finally, different suggested recommendations which are the most appropriate to be implemented in Egypt will be presented and discussed.

2- Water Pollution Variation in the Nile Delta

The Nile water is of high quality as the river reaches Cairo. Decays in water quality occur when the Nile splits into the Damietta and Rosetta branches in a northward direction due to the disposal of domestic and industrial outflows and agricultural drainage with decreasing flows (World Bank, 2005). Therefore, optimizing the quantity and quality of Nile water is the major interest of any strategic planning for better water resources management in Egypt.

In 1999, a task force from the Ministry of Water Resources and Irrigation (MWRI) was specified to draft the water quality priorities and strategies of the Ministry. The study identified priority areas where high pollution and high chances of contact occur. Indicators used to assess pollution conditions were heavy metals and nitrates for toxins and E-coli bacteria for pathogens. The approach was applied to the Nile River, groundwater, and drainage system. The study showed that the priority areas where high pollution and high chances of contact occur can all related to the larger urban accumulation of the county. The high population densities and industrial activities in combination with insufficient sewerage and treatment facilities cause a high pollution load on surface and groundwater to the extent that there is a health hazard. The study identified the priority areas in need for pollution control actions as shown in Figure 1.

2-1- Water Quality Monitoring Network

The Drainage Research Institute (DRI) monitors the quantity and the quality of the agricultural drainage water in the Nile Delta and Fayoum region. DRI measures a large number of parameters from more than 138 locations (Figure 2) (NAWQAM, 2001a). The quality parameters include organic contamination, chemical composition, salinity and other physical properties. The following paragraph describe the nature of the drainage systems within the Eastern Delta in detail (NAWQAM, 2001a,b;

DRI, 2007a). Table 1 lists drains which discharge to Eastern Delta Lakes of Egypt (NAWQAM, 2001a,b; DRI, 2007a). Most of small drains in the Nile Delta discharge in these main drains.

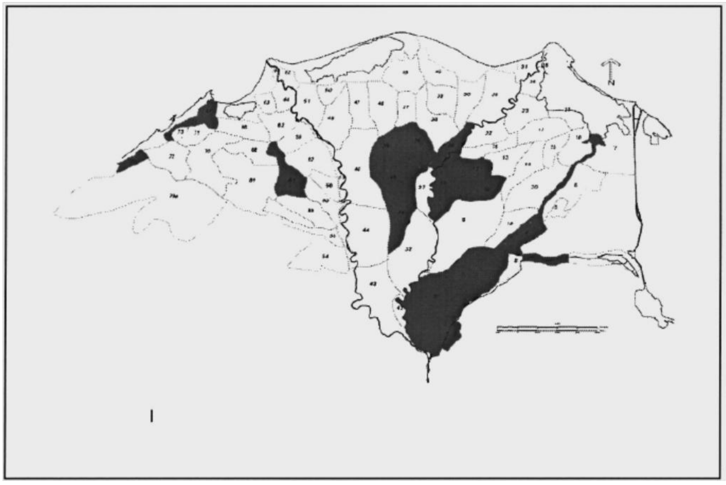

Figure 1: Priority areas in the Nile Delta based on health criteria

Table 1: Drains discharged to eastern Delta lagoons and Mediterranean Sea.

Code	Main name	Discharged to
EB11	Bahr El-Baqar Drain	Lake Manzala
EH17	Bahr Hadus Drain	Lake Manzala
EM01	Matareya Drain	Lake Manzala
EH12	Ramsis Drain	Lake Manzala
ET03	Mahsama Drain	Lake Timsah

The drainage systems of the Eastern Delta, except for a few catchments, drain to Lake Manzala, which consequently discharges freely into the Mediterranean Sea. Two main drainage systems, Bahr El-Baqar and Bahr Hadus, discharge into Lake Manzala. Each one consists of several sub-catchments. However, the drainage systems of Matarya, Lower Serw and Farasqur are located in one catchment. Their pump stations deliver the drainage water directly to Lake Manzala (Figure 2).

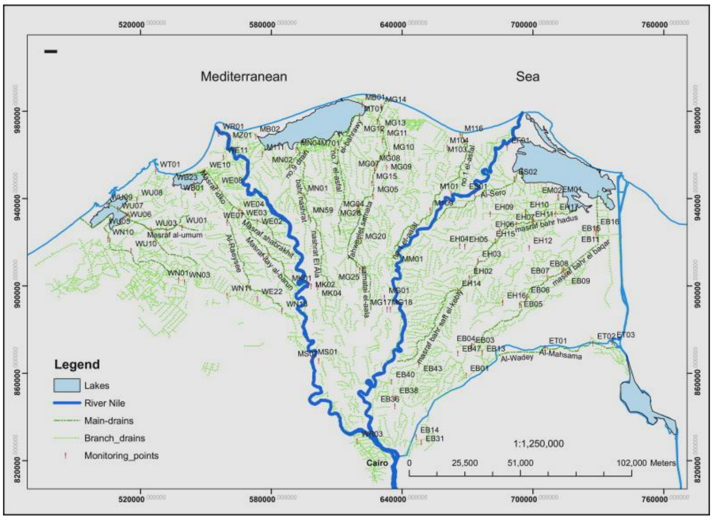

Figure 2: Water quality monitoring locations over Nile Delta and their covered reaches.

2-2- Drain Estuaries' Water Quality

Abukila (2015) assessed 12 years of pollution abatement efforts in all drain estuaries in Northern Egypt, which discharge to Northern Lakes and the Mediterranean Sea, by providing temporal trends in water quality indices from 2002 to 2013 for the estuary of 20 drains. Water quality fluctuated over that time period. On average, temporal changes in deviation of coliform count from their starting can explain 83.3% of the temporal variability observed in water quality indicators monitored in all drain estuaries. Therefore, the most effective water quality variables among a set of variables affecting the WQI outcome was total coliform.

After collection the samples from different sites; salinity, temperature, dissolved oxygen and turbidity were measured promptly with portable sensors. The remaining variables were analyzed at the Central Laboratory for Environmental Quality Monitoring (CLEQM) of the National Water Research Center.

2-2-1- Water Quality Index (WQI)

According to the Canadian Council of Ministers of the Environment (CCME, 2001), Water Quality Index (CCME WQI) supply a measure of the deviation of water quality from water quality guidelines. The CCME WQI model consists of three measures of variance from selected water quality objectives (scope; frequency; and amplitude). These three measures of variance are combined to produce a value between 0 (worst water quality) and 100 (best water quality) that represents the overall water quality (CCME, 2001). These numbers are splited into 5 descriptive categories to simplify the presentation.

Excellent: (CCME WQI Value 95–100): water quality is protected with a virtual absence of threat or impairment; conditions very close to natural or pristine levels.

Good: (CCME WQI Value 80–94): water quality is protected with only a minor degree of threat or impairment; conditions rarely depart from natural or desirable levels.

Fair: (CCME WQI Value 65–79): water quality is usually protected but occasionally threatened or impaired; conditions sometimes depart from natural or desirable levels.

Marginal: (CCME WQI Value 45–64): water quality is frequently threatened or impaired; conditions often depart from natural or desirable levels.

Poor: (CCME WQI Value 0–44): water quality is almost always threatened or impaired; conditions usually depart from natural or desirable levels.

The water quality outcomes were computed by CCME WQI based on law No. 4 of the year 1994, the water quality guidelines for discharging into the marine environment (EEAA, 1994). To evaluate the WQI of the drains estuaries, 11 water quality variables are used, including pH, temperature, total suspended solid (TSS, mg/l), total dissolved solid (TDS, mg/l), biochemical oxygen demand (BOD5, mg/l), dissolved oxygen (DO, mg/l), ammonium-nitrogen (NH4-N mg/l), total coliform (CFU/100 ml), cadmium (Cd, mg/l), lead (Pb, mg/l) and nickel (Ni, mg/l). For each dependent variable (*Y*, WQI), the coefficient-of-determination of the corresponding linear regression model (R^2 %), the unstandardized regression coefficient (*B*) and the statistical significance (*P*) on the year of measurement (*X*) are shown.

2-2-2- Bahr El-Baqar Drain Estuaries' Water Quality

CCME WQI values of Bahr El-Baqar Drain showed that water quality for aquatic uses could be related as poor to marginal (Figure 3). The temporal trend significance increases ($P < 0.05$; Table 2). Unstandardized (*B*) regression coefficient illustrates how much the dependent variable goes up, on average, given that the independent variable goes up one unit. Therefore, for independent variable (year of measurement), the coefficient 0.928 (Table 2) means that an increase of one year (independent variable) corresponds to an increase of 0.928 (less than 1) points of WQI (dependent variable). Hence, the improvement rate in water quality is very slow. Consequently, WQI score is 37–48 over tested period.

2-3- Mapping of Water Pollution Variation in the Nile Delta

The amount of annually reused drainage water at present is 7.0 Bm^3/yr and it can be increased to 9.0 BCM/year by the year 2017 (DRI, 2007a). However, spreading pollution especially in the drainage system threatens the application of these reuse strategies (DRI, 2007a).

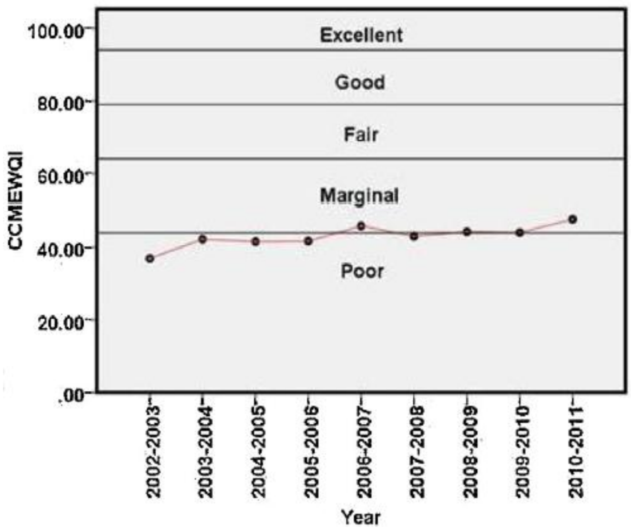

Figure 3: Temporal trends in indicators of water quality index for the drainage water of Bahr El-Baqar Drain.

Table 2: Drains discharged to coast Delta lagoons and Mediterranean Sea.

Drains	Discharged to	WQI (Y)		
		P	R^2%	B
Bahr El-Baqar Drain	Lake Manzala	0.006	68.7	0.928
Bahr Hadus Drain	Lake Manzala	0.294	12.1	-0.707
Matareya Drain	Lake Manzala	0.076	30.8	2.277
Ramsis Drain	Lake Manzala	0.008	55.9	-2.038
Mahsama Drain	Lake Timsah	0.371	9.0	1.104

(Shaban et. al., 2010) improved a tool for planning and managing the reuse of drainage water for irrigation in the Nile Delta. They achieved it by classifying the pollution levels of the drainage water into several categories based on a statistical clustering approach which can give simple but accurate information about pollution level and water quality at any point in the system.

In general, drainage systems of the River Nile Delta can be classified statistically into the following clusters (Figure 4):

Cluster 1: high biological pollution, low salt constituents, moderate nutrients and iron concentration.

Cluster 2: high biological pollution, moderate salt and iron constituents and low nutrients.

Cluster 3: low biological pollution and salt constituents, moderate nutrients and high iron concentrations.

Cluster 4: low biological pollution, high salt and iron constituents and moderate nutrients.

Cluster 5: very low biological pollution, moderate salt and iron constituents and high nutrients.

Cluster 6: moderate biological pollution and salt constituents, low nutrients, and high iron concentration.

Treated sewage outflow has BOD values ranging from 20 to 100 mg/l (Chapman, 1996). Therefore, as the average BOD in cluster 1 was over 100 mg/l (Table 3), it can be suggested that drains belonging to cluster 1 not only receive sewage effluents but also partially treated sewage and/or industrial effluents containing high biological constituents.

High TDS values (clusters 1 and 2) may lead to less light penetrating the water (less photosynthesis). This can reduce the level of oxygen in water (Chapman, 1996) and partially explain the low DO values in the drains laid in these clusters. However, the low concentration of DO is mainly explained by the high concentrations of biological constituents.

As clarified in Figure 4, Bahr El-Baqar drain fell mainly into cluster1. Bahr El-Baqar drain is individual in its water quality among the Delta drainage systems and canal most form a special cluster. However, few of its secondary branches fell into other clusters. Qalubeya and Belbis drains form Bahr El-Baqar drain with their confluence at Wadi railways. They receive considerable partially treated sewage and untreated industrial effluents from Greater Cairo sewerage systems. In addition, the industrial area of Shobra El Khaima in the north of Cairo discharges into the Belbis drain. This explains the low water quality conditions in Bahr El-Baqar drain.

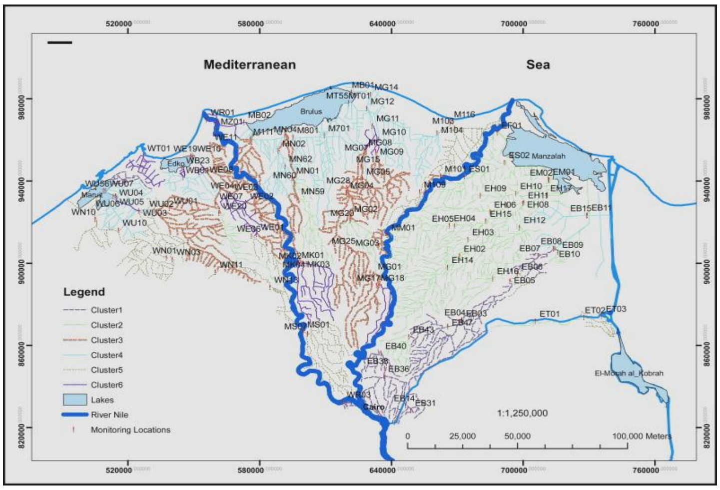

Figure 4: Water quality classification of the drainage system in the Nile Delta.

Table 3: Clusters centroids for WQM locations in the main drains in Nile Delta.

Clusters	BOD (mg/l)		TSS (mg/l)		N-NO3 (mg/l)		Fe (mg/l)	
	Mean	Stdev.	Mean	Stdev.	Mean	Stdev.	Mean	Stdev.
1	129.23	30.03	167.21	49.21	6.44	3.09	0.50	0.10
2	61.10	15.88	129.04	32.83	4.89	2.26	0.46	0.10
3	39.42	10.76	64.49	13.08	8.62	1.72	0.70	0.11
4	35.68	8.39	114.40	56.83	8.52	3.42	0.76	0.15
5	33.73	10.82	62.32	22.25	10.85	5.93	0.55	0.12
6	45.89	11.55	78.26	14.65	1.21	0.82	0.80	0.29
Clusters	pH		TDS (mg/l)		SAR		DO (mg/l)	
	Mean	Stdev.	Mean	Stdev.	Mean	Stdev.	Mean	Stdev.
1	7.24	0.10	984.68	287.59	4.01	1.26	0.41	0.18
2	7.43	0.10	1274.49	594.97	5.24	2.12	2.99	1.02
3	7.44	0.06	1033.83	240.48	4.23	1.10	2.63	1.26
4	7.56	0.10	3131.91	1309.33	10.32	2.86	4.88	1.55
5	7.62	0.18	1351.82	659.58	5.08	2.27	5.77	1.88
6	7.37	0.10	1362.82	415.07	4.85	1.20	4.37	2.27

Stdev., Standard deviation.

3 - Bahr El-Baqar Drain

Bahr El-Baqar drain is considered as one of the most polluted drains in Egypt (Abdel-Shafy and Aly, 2002). The total discharge pumped to Lake Manzala from that drain is 2.3 BCM/year. It is passing through four highly populated Governorates; Qalubeya, Sharkia, Ismailia and Port Said. Unfortunately, at the last decades, great areas on both sides of the drain were using its polluted water for irrigation and raising fish. It has a high risk to the surrounding environment.

- ***Bahr El-Baqar Wastewater Sources***

a. Treated sewage from El-Gabal El-Asfar and El-Berka Wastewater Treatment Plants which treat sewage water of the north astern quarter of the Greater Cairo City

b. Industrial Wastewater both treated and raw from the Shoubra El-Khiema, Abu-Zabal, El-Khanka and other parts of the industrial zone in the north eastern suburbs of the Greater Cairo City.

c. Land drainage of a cultivated area which is more than 1.2 million feddans.

3-1- Bahr El-Baqar Drain System

The Bahr El-Baqar drain system is shown in Figure 5. It consists of a main drain that starts near the city of Zagazig where it collects the effluents from two secondary drains. First, the Bilbeis drain which starts from its upstream at the discharging point of El-Gabal El-Asfar treatment work and has a total length of about 60 kilometres. All sewage and industrial wastewater, treated or untreated, from the eastern zone of Greater Cairo is dumped into this drain. Second, El-Qalubeya drain which is about 70 km long and runs parallel to the Bilbeis Drain at a distance of about 20 kilometres. It collects treated and untreated wastewater from the critical area of Sohbra El-Khemma and its large industrial area and the urban communities of the Qalubeya and Sharkia Governorates. Both drains are more like open sewers than like agricultural drains. In 1999 a study showed that the water quality parameters measured along the drain exceed the legal limits (Zhu et. al., 1999).

From El-Zagazig the Bahr El-Baqar drain transports water for about 100 km to the Ginka sub-basin in the southeast sector of the Lake Manzala which is located on the north-eastern edge of the Nile Delta (Figure 5). The Bahr El-Baqar drain contributes to almost 45% of the total discharge into the lake. In turn, Lake Manzala discharges into the Mediterranean Sea. The Ginka sub-basin acts as a sink and as a result high levels of toxic metals were found in the sediments.

The Bilbeis – Bahr El-Baqar Drain is 160 km long and its depth is about 1-3 m and its width is about 30 - 70 m. A big part leads through cultivated agricultural areas. Along the drain there are several discharges – industries in the region of Cairo - as well as several agricultural run-offs in the north eastern part, in larger cities or villages large amounts of untreated urban municipal water are discharged into the drain. Saad (1997) concluded that 58% of the total drainage water comes from agricultural drainage, 2% from industrial drainage and 40% from domestic and commercial drainage. The total quantity of waste water discharged into Bahr El- Baqar drain is shown in Table 4. Near Port Said in 1997 a project of engineered wetland technology started to treat 25000 m^3/day of polluted water from Bahr El-Baqar Drain. The risk of groundwater pollution is high. Especially in the north east the drain passes the old deltaic plain which shows a high vulnerability to pollution.

Figure 5: Layout of Bahr El-Baqar drain and its tributaries.

3-2- Environmental Studies on Bahr El-Baqar Drain Water Quality

Along its way from Cairo down to Lake Manzala there are a lot of discharges like agricultural run-offs in the north eastern cultivated areas. In larger cities or villages large amounts of untreated urban municipal water are discharged into the drain. Despite of these facts the water is also used for irrigation of farmland too. In several sections of the drain the surface was completely covered by weed flourishing which provides habitats for Billharzia snails. It was estimated that Lake Manzala which is an important resource of fishing in Egypt receives at least 60 m^3/s of wastewater from Bahr El-Baqar Drain.

Table 4: Sources of waste water and their discharges into Bahr El-Baqar drain system

Drain	Source of waste water	Waste water flow m^3/d
Bilbeis Drain	Berka WWTP	300,000
	Gebel El-Asfar Drain.	1,000,000
Total Discharge into Bilbeis Drain		**1,300,000**
Qalubiya Drain	Shebeen El- Kanater Drain (Shoubra El-Khema City) (Domestic and Industrial)	600,000
	El Aslougi Drain (Zagazig City) (Domestic and Industrial)	90,000
	Banha City	42,000
	Industry from Sharqiya Governorate	17,030
Total Discharge into Qalubiya Drain		**749,030**
Total discharge into Bahr El-Baqar Drain		**2,049,030**

EPIQ (1999) studied the availability of drainage for intermediate reuse pumping. The middle part of the Bahr El-Baqar basin is a traditional agricultural area. The area generates good quality irrigation drainage and provides a favorable condition for the development of intermediate drainage reuse. A drainage-monitoring program was conducted in Abou Hammad from August 15, 1998 to May 15, 1999. The monitored water quality parameters include BOD, COD, MPN, pH, TDS, and adj SAR. Clearly, the branch drains have better water quality than the Bahr El-Baqar main drain. MPN in most of the branch drains did not exceed a level of 1 million cells / 100 ml, compared to that of 2.4-11 million cells / 100 ml in Bahr El-Baqar main drain The COD/BOD ratios were low at all locations. This is an indicator of low industrial pollution components in the drain water. Salinity levels in the branch drains were low at 400-600 ppm, the equivalent level of the canal freshwater in the Delta. Such drainage water can be used in irrigation without mixing. Salt concentration is not a constraint in Abou Hammad’s intermediate drainage reuse development.

El-Eweddy (2000) found that in Bahr El-Baqar wastewater, the concentration of heavy metals in water drain followed the order: Fe>Zn>Mn>Cu>Pb>Ni>Cd. The highest concentrations for all the studied elements were mostly found in Baher El-Baqar drainage water. The variations encountered in the concentrations of heavy metals in the irrigation canals are mainly rendered to the contaminated sources, which varied from one location to another.

Brown et. al. (2003) made a report for Egypt Water Policy Reform in this report, the United Nations Development Programme (UNDP) method is applied to all drains in Upper Egypt, the Delta region and Fayoum. The method provides an index of the quality of drainage water. Nine parameters were selected to comprise the index. These are dissolved oxygen (DO), biological oxygen demand (BOD), total dissolved salts (TDS), fecal coliform, pH, temperature, turbidity, nitrites and phosphorus. The Water Quality Index (WQI) has been identified due to the annual averages of the nine selected parameters for the years 1999, 2000, 2001, and 2002. The method provides an index of the quality of drainage water (0 – 25) very poor, (26 – 50) poor ,(51 – 70) good (71 – 100) very good. Classification of drains water quality by WQI indicated that Bahr El-Baqar is very poor class.

As part of the study, a case study was identified and carried out. The study follows-up on work on Intermediate Drainage Reuse in the Bahr El-Baqar Drain Basin (EPIQ, 1999). The Negative impacts expected to intermediate reuse were the reduction of the water flow at all downstream points. This will ultimately reduce the capability of the drain system to dilute various kinds of pollutants. Since the project does divert some of the drain's flow, there could be some significant downstream effects. These would include reduction in wetlands habitat and less water available downstream for reuse in agriculture. Moreover, a reduction in natural river flow, together with a discharge in of low quality drainage water, can have negative impacts on downstream users. Similarly during periods of low flow, an increase in concentration of suspended particles and nutrients in the water resulting from soil erosion and run off could cause some damage to downstream areas. Increased nutrients can increase aquatic weeds that impede irrigation and cause some significant loss of water. The Bahr El-Baqar drain ends up in Manzala Lake, one of the biggest wetlands in North Africa. Changes in the water flow regime, and the various nutritional and ecological changes that follow, may have some long-term impacts on this wetland system.

Nile Transboundary Environmental Action Project (2005) assessed Water Quality in Agricultural Drains in Egypt depending on the NWRC (2001) survey data and study carried out by Drainage Research Institute (DRI, 2000). It has been estimated that the Delta and Fayoum drains receive about 13.5 BCM/year of effluent. Almost 89.7% of which is contributed from agricultural diffuse source, 6.2% from domestic point sources, 3.5% from domestic diffuse sources and the rest (0.5%) from industrial point sources. In terms of organic loads (BOD and COD), Bahr El-Baqar drain receives the highest load in the Delta, as it receives the greatest part of wastewater (about 2.3 BCM/year).

El-Baz et. al. (2005) developed a systematic methodology for mass integration in drain systems and watersheds. The integration model was used to develop management strategies to control the concentration of ammonium in Bahr El-Baqar drain system and its discharge into Manzala Lake. The solution strategies were ranked in order of cost. They found that the solution starts by effective utilization of existing infrastructure such as the operation of the secondary stage at Balaqs treatment units, the operation of the WWTP in cities along the drain, and the maximization of reuse from the existing reuse pump stations. At the pump station the discharge concentration of ammonium at the outfall was reduced from 4.25 ppm to 3.09 ppm by maximizing the use of existing infrastructure without additional investment as shown in Figure 6. Next, the solution strategies include the construction of advanced wastewater treatment units for Balaqs and El-Gabal El-Asfar. Finally, engineered wetlands are used to provide additional residence time and biochemical depletion of ammonium prior to discharge into Manzala Lake.

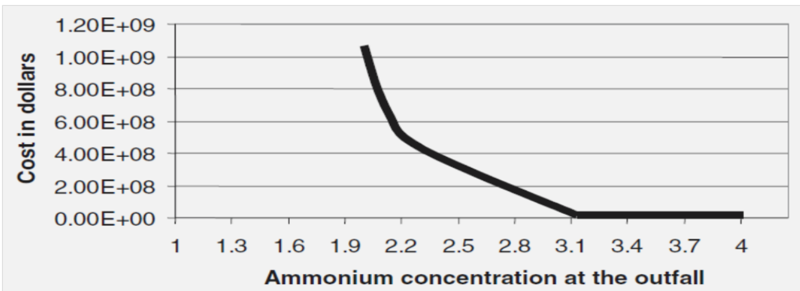

Figure 6: Cost of reduction in ammonium concentration at the outfall

El-Kholi (2005) evaluated pollution along Bahr El-Baqer drain and Manzala Lake. He found that the EC of the main drain of Bahr El- Baqer drainage water is slight to moderate to reuse for irrigation, but for the end of the drain saline level increase. While at Manzala lake water samples EC ranged between 5.6 to 5.9 dS/ m. Measured pH values ranged between 7.8 to 8.70 and 7.20 to 7.40 for both Bahr El-Baqer drain and Manzala Lake, respectively. Generally, ammonium is found in markedly higher concentration than nitrate. It exceeds FAO guidelines (1992) along the drain. Also Phosphorus concentration along the drain and the lake is presented in high level. Micronutrients and trace metals (Fe, Mn, Zn, Cu, B, Cd, Pb, Co, Ni and Cr) are represented below the recommended limits adapted by pratt (1972) For both Bahr El-Baqer and Manzala Lake. Total and faecal coliforms showed a similar trend along Bahr El-Baqer drain and generally, exceed the permissible limits for reusing such water for irrigation. Water samples at Manzala Lake showed a gradual decrease from southern part of the lake, 10 kilometers, in direction to the north. COD,BOD values as well as suspended solids along Bahr El –

Baqer drain are exceeding the maximum limits in the degree of wastewater treatment for agriculture reuse in Egypt.

El-Korashey (2009) used regression analysis of water-quality data collected in 2004-06 to estimate concentrations for total nitrogen, ammonia, sodium, chloride, calcium, and biochemical oxygen demand. To test the developed regression equations from the first 3 years of data collection (2004-2006), the equations were applied to the fourth year of data collect in 2007 and calculate the estimated concentrations and errors associated with this concentration. She concluded that the use of regression equations to estimate constituent concentrations provides timely water-quality information to resource managers that are otherwise not available. The regression relations may be used to continuously estimate constituent concentrations in Bahr El-Baqar Drainage System and these estimates may be used to continuously estimate concentration loads. The regression equations presented in this study are site specific and apply only to Bahr El-Baqar Drainage System.

Stahl et. al. (2009) performed a preliminary assessment of the Bahr El-Baqar/Bilbeis drain water. Water samples were taken along the course of the drains. Various chemical parameters including concentrations of anions and cations and radioactive compounds were analyzed. They observed that the amount of dissolved oxygen is too low. Even the pH-value of the drain water is outside of a range from 6.0 to 9.0 and the activity of the micro-organism needed for the cleaning process will cease. The drain is unable to clean itself and break down pollutants. The heavy metals attach themselves to silt particles and hence the pollutants are focussed on the fields. They compared the result with the situation in 1996-97. They also found that the situation has moderately changed. The chemical oxygen demand (COD) and the Ammonia level decreased significantly but the amount of dissolved oxygen is still very low. The concentrations still exceed the legal limits.

At twelve different sites along the Bilbeis- and Bahr El-Baqar Drain (as shown in Figure 7) water samples were taken and analysed for sum parameters, salts, heavy metals and natural radioactivity. The study of the canal was performed in a sampling campaign in the period 8-3-2006 to 9-4-2006 within two days. The first sample was taken in the north east of Cairo in the area of Al-Materiya – Al Marag (Figure 8). This site was chosen as a starting point were the distances of all the other sampling points were related to. The study checked a possible influence of Bahr El-Baqar Drain water onto the groundwater. In 2004 near Abu Za'bal, groundwater samples were taken. The results of the groundwater analysis showed that the electrical conductivity of the groundwater was high this was mainly caused by a higher level of chloride, sulphate and calcium. It seems also that the risk is high that the groundwater resources are supported by seepage water from Bahr El-Baqar Drain.

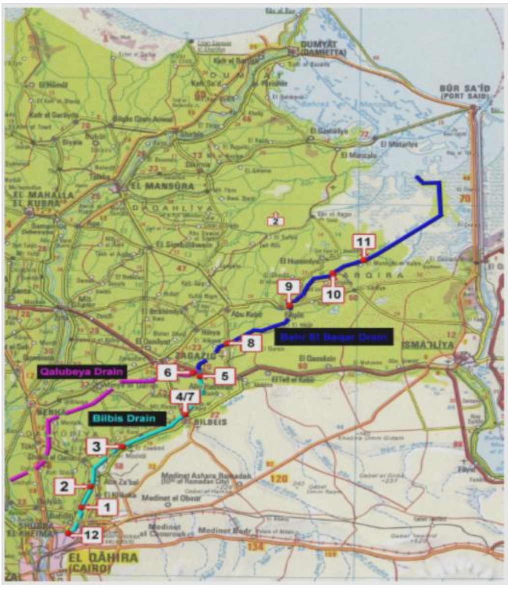

Figure 7: Sampling sites on the Bilbeis- and Bahr El-Baqar Drain

The situation at the year of the study i.e. 2006 was at Cairo the bank of the drain was completely covered with all kinds of munipicial waste. Even the water surface was covered with plastics. The water in general was muddy with a high level of suspended particles. Methane and hydrogen sulphide bubbled up to the surface. Domestic discharges and partially treated sewage were the main water source. Along with its course to Manzala Lake numerous agricultural runoffs added large amounts of particulate matter. It is characterized by a high conductivity caused by high levels of chloride (213 mg/L), sodium (187 mg/L) and typical compounds of fertilizers like phosphorus (13,8 mg/L), Ammonium (125 mg/L) and potassium (102 mg/L). Local farmers transported liquid manure by tractor to pump it into the drain. Waste water from many local small-scale industries was dumped into the drain too. Despite of these facts the water was used for washing dishes and vegetables and for the irrigation of farmland too. In several sections of the drain the surface was completely covered by weed flourishing which provides habitats for Billharzia snails.

The volumetric flow was estimated from the average water velocity and the cross section of the canal. The cross section was determined from the width and the depth of the canal. Because of the colored water it was not possible to see the ground. The water depth was measured two times. Assuming a constant depth along the width of the canal and a rising land bordering angle of about 25° the cross section was calculated. As Figure 9 shows during the first 60 kilometres the water flow increased continuously up to ~ 65 m^3/s. Afterwards the flow rate remained constant.

Figure 8: Location of the point No. 12 which was chosen as a starting point.

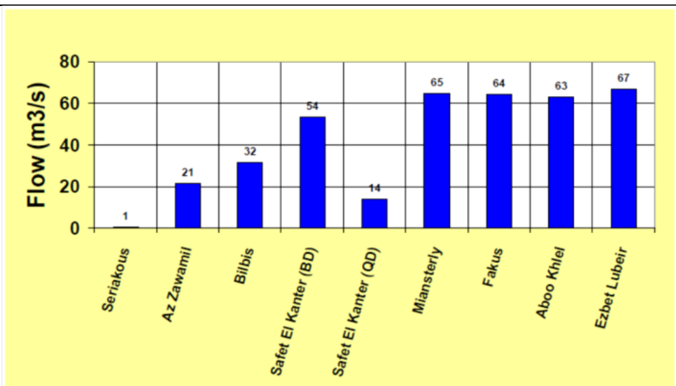

Figure 9: Water flow rate along the drain.

Temperature along the drain

The water temperature of a river or canal is very important for water quality. Many of the physical, biological and chemical characteristics are directly affected by temperature like amount of oxygen that can be dissolved in water, rate of photosynthesis by algae or larger aquatic plants, metabolic rates of aquatic organisms and sensitivity of organisms to toxic wastes, parasites and diseases. A temperature increase of the canal water will result in an even greater plant growth resulting in an increased oxygen demand during their decomposition. As Figure10 shows the water temperature was constant during the spring period studied. Only in El Khsous (km 0) the temperature is different because of the sewage water. In the hot summer time the situation may be different. At canal km 57 the Bilbeis Drain and El-Baqar Drain flow together. The temperature of the El-Bauer Drain was lower. Because of the daily fluctuations the water temperature in the rest of the canal as well as the second measurement at Bibles (km 40) was lower too. Along the banks of the canal there is only little native vegetation to control the water temperature through natural shading. The risk is high that in the summertime a high temperature level will reduce available oxygen in the water. Simultaneously the rate of oxygen consuming processes like photosynthesis and the decomposition of organic residues will increase.

Dissolved oxygen (DO) along the drain

Dissolved oxygen is essential for the maintenance of healthy rivers. The presence of oxygen in water is a positive sign since most aquatic plants and animals need oxygen to survive. The DO can change during a day as a result of different photosynthesis activities. Large daily variations in dissolved oxygen are a characteristic of bodies of water with extensive plant growth. During dry periods, the flow may be decreased and air and water temperatures are often higher. Both of these factors tend to decrease DO levels. Any oxidizable material present in a natural waterway or in an industrial wastewater will be oxidized both by biochemical (bacterial) or chemical processes. The result is that the oxygen content of the water will decrease. Since all natural waterways contain bacteria and nutrient, almost any waste compounds introduced into such waterways will initiate such biochemical reactions.

As shown in Figure 11 the DO level of the canal water was very low (~0.3 mg/L). Only in the region of Cairo during the first part the DO is a little bit higher because of the inflow of pure water. No differences were found in the oxygen content between surface and bottom of the canal. During the cleaning process of water a sufficient amount of dissolved oxygen for growth and metabolism of micro-organism has to be ensured. In general a DO concentration of 1-2 mg/L is necessary in an aeration tank. The observed oxygen level is therefore to low to keep up the self cleaning efficiency. Consequently under these anoxic conditions there will be no self cleaning effect and no aquatic life.

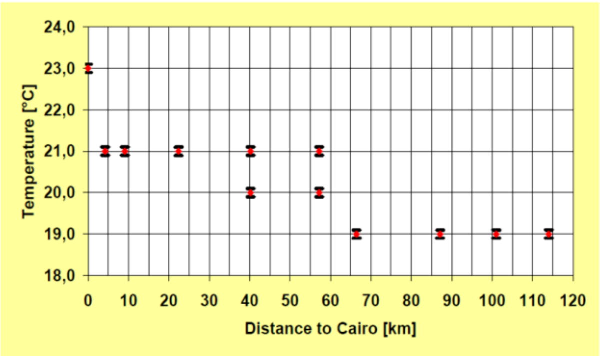

Figure 10: Temperature along the Bahr El-Baqar drain in March 2006.

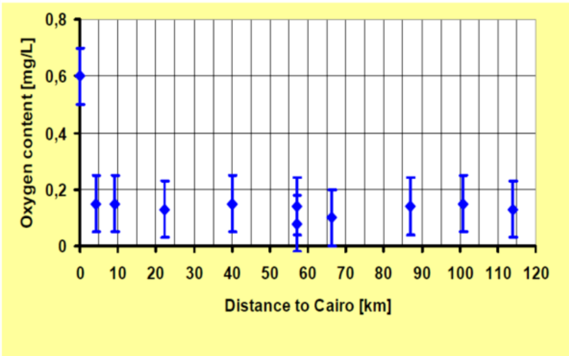

Figure 11: Dissolved oxygen along the Bar El-Baqar Drain.

pH along the drain

The pH is important for aquatic life. Most organisms have adapted to life in a pH ranging from 6.5 up to 8.5. Runoff from agricultural, domestic and industrial areas may contain iron, aluminium, ammonia, mercury or other species. The pH of the water will determine the toxic effects, if any, of these substances. Especially acetic waters will cause heavy metals to be released into the water. Figure 12 shows the pH along the drain. The pH in general was low. Especially at position no. 2 near Seriakus the pH was extremely low and goes up to a pH of 4 – 4.5 during the next 20 km. The reason for this very low pH is yet unknown. In any case the pH measurement should be repeated there several times to prove its permanence. During transport and storage the pH of the samples changed significantly up 6,6

-7,0. The pH is below the normal pH range recommended for irrigation water (6,0-8,5). Also, the activity of the micro-organism needed for the cleaning process will cease.

Electrical Conductivity along the drain

The electrical conductivity along the canal is given in Figure 13. Starting at 1080 mS/m the conductivity increases up to 1550 mS/m, decreases to 1350 mS/m and remains nearly constant along the rest of the canal. At km 57 the Qalubeya drain showed a higher conductivity of about 1500 mS/m. According to Hölting and Coldwwey (1996) the amount of dissolved solids remaining at 100°C was estimated to be about 700 – 1700 mg/L by multiplying the electrical conductivity in µS/cm by a factor of 0.725. The result is about 3,5 times higher when compared to the fresh water of the Ismalia canal. The electrical conductivity was calculated by means of the equivalent conductivity. According to actual evaluation of irrigation water salinity by the Food and Agriculture Organisation of the United Nations (FAO) the drain water was classified to be slightly/moderately saline (Schleiff, 2009).

Chemical oxygen demand (COD) along the drain

The chemical oxygen demand indicates the amount of oxygen required to oxidise the organic and inorganic matter in wastewater. The higher the COD of waste water, the more oxygen the discharges demand from water bodies. In practice, it is usually expressed in milligrams O_2 per litre. Typical values are in the range from 5 to 20 mg/L for open watercourses, for domestic and municipal waste water 20 to 100 mg/L (after biological cleaning) and 300 to 1000 mg/L (without cleaning). The COD along the drain is shown in Figure 14. At the beginning of the drain the water showed a COD of 30 mg/L. There the initial main water stream is caused by the discharge of large water purification plants in the north of Cairo. The sampling directly at the purification plant discharge is subjected to the next sampling tour. Due to several small discharges along the drain the COD increased to 35 mg/L.

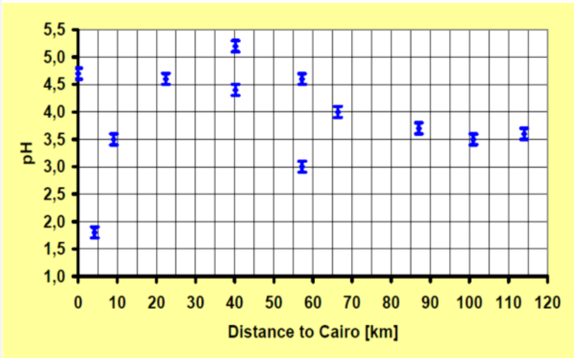

Figure 12: pH along the drain.

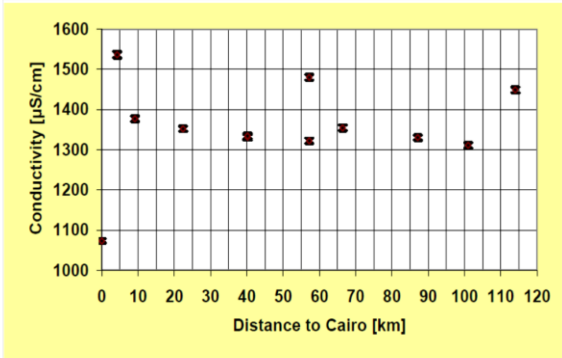

Figure 13: Electrical conductivity along the drain.

Sodium, Potassium, Magnesium and Calcium along the drain

The concentrations of Sodium, Potassium, Magnesium and Calcium determined along the course of the canal are given in Figure 15. The Calcium and Magnesium concentration were found to be constant along the whole drain at a concentration level of about 22 mg/L for magnesium and 67 mg/L for Calcium. At the beginning of the drain the potassium concentration increases slightly from ~ 18mg/L up to ~ 24. mg/L and remains constant along the further curse of the drain. The normal concentration for natural waters is about 0-3 mg/L. In contrast the sodium concentration goes up to ~150 mg/L. Sodium in the household is derived from foodstuffs, cooking additions and numerous chemicals which utilize the high solubility of sodium salts. The most significant source of sodium is from laundry detergents, particularly the standard, non concentrated powders which use various sodium salts as active ingredients and as fillers. In the standards of the fresh water (Law 48 of 1982) the total alkalinity not less than 20 and not more than 150 mg/L.

Ammonia along the drain

Ammonia is environmentally hazardous both because of its toxicity to fish and because of its ease of oxidation, enabling it to consume dissolved oxygen rapidly. It is the initial product of the decay of nitrogenous organic wastes, and the breakdown of animal and vegetable wastes. These are the principal sources of ammonia in river water. Sewage effluent from treatment plants is a major source of ammonia in water, and the daily fluctuations of the sewage plants' effluents can give rise to fluctuating ammonia concentrations downstream of their discharges. Agricultural diffuse sources of ammonia have some correlation with irrigation schedules but are otherwise difficult to characterize. The ammoniac nitrogen concentrations in the Bahr El-Bagar draining system during 1996-97 were reported to be about 20-25 mg/L (Badawy and Wahaab, 1997). As shown in Figure 16 the NH4-N level was found to be nearly constant at ~10-14 mg/L along the Bilbeis – Bahr El-Baqar drain with a slight increase towards the end of the drain. Only the Qalubeya drain showed a two time s higher NH4-N level before the confluence of both drains after a distance of 58 kilometres. In the standards of the fresh water (Law 48 of 1982), the concentration of Ammonia is not more than 0.5 mg/L.

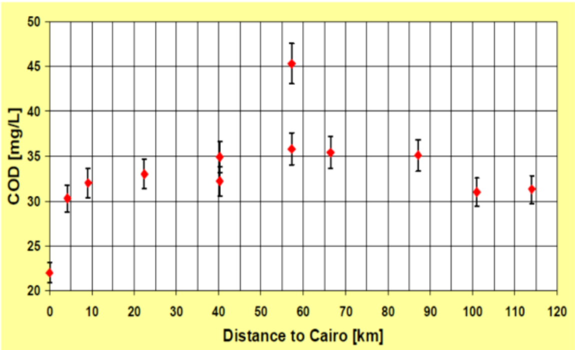

Figure 14: Chemical oxygen demand along the drain.

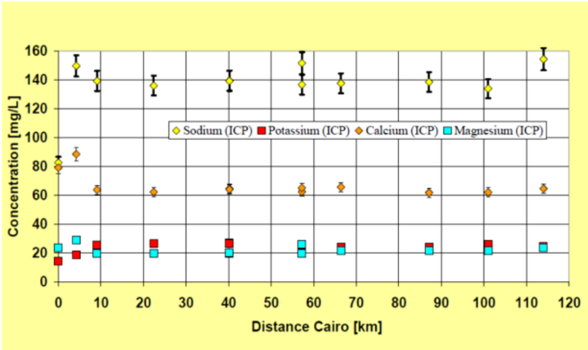

Figure 15: Concentrations of Sodium, Potassium, Magnesium and Calcium along the drain.

Anions along the drain

The dominant anions in the canal water are hydrogen carbonate (HCO_3^-),chloride (Cl^-) , sulphate (SO_4^{2-}) and nitrate (NO_3^-). Because of the uncontrolled access of oxygen the amount of nitrate and nitride was not reproducible. As a consequence the nitride concentration was calculated as nitrate. The mean HCO_3^- concentration of the canal water has been calculated and found to be nearly constant at level of about 250 - 300 mg/L. The chloride and nitrate concentrations nearly double during the first 10 km of the drain to decrease again constantly until the end by dilution. (Fig 17). In contrast to the Bilbeis drain which shows a nitrate level of ~70 mg/L no nitrate was found in the Qalubeya drain. In the literature at the outfall of Bahr El-Baqar drain to Lake Manzala nitrate concentrations of about 40 mg/L were reported (El-Sadek, 2003). In the standards of the fresh water (Law 48 of 1982), Nitrate is not more than 45 mg/L, Sulfate is not more than 200 mg/L, and Chloride is not more than 200 mg/L. No daily fluctuations were found for all anions at Bilbeis (40 km).

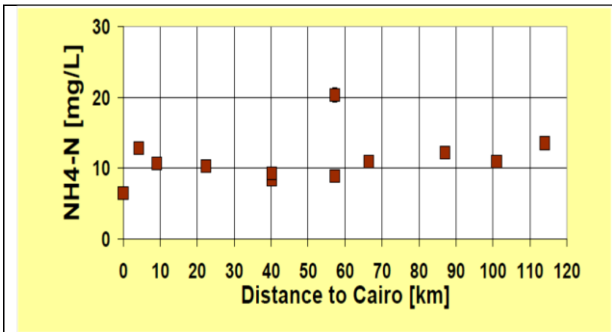

Figure 16: NH4-N concentrations along the drain.

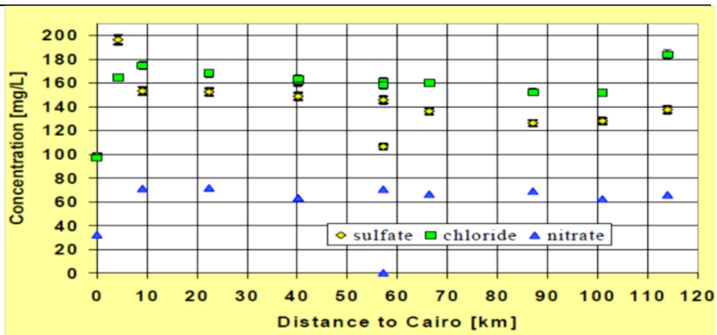

Figure 17: Chloride, Nitrate and sulphate concentrations along the drain.

Phosphorus, boron, aluminium, silicon and heavy metals along the drain

Boron, Aluminium, Silicon and the heavy metals were analysed using AAS or ICP technology. Several elements were studied additionally, but their concentrations in the drain water were found to be below the detection limit: Cr, Ni, Pb, Cu, Cd, Co, Zn, are 0.01 mg/L and Sn is 0.03. Consequently these concentrations were below the recommended maximum concentrations of trace elements in irrigation water (Ayers and Westcot, 1994) and also lower than the standards of the fresh water (Law 48 of 1982). The observed concentrations are illustrated in Figure 18. Except from the beginning of the drain all concentration profiles remain constant. During the first 10 kilometres the concentration of boron and phosphorus increased up to 0.3 mg/L and 2.5 mg/L respectively. The concentration of silica decreased from 13 mg/L down to about 6 mg/L. Boron can be toxic at very low concentration levels. Boron concentration less than 1mg/L is essential for plant development, but higher levels can cause problems in sensitive plants. Most plants exhibit toxicity problems when the concentration of boron exceeds 2 mg/L. The main source of anthropogenic boron comes from domestic effluents where products such as perborate are used as bleaching agent (i.e. boron can be found in urban wastewater at concentration levels as high as 5 mg/L in dry countries and concentrated sewage) with an average level of 1 mg/L. According to guidelines for interpretation of water quality (Ayers and Westcot, 1994) there will be no restriction on the use for irrigation at concentrations lower than 0.7 mg/l boron. Very low concentration levels were found for Iron and Aluminium.

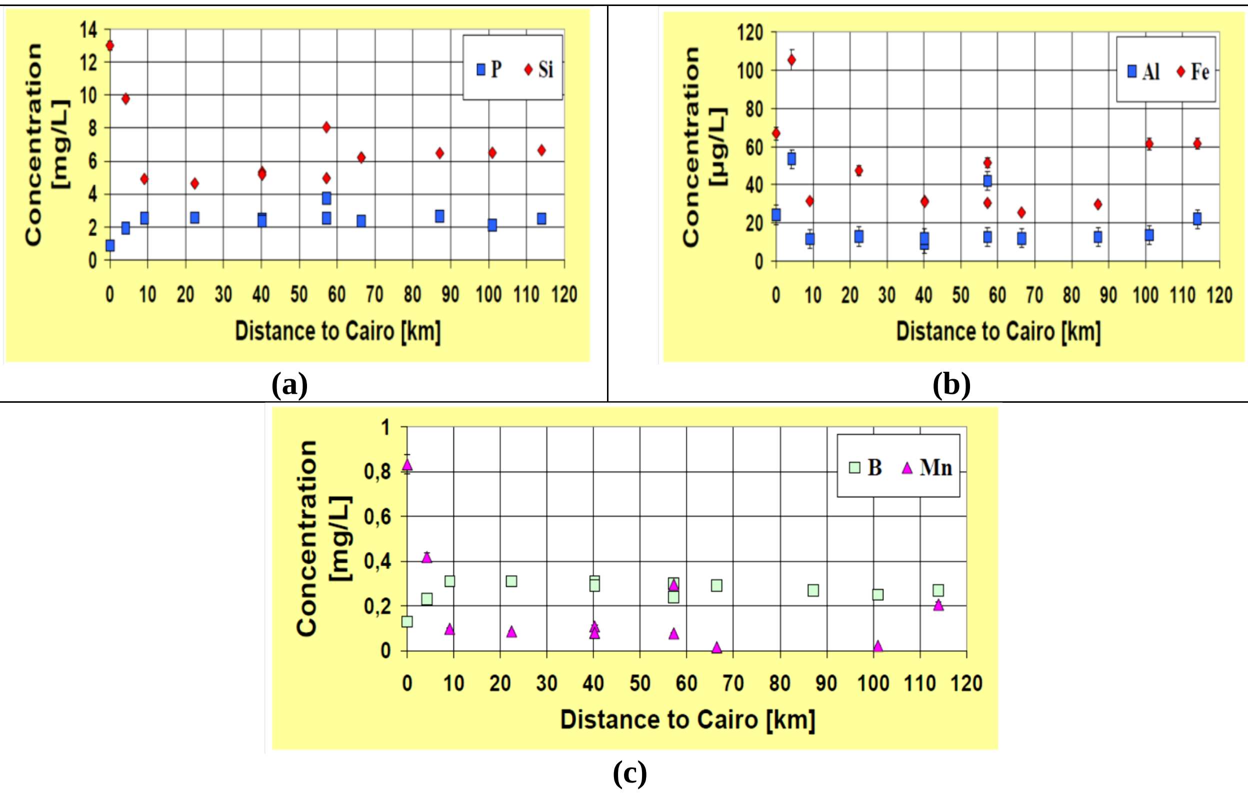

Figure 18: Concentrations of (a) P, Si; (b) Al, Fe; and (c) B, Mn along the drain.

Abdel-Fatah and Helmy (2015) collected samples of agricultural drainage water monthly for one year from October 2013 to September 2014 from the drain of Bahr El-Baqar, Bilbies and El-Qalyubia, East Delta, Egypt to evaluate water quality and suitability for irrigation purpose. It concluded that, drainage waters of Bahr El-Baqar Drain, Bilbies and El-Qalyubia Drains are classified as class high salinity low sodicity hazard according to USDA (1954) and could be used for irrigation with some precautions. Even with adequate drainage, special management for salinity control may be required and plants with good tolerance should be selected. According to Gupta classification(1979a and 1979b), Bahr El-Baqar water is classified of low salinity with non-sodic hazard while waters of Bilbies and El-Qalyubia Drains are normal water with non-sodic hazard and can be used for irrigation with most crops on most soils. Most of the crops except sensitive ones comprising some horticultural and leguminous plants can be grown on all soils except very heavy textured, with impeded drainage. Waters of the three drains do not have any sodicity hazard problem.

3-3- Effect of Bahr El-Baqar Drain on Agricultural Lands and Fish Farms

Siegel et. al. 1994 studied the effect of contaminates accumulation in Manzala lagoon and Ginka sediment. They collected 10-cm-diameter cores at 30 locations in Manzala lagoon and Ginka sub-basin during September-October 1990. The load carried by Bahr E1-Baqar drain discharges into the Ginka sub-basin. From the result of samples analysis, they determined that the cultural enrichment factors (degree of metal loading) for Hg, Pb, Sn, Zn, Cu, Ag, As and Cr in the upper 20 cm of sediment cores from the southeastern Ginka . They found that the cultural enrichment factors is high for Pb (22.1 x) and Hg (13 x). The sediments from the Ginka sub-basin cores have element concentrations that vary with time (from base to top of cores) and in space (along the core sampling transect). The result shown strong increases in metal concentrations in the upper 20 cm in cores were taken in Ginka when compared with metal contents in lower parts of cores.

Abdel-Azeem et al. (2007) studied the effect of prolonged use of drain water for irrigation on the heavy metal content of south Port-Said city soils. During the period from September (2004) to February (2005), 25 soil profiles, 100 soil and 30 water samples were collected from cultivated soil and drain of Bahr El-Baqar. Soil heavy metals content (Zn, Pb, Cd, Co, Mn and Cu), gypsum, organic matter, total calcium carbonates, cations, anions, electric conductivity, and pH were specified. Water samples has been subjected to different analyses including water temperature, pH, total soluble salts, electric conductivity, total nitrogen, total phosphate, heavy metals and organic loads (chemical oxygen demand and biological oxygen demand). Results (As shown in Table 5) illustrated that concentrations of heavy metals exceeded the maximum allowable limits while water analyses illustrated that organic load values are slightly increase in all tested samples and samples were not responding with the standard values given by law 48/1982. For ambient water quality in the drain total levels of heavy metals showed a trend relationship between metal concentration in soil and long term of irrigation assuming that there is a continuous deposition of heavy metals on the soils due the continuous use of Bahr El-Baqar drain in watering soil for many years.

Table 5: Chemical composition of Bahr El-Baqar drain water

Parameter		Mean	S. D.	Min.	Max.
pH		8.09	0.16	7.90	8.30
Dissolved oxygen (%)		0.21	0.10	0.10	0.35
TSS (gm L^{-1})		1.98	0.25	1.26	2.30
Organic loads	BOD (mg O_2/L)	50.94	10.85	37.15	68
	COD (mg O_2/L)	144.90	14.48	123	163.15
Nutrients (%)	Total nitrogen	6.45	1.15	5.10	8.10
	Total phosphate	7.63	0.36	6.99	7.98
Heavy Metals (ppm)	Zn	124.25	6.74	113	134
	Cu	215.50	10.60	200	236
	Mn	338.75	17.34	310	361
	Cd	56.58	11.21	44	82
	Pb	395.75	16.29	366	420
	Co	534.42	84.96	400	660

SMAP (2007) conducted a study for the water quality parameters at fish farms irrigated from Baher El-Baqar Drain and El-Manzala Lake. The study indicated that ammonia was the most dominant constituent of the total inorganic nitrogen compounds in earthen ponds irrigated from Bahr El-Baqar (Sewage wastewater) and irrigated from Manzala Lake near the main drains which spill in lake. Also showed that the concentration of heavy metals in earthen ponds irrigated from Baher El Bakar drain increased than in Manzala Lake and earthen ponds marine fish ponds. Also in the study, TDS value of Bahr El-Baqar drain water had been measured at two points first point was before the South Husseinia station pumping (it lays at Bahr El-Baqar drain about 20 Km from Manzala Lake). The lowest TDS value of Bahr El-Baqar drain is about 1100 ppm while, the highest TDS value is not more than 3000 ppm. Secoand point was after the South Husseinia station pumping, the lowest measured TDS value after the South Husseinia Valley pumping station is about 1,700 ppm, while the highest TDS values are near to 5000 ppm.

Abou Hussien et. al. (2008) performed a study on saline soils of Sahl El-Houssinia, El-Sharkia Governorate to evaluate three different water sources as a leaching and irrigation water in these soils and their use effect on some trace elements accumulation in the different soil layers. The using water sources were Bahr El-Baqar drain, Bahr Hadoos drain and El-Salam canal. These sources were used in the leaching three different locations of saline soils under fish-pond farms (contentious leaching) for 0, 3, 5 years followed by cultivation of rice and wheat. He concluded that, a) The tested water sources can be used in the leaching process of saline soils also its can be used in the irrigation these soils especially at short-time, b) These water sources contents of trace elements were in safe limits, c) The accumulation rates of trace elements in the soils followed by leaching and irrigation soils were high where their increased with the increase the used periods and d) The accumulation rates of trace elements related to water source , water used period, the type of elements, cultivated plant and soil depth.

National water research center (2010) studied the water quality of Bahr El-Baqar drain and the effects of use the drain water for irrigation on soil and plant at south Port Said . Water, soil and plant samples was collected from agricultural land using Bahr El-Baqar drain water. The result showed that the high salinity of water (2560 ppm) affected the soil salinity. Salinity, number of Coliform bacteria, Fe and Zn exceed the permitted value. The effect of high concentration of Fe and Zn in Bahr El-Baqar drain water in this area appeared in soil and plant samples. The report recommends that Bahr El-Baqar drain water must be treated before using in irrigation.

Agricultural Research Center (2010) assessed the water quality of Bahr El-Baqar drain water at south Port Said and the effect of using the drain water in irrigation on soil and plants. the report indicated to the high salinity of Bahr El-Baqar drain water. BOD and COD were found in the premises limits as a reuse sewage water but number of Coliform bacteria was very high. The result showed that Cu and Mn concentration in water samples is higher than the permitted limits. Heavy metals concentration of Bahr El-Baqar drain sediments were very high compared with heavy metal contents in cultivated land. High concentration of heavy metal in sediments indicated to deposit this element with the suspended solids in drain bed and sides. High number of Coliform bacteria was founded in cultivated land. Plant samples had a slight high concentration Fe, Zn, Ca and B also it had polluted with bacteria. Heavy metal concentration in Alfalfa and radishes were low than its concentration in Hyacinth, it may be useful in heavy metal concentrations reduction.

Hamed et. al. (2011) conducted an integrated environmental assessment for fish farms located adjacent to Bahr El-Baqar Drain. The drain's water was used for raising fish. They collected samples from different location adjacent the drain to measure the concentrations of five heavy metals (Pb, Zn, Cd, Cu and Mn). Results showed that the most polluted areas are the old fish farms using polluted water from the drain for raising fish and the land adjacent to it. The level of pollution in fish farms using polluted water is much more the level of pollution in agricultural lands using polluted water from the drain in irrigation. The quality of older fill from the polluted drain is better than the recent one; the difference in concentration is too high in a relatively short period of time. This reflects the rapid deterioration of the environmental situation for Bahr El-Baqar drain by time.

Salem et. al. (2012) conducted an integrated environmental assessment at the last 20 km length of the drain before it charges its water into Manzala Lake for areas located both sides of Bahr El- Baqar drain. In order to conduct that, the effects of using polluted drain water in new/old fish farms and agricultural lands were investigated. Pollution level in moor and fill lands adjacent to the drain were also investigated. In addition, effect of seepage from the polluted drain to the adjacent lands has been studied. Water and soil samples have been collected and analyzed in order to calculate the concentrations of five main heavy metals (Pb, Zn, Cd, Cu and Mn). Samples were collected from different depths ranging from 0.5m to 4m in 24 different locations for the study area. Different locations have been chosen in new/old fish farms, lands adjacent to the fish farms, moor lands, fill lands and agricultural lands using polluted drain water and fresh water from the canal.

Results (as shown in Figure 19) showed that the areas of old fish farms have received the highest concentration ratios in heavy metals. Results also illustrated that the fish farms using polluted water have not only dangerous effect on its own soil but also has almost the same bad effect on the adjacent areas surrounding it. The next highest ratios were found in agricultural lands using polluted water for irrigation. Furthermore, Results illustrated that the effect of using polluted water for irrigation or raising fish is more dangerous than the effect of seepage from the polluted drain.

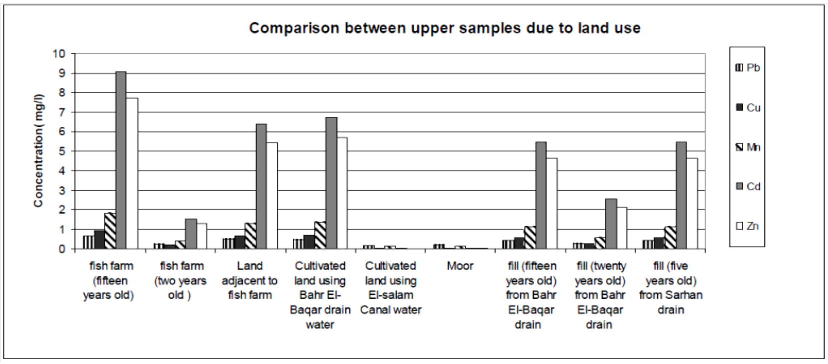

Figure 19: Mean heavy metals concentrations in upper soil samples for different land uses.

Omran and Abd El Razek (2012) stated that the abundance of heavy metals measured in the soils of Bahr EL-Baqar region decreases as follows: Cd > Cu> Zn > Cr> Ni> Pb. Total concentrations of Cd and Cu in some soils exceed the thresholds values for non-polluted soils. The most important heavy metals with regards to potential hazards in studied soils are Cu and Cd. These soils by their properties are still able to load with over concentrations of these metals and retained them since they do not reach their saturation capacities except for Cu and Cd in some areas.

EL-Bady (2014) conducted a study to establish the distribution of Iron, Copper, Cobalt, Nickel, Zinc, Lead, Cadmium and Chromium in the soils of Bahr EL-Baqar Region. Where, eight soil samples were collected from Bahr EL-Baqar Region, South of Manzala Lake. Elements (Metals) concentrations in the soils were varied between Fe (11987.67-33567.43), Cu (62.22-270.20), Co (74.6-106.44), Ni (54.29-80.30), Zn (95.13-211.22), Pb (33.73-54.40), Cd (12.22-19.39), and Cr (96.76-144.55) mg/kg. The abundance of heavy metals measured in these soils decreases as follows: Fe > Zn > Cr > Cu > Co > Ni > Pb > Cd. The heavy metals concentrations of Fe, Cu, Co, Ni, Zn, Pb, Cd, and Cr from the soil samples of Bahr EL-Baqar region compared with Canadian soil quality guidelines (CSQG) of Canadian Council of Ministers of the Environment.(CCME), (2007) and European Union Standards (EU, 2002) as well as with average upper earth crust of Wedepohl (1995). Another assessment method was applied using certain indices to assess the environmental impacts of the heavy metal pollution of the soils of Bahr EL-Baqar Region. These indices include the Enrichment Factor, Contamination Factor, Pollution Load Index and Degree of Contamination. The most important heavy metals with regards to potential hazards in studied soils are Cu, Pb and Cd.

Fe concentrations in the study area is more than the average upper earth crust values (Table 6). Cu concentrations is more than that CSQG values, EU Values and that of average upper earth crust of Wedepohl (1995) (Table 6). Co concentrations are higher than that of CSQG, EU and average upper earth crust of Wedepohl (1995) (Table 6). The Co is released in the drain from industrial processes that use the metal or its compounds. The toxicity of cobalt is quite low compared to many other metals in soil. The concentrations of Cu and Co are higher in the samples due to the irrigation of agricultural lands with untreated Bahr EL-Baqar water which led to the accumulation of Cu and Co in the soils.

Ni concentrations in the soil samples of the study area are higher than that of CSQG, EU and average upper earth crust of Wedepohl (1995) values (Table 6). Agricultural fertilizers, especially phosphates, are a significant source of nickel in soil but it is unlikely to build-up in the soil in the long term from their use. The irrigation by Bahr El-Baqar wastewater and uses of agricultural fertilizers led to the increasing the Ni concentrations.

Table 6. Concentrations of heavy metals of the soil in Bahr EL-Baqar Region

	Fe	Cu	Co	Ni	Zn	Pb	Cd	Cr
Average concentration (mg/kg)	35,744	167.54	131.81	102.35	194.23	67.12	21.08	177.71
CSQG (Agricultural soil) (mg/kg)	-	63	40	50	200	70	1.4	64
(EU, 2002) (mg/kg)	-	140	-	75	300	300	3	150
Average upper earth crust (mg/kg)	30,890	14.3	11.6	18.6	52	17	0.1	35

Zn concentrations of the study area are lower than that of CSQG and EU and its concentrations are higher than the average upper earth crust values of Wedepohl (1995) (Table 6). It is released to the environment from both natural and human sources; however, releases from human sources are greater than those from natural sources. The most importantly human sources zinc in the soil come from the use of commercial products like fertilizers that contain zinc. Although zinc usually remains adsorbed to soil, leaching has been reported at waste disposal sites. The lower concentrations of the Zn than the safe limits of CSQG and EU at most sites might be due to the continuous removal of heavy metals by the food crops grown in this area and also due to leaching of heavy metals into the deeper layer of the soil and to the groundwater.

Pb concentrations of the study area are lower than that of CSQG, EU and higher than the average upper earth crust values of Wedepohl (1995) (Table 6). Lead particles are deposited in the soil from flaking lead paint, from burners (and similar sources), and from motor vehicles that use leaded gasoline. Waste disposal is also a factor. Urban environments in general have received higher depositions of lead from vehicular emissions than have rural areas. When lead is deposited in soil from human sources, it does not biodegrade or decay and is not rapidly absorbed by plants, so it remains in the soil at elevated levels. Lead is toxic to humans, and poisoning can occur either through swallow of lead or by breathing in lead dust. Both long-term low-dose and short-term high-dose exposure can permanently damage the nervous, kidney, and blood-forming systems. The concentrations of Lead is lower due to the study area has a little sources of Lead, where little vehicles and populations.

Cd concentrations of the study area are higher than that of CSQG, EU and average upper earth crust of Wedepohl (1995) (Table 6). Cadmium (Cd) is regarded as one of the most toxic trace elements in the environment. Human sources of cadmium are much more significant than natural emissions and account for its wide presence in soil. Cadmium is a trace element in phosphatic fertilizers. Cadmium strongly adsorbs to organic matter in soils. When cadmium is present in soils it can be extremely dangerous, as the uptake through food will increase. Among the commercial fertilizers, phosphorus fertilizers contain somewhat elevated levels of Cd. Surface soils commonly contain higher concentrations of Cd than subsurface horizons. Cadmium is higher in the study area due to the uses of phosphatic fertilizers, irrigation by untreated wastewater of Bahr EL-Baqar Darin and due to the soils of the study area are recent and derived from sediments (sand, silt and clay).

Cr concentrations of the study area are higher than that of CSQG and average upper earth crust of Wedepohl (1995) and lower than EU values (Table 6). At many industrial and waste disposal locations, chromium has been released to the environment via leakage and poor storage during manufacturing or improper disposal practices. Chromium concentrations are higher in some sites due to irrigation by untreated wastewater of Bahr EL-Baqar drain and the study area near from the waste burns and outcome emissions from industrial sites in port said and around the Cairo Ismailia road. Chromium may be lower in some sites due to the continuous removal of heavy metals by the food crops grown in this area and also due to leaching of heavy metals into the deeper layer of the soil and to the ground water.

Transport of five main heavy metals (Cu, Pb, Zn, Cd, and Ni) was simulated using a numerical model (Hydrus-2D) (Hamed, 2015). Downward infiltration and seepage from a heavily polluted drain was simulated using Hydrus model. The area is located in the end of polluted drain (Bahr El-Baqar drain) northeast of Egypt. Possible future heavy metal impact on soil in the area were simulated. Comparison between the effect of downward infiltration from polluted irrigation water and seepage from the polluted drain was evaluated. Effects of a minor drain parallel to the polluted drain as a potential pollution reduction was studied. Also, using fresh water for irrigation on polluted soil was investigated.

In general, results showed that the prediction of 20, 50 years heavy metals impacts on soil could be serious. Soil pollution will extend deeper if the use of polluted water for irrigation will be continued.

The effect of downward infiltration of polluted irrigation/fish raising water is the dominant factor of the soil pollution and it is larger than the effect of seepage from the drain. Pollution as a result of seepage coming from the polluted drain is limited due to the low soil permeability. Results showed also that a small deep ditch excavated adjacent to the polluted drain at small distance interval (10 m) will reduce seepage from the drain. However, its effects on reduction of pollution from downward infiltration are limited. The study illustrated that using fresh water for irrigation of polluted soil during a reasonable time is an effective methodology for reducing soil pollution.

Omran (2016) provided a comprehensive analysis of heavy metal assessment in Bahr El Baqar surface soils. Thirty-four samples were collected and analyzed for heavy metals, which were assessed using different indices. The study area is located in northern Egypt, Bahr El-Baqar region, between $31^{o}50^{/}$ to $32^{o}20^{/}$ longitude and $30^{o}40^{/}$ to $31^{o}10^{/}$ latitude. The impact of anthropogenic heavy metal pollution in the sampling locations was evaluated using Enrichment Factor (EF), Contamination Factor (CF), Contamination degree, Pollution load Index, Metal Pollution Index (MPI), Metal Contamination Index and Geoaccumulation Index (I-geo). The statistics results indicated that Pb, Cd, Cu, Co, Cr and Ni concentrations in Bahr El Baqar soils are higher than those in the reference soil. The results of EF of all sampling sites were found to be less than 2, indicated that the study area falls into the category of shortage to low enrichment. However, the results showed that average CF values for heavy metals have an order Cd>Cr>Co>Ni>Cu>Pb>Zn> Mn>Fe, indicating that soil samples were considerably highly enriched with Cd, while Pb showed significant enrichment. Whereas The results of Contamination degree, showed that the study area falls under moderate to very high contamination degree. Calculation of the pollution load Index, Metal Pollution Index, Metal Contamination Index and Geo accumulation Index indicated that the study area is regarded as polluted. These indices are useful tools for identification of anthropogenic source of soil contamination. According to this, the agricultural activity in the Bahr El Baqar area requires careful consideration.

3-3- Effect of Bahr El-Baqar Drain on Manzala Lake Water Quality

Manzala Lake is located in the north-eastern extremity of the Nile Delta. Its northern border is a narrow sandy fringe which separates the lake from the Mediterranean Sea. It is bordered by the Suez Canal to the east, Damietta Branch of the Nile to the west and cultivated lands to the south. The lake is the largest of the coastal lakes of Egypt. It covers an area of approximately 136 000 hectares, and has a maximum length of 64.5 km, a maximum width of 49 km, and a total shoreline length of 293 km. The lake is shallow with an average depth of about 1.0 m. It contains numerous islands which consist of former shorelines, sand dunes and clay hummocks.

Fresh and drainage water flows to the lake via seven main sources. The total annual input from these is approximately 6.66 BCM. Bahr El-Baqar and Hadous drains contribute about 75 % of the total inflow. These flows constitute an important source of nutrients to the lake, which in turn promote the high level of fish productivity.

As a polluted drain flowing into Manzala Lake, Ali et al., (1993) and Abdel-Azeem et al., (2007) studied the effect of prolonged use of drain water for irrigation on the total heavy metals content of south Port-Said soils. Water quality, chemical composition, and hazardous effects on Manzala Lake water and living organisms caused by Bahr El-Baqar drain water has also been studied by Rashed and

Holmes (1984), Khalil (1985) and Ezzat (1989). Special attention has been paid to the effect of environmental pollution from microbiological and toxicological points of view (Zaki, 1994).

The spatial changes in average salinity of Manzala Lake show a declining trend from the northern sector to the southern one, as detected from five stations and reported by Khalil (1990). Region I in the southern sector at the estuary of Bahr El-Baqar Drain is of the lowest salinity (~1,500 mg/L). These low salinity levels are the result of the southern drains which supply the lake with about 90 % of its total freshwater.

Hamed et. al. (2013) quantified the amount of heavy metals spilled daily from Bahr El-Baqar drain into the Manzala Lake, the daily discharge from the drain to the lake was measured monthly at section near the spill of drain into the lake waters and sediments samples were analyzed every month in order to calculate the ratios of the main heavy metals (Zn, Pb, Cd, Mn and Cu) at the samples. From the values of the discharge and the ratio of heavy metals, the amount of heavy metals spills daily/monthly into the lake could be calculated. Also they Detected heavy metals in fish flesh which caught from the lake. They found that Heavy metals appears in water, soil and fish with concentration exceeds the permissible limits in many samples especially fish samples. The results concluded that all values of concentrations of all heavy metals and total count faecal coliform bacteria are found in the site at the end of Bahr El-Baqar drain.

The results confirmed that the maximum calculated amount of Mn in lake water during study period was found as 0.72 mg/l at mean pH 7.5 when water temperature mean 22 °C and water current 0.095 m/s. It is probably due to the agricultural drainage water filled with fertilizes spilled into the drain. Furthermore, the fish farms adjacent to the drain use some chicken farms residuals rich with Mn for feeding fish.

The results illustrated that the difference between sites in Cd concentration values is not much but the maximum calculated concentration of Cd in lake water was recorded in Bahr El-Baqar drain, mean 0.057 mg/l at mean pH 7.5 when water temperature mean 22 °C and water current 0.095 m/s in mean. It is probably due to the industrial disposal into the drain. All the sites contain a reasonable concentration of Cd. Also results showed that the maximum calculated concentration of Zn in sediment was found as mean 23.5 μg/g, when water current found at 0.08 m/s. It is probably due to the deposition of the industrial disposal spilled into the drain into the bottom of the drain for a long time.

Data conducted that the maximum calculated concentration of Pb in sediment was as mean 100 μg/g, with water current found at 0.08 m/s. It is probably due to the deposition of the industrial disposal into the bottom of the drain for a long time. Finally results showed that the maximum calculated amounts of Cu in soil sediment samples were as mean 32.5 μg/g with water current found at 0.016 m/s. Again, it is probably due to the industrial disposal spilled into the drain and settled down at the bottom of the drain.

The maximum calculated values of total count faecal coliform bacteria (FCB) in water samples were recorded clearly in Bahr El-Baqar drain at mean values of pH 7.5 and water temperature 22.9 °C in the presence of water current at rate 0.095m/s. It is probably due to the effect untreated waste water at the drain. Tainted drinking water from the lake leads to enteric diseases of the population.

3-4- Lake Manzala Engineered Wetland Project (LMEWP)

Studies (conducted in the 1980’s) suggested the use of Engineered Wetland to improve the water quality of Bahr El-Baqar drain, before entering the Manzala Lake. In the early 1990’s, a project for constructing an engineered wetland, at the Bahr El-Baqr drain outlet, was approved as a collaborative effort among the Global Environment Facility (GEF), United Nations Development Programme (UNDP), and Egyptian Environmental Affair Agency (EEAA). LMEWP is located in the NE edge of the Nile Delta, 170 km from Cairo and 15 km from Port Said city (Figure 20). Since 2005, the (NWRC)/(DRI) had taken the full responsibilities of the LMEWP management, rehabilitation and research activities. The main project purposes are constructing and operating an engineered wetland to treat 25,000 m^3/d of Bahr El-Baqar Drainage water. Therefore assessing feasibility of engineered wetland system to improve environmental conditions at Manzala Lake and Mediterranean Sea and to treat wastewater so that it becomes suitable for different uses also, assist in transferring wetland technology to Egypt and other neighboring countries. The facility includes, as shown in Figure 21, 1 - intake, 2 - screw pumps, 3 - sediment basins, 4 - distribution channel, 5 - surface treatment cells, 6 - subsurface reciprocating cells, 7 - fingerling ponds , and 8 - effluent reuse area.

Figure 20: The site of the LMEWP project.

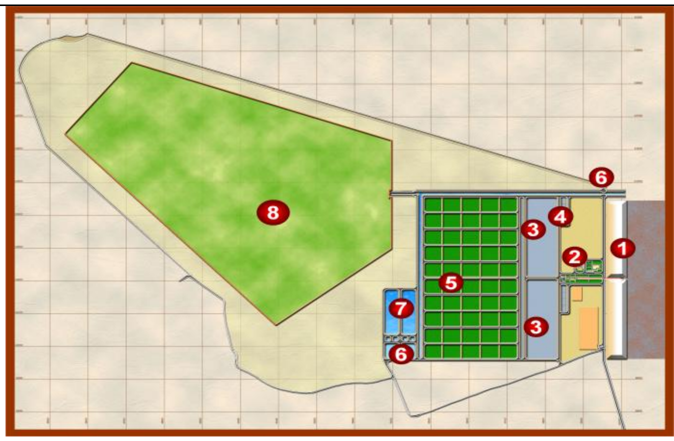

Figure 21: Detailed Project Elements.

Constructed wetland treatment systems are engineered systems that utilize the natural processes involving wetland vegetation, soils, and their associated microbial assemblages to assist in treating wastewater. They are designed to take the advantage of the same processes that occur in natural wetlands, but with more controlled environment. Typically, a constructed wetland is a series of rectangular plots filled with soil or gravel and lined to prevent waste form leaching into groundwater. The plants grown in these plots, not only offer a root mass for filtration, but also provide oxygen and carbon for wastewater treatment. The roots offer attachment sites for microbes, which consume the available oxygen in the process of breaking down pollutants. Figure 22 shows a schematic diagram for the wetland treatment system used in LMEWP.

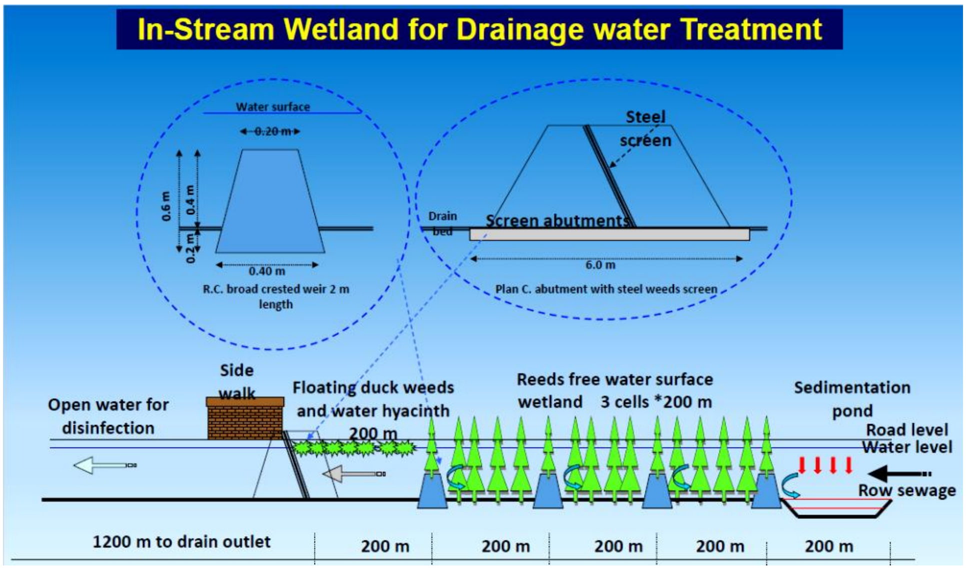

Figure 22: A schematic diagram for the wetland treatment system used in LMEWP.

The project is exploring the possibilities of reuse of the wetland effluent reuse for aquaculture and for irrigated agriculture. The facility treats 25,000 m^3/day with excellent effluent quality. The treated water is used for raising healthy fish suitable for human consumption and serves as a Center of Excellence for local, regional and international bodies. Due to climatic differences between Egypt and

Western Countries, retention time and dimensions could be reduced substantially. The project shows a good results for the removal efficiencies for TSS, BOD, TP, TN, ON, NH_4^-N and Fecal coliform (Table 7) and Figures 23 & 24. Also, Heavy Metals Treatment Efficiency shows an excellent result (Table 8).

Table 7: Average effluent concentration and removal efficiencies (2004-2016)

Bahr El-Baqar Drain Initial Conditions		Sedimentation Bond			Wetland Treatment System		
Parameter	**Influent Conc. mg/L**	**Influent Conc. mg/L**	**Effluent Conc. mg/L**	**Removal Efficiency %**	**Influent Conc. mg/L**	**Effluent Conc. mg/L**	**Removal Efficiency %**
TSS	80-160	80-160	32	80	32	4.8-8.4	85-74
BOD	40-84	40-84	24	40	24	6.8-19.3	72-20
Total P	3-5	3-5	4	25	4	1.4-3.4	65-15
Total N	12-30	12-30	12	0	12	3.9-10.3	68-14
Organic-N	4-15	4-15	4	0	4	1.9-3.8	53-5
NH_4-N	5-17	5-17	5	0	5	2-4.1	60-18
F. Coliform MPN/100ml	4 E+5	4 E+5	1.5 E+5	61	1.5 E+5	150-1000	99.9

Table 8: Heavy Metals Treatment Efficiency

Metal	Influent Conc. mg/L	Effluent Conc. mg/L	Removal Efficiency %
Cu	0.019	0.0006	97
Ni	0.012	0.0007	94
Pb	0.05	0.0072	87
Zn	0.085	0.0009	99
Cr	0.007	0.0002	97
Hg	0.003	0.0022	26
Cd	0.012	0.0018	86

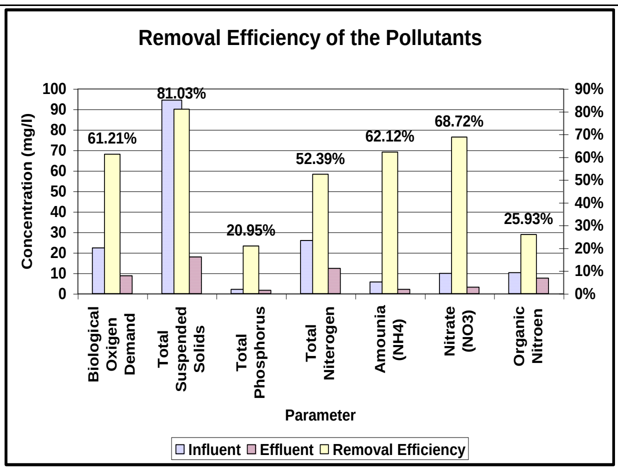

Figure 23: Removal Efficiencies for BOD, TSS, TP, TN, NH4, NO3 and ON (2004-2016)

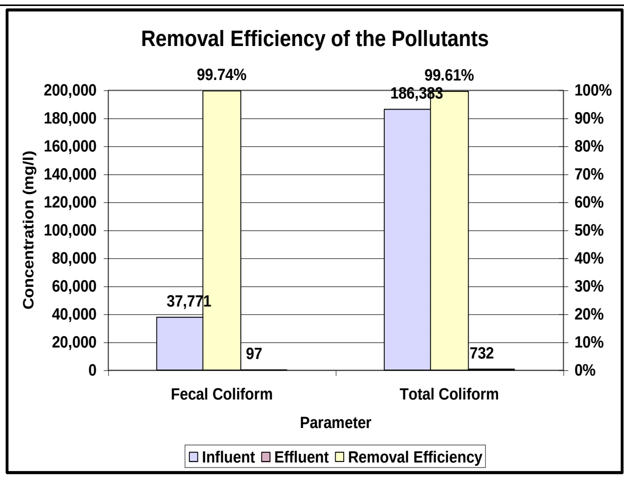

Figure 23: Removal Efficiencies for Fecal Coliform and Total Coliorm (2004-2016)

4 - Discussion

Pollution is the entrance of a contamination into the environment. In the Delta region the amount of agricultural drainage water reuse was estimated in 1997/98 to be around 3.50 BCM, in addition to about 0.3 BCM lifted to Rosetta branch from west Delta drains. Particularly in the Nile Delta, about 420000 acres were irrigated with such waters this considered as the official reuse transferred by pumping stations of the Ministry of Water Resources and Irrigation (MWRI). Additional unofficial reuse, done by the farmers themselves, is estimated to be around 2.8 BCM in case of shortage in canal water. The remaining drainage water is discharged to the sea and the northern lakes through drainage pump stations. The total amount of drainage water that was pumped to the sea during the year 1997/98 has been estimated to be 12.94 BCM with an overall average salinity of 2400 ppm.

The Reuse of this drainage water without suitable treatment may cause adverse effects on soil and crops. Reuse of agricultural drainage water in the Delta is limited by the quality of the drainage water. Taking the salt concentration as an important parameter, the level of salinity increases from upstream to downstream but in most of the Valley and in the southern part of the Delta region, the salinity remains below the critical level of 1,000 ppm making it possible for reuse. However, in the northern part of the Delta region, large quantities of salt infiltrate through groundwater to the drainage water due to the seawater intrusion. The amount of seawater that infiltrates into the drains is estimated to be about 2.0 BCM/year. This water is pumped back to the sea and northern lakes to maintain the salt balance of the system.

Using the water twice increases the salinity especially in drains near the lakes bordering the Mediterranean Sea. The mixing of drain water with clean water deploys all components that still have negative environmental and health impacts. Without seasonal flushing floods, the former delta plain surface is now unable for recycling and/or removing agricultural, domestic and industrial waste generated by Egypt’s rapidly expanding population. The necessary expansion of the water supply services is not always fitting to the associated development of the sewerage system. This results to an increasing pollution load to canals and drains - the most typical example is Bahr El-Baqar drain system.

One of the most polluted drains in Egypt is Bahr El-Baqar drain. The Bahr El-Baqar coordinates are 31°7'0" N and 32°6'0" E. Bahr El-Baqar is located in the eastern part of the Nile Delta and runs for about 170 km from Cairo to Manzala Lake. Arable lands irrigated by the water of this drain and its tributaries are about 317,000 acres. The main drain collects water from the two secondary drains of Bilbeis and Qalyubya, which collect water from the two drains, of Gabal El Asfar and Shebeen. Bahr El-Baqar drain receives untreated wastewater starting from east of Cairo, at El-Gebel El-Asfar and then joined by the Belbeis drain, down to Qalubiya drain. The length of the main drain is 170 km with a depth of 1 to 3 meter and width is about 30 to 70 meter. Manzala Lake receives and carries the greatest part of wastewater (about 2.3 BCM/year) into Lake, which passed through Qalubyia, Sharkia, Ismailia and Port Said regions. Many sources of pollutants cause water quality decaying in Bahr El-Baqar drain. Wastewaters of the industrial activities in region including metal, food processing, detergents and soaps manufacturing, textile and paper production are discharges into the drain. The drain, lake and the surrounding land soils receive many pollutants, such as heavy metals including lead, cadmium, nickel, and mercury. Extended use of such drain water for irrigation leads to accumulation of heavy metals in Port-Said soils.

However the impact of canal water on adjacent soil and groundwater systems is great. In Greater Cairo the vulnerability of groundwater to pollution from the surface varies from moderate to high. Preliminary results indicate that seepage water from the drain has entered the ground water.

CCME WQI values of Bahr El-Baqar Drain showed that water quality for aquatic uses could be related as poor to marginal. Also, Classification of drains water quality by WQI indicated that Bahr El-Baqar is very poor class.

The lowest TDS value of Bahr El-Baqar drain is about 1100 ppm while, the highest TDS value is not more than 3000 ppm before the South Husseinia station pumping. After the station pumping, the lowest measured TDS value after the South Husseinia Valley pumping station is about 1,700 ppm, while the highest TDS values are near to 5000 ppm.

In terms of organic loads (BOD and COD), Bahr El-Baqar drain receives the highest load in the Delta, as it receives the greatest part of wastewater (about 3 BCM/year). Total and faecal coliforms showed a similar trend along Bahr El-Baqer drain and generally, exceed the permissible limits for reusing such water for irrigation. Water samples at Manzala Lake showed a gradual decrease from southern part of the lake, 10 kilometers, in direction to the north. COD,BOD values as well as suspended solids along Bahr El–Baqer drain are exceeding the maximum limits in the degree of wastewater treatment for agriculture reuse in Egypt.

Results illustrated that concentrations of heavy metals exceeded the maximum allowable limits in most studies and the samples were not responding with the standard values given by law 48/1982. Heavy metals concentration of Bahr El-Baqar drain sediments were very high compared with heavy metal contents in cultivated land. High concentration of heavy metal in sediments indicated to deposit this element with the suspended solids in drain bed and sides. The abundance of heavy metals measured in these soils decreases as follows: Fe > Zn > Cr > Cu > Co > Ni > Pb > Cd. The concentration of Fe, Cr, Cu, Co, Ni, and Cd are more than that CSQG values, EU Values and that of average upper earth crust of Wedepohl (1995). Whereas The concentration of Zn and Pb are less than the same comparison references. The results showed strong increases in metal concentrations in the upper 20 cm in cores were taken in Ginka when compared with metal contents in lower parts of cores.

The Negative impacts expected to intermediate reuse were the reduction of the water flow at all downstream points. This will ultimately reduce the capability of the drain system to dilute various kinds of pollutants.

From the previous studies it is revealed that the most polluted areas within the service area of the most polluted drain in Egypt (Bahr El-Baqar drain) are the old fish farms which use polluted water from the drain for raising fish and the land adjacent to it. That reflects the harmful effect of using polluted water for long time for raising fish not only on farms soil itself but also on the soil adjacent to the fish farms. Consequently, the pollution will reach fish coming from these farms and transferred to human being affecting their health. Moreover, even in new fish farms the increase in heavy metals concentrations in soil is quite high during short period of time. The second higher ratio of pollution concentration is found in agricultural lands which use polluted water from the drain in irrigation. This is a good proof for the bad effect of such kind of water on soil and hence in plants since the digging depth is within the root zone. This conclusion will stand against those people supporting the use of polluted drain water for irrigation.

The fill from Bahr El-Baqar drain comes after as a third higher ratio of pollution. The quality of older fill from the polluted drain is better than the recent one. It is probably due to the increase in concentration of pollution by time in drain bottom soil. The difference in concentration is too high in a relatively short period of time. This reflects the rapid deterioration of the environmental situation for Bahr El -Baqar drain by time.

For agricultural lands which have used polluted water for irrigation for long time (20 years) and changed to use fresh water for relatively less period of time (5 years), the improvement of its soil quality is quite clear. The decrease in heavy metals due to using good quality of water is rather high. It will give an optimistic view for obtaining a clue for pollution in the area. Furthermore, the existing of minor drain parallel to the major polluted drain in relatively small distance (90-100m) contributes for reducing pollution for lands located after the minor drain in most cases.

Also, the previous studies revealed that the overall environmental situation at the area on both sides of the drain is quite dangerous. Five dangerous heavy metals with different concentrations have been found in each soil sample on surface or deep on the ground and its impacts on soil could be serious. Soil pollution will extend deeper if the use of polluted water for irrigation will be continued. This pollution hazardous level has its bad effect on environment at the area.

The observed amount of dissolved oxygen is too low to keep up the self-cleaning efficiency. Even the pH-value of the drain water is outside of a range from 6.0 to 9.0 and the activity the micro-organism needed for the cleaning process will cease. The canal is unable to clean itself and break down pollutants. Not all pollutants are biodegradable and the risk is high that contaminants will concentrate downstream on the irrigated land, in fishes or at least in the Mediterranean Sea. The heavy metals attach themselves to silt particles and hence the pollutants are focused on the fields. When the drain water is used for irrigation two types of salt problems exist which are very different: those associated with the total salinity and those associated with sodium. The results indicate that for the salinity and water infiltration rate a light to moderate restriction on use is recommended.

LMEWP is a project constructed to improve the water quality of Bahr El-Baqar drain by treating 25,000 m^3/day of the polluted drainage water. Constructed wetlands are engineered systems that use natural functions vegetation, soil, and organisms to treat wastewater. The removal efficiencies for the organic parameters ranged from 5 to 85 % whereas it reaches to 99.9 for the removing of Fecal coliform. Also, The removal efficiencies for the Heavy Metals ranged from 26 to 96 %.

In the area of wastewater treatment plants, the Engineering Authority of the Armed Forces announced on January 21, 2018 that the Biological Treatment Plant of Bahr Al-Baqar drain is currently being constructed with capacity of 5 million m^3 / day. The water of the Bahr al-Baqar drain is transferred from the west of the canal through the El-Salam syphon to the treatment plant east of the canal. The treated water is enough to grow 250,000 feddans in Sinai to create urban communities and create new jobs. The inlet of new drainage canal is located 30 km from Manzala Lake on the Bahr El-Baqar drain, heading east to the Suez Canal and then heading north to pass through the syphon of the El-Salam Canal to the west of the canal where the new treatment plant is located.

5- Conclusions and Recommendations

Pollution phenomenon is considered the most hazardous problem affecting the environment. Bahr El-Baqar drain in the north east of Egypt is considered as the most polluted drain in Egypt. The pollution levels in this drain reached very dangerous levels and its impacts on the surrounding environment become hazardous. The implementation of suitable monitoring for the pollution in drainage water by monitoring water quality in water drains are essential for sustainable management of environment and to seek protection actions.

The article recommends that:

1- The problem of pollution must be solved from the source by preventing the dumping of industrial wastes and untreated sewage in Bahr El-Baqar drain to reduce the contamination.

2 - Many initiatives should be taken by the Government of Egypt to protect the water resources and combat pollution in Bahr El-Baqar drain such as:

Agriculture Sector

a - Removal of the Government subsidies on fertilizers and pesticides and promotion of pest control management. This results in a considerable decline in the use of nitrogen and phosphate fertilizers. Also, the overuse of herbicides to control aquatic weeds must be completely prohibited, and mechanical and biological maintenance are in practice.

b - Development of an educational program to farmers on the proper use of pesticides and fertilizers, and information dissemination regarding the management practices that reduce the need for pesticides.

Municipal Sector

a - The immediate solution include the construction of advanced wastewater treatment units for Balaqs and El-Gabal El-Asfar.

b - Major programmes for sewage treatment plants for Cairo, Qalubeya, Sharkia, Ismailia and Port Said Governorates.

c - An extensive program for the installation of new sewer systems and sewage treatment plants in smaller cities and villages around the drain must be taking into account.

Industrial Sector

a - All new industrial communities are located in new cities in the desert areas and provided with sewage system.

b - The industrial activities are based on new technologies developed for both source reduction and recycling.

c - With respect to old industries, the government supports technology changes involving heavy capital investment.

3 - The principles of “Polluter Pays” would provide the government with the funds to provide the necessary treatment.

4 - Future research should clearly be oriented towards development of a fully integrated water quality monitoring for the Bahr El-Baqar drain system.

5 - Continuous standardized monitoring of the most polluted location through a national integrated project for the whole area of the Bahr El-Baqar drain system.

6 - Expansion of the biological treatment plant such as the Lake Manzala Engineered Wetland Project and the Biological Treatment Plant of Bahr Al-Baqar drain which the Engineering Authority of the Armed Forces announced later.

7 - The establishment of a Weir on the outlet of the drain (works as sludge reactivation basins in sewage stations) provides water and aerobic bacteria with oxygen and makes it the process of decomposition of organic matter.

8 - Expansion of the cultivation of plants that absorb contaminated metals and pollutants such as Hyacinth and Reed, in the drain and in the areas of the lake near the drain.

9- The use of the drain's water in agriculture and fish breeding specially in south of Port Said should be criminalized and preventing the consumption of the fish of the drain or fish farms there, and activating the environmental law.

10 - Research in water treatment in the developed world has made considerable progress in recent years, both in the production of water of high quality and in wastewater treatment. Therefore, the research has to be local or at least adaptive of imported technology.

11 - Public and governments awareness raising of the value of water and hazard of pollution to all stakeholders is a prerequisite. Promote community involvement in water quality management to enable identifying actual needs, proposing response and fostering sense of belonging among the benefiting citizens. Awareness campaigns could be directed through the media, schools, training institutions, professional associations and political fora.

6- Refrences

Abdel-Azeem, A.M., Abdel-Moneim, T.S., Ibrahim, M.E., Hassan, M.A.A. and Saleh, M.Y., 2007. Effects of Long-Term Heavy Metal Contamination on Diversity of Terricolous Fungi and Nematodes in Egypt - A Case Study. Water Air Soil Pollut. Journal, No. 186, pp.:233–254.

Abdel-Fattah, M.K., and Helmy, A.M., 2015. Assessment of Water Quality of Wastewaters of Bahr El-Baqar, Bilbies and El-Qalyubia Drains in East Delta, Egypt for Irrigation Purposes. Egypt. J. Soil Sci. Vol. 55, No. 3, pp.287-302.

Abdel-Shafy, H.I., and Aly, R.O., 2002. Water issue in Egypt: Resources, pollution and protection endeavors. CEJOEM, 8(1), 3-21.

Abou Hussien, E.A., and Shaban, Kh.A., 2008. Trace elements status in the saline soils leached by using low quality water . Twelfth International Water Technology Conference, IWTC12 2008, Alexandria, Egypt: 1031-1043.

Abukila, A.F., 2015. Assessing the drain estuaries’ water quality in response to pollution abatement, Water Sci. (2015), http://dx.doi.org/10.1016/j.wsj.2015.02.002

Agricultural Research Center Soil, Water and Environmental Research Institute, 2010. Report about environmental study in south Port Said.

Ali, O.M., El-Sikhry, E.M., and El-Farghal, W.M., 1993. Effect of prolonged use of Bahr El-Baqar drain water for irrigation on the total heavy metals content of South Port Said soils. In: Proc. 1st Conf. Egypt. Hung. Env. Egypt. 53–57.

Ayers, R.S., and Westcot, D.W., 1994. FAO irrigation and drainage paper, 29 Rev.1, Food and Agriculture Organisation of the United Nations Rome, 1985. http://www.fao.org/documents/

Badawy, M.I. and Wahaab, R.A., 1997. Environmental impact of some chemical pollutants on Lake Manzala", Int. J. of Environmental Health Research, Vol. 7,No.2.

Bazaraa, A.S., 2002. Reuse of Agricultural Drainage Water: Revision of the Reuse Mixing Policy. Cairo: Advisory Panel Project on Water Management.

Brown, P., El Gohary, F., Tawfic, M., Hamdy, E., and Gawad, S., 2003. Nile River Water Quality Management Study. Egypt Water Policy Reform, project between Ministry of Water Resources and Irrigation and US Agency for International Development, Report No.67.

CCME (Canadian Council of Ministers of the Environment), 2001. Canadian water quality guidelines for the protection of aquatic life: CCME water quality index 1.0, technical report. In: Canadian Environmental Quality Guidelines, 1999. Canadian Council of Ministers of the Environment, Winnipeg.

Canadian Soil Quality Guidelines (CSQG), 2007. Canadian soil quality guidelines (CSQG) for the protection of environmental and human health: Summary tables. Updated September, 2007. In: Canadian environmental quality guidelines, 1999, Canadian Council of Ministers of the Environment, Winnipeg.by Canadian Council of Ministers of the Environment.(CCME).

Chapman, D., 1996. Water Quality Assessments - A Guide to Use of Biota, Sediments and Water in Environmental Monitoring, Published on behalf of UNESCO WHO United Nations environment program. second ed. E&FN Spon An imprint of Chapman & Hall, 1992, 1996 UNESCO/WHO/UNEP.

DRI (Drainage Research Institute), 2001. Subsurface Drainage Research on Design, Technology and Management 1994–2001. Final Report Drainage Research Projects I and II. Cairo/Wageningen/Arnhem: DRI/International Land Reclamation Institute/Arcadis Euroconsult.

DRI (Drainage Research Institute), 2007a. Drainage Water Status in the Nile Delta, Year Book 2005/2006. Technical Report No.76. DRI, NWRC, Egypt.

DRI (Drainage Research Institute), 2007b. Atlas of Water Objective Uses. Report submitted to: National Water Quality and Availability Management Project (NAWQAM), March 2007. DRI, NWRC, Egypt.

El-Bady, 2014. Spatial Distribution of some Important Heavy Metals in the Soils South of Manzala Lake in Bahr El-Baqar Region, Egypt. Nova Journal of Engineering and Applied Sciences, Vol. 3(2), pp: 1-12.

El-Baz, A.A., Ewida, M.K.T., Shouman, M.A., and El-Halwagi, M.M., 2005. Material flow analysis and integration of watersheds and drain systems: II. Integration and solution strategies with application to ammonium management in Bahr El-Baqar drain system, Clean Techn Environ Policy, 7: p.p 78–86.

El-Eweddy, E.A.I., 2000. Factors Affecting the Accumulation Rate of Pollutants in Desert Soils under the Condition of Irrigation with El-Salam Canal Waters, Ph.D. Thesis, Agricultural Sciences, Minufiya University.

El-Kholi, 2005. Pollution Assessment And Removal From Manzala Lake Area, A thesis submitted to Benha University.

El-Korashey, R., 2009. Using Regression Analysis to Estimate Water Quality Constituents in Bahr El-Baqar Drain. Journal of Applied Sciences Research, No.5(8),PP: 1067-1076.

EPIQ, 1999., Intermediate drainage reuse in Bahr El-Bbaqar drain basin. Report No. 20.

European Union, 2002. Heavy Metals in Wastes, European Commission on Environment.http://ec.europa.eu/environment/waste/studies/pdf/ heavymetalsreport.pdf

Ezzat, A. I., 1989. Studies on phytoplankton in some polluted areas of Lake Manzala. Bulletin of the National Institute of Oceanography and Fisheries, ARE, 15(1):1–19.

Gupta, I.C., 1979a. Use of Saline Water in Agriculture in Arid and Semi-arid Zones of India. Oxford and IBH publishing Co. Pvt Ltd., New Delhi, India.

Gupta, I.C., 1979b. Note on the effect of leaching and gypsum on the detoxification of Boron in saline-sodic soils. Current Agri. 4, 51-55.

Hamed, Y., Salem, Sh., Ali, A., and Sheshtawi, A., 2011. Book title: Fish farms, Chapter title: Environmental Effect of Using Polluted Water in New/Old Fish Farms.

Hamed, Y.A., Abdelmoneim, T.S. El-Kiki, M.H., Hassan, M.A., and Berndtsson, R. 2013. Assessment of Heavy Metals Pollution and Microbial Contamination in Water, Sediments and Fish of Lake Manzala, Egypt. Life Science Journal, 10(1).

Hamed, Y. 2015. Numerical Simulation of Metal Transport from Polluted Drain. International Water Technology Journal, IWTJ. Vol. 5 –No.3, September.

Hedberg, T., 1999. Attitudes to traditional and alternative sanitary systems. Water Science and Technology 39 (5) 9-16.

Hölting, B., and Coldwwey, 1996. W.G., Hydrogelogie. Enke, Stuttgart.

Khalil, M.T., 1985. The effect of sewage and pollutional wastes upon Bahr El-Baqar Drain and the southern area of Lake Manzala, Egypt. Egyptian Journal of Wildlife and Natural Resources, 6:162–171.

Khalil, M. T., 1990. The physical and chemical environment of lake Manzala, Egypt. Hydrobiologia, 196:193-199.

National Water Research Center report (2010).

NAWQAM, 2001a. The National Water Quality and Availability Management Project, Evaluation and Design of Egypt National Water Quality Monitoring Network.

NAWQAM, 2001b. NAWQAM Project Information Bulletin. National Water Research Center.

Nile Basin Initiative Nile Trans boundary Environmental Action Project, 2005. Nile Basin National Water Quality Monitoring Baseline Study.

Omran, E.E., and Abd El Razek, A.A., 2012. Mapping and screening risk assessment of heavy metals concentrations in soils of the Bahr El-Baqer Region, Egypt . Journal of Soil Science and Environmental Management Vol. 6(7), pp. 182-195, Available online at http://www.academicjournals.org/JSSEM,ISSN 2141-2391

Omran, E.E., 2016. Environmental modelling of heavy metals using pollution indices and multivariate techniques in the soils of Bahr El Baqar, Egypt. Model. Earth Syst. Environ. (2016) 2:119. DOI 10.1007/s40808-016-0178-7.

Rashed, I.G. and Holmes, P.G., 1984. Chemical survey of Bahr El-Baqar drain system and its effects on Manzala Lake. In: Proceedings of the 2nd Egyptian Congress of Chemical Engineering, Cairo, Egypt. 1–10.

RIZA, 1996. Guidelines on Water Quality Monitoring and Assessment of Trans-Boundary Rivers. UN/ECE Taskforce on monitoring and assessment, RIZA Institute for Inland Water Management and Wastewater Treatment, Lelystad, the Netherlands. report on.96.034.

Saad, A.K., 1997. Environmental hydrogeologic impacts groundwater withdrawal in the eastern Nile Delta region with emphasis on groundwater pollution potential. Ph. D. Thesis, Institute of Environmental Studies. Ain Shams Univ. p. 232.

Salem, Sh., Hamed, Y., Sheshtawy, A., and Ali, A. 2012. Environmental Assessments For Areas Located Both Sides of Bahr El-Baqar Polluted Drain Northeastern Egypt. Port Said Engineering Research Journal, Vol. 16, No.1, pp: 137-149.

Schleiff, U., 2009. Research Aspects for Crop Salt Tolerance under Irrigation with Special Reference to Root Environment. http://www.salinity.de/research.aspects.html

Shaban, M., Urban, B., ElSaadi, A., and Faisal, M., 2010. Detection and mapping of water pollution variation in the Nile Delta using multivariate clustering and GIS techniques. Journal of Environmental Management 91(2010), pp. 1785-1793

Siegel, F.R., Slaboda, M.L., and Stanley, D.J., 1994. Metal pollution loading, Manzalah Lagoon, Nile Delta, Egypt: Implications for aquaculture, Environmental Geology, 23: p.p 89- 98

SMAP, 2007. The european union's short and medium-term priority environmental action programme (SMAP) Final Report - Volume I December.

Stahl, R., Ramadan, A.B., and Pimpl, M., 2009. Bahr El-Baqar Drain System/Egypt Environmental Studies on Water Quality, Forschungszentrum Karlsruhe GmbH, Karlsruhe

USDA, 1954. Diagnosis and Improvement of Saline and Alkali Soils. Agriculture Handbook 60, US Gov. Printing Office, Washington, DC, USA.

Wedepohl, K.H., 1995. The composition of the continental crust. Geochimica et Cosmochimica Acta 59: 1,217-1,239. doi: 10.1016/0016-7037(95)00038-2.

World Bank, 2005. Country Environmental Analysis (1992-2002). Arab Republic of Egypt, Water and Environment Department, The Middle East and North Africa Region. World Bank.

Zaki, M.M.M., 1994. Microbiological and toxicological study of the environmental pollution of Lake Manzala. M.Sc Thesis, Faculty of Science, Suez Canal University, Ismailia, Egypt. Pp.108.

Zhu, Z., Khattab, F., Elassiouti, I., Abdel Azim, R., Keith, J., Mahdy, E., Cardinalli, R., Galal Saad, S., and Mohiedin, M., 1999. Intermediate Drainage Reuse in Bahr Bagar Drain Basin, United States Agency for International Development/Egypt, June.

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