EFFECT OF INCREASING DISCHARGE ON WATER QUALITY: A CASE STUDY

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ABSTRACT

In Egypt, River Nile is the main source of water for drinking purposes, domestic, irrigation and industry. Unfortunately, in spite of this vital role of the River Nile, a variety of wastes coming from sanitary drainage (sewage), industrial discharge from factories located on its shores as well as soil run–off have a considerable potential effect on its water quality. Of most concern are those pollutants that can cause injury substances or disease outbreak specifically, pathogenic or parasitic organisms and toxic. This study is devoted to achieve the following objectives: i) Measure physio–chemical characteristics of the different pollution sources along Rosetta Branch, ii) Assess the environmental impact of wastewater discharge on water quality of Rosetta branch taking into consideration seasonal variations, iii) To apply water quality SOBEK model and to recommend suitable method for the treatment of wastewater discharging from five drains to propose different scenarios and control the pollution along Rosetta branch.

Keywords: Water Quality Modelling, Discharge, River Nile, Drainage System

Introduction

The discharge volume of a river is a major factor in understanding the river system. Since the concentrations of most dissolved constituents in streams decrease during periods of high streamflow and increase during base flow (Anderson et al. 1997, House et al. 1998, Besser and Leib 1999), it is important to characterize seasonal concentration patterns of water quality variables over an entire annual cycle. An understanding of when constituent concentrations are highest, improves the ability of scientist to evaluate the potential changes to the health of aquatic ecosystems and/or usage of water for other purposes. Several years of sample collection often are needed to adequately characterize an annual water-quality cycle because wet, dry, and normal years may have dissimilar water-quality patterns (Leib et al. 2003).

Water Pollution is considered to be one of the most dangerous hazards affecting Egypt. Pollution in the Nile River System (main stem Nile, drains and canals) has increased in the past few decades because of increases in population; several new irrigated agriculture projects, industrial development and other activities along the Nile. Pollution sources that can be divided in:

i. Industrial wastewater pollution;
ii. Domestic wastewater pollution;
iii. Agricultural drainage water pollution; and
iv. Pollution originating from dumping of solid waste.

In the rural areas accommodating about half of the population have no access to sewer systems or wastewater treatment facilities. Accordingly, Delta drains mainly used for

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discharge of predominantly treated or poorly treated wastewater (domestic & industrial), and drainage of agricultural areas. Therefore, they contain high concentrations of various pollutants such as organic matter (BOD, COD), nutrients, fecal bacteria, heavy metals and pesticides.

The drainage water is becoming more saline; on average, its salinity increased from 2400 g/m^3 in 1985 to 2750 g/m^3 in 1995. But there are local variations. For example, in the southern part of the Nile Delta drainage water has salinity between 750 and 1000 g/m^3, whereas the salinity in the middle parts of the Delta reaches about 2000 g/m^3 and in the northern parts between 3500 and 6000 g/m^3.

According to the National Water Resources plan for Egypt, the Nile River from Aswan to Delta Barrage receives wastewater discharging from 124 point sources, of which 67 are agricultural drain and the remainder are industrial sources.

Physio-chemical characteristics and fecal coliform counts of 43 major drains at the tail ends, before discharge into the River Nile. The data indicates that out of the 43 drains, only 10 are complying with the standards set by Law 48/1982 (article 65) regulating the quality of drainage water which can be mixed with fresh water.

Legal Framework

The Egyptian Environmental Affairs Agency (EEAA) is the main organization responsible for environmental protection. The agency wrote the 1993 Environmental Action Plan that is now being updated. The two most important laws for water are Law No. 4 of 1994 that gives the EEAA enforcement authority for environmental pollution, with the exception of fresh water, and Law No. 48 of1982 Protection of the Nile River from Pollution. The latter is the main instrument for water quality management. Standards were also set in 1982 for point sources of surface water pollution, ambient concentrations of minerals and pollutants in surface water and drainage water reuse stations. Drinking water standards set by the Ministry of Health and Population were adjusted in 1998.

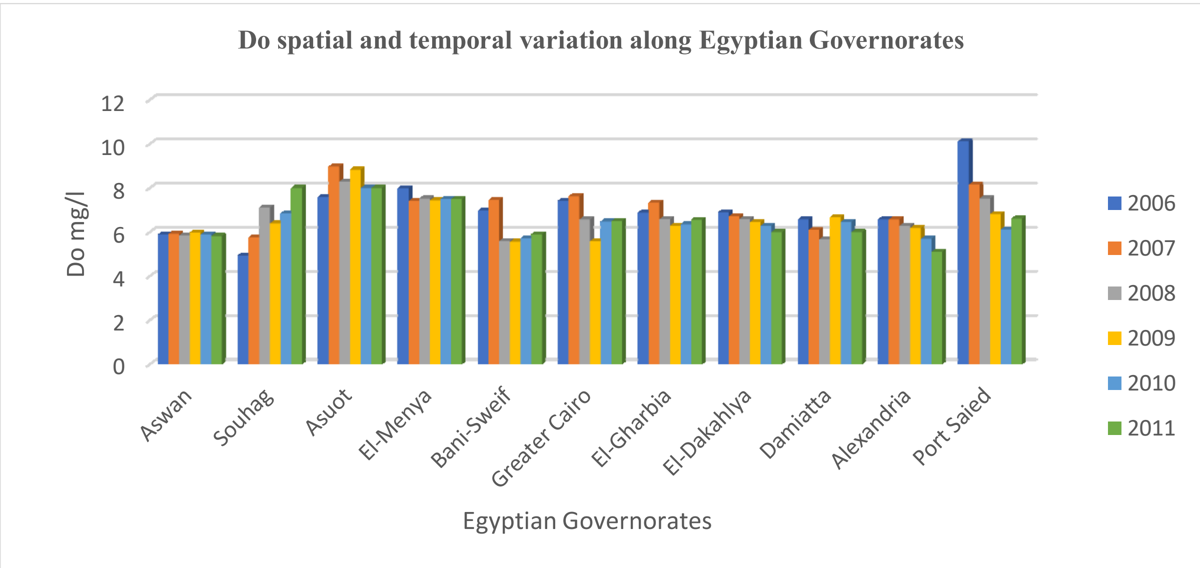

Figure 1. Comparison between the Average of DO Parameter for River Nile Water Samples Collected from Governorates (Years 2006 – 2011)

Source: National Network for Monitoring the Pollutants

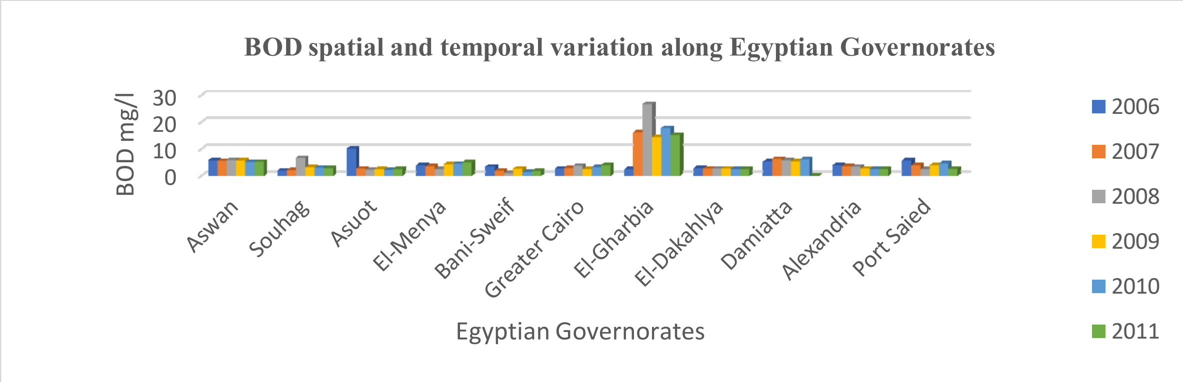

Figure 2. Comparison between the Average of BOD Parameter for River Nile Water Samples Collected from Governorates (Years 2006 – 2011)

Source: National Network for Monitoring the Pollutants

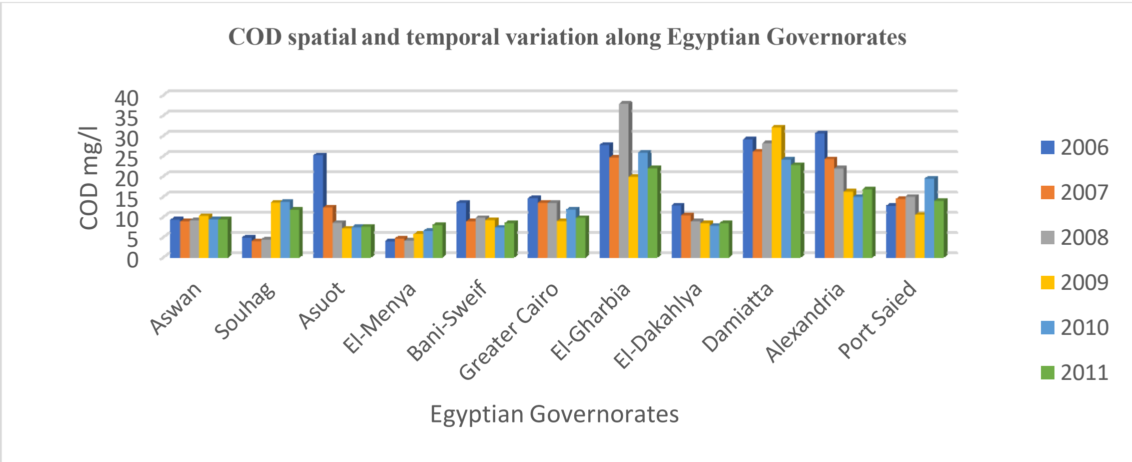

Figure 3. Comparison between the Average of COD Parameter for River Nile Water Samples Collected from Governorates (Years 2006 – 2011)

Source: National Network for Monitoring the Pollutants

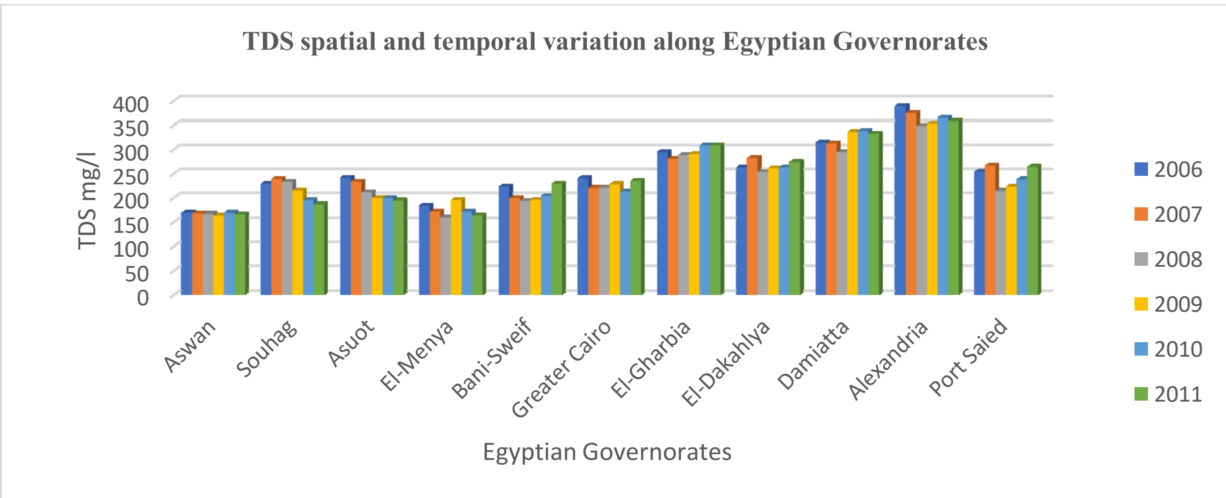

Figure 4. Comparison between the Average of TDS Parameter for River Nile Water Samples Collected from Governorates (Years 2006 – 2011)

Source: National Network for Monitoring the Pollutants

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MATERIALS AND METHODS

Aim of Study

This study was devoted to achieve the following objectives:

i. Measure phyico–chemical characteristics of the different pollution sources along Rosetta Branch.
ii. Assess the environmental impact of wastewater discharge on water quality of Rosetta branch taking into consideration seasonal variations.
iii. To apply water quality SOBEK model and to recommend suitable method for the treatment of wastewater discharging from five drains to propose different scenarios and control the pollution along Rosetta branch , Figure 5 represents the drain locations.

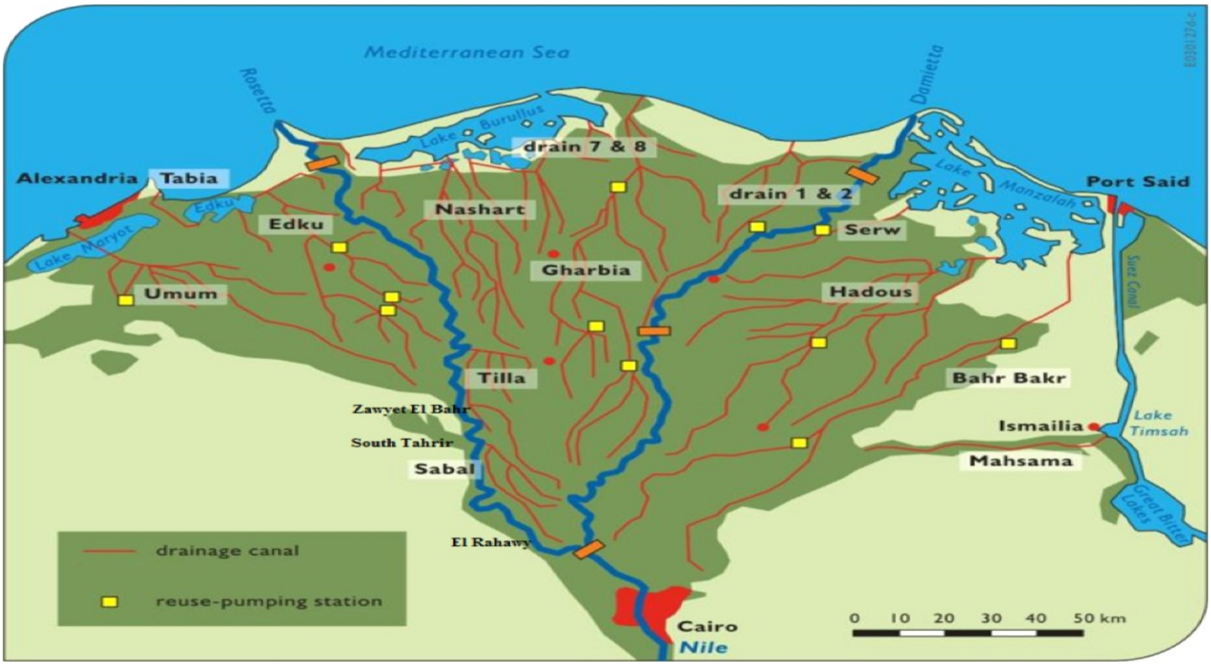

Figure 5. Egyptian Drainage locations

Mathematical Model SOBEK

A mathematical model was constructed to all Rosetta branch using field measurements using mathematical model (SOBEK -1D) which was developed in Delft Hydraulics in Netherlands. Concerning the model setup,

i. All cross sections along Rosetta branch from Km 0.00 to Km 207.00.
ii. All the drains such as (El Rahawy – sabal – south el tahrer – Tala- Zawyet El Bahr) along the Rosetta branch.

Model Calibration

Discharges and water levels measured from field have been used for the hydrodynamic calibration. The roughness coefficient (manning) along the branch were defined to ensure the water levels calculated from the model is similar to the measured water levels.

Figure (6) shows water levels along Rosetta branch at discharge 70 M.m3/day, Water quality preliminary calibration was conducted using the concentrations of all the measured water quality parameters along Rosetta branch and its drains.

The results showed that the concentrations of the parameters between every drain were similar to the results calculated from the model along Rosetta branch and Figures (7,8,9) shows comparison between measured concentration of some parameters and the calculated concentration from the model.

After calibration, the model can be used accurately to run many scenarios, to simulate future conditions. The calibrated model can be used to predict the response of the system to future events. The object of sensitivity analysis is to measure the effect on the outputs of a controlled perturbation in the inputs of the model. Sensitivity analysis also tests the capacity of the model to reproduce non-linearity of the physical system. It means that if we increase or decrease by a factor of two, for example, one input condition (internal or external) the model response is not increased or decreased by the same factor. Internal factor like space step, time of simulation External factor like input time series of discharge or rainfall, etc.

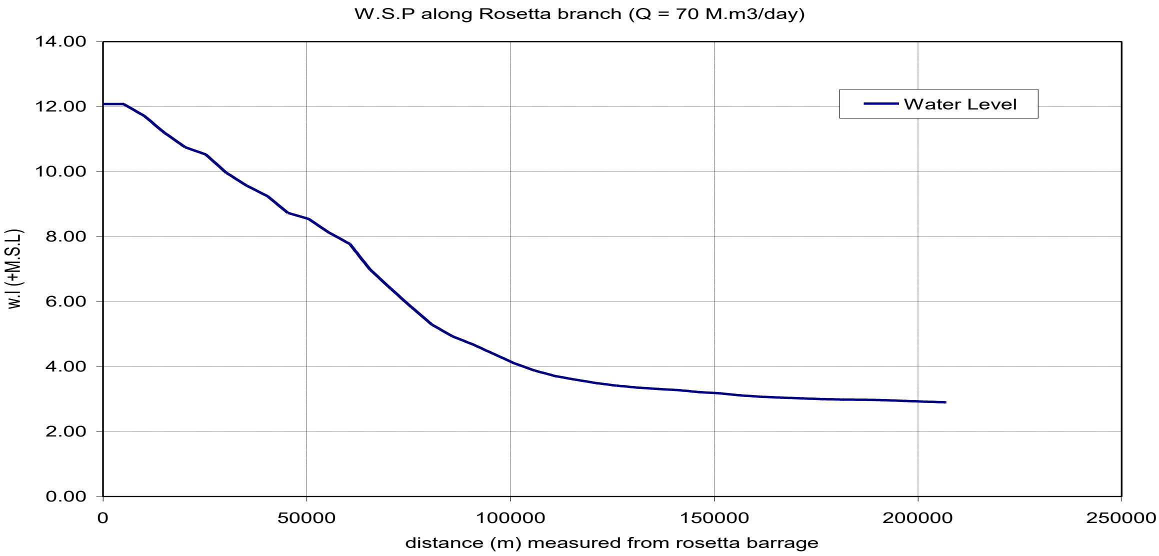

Figure 6. water levels along Rosetta branch at discharge 70 M.m3/day

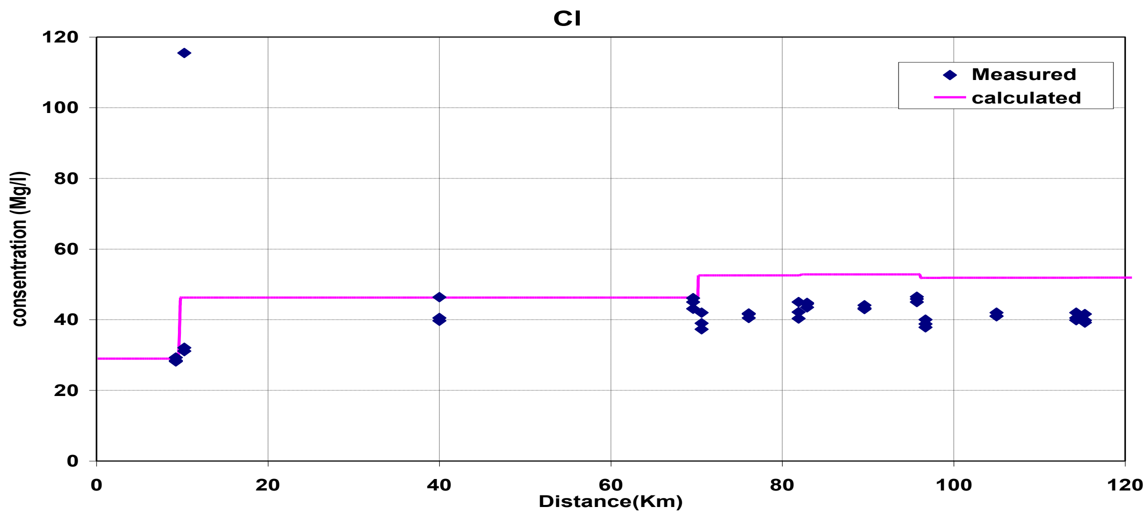

Figure 7. Comparison between concentration for Chloride (Cl) calculated from model and measured from field

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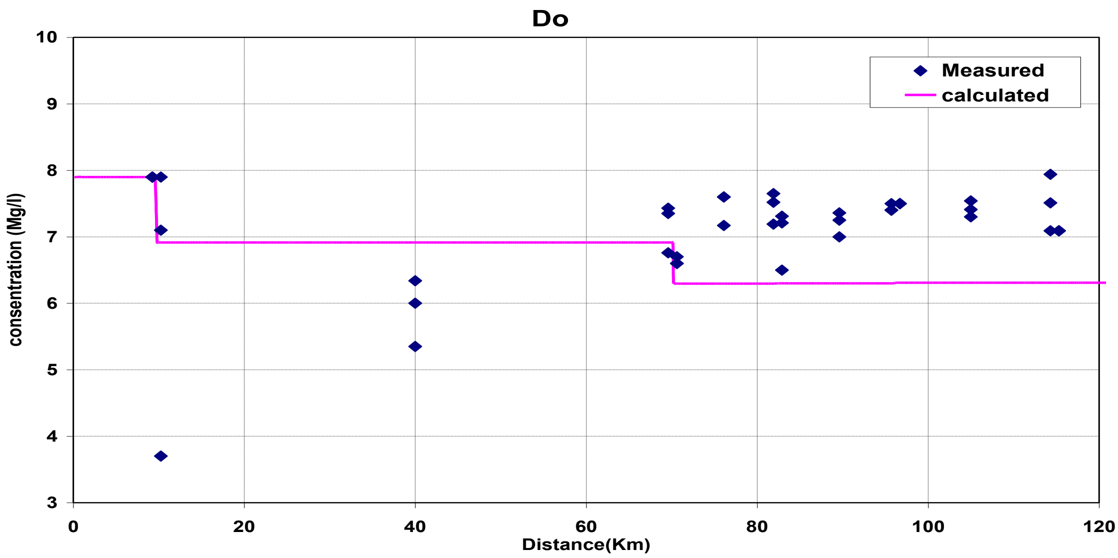

Figure 8. Comparison between concentration for Dissolved Oxygen (Do) calculated from model and measured from field

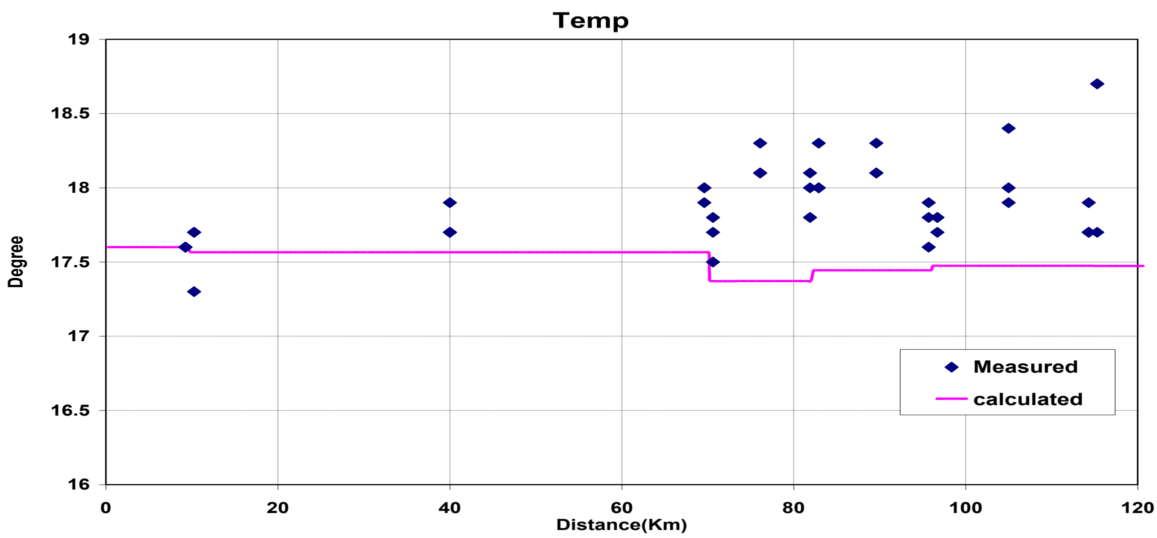

Figure 9. Comparison between concentration for Temperature calculated from model and measured from field

MODEL SCENARIOS AND RESULTS

SOBEK Model Scenarios

It was suggested three scenarios for model operation to represent the current condition:

1. **Scenario No. 1**, in this scenario we increase the discharges into Rosetta branch between (20 Mm^3/day to 50 Mm^3/day) **25% treatment**.
2. **Scenario No. 2**, in this scenario we increase the discharges into Rosetta branch between (20 Mm^3/day to 50 Mm^3/day) and curing the drains by different ratios between (25% - 50%) **50% treatment**.
3. **Scenario No. 3**, in this scenario we increase the discharges into Rosetta branch between (20 Mm^3/day to 50 Mm^3/day) and curing the drains by different ratios between (50% - 75%) **75% treatment**.

Mathematical Model SOBEK Results

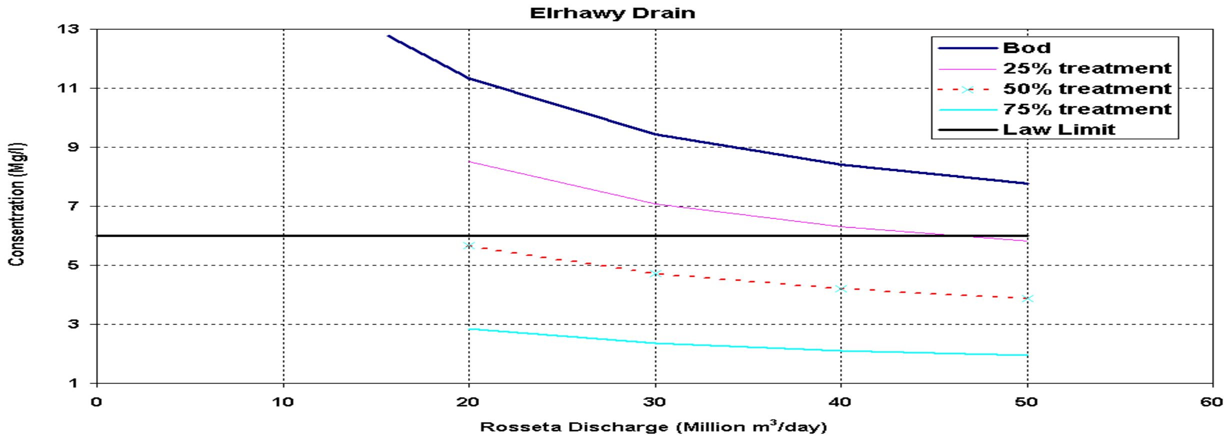

Figure 10. Estimated BOD mg/l improvement after treatment scenarios by SOBEK Model compared by Egyptian Law 48/1982 limits at El Rahawy Drain

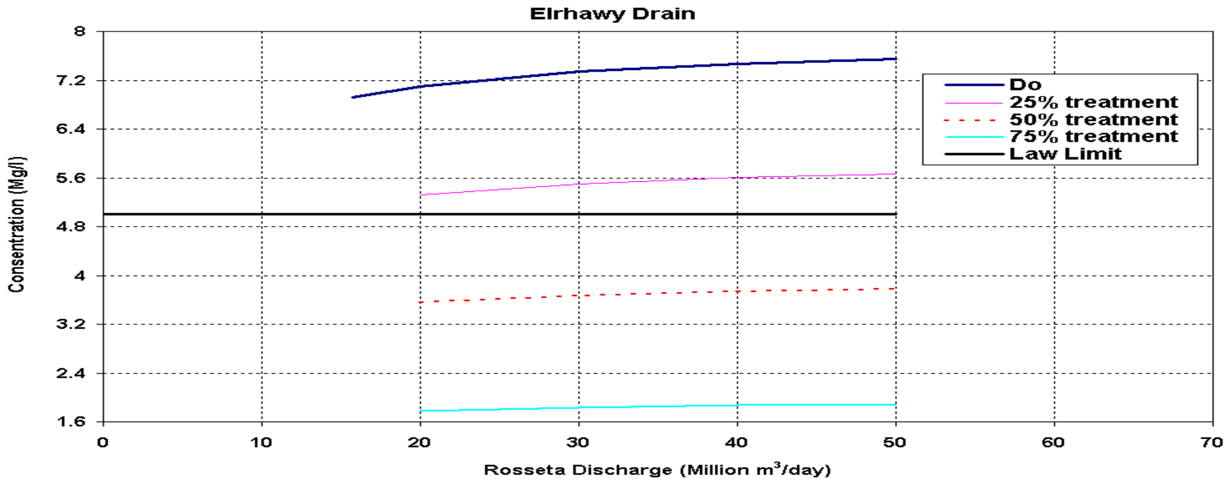

Figure 11. Estimated DO mg/l improvement after treatment scenarios by SOBEK Model compared by Egyptian Law 48/1982 limits at El Rahawy Drain

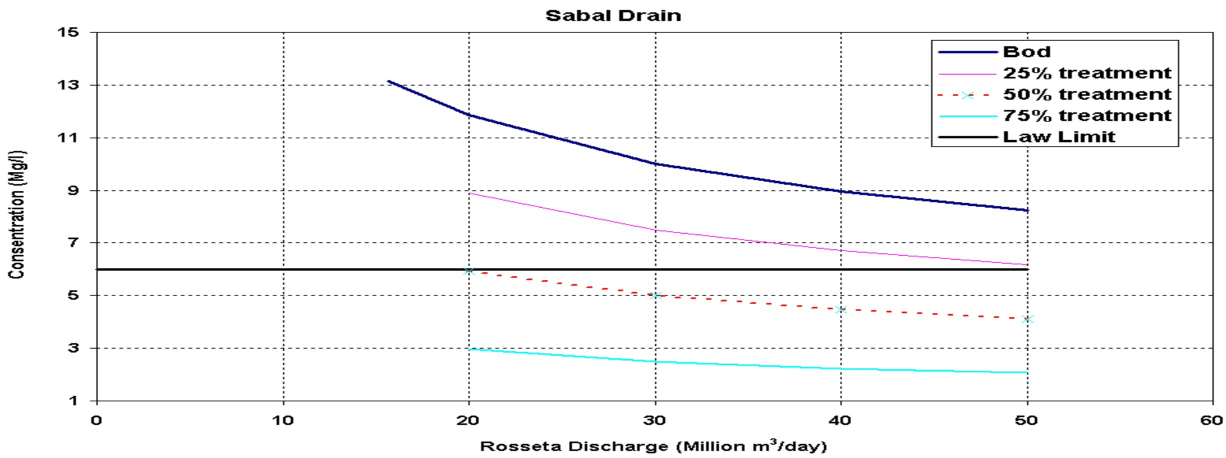

Figure 12. Estimated BOD mg/l improvement after treatment scenarios by SOBEK Model compared by Egyptian Law 48/1982 limits at Sabal Drain

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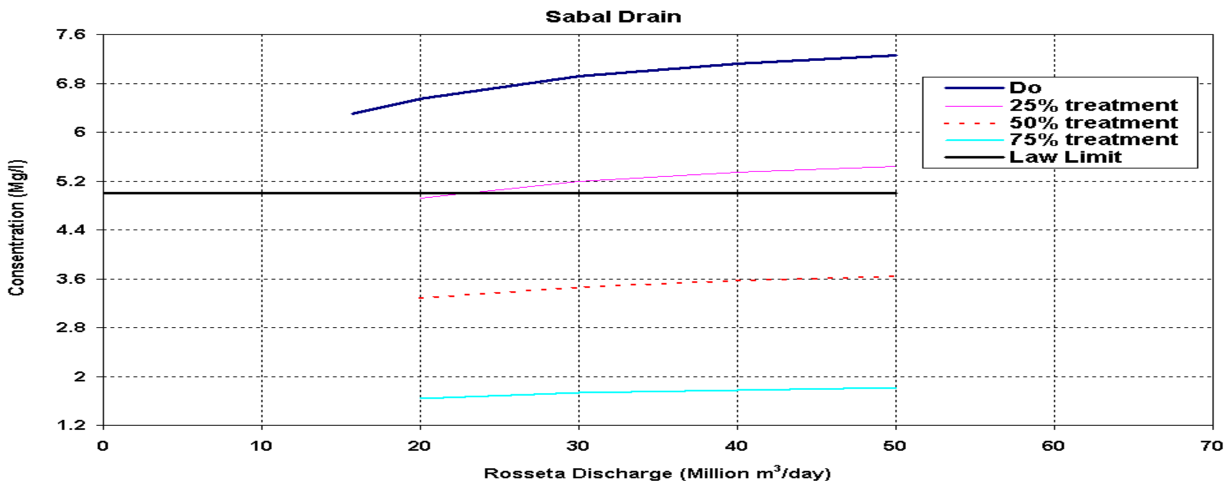

Figure 13. Estimated DO mg/l improvement after treatment scenarios by SOBEK Model compared by Egyptian Law 48/1982 limits at Sabal Drain

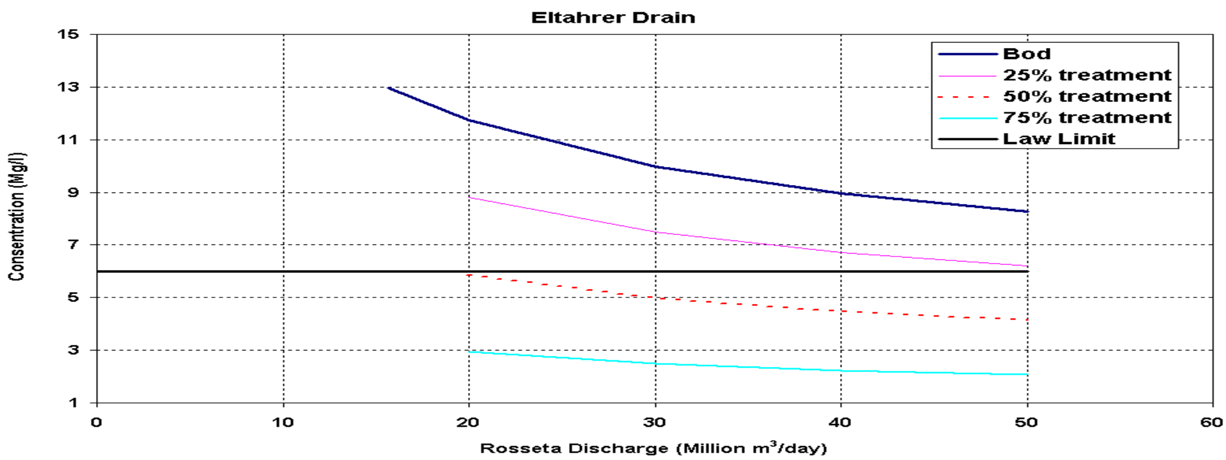

Figure 14. Estimated BOD mg/l improvement after treatment scenarios by SOBEK Model compared by Egyptian Law 48/1982 limits at El Tahrer Drain

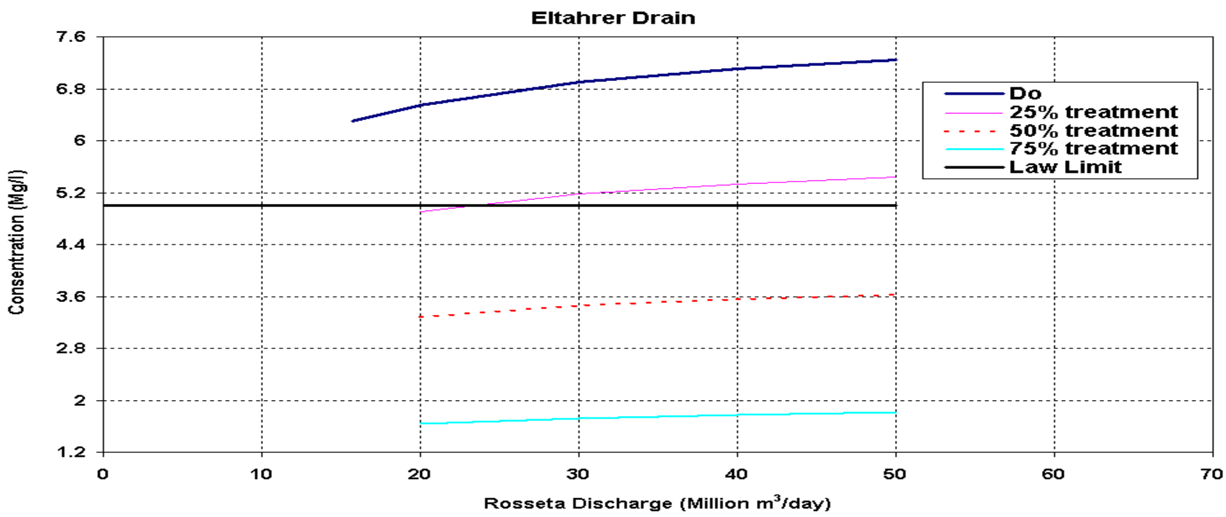

Figure 15. Estimated DO mg/l improvement after treatment scenarios by SOBEK Model compared by Egyptian Law 48/1982 limits at El Tahrer Drain

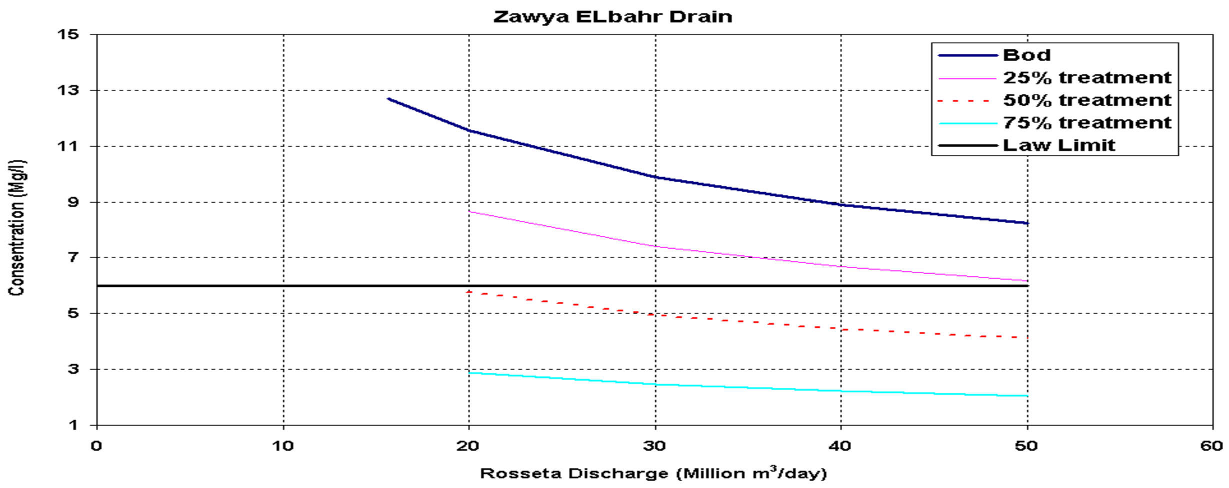

Figure 16. Estimated BOD mg/l improvement after treatment scenarios by SOBEK Model compared by Egyptian Law 48/1982 limits at Zawya El Bahr Drain

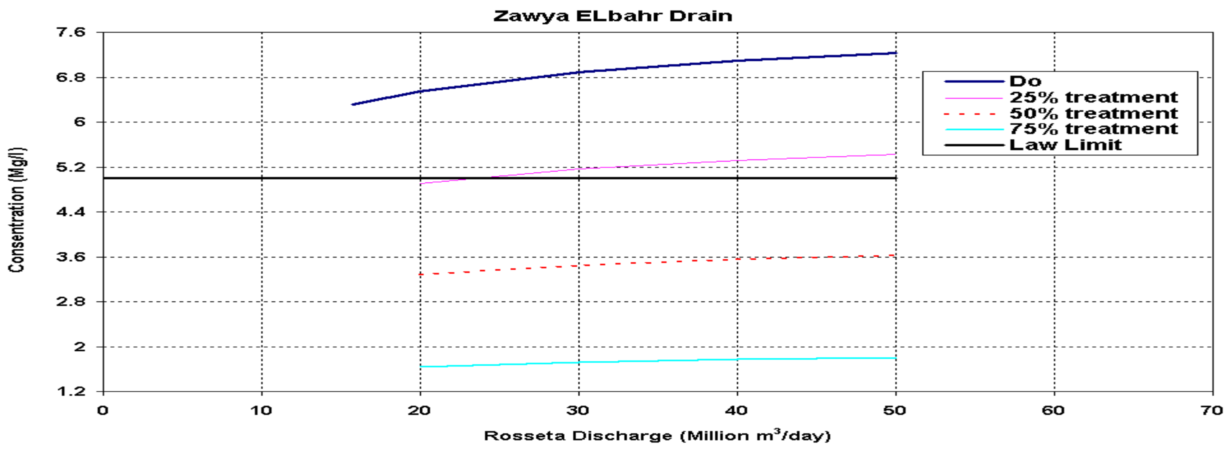

Figure 17. Estimated DO mg/l improvement after treatment scenarios by SOBEK Model compared by Egyptian Law 48/1982 limits at Zawya El Bahr Drain

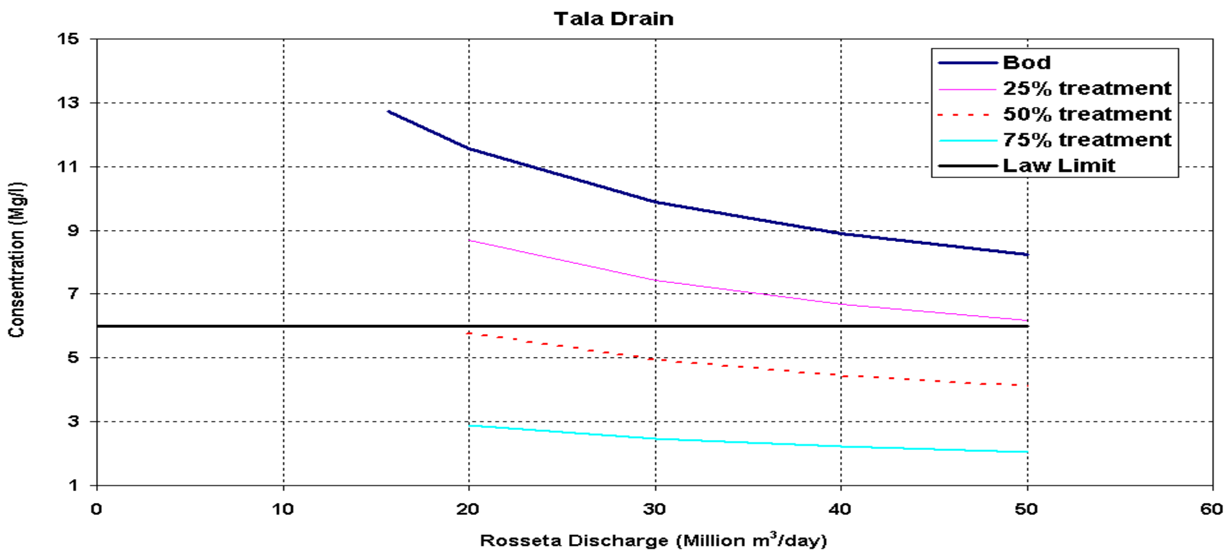

Figure 18. Estimated BOD mg/l improvement after treatment scenarios by SOBEK Model compared by Egyptian Law 48/1982 limits at Tala Drain

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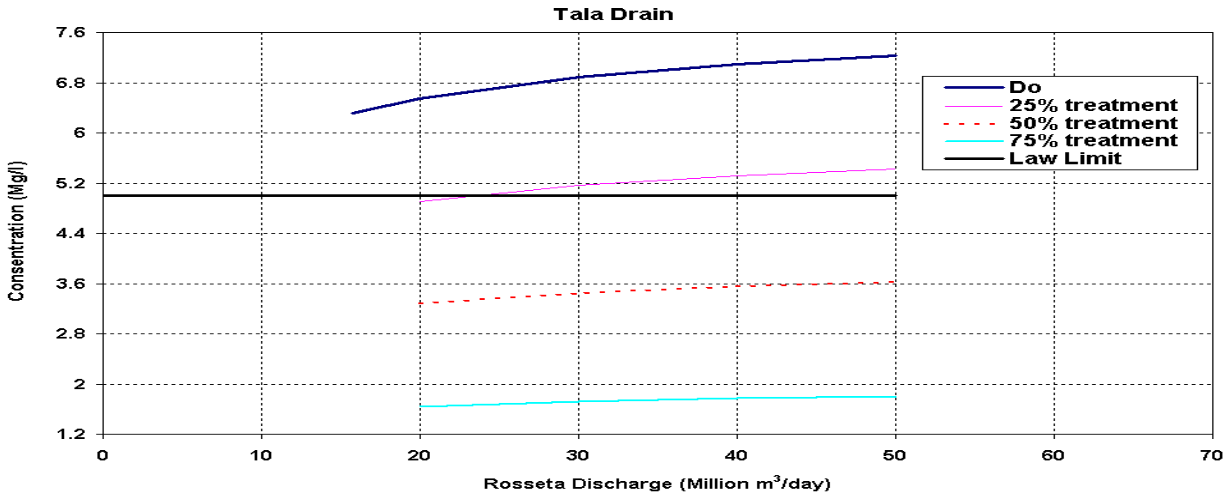

Figure 19. Estimated DO mg/l improvement after treatment scenarios by SOBEK Model compared by Egyptian Law 48/1982 limits at Tala Drain

CONCLUSION

1. In Scenario No. 1 we found that increasing the discharges affecting on the water quality parameters by different rations ranges between 10% to 50% and figures show the result of every parameter at each drain.
2. In Scenario No. 2 found that increasing the discharges and curing the water at the drains improve the water quality by different ratios ranges between 35% to 50% and figures show the result of every parameter at each drain.
3. In Scenario No. 3 found that increasing the discharges and curing the water at the drains improve the water quality by different ratios ranges between 50% to 85% and figures show the result of every parameter at each drain.
4. The treatment of Rosetta Branch is very important improving the quality of all its drain instead of treatment of each drain separately as the results from scenario No.1, also taking into account the cost of treatment.

RECOMMENDATIONS

We recommend using any of the above scenarios taking in consideration the cost of curing and water quality ratio to the local law.

1. To achieve safe use of drainage water in irrigation, many practices can be combined. The appropriate combination depends upon strategies of water, soil and plant. Soil management should be done. A selection of crops or crops tolerant varieties and special planting should be taken into consideration.
2. Using controlled soil drainage condition, water management and efficient use of N-Fertilizer are important for reuse drainage water in irrigation purposes.
3. Most of the available studies assumed that organic loads received by drains are from domestic and industrial sources while the effect of diffuse agricultural discharges from the irrigated fields has been neglected. It should also be noted that the use of animal manure, dredged sediments from drains and sludge as fertilizers is practiced in Egypt. Leaching of part of these bio-fertilizers, which contains high concentrations of pathogens, heavy metals, organic compounds and nutrients is a major source of

pollution. This is confirmed by the low water quality of the drains in spite of the high dilution factor.

4. Data about this source of pollution is scarce and should be studied.
5. Sewage contamination for drains water is proved by high incidence of bacterial indicator of pollution (fecal coliform) due to lack of sewerage system or insufficient wastewater treatment. To protect public health, the effluent of wastewater treatment plants should be properly disinfected before discharging to the drainage network and reuse for irrigation. The alternative is to use in restriction to certain crops which do not reach any part of a plant used for human or animal consumption.
6. Monitoring the canals has only recently been included in the monitoring programs.
7. Generally, treatment of pollution sources before draining into water ways is not only important but vital process. Finding simple and low-cost treatment as wetland techniques are the role of scientific research or technology transfer process.

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