Water Quality Evaluation of El Umoum Drain, West Nile Delta of Egypt, During the Period 1989-2010

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ABSTRACT

Planning for reuse of agricultural drainage water, for agricultural irrigation, was elaborated by the desire of the Egyptian government to use the water of the drain catchments rather than the use of isolated drain. El Umoum drain project (West Nile Delta region) is planned for mixing drainage water with fresh water. The objectives of this study, therefore, were to evaluate the quality of the water of the drains of El Umoum catchments area and to calculate the water quality index (WQI) for the drains in this area.

Samples of water were collected in the years: 1989, 2000 and 2010 at three flow conditions: low flow winter season (December), winter closure period (January) and high flow summer season (August).

The obtained results indicated high pollution of the main drains by inorganic and organic compounds. The concentration of total dissolved solid (TDS) had been increased in the drains with time proceeding and were higher in water collected in 2010 than in water collected in 1989 and 2000, and also increased with water flow from south to north direction. The lowest levels of TDS were recorded in water of Abu Hommos drain (average values of 1304 and 1408 mg/l in 1989 and 2000, respectively) and the highest levels were recorded in the water of El Umoum drain at Bab ElAbeed (average values of 4117 and 4200 mg/l in 1989 and 2000, respectively).

The highest concentrations of COD were recorded in the water of Abu Hommos drain (average values of 56 and 68 mg/l in 1989 and 2000, respectively) and lowest levels were recorded in the water of El Umoum drain at Bab ElAbeed (Average values of 30, 34 and 30 mg/l in 1989, 2000 and 2010, respectively).

The concentrations of BOD_5 were the highest in water of Abu Hommos drain (average values of 23 and 34 mg/l in 1989 and 2000, respectively) and the lowest values were in water of El Umoum drain at Bab ElAbeed (average values of 12, 15 and 13 in 1989, 2000 and 2010, respectively).

It is clear, therefore, that the concentrations of TDS, COD and BOD_5 were high and did not meet the requirements of the standard limits of the Egyptian law 48/1982. However, the concentrations of NO_3^-, total Cd, Cu, Pb and Zn in the water of all drains of El Umoum catchments were within the standard levels of the law 48/1982.

Key Words: TDS, COD, BOD_5, heavy metals, El Umoum catchments

INTRODUCTION

Water scarcity is a growing global serious problem and it is challenging the agricultural sustainable development in the arid region. In Egypt, the increasing population and the limited fresh water resources, in addition to pollution of surface and ground water resources, are considered the main reasons of water scarcity especially in the long term. Actually, the country receives about 98% of its freshwater from outside its national borders and this represents a fixed annual share from the Nile River (55.5 bilion cubic meter) according to the 1959 agreement with Sudan (Abu Zeid, 1991). Practically, about 84% of the Nile water flow (49.7 BCM) is used for agriculture (Abu Zeid, 1991).

Since the fresh water demand in Egypt will continue to increase because of agricultural expansion, increasing population growth and rapid industrial development, the fixed annual amount of fresh water from the Nile River will always impose great challenges. As a result, the Egyptian national water policy is directed towards solving this problem by increasing water use efficiency in agriculture, recycling more groundwater within the safe limits, prevention to some extent cultivation of highly water consuming crops, and the use of unconventional water resources such as agricultural drainage water. Planning for reuse of drainage water projects was elaborated by the desire to use the water of drain catchments rather than of isolate drain in order to use as much drainage water as possible (El Quosy, 1989). Accordingly, there are three main projects namely; Al Salam canal, El Umoum drain and Batita pumping. It has been reported that more than 4.141 BCM/ year of drainage water are already reused after mixing with fresh water (DRI, 2000).

Reuse of drainage water for irrigation involves some risks which may limit its availability because this water is characterized generally by the low quality. It contains high concentrations of total dissolved solids (TDS),

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several types of toxic materials and compounds released from fertilizers and pesticides, pathogens and high concentrations of organic and chemical compounds (Abu Zeid, 1991). Thus, pollution of drainage water can be caused from point and non-point (diffuse) sources of pollutants. Of a great concern in Egypt is the increasing population which will cause ever increasing wastes that can be disposal into the waterways and lead to high concentrations of several pollutants. Generally, it has been proved that there is positive relation between population growth, volume of domestic effluent released into the waterway and magnitude of water pollution (Bouwer, 2002; and Meybeck, 2005).

Abdel-Gawad (1994) ranked pollutants in the drainage water according to their severity as pathogens, pesticides, heavy metals, nutrients and salinity. Due to both increasing size of the cultivated lands and drainage network, wide variations of pollutants and increasing population; the pollution of drainage water would be seriously increased.

Drainage water seeping from agriculture fields are considered non-point sources of pollution. These non-point sources are collected and concentrated in agriculture drains and became point sources of pollution of the fresh water irrigation canals in case of mixing water for reuse. Major pollutants in agriculture drains, therefore, are salts, nutrients (N and P), pesticide residues, pathogens which are discharged from domestic wastewater, and to some extent from industrial sources. (APRP, 2002).

Drains, in El Umoum catchment, are mainly used for discharge of predominantly untreated wastewater (domestic and industrial) and also for drainage of agricultural lands. Therefore, they contain high concentrations of various pollutants such as organic materials (COD, BOD), nutrients (N) and heavy metals. (APRP, 2002).

One of the simplest tools for evaluation the quality of water is calculated an index, for a group of parameters, known as water quality index (WQI). It is defined as a rate reflecting the composite effects of a number of parameters on the overall water quality. Also, it reduces the great amounts of data on a range of parameters to a single number in a simple reproducible manner (Ott, 1978 and Tiwari and Ali, 1987).

The objectives of this study, therefore, were to evaluate the quality of the water of El Umoum catchment throughout the period 1989-2010 and to calculate the water quality index of the drains of El Umoum catchments area.

MATERIALS AND METHODS

Site Description

El Umoum drain is located in the west of Nile Delta and is considered one of the largest drains in this region. Geographically, the drain catchment area is located on latitude 35° N and longitude of 33° E (Figs. 1and 2). The atmospheric temperatures at the area vary from a minimum of 10° C at winter season to a maximum of 30° C at summer season. The water temperature varies from 10 to 20° C in winter and from 28 to 30° C in summer. The drain catchment area covers approximately 1776 Km^2 (422.860 Feddan) with a travel distance of about 41 km. The drain conveys annual flow of about 2.50 billion m^3/year and is surged into the Mediterranean Sea through El Max pump station. The sources of water in the drain are the discharges of drainage water of Abu Hommos, Shrishra, Truga, El Deshoudy and El Haris drains. Some others drains, including Abis and El Qalaa drains are not included in the present investigation.

During the winter closure period (from January to February), the fresh water in the canals is subjected to strong un-steady-state flow conditions. However, a relatively high and stable flow pattern occurred during the period June-October. Also, during the winter closure period, the drains stop receiving excess water from irrigation which leads to accumulation of pollutants in the drain.

Water Sampling and Analysis

Samples of water were collected at three flow conditions: at December (low flow winter season), January (winter closure period) and August (high flow summer season).

Water sampling was carried in the years: 1989, 2000 and 2010, from the specific site. Three water samples (2 liter volume) were collected from the upper 0-30 cm water layer, placed in a pre-washed polyethylene bottle and transported to the laboratory and preserved in the refrigerator for analysis (APHA, 1992).

In situ, the TDS and the pH of the water were measured, directly in the water of the drain, using portable TDS/pH meter. The concentrations of COD and BOD_5 were determined according to the standard methods outlined in APHA (1992). The concentrations of NO_3^- were measured volumetrically by $AgNO_3$ titration (APHA, 1992). The concentrations of total Cd, Cu, Pb and Zn were measured in the filtrate of the water by atomic absorption spectrophotometer (APHA, 1992).

Water quality index (WQI)

According to the Canadian Council of Ministers of the Environment (CCME, 2001), Water Quality Index

(CCME WQI) provides 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; Amplitude). These three measures of variance combine to produce a value between 0 and 100 that represents the overall water quality (CCME, 2001).

The detailed formulation of the WQI Canadian Water Quality Index consists of three measures which are described as follows:

Scope, F1: it represents the extent of water quality guideline non-compliance over the time period of interest which was calculated as equation (1).

$$F1 = \left(\frac{\text{Number of failed variables}}{\text{Total number of Variables}} \right) X\ 100 \qquad (1)$$

Frequency, F2: it represents the percentage of individual tests that do not meet objectives ("failed tests") was calculated as equation (2).

$$F2 = \left(\frac{\text{Number of failed tests}}{\text{Total number of tests}} \right) X\ 100 \qquad (2)$$

Amplitude, F3: it represents the amount by which failed tests do not meet their objectives. This is calculated in three steps:

Step 1- Calculation of Excursion: Excursion is the number of times by which an individual concentration is greater than (or less than, when the objective is a minimum) the objective. When the test value did not exceed the objective was calculated as equation (3).

$$\text{excursion}_i = \left(\frac{\text{Failed test Value}_i}{\text{Objective}_J} \right) -1 \qquad (3)$$

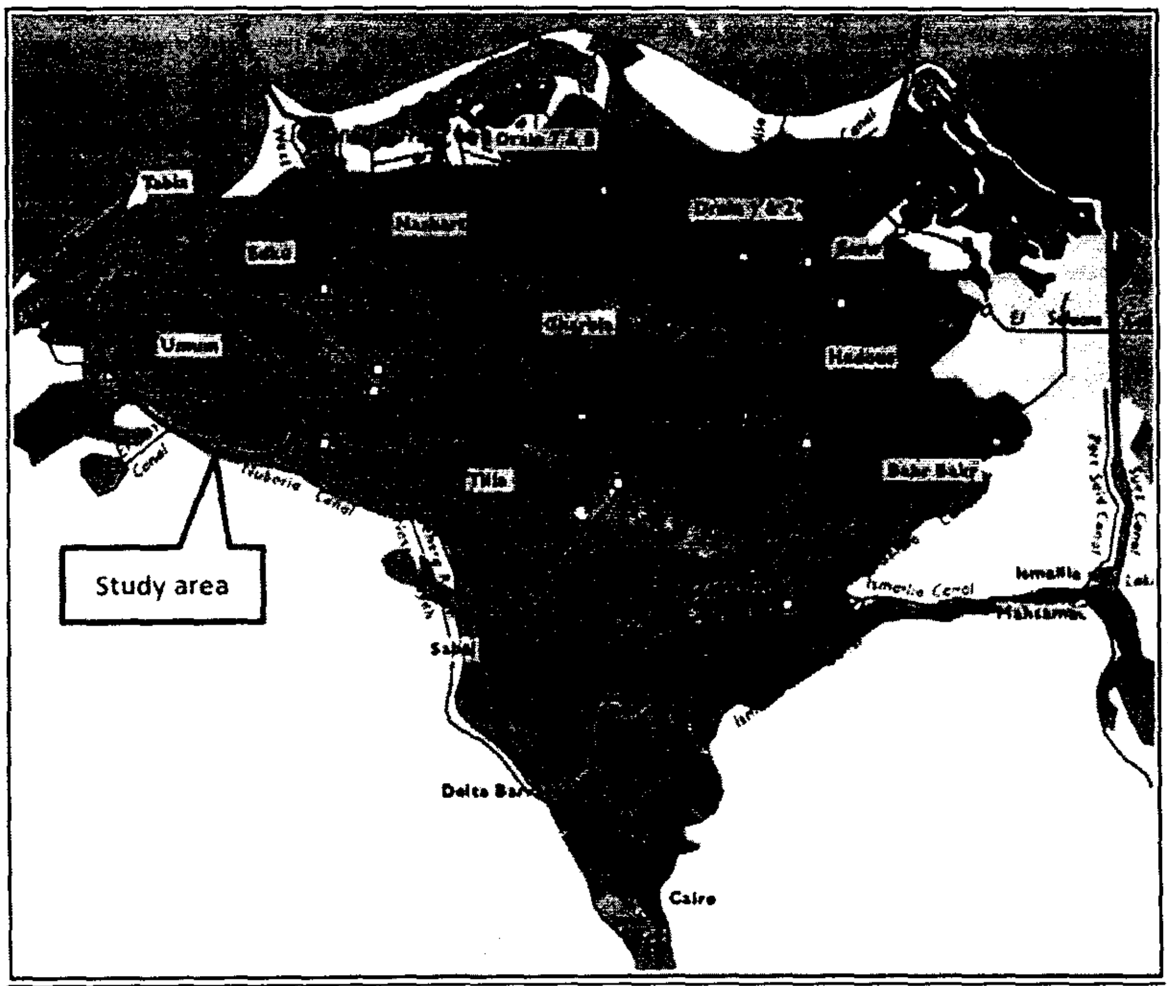

Fig.1. Geographical location of El Umoum catchment area

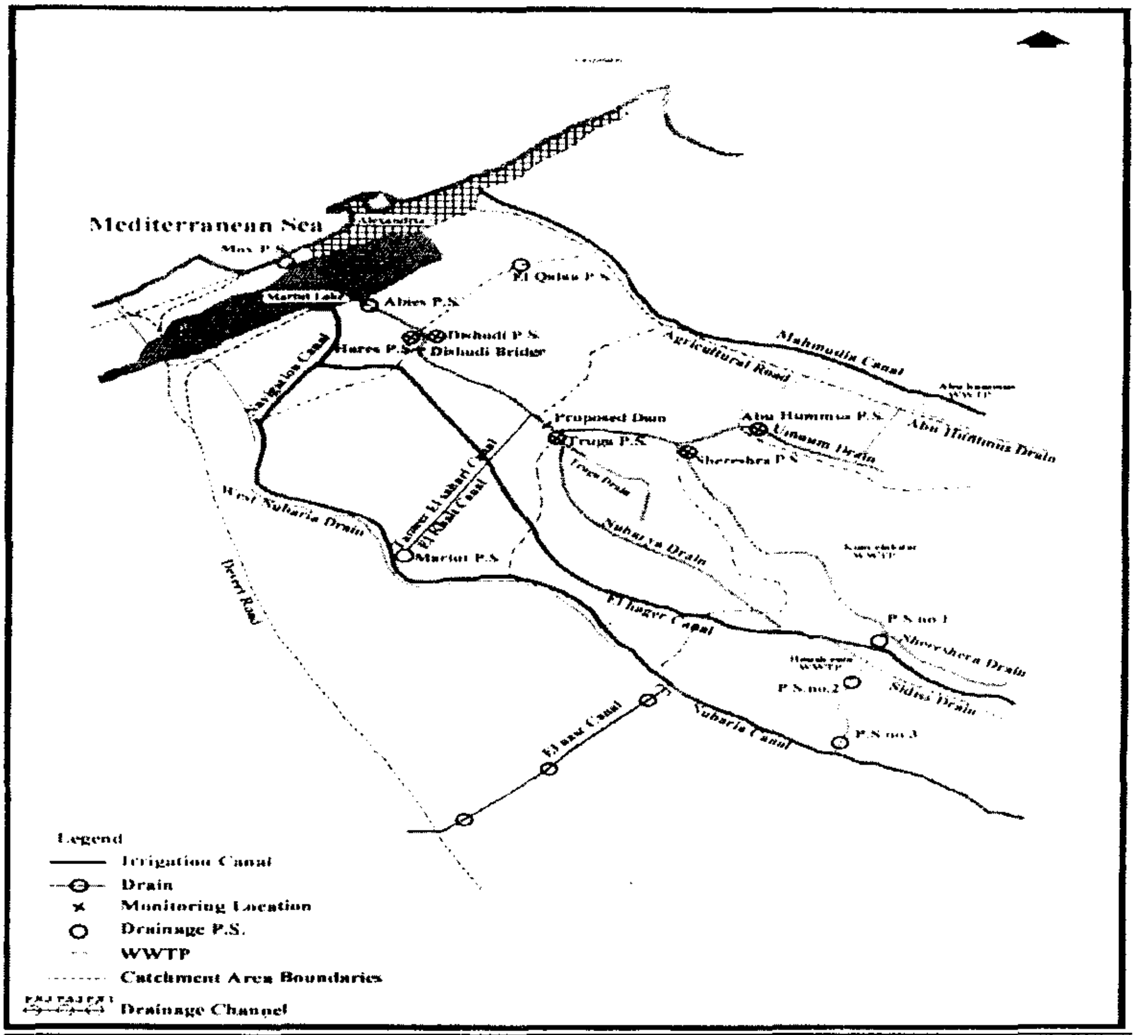

Fig.2. Schematic layout of the El Umoum drainage water reuse and the main drain of El Umoum catchment area

When the test value must not fall below the objective, it was calculated as equation (4).

$$\text{excursion} = \left[\frac{\text{Objective}_j}{\text{Failed test Value}_j}\right] - 1 \qquad (4)$$

Step 2- Calculation of Normalized Sum of Excursions: The normalized sum of excursions, *nse*, is the collective amounts by which individual tests are out of compliance. This is calculated by summing the excursions of individual tests from their objectives and dividing by the total number of tests (both those meeting objectives and those not meeting objectives), it was calculated as equation (5).

$$nse = \left(\frac{\sum_{i=1}^{n} excursion_i}{\text{Number Of test}}\right) \qquad (5)$$

Step 3-Calculation of F3: F3 is calculated by an asymptotic function that scales the normalized sum of the excursions from objectives to yield a range from 0 to 100 it was calculated as equation (6).

$$F3 = \left(\frac{nse}{0.01 nse + 0.01}\right) \qquad (6)$$

The WQI is then calculated as equation (7):

$$WQI = 100 - \left(\frac{\sqrt{F_1^2 + F_2^2 + F_3^2}}{1.732}\right) \qquad (7)$$

The factor of 1.732 arises because each of the three individual index factors can range as high as 100. This means that the vector length can reach $\sqrt{100^2 - 100^2 + 100^2} = \sqrt{30000} = 173.2$ as a maximum. Division by 1.732 brings the vector length down to 100.

The index produces a number between 0 (worst water quality) and 100 (best water quality). These numbers are divided into 5 descriptive categories to simplify 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 specific variables, objectives, and period used in the index are not specified and indeed could vary from a region to another depending on local conditions and issues. It is recommended that at a minimum of four variables sampled at least four times would be used in the calculation of index values. It is also expected that the variables and objectives chosen will provide relevant information about a particular site. The index can be used both for tracking changes at one site over time, and for comparisons among sites. If it used for the later purpose, care should be taken to ensure that there is a valid basis for comparison. Sites can be compared directly only if the same variables and objectives are used; otherwise, a comparison of the sites' ability to meet relevant objectives must be made in terms of the category obtained. The index is based on water quality guidelines so it is able to evaluate water quality based on the intended use of the water and is not restricted by the number of variables. This allows all relevant variables for each designated water use to be included in the computation (Khan et al., 2005). At the present study the irrigation water quality scores were computed by CCME WQI (2001) based on the law 48/1982 concerning the water quality guidelines for irrigation.

RERSULTS AND DISCUSSION

In the current investigation, interests have been devoted for evaluating the quality of the water of the drains of El Umoum catchment. These water qualities included the pH, TDS, COD, BOD_5, NO_3, Cd, Cu, Pb and Zn. These parameters have been achieved because most of these drains are receiving different sources of effluents including agricultural drainage water, domestic effluents from the surrounding rural communities and effluents of industrial sources such as fabrication and machines restorations.

The pH:

Tables 1-16 showed that the pH values of the water of the drains are within the standard limits of the law 48/1982 (7-8.5). The lowest pH value (pH=7.00) was recorded in the water of Abu Hommos drain for water collected in January 1989 and the water of downstream Abu Hommos pump station (7.02) for water collected in January 2000, and the highest pH value (7.95) was recorded for the water downstream El Haris P.S. collected in December 1989.

Total dissolved Solids (TDS):

Figs 3-8 showed that the levels of TDS in the water of drains have been exceeded the standard level of law 48/1982 (500 mg/l). The highest concentration of TDS was recorded for the water of El Umoum at Bab ElAbeed and the lowest concentrations of TDS were recorded in the water of Abu Hommos drain. It is also clear that the concentrations of TDS were lower in water of Abu Hommos drain than Shrishra and Truga drains and that the water of El Deshoudy drain contained high levels of TDS than these formerly three drains. Thus, it can be stated that the salinity of the drains increases through water flow from south to north direction. Figs 3-8 also showed that the concentrations of TDS in the water of drains have increase with proceeding time and were lower for water samples collected in 1989 than for water samples collected in 2000. In comparison with data belongings to the year 2010, high concentrations of TDS were recorded for water collected from downstream Shrishra P.S., downstream El Deshoudy P.S. and downstream El Haris P.S.

Comparing the data presented for TDS indicated that the salinity of water in the drains of El Umoum catchment area have been varied markedly according to both the drain location and the time of sampling (Figs 3-8).

Chemical Oxygen Demand (COD)

Figs 9-14 showed higher levels of COD in the water of the drains of El Umoum catchment area greater than the standard level of law 48/1982 (15mg/l) except those in water samples of Shrishra drain collected in 2010. It is also clear that the highest levels of COD were recorded in water of Abu Hommos drain especially those collected in both January 1989 and 2000; and December 1989 and 2000. However, lower values were recorded in water samples collected in August 1989 and 2000. It is also clear that the levels of COD were

Table1. Chemical Characters of the water of Abu Hommos drain

Months/year	pH	NO_3	Cd	Cu	Pb	Zn
		mg/l				
Jan. 1989	7.00	1.83	0.001	0.058	0.005	0.046
Aug. 1989	7.37	2.68	0.001	0.046	0.018	0.058
Dec. 1989	7.45	1.85	0.001	0.054	0.010	0.036
Jan. 2000	7.37	2.88	0.001	0.055	0.006	0.058
Aug. 2000	7.30	1.41	0.001	0.066	0.015	0.064
Dec. 2000	7.38	1.30	0.001	0.061	0.005	0.482

Table 2. Chemical Characters of the water of upstream Abu Hommos P.S.

Months/year	pH	NO_3	Cd	Cu	Pb	Zn
		mg/l				
Jan. 1989	7.35	2.62	0.001	0.065	0.003	0.055
Aug. 1989	7.60	2.94	0.001	0.048	0.004	0.048
Dec. 1989	7.40	2.95	0.001	0.048	0.005	0.255
Jan. 2000	7.35	2.22	0.001	0.048	0.004	0.066
Aug. 2000	7.45	1.84	0.002	0.058	0.003	0.134
Dec. 2000	7.37	2.00	0.002	0.065	0.002	0.388

Table 3. Chemical Characters of the water of downstream Abu Hommos P.S.

Months/year	pH	NO_3	Cd	Cu	Pb	Zn
		mg/l				
Jan. 1989	7.55	2.85	0.001	0.018	0.001	0.042
Aug. 1989	7.70	3.96	0.001	0.048	0.003	0.045
Dec. 1989	7.65	2.80	0.001	0.040	0.002	0.048
Jan. 2000	7.02	2.85	0.001	0.010	0.001	0.055
Aug. 2000	7.50	4.85	0.001	0.008	0.001	0.048
Dec. 2000	7.80	3.40	0.001	0.006	0.001	0.085
Jan. 2010	7.80	3.00	0.000	0.008	0.000	0.033
Aug. 2010	7.32	3.00	0.000	0.008	0.000	0.033
Dec. 2010	7.72	3.00	0.000	0.008	0.000	0.033

Table 4. Chemical Characters of the water of Shrishra drain

Months/year	pH	NO_3	Cd	Cu	Pb	Zn
		mg/l				
Jan. 1989	7.85	3.45	0.001	0.055	0.002	0.085
Aug. 1989	7.55	4.85	0.001	0.053	0.002	0.098
Dec. 1989	7.62	3.25	0.001	0.055	0.002	0.088
Jan. 2000	7.55	3.85	0.004	0.060	0.008	0.048
Aug. 2000	7.65	2.85	0.001	0.050	0.004	0.035
Dec. 2000	7.75	2.94	0.001	0.056	0.004	0.155

Table 5. Chemical Characters of the water of upstream Shrishra P.S.

Months/year	pH	NO_3	Cd	Cu	Pb	Zn
		mg/l				
Jan. 1989	7.62	3.00	0.001	0.069	0.002	0.085
Aug. 1989	7.90	3.85	0.001	0.056	0.001	0.056
Dec. 1989	7.77	3.70	0.001	0.057	0.003	0.176
Jan. 2000	7.95	2.16	0.000	0.058	0.005	0.076
Aug. 2000	7.75	2.98	0.006	0.058	0.004	0.056
Dec. 2000	7.75	2.19	0.001	0.075	0.005	0.185

Table 6. Chemical Characters of the water of downstream Shrishra P.S.

Months/year	pH	NO_3	Cd	Cu	Pb	Zn
		mg/l				
Jan. 1989	7.75	3.40	0.001	0.038	0.001	0.054
Aug. 1989	7.70	4.48	0.001	0.036	0.001	0.035
Dec. 1989	7.64	3.80	0.001	0.038	0.001	0.048
Jan. 2000	7.74	3.90	0.001	0.040	0.001	0.046
Aug. 2000	7.48	3.50	0.001	0.035	0.001	0.043
Dec. 2000	7.80	3.84	0.001	0.039	0.001	0.047
Jan. 2010	7.86	4.17	0.000	0.035	0.000	0.034
Aug. 2010	7.26	4.17	0.000	0.035	0.000	0.034
Dec. 2010	7.79	4.17	0.000	0.035	0.000	0.034

Table 7. Chemical Characters of the water of Trouga drain

Months/year	pH	NO_3	Cd	Cu	Pb	Zn
		mg/l				
Jan. 1989	7.75	3.00	0.001	0.019	0.001	0.048
Aug. 1989	7.10	4.80	0.001	0.036	0.001	0.044
Dec. 1989	7.78	3.10	0.001	0.038	0.001	0.058
Jan. 2000	7.50	2.60	0.001	0.026	0.004	0.030
Aug. 2000	7.46	3.30	0.002	0.024	0.003	0.044
Dec. 2000	7.50	2.50	0.001	0.027	0.004	0.043

Table 8. Chemical Characters of the water of upstream Trouga P.S.

Months/year	pH	NO_3	Cd	Cu	Pb	Zn
		mg/l				
Jan. 1989	7.65	3.90	0.001	0.028	0.001	0.035
Aug. 1989	7.68	3.66	0.001	0.035	0.001	0.028
Dec. 1989	7.73	3.90	0.001	0.042	0.001	0.038
Jan. 2000	7.50	2.90	0.001	0.035	0.001	0.038
Aug. 2000	7.65	3.90	0.001	0.045	0.001	0.036
Dec. 2000	7.50	3.85	0.001	0.049	0.001	0.042

Table 9. Chemical Characters of the water of downstream Trouga P.S.

Months/year	pH	NO_3	Cd	Cu	Pb	Zn
		mg/l				
Jan. 1989	7.72	3.80	0.001	0.015	0.001	0.050
Aug. 1989	7.78	3.86	0.001	0.046	0.002	0.042
Dec. 1989	7.75	3.15	0.001	0.042	0.005	0.040
Jan. 2000	7.55	3.80	0.001	0.025	0.001	0.046
Aug. 2000	7.60	4.88	0.001	0.017	0.001	0.044
Dec. 2000	7.55	4.70	0.001	0.019	0.001	0.040
Jan. 2010	7.85	5.00	0.000	0.017	0.000	0.026
Aug. 2010	7.16	5.00	0.000	0.017	0.000	0.026
Dec. 2010	7.91	5.00	0.000	0.017	0.000	0.026

Table 10. Chemical Characters of the water of El Deshoudy drain

Months/year	pH	NO_3	Cd	Cu	Pb	Zn
		mg/l				
Jan. 1989	7.70	3.85	0.003	0.001	0.001	0.014
Aug. 1989	7.70	4.65	0.004	0.007	0.006	0.018
Dec. 1989	7.60	3.95	0.004	0.001	0.004	0.025
Jan. 2000	7.60	3.80	0.002	0.006	0.001	0.018
Aug. 2000	7.50	5.60	0.003	0.004	0.001	0.028
Dec. 2000	7.50	4.55	0.003	0.004	0.001	0.035

Table 11. Chemical Characters of the water of upstream El Deshoudy P.S.

Months/year	pH	NO_3	Cd	Cu	Pb	Zn
		mg/l				
Jan. 1989	7.75	3.60	0.001	0.001	0.001	0.010
Aug. 1989	7.55	3.90	0.002	0.003	0.002	0.018
Dec. 1989	7.57	3.85	0.004	0.002	0.001	0.016
Jan. 2000	7.80	3.90	0.001	0.004	0.001	0.011
Aug. 2000	7.55	3.95	0.002	0.005	0.001	0.019
Dec. 2000	7.35	3.86	0.003	0.015	0.001	0.035

Table 12. Chemical Characters of the water of downstream El Deshoudy P.S.

Months/year	pH	NO_3	Cd	Cu	Pb	Zn
		mg/l				
Jan. 1989	7.62	3.90	0.001	0.005	0.003	0.008
Aug. 1989	7.60	3.65	0.001	0.009	0.001	0.008
Dec. 1989	7.60	4.85	0.001	0.018	0.001	0.044
Jan. 2000	7.50	4.25	0.001	0.001	0.001	0.009
Aug. 2000	7.70	4.82	0.001	0.018	0.001	0.008
Dec. 2000	7.72	5.10	0.001	0.016	0.001	0.005
Jan. 2010	7.88	8.00	0.006	0.000	0.000	0.000
Aug. 2010	7.88	8.00	0.006	0.000	0.000	0.000
Dec. 2010	7.60	8.00	0.006	0.000	0.000	0.000

Table 13. Chemical Characters of the water of El Haris drain

Months/year	pH	NO_3	Cd	Cu	Pb	Zn
		mg/l				
Jan. 1989	7.82	3.85	0.000	0.018	0.000	0.010
Aug. 1989	7.84	3.54	0.000	0.026	0.000	0.015
Dec. 1989	7.86	3.79	0.000	0.012	0.000	0.014
Jan. 2000	7.78	3.84	0.000	0.010	0.000	0.019
Aug. 2000	7.88	3.68	0.000	0.012	0.000	0.007
Dec. 2000	7.85	4.75	0.000	0.020	0.000	0.014

Table 14. Chemical Characters of the water of upstream El Haris P.S.

Months/year	pH	NO_3	Cd	Cu	Pb	Zn
		mg/l				
Jan. 1989	7.70	3.60	0.000	0.010	0.000	0.010
Aug. 1989	7.80	3.85	0.000	0.010	0.000	0.010
Dec. 1989	7.76	3.20	0.000	0.010	0.000	0.010
Jan. 2000	7.80	3.60	0.000	0.015	0.000	0.018
Aug. 2000	7.88	3.57	0.000	0.011	0.000	0.013
Dec. 2000	7.84	3.60	0.000	0.018	0.000	0.019

Table 15. Chemical Characters of the water of downstream El Haris P.S.

Months/year	pH	NO_3	Cd	Cu	Pb	Zn
		mg/l				
Jan. 1989	7.85	3.80	0.000	0.014	0.000	0.000
Aug. 1989	7.75	3.75	0.000	0.018	0.000	0.000
Dec. 1989	7.95	3.80	0.000	0.019	0.000	0.000
Jan. 2000	7.80	3.67	0.000	0.018	0.000	0.001
Aug. 2000	7.82	3.68	0.000	0.018	0.000	0.007
Dec. 2000	7.84	3.86	0.000	0.019	0.001	0.020
Jan. 2010	7.30	7.00	0.029	0.000	0.000	0.000
Aug. 2010	7.61	7.00	0.029	0.000	0.000	0.000
Dec. 2010	7.66	7.00	0.029	0.000	0.000	0.000

Table 16. Chemical Characters of the water of El Umoum drain at Bab ElAbeed

Months/year	pH	NO_3	Cd	Cu	Pb	Zn
		mg/l				
Jan. 1989	7.36	3.95	0.011	0.012	0.002	0.012
Aug. 1989	7.50	4.20	0.011	0.040	0.005	0.040
Dec. 1989	7.45	4.20	0.011	0.028	0.005	0.040
Jan. 2000	7.40	3.20	0.018	0.083	0.003	0.014
Aug. 2000	7.48	4.30	0.016	0.042	0.008	0.028
Dec. 2000	7.38	4.50	0.024	0.044	0.008	0.046
Jan. 2010	7.75	6.00	0.005	0.000	0.000	0.000
Aug. 2010	7.80	11.00	0.005	0.000	0.000	0.006
Dec. 2010	7.90	11.00	0.000	0.014	0.000	0.028

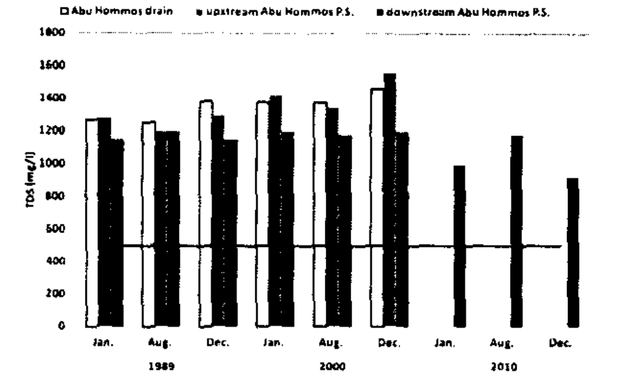

Fig.3. The relation between TDS and time of sampling of Abu Hommos drain, upstream Abu Hommos P.S. and downstream Abu Hommos P.S.

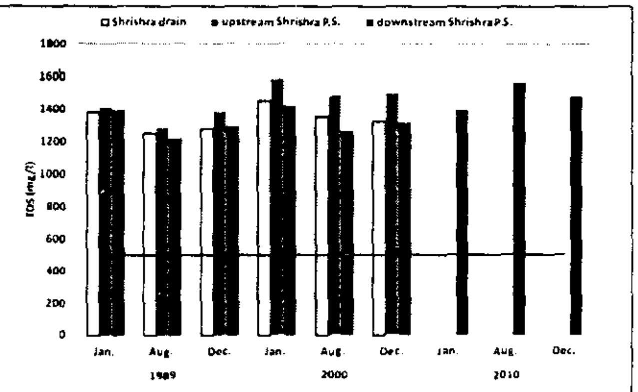

Fig.4. The relation between TDS and time of sampling of Shrishra drain, upstream Shrishra P.S. and downstream Shrishra P.S.

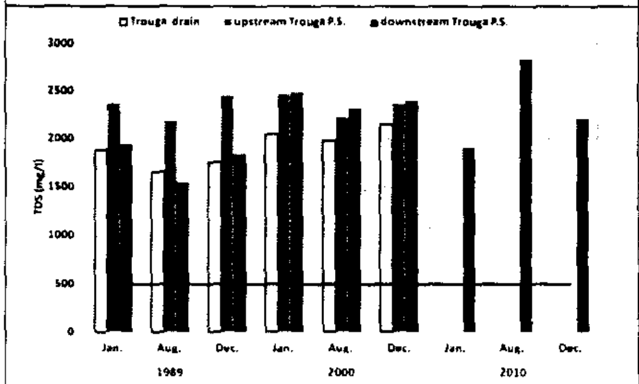

Fig.5. The relation between TDS and time of sampling of Trouga drain, upstream Trouga P.S. and downstream Trouga P.S.

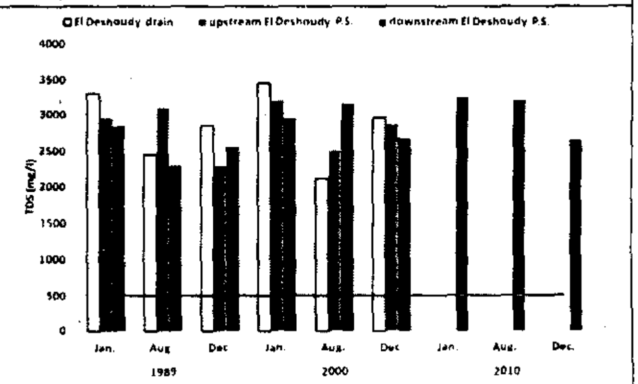

Fig.6. The relation between TDS and time of sampling of El Deshoudy drain, upstream El Deshoudy P.S. and downstream El Deshoudy P.S.

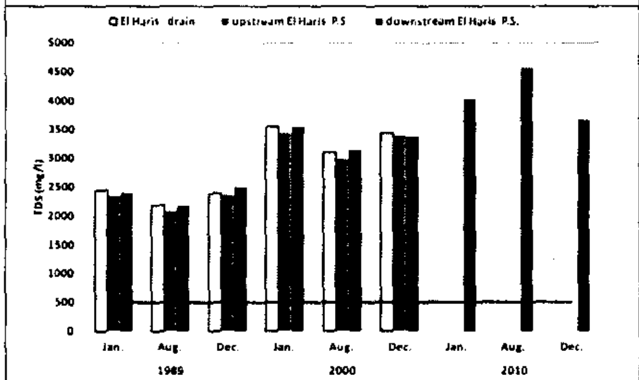

Fig.7. The relation between TDS and time of sampling of El Haris drain, upstream El Haris P.S. and downstream El Haris P.S.

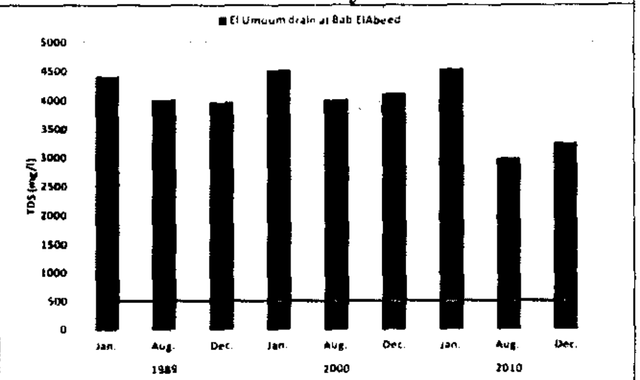

Fig.8. The relation between TDS and time of sampling of El Umoum drain at Bab ElAbeed.

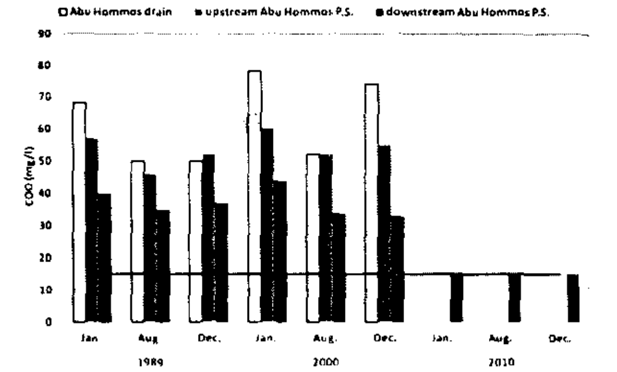

Fig.9. The relation between COD and time of sampling of Abu Hommos drain, upstream Abu Hommos P.S. and downstream Abu Hommos P.S.

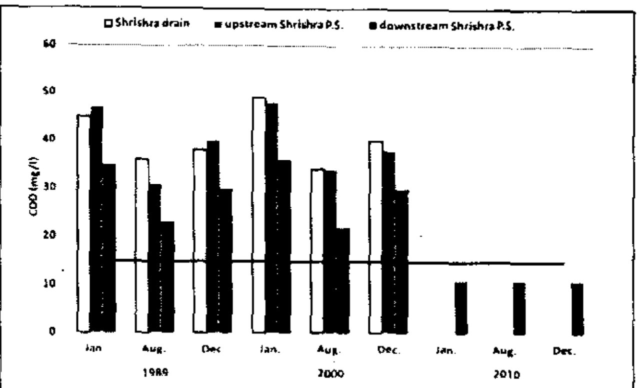

Fig.10. The relation between COD and time of sampling of Shrishra drain, upstream Shrishra P.S. and downstream Shrishra P.S.

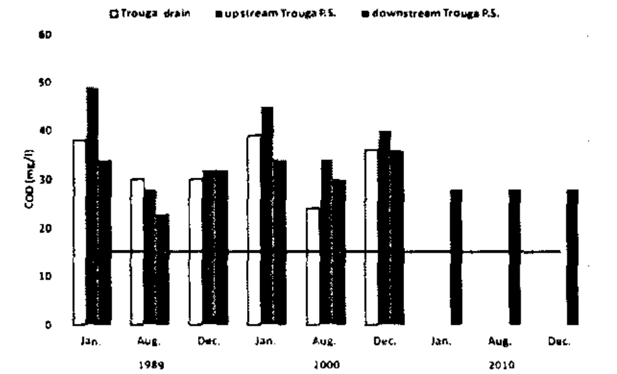

Fig.11. The relation between COD and time of sampling of Trouga drain, upstream Trouga P.S. and downstream Trouga P.S.

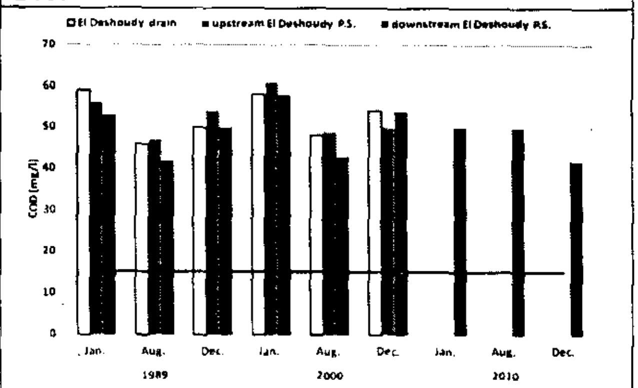

Fig.12. The relation between COD and time of sampling of El Deshoudy drain, upstream El Deshoudy P.S. and downstream El Deshoudy P.S.

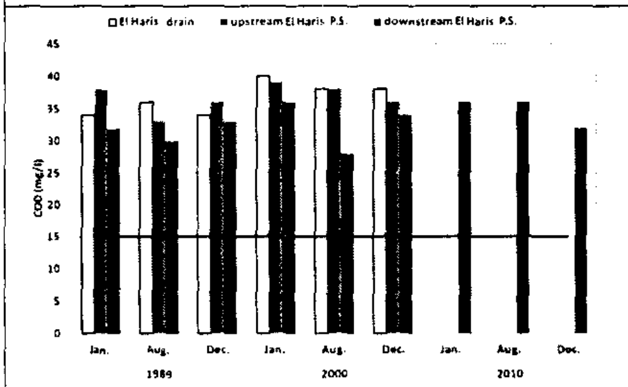

Fig.13. The relation between COD and time of sampling of El Haris drain, upstream El Haris P.S. and downstream El Haris P.S.

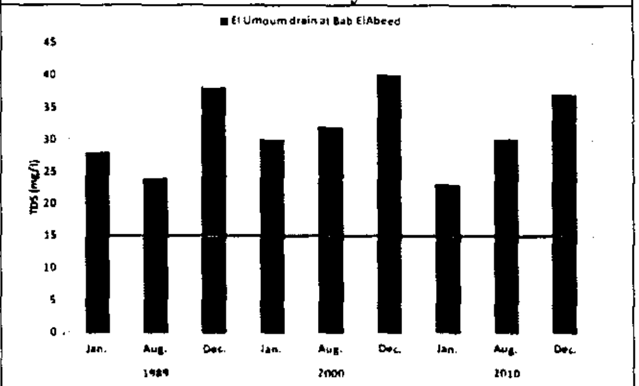

Fig.14. The relation between COD and time of sampling of El Umoum drain at Bab ElAbeed.

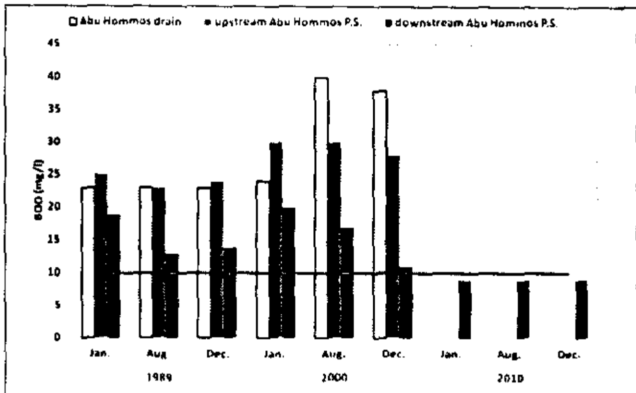

Fig.15. The relation between BOD and time of sampling of Abu Hommos drain, upstream Abu Hommos P.S. and downstream Abu Hommos P.S.

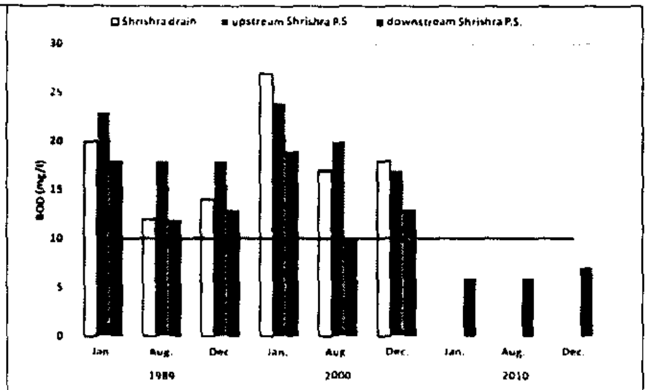

Fig.16. The relation between BOD and time of sampling of Shrishra drain, upstream Shrishra P.S. and downstream Shrishra P.S.

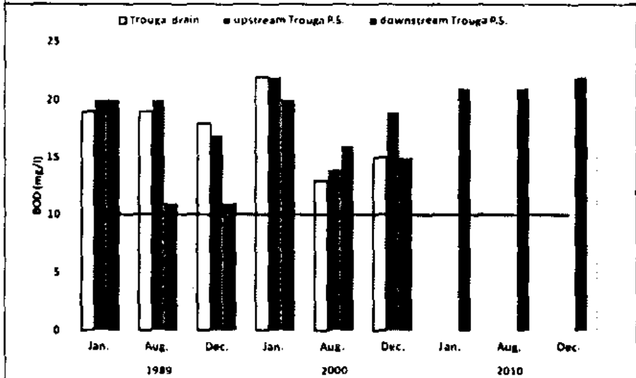

Fig.17. The relation between BOD and time of sampling of Trouga drain, upstream Trouga P.S. and downstream Trouga P.S.

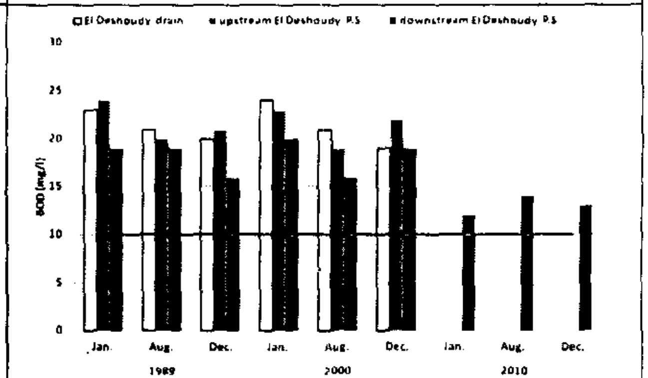

Fig.18. The relation between BOD and time of sampling of El Deshoudy drain, upstream El Deshoudy P.S. and downstream El Deshoudy P.S.

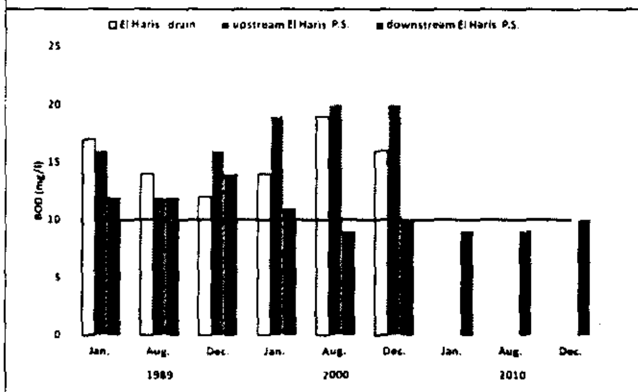

Fig.19. The relation between BOD and time of sampling of El Haris drain, upstream El Haris P.S. and downstream El Haris P.S.

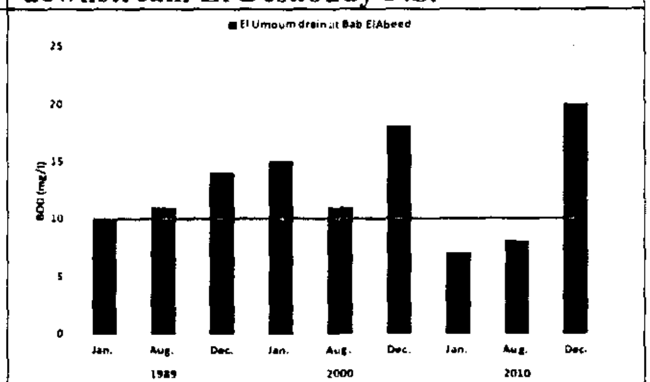

Fig.20. The relation between BOD and time of sampling of El Umoum drain at Bab ElAbeed.

extremely the lowest for water samples collected in 2010 as compared with those in 1989 and 2000. Figs 9-14 showed that the concentrations of COD were lower in water of El Haris and El Umoum drains (Bab ElAbeed) as compared with those of Abu Hommos, Shrishra, Trouga and El Deshoudy drains. These data indicate that the concentrations of COD decrease with proceeding water flow from south to north El Umoum catchment area.

Biological Oxygen Demand (BOD_5):

Figs 15-20 showed that the concentrations of BOD_5 in the drains of El Umoum catchment area have been exceeded the standard level of law 48/1982 (10mg/l). The highest levels of BOD_5 were recorded for the water of Abu Hommos drain for samples collected in the year 2000 especially in the months; January, August and December. It is clear from Fig. 15 that water samples collected from the downstream Abu Hommos P.S. contained the lowest levels of BOD_5 with respect to Abu Hommous drain. This can be observed for the drains: Shrishra, Trouga, El Deshoudy and El Haris. This may be due to physicochemical degradation of the organic compounds when subjected to some types of aeration/oxidation reactions.

Nitrate (NO_3):

Tables 1-16 showed that the concentrations of NO_3^- in the water of the drains of El Umoum catchment are less than the standard levels of law 48/1982. The low levels of NO_3^- in the water of drains may be related to the absence of oxygen in water which could be associated with high levels of organic compounds in this water.

Cadmium (Cd):

Tables 1-16 showed that the concentrations of Cd in the water of the drains were less than the permissible levels of the law 48/1982 (0.010 mg/l). However, the water of El Haris drain contained high level of Cd (0.029 mg/l) in water samples collected in January, Auguest and Decamber 2010 which exceeded the level 0.010 mg/l which was recommended by the law 48/1982.

Copper (Cu):

Tables 1-16 showed that the concentrations of Cu in the water of the drains did not exceeded the standard level of the law 48/1982 (1.000 mg/l). The concentrations of Cu in the water of the drains were the highest in water of Abu Hommos and Shrishrs drains as compared with the others. It is clear that water collected at the downstream drain P.S., in general, contained lower levels of Cu than those collected from the drain itself and from upstream drain P.S.

Lead (Pb):

Tables 1-16 showed that the concentrations of Pb in the water of the drains were lower than the standard level of the law 48/1982 (0.050 mg/l). In addition, the concentrations of Pb in water of some drains collected in the different months and years were below the detection limit of the atomic absorption spectrophotometer.

Zinc (Zn):

Tables 1-16 showed that the concentrations of Zn in the drains were less than the standard permissible levels of the law 48/1982 (1.000 mg/l). However, there were high concentrations levels of Zn in water collected in December from Abu Hommos drain but still lower than that of the law 48/1982.

Water quality index (WQI):

The water quality index is calculated for the 16 sites at El Umoum catchment throughout the years: 1989, 2000 and 2010. Nine variables are considered in the index (TDS, pH, COD, BOD_5, NO_3^- and total Cd, Cu, Pb and Zn). The water quality index of El Umoum catchment is shown in Table 17 which shows that catchments ranked between marginal and fair categories. According to CCME (2001).

As shown in Table 17, the value of WQI of Abu Hommos drain was 64.85 and had a marginal category in 1989 then decreased to 61.87 and had the same category in 2000. On the other hand, the values of WQI of Shrishra drain were 67.86 and 66.58 in the years 1989 and 2000 and had a fair category in both. Similarly, the values of WQI of Trouga drain were 66.53 and 65.87 in 1989 and 2000, respectively and had therefore a fair category in both.

El Deshoudy drain had values of WQI of 61.15 and 61.08 in 1989 and 2000, respectively and therefore had a marginal category in both. Also, El Umoum drain at Bab ElAbeed had a marginal category in the year 1989 and 2000. However, the values of WQI of El Haris drain were 65.15 and 61.61 in 1989 and 2000 and had, therefore, a fair category and then marginal category, respectively.

The above mentioned data revealed that the drains of El Umoum catchment area had been markedly polluted and that the magnitude of pollution proceeded with time from 1989 to 2000.

Studying the changes in the values of WQI for samples collected from downstream drain P.S. and from upstream drain P.S. showed that these values were markedly higher for samples collected from downstream drain P.S. than those from upstream drain P.S. This observation had been recorded with the samples collected from all the drains of El Umoum catchment area, and also with samples collected in 1989 and 2000.

Table 17. The values of water quality index and categories of El Umoum catchments

Location	1989		2000		2010	
	Value	Categories	Value	Categories	Value	Categories
Abu Hommos drain	64.85	marginal	61.87	marginal		
Upstream Abu Hommos P.S.	65.27	fair	63.53	marginal		
Downstream Abu Hommos P.S.	68.59	fair	68.42	fair	80.85	good
Shrishra drain	67.86	fair	66.58	fair		
Upstream Shrishra P.S.	66.98	fair	66.27	fair		
Downstream Shrishra P.S.	69.20	fair	69.15	fair	79.13	fair
Trouga drain	66.53	fair	65.87	fair		
Upstream Trouga P.S.	64.33	marginal	64.04	marginal		
Downstream Trouga P.S.	67.60	fair	64.72	marginal	64.84	marginal
El Deshoudy drain	61.15	marginal	61.08	marginal		
Upstream El Deshoudy P.S.	61.25	marginal	61.05	marginal		
Downstream El Deshoudy P.S.	62.65	marginal	61.38	marginal	62.15	marginal
El Haris drain	65.15	fair	61.61	marginal		
Upstream El Haris P.S.	65.22	fair	61.50	marginal		
Downstream El Haris P.S.	65.70	fair	64.01	marginal	62.82	marginal
El Umoum drain at Bab ElAbeed	61.04	marginal	60.17	marginal	64.21	marginal

These data reveal the occurrence of some types restorations of water of the drain after its upward flow within the pump station. This can be achieved by comparing the values of WQI for samples collected from upstream Trouga P.S. (marginal category) and those from downstream Trouga P.S. (fair category) in the year 1989. Also, the values of WQI for samples collected from upstream Abu Hommos P.S. (marginal category) and those from downstream Abu Hommos P.S. (fair category) in the year 2000.

CONCLUSION

The drainage water of El Umoum catchment area are used for receiving mainly drainage water from agricultural lands, and occasionally the discharges of untreated effluents from domestic and industrial origins. These drains include Abu Hommos, Shrishra, Trouga, El Deshoudy and El Haris and are considered the main water sources which supply El Umoum main drain with water. The obtained results showed that the water of these drains is highly polluted especially with high salts concentrations and heavy loads of COD and BOD_5.

The concentration of TDS had increased dramatically from south to north flow direction of El Umoum catchment area. This can be achieved by comparing the levels of the TDS of Abu Hommos drain and El Umoum drain at Bab ElAbeed. The average concentrations of TDS, in water of Abu Hommos drain, were 1311 and 1407 mg/l for samples collected in 1989 and 2000, respectively, and in water of El Umoum drain at Bab ElAbeed were 4119 and 4200 and 3573 mg/l for samples collected in 1989, 2000 and 2010, respectively.

The concentrations of COD and BOD_5 behaved in opposite direction to that of TDS, in the drains of El Umoum catchment area, since it had markedly decreased from south to north flow direction. The average concentrations of COD and BOD_5 in water of Abu Hommos drain were 56 and 23 mg/l for samples collected in 1989 and then were 68 and 34 mg/l and 15 and 9 for samples collected in 2000 and 2010, respectively. On the other hand, the average concentrations of COD and BOD_5 in water of El Umoum drain at Bab ElAbeed were 30 and 12 mg/l for samples collected in 1989, and then were 34 and 15 mg/l and 30 and 12 mg/l for samples collected in 2000 and 2010, respectively.

According to the Egyptian law 48/1982, the water quality of the drains of El Umoum catchment area did not meet the requirements of this law with respect to TDS, COD and BODs to be discharged into fresh water canals for reuse in agricultural irrigation.

Evaluation of the values of WQI showed that Abu Hommos drain had values of 69.85 and 61.87 which suited marginal category for samples collected in 1989 and 2000, respectively. Close values of WQI were recorded for water samples collected from El Umoum drain at Bab ElAbeed which were 61.04, and 60.17 and 64.21 and having marginal category for samples collected in 1989, 2000 and 2010, respectively. An exception was the water collected from downstream Abu Hommos P.S. which showed relatively high WQI of 68.59 (fair category), 68.20 (fari category) and 80.85 (good category) in 1989, 2000 and 2010, respectively. Also the water from downstream Shrishra P.S. behaved in similar trend since the values of WQI were 69.20, 69.15 and 79.13 (fair category) in the years 1989, 2000 and 2010, respectively.

According to the data of WQI, it can be realized that the water of the drains: Abu Hommos, Trouga, El Deshoudy, El Haris and El Umoum drain at Bab ElAbeed would be characterized by the marginal category, during the study period from 1989 to 2010.

RECOMMENDATION

Identifying appropriate treatment options, at the hot spot point source of pollution, i.e. village, for improving or reclamation domestic effluents, has a high priority since villages without sanitation facilities can be expected to continue discharging their wastes into the agricultural drains and pollution of the drainage water will be progressively increased. Thus, wastewater treatment at the point sources of pollution can be recommended in small settlement like that for Egyptian villages. Simple low-tech passive water treatment technology can be constructed into the polluted drain which receives domestic wastes in reaches close to the neighborhood villages with certain conditions. That is called the in-stream treatment wetland system. This system can enhance water quality treatment to meet the Egyptian law 48/1982. Wetland system can reduce high levels of TDS, COD, BODs, suspended solids, nitrogen and heavy metals (Wetzel, 1993; Mitsch, 1993; Mitsch and Gosselink, 2000 and Zidan et al., 2005). It has been reported that the"in-stream wetland treatment system" is expected to be equivalent to the primry/secondary conventional wastewater treatment.

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الملخص العربي

تقييم نوعية مياه مصرف العموم، غرب دلتا النيل بمصر خلال الفترة١٩٨٩- ٢٠١٠

إبراهيم حسين السكري، علاء فاروق أبوكيلة

وضعت خطة استخدام مياه الصرف الزراعي تبعا لرغبة الحكومة المصرية والخاصة بشبكة المصارف مع بعضها البعض وليس باستخدام كل مصرف علي حده. وعلي ذلك تهدف الدراسة الحالية تقييم نوعية هذه المياه وكذا حساب دليل نوعية المياه لشبكة مصرف العموم الذي يقع غرب دلتا النيل. ولتحقيق هذا الهدف جمعت عينات المياه في الأعوام: ١٩٨٩، ٢٠٠٠، ٢٠١٠ في فترات الجريان المنخفض(ديسمبر) والسدة الشتوية(يناير) والجريان المرتفع (أغسطس). توضح نتائج الدراسة تلوث المصارف الرئيسية بالمركبات الغير عضوية والعضوية. فقد وجد أن تركيز المواد الصلبة الكلية الذائبة قد ازداد مع الزمن وكذا في مياه المصارف في الاتجاه من الجنوب إلي الشمال. وقد وجد ادني تركيز في مصرف أبوحمص بمتوسط ١٣٠٤، ١٤٠٨ ملليجرام/لتر في عامي ١٩٨٩، ٢٠٠٠ علي التوالي. وقد وجد أعلي تركيز في مياه مصرف العموم عند باب العبيد بمتوسط ٤١١٧، ٤٢٠٠ ملليجرام/لتر في عامي ١٩٨٩، ٢٠٠٠ علي التوالي.

كما وجد أن أعلي تركيز للأكسجين الكيميائي المستهلك في مياه مصرف ابوحمص بمتوسط ٥٦، ٦٨ ملليجرام/لتر في عامي ١٩٨٩، ٢٠٠٠ علي التوالي. وأدني تركيز في مياه مصرف العموم عند باب الحديد بمتوسط ٣٠، ٣٤، ٣٠ ملليجرام/لتر في عامي ١٩٨٩، ٢٠٠٠، ٢٠١٠ علي التوالي. وكان تركيز الأكسجين الحيوي المستهلك عند أقصاه في مياه مصرف أبوحمص بمتوسط ٢٣، ٣٤ ملليجرام/لتر في عامي ١٩٨٩، ٢٠٠٠ علي التوالي. وأدني تركيز في مياه مصرف العموم عند باب الجبيد بمتوسط ١٢، ١٥، ١٣ ملليجرام/لتر في عامي ١٩٨٩، ٢٠٠٠، ٢٠١٠ علي التوالي.

يتضح من هذه النتائج أن تركيز هذه المواد الثلاثة أعلي كثيرا من المستويات الحدية للقانون المصري ١٩٨٢/٤٨. كذلك وجد أن تركيز النترات والكادميوم والنحاس والرصاص والزنك في مياه جميع المصارف تحت الدراسة في الحدود المسموح بها تبعا للقانون ١٩٨٢/٤٨.