Microbiological and Chemical Impacts of Pollution Sources on Rosetta Branch Water Quality

Mohamed.M. Yehia and Aya.S.Hakim

ABSTRACT

Rosetta branch is the main source of water to many cities and industrial areas in the northern part of Egypt . This branch is subjected to different sources of pollution which affect its physical, chemical and bacteriological characteristics .The main sources of pollution are the discharges of domestic and industrial wastes from the western bank of greater Cairo until Kafr El-Zayat town. The present study was carried out to evaluate the water quality condition along the Rosetta branch during winter and summer months of 2004-2005. Samples were collected seasonally from seven point source of pollution along the branch . El Rahawy drain records the highest percentage of microbiological hazards (80.4%) , followed by El-Tahreer drain (19%), then Sabal drain (0.4%), Zawiet El Bahr drain (0.1%) , Tala drain records the lowest percentage (0.005 %).The variation in microbial contents of sewage may be due to the dilution factor which varied according to the daily water consumption and the interaction between the different microbial species which may be in the form of antagonistic effect. Other ecological factors such as pH, temperature, availability of nutrients and presence of toxic or stimulating substances play an important role on numbers as well as the dominant microbial species in sewage. Although the Rosetta branch receives effluents from various sources of pollution, it showed a considerable self-purification capability resulting in waters of good quality after the city of Kafr-El-Zayat segment. Following the previous segment the water is released into Mahmoudia canal maintaining a better water quality. The overall findings of this research indicated that the impact of all point sources of pollution were limited and localized.

Key words: indicator bacteria , total coliform , fecal coliform ,wastewater, water quality.

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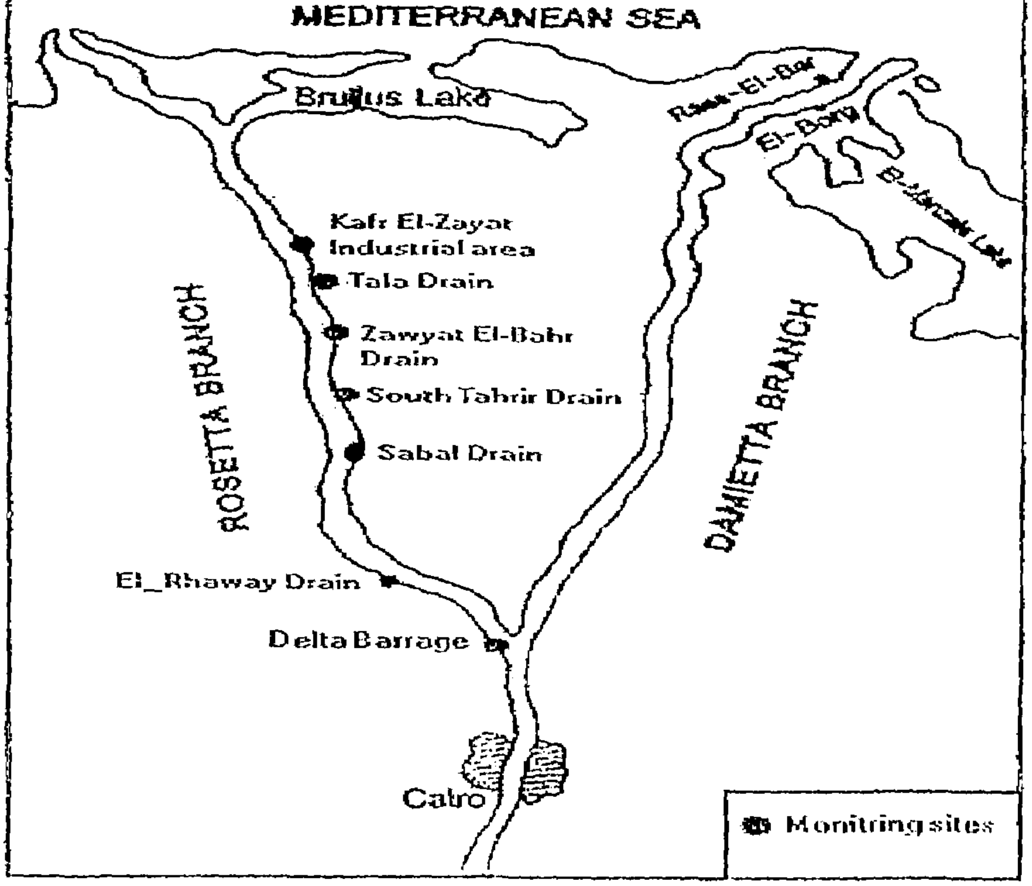
INTRODUCTION

Rosetta Branch is one of the two Nile branches, it flows downstream Delta Barrage to the North –West and ends with Edfina Barrage. Edfina Barrage releases water to the Mediterranean Sea during the winter closure period (when canals are closed to carry out maintenance and construction works). Along Rosetta Branch , there are two main sources of pollution that degraded the quality of the water. These are : agricultural drainage water and industrial wastewater. The branch receives agricultural drainage water from five drains namely : El-Rahawy , Sabal , El-Tahreer, Zawiet El Bahr, and Tala. The quantities and characteristics of the agricultural wastewater are highly variable. The most important pollutants found in the run off from agricultural areas are sediments , animal wastes, plant nutrients, crop residues, inorganic salts, minerals, chemical fertilizers and pesticides . In addition to that the agricultural drains receives also domestic wastes from fifty five towns and villages distributed along the branch. Rosetta branch receives pesticides and other toxic chemicals from Kafr El-Zayat area. The estimated flow of industrial wastewater discharge to the Rosetta branch is about 0.05 million m^3 /day (Soheir et al ; 1993).
The present study was carried out along Rosetta branch during the year of 2004/2005 to evaluate the quality of wastewater discharged from all the pollution sources into Rosetta branch.

Location of Sampling sites

Seven sampling sites were selected along the Rosetta branch in addition to one site upstream of the Delta barrage which was sampled as background information. In addition, samples were collected from drains discharging into branch in order to study their impact on water quality. Map. 1 provides the general location of the sampling sites which are:

- Delta Barrage	km20 from El Roda
- El-Rahawy Drain out fall	km35 from El-Roda
-Sabal drain out fall	km97 from El-Roda
-El-Tahreer Drain out fall	km112 from El-Roda
-Zawiet El-Bahr Drain out fall	km126 from El-Roda
-Tala Drain out fall	km147 from El-Roda
- Malia and Senaie Industrial Waste	km147 from El-Roda
-Salt and Soda Industsrial Wastes	km147 from El-Roda



Map.1 Sampling Locations along Rosetta Branch

METHODS:

The samples were selected according to the specific objectives of the study, the selected samples were subjected to the following analyses :

Physicochemical analyses .The following parameters were measured in all water samples ; Temperature, electric conductivity, pH, turbidity ,total dissolved solids, nitrate, nitrite and ammonia, in addition to Biological Oxygen Demand (BOD) and Chemical Oxygen Demand (COD).

Bacteriological analysis. Samples were collected in sterile glass bottles and transported in ice boxes to the laboratory for bacteriological analysis (within 6 h) , all bacteriological analyses were performed by membrane filtration methods .The total coliform count was evaluated on M-Endo agar LES , fecal coliforms on m-FC agar, as recommended by standard methods for the examination of water and wastewater APHA (1995).

RESULTS AND DISCUSSION

Environmental setting:

The water quality of collected samples taken from the branch polluting streams is poor due to the following reasons ;

All agricultural drains receive mixed wastes from point-sources and non-point - sources of pollution. In addition to receiving the excess run off from irrigation applied to cultivated land. The wastes in these drains contain high levels of suspended materials and dissolved solids, nutrients and organic matter.

The industrial waste effluents discharging into the Rosetta branch without treatment from both the Malia chemical industry, and the Salt and Soda company at Kafr El-Zayat contain high levels of total solids.

Water quality of the branch

The physico-chemical characteristics and bacterial indicator of pollution sources were monitored, the results of the physical , chemical and bacteriological analysis of Rosetta branch water at different sampling sites are shown in Tables 2 through 8 and plotted in Figures 2, (A.B.C.) through 8,(A.B.C.) .Table and Figures 1, (A.B.C.) represent the water quality in El-Kanater as reference data. These tables and figures show the temperature, pH, conductivity , DO, BOD, COD, total dissolved solids (TDS), ammonia, nitrite, total coliforms and fecal coliforms. These characteristics are evaluated as follows ;

1- El-Kanater site:

Table 1 and Figurers 1(A.B.C)

The dissolved oxygen content in the water upstream of El-Kanater was 7.95 mg/L in January and 3.5 in april. Total coliforms value were fluctuated around 8 $x10^3$ CFU/100ml most of the time while Faecal coliforms varied from 400 CFU/100ml in January to 2500 CFU/100ml in October. BOD values ranged from 5 mg /L in October to 9 mg/L in July , BOD values were within the permissible limits (up to 10 mg/L) except in April as it recorded 12 mg/L .The nitrate concentrations remained between 0.2 and 3.7 mg/L. The nitrogen concentrations of compounds found upstream of the Delta barrage remained within the stream standards of Article 60 in law 48 for 1982.

2- El-Rahawy Drain

Table 2 and Figurers 2(A.B.C)

The water quality of a given stream is related to climate, such as wind, humidity and atmposphereic temperature as well as all activities in its catshment. Saturated concentration of dissolved oxygen and activity of organisms are deeply related to water temperature. The water temperature in El-Rahawy drain ranged from 15-18^{0}C during winter and increased to about 28^{0}C during summer.

Dissolved Oxygen , The DO values ranged from 2.3 to 7.2 mg/L. The lowest DO values recorded as 2.3 mg/L during October while the highest was 7.2 mg/L during July. However, these results are not in complaince with (Law 48,1982).

pH, the pH value is approximately 7.5 which is considered moderately alkaline. It seems that this pH value is affected by a number of factors as the Nile River often contains loads of organic matter and nutrient salts, as long hours of sunlight plant organism proliferate, Plant organisms consume carbon dioxide and oxygen, carbon dioxide is dissolved in water to form carbonic acid. When carbon dioxide is consumed by plant organisms, the amount of carbonic acid decreases and O_2 concentration increases. Such chemical reactions favors the formation of metal oxides and hydroxyles which increases so the pH value. Additionally, most of the Egyptian soils are calcerious with alkaline nature. The overall assessment of pH values did not exceed the permissible limits of Law (48 / 1982), as most values were between 7.13 to 7.97 down stream of El- Rahawy drain.

The recorded **conductivity** varied from 0.367 mmhos/cm during April to 0.855 mmhos /cm during July, while **total dissolved solids** (TDS) ranged between 235 mg/L in April and a maximum of July 548 mg/L

Ammonia concentrations were as high as 18 and 14 mg/l during July and October in some locations, while the lowest recorded concentration was 0.15 during April , due to excess water released by the (MWRI) Ministry of Water Resources and Irrigation to overcome industrial pollution. The high levels are belived to be a result of direct discharge of industrial wastes which enhances chemical reaction producing ammonia.

The **nitrites** were presented in minor quantities along the period of study. Their presence are considered unstable form ammonia and nitrate as a result of oxidation or from nitrate to ammonia by reduction.

Nitrate values in all seasons did not exceed the permissible limits of law 48 /1982 (45mg/L). Figure 2 shows the seasonal variation of ammonia , nitrites and nitrates.

Biochemical oxygen Demand (BOD), At the outfall of El-Rahawy drain ,the BOD values exceeded the standard values of (10mg/L), 11 mg/L in April and as high as (48 mg/L) in October while in July 80 mg/L value was recorded. The noticeable increase in the BOD value in El-Rahawy drain is attributed to the increase in the organic matter discharged to the drain directly without treatment.

Chemical Oxygen Demand (COD), The COD results exceeded the standard value (15 mg/L)for all seasons The minimum recorded value was 34 mg/l during April ,while the maximum value was 140mg/L in July followed by 80 mg/l during October. COD values exceeded the permissible limits (15 mg/L), this is due to high organic load ,industrial and agricultural wastewater along the drain.

Microbiological examination of water samples is typically used to determine the sanitary quality and public health risk from waterborne disease. Contamination of natural waters by microorganisms directly affects public health because of the use of these resources for potable water supply and irrigation.

Total coliforms were detected in 100% of the stream water samples analyzed. It varied from1000 CFU/100ml that recorded in April after the winter closure period to $52x10^6$ CFU/100ml during October exceeding the permissible limits recommended by Law 48,1982 (2500CFU/100ml).On the same time ,the **fecal coliforms** recorded the lowest value 200CFU/100ml during April to reach its maximum 38x 10^6 CFU/100ml during October. The greatest median concentration found was for total coliforms, and the lowest median concentration found was for fecal coliforms .The microbiological examination indicated that the concentration of total and fecal coliforms in the waters of the drain are generally higher than the limit recommended by law (48, 1982).Therefore a serious restriction should be undertaken before discharging El - Rahawy water mixed with sewage into the Rosetta branch. However Our study has shown that the degree of total coliform population was reduced from few million in the drain to less than few thousands after few kilometers as a result of self purification process .

EL-Rahawy represents the worst condition among all sources of pollution, since it receives a great part of raw municipal and domestic wastes from greater Cairo, and from El Moheet drain.

3- Sabal Drain:

Table 3 and Figurers 3(A.B.C)

Sabal drain is an agricultural drain , which serves about 140000 feddan of fertile old land. It has 13 branch drains that carry the drainage water from agricultural land to the main Sabal drain, which spills about 290 million m^3/year to the Rosetta branch. The sewage water in Sabal drain comes from six towns discharging their sewage water in the drain. It was observed that there is a remarkable increase in ammonia concentration in the branch due to the drain discharge, all over the year except in April , due to excess water released by MWRI to overcome industrial pollution . COD recorded high values specially Jan and October .the value were 32 and 44 mg/L respectively exceeding the standard limits of law 48 ,1982 (10 mg/L), The BOD recorded 17 and 38 mg/L in July and October. Bacteriological content was at its highest value in January 163 $x10^3$ CFU/100ml for total coliforms and 23 $x10^3$ CFU/100ml for fecal coliforms. It start to decrease through April and July then increased again in October to 82 $x10^3$ CFU/100ml and 21 $x10^3$ CFU/100ml , exceeding the standard limits (2500 CFU/100ml)

4- El-Tahreer Drain:

Table 4 and Figurers 4(A.B.C)

There is wide variations in the levels of ammonia measurements in collected water samples of the drain, with the highest recorded value 5 mg/L during April. There were remarkable variation in the levels of total coliform and faecal coliform in July . It reached 18 $x10^6$ CFU/100ml and 40 $x10^4$ CFU/100ml for total and faecal coliforms respectively exceeding the standard limits.

5- Zawiet El-Bahr drain

Table 5 and Figurers 5(A.B.C)

This drain has the lowest impact on the branch. Ammonia levels recorded varied from 0.15 mg /L in July to reach its maximum of 3.0 mg/L in April The total coliform varied from14 $x10^3$ CFU/100ml in October to 29x 10^3CFU/100ml in April.

6- Tala Drain :

Table 6 and Figurers 6(A.B.C)

There were remarkable increase in the concentration of ammonia in July and October (19 and 12 mg/L) .The bacterial content represent the lowest contamination and did not exeed the standard limits except in January (12000 CFU/100ml).

7- Salt and Soda point source.

Table 7and Figurers 7(A.B.C)

This point represents the water quality characteristics in front of Soda and Soap company. Wastewater produced from this plant (about 31 000 m^3/day) is continously discharged into the river without suitable treatment (El Zeftawy 1994).This waste is alkaline in nature.

8- El- Malia company point source.

Table 8and Figurers 8(A.B.C)

This point was chosen to represent the water quality characteristics in front of Malia company . Malia company produces both sulfuric acid and superphosphate fertilizer as main products. Wastewater produced from this plant (about 20 000 m^3/day) is continuously discharged into the river without suitable treatment (El Zeftawy 1994). This waste is acidic in nature with high content of bacteria (total and faecal coliforms).

It is clear from the above results that variation in pollutant concentration in industrial (wastewater during 2004-2005) may be due to seasonal change in the production activity of these factories and consequently their wastewater, rather than due to measures taken by factories to improve the quality of their wastes.

The extent of the impact varies depending on the size of the cities, the volumes and flow rate of the river, the temperature, and a host of other factors. Despite all this, rivers do have a natural capacity to restore themselves.

CONCLUSION

The present investigation was devoted to determine the impact of five drains namely, El-Rahawy, Sabal, El-Tahreer, Tala and Zawiet –El-Bahr in addition to two industrial companies, Salt & Soda and El-Malia, as point sources of pollution on water quality of Rosetta branch .

Physico-chemical analysis included determination of temperature, pH, electric conductivity, dissolved oxygen, ammonia, nitrite and nitrate chemical and biochemical oxygen demand .The bacteriological evaluation was carried out through the detection of total coliforms and fecal coliforms as indicators of water contamination .

The physico –chemical analysis of collected water samples revealed that all the drains as well as Rosetta branch especially downstream El-Rahawy drain were suffering from chemical pollution and bacteriological pollution while River Nile is so far within the permissible standards limits. In El Rahawy drain, there was a sharp increase in electric conductivity, ammonia ,biochemical and chemical oxygen demand, total dissolved solids, and great depletion in dissolved oxygen , this was directly reflected on the water quality of Rosetta branch which is seriously deteriorating down stream. El-Rahawy drain and recorded pollution levels higher than the main River Nile .

The bacteriological analysis of water samples revealed obvious bacterial contamination in all studied samples with varying levels of pollution, being maximum at EL -Rahawy drain and its downstream in Rosetta branch indicating unsafe water from bacteriological point of view.

El Rahawy drain records the highest percentage of bacteriolgical hazards (80.4%) , followed by El-Tahreer drain (19%), then by Sabal drain (0.4%), Zawiet El Bahr drain (0.1%) , Tala drain records the lowest percentage (0.005 %).as Shown in Table 9 and Figure 9.

The present investigation concluded that drainage wastewater on (Rosetta branch) are suffering from extreme pollution concerning both physico- chemical and bacteriological characteristics however, It was found that, although the Rosetta branch receives effluents from various sources of pollution, it showed a considerable self-purification capability resulting in waters of good quality after the kafr-El-Zayat segment and being released into Mahmoudia canal. The effect of all point sources of pollution were however, limited to local impacts.

RECOMMENDATIONS

Finally, in addition to above conclusions, the following recommendations can be suggested:-

1. Rigid regulations and instructions should be enforced when any violation to the law is made.
2. Periodical inspection must be carried out to discover any; discharge of wastes which do not obey the limits set by the law.
3. Discharge of different pollution loads (quantity and quality) should be based on the self-purification capacity of the branch water.
4. Investigating the different treatment methods necessary for wastes (sewage discharging from Soda and Malia factories) as well as diversion domestic sewage discharging into Rahawy drain water (sewage needs secondary treatment before disposal).
5. Permission of the construction of new industries should be allowed only to those having treatment facilities.
6. Health education programs should be implemented with the farmers and inhabitants with emphasis on health hazards as a result of their unhygenic habits.

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Table (1) Rosetta branch before the dicharge of the drains (El-kanater) through 2004/2005

	Units	Jan	Apr	July	Oct
Temp	C°	16.2	23.5	26	24
Ec	mmhos/cm	0.458	0.426	0.323	0.448
TDS	mg/l	293	273	206	287
Ammonia	mg/l	<0.01	1.6	0.032	0.22
pH		8.21	7.72	7.55	8.14
DO	mg/l	7.95	3.5	6.9	4.2
BOD	mg/l	8	12	9	5
COD	mg/l	21	34	13	9
Nitrite	mg/l	0.4	1	<0.2	0
Nitrate	mg/l	0.2	3.7	0.5	2.4
TC	CFU/100ml	3700	15600	8000	8000
FC	CFU/100ml	400	1000	1000	2500

Fig (1-a)

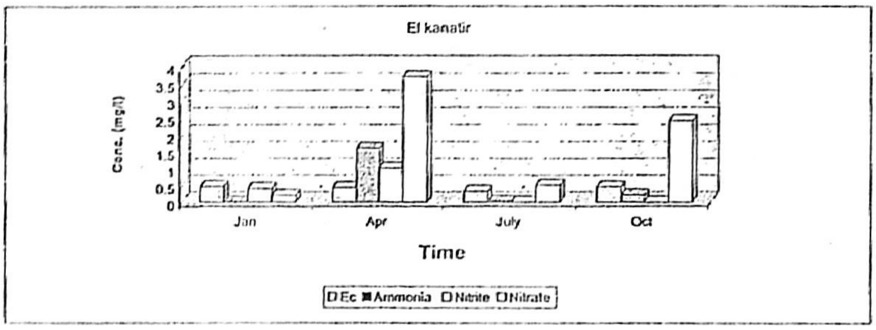


Fig (1-b)

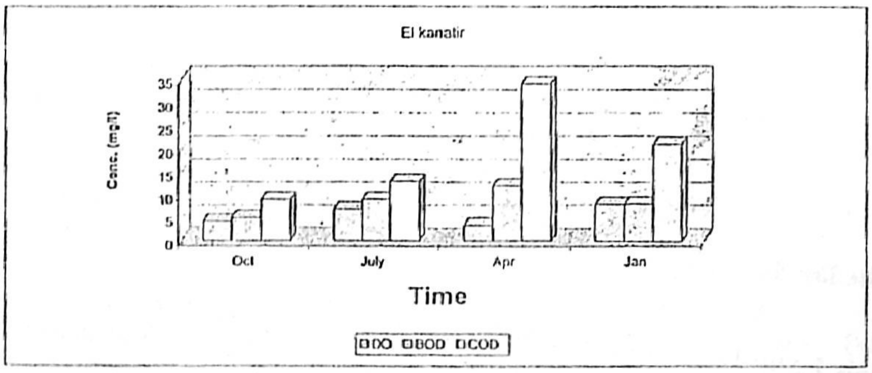


Fig (1-c)

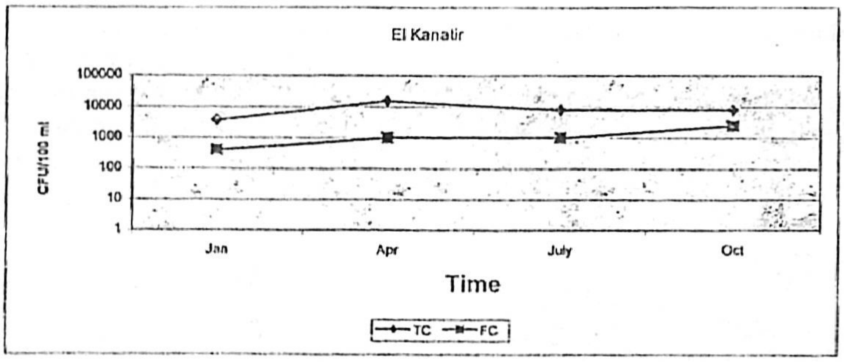


Table (2)The effect of El Rahawy drain on the quality of Rosetta branch through 2004/2005

	Units	Jan	Apr	July	Oct
Temp.	C°	18.1	24	28.8	24.5
Ec	mmhos/cm	0.849	0.367	0.855	0.763
TDS	mg/l	543	235	548	488
pH		7.51	7.63	7.13	7.97
Ammonia	mg/l	5.6	0.15	18	14
DO	mg/l	4.3	5.8	7.2	2.3
BOD	mg/l	14	11	80	48
COD	mg/l	43	34	140	80
Nitrite	mg/l	0.373	0.2	<0.2	<0.2
Nitrate	mg/l	0.68	0.4	<0.2	3.4
Total Coliforms	CFU/100ml	12500000	1000	14000000	52000000
Fecal Coliforms	CFU/100ml	2200000	200	4100000	38000000

Fig 2 a

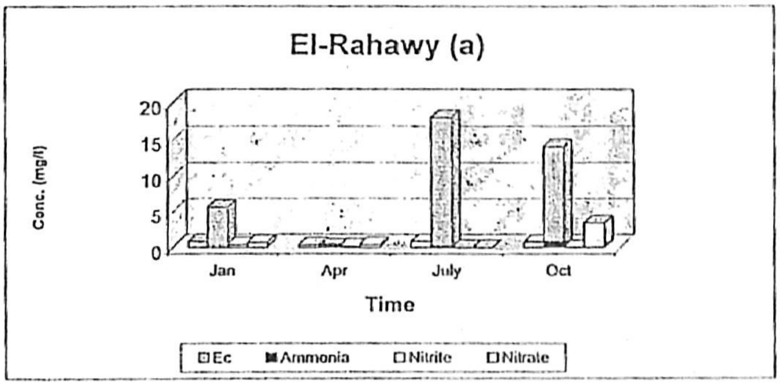


Fig 2 b

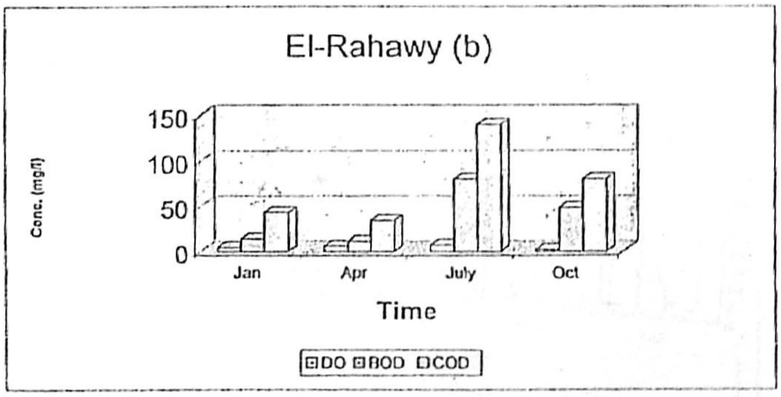


Fig 2 c

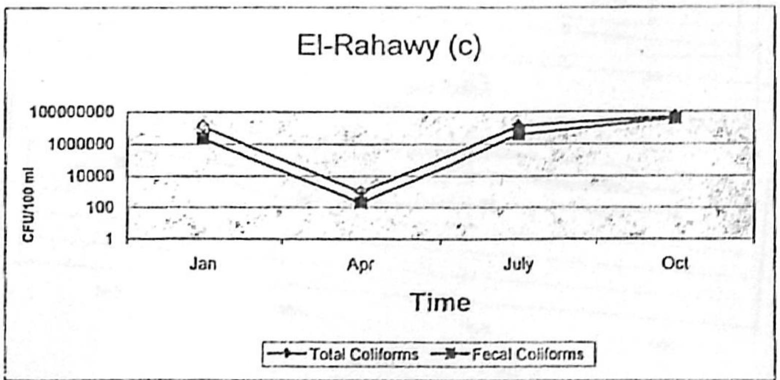


Table (3)The effect of Sabal drain on the quality of Rosetta branch through 2004/2005

	Units	Jan	Apr	July	Oct
Temp.	C°	16.6	22.2	24.1	25.7
Ec	mmhos/cm	0.784	0.471	0.683	0.703
TDS	mg/l	502	301	437	450
Ammonia	mg/l	3.8	0.14	3.2	3.2
DO	mg/l	2	3.94	4.8	5.3
pH		7.51	7.63	7.13	7.97
BOD	mg/l	9	6	17	38
COD	mg/l	32	21	23	44
Nitrite	mg/l	0.180	1.5	<0.2	3
Nitrate	mg/l	0.28	2.1	3.26	4.5
Total Coliforms	CFU/100ml	163000	150000	22600	82000
Fecal Coliforms	CFU/100ml	23000	9000	3000	21000

Fig 3 a

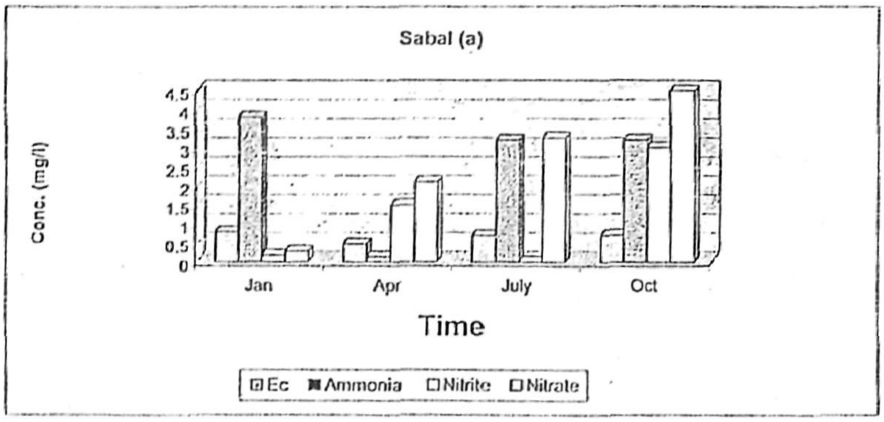
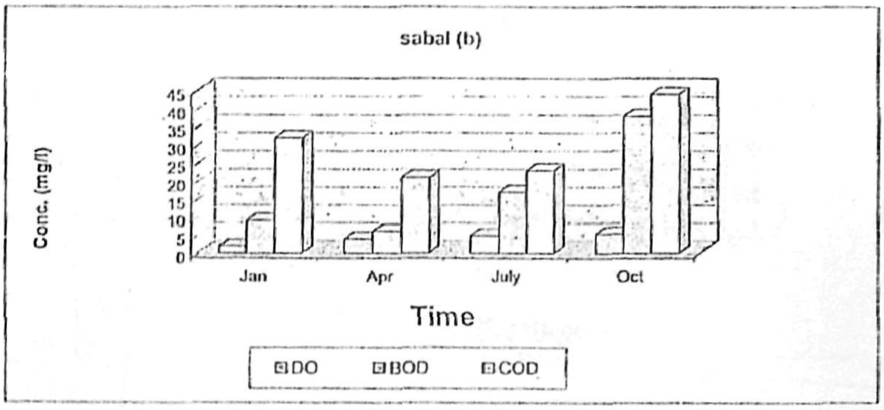


Fig 3 b



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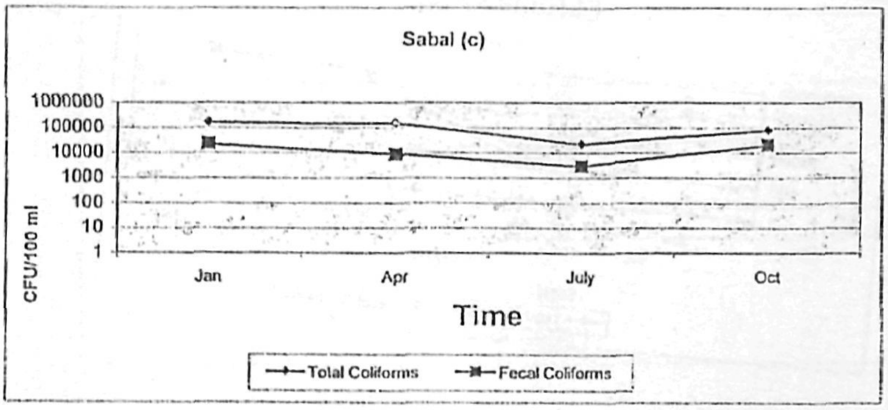


Table (4) The effect of El-Tahreer drain on the quality of Rosetta branch through 2004/2005

	Units	Jan	Apr	July	Oct
Temp.	C°	14.5	22.5	22.7	22.6
Ec	mmhos/cm	0.613	0.508	0.451	0.694
TDS	mg/l	392	325	289	444
Ammonia	mg/l	3.5	5	2.1	0.78
DO	mg/l	5	3.9	9.25	6.5
pH		7.71	7.45	7.57	7.94
BOD	mg/l	9	8	38	16
COD	mg/l	26	30	46	35
Nitrite	mg/l	0	<0.2	<0.2	0.2
Nitrate	mg/l	0.89	0.4	9.64	2
Total Coliform	CFU/100ml	16800	60400	18800000	40000
Fecal Coliform	CFU/100ml	800	5100	400000	20000

Fig 4 a

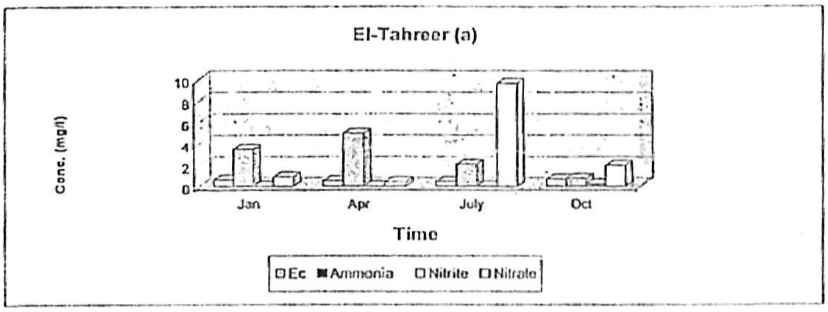
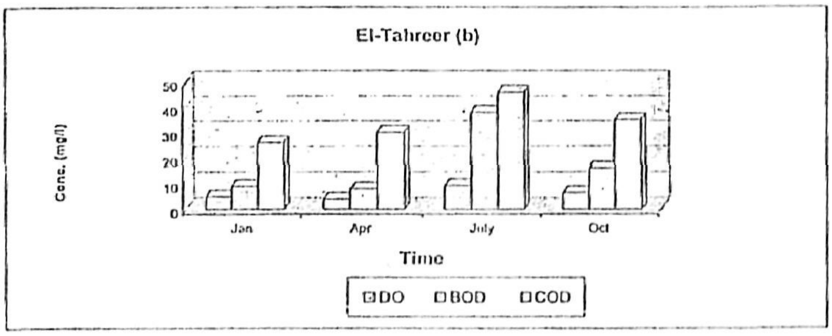


Fig 4 b



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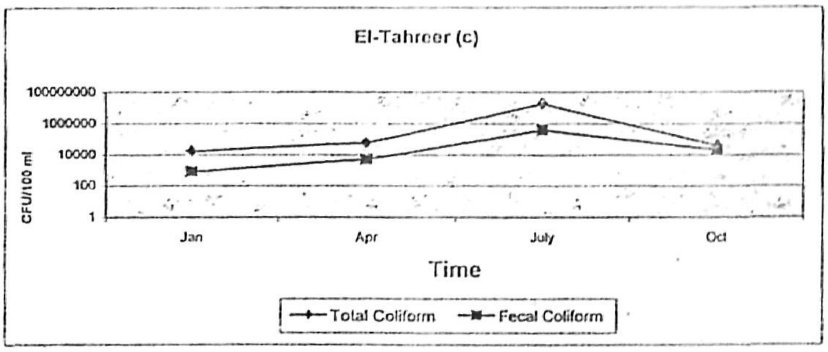


Table (5) The effect of *Zawiet El-Bahr* drain on the quality of Rosetta branch through 2004/2005

	Units	Jan	Apr	July	Oct
Temp. °C	C^0	14.5	22.5	23.2	23.2
Ec	mmhos/cm	0.555	0.522	0.415	0.632
TDS	mg/l	355	334	266	404
Ammonia	mg/l	2.8	3	0.15	1.5
DO	mg/l	6.44	4.5	9.58	4.1
pH		7.7	7.4	7.87	7.94
BOD	mg/l	19	7	11	12
COD	mg/l	33	24	25	25
Nitrite	mg/l	<0.2	<0.2	<0.2	<0.2
Nitrate	mg/l	3.88	0.8	1.4	21
Total Coliforms	CFU/100ml	22700	29100	23000	14000
Fecal Coliforms	CFU/100ml	1300	200	2000	5000

Fig 5 a

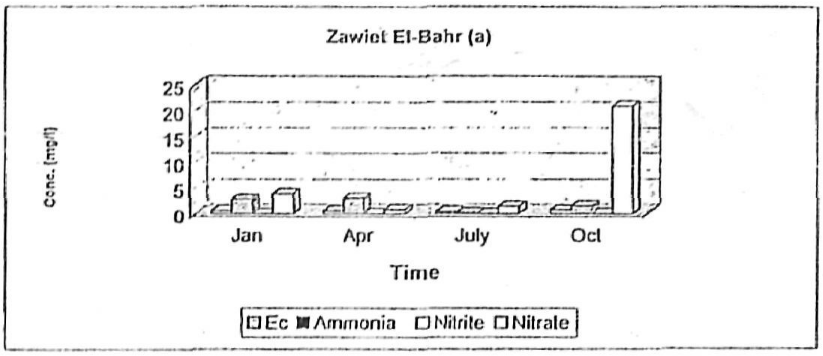


Fig 5 b

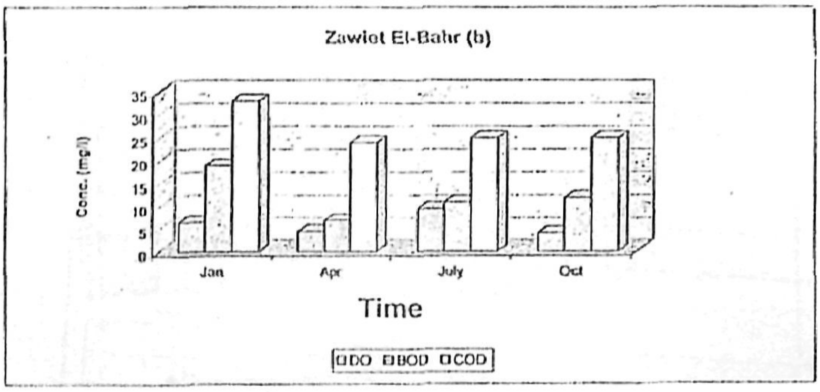


Fig 5 c

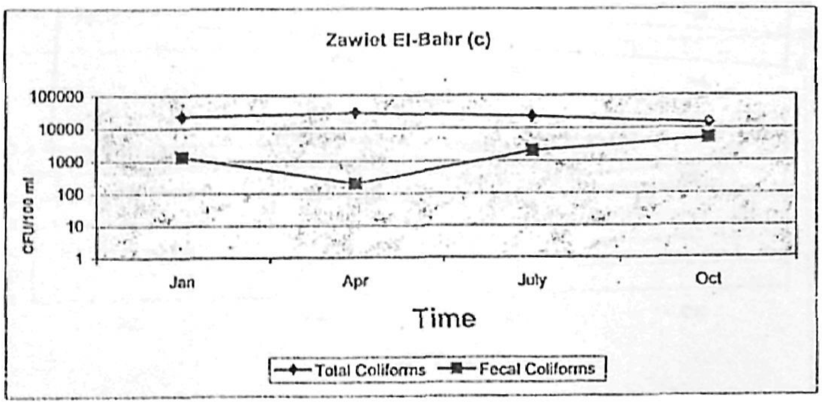


Table (6)The effect of Tala drain on the quality of Rosetta branch through 2004/2005

	Units	Jan	Apr	July	Oct
Temp.	C^0	14.3	19.9	22.4	25
Ec	mmhos/cm	0.797	0.576	1.68	0.474
TDS	mg/l	510	367	1077	303
pH		7.48	7.64	7.73	7.64
Ammonia	mg/l	3.5	3.1	19	12
DO	mg/l	2.4	6.18	4.9	2.32
BOD	mg/l	20	18	12	7
COD	mg/l	25	29	23	38
Nitrite	mg/l	0.17	<0.2	<0.2	2.10
Nitrate	mg/l	0.42	0.6	0.78	10.40
Total Coliform	CFU/100ml	12000	1100	1300	2000
Fecal Coliform	CFU/100ml	2000	90	200	330

Fig 6 a

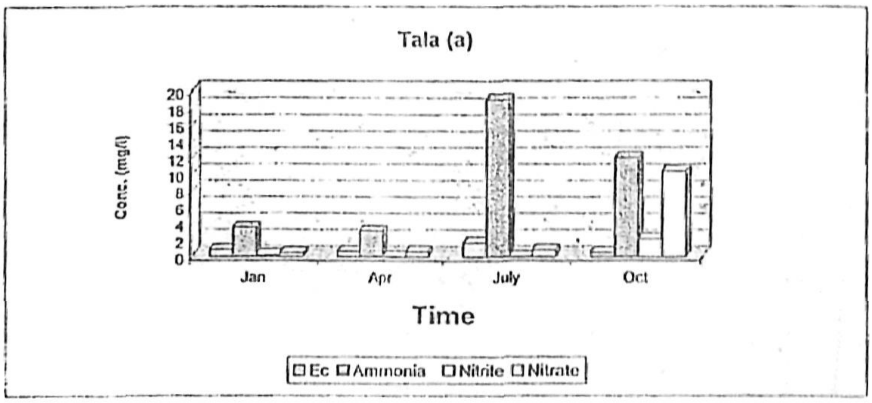


Fig 6b

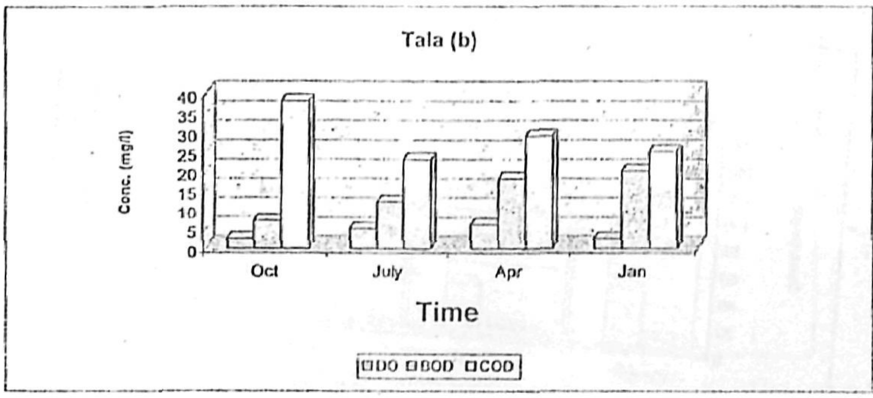


Fig 6c

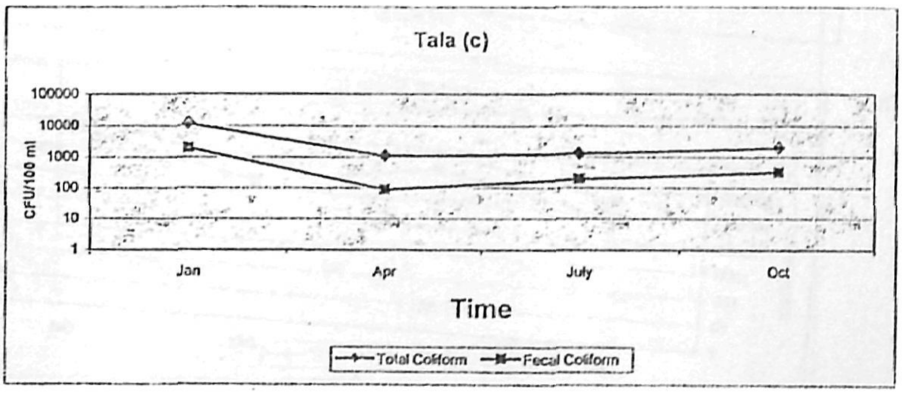


Table (7)Follow up of the effect of Salt & Soda wastes on the quality of Rosetta branch through 2004/2005

	Units	Jan	Apr	July	Oct
Temp.	C^0	25.2	22.9	30.7	24
Ec	mmhos/cm	1.229	0.881	0.567	1.438
TDS	mg/l	786.56	562	363	920
pH		8.42	10	8	7
Ammonia	mg/l	0.98	3	0.072	3.42
DO	mg/l	5.4	6	4.33	5
BOD	mg/l	42	35	29	50
COD	mg/l	90	57	43	150
Nitrite	mg/l	0.69	<0.2	<0.2	7
Nitrate	mg/l	10.5	<0.2	1.4	11
TC	CFU/100ml	350000	7500000	1050000	10000000
FC	CFU/100ml	65000	1750000	180000	5000000

Fig 7a

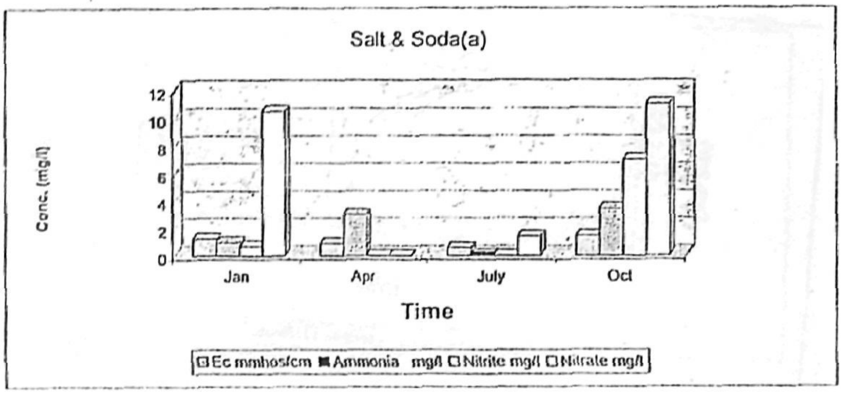


Fig 7b

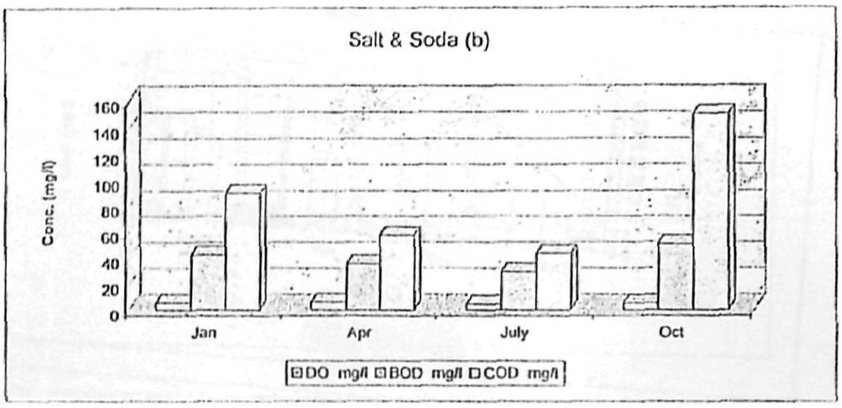


Fig 7c

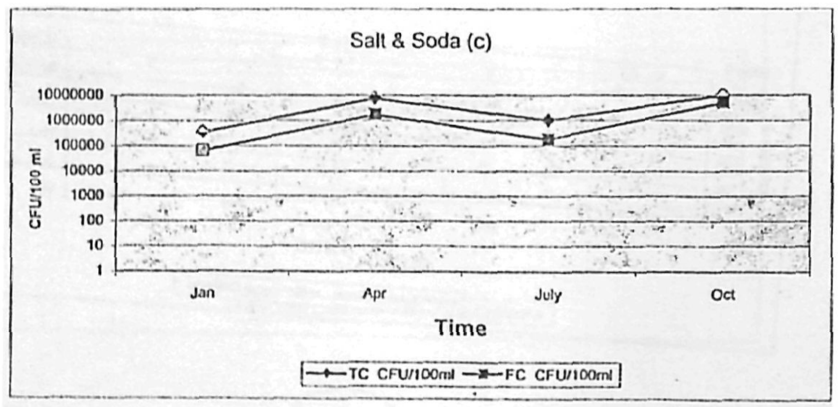


Table (8) The effect of El-Malia wastes on the quality of Rosetta branch through 2004/2005

	Units	Jan	Apr	July	Oct
Temp.	C^0	23.7	25	26	24
Ec	mmhos/cm	1.207	0.882	1.004	0.984
TDS	mg/l	772.48	565	642	595
pH		7.77	7.53	6.58	7.50
Ammonia	mg/l	0.15	14	0.77	2.1
DO	mg/l	2.4	4.9	3.5	5.5
BOD	mg/l	8	11	7	10
COD	mg/l	32	35	9	20
Nitrite	mg/l	0.698	2.00	<0.2	0.42
Nitrate	mg/l	8.5	11.00	2.08	14
TC	CFU/100ml	4300	9500	2740	6000
FC	CFU/100ml	400	1800	1110	1000

Fig 8a

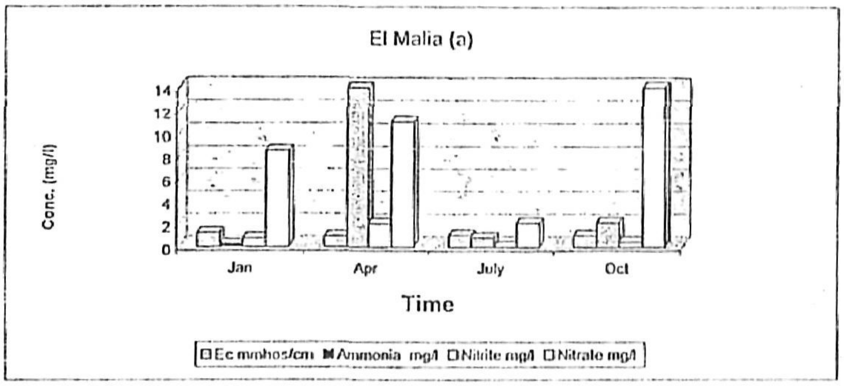


Fig 8b

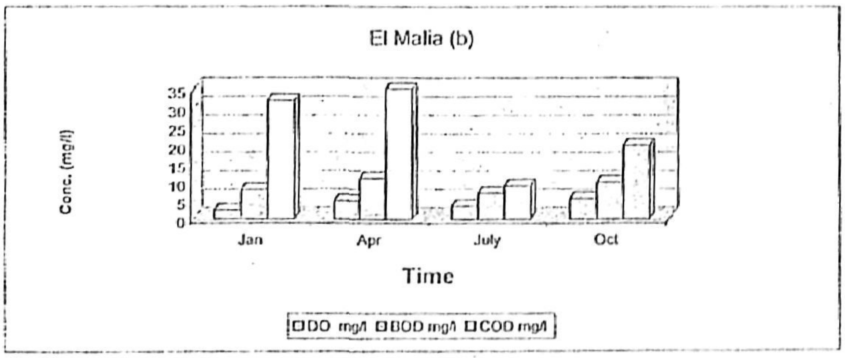


Fig 8c

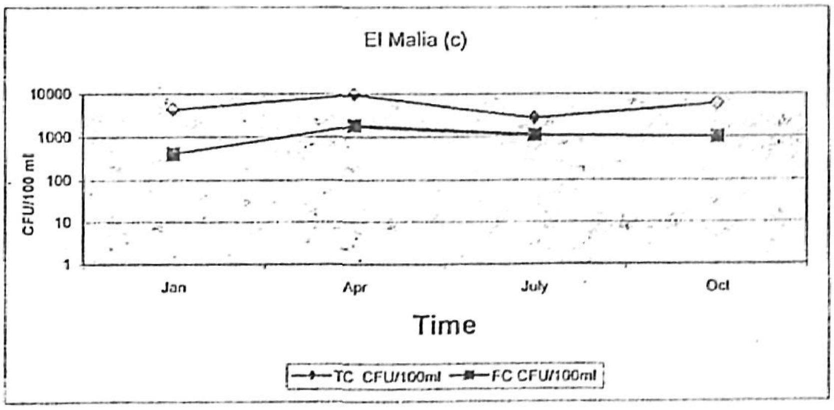
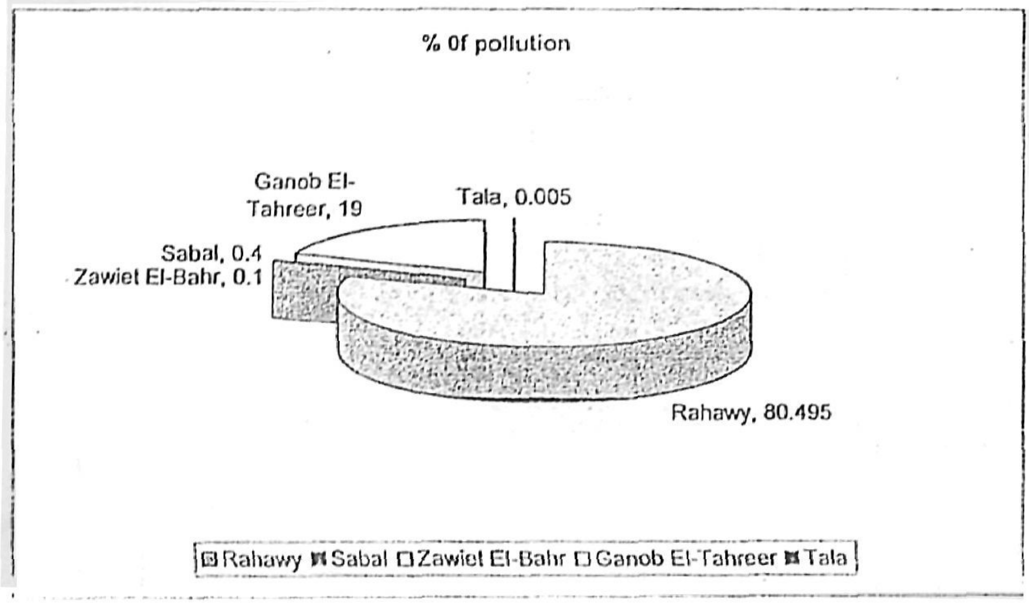


Table (9) The percentage of bacteral pollution of each drain through 2004/2005

Rahawy	Sabal	Zawiet El-Bahr	Ganob El-Tahreer	Tala	total
78501000	417600	88800	18917200	5600	97930200
44300200	56000	8500	425900	2620	44793220
80.495	0.4	0.1	19	0.005	
98.8	0.12	0.1	0.95	0.03	

Fig 9



GUIDE FOR AUTHORS

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2. Three copies of the manuscript should be submitted for review purposes.
3. Manuscripts should be typewritten and double spaced. Leave good margins on each side of the paper. Maximum number of pages is limited to 15 pages.
4. The entire manuscript should be paginated starting with the title page.
5. The metric system should be used and temperatures expressed in degrees Celsius or Kelvin. The use of S.I. units is recommended.
6. Manuscripts should in general be organized in the following order :-
   a) Title' b) Name(s) and affiliation(s) of author(s). c) Abstract
   d) Introduction. e) Methods, techniques, material studied. f) Results
   g) Conclusions h) Acknowledgements i) References
   j) Tables. k) Figures.
7. TESCE reserves the privilege of returning to the author for revision accepted manuscripts and illustrations which are not in the form given in this guide.
8. Submission of an article is understood to imply that the article is original and unpublished and is not considered for publication elsewhere.
9. One copy of the manuscript will be returned to the author with reviewers remarks and corrections. Author should make all necessary corrections and submit the original of the article for printing.

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The abstract should not exceed 500 words.

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1. A table should not exceed the printed area of the page.
2. Tables should be numbered according to their sequence in the text. The text should include reference to all tables.
3. Tables should be typewritten on separate pages, added to the manuscript. They should never be included in the text.
4. Each table should have a brief and self-explanatory title. Units of measurements should be added between parentheses.
5. Explanations essential to the understanding of the table should be given in footnotes at the bottom of the table.

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1. All Illustrations should be given separately, not pasted on pages and not folded.
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1. Formulas should be typewritten, if possible. Ample space should be left around the formula.
2. Subcripts and supercripts should be set off clearly.
3. Greek letters and other non-Latin or handwritten symbols should be explained in the margin where they are first used.
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5. Equations should be numbered serially on the right-hand side and in parantheses.
6. In chemical formulas the valence of ions should be given as e.g. :
   Ca^{2+} and CO_3^{2-} rather than Ca^{++} and CO_3^{--}
7. Isotope number should precede the symbol e.g. : ^{18}O.

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   b) For Books : Vanmeurs, A.P., Petroleum Economics, Elsevier (1972).
4. Periodical names can be given in full or abbreviated.

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1. Footnotes should only be used if absolutely essential.
2. If used, footnotes should be indicated by astrisks and kept as short as possible.

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