ENVIRONMENTAL INTERACTION OF DRAINED POLLUTANTS ON PLANKTONIC STRUCTURE (PHYTO-ZOOPLANKTON AND BACTERIA) OF WADI EL-RAYIAN AQUATIC ECOSYSTEM (EL-FAYOUM-EGYPT)

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Abstract

An ecological threat was recorded in El-Wadi Drain and its discharging area into the upper part of Wadi El-Rayian Lakes during June 11^{th}, 2001, conducting in mass death of fishes. Water samples were collected from different locations. Structure and density of phytoplankton, zooplankton and bacteria were investigated as the main biological indices which could explain some criteria about the status of the environmental conditions wcich caused the problem.

A total of 62 phytoplankton and 24 zooplankton taxa were identified and counted in the investigated samples. In the drainage water; density of both phyto and zooplankton were low comparing to that recorded under the common environmental conditions. Also, most of the recorded taxa in the drain were specific to polluted environment and completely different with that inhabiting the lake. Diatoms were dominated phytoplankton and most recorded genera (*Aulacoseira, Navicula, Nitzschia* and *Euglina)* are being tolerant to high organic pollution. Zooplankton was represented by only two species of Rotifers (*Lucane bulla* and *Cephalodella* sp) in addition to limited number of Protozoa (*Ciliophora* sp.) and free living nematodes.

Bacteriological status indicated that saprophytic and parasitic (total bacterial counts) ratio was lower than 1, and its population was maximized to $65x10^{11}/cm^3$. It was predicted that the drainage water might subjected to heavy polluted conditions. This conclusion was confirmed by high density of most probable number for both total and faecal coliforms (460 and $95x10^6/cm^3$) which is characterized to the raw sewage pollution.

Finally it was concluded that high amount of raw sewage was drained off in El-Wadi Drain water. Such pollution created sudden disturbance in the existence aquatic environment and exerted a destructive interaction with in the aquatic organisms and could result in the sudden death of fishes.

***Key wards*:** phytoplankton, zooplankton, bacteria, pollution, lakes, Wadi El-Rayian.

Introduction

In June 2001, the first part of Wadi El-Rayian Lakes was subjected to an ecological threat. It resulted in mass death of fishes at the discharging area of El-Wadi

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Drain into the Lake. *Inland Waters and Aquaculture Branch, National Institute of Oceanography & Fisheries* was arranged scientific teamwork to study the case and investigate the main environmental inference for the phenomena, and to recommend the solution program for recovering the problem.

Pollution is usually harmful to human health or capable of interfering seriously with the use of the water or its immediate environment. Changes in water quality exert a selective action on the flora and fauna, which constitute the living population of water, and the effects occurred can be used to establish biological indices of water quality. Changes in water quality may affect the amount of oxygen and nutrients present or cause the water to become toxic to some types of organisms. The change may result from the amount of inert solids present in the water (VanHorn, 1950).

Previously, chemical, physical and bacteriological criteria were considered to be easier to evaluate and apply than biological indices, which were thought to be relatively underdeveloped. Chemical and physical measurements, however, tend to measure only the cause of change in water quality, while biological tests deal primarily with effects of the change. In some cases particular groups of algae have been used to indicate the quality or type of water (Brook, 1965). Palmer, (1969) reported that most of the information available concerning algae in relation to polluted water is limited to water containing treated or untreated domestic sewage and closely related organic wastes. Latterly, Palmer (1980) discussed the natural purification of sewage pollution (and to some extent with regard to industrial organic wastes), algae and bacteria (and to a lesser extent, other organisms) are capable of bringing about the self-purification of water. Some kinds of algae are tolerant to sewage, that is, they are able to survive and may even be capable of growing and multiplying.

Zooplankton distribution is useful for the general monitoring of certain aspects of the environmental such as hydrography events, eutrophication, pollution, warming trends and long-term changes, which are sings of environmental disturbance (Michael, 1984)

The quality of water may depend decisively on its microbial content and identity of its microbial flora, water can be rendered unsatisfactory from technical or aesthetic point of view by the microorganisms it contains. However, the bacteriological examination of water is necessary first and foremost to disclose the presence of microorganisms that might constitute a health hazard. The total bacterial counts is presently the recommended procedure for water as well as wastewater bacterial determinations (Garbow, 1990). On the other hand, total coliform which includes faecal coliform, are the standard indicator of faecal pollution (APHA, 1980).

The present study was conducted as a part of a complete program to investigate the biological variables associated with the occurrence of this phenomenon. It was included phytoplankton, zooplankton structure and total bacterial counts, as well as total and faecal coliform as indicator for sewage pollution.

Materials and methods
Site description

Wadi El-Raiyan depression (703 km^2) is located in the Western Desert, Egypt, at El-Fayioum province (30°25`E and 29°10`N). After water level of Lake Qarun was rised above its normal standard and inundated the surrounding cultivated land. Fox (1951) suggested utilizing Wadi El-Raiyan depression as a reservoir for agriculture drainage water of El-Fayioum Governorate to solve the problem of increasing water level in Lake Qarun. A huge project involved a construction of an uncovered canal (10 km long) from the south-western edge of El-Fayoum, followed by a tunnel (8 km long and 3m diameter) to connect El-Wadi drain with the depression and to transfer about 2/3 of its drain water into the depression. It was exploited for the first time on April 26th 1973. The lakes consist of two major aquatic areas (Fig 1a). The first one receive the drainage water from El-Wadi Drain and lies at 10.5 m below sea level (covers an area about 52.8 km^2) and the second lies at 18.5m below sea level (covers about 110 km^2). The two lakes are connected by shallow canal (4.5km length) and densely covered with macrophytes. The formation of these lakes created a variety of new habitats, however, the adverse of creation on ecology of the area can not be ignored (Fouda & Saleh, 1988). The agriculture drainage water drained into the 1st part is loaded with pesticides, sewage and fertilizers as well as other effluents (Saleh *et al.*, 1988). Recently, El-Shabrawy (1996) studied zooplankton and benthos inhabiting the lakes. Fish resources development and water quality of the lakes were details by Anonymous (1997). Taha and Abd El-Monem (1999) investigated phytoplankton composition, biomass, and primary productivity of both lakes. In addition, Rabeh (1996 & 1999) monitored the faecal pollution of its environments.

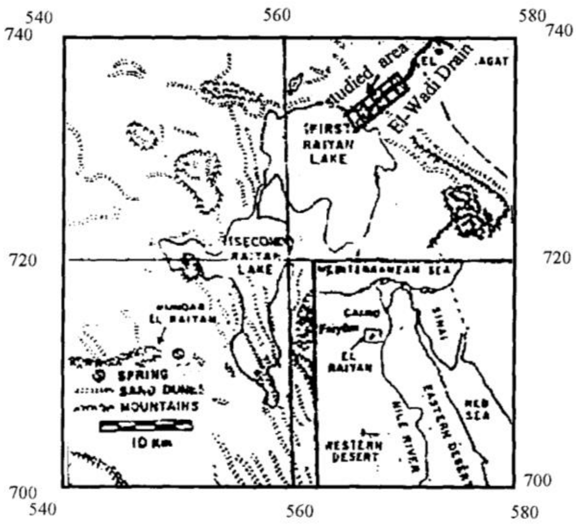

Fig. 1,a: Map of Wad El-Rayain Lakes.

Sampling stations

To cover the different ecological habitats of the studied area, 4 sampling locations were selecred as follow; two locations in El-Wadi Drain; the first was located before the tunnel at the pumping station, while second after the tunnel, just before the discharging point.

The third one was at the discharging (mixing) area, in front of the drain (Discharging area). The forth site was located inside the lake, away from the action of the drained water (inside the Lake) as shown in Fig. (1b).

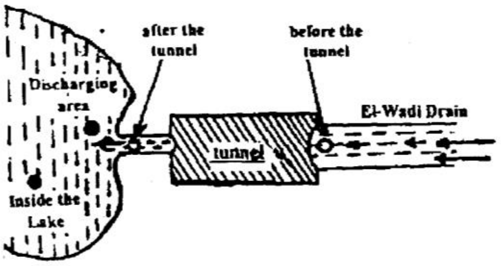

Fig. 1,b: Sketch for the sampling locations in El-Wadi Drain and the First Lake.

Phytoplankton examination

Samples of water for phytoplankton samples were preserved in 4% formalin immediately in the field. In the Lab, samples transferred into a glass cylinder and Lugol Iodine solution was added until its color reached to faint tea color. It was left 5 days for settling, then 90% of the supernatant was siphoned off using plastic tubes tided with plankton net (20μ) and adjusted to a fixed volume. Reduced samples were identified and counted under inverted microscope (mod. MEIGI) using Pallmar cell with a high power magnification (X 40 & 100). Phytoplankton identification was carried out according to: Cupp (1943); Hannford and Britton (1952); Deskachary (1959); Weber (1971); Tikkanen (1986); Mizuno (1990); Comper (1991) and Krammer and Long-Bertalot (1991).

Some diversity indexes were applied concerned with species structure and density to calculate diversity (Shannon and Weaver, 1949), richness (Menhinick, 1964) and evenness (Pielou, 1977) for each location.

Zooplankton investigation

Zooplankton samples were collected from the selected stations at the surveyed area. 50 liters were filtered through plankton net of 55μm mesh size at each station. Samples were immediately preserved in 4% formalin after collection. The major groups of zooplankton were subjected to detailed microscopic analysis. Zooplankton species were identified according to Koste (1987), Smirnov (1990) and Einsle (1993).

Bacteriological analysis

Bacteriological analyses were carried out to determine total bacterial counts (TBCs) using spread plate method (SPM) at 22 and 37°C, as well as most probable number (MPN) of total and faecal coliforms.

Media and incubation temperatures:

A. Plate count agar (APHA,1980) was used for detecting TBCs at 22 and 37°C for 72 and 48 hr., respectively.
B. MacConkey Broth was used for determining total coliform (TC) and faecal coliform (FC) at 37°C for 48 hr and 44.4°C for 24 hr., respectively.

Bacterial nature and density were used as indicator for pollution status. TBCs is a good criteria for the degree of pollution for each site and represented for statistical analysis with other parameters. Effect of such pollution on phyto and zooplankton community structure was interacted, particularly, to emphasize the tolerant and sensitive species.

Results

Some physical variables

Table (I) shows the main physical characteristics for the investigated locations in El Wadi Drain, discharging area and inside the first lake. The pH values of the drainage water tends to be in the acidic site (6.29 & 6.62) with slow respective increasing towards the lake. It was maximized to 7.45 inside the lake. The drainage water had low oxygen content with an average value of about 2.83 mgO_2l^{-1}, while it reached to more than 6.4 mgO_2l^{-1} in the lake water. The drain water salinity were 1.25 and 1.5‰ before and after the tunnel.

Phytoplankton

62 phytoplankton taxa related to 4 classes were identified in the given samples at the different locations as illustrated in Table (II & III). Among them, 24 species related to Bacillariophyceae, 14 Cyanophyceae, 16 Chlorophyceae and 8 Euglinophyceae. Phytoplankton density for each site are shown in Fig. (2), while the number of species are illustrated in Fig (3) and density ratio for the different classes are presented in Fig (4). From the given tables and figures, it can be summarized the local variations in phytoplankton composition as follow:

The two stations of El-Wadi Drain (before and after the tunnel) were more or less similar in both density (95 and 91unit.l^{-1}) and number of phytoplankton species (21 and 19). Their species structure were dominated by diatoms (8 & 10 spp) as shown in Fig (3) and contributed to 74.7 and 64.8% from the total density, respectively (Fig 4). *Aulacoseira granulata var. angustissima* (31% from diatoms), *Navicula canalis* (25.4%) and *Nizschia fonticula* (23.9%) were predominated in the first location, while in the second one, diatoms were dominated by *Aulacoseira granulata* (28.8%) and *Navicula exigua* (18.6%). Euglinophyceae occupied the second position (5 spp) constituting 12.6% from the total count at the pumping station while blue-greens occupied the second rank

(5 spp) at the discharging point forming 20.9%. Green algae represented lowest species diversity (4spp) and density (4.2%) in the first station and did not observed in the second.

Table (I): Physical characteristics, Phytoplankton statistics, zooplankton density, and bacterial counts for the different study sites at Wadi El-Rayian aquatic ecosystem.

Phytoplankton parameters	El-Wadi Drain		Discharging area	Inside the lake
	before the tunnel	after the tunnel		
Physical variables				
pH	6.29	6.62	6.75	7.45
Dissolved oxygen ($mg.l^{-1}$)	2.83	2.83	6.4	> 6.4
Salinity (‰)	1.25	1.5	-----	----
Phytoplankton statistics				
Density ($x10^3 unit.l^{-1}$)	95	91	120	200
Number of spp.	21	19	25	30
Diversity	0.491	0.401	0.338	0.642
Richness	2.155	1.992	2.282	2.739
Evenness	0.161	0.136	0.105	0.189
Zooplankton density ($org.m^{-3}$)				
Rotifers	30	30	40	435
Copepods	0	0	0	775
Cladocera	0	0	0	215
Protozoa	10	20	100	0
Total count	40	50	140	1425
Bacteriological counts				
Total count ($x10^{11} cm^3$)				
Saprophytic	51	47	33	30
parasitic	65	63	30	28
Saprophytic: parasitic	0.78	0.75	1.1	1.07
Coliform ($x10^6 cm^3$)				
Total	460	290	23	12
Faecal	95	93	0.75	0.14

Table (II): Statistical correlation between the planktonic variables investigated in the different study sites at Wadi El-Rayian aquatic ecosystem.

Parameters	*Row 1*	*Row 2*	*Row 3*	*Row 4*	*Row 5*	*Row 6*	*Row 7*	*Row 8*	*Row 9*
1. Bacillariophyceae	*1*								
2. Cyanophyceae	*-0.94*	*1*							
3. Chlorophyceae	*-0.73*	*0.92*	*1*						
4. Euglenophyceae	*0.93*	*-0.95*	*-0.83*	*1*					
5. Total phytoplankton	*-0.83*	*0.97*	*0.98*	*-0.90*	*1*				
6. Total zooplankton	*-0.91*	*0.997*	*0.94*	*-0.96*	*0.98*	*1*			
7. Faecal coliform	*0.34*	*-0.61*	*-0.84*	*0.40*	*-0.77*	*-0.63*	*1*		
8. Total coliform	*0.41*	*-0.62*	*-0.77*	*0.36*	*-0.73*	*-0.62*	*0.95*	*1*	
9. Total bacterial count	*0.47*	*-0.70*	*-0.87*	*0.48*	*-0.82*	*-0.71*	*0.98*	*0.98*	*1*

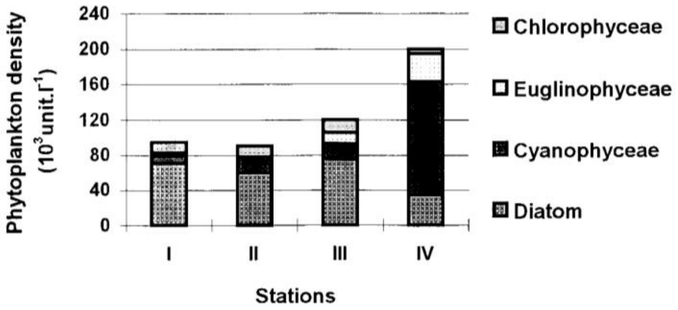

Fig. 2: Phytoplankton density in the investigated sites.

In the discharging area, phytoplankton structure was more diverse and its class composition was different comparing with that found in the Drain. It comprises 25 spp and density of 120 unit.l^{-1}. However, the diatom species (predominant) increased to 12 spp, and its density ratio decreased to 62.5% with the dominance of *Navicula exigua* (17.3%) and *Nizschia holsatica* (14.7%) while the ratios of the other classes were increased.

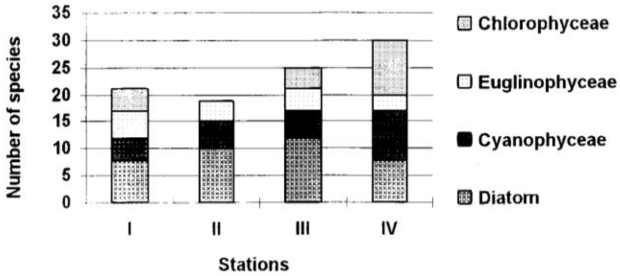

Fig. 3: Number of phytoplankton species for different classes in the investigated sites.

In site the lake, the picture of the phytoplankton structure was completely different from that sited in the other locations. It showed an increase in both quantitative and qualitative contents of phytoplankton. Its density reached to $200x10^3$ unitl^{-1} and the identified taxa reached to 30 spp (Figs. 2&3). Species composition of that station was predominated by blue-greens (9 spp) forming about 64.5% of the total count, while diatoms ratio decreased to about 17.0% (8 spp) as shown in Fig. (4). *Gomphosphaeria pusilla* and *Lyngbya limnetica* were the most dominated blue-greens accounted for 62.8 and 21.7% of the total algal density, respectively. Green algae composed about 15.5% from the total count but it represented by the highest number of species (10 spp). Euglinophyceae was scarce in both counting (3%) and number of species (3 spp).

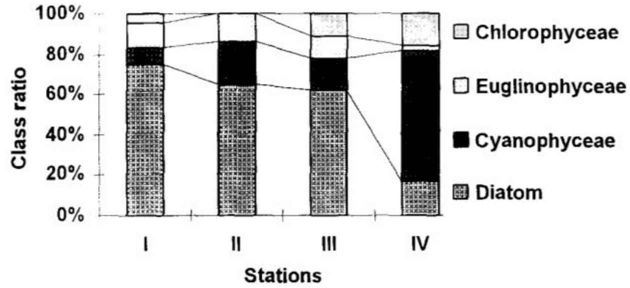

Fig. (4): Density ratio for different phytoplankton classes in the investigated sites.

Table (III): Phytoplankton species of Wadi El-Rayian aquatic ecosystem (El-Wadi Drain, discharging point, discharging area and the upper lake) during fish's mortality (June 2001).

Phytoplankton taxa	El-Wadi Drain I	El-Wadi Drain II	III	IV
- **Bacillariophyceae**				
Aulacoseira granulata Her. Simon.		+	+	
A. g. var. *angustissima* O.Muller.	+			
Cocconeis diminuta pant				+
Cyclotella ocellate Pant		+	+	+
Cymbella affinis Kutz			+	+
Diatoma vulgare Bory				+
Fragilaria capucina Desm.			+	
Navicula canalis Bory	+			
N. confervacea Kutz.			+	
N. creptocephala Kutz.		+		
N. exigua Muell.	+	+	+	+
Nizschia acicularis W. Sm.		+		
N. amphibia Grun.		+		
N. closterium (Ehr.) W. Sm.	+	+	+	
N. filiformis W. Sm.	+			
N. fonticula Grun.	+			
N. holsatica Kutz.			+	
N. lorenziana	+	+		+
N. palea (Kutz.) W. Sm.			+	
N. paradoxa Bory.				+

Table (III): continued.

	El-Wadi Drain			
Phytoplankton taxa	**I**	**II**	**III**	**IV**
Pleurosigma delicatulum Her.		+	+	
Rhoicosphenia curvata Kutz.				+
Syndera ulna Ehr.	+	+	+	
S. rumpens Kutz.			+	
II- Cyanophyceae				
Anabaena circinalis Kutz.			+	
A. flosaquae Breb.		+	+	+
Chroococcus dispersa Lemm.		+	+	+
C. limneticus Lemm.				+
C. minutus Kutz.				+
Coelosphaerium kuetzingianum Nageli.				+
Gomphosphaeria pusilla Van Goor.				+
Lyngbya limnetica Lemm.	+			+
Microcystis aeruginosa Kutz.	+	+	+	+
Mirismopidia tinnisima Lemm.		+		
Phormidium incrustatum Nageli.	+			
P. retzii (Agardh) Gomont.		+	+	
Oscillatoria agardii Gomont.	+			
O. tenuis C. A. Agardh.				+
III- Chlorophyceae				
Ankistrodesmus fusiformis Corda.				+
Chlorella vulgaris Beyer.				+
Chlorogonium maximum Skuj.	+			
C. elongatum Dang.				+
Closterium dianae. Her.	+			+
C. kuetzingii Breb.				+
C. setaceum Breb.				+
Coelastrum microporum Nageli.				+
Micractinum pusillum Fres.			+	
Oocystis borgei Snow.				+
Planktonema lauterbornii Schmid.				+
Pediastrum tetras Her.			+	
Protococeus viridis Agar.			+	
Scenedesmus obiquus Kutz.	+			+
S.quadricauda (Turp.)			+	
Tetraedron trigonum Naeg.	+			
IV-Euglinophyceae				
Euglina acus Her.			+	+
E. gracillis Klebs.	+		+	
E. intermidia Schmid.	+	+		+
E. proxima Dang.	+	+		
E. spp	+	+		+
Paramisium sp.			+	
Phacus sp.	+		+	
Trachelomonus acanthostoma Stok.		+		

Species diversity of phytoplankton (Table I) indicated that the highest diversity, richness and evenness were found inside the lake, while the lowest values of diversity and evenness were recorded at the discharging area. It is important to mention that, in the drainage water, the diversity indixes values were lower after the tunnel comparing to that found before the tunnel.

Zooplankton

A total of 24 zooplankton taxa belonging to Rotifera, Copepoda and Cladocera were recorded in the surveyed area. As shown in Table (IV) almost entire of zooplanktonic species were missed at stations 1&2 (El-Wadi Drain before and after the tunnel), faintly represented at station 3 (discharging area) and well represented at station 4 (inside the lake). The spatial structure of zooplankton in the area under investigation can be summarized as follows:

In the drain water, zooplankton standing crop was negligible. It was only represented by two rotiferian species (*Lucane bulla* and *Cephalodella* sp.) with low density (1-3X 10^3 org.m^{-3}). A limited number of protozoa (*Ciliophora* sp.) was also detected. There was no sign of copepoda and cladocera.

Table (IV): Zooplankton species and density (X10^2 org.m^{-3}) inhabiting in Wadi El-Rayian aquatic ecosystem (El-Wadi Drain, discharging point, discharging area and the upper lake) during fish's mortality (June 2001).

	El-Wadi Drain			
zooplankton taxa	**I**	**II**	**III**	**IV**
- **Rotifers**				
Brachionus calyciflorus				15
B. plicatilis				25
Cephalodella sp.	30	10	20	
Euchalanus dilitata			20	15
Hexarthra oxyuris				25
Keratella tropica				15
Lecane bulla		20		25
L. luna				15
Proalides sp.				275
Trichocerca pusilla				25
II-Copepods				
Calaniod copepodid				75
Cyclopiod copepodid				20
Mesocyclops ougunns				25
Nauplius larvae				250
Thermodaiptomus galebi				175
Thremocyclops neglectus				50
III- Cladocera				
Alona rectangular				25
Ceriodaphnia reticulata				25
Chydorus sphearicus				25
Diaphanosoma mogolainum				90
Macrothrix laticornis				50
IV-Protozoa				
Ciliophora sp.		20	40	
Textularia sp.			40	
V-Free living nematodes	10		20	

The situation in the discharging area shows a slight increase in zooplankton population density to $14X10^3$ org.m^{-3}. It was mainly due to increasing the neroplanktonic density.

Comparing with the upper 3 locations, zooplankton community was highly flourishing in te firest lake of Wadi El-Rayan, where 10 rotiferian, 3 copepods and 5 cladoceran species were detected, with standing crop of about $143X10^3$ org.m^{-3}. Copepoda dominated the other groups, contributing 54.4% of the total zooplankton numbers. It was represented by two cyclopoid (*Thermocyclops neglectus* & *Mesocyclops ougunnus*) and one calanoid (*Thrmodiaptomus galebi*). Rotifera occupied the second rank, forming 30.5%, with standing crop of $44X10^3$ org.m^{-3}. *Proalides* sp. seems to be the most abundant species whereas *Cephalodella* sp. was completely missed in spite of its occurrence in the upper 3 locations. Cladocera had the third position with a population density of $22X10^3$ org.m^{-3}. Five species, dominated by *Diaphanosoma mogolainum,* were recorded.

Bacteriological counting

The total bacteria developed at 20-22 °C are saprophytic and non-pathogenic to human being. Variation in their counts usually reflects changes in the environment and its content of organic matter. Their counts in the studied area ranged from $30x10^{11}$ to $51x10^{11}$/ml. On the other hand, bacteria developed at 37 °C are mainly parasitic types. Their counts fluctuated from $28x10^{11}$ to $65x10^{11}$/ml with a sharp increase comparing with that recorded previously (Rabeh, 1999). As regards site-wise variation there was a gradual decrease in TBCs from the drain water toward inside the lake. Bacterial ratio between saprophytic and parasitic counts was less than one in the drain being 0.78 and 0.75, while the ratio was slightly increased in the other two stations (discharging area and inside the lake) recording 1.1 and 1.07. TC ranged from $12x10^6$ to $460x10^6$ /100ml while FC fluctuated between $0.14x10^6$ and $95x10^6$ /100ml. Again here, there was a gradual decrease in TC and FC from the drain water towards inside the lake.

Statistical correlation

Statistical correlations between the planktonic variables inhabiting the studied area are illustrated in Table (II). It is indicated that oscillation of phyto and zooplankton density were associated together ($r = 0.98$) and the increase in zooplankton was mainly correlated with blue-greens ($r = 0.997$). Water environment contained high bacterial count, coliform and faecal coliform are limited to both phytoplankton ($r = -0.82$, -0.73, and -0.77, respectively) and zooplankton ($r = -0.71$, -0.62, and -0.63, respectively). Greens and blue-greens algae were more sensitive for such pollution ($r = -0.87$, -0.77, and -0.87 for greens and -0.70, -0.62, and -0.60 for blue greens, respectively) comparing with the other two species.

Discussion

The type, number and distribution of organisms in an aquatic habitat are the basic components of community structure, and these reflect the environmental conditions of the life support system. In the present environmental conditions, the main tolerant phytoplankton genera flourished were *Aulacoseira, Navicula, Nitzschia* and *Euglina*, which are known as tolerant forms to high organic pollution (Palmer, 1969). Bacteriological investigation confirmed the presence of pollutants and revealed that both drain and lake environments were loaded with saprophytic and parasitic bacteria (developed at 37°C) which can be derived from soil, sewage excreta. (APHA, 1980).

The defined pollution in the drain water effected not only the plankton structure but also its physical and chemical characteristics. In addition that, its action has extended to the lake water. The destructive interaction of the pollutants was noticed on both phyto and zooplankton population comparing with that recorded at the corresponding locations previously (Anonymous, 1997). Phytoplankton can be affected by such pollution in a number of ways. They may be discouraged from growing as a result of being deprived of sunlight. The substances may be toxic or may ecologically modify the physical or chemical environment sufficiently to retard or prevent the plankton growth; they may suddenly have competition with additional organisms. Certain phytoplankton may be stimulated by an increase in their growth and multiplication; a change may also occur in the individual types or the groups of organisms that predominate. Some phytoplankton may form blooms, the total algal population may be increased or decreased; oxygen production and utilization of nutrient substances by algae may be greatly modified as well as the color, odor, and taste of the water may be changed by the algae (Palmer, 1980). The effect of the drainage pollutants on zooplankton community can be cleared by comparing the present results with that recorded by El-Shabrawy (1999), when he recorded 23 rotifer species at El-Wadi Drain (input), in addition to 6 copepods and 8 cladocerans. Also, the drainage water showed an abnormal increase in its bacterial content. Using the TBCs as indicator for pollution status, phytoplankton was more sensitive for such pollution (r -0.82) than zooplankton (r -0.71). Variations of their densities were correlated together (r 0.98) in response to the action of the pollutants in the aquatic environment. On the same way, Yen *et al* (1996) mentioned that the wastewater characterization from the *Godige pulp* and *papors* in River Bein Hoa (Vietnam) lowered the species diversity and abundance of phytoplankton, zooplankton and zoobenthos to 20-40%.

In the present study, blue-greens and green algae were high sensitive for such pollution (r -0.70 and -0.87), while Euglinophyceae and diatoms were slightly tolerant (r 0.48 and 0.47). So, diatoms constituted the highest ratio of phytoplankton density (74.7%) in the high contaminated site (the Drain) and minimized (17.0%) in the lowest polluted area (inside the lake). In this respect, Cupp (1943) stated that diatom species can live as single, free in water, may become attached to the substratum by gelatinous stalk. Several types of associations exist between diatoms and other organisms. It may live on animals or attached to other plants and occasionally become broken off to be collected with the plankton. A few species with a complete absence of pigment have been described as saprophytic. Such forms are found usually where decaying organic matter is abundant in the water. Also, diatoms utilize ammonium nitrogen as readily as, or even in preference to, nitrogen (Harvey 1940) which increased in such conditions as byproduct for degradation of the organic matter.

The sudden increase in bacterial counts comparing with the previous data (Rabeh, 1999) reflects an early sign of sewage pollution (Senior, 1989). The ratio of the bacteria recovered at 22 and 37 °C helps to explain any sudden fluctuation in the bacterial contents. In non-polluted water, the ratio is usually 10, while in polluted waters it is less than 10. The ratio of the counts at 22 °C to those at 37 °C in the studied area were slightly lower or higher than 1. So, the studied area would be heavily polluted with crude sewage (APHA, 1980). A more direct and sensitive measure of pollution by sewage is by the counting of indicator organisms such as total and faecal coliforms in the water sample. Coliform bacteria have served as indicators of recent faecal contamination of water and their densities have been utilized as criteria for the degree of such pollution (Menon, 1974 and Rabeh, 2001). Thus, the densities of these bacteria in the present investigation confirm that the studied area might subjected to heavy recent sewage pollution.

Presence of such pollution on the drain water led to severe drop in its oxygen contents and shifted the pH to slightly acidic. These variables had a direct and indirect influence on density and/or activity of the aquatic habitat. Myers (1934) distinguished *Cephalodella* sp as acidic water species. This agree typically with the occurrence of that species in El-Wadi Drain and its discharging area. in this respect; Bagde and Varma (1991) reported that the pollution by raw sewage are heavily consumed dissolved oxygen, consequently reduce its contents in the water body which is more vigorous in warm weather. In addition, raw sewage creats favorable anaerobic conditions for the growth of anaerobic bacteria especially sulphate-reducing bacteria, which produce the hydrogen sulphide (H_2S) gas. In this connection, Zobbel (1946) reported that H_2S in concentrations of about 3 $mg.l^{-1}$ is toxic to almost all forms of life in the aquatic systems.

Household sewage contains many kinds of organic material together with products formed from their partial, preliminary decomposition. In addition, the phosphates from detergents and small amounts of other wastes are usually present (Gainey and Lord, 1952). The interaction of both algae and bacteria on sewage-polluted water has been discussed by Palmer (1980) and it can be summarized as follow: algae utilize nitrogen and phosphorus salts that are present, and in growing vigorously they carry on photosynthesis and release oxygen into the water as a byproduct. Sewage-polluted water is low in its dissolved oxygen as found in the drain, since bacteria have already used what oxygen in initiating the decomposition of organic wastes. The oxygen added by the algae permits the bacteria to continue decomposing of sewage. The waste products produced include ammonia nitrates and phosphates, which immediately serve as additional nutrients for the algae. Thus, algae stimulate bacteria and bacteria stimulate algae. Both types of organisms increase rapidly in numbers and the breakdown of the sewage is therefore enhanced. Unsightly partially insoluble turbid, gray, unstable, odoriferous material is changed into simpler, soluble, odorless, stable, clear, colorless, inorganic compounds.

Phytoplankton diversity, richness and evenness were lower in the drain and increased inside the lake water due to the action of the pollutant contents in such locations. In a similar case Kulshrestha *et al* (1989) found an obvious decrease in the diversity and abundance of phytoplankton and zooplankton with increasing sewage and industrial pollution in River Khan (India). Also, Coler and Rockwood (1989) reported that the more diverse a community is the greater the degree of interaction within and between the biota and the abiotic environment.

The variation of phytoplankton structure in the different locations of the studied area can be realized to: after domestic sewage or effluent has polluted the drain water, the algae present react in a manner that is of considerable importance. During the process of natural purification, algae oxygenate the water and also utilize byproducts of the purification process. The kinds and numbers of algae and other organisms in the sewage-polluted portion are different from those present in the unpolluted portion inside the lake or above the sewer outlet. On this manner; Palmer (1969) stated that as the sewage goes through stages of decomposition in the stream, the numbers and kinds of microorganisms continue to change until eventually the aquatic flora and fauna in the newly purified water become somewhat similar to those found above the point of pollution.

The presence of organism in an environment indicates that its minimal environmental requirements are being met, while its absence could be attributed not only to unsuitable environmental conditions, but to lack of access to the area or competition for its particular niche (Coler and Rockwood 1989). These common-sense observations form the rationale behind the use of organisms as indicators of pollution. Certain species of zooplankton become adapted to certain levels of pollutant, several species of freshwater protozoa are excellent indicators of certain specific conditions of pollution (Cairns, 1965). Also, rotifers are good indicators of saprobity (organic pollution manifested by BOD and dissolved oxygen) (Sladecek, 1983).

During the process of purification in the polluted water, Whipple, *et al* (1948) divided the stream into several zones. The zone of degradation, (polysaprobic zone), the zone of active decomposition, the third area is the zone of recovery (beta-mesosaprobic zone) and the zone of cleaner water (oligosaprobic zone) and discussed the specific characters for each zone. In the present case, the biological recovery cleared that it lies in the zone of active decomposition. This suggestion was confirmed by the presence of some zooplankton species such as *Lucane Bulla* and *Cephalodella* sp which can be used as indicator for active stage. Klimowicz (1973) found *Lucane luna* and *Cephalodella* sp in an activated sludge plant in Warsaw.

Conclusion

High amount of raw sewage was drained off in El-Wadi Drain water that caused a sudden disturbance in the existed aquatic environment. It exert a destructive interaction with the aquatic organisms and could result in the sudden death of fishes by either of the following: consumption of more oxygen by bacteria in biodegradation of the heavy organic matter (load) of raw sewage and/or creating a favorable anaerobic conditions for the growth of anaerobic bacteria. It is worthy to mention that the tunnel (9 km long) help in creating the anaerobic conditions especially in the hot weather. To reduce the destructive action of the drainage water on the lake environment, it must be allowed to stay under natural treatment process before drained into the lake.

Warning for future problems and nuisance in the lake water

Streams and lakes which have been polluted with organic compound gradually become richer in algal nutrients, especially nitrates and phosphates, which are incorporated into the cells of algae during self-purification process. As algae die, the nutrients are released into the water after the algal protoplasm decomposed. This often stimulates the rapid development of nuisance algae that may form blooms or surface mats, cause taste and odor problems, and clog filters and screens in water treatment plants. It may also interfere with fishing, boating, swimming, and fish culture. In some cases the nuisance algae are toxic to both man and animals. They also make the body of water unsightly (Heukelekian 1960).

It is essential, therefore, to emphasize that there great need for reducing the pollution load in streams and lakes by developing sewage treatment plants and processes for treating wastes. Tertiary sewage treatment is now being tried in which phosphate is removed before the effluent flows into the water. This would rob the algae of one of the essential nutrients required for growth (Albertson and Sherwood, 1969).

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الأثر البيئى لملوثات الصرف على مكونات الهائمات (النباتية-الحيوانية البكتريا) فى مياة وادى الريان (الفيوم- مصر)

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تعرض مصرف الوادى الذى يصب فى الجزء الأول من بحيرات وادى الريان إلى كارثة بيئية يوم ١١ يونيو ٢٠٠١، حيث لوحظ نفوق كميات كبيرة من الأسماك أمام مصب المصرف.

تم جمع عينات من مياه المصرف والمصب ومنطقة الخلط ثم من داخل البحيرة. وقد تم تحليل العوالق الموجودة بها (نباتيه وحيوانية وبكتيرية) وذلك لفحص نوعية وكثافة تلك العوالق والتى هى من أهم العوامل البيولوجية التى تسهم فى إبراز بعض المعلومات عن وضع المتغيرات البيئية التى أدت إلى هذه الكارثة.

تم تعريف ٦٥ نوع من العوالق النباتية و ٢٤ نوع من العوالق الحيوانية فى تلك العينات. فى مياه المصرف كانت كثافة هذه العوالق قليلة ونادرة مقارنة بما سبق تسجيلها فى الظروف البيئية المعتادة. كما أن معظم الأنواع التى سجلت كانت من تلك التى تتواجد فى البيئات الملوثة وقد اختلفت تماماً مع تلك التى تعيش داخل البحيرة.

تسيدت الدياتومات الهائمات النباتية وكانت معظمها من (*Aulacoseira*, *Navicula*, *Nitzschia* and *Euglina*) التى تتحمل الملوثات العضوية. أما الهائمات الحيوانية فقد مثلت بنوعين من العجليات (*Lucane Bulla* and *Cephalodella* sp) بالإضافة إلى عدد محدود من الأوليات (*Ciliophora* sp) والطفيليات.

وقد أظهرت الدراسات البكتيرية أن النسبة بين الأنواع المترممة والطفيلية أقل من ١. مما يجزم بتعرض المصرف إلى حالة تلوث كثيفة. والتى قد وصلت كثافتها العددية إلى ٦٥ ، ٥١ × ١٠^{١١} /سم^{٣}. وقد حسم هذا الاستنتاج بزيادة كثافة البكتيريا القولونية والبرازية (٦٠ ، ٩٥ × ١٠^{٦} / سم^{٣}) والمميزة لتلوث الصرف الصحى.

وأخيراً يتضح أنه قد تم تسرب كمية كبيرة من مياة الصرف الصحى إلى مصرف الوادى مما ترتب عليه خلل بيئى مفاجئ فى مياه المصرف تسبب فى تأثير مدمر على الأحياء المائية وكذلك نفوق الأسماك.