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ECOLOGICAL AND FISHERY INVESTIGATIONS OF THE NOZHA HYDRODROME NEAR ALEXANDRIA 2000 – 2001

1. CHEMISTRY OF THE NOZHA HYDRODROME WATER UNDER THE CONDITIONS OF FERTILIZERS APPLICATIONS

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ABSTRACT

The Nozha Hydrodrome near Alexandria is being fertilized by superphosphate and ammonium nitrate. Fertilization is carried out with the aim of increasing the annual fish production of the Hydrodrome. This production has been about 60,000 tons and increased to 200,000 tons after fertilizers application. The water chemistry of both the Hydrodrome as well as its feeding canal were investigated.

The average seasonal values of pH ranged from 7.02 to 7.73 and from 8.13 to 8.67 in the feeding canal and the Hydrodrome waters respectively.

The average values of total dissolved solids ranged from 0.32 and 0.58 gm/L in the feeding canal, compared with 2.34 and 3.86 gm/L in the Hydrodrome water.

It can be pointed out to the fact that the Nozha Hydrodrome is well aerated. The average values of dissolved oxygen varied between 5.60 and 9.05 ml/L during summer and winter in respective.

The average values of nutrient salts in the Hydrodrome water were found to fluctuate between: 0.92 to 2.35 µg at/L for phosphate 1.44 to 6.98 µg at/L for nitrate and 3.94 to 24.43 µg at/L for silicate.

These ecological parameters indicate that the Nozha Hydrodrome water is a suitable environment for living, growing, and breeding of most of the fish species inhabiting this fish farm under the conditions of the application of inorganic fertilizers.

Among the inorganic nitrogen compounds it was found that nitrate is the dominant species in the Nozha Hydrodrome.

Based on the data presented it seems that the rates of fertilization being applied at the Hydrodrome during the last few years may be decreased. This will reduce the expenses of fertilization process without any expected serious effect on decreasing either the primary or annual fish production. On the other hand this will help in avoiding the attacks of blue green algal blooms.

INTRODUCTION

The Nozha Hydrodrome is an artificial small lake separated from Lake Mariut since 1939. Rearing of fresh water fish species, mainly Tilapia, as well as other species of marine origin such as gray mullet was being carried out in the Hydrodrome during the last 50 years.

The annual fish production of the Nozha Hydrodrome hardly exceeded 200 tons through the last ten years (Records of Egyptian Fisheries Company). This means that the rate of fish production was about 167 kg per feddan. Therefore, a long term of fertilizing the water budget of the Hydrodrome started in 1982 using phosphorus and nitrogen fertilizers on experimental scale for two years.

As a result of such fertilizers application, chlorophyll as an index of plankton biomass increased from 2 mg/m^3 before fertilization to 29 mg/m^3. This increase in plankton biomass resulted in an increase in fish yield from 54 ton/year to 346 ton/year at the end of the experiment (Wahby *et al*, 1993).

It is believed, that the low rates of fish yield in the Hydrodrome can be attributed to other reasons rather than food availability. One of such reasons is the abundance of carnivorous fish species, specially those belonging to catfishes which occur in high densities. These fish species depend in their feeding on consuming fish larvae with considerable numbers (Alsayes *et al*, 2002).

However, the fisheries and environment authorities at the Nozha Hydrodrome tended, during the last few years, to the application of phosphorus and nitrogen fertilization with the aim of increasing the primary production. Such fertilization started on long-term process and durated through the last five years.

The present study aims to investigate the effects of fertilizing the Hydrodrome with phosphorous and nitrogen fertilizers on the chemical composition of the water.

It is aimed also to indicate to what extent is the water quality of the Hydrodrome suitable for the survival of the fish populations under the conditions of fertilizers application.

It is worth mentioning that the present study is a part of the second phase in the research plan of the Fisheries Division, National Institute of Oceanography and Fisheries.

Description of the Nozha Hydrodrome:

The Nozha Hydrodrome is an isolated part of Lake Mariut where an embankment was established between the lake and the separated part. This embankment is nine kilometers long and surrounds the Hydrodrome. The sides of the embankment are reinforced with concrete. The area of the Hydrodrome is 1200 feddans.

The material from which the embankment was built was taken from the bottom. As a result, on the inside of the embankment there is a deep depression eight meters wide and seven meters deep running all round the Hydrodrome.

The inlet to the Hydrodrome is a circular hole of one meter diameter, the upper edge of which lies 1.00 m below mean sea level. This hole lies at the northwestern part of the embankment. The inlet is connected to a feeding canal 500 m long having concrete walls. This channel is connected through subterranean tube 100 m long to Mahmoudiah Canal which is fed with fresh water from the Nile.

The outlet of the Hydrodrome is in the southeastern part of the embankment diametrically opposite to the inlet. The inlet is opened occasionally to compensate for the water lost by evaporation and to keep the level of the Hydrodrome constant. The outlet is occasionally closed by wooden bars through which any amount of water could be withdrawn.

MATERIALS AND METHODS

Surface water samples were monthly collected from 8 stations representing the whole area of the Hydrodrome Fig (1), and one sample from the feeding canal. Collection of the water samples was carried out during the period from July 2000 to Sept. 2001 using Plastic Ruttner sampler of 2 liters capacity.

Water transparency was measured using a white enameled sechi disc of 30 cm diameter. The sechi depth measurements were usually carried out on the shaded side of the boat. Water temperature was measured using a simple protected metallic thermometer graduated to 0.1°C.

The pH was measured using a portable glass· electrode pH meter (Lutron Researchmodel 206). Dissolved oxygen was measured by the Azide according to the modification of Winkler method (Carritt and Carpenter, 1966)

The dissolved solids were measured as total dissolved solids expressed as grams dissolved in one liter of water. The measurement of TDS was carried out using pH/Conductivity/TDS meter EXTECH model "Oyster".

Nutrient salts, nitrate, nitrite, ammonia, dissolved inorganic phosphate and silicate were determined spectrophotometrically according to Grasshoff (1976) and measured using Ashumadzue double beam spectrophotometer UV-150-02.

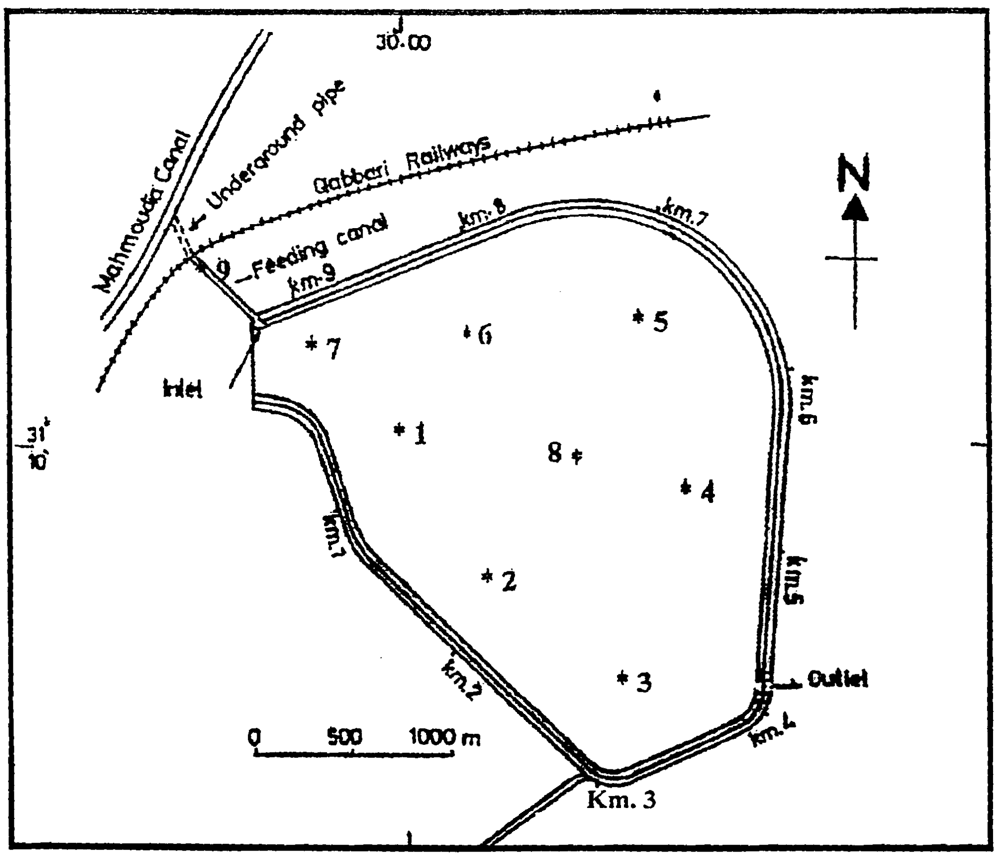

Fig. 1 : Nozha Hydrodrome and position of station .

Application of fertilizers at the Nozha Hvdrodrome:

The fertilization of ponds and lakes for increasing production of fish has its origin in adequity. For centuries it has been common practice in Europe and parts of Asia to fertilize carp ponds (Mortimer and Hickling, 1954). The increased fish production of the fertilized farms and fish ponds was emphasized by various authors.

Swingle and Smith (1947) stated that, fertilized ponds in Alabama support four to five times as great a weight of fish as unfertilized ones and consequently the former give much better fishing. They recommended the use of 100 lb of 6-8-4 (N-P-K) and 10 lb of nitrate of soda per acre of pond for each application, with a seasonal schedule of eight to fourteen treatments. Swingle (1965) also recommended that for old ponds only super phosphate at the rate of 40 lb/acre/treatment or 15 lb/acre for triple super phosphate is necessary because enough potassium is available in the pond and atmospheric nitrogen is fixed by bacteria and algae in the pond.

Mortimer and Hickling (1954) stated that, there is no question but that the application of balanced inorganic fertilizers will increase the production of fish in a pond or lake by increasing the phytoplankton and in turn the aquatic animals at various trophic levels between the phytoplankton and fishes.

As for fertilization with phosphorous compounds, Hepher (1958), indicated that phosphorous is the most important fertilizing element in the lakes and ponds but may be easily lost through combination with an excess of calcium to form tricalcium phosphate $Ca_3(PO_4)_2$. As carbon dioxide increases the precipitated salt may be converted to the more soluble di- and mono-calcium phosphates.

Hepher (1963) developed what he called a standard dose of fertilizer for fish pond which consisted of 53.5 lb of super phosphate and 53.5 lb of ammonium sulphate per acre for a pond 32-39 inch deep applied each time at intervals of two weeks.

Fertilization of the Nozha Hydrodrome with phosphorous fertilizers during the period of the present investigation was applied as follows:

1. Fertilization was carried out using calcium phosphate (super phosphate) fertilizer.
2. Fertilization was applied weekly during the period from May to September.
3. The weight of the applied phosphate fertilizer was as follows:

Period	**Weight**
From 6th April to 5th June 2000	4.0 tons
From 6th July to 27th July 2000	2.0 tons
From 2nd August to 31st August 2000	3.0 tons
From 5th September to 30th September 2000	1.75 tons
Total	**10.75 tons**

Therefore, fertilization was applied for 116 days where the area of the Hydrodrome is 1200 feddans, i.e. 3226 acre. This means that fertilization with super phosphate was applied using 8.96 Kg per feddan or 7.46 lb/acre.

Swingle *et al* (1965) indicated that some phosphorous may be available from the pond basins of old ponds that had been fertilized where phosphorous was being trapped in the muddy bottom of the pond. Phosphorous that has been accumulated may be circulated by releasing compressed air above the acidified phosphorous rich mud.

Probst (1950) indicated that phosphate fertilizer has a notable after-effect. This is certainly a consequence of its adsorption on the soil. It must be so far the after effect or residual effect, it must be felt even after the pond has been dried for the winter. It was found that one year after fertilization a pond was giving a 92 percent increase in yield over an unfertilized control pond and 90 percent even in the second year without additional fertilizer.

However, it is believed that the muddy bottom of the Nozha Hydrodrome is rich with phosphorous as a result of being used as water reservoir for long period without being dried for about 35 years. The present study shows that the bottom water of the Hydrodrome is rich with inorganic phosphorous in comparison with its surface water.

Regarding fertilization the fish farms with nitrogen compounds, Sawyer (1952) indicated that some algae are able to fix nitrogen from the atmosphere if phosphorous is available particularly the blue-green algae, *Anabaena* and *Nosroc*. However, nitrogen in fertilizers gives a quick source of this element to the algae. Mortimer and Hickling (1954) and Bishai (1962) claimed that manuring with phosphate alone is effective as when phosphate and nitrogen fertilizers are added.

Schaperclaus (1959) reported also that nitrogen fertilizer is not economical. The abundant denitrifying bacteria in the water quickly break down the added fertilizer, and nullify its effect. He considered that the undoubted need for nitrogen is generally met by activities of nitrogen-fixing blue green algae and bacteria which live in the pond mud in the presence of light and oxygen. The presence of phosphate may help this nitrogen fixation.

Hickling (1962) reported that there is conflicting evidence about the value of nitrogenous fertilizers in fishponds. The general view is that they are either ineffective or if they are effective the gain in fish is not in proportion to the cost of fertilizer.

In Mex experimental station, near Alexandria, Wahby (1974) used phosphorous and nitrogen fertilizers. Bishara (1978 and 1979) studying the growth rate of mugil in the ponds came to the conclusion that the benefit gained by the addition of nitrate to the ponds is negligible.

Fertilization of the Nozha Hydrodrome with inorganic nitrogen compounds during the period of the present study was carried out as follows:

1. Fertilization was applied using ammonium nitrate as fertilizer.
2. The weights of ammonium nitrates added as fertilizers were as follows:

Period	**Weight**
From 6^{th} April to 5^{th} June 2000	11.0 tons
From 6^{th} July to 27^{th} July 2000	8.0 tons
From 2^{nd} August to 31^{st} August 2000	8.0 tons
From 5^{th} September to 30^{th} September 2000	5.25 tons
Total	**32.25 tons**

This means that fertilization with ammonium nitrate was applied during the whole period of fertilization (116 days) using 27.30 Kg/feddan or 22.39 lb/acre. It can be observed that the ratio between the weight of ammonium nitrate and that of calcium phosphate applied for the Hydrodrome fertilization was 3:1. According to Wolny (1967), it is above all the relationship between the phosphate and nitrogen which is important and the best N/P ratio is 4:1. In well-mineralized water with an alkaline bottom the N/P ratio can reach 8:1.

Among the environmental problems that can be created in the fish farms and ponds as a result of fertilization is its adversely effect on the spawning process of some economic fish species. In this concern, Bennett (1970) pointed out that, although no controlled experiments have been reported to date, it seems likely that undissolved salts of commercial fertilizers falling into nests of centrarchids containing developing eggs of yolk-sac fry would cause the embryos to die. This might give substantial assistance in keeping some fish species from becoming overly abundant. In our case, it is believed that fertilization the Nozha Hydrodrome affected the abundance of the most important fish species ***Oreochromis niloticus*** from the fish populations at the Hydrodrome.

Another problem that can be resulted from fertilizing fish farms is the flourishment of some species of algae which may affect the development of others. Swingle and Smith (1947) indicated that, in Alabama, the fertilization program produced a bloom of plankton algae that prevents the development of filamentous algae and shades out any rooted submerged vegetation.

Hasler and Einsele (1948) cited the danger that has taken place in fish ponds. They pointed out to the possibility that fertilization may replace an efficient natural food chain with one that is much less efficient. For example, in a small diatom fulfills the ideal food requirement of ***Daphnia***, but fertilization encourage previously rare or nonexistant algae which are not very suitable for ***Daphnia*** while the desirableform *Cyclotella* is suppressed.

RESULTS AND DISCUSSION

A. Chemistry of the feeding canal water: (Hydrodrome water supply before fertilization)

It is a matter of fact that the Nozha Hydrodrome receives its water budget mainly from Mahmoudiah Canal through the feeding canal which is connected to the inlet of the Hydrodrome. On the other hand, rainwater adds a small portion to this water budget during winter season.

It is believed, therefore, that the water chemistry of the feeding canal shows the composition of the Hydrodrome water before fertilizers application. The chemical composition of the canal water is shown in Tables (1-14) (Station No. 9). Comparing the chemical composition of this canal with that of the Hydrodrome it can be indicated that:

1. The water temperature of the feeding canal was not significantly different from the average water temperature of the Hydrodrome.

2. In all cases, the pH of the feeding canal water was lower than that of the Hydrodrome. With few exceptions, the pH of the feeding canal water lied to the slightly alkaline side (over 7.0) In two cases, it showed very slightly acidic character (pH= 6.33 and 6.8) The agriculture waste water discharged in the canal may have played an important role in decreasing the pH of the canal water. On the other hand, the relatively fast flow of the canal water may not allow the fresh water plants to grow, therefore, the

consumption of CO_2 can not be attained with high rates which leads to the decreased of pH in the water of the feeding canal.

3. The total dissolved solids in the canal water was almost lower than that of the Hydrodrome. The lowest value of TDS in the water of the canal was 0.16 gm/l while the maximum was 0.65 mg/l. These concentrations indicate that the water flowing in the feeding canal is more or less fresh water. Fertilizers application, as well as evaporation, are the main factors that increased the TDS at the Hydrodrome water.

4. In all cases, the dissolved oxygen in the canal water was lower than that in the Hydrodrome. The dissolved oxygen in the canal water ranged between a minimum of 4.20 ml/L and a maximum of 6.02 ml/L. Signs of oxygen deficiency have not markedly observed in the feeding canal water during the present period of study.

Wahby *et al* (1993) in their investigation on the hydrochemistry of the Nozha Hydrodrome water pointed out that the dissolved oxygen in the canal water was lower than that in the Hydrodrome. On the other hand, they indicated that signs of oxygen deficiency were observed in the canal water during some months of their period of investigation which durated from June 1982 to September 1983. The concentrations of oxygen were 2.85, 3.80, 3.84, 3.74 ml/L during July, October December 1982 and January 1983 respectively.

The absence of plants in the feeding canal may have played an important role in decreasing the concentrations of dissolved oxygen in its water.

5. In most of the cases, the ammonia content in the water of the feeding canal was higher than that in the Hydrodrome. It ranged from an average of 1.54 during winter to 4.44 ug at/L during summer.

6. The nitrite concentrations ranged from 1.32 to 7.42 μg at/L during the whole period of investigation. These concentrations were higher in all cases than the concentrations of nitrite in the Hydrodrome water.

7. Although not fertilized with any nitrogen fertilizer, the nitrate contents in the feeding canal during all months of investigation were much more higher than the Hydrodrome. The average concentrations of nitrates in the feeding canal water were 39.07, 43.95, 34.02, 23.14 and 25.40 μg at/L during summer 2000, autumn 2000, winter 2000, spring 2001 and summer 2001 respectively. The corresponding concentrations at the Hydrodrome were 4.42, 6.98, 1.44, 4.10 and 2.46 μg at/L respectively.

The increased concentrations of nitrates, nitrites and ammonia in the feeding canal water may be attributed to the agriculture waste water discharged in Mahmoudiah Canal from which the feeding canal attains its water supply.

Elester and Jensen (1960) attributed the high nitrate concentration of the Mahmoudiah Canal partly to the factories and villages lying along its banks, in addition, the absence of plants with high densities in the feeding canal water may have played an important role in keeping on high water content of nitrates, nitrites and ammonia.

8. The concentrations of phosphates in the water of the feeding canal were higher than that in the Hydrodrome water in some months during the period of investigation. The main source for phosphates in this canal may be the agriculture wastes which discharge in Mahmoudiah Canal.

9. Comparing the concentrations of silicates in the feeding canal with those in the Hydrodrome waters, it can be pointed out that the concentrations of silicates in the water of the Hydrodrome were in all months higher than those in the feeding canal. It can be indicated also that the difference was in all cases significant as the concentrations of SiO_4 at the Hydrodrome attained double values in comparison with its concentrations in the feeding canal.

It appears, therefore, that the water of the feeding canal contained high concentrations of the nutrient salts specially phosphates and nitrates. This water can be considered as fresh water due to its very low content of dissolved solids.

Wahby *et al* 1993 indicated that as a result of the high phosphorous and nitrogen content of the feeding canal water its chlorophyll a content, being an index of plankton biomass was high, sometimes higher than the fertilized Hydrodrome water giving signs to eutrophication.

Table 1 : Surface water temperature (°C) of the Nozha Hydrodrome and Mahmoudiah Canal.

Season	Station	1	2	3	4	5	6	7	8	Average	9
Summer 2000	July	28.5	28.2	28.2	28.3	28.5	28.6	28.9	28.4	**28.5**	29.5
	Aug.	28.0	28.1	28.1	28.2	28.1	28.2	28.2	28.2	**28.1**	28.0
	Sept.	27.0	27.0	27.0	27.1	27.1	27.0	27.1	27.0	**27.0**	27.0
	Average	**27.8**	**27.8**	**27.8**	**27.8**	**27.9**	**27.9**	**28.1**	**27.9**	27.9	**28.2**
Autumn 2000	Oct.	26.0	26.0	26.1	26.2	26.1	26.2	26.1	26.1	**25.6**	26.1
	Nov.	25.0	25.0	25.1	25.1	25.1	25.0	25.0	25.0	**25.0**	25.0
	Dec.	18.0	18.0	18.0	17.3	17.4	17.3	17.3	17.5	**17.6**	17.2
	Average	**23.0**	**23.0**	**23.1**	**22.9**	**22.9**	**22.8**	**22.8**	**22.9**	22.7	**22.8**
Winter 2001	Jan.	16.5	16.5	16.5	16.5	17.0	17.0	17.0	16.5	**16.9**	17.0
	Feb.	16.5	16.8	16.8	16.9	17.0	17.0	16.9	16.9	**16.9**	17.0
	Mar.	19.0	19.5	20.0	20.0	19.0	19.0	20.0	20.0	**19.6**	20.0
	Average	**17.3**	**17.6**	**17.8**	**17.8**	**17.7**	**17.7**	**18.0**	**17.8**	17.8	**18.0**
Spring 2001	April	20.5	21.5	21.0	21.0	20.0	20.5	20.5	20.5	**20.7**	20.5
	May	26.0	25.0	25.0	25.5	26.0	25.5	26.0	25.0	**25.5**	25.5
	June	27.5	27.5	27.5	27.5	28.0	27.5	27.5	27.5	**27.6**	27.5
	Average	**24.7**	**24.7**	**24.5**	**24.7**	**24.7**	**24.5**	**24.7**	**24.3**	24.6	**24.5**
Summer 2001	July	28.5	28.2	28.2	28.3	28.5	28.6	28.9	28.9	**28.5**	29.0
	Aug.	28.0	28.1	28.1	28.2	28.1	28.2	28.2	28.2	**28.1**	28.0
	Sept.	26.1	26.2	26.2	26.2	25.9	25.8	25.8	26.0	**26.0**	26.0
	Average	**27.5**	**27.5**	**27.5**	**27.6**	**27.5**	**27.5**	**27.6**	**27.7**	27.5	**27.7**

Table 2 : Water depth (cm) at different stations of the Nozha Hydrodrome.

Season	Station	1	2	3	4	5	6	7	8	9	Average
Summer 2000	July	170	200	225	225	190	180	90	190	--	**184**
	Aug.	165	200	220	225	190	180	180	190	--	**194**
	Sept.	170	210	220	225	200	180	110	220	--	**192**
	Average	168	203	222	225	193	180	127	200	--	190
Autumn 2000	Oct.	190	230	230	250	220	190	170	250	--	**216**
	Nov.	250	260	260	260	230	200	120	220	--	**225**
	Dec.	230	230	230	240	210	170	110	235	--	**207**
	Average	**223**	**240**	**240**	**250**	220	**187**	133	235	--	**216**
Winter 2001	Jan.	260	230	230	235	210	190	130	235	--	**215**
	Feb.	235	230	230	230	215	230	150	240	--	**220**
	Mar.	235	220	210	230	190	170	110	240	--	**201**
	Average	**243**	**227**	**223**	**232**	**205**	197	130	**238**	--	**212**
Spring 2001	April	225	210	205	220	185	160	105	230	--	**193**
	May	200	180	180	180	145	140	85	165	--	**159**
	June	175	170	160	170	150	130	70	150	--	**147**
	Average	**200**	**187**	**182**	**190**	**160**	**143**	**87**	**182**	--	**166**
Summer 2001	July	140	120	130	140	130	50	50	140	--	**113**
	Aug.	140	130	130	120	110	60	45	130	--	**108**
	Sept.	150	130	130	130	110	70	40	130	--	**111**
	Average	**143**	**127**	**130**	**130**	**117**	**60**	**45**	**133**	--	**111**

Table 3 : Sechi depth (cm) at various stations of the area of study during 2000-2001.

Season	Station	1	2	3	4	5	6	7	8	9	Average
Summer 2000	July	35	50	45	50	45	45	35	45	--	43.75
	Aug.	40	45	45	45	40	50	45	40	--	43.75
	Sept.	40	45	50	45	45	50	45	45	--	45.63
	Average	41.7	46.7	46.7	46.7	43.3	48.3	41.7	43.3	--	44.38
Autumn 2000	Oct.	40	50	55	50	45	45	40	50	--	46.88
	Nov.	40	50	50	60	50	45	30	45	--	46.25
	Dec.	40	40	42	42	45	45	40	45	--	42.38
	Average	40.0	46.7	49.0	50.7	46.7	45.0	36.7	46.7	--	45.17
Winter 2001	Jan.	50	60	60	70	55	50	40	55	--	55.00
	Feb.	40	60	50	50	50	40	40	50	--	47.50
	Mar.	50	60	60	55	50	60	45	60	--	55.00
	Average	46.7	60.0	56.7	85.3	51.7	50.0	41.7	55.0	--	52.50
Spring 2001	April	50	60	60	55	50	60	45	60	--	55.00
	May	35	40	45	50	45	40	45	50	--	43.75
	June	38	40	45	45	40	35	35	45	--	40.37
	Average	41.0	46.7	50.0	50.0	45.0	45.0	41.7	51.7	--	46.37
Summer 2001	July	30	40	40	40	40	40	30	40	--	37.50
	Aug.	40	35	35	35	35	30	30	35	--	34.38
	Sept.	30	40	40	40	40	35	30	40	--	33.13
	Average	33.3	38.3	38.3	38.3	38.3	35.0	30.0	38.3	--	35.00

Table 4: pH values at different stations of the Nozha Hydrodrome and Mahmoudiah Canal.

Season	Station	1	2	3	4	5	6	7	8	Average	9
Summer 2000	July	8.25	8.25	8.25	8.29	8.26	8.32	8.20	8.25	8.26	6.80
	Aug.	8.15	8.20	8.23	8.25	8.25	8.25	8.26	8.25	8.23	7.50
	Sept.	8.20	8.30	8.25	8.30	8.30	8.25	8.30	8.30	8.28	7.50
	Average	8.20	8.25	8.24	8.28	8.27	8.27	8.25	8.27	8.26	7.27
Autumn 2000	Oct.	8.42	8.45	8.37	8.36	8.33	8.18	8.35	8.33	8.35	7.60
	Nov.	8.20	8.30	8.30	8.30	8.33	8.32	8.32	8.34	8.30	7.40
	Dec.	7.92	8.12	8.19	8.20	8.21	7.84	8.14	8.13	8.09	7.51
	Average	8.18	8.29	8.29	8.29	8.29	8.11	8.27	8.27	8.25	7.50
Winter 2001	Jan.	8.35	8.46	8.54	8.35	8.45	8.50	8.36	8.45	8.43	7.55
	Feb.	8.08	8.74	8.85	8.88	8.93	8.94	8.95	8.96	8.79	7.19
	Mar.	8.68	8.72	8.71	8.66	8.60	8.55	8.52	8.27	8.59	6.33
	Average	8.37	8.64	8.70	8.63	8.66	8.66	8.62	8.56	8.60	7.02
Spring 2001	April	8.90	8.93	8.95	8.97	9.00	9.10	9.15	8.50	8.94	7.45
	May	8.55	8.70	8.72	8.78	8.72	8.68	8.54	8.30	8.62	7.31
	June	8.72	8.40	8.70	8.24	8.42	8.36	8.34	8.33	8.44	7.07
	Average	8.72	8.68	8.79	8.66	8.71	8.71	8.68	8.38	8.67	7.28
Summer 2001	July	8.20	8.20	8.20	8.25	8.20	8.30	8.20	8.25	8.23	7.30
	Aug.	8.42	8.40	8.37	8.30	8.20	8.35	8.35	8.30	8.34	7.50
	Sept.	7.60	7.55	7.60	8.30	7.75	7.70	8.60	7.50	7.83	8.40
	Average	8.07	8.05	8.06	8.28	8.05	8.12	8.12	8.02	8.13	7.73

Table 5: Total dissolved solids (gm/L) in the Hydrodrome water and Mahmoudiah Canal.

Season	Station	1	2	3	4	5	6	7	8	Average	9
Summer 2000	July	1.46	2.75	2.26	2.66	2.47	2.77	1.75	2.42	2.32	0.16
	Aug.	3.10	4.35	5.08	4.95	5.40	5.20	5.51	4.13	4.72	0.64
	Sept.	2.45	3.50	4.90	4.95	5.10	5.40	5.50	4.40	4.53	0.62
	Average	**2.34**	**3.53**	**4.08**	**4.19**	**4.32**	**4.46**	**4.25**	**3.65**	3.86	**0.47**
Autumn 2000	Oct.	2.56	2.96	4.80	4.97	5.65	5.50	4.71	4.18	4.42	0.65
	Nov.	1.57	2.39	2.52	2.63	2.64	2.66	2.65	2.66	2.47	0.65
	Dec.	2.57	2.57	2.59	2.57	2.62	2.59	2.12	2.57	2.53	0.44
	Average	**2.23**	**2.64**	**3.30**	**3.39**	**3.64**	**3.58**	**3.16**	**3.14**	3.13	**0.58**
Winter 2001	Jan.	1.95	2.23	2.28	2.34	2.34	2.35	2.08	2.36	2.24	0.51
	Feb.	2.18	2.30	2.34	2.41	2.40	2.39	2.38	2.41	2.35	0.46
	Mar.	2.31	2.45	2.45	2.46	2.45	2.47	2.45	2.49	2.44	0.40
	Average	**2.15**	**2.33**	**2.36**	**2.36**	**2.40**	**2.40**	**2.30**	**2.42**	2.34	**0.46**
Spring 2001	April	2.52	2.57	2.58	2.58	2.58	2.59	2.55	2.58	2.74	0.41
	May	2.83	2.80	2.81	2.82	2.81	2.80	2.76	2.62	2.78	0.34
	June	1.81	2.46	2.10	3.07	2.86	1.79	0.83	2.99	2.24	0.21
	Average	**2.39**	**2.61**	**2.50**	**2.82**	**2.75**	**2.39**	**2.04**	**2.73**	2.59	**0.32**
Summer 2001	July	2.14	2.25	2.45	3.44	2.59	3.41	2.88	3.12	2.79	0.45
	Aug.	2.19	2.25	1.74	1.64	1.91	3.70	1.00	2.25	2.09	0.40
	Sept.	2.26	2.78	2.87	2.69	3.90	3.80	0.43	3.70	2.80	0.34
	Average	**2.20**	**2.43**	**2.35**	**2.59**	**2.80**	**3.64**	**1.44**	**3.02**	**2.56**	**0.40**

Table 6 : Dissolved oxygen (mg/L) in the water of the area investigated.

Season	Station	1	2	3	4	5	6	7	8	Average	9
Summer 2000	July	3.50	5.10	8.30	4.60	4.50	4.70	4.70	5.10	5.06	5.20
	Aug.	4.80	5.10	5.10	5.10	6.70	6.40	6.70	6.40	5.79	4.92
	Sept.	5.10	5.40	6.10	5.80	6.40	5.90	6.10	6.90	5.96	4.30
	Average	**4.47**	**5.20**	**6.50**	**5.17**	**5.87**	**5.83**	**6.10**	**6.13**	5.60	**4.81**
Autumn 2000	Oct.	7.30	6.90	8.70	8.70	8.20	5.70	6.50	7.30	7.41	4.60
	Nov.	5.57	5.57	5.57	5.57	5.57	6.40	5.80	5.57	5.83	4.20
	Dec.	6.80	8.30	7.60	7.10	7.90	8.30	6.80	8.20	7.63	5.50
	Average	**6.56**	**6.92**	**7.29**	**7.12**	**7.56**	**6.80**	**6.37**	**7.02**	6.96	**4.77**
Winter 2001	Jan.	9.95	11.86	15.13	10.49	12.41	9.54	9.54	8.45	10.93	4.49
	Feb.	8.13	9.17	8.02	7.73	7.59	7.73	9.02	9.17	8.32	5.16
	Mar.	6.40	8.44	8.88	6.98	6.84	8.00	8.73	8.88	7.89	5.24
	Average	**8.16**	**9.82**	10.68	**8.40**	**8.95**	**8.42**	**9.10**	**8.83**	9.05	4.96
Spring 2001	April	10.10	6.75	7.04	9.00	12.00	7.00	8.86	6.20	8.37	5.63
	May	6.41	7.87	10.20	7.29	9.04	6.56	6.99	10.2	8.07	5.42
	June	6.80	6.20	5.60	5.50	7.00	7.04	6.20	7.00	6.42	5.63
	Average	**7.77**	**6.94**	**7.61**	**7.26**	**9.35**	**6.87**	**7.35**	**7.80**	7.62	**5.56**
Summer 2001	July	7.87	8.16	5.54	8.75	7.87	6.71	5.25	6.12	7.03	5.39
	Aug.	5.10	8.02	5.69	10.2	5.83	5.39	5.54	8.02	6.72	5.33
	Sept.	6.16	7.59	7.65	6.87	6.87	6.87	5.73	7.45	**6.90**	6.02
	Average	**6.38**	**7.92**	**6.29**	**8.61**	**6.86**	**6.32**	**5.51**	**7.20**	6.88	**5.58**

Table 7: Phosphate – P concentration (µg at./L) in the water of the area of study.

Season	Station	1	2	3	4	5	6	7	8	Average	9
Summer 2000	July	6.37	0.36	0.15	1.02	1.53	3.06	3.57	0.68	2.09	1.84
	Aug.	3.79	4.34	1.71	2.33	2.56	2.17	4.34	2.71	2.99	2.40
	Sept.	2.18	2.27	1.63	2.01	1.78	1.65	2.58	1.76	1.98	2.20
	Average	**4.11**	**2.32**	**1.16**	**1.79**	**1.96**	**2.29**	**3.50**	**1.72**	2.35	**2.15**
Autumn 2000	Oct.	1.40	1.20	2.60	1.40	0.80	0.98	0.70	0.80	1.24	1.35
	Nov.	0.55	0.49	0.73	0.18	0.18	0.49	0.18	0.37	0.40	2.81
	Dec.	1.47	1.96	1.29	0.73	1.22	1.77	3.79	2.08	1.79	1.84
	Average	**1.14**	**1.22**	**1.54**	**0.77**	**0.73**	**1.08**	**1.56**	**1.08**	1.14	**2.00**
Winter 2001	Jan.	0.49	0.37	0.79	3.61	0.43	0.24	1.10	0.55	0.95	0.67
	Feb.	2.81	0.37	0.43	0.31	0.18	0.37	0.49	0.86	0.77	0.31
	Mar.	0.49	0.55	1.04	0.73	0.86	1.35	1.10	2.75	1.11	5.08
	Average	**1.26**	**0.43**	**0.75**	**1.55**	**0.49**	**0.65**	**0.90**	**1.39**	0.94	**2.02**
Spring 2001	April	1.71	1.29	1.53	2.20	1.59	1.29	0.86	1.11	1.45	1.29
	May	0.65	0.37	1.47	0.92	0.62	0.98	0.73	1.59	0.92	0.10
	June	7.28	9.97	1.16	8.01	1.77	1.96	2.02	2.39	4.32	5.38
	Average	**3.21**	**3.88**	**1.39**	3.71	**1.33**	**1.41**	**1.20**	**1.70**	2.23	**2.25**
Summer 2001	July	0.43	0.55	1.41	1.22	1.29	1.29	0.73	0.73	0.96	0.98
	Aug.	0.75	0.98	1.53	1.22	0.92	1.04	1.23	0.86	1.07	1.03
	Sept.	0.92	0.61	0.25	0.61	1.22	0.61	1.04	0.49	0.72	0.61
	Average	**0.70**	**0.71**	**1.06**	**1.02**	**1.14**	**0.98**	**0.98**	**0.69**	**0.92**	**0.87**

Table 8 : Silicate – Si concentration (µg at./L) in the water of the Hydrodrome and the Canal.

Season	Station	1	2	3	4	5	6	7	8	Average	9
Summer 2000	July	6.20	8.60	8.90	8.30	3.10	3.40	1.10	6.50	**5.76**	0.60
	Aug.	2.40	2.90	2.70	1.90	1.70	1.20	1.40	1.50	**1.96**	1.10
	Sept.	4.23	3.79	4.25	2.56	3.62	4.11	4.50	5.70	**4.10**	2.80
	Average	**4.28**	12.76	**5.28**	**4.25**	**2.81**	**2.90**	**2.33**	**4.57**	**3.94**	1.50
Autumn 2000	Oct.	5.80	4.70	6.60	3.20	5.30	6.50	8.40	12.80	**6.66**	4.30
	Nov.	10.44	15.07	18.63	25.61	6.31	7.59	9.16	7.54	**12.54**	13.55
	Dec.	10.91	11.93	9.25	7.71	18.54	15.09	19.90	11.76	**13.14**	7.93
	Average	**9.05**	**10.57**	**11.49**	**12.17**	**10.05**	**9.73**	**12.49**	**10.70**	**10.11**	8.59
Winter 2001	Jan.	20.54	12.53	15.85	18.41	18.84	12.87	11.72	16.71	**15.93**	6.22
	Feb.	9.13	12.89	14.86	15.91	18.79	17.72	17.89	19.69	**15.86**	8.77
	Mar.	18.61	22.37	11.45	13.60	16.47	16.82	12.53	11.63	**15.44**	10.74
	Average	**16.09**	**15.93**	**14.05**	**15.97**	**18.03**	**15.80**	**14.05**	**16.01**	**15.74**	8.58
Spring 2001	April	5.75	21.52	35.54	20.27	23.23	16.49	17.78	17.19	**19.72**	8.18
	May	13.59	9.80	12.10	10.82	8.95	9.59	10.23	12.66	10.97	7.80
	June	12.32	17.69	11.85	19.26	20.67	19.18	14.57	22.03	17.20	11.37
	Average	**10.55**	**16.34**	**19.83**	**16.78**	**17.62**	**15.09**	**14.19**	**17.29**	**15.96**	**9.12**
Summer 2001	July	26.01	30.06	22.05	24.73	10.50	15.79	28.44	23.37	23.87	13.87
	Aug.	31.14	40.09	27.22	23.73	28.50	30.59	29.14	29.27	29.96	13.12
	Sept.	21.25	22.88	20.46	27.23	15.24	19.18	10.37	19.01	19.45	10.31
	Average	**26.13**	**31.01**	**23.24**	**25.23**	**18.08**	**21.85**	**22.65**	**23.88**	**24.43**	**12.43**

Table 9: Ammonia – N concentration (µg at./L) in the water of the area studied.

Season	Station	1	2	3	4	5	6	7	8	Average	9
Summer 2000	July	14.25	5.10	11.32	12.61	8.35	10.72	12.61	6.93	**10.23**	2.13
	Aug.	27.97	4.28	6.96	11.26	7.72	4.93	10.08	6.22	**9.93**	2.65
	Sept.	11.28	5.20	18.70	13.65	8.20	18.90	15.20	7.50	**12.32**	4.15
	Average	**17.83**	**4.86**	**12.33**	**12.51**	**8.09**	**11.52**	**12.63**	**6.88**	**10.83**	**2.97**
Autumn 2000	Oct.	10.02	5.80	60.76	16.18	7.27	38.47	20.95	9.77	**21.15**	2.17
	Nov.	4.28	0.16	3.62	0.16	2.18	0.81	1.44	1.71	**1.80**	2.38
	Dec.	1.39	1.23	1.47	1.10	1.05	1.76	2.02	1.49	**1.44**	2.83
	Average	**5.23**	**2.40**	**21.95**	**5.81**	**3.50**	**13.68**	**8.14**	**4.32**	**8.13**	**2.46**
Winter 2001	Jan.	0.53	0.66	0.32	0.39	0.39	0.42	0.84	0.34	**0.49**	1.60
	Feb.	0.45	0.21	0.24	0.21	0.18	0.21	0.29	0.60	**0.30**	1.15
	Mar.	0.26	0.05	0.21	0.03	0.39	0.08	0.05	0.05	**0.14**	1.86
	Average	**0.41**	**0.31**	**0.26**	**0.21**	**0.32**	**0.24**	**0.39**	**0.33**	**0.31**	**1.54**
Spring 2001	April	0.97	0.60	0.60	0.42	0.71	0.63	0.94	0.42	**0.66**	1.21
	May	1.70	1.10	1.18	1.13	0.97	1.31	1.81	0.99	**1.27**	1.50
	June	2.10	46.16	3.12	28.33	1.57	1.57	2.62	1.52	**10.87**	2.23
	Average	**1.59**	**15.95**	**1.63**	**9.96**	**1.08**	**1.08**	**1.79**	**0.98**	**4.27**	**1.65**
Summer 2001	July	1.23	1.34	0.03	1.29	0.05	0.13	0.63	0.66	**0.67**	3.25
	Aug.	0.60	0.99	0.89	1.29	0.97	0.50	0.84	0.18	**0.78**	3.02
	Sept.	2.68	1.34	1.34	1.34	1.39	1.23	7.34	1.36	**2.25**	7.06
	Average	**1.50**	**1.22**	**0.75**	**1.31**	**0.80**	**0.62**	**2.94**	**0.73**	**1.23**	**4.44**

Table 10: Nitrite – N concentration (µg at./l) during the period of study of Nozha Hydrodrome and Mahmoudiah Canal.

Season	Station	1	2	3	4	5	6	7	8	Average	9
Summer 2000	July	0.42	0.19	0.15	0.15	0.15	0.34	0.17	0.11	0.21	1.93
	Aug.	1.05	0.28	0.13	0.67	0.08	0.51	0.31	0.18	0.40	1.32
	Sept.	0.72	0.90	0.36	0.52	0.13	0.41	0.32	0.20	0.45	1.75
	Average	**0.73**	**0.46**	**0.21**	**0.45**	**0.12**	**0.42**	**0.27**	**0.16**	**0.35**	**1.67**
Autumn 2000	Oct.	0.33	0.15	0.62	0.26	0.15	0.26	0.28	0.21	**0.28**	0.64
	Nov.	2.00	0.56	0.39	0.18	0.03	0.13	0.03	0.18	**0.44**	7.21
	Dec.	0.10	0.23	0.21	0.05	0.31	1.01	0.98	0.64	**0.44**	3.77
	Average	**0.81**	**0.31**	**0.41**	**0.16**	**0.16**	**0.47**	**0.43**	**0.34**	**0.39**	**3.87**
Winter 2001	Jan.	0.46	0.33	0.31	0.41	0.39	0.39	0.72	0.56	**0.45**	3.26
	Feb.	2.39	0.08	0.03	0.18	0.08	0.33	0.33	0.28	**0.46**	4.01
	Mar.	0.26	0.01	0.03	0.85	0.03	0.31	0.01	0.08	**0.20**	2.39
	Average	**0.37**	**0.14**	**0.12**	**0.48**	**0.17**	**0.34**	**0.35**	**0.31**	**0.37**	**3.22**
Spring 2001	April	0.77	0.23	0.33	0.23	0.23	0.33	0.49	0.95	**0.45**	7.42
	May	1.87	2.18	1.62	1.93	2.08	2.23	1.33	2.85	**2.01**	3.31
	June	0.21	1.75	1.87	1.93	1.82	1.41	0.57	2.58	**1.52**	3.34
	Average	**0.95**	**1.39**	**1.27**	**1.36**	**1.38**	**1.32**	**0.80**	**2.13**	**1.33**	**4.69**
Summer 2001	July	0.49	0.46	0.46	0.46	0.54	0.49	0.59	0.98	**0.56**	2.90
	Aug.	0.10	0.15	0.18	0.15	0.13	0.64	0.21	0.33	**0.24**	3.98
	Sept.	0.44	0.15	0.21	0.18	0.26	0.18	1.95	0.23	**0.45**	1.39
	Average	**0.34**	**0.25**	**0.28**	**0.26**	**0.31**	**0.44**	**0.92**	**0.51**	**0.42**	**2.76**

Table 11 : Nitrate – N concentration (μg at./L) in the water of the area studied.

Season	Station	1	2	3	4	5	6	7	8	A verage	9
Summer 2000	July	0.54	0.96	1.42	0.19	0.72	0.45	1.20	0.42	0.74	11.26
	Aug.	1.29	16.09	2.72	15.17	4.20	1.83	2.50	1.53	5.67	32.27
	Sept.	3.43	12.2	8.94	11.68	8.30	2.84	5.08	2.23	6.84	73.67
	Average	**1.75**	**9.75**	**4.34**	**9.01**	**4.41**	**1.71**	**2.93**	**1.39**	**4.42**	**39.07**
Autumn 2000	Oct.	6.02	12.18	15.75	8.36	8.27	4.47	5.45	3.02	7.94	76.85
	Nov.	32.86	18.38	7.81	5.04	1.75	1.23	1.58	1.21	8.73	15.89
	Dec.	4.49	4.19	6.08	3.18	2.45	1.75	10.37	1.70	4.28	39.12
	Average	**14.46**	**10.58**	**9.88**	**5.53**	**4.16**	**2.48**	**5.80**	**1.98**	**6.98**	**43.95**
Winter 2001	Jan	2.59	1.07	0.84	0.86	0.80	1.16	3.68	0.29	1.41	32.09
	Feb.	0.56	1.19	1.03	0.75	1.36	0.52	1.33	1.12	0.98	26.35
	Mar.	0.93	2.99	3.07	2.68	0.63	1.52	1.40	2.28	1.94	33.62
	Average	**1.36**	**1.75**	**1.65**	**1.43**	**0.93**	**1.07**	**2.14**	**1.23**	**1.44**	**34.02**
Spring 2001	April	4.20	1.60	2.30	2.87	1.85	2.89	2.27	2.02	2.50	41.58
	May	1.57	1.36	2.04	2.47	1.89	3.92	3.27	2.71	2.40	10.53
	June	4.95	145.59*	12.84	153.65*	11.51	3.43	85.37*	4.28	7.40	17.32
	Average	**3.57**	**1.48**	**5.73**	**2.67**	**5.08**	**3.41**	**3.27**	**3.00**	**4.10**	**23.14**
Summer 2001	July	1.64	1.77	1.66	1.77	1.69	4.08	2.17	4.23	2.38	22.37
	Aug.	2.32	2.37	2.88	2.69	2.93	2.63	5.08	3.15	3.00	30.39
	Sept.	3.13	0.65	0.13	0.66	0.64	0.37	9.60	0.79	2.00	23.45
	Average	**2.36**	**1.60**	**1.56**	**1.71**	**1.75**	**2.36**	**5.62**	**2.72**	**2.46**	**25.40**

Table 12 : Percentage of Ammonia to total inorganic Nitrogen in the water of the area of study.

Season	Station	1	2	3	4	5	6	7	8	Average	9
Summer 2000	July	93.70	81.60	87.82	97.37	90.56	93.14	90.20	92.90	**90.91**	13.90
	Aug.	92.28	20.73	70.95	41.55	64.33	67.81	78.20	78.44	**64.29**	7.31
	Sept.	73.10	28.42	66.79	52.80	49.30	85.33	73.79	75.52	**63.13**	5.22
	Average	**86.36**	**43.58**	**75.19**	**63.91**	**68.06**	**82.09**	**80.73**	**82.29**	**72.78**	**8.81**
Autumn 2000	Oct.	61.21	31.99	78.78	65.24	4.43	89.67	78.52	75.15	**60.26**	2.72
	Nov.	10.94	0.84	30.63	2.97	55.05	37.33	47.21	55.16	**30.02**	9.34
	Dec.	23.24	21.77	18.94	25.40	27.56	38.94	15.11	38.90	**26.23**	6.19
	Average	**31.80**	**18.20**	**42.78**	**31.20**	**29.01**	**55.31**	**46.95**	**56.40**	**38.84**	**6.08**
Winter 2001	Jan.	14.80	32.03	21.77	23.49	24.68	21.32	16.03	28.10	**22.78**	4.33
	Feb.	13.23	14.19	18.46	18.42	12.96	19.81	14.87	30.00	**17.74**	3.65
	Mar.	17.93	1.64	6.34	0.84	37.14	4.19	3.42	2.07	**9.20**	4.91
	Average	**15.32**	**15.95**	**15.52**	**14.25**	**24.93**	**15.11**	**11.44**	**20.06**	**16.57**	**4.30**
Spring 2001	April	16.33	24.69	18.58	11.93	25.45	16.36	25.41	12.39	**18.89**	2.41
	May	33.07	23.71	24.38	20.43	19.64	17.56	28.24	15.11	**22.77**	9.78
	June	28.93	--	17.50	--	10.54	24.49	--	18.14	**19.92**	9.74
	Average	**26.11**	**24.20**	**20.15**	**16.18**	**18.54**	**19.47**	**26.83**	**18.08**	**20.53**	**6.98**
Summer 2001	July	36.61	37.54	1.40	36.65	2.19	2.77	18.58	11.24	**18.37**	13.62
	Aug.	19.87	28.21	22.53	31.23	24.07	15.92	13.70	4.92	**20.06**	8.08
	Sept.	42.88	62.62	79.76	61.47	60.70	69.10	38.86	54.14	**58.82**	22.13
	Average	**33.12**	**42.49**	**34.56**	**43.12**	**28.99**	**29.26**	**23.71**	**24.93**	**32.42**	**14.61**

Table 13: Percentage of nitrite total inorganic nitrogen in the water of Nozha Hydrodrome and Mahmoudiah Canal.

Season	Station	1	2	3	4	5	6	7	8	Average	9
Summer 2000	July	2.76	3.04	1.16	1.16	1.63	2.95	1.22	1.47	**1.92**	12.60
	Aug.	3.46	1.36	1.33	2.47	0.67	7.02	2.40	2.27	**2.62**	3.64
	Sept.	4.67	4.92	1.29	2.01	0.78	1.85	1.55	2.01	**2.39**	2.20
	Average	**3.63**	**3.11**	**1.26**	**1.88**	**1.63**	**3.94**	**1.72**	**1.92**	**2.31**	**6.15**
Autumn 2000	Oct.	2.02	0.83	0.81	1.05	1.70	0.61	1.05	1.62	**1.21**	0.80
	Nov.	5.11	2.93	3.30	3.35	0.76	5.99	0.98	5.81	**3.53**	28.30
	Dec.	1.67	4.07	2.71	1.15	8.14	22.35	7.33	16.71	**8.02**	8.25
	Average	**2.93**	**2.61**	**2.27**	**1.85**	**3.53**	**9.65**	**3.11**	**8.05**	**4.25**	**12.45**
Winter 2001	Jan.	12.85	16.02	21.09	24.70	24.68	19.80	13.74	46.28	**22.40**	8.82
	Feb.	70.29	5.41	2.31	15.79	4.94	31.13	16.92	14.00	**20.10**	12.73
	Mar.	17.93	0.33	0.91	23.87	2.86	16.23	0.68	3.32	**8.27**	6.31
	Average	**33.69**	**7.25**	**8.10**	**21.45**	**10.83**	**22.39**	**10.45**	**21.20**	**16.92**	**9.29**
Spring 2001	April	12.96	9.46	10.22	6.53	8.24	8.57	13.24	28.02	**12.16**	14.78
	May	36.38	29.31	33.47	34.90	42.11	29.89	20.75	43.51	**33.79**	21.58
	June	2.89	--	10.49	--	12.21	22.00	--	30.79	**15.68**	14.59
	Average	**17.41**	**19.39**	**18.06**	**20.72**	**20.85**	**20.15**	**17.00**	**34.11**	**20.54**	**16.98**
Summer 2001	July	14.58	12.89	21.40	13.07	23.68	10.43	17.40	16.69	**16.27**	8.47
	Aug.	3.31	4.27	4.56	3.63	3.22	16.98	3.43	9.02	**6.05**	10.64
	Sept.	7.04	7.01	12.50	8.25	11.35	10.11	10.32	9.66	**9.53**	4.36
	Average	**8.31**	**8.06**	**12.85**	**8.32**	**12.75**	**12.51**	**10.38**	**11.79**	**10.62**	**7.82**

Table 14: Percentage of nitrate to total nitrogen in the water of the area investigated.

Season	Station	1	2	3	4	5	6	7	8	Average	9
Summer 2000	July	3.55	15.36	11.02	1.47	7.81	3.91	8.58	5.63	7.17	73.50
	Aug.	4.25	77.92	27.73	55.98	35.00	25.17	19.39	19.29	33.09	89.05
	Sept.	22.23	66.67	31.93	45.18	49.91	12.82	24.66	22.46	34.48	92.59
	Average	**10.01**	**53.32**	**23.56**	**34.21**	**30.91**	**13.97**	**52.63**	**15.79**	**24.91**	**85.04**
Autumn 2000	Oct.	36.77	67.18	20.42	33.71	93.87	10.42	20.43	23.23	38.25	96.47
	Nov.	83.96	96.23	66.07	93.68	44.19	56.68	51.80	39.03	66.46	62.36
	Dec.	75.08	74.16	78.35	73.44	64.30	38.72	77.56	44.39	65.75	85.56
	Average	**65.27**	**79.19**	**54.95**	**66.94**	**67.45**	**35.27**	**49.93**	**35.55**	**56.82**	**56.82**
Winter 2001	Jan.	72.35	51.94	57.14	51.81	50.63	58.88	70.23	23.97	54.62	86.85
	Feb.	16.47	80.41	79.23	65.79	83.95	49.06	68.21	56.00	62.39	83.62
	Mar.	64.14	98.03	92.75	75.28	60.00	79.58	95.89	94.61	82.54	88.78
	Average	**50.99**	**76.93**	**76.37**	**64.29**	**64.86**	**62.51**	**78.11**	**58.19**	**66.52**	**86.42**
Spring 2001	April	70.70	65.84	71.21	81.53	66.31	75.06	61.35	59.59	68.95	82.81
	May	30.54	46.98	42.15	44.67	38.26	52.45	51.01	41.37	43.43	68.64
	June	68.18	--	72.01	--	77.25	53.51	--	51.07	64.40	75.67
	Average	**56.47**	**56.41**	**61.79**	**63.10**	**60.61**	**60.34**	**56.18**	**50.68**	**58.93**	**75.71**
Summer 2001	July	48.81	49.58	77.21	50.28	74.12	86.81	64.01	72.06	65.36	77.91
	Aug.	76.82	67.52	27.91	65.13	72.70	69.76	82.87	86.07	68.59	81.28
	Sept.	50.08	30.37	7.73	30.27	27.95	20.79	50.82	33.19	31.40	73.51
	Average	**58.57**	**49.16**	**37.62**	**48.56**	**58.26**	**59.12**	**65.90**	**63.77**	**55.45**	**77.57**

B. Chemistry of the Hydrodrome (Fertilized Water)

1. Water temperature:

Temperature plays an important role in the aquatic environment in that certain organisms including fish are sensitive to water temperature. It can be mentioned that no other single factor rather than water temperature has so many profound influences and so many direct and indirect influences. The direct effect on the metabolic activities of plankton caused by temperature variations are controlled by van Hoff's law implies that the metabolic activity is doubled of a rise of 10°C.

The indirect effect of temperature may be manifested by changing the viscosity of water which in turn affects the rate of sinking of suspended particles either planktonic organisms or clay suspensions. Also the solubility of gases involved in the metabolic activity as carbon dioxide and oxygen will also decrease by increasing temperature (El-Gohary, 1984).

Water temperature influences the rate of metabolism and, therefore, the growth rate is often critical to spawning and to development of normal embryos. A general knowledge of temperature requirements of common fishes may enable a fishery biologist to prevent the release of fish stocks in thermally unsuitable waters (Bennett, 1970).

Although temperature receptors have not been discovered in a fish's skin there is a little doubt that fish are capable of feeling relatively slight changes in temperature. Sullivan (1954) described experiments in which fish were fed at the same time that the temperature was slightly raised so that feeding became associated with small rises in temperature. Fish may die of high water temperature or high or low dissolved oxygen tensions. The temperature at which fish dies (both high or low) is affected by the temperature to which the fish was acclimated prior to exposure. Brett (1956) lists upper and lower lethal temperatures for a number of fresh water fishes when these fishes previously had been acclimated to various temperatures.

Hickling (1962) indicated that, in tropics where there is usually little seasonal variations in temperature, which is also usually high fish growth may proceed the year round without any check. Swingle (1957) reports that *Tilapia mossambica* is killed at 48°F and *Tilapia melanopleura* at about 53°F. The water temperature of the Nozha Hydrodrome was recorded during the period of investigation at the various sampling stations as shown in Table (1). The lowest water temperatures were recorded during winter months with an average of 17.8°C. The minimum was during January and February with an average of 16.9°C. Another increase of water temperature occurred again during summer with an average of 27.9°C .

Decrease of temperature was recorded during autumn to reach an average of 22.7°C with a minimum of 17.6°C during December. It is worth mention that a sharp drop in water temperature can be expected at the Nozha Hydrodrome. Such sharp drop happens occasionally during winter months specially December. Banoub and Wahby (1961) pointed out that the water temperature in the Hydrodrome decreased sharply to 9°C during December. If water temperature is decreased to the lower limit such as the case observed by Banoub and Wahby (1961), it can be expected that both ***Oreochromis niloticus*** and ***Oreochromis aureus*** living at the Hydrodrome may be affected by such drop in temperature.

It was pointed out by Huet (1972) that the optimum development of Tilapias is above 20°C but these fish do not withstand temperatures as low as carp. Many species suffer and die below 12°C.

It was found that Tilapias become in active at water temperature below 16°C which is the minimal for normal growth. One of the major problems is their inability in general to survive in water of water temperature below 10°C for more than few days. In order to breed, most Tilapias need a water temperature of at least 20°C (Pullin and McConnell, 1982). It can be indicated, therefore, that the water temperature of the Hydrodrome water is in general suitable for the living of Tilapias.

The annual heat budget of the Hydrodrome can be calculated according to Elester and Jensen (1960) as the difference of calories in the whole water body between minimum and maximum temperatures. As the Hydrodrome is a basin with steep slopes at its edge and the water is usually not stratified the annual heat budget can be calculated as follows:

$$\Delta \text{ Kg . Cal} = (T_{max} - T_{min}) \cdot D_m \times \text{area } m^2 \times 1000$$

Where: D_m = depth in meters

T_{max} = mean maximum summer temperature = 27.9°C

T_{min} = mean maximum winter temperature = 17.8°C

Mean depth of the Hydrodrome = 197 cm

Δ Kg . Cal = 112.42×10^9 Kg Cal

2. <u>Water depth:</u>

Table (2) shows the fluctuations of the water level at the different sampling stations through the period of this study.

The water level was low with an average of 190 cm during the summer of the year 2000. This level started to increase gradually as a result of water supply to reach its higher level by the end of the autumn of the year 2000 with an average of 216 cm. The level started to decrease due to closing the gate which started in January 2001. Gradual decrease was observed through winter of the year 2000 up to the summer 2001 where the average depth reached its minimum of 179 cm.

Since the surface of the Hydrodrome is about 2 m higher than that of the neighboring Lake Mariut and the surroundings (Elester and Jensen, 1960) there could be seepage through the Hydrodrome walls.

3. **Transparency:**

It is a matter of fact that the suspension of the particles of silt and clay increases the turbidity of water. This reduces the penetration of light and photosynthesis activity as well as reducing waste assimilation capacities and may impair or curtail fish spawning (Wilson, 1959).

It was reported by Butler, 1964 that the very fine clay particles carry the same electrical charges and, therefore, tend to repel one another whenever they come close together. The electrical potential on the particles results from a double layer charges. An inner negative layer is present around the surface of an aluminosilicate core. An outer positive layer is formed by cations that surround the core. Cations in the outer layer are exchanged with cations in the surrounding medium. Potential on a particle varies with the rate of exchanges of cations. Precipitation is stimulated by an increase of other cations in a pond through for example the addition of gypsum. It was found that a little as 100-150 lb of gypsum per acre cleared some muddy ponds in about two days.

The secchi disc was used through the present study for measurement of transparency in the Nozha Hydrodrome. Table (3) gives the average monthly and seasonal results during the period of investigation. It can be observed from the data given in Table (3) that water of stations 1 and 7 were the least transparent through the whole period.

The highest transparency was recorded at stations 2 and 4, the southern part of the Hydrodrome and near to its outlet. Sechi depth was mostly less than 50.0 cm at stations 2 and 4. However, it was observed that the western area of the Hydrodrome was more transparent and less windy than the eastern area. The winds are expected to simulate the stability of the water column where movement and mixing of water are mostly expected at the eastern area of the Hydrodrome.

The middle area of the Hydrodrome is characterized also by high transparency where the secchi depths were mostly high throughout the whole period of study. These depths were more or less comparable to the water depth which depends on the water flow to the Hydrodrome. As for the effects of turbidity on the productivity of fishponds, Murphy (1962) pointed out that although high turbidities from soil particles may not be lethal to fishes turbid water may affect the productivity of the aquatic environment and the growth of fishes. Turbidity also affects the success of reproduction. It was also shown that the volume of basic food in clear ponds was approximately 8 times greater than in ponds of intermediate turbidities and 12.8 times greater than in muddiest ponds. However, it is believed that the high turbidity of the Nozha Hydrodrome water is affecting the primary production at such fishing area.

4. **Hydrogen ion concentration (pH):**

The Hydrogen ion plays an important role in many of the life processes, and living organisms are very dependent on and sensitive to pH. Probably the greatest difficulty involved in determining the effects of pH upon aquatic organisms is to discover to what extent the effects of an acid are due to its ionized Hydrogen, the negative ions and to the undissociated molecules (Welch, 1952).

Ness (1949) indicated that fish are able to live in water having a pH range from about 5 to 10 where at pH 5.5 fish develop hypersensitivity to bacterial parasites and usually die within a short time if the pH is as low as or lower than 4.5. Moreover, very hard waters are sometimes toxic to fish. The pH of the Hydrodrome water was always on the alkaline side as shown in Table (4). Higher values, with an average of 8.60 and 8.67 were recorded during winter and spring respectively. These higher values may reflect the increased productivity of the Hydrodrome.

Lower pH values were recorded during summer and autumn averages of 8.26 and 8.25 respectively. Banoub and Wahby (1961) found that the pH varied in the range of 8.91 in October and 8.15 in March, which are very close values to those recorded in the present investigation.

Swingle (1957) considered water with a pH ranging from 6.5 to 9.0 before daybreak as the most suitable for pond culture. Huet, 1979, recommended pH 7 to 8 for fishponds to be the most optimum. It can, therefore, be indicated that the pH range of the Nozha Hydrodrome water is very suitable for the growth and development of various fish species living in this Hydrodrome.

5. Total dissolved solids (TDS):

Total dissolved solids can be defined as the weight in grams of inorganic matter in one liter of seawater. The origin of the Nozha Hydrodrome dissolved solids is the feeding canal water itself which originates from Mahmoudiah Canal, the salts of which are concentrated by evaporation. It is believed that only a small proportion of its salinity is attributable to the salts originally retained at the time of isolation of the Hydrodrome from lake Edku (Elester and Jensen, 1960).

Comparing the salinity of the Hydrodrome during the last 40 years it can be indicated that the average salinity of the Hydrodrome was 3.28‰, 3.36‰ in February and March 1995 (Elester and Jensen, 1960). In 1958, the salinity was found to be 3.07‰ (Banoub and Wahby, 1961). This indicates that the water salinity was more or less constant.

Table (5) shows the total dissolved solids at the various sampling stations during the period of the present investigation. The data given indicate that the average value of total dissolved solids in the Hydrodrome during summer 2000 was 3.86 gm/l. This can be attributed to the higher rates of evaporation as well as cessation of fresh water supply which usually occurs during summer. On the other hand the lowest average values of total dissolved solids were recorded during winter and spring to be 2.34 and 2.59 gm/l.

The rain water as well as the fresh water supply during the winter season is believed to play an important role in decreasing the salinity of the Hydrodrodrome water. The lowest values of total dissolved solids were usually recorded at stations 1 and 7 where station 1 is very close to the water inlet and station 7 is near to it. As for the suitability of the salinity of Nozha Hydrodrome water to the living fish species at this area, it was pointed out by Hickling (1962) that Tilapias are in many cases very euryhaline that is they can live and grow in water with a wide range of salinity. At High salinity some species of Tilapia the fish may not breed, and growth is slowed, but the fish is not harmed.

Pullin and McConnell (1982) indicated that neither ***O. aureus*** nor *T. zillii* reproduce in seawater but they are able to survive direct transfer from fresh water to 60 to 70% seawater where the salinity can range then from 20.2 to 25.0‰. Mullets also have a remarkably wide tolerance of salinity as they live in salt and brackish water without harm and will grow well there (Hickling, 1962). The common carp lives in water at a salinity of 2‰ and can be in water of that or lower salinity while the Chinese carp will also grow in the brackish water which may have a salinity of 2.5‰ (Chow, 1958). This indicates that the salinity of the Nozha Hydrodrome water is suitable to the living, breeding and growth of most of fish species living at the Hydrodrome. It is doubted that this water favors the breeding of most sensitive species ***Oreachronis niloticus***.

6. <u>Dissolved oxygen:</u>

It is a matter of fact that the dissolved oxygen in water depends on its temperature and salinity. It also depends, to a considerable degree, on the quantity of organic matter present and the submerged aquatic visitation. If decomposing organic matter is in too great proportion, it will absorb too much of the dissolved oxygen in water. The content of oxygen dissolved could then fall below the minimum level acceptable to the fish. This danger is particularly great in warm water (Huet, 1979). Hickling (1962), pointed out to the idea that the oxygen content of water, may be of more important quality than either temperature or composition.

As for the effect of fertilization on oxygen content of pond water, Wunder (1949) states that dangerous oxygen deficiency may be caused in fishponds as a result of fertilization. A very rich algal flora may develop, which gives a high oxygen content to the water during the day, but at night respiration of the algae may reduce to dangerous levels the oxygen in the pond water. If there is a lack of oxygen in a pond then as much good quality water as possible must be supplies. It is possible also to aerate water by projecting it into the air with a pump (Huet, 1979).

The average data for dissolved oxygen at the various sampling stations of the Nozha Hydrodrome during the period of study are given in Table (6). It can be indicated from the data given that the average concentrations of oxygen dissolved in the water of the Hydrodrome ranged from a minimum of 5.60 ml/L during summer and a maximum of 9.05 ml/L during winter. This means that the water temperature played an important factor in changing the oxygen content of the Hydrodrome water. In their investigation on the hydrography of Nozha Hydrodrome water, Elester and Jensen (1960) stated that, in general, the oxygen standard of the Hydrodrome has been affected more by physical (temperature) than by biological (assimilation) factors. Therefore, the oxygen content was inverse to the temperature.

Another important factor that can affect the dissolved oxygen content in the Hydrodrome water was the exhaustion in the oxidation of ammonia and nitrite compounds which were present as a result of fertilization application with ammonium nitrates. In this concern, Vanloon and Duffy (2000) mentioned that the use of ammonium-containing fertilizer (ammonium sulphate, ammonium nitrate, urea and ammonia itself) is a source of ammonium in water. In an aerobic environment, nitrification takes place in two steps.

$$2NH_4^+ (aq) + 3O_2 + 2H_2O \xrightarrow{\text{Nitrosomonas}} 2No_2^- (aq) + H_3O^+ (Aq)$$

$$2NO_2^- (Aq) + O_2 + H_2O \xrightarrow{\text{Nitrobacter}} 2No_3^- (Aq)$$

The overall reaction is

$$NH_4^+ (Aq) + 2O_2 + H_2O \rightarrow No_3 (aq) + 3H_3O^- (Aq)$$

The optimum environmental pH for nitrification lies between 6.5 and 8.0 and the reaction rate decreases significantly when the pH falls below 6.0. As for the horizontal distribution in the Hydrodrome it can be indicated from the data given in Table (6) that the horizontal differences are not significant and have no definite pattern. The near homogeneity of oxygen distribution is caused by mixing action of wind. This agrees to great extent with the results given by Elester and Jensen (1960) where they found that there were small differences between oxygen contents from one area to another at the Hydrodrome. They indicated also that there were nearly uniform oxygen concentrations in the Hydrodrome and the variation of oxygen content from the surface down to the bottom is small and has no general trend to increase or decrease. However, it can be emphasized from the present investigation that the Nozha Hydrodrome water is well aerated and oxygenated and the dissolved oxygen is optimum for the living at various fish species all around the year.

7. Nutrient salts:

A. Phosphates:

The environmental significance of phosphorous arises out of its role as a major nutrient for both plants and microorganisms (Vanloon and Duffy, 2000). These authors mentioned that, of the nutrients that contribute to eutrophication, most commonly the limiting one is phosphorous. The whole PO_4 concentration in the Nozha Hydrodrome water is affected by the following main factors:

1. Increase caused by:

a. Introduction of P by water fed through the inlet.
b. Fertilization with calcium phosphate.

c. Phosphorous regeneration by mineralization of organic matter by bacterial activity.

d. The release of chemical combined or physically absorbed phosphates by reduction process and by pH changes.

2. Decrease caused by:

a. Consumption of P by plants.

b. Chemical combination of phosphates with manganese and iron dependant on oxidation and pH condition.

c. Absorption of phosphates on clay particles and on organic material and sedimentation together with those colloids.

The data given in Table (7) show that the concentrations of phosphates of the feeding canal water were in most cases higher than that at the Hydrodrome, this emphasizes that the Hydrodrome water is enriched with phosphates through the introduction of Mahmoudiah Canal water.

The effect of fertilizing the Hydrodrome water with phosphates during April, July, August and September 2000 can be markedly observed from the higher concentrations at PO_4 through the whole area of the Hydrodrome. These concentrations decreased to the minimum during the summer of the year 2001 where fertilization was completely stopped because of the decreased water level of the Hydrodrome. This happened as a result of cessation of supplying the Hydrodrome with Mahmoudiah Canal water during the summer of the year 2001. The Hydrodrome authorities expected that fertilizing the water under such condition of shallowness may create further environmental problems specially eutrophication and depletion of dissolved oxygen in the Hydrodrome water. It is attempted in the present investigation to compare between the concentrations of phosphates in the surface and bottom water of the Hydrodrome. The following data show the concentrations of phosphates at the various sampling stations during the summer of the year 2000 where fertilization with calcium phosphate was applied.

Concentrations of phosphates (μgm at/L) at the surface and bottom water of the Hydrodrome

Station №	Surface Water	Bottom Water
I	3.79	24.53
II	4.34	12.17
III	1.70	5.26
IV	2.32	--
V	2.55	8.38
VI	2.17	--
VII	4.34	6.73
VIII	2.71	5.02
Average	**2.99**	**10.35**
Standard deviation	**1.02**	**7.43**

It can be emphasized from these values that the concentrations of phosphates were much more higher in the bottom water if compared with its concentrations in the surface water. The increased concentrations of phosphates in the bottom water can be attributed to its release from the bottom of the Hydrodrome.

In this concern, Probst (1950) pointed out to the fact that phosphate fertilization has a notable after effect as it is adsorbed on the soil. Swingle *et al* (1965) indicated that the accumulated phosphorous on the muddy bottom may be circulated by releasing compressed air above such bottom.

B. Inorganic Nitrogen Species:

The dominating inorganic nitrogen species in seawater is the nitrate ion, the concentration of which may vary over a very wide range (e.g. from zero to about 45µg per liter). The amount of nitrite is usually small. In oxygenated waters, the amount of ammonia varies from zero to few µg per liter (Grasshoff *et al*, 1976).

Vanloon and Duffy (2000) pointed out that, under aerobic conditions, nitrate is the stable species in water. A low pE state leads to reduction from nitrate through nitrite to ammonia in its protonated and unprotonated forms (Vanloon and Duffy, 2000). Harvey (1974) noted that, in the marine environment, if ammonia does not happen to be absorbed by plants, it is oxidized with loss of heat to nitrite and then to nitrate, this oxidation being activated by bacteria. The oxidation to nitrite takes place immediately and is followed by oxidation to nitrate.

All three inorganic nitrogen compounds, ammonium, nitrite and nitrate, can be absorbed by phytoplankton or at least by some species. When the organisms become nitrogen-deficient and are supplied with a nitrogen source they absorb ammonium and nitrate in the dark converting them into organic compounds including chlorophyll. Nitrite cannot be utilized in the dark (Ketchum, 1939 and Harvey, 1974). In the Hydrodrome water, the added nitrogen fertilizer is dissociated into ammonium ion NH_4^+ and nitrate ion No_3^-. Ammonia seems to be the preferred form for algal growth and nitrate is first converted to No_2^- and then ammonia NH_3 when assimilated by algae. Denitrification is a function of temperature and substrate oxygen concentration (Wahby *et al*, 1993).

Ammonia:

Ammonia is the nitrogenous end product of the bacterial decomposition of natural organic matter containing N, and is important excretory product of animals in the aquatic system. It also discharges into water bodies by industrial processes and as a product of municipal or community wastes as well as the use of ammonia containing fertilizers such as ammonium sulphate, ammonium nitrate, urea and ammonia itself.

As for the concentrations of ammonia in the Hydrodrome, it is obvious from Table (9), that the highest levels were found during the summer and autumn of the year 2000. The average concentrations were found to be 10.83µg at/L and 8.13µg at/L during summer and autumn respectively.

Such high concentrations can be attributed to the application of ammonium nitrate fertilization which was carried out during these two seasons. This can be obviously medicated from the comparatively lower concentrations of ammonia recorded during the summer of the year 2001 where it ranged from 0.67 to 2.25 with an average concentration of 1.23µg at/L. The application of inorganic nitrogen fertilization was stopped during the summer of the year 2001 because of the cessation of water supply from Mahmoudiah Canal for a long period of time during 2001.

Nitrite:

Nitrite is an intermediate oxidation state between the low oxidant state (ammonia) and the higher oxidant state (nitrate). Nitrite appears in the water mainly as a result of biochemical oxidation of ammonia (nitrification) or the reduction of nitrite (denitrification) (Abdel-Moneim, 1977). The concentrations of nitrite at the various sampling stations of the Hydrodrome are shown in Table (10).

The average concentrations of nitrites were found to range from a minimum of 0.35µg at/L during summer of the year 2000 and a maximum of 1.33µg at/L during the spring of the year 2001.

It can be indicated from the data given in Table (10) that in most cases there were no significant differences between the concentrations of nitrite from one station to another in the Hydrodrome. This means that the horizontal nitrite distribution in the water was homogenous with the exception of station (1) which was characterized by relatively higher concentrations of nitrites. It is believed that the wind stirring action of the relatively shallow water of the Hydrodrome have played an important role in the release of nutrients from the bottom and distributing it in the whole water mass of the Hydrodrome.

Nitrates:

Nitrate is the most stable form of inorganic nitrogen in oxygenated water. It is the end product of nitrification process in natural water. Sillen (1961) denoted that nitrate is considered to be the only thermodynamically stable oxidation level in the presence of oxygen in the water.

In many areas nitrate is considered to be the micronutrient controlling primary production in the water. If the oxygen content of the water is depleted as a result of microbial remineralization process nitrate may be used as alternative electron acceptor instead of oxygen. This process called denitrification leads to the reduction of a portion of the nitrate to molecular nitrogen (Grasshoff, 1976).

The concentrations of nitrates at the various sampling stations of the Hydrodrome during the period of the present study are given in Table (11). It can be indicated from the data given that the nitrates attained the highest concentrations during autumn with an average of 6.98µg at/L. On the other hand, the lowest concentrations of nitrates were found during winter with an average of 1.44µg at/L. It can be observed also that the concentrations of nitrates during the summer of the year 2000 were higher than its concentrations during the same season of the year 2001. The average concentrations during these two seasons were 4.42 and 2.46µg at/L respectively. Such high concentrations are attributed to the application of fertilization during summer 2000 which stopped during the next summer. It can be pointed out that the average concentrations of nitrates in the feeding canal water were much higher in comparison with its concentration in the Hydrodrome. This means that the feeding canal supplies the water of the Hydrodrome by water rich with nitrates. Similar finding which confirms the effect of the inflowing water was indicated by Elester and Jensen (1960) who pointed out that there was a quick and sharp increase of the nitrates content in the Hydrodrome water after opening the inlet.

In general it can be observed that nitrates were not detected in high concentrations in the Hydrodrome water in spite of the fertilization with ammonium nitrate even being lower than the feeding canal as mentioned before. Nitrate nitrogen concentration in the Hydrodrome water was below 10µg at/L during a total of 15 months of the investigation.

Greatz *et al* (1973) explained how the nitrogen transformation in lake waters is affected greatly by water aeration. He showed that ammonium nitrogen accumulated in the water during anaerobic conditions, but upon aeration it was almost completely nitrified after a long period of few days. Nitrate nitrogen, however, did not continue to accumulate under aerobic conditions, but rather decreased steadily with time. Several processes may be responsible for this decrease, among which the diffusion of nitrate ions NO_3^- and nitrites NO_2^- into the anaerobic muds and subsequent denitrification are of importance.

This explains why nitrogenous compounds were not detected in high concentrations in the Hydrodrome water even often fertilization. Denitrification is an active process specially in warm water like Nozha Hydrodrome and retentions of ammonia by bottom sediments occurs. Librated ammonia is quickly used by growing phytoplankton.

The percentages of ammonia, nitrite and nitrate to total inorganic nitrogen are shown in Tables 12, 13 and 14 respectively. It can be indicated from the data given in these tables that during the course of the present investigation about 55.8% of the samples have the percentage of nitrate to total inorganic nitrogen species exceeds 50%. On the other hand, in about 26.7% of the samples ammonia represents 50% of the total inorganic nitrogen. For about 17.5% of the samples nitrite exhibited the lowest percentage of the total inorganic species. Vanloon and Duffy (2000) mentioned that intermediate pE values are uncommon in water and nitrite is usually a transient species measured only in small concentrations. This indicates that nitrate is the dominant species of the total inorganic nitrogen content of the Nozha Hydrodrome and this fish farm is highly oxygenated environment.

C. Reactive Silicates:

Silicon occurs in seawater as silicate, probably in true rather than in colloidal solution. It is utilized by diatoms. When diatoms are eaten the remains sink silica dissolves slowly into the water. In addition to dissolved silica, the water even far off land, contains a material quantity of silicon in particulate matter in suspension, in clay and presumably in undissolved diatom frustules (Harvey, 1974). Various analyses of diatoms quoted by Vinogradov (1953) show a Si/P ratio of 16 to 50 varying greatly with the species.

It appears, therefore, that the diatoms play an important role that influences the concentration of silicate in the seawater. The concentrations of silicate water during the course of the present investigation are given in Table (8). It appears from the data given that the concentrations of silicates were comparatively high in either the Hydrodrome or feeding canal water. The highest concentration of silicate was recorded during the summer of the year 2001 with an average of 24.43µg at/L. The lowest concentrations were found during the previous summer with an average of 3.94µg at/L. It is obvious from the data given in Table (8) that the concentrations of silicate in the Hydrodrome water were higher than its concentrations in the feeding canal water. This means that the inflow of the canal water dilutes the concentration of silicates in the Hydrodrome water.

CONCLUSIONS

The following points can be concluded from the present investigation:

1. Apart from supplementary feeding fertilization with inorganic phosphorous and inorganic nitrogen compounds was applied at the Nozha Hydrodrome with the aim of increasing the annual fish production. The total weights of calcium phosphate and ammonium nitrate added to the Hydrodrome during the period of investigation were 10.75 and 32.25 tons respectively.

2. The pH of the feeding canal water which slightly lied to the alkaline side was in all cases lower than the pH of the Hydrodrome water. The pH of the Hydrodrome water ranged from 8.13 to 8.67.

3. The average values of total dissolved solids in the feeding canal water ranged between 0.32 and 0.58 gm/L. On the other hand, it ranged from 2.34 to 3.86 gm/L in the Hydrodrome water. Evaporation as well as fertilizers application are important factors in increasing the total dissolved solids in the water of the Hydrodrome.

4. The pH and total dissolved solids ranges at the Hydrodrome water are suitable for the living, breeding and growth of most of the fish species living at Nozha Hydrodrome.

5. The average values of dissolved oxygen in the feeding canal water ranged from 4.81 to 5.58 ml/L compared with 5.60 to 9.05 ml/L for the Hydrodrome water. This indicates that the Hydrodrome water is more aerated than the feeding canal.

6. The average concentrations of phosphates at the Hydrodrome water were found to fluctuate between 0.92 and 2.35µg at/L revealing no significant difference from that of the feeding canal. The concentrations of phosphate showed higher values at the bottom water of the hydrodrome which may indicate that the phosphates accumulate on the soil and can be released to the adjacent water.

7. Among the inorganic nitrogen compounds it was found that nitrate was the dominant species in the Nozha Hydrodrome.

8. The average concentrations of Nitrate at the unfertilized feeding canal water ranged between 23.14 and 43.95µg at/L compared with 1.44 and 6.98µg at/L in the fertilized Hydrodrome water. It is believed that the abundant denitrifying bacteria in Hydrodrome water quickly bread down the added fertilizers and may nullify its effect.

According to the data presented it can be recommended that the rates of fertilization with inorganic nitrogen can be decreased. This will reduce the expenses of fertilization process, without any expected serious effect on its primary production.

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