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COMPARATIVE STUDIES ON MICROBIOLOGICAL AND CHEMICAL CHARACTERISTICS OF HIGH DAM LAKE WITHEN TEN YEARS.

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ABSTRACT

High Dam Lake is a tropical eutrophic empoundment in upper Egypt. The Late drought period led to a pronouced changes in chemical and microbioloical characteristics of the reservoir.

The physical and chemical changes as affected by drought are described. Total bacterial counts at both 22 and 37°C increased mainly in Summer and Autumn. On the other hand, counts of asymbiotic nitrogen fixers decreased.

INTRODUCTION

Like any living organism lakes are aging, since their shore lines have been eroding, their concentration of gases and salts building up, their transparencies decreasing, their bottom sediments thickening. Biologically, lakes experience orderly processes of ecological succession: producers, consumers and decomposers (Schmidt, 1969; Golterman, 1975).

High-Dam Lake is one of the largest man-made lakes in Africa and was initiated after the flowing river-Nile was dammed during year 1964. Two major changes occurred as a result of impoundment and had a marked effect on the water quality, 1) increase in time required for water travel from head water to discharge at the Dam; 2) formation of chemical stratification due to thermal effect which consequently affected microbial activities. Both delation of time and thermal stratification would change the characteristics of water quality (Symons et al., 1965).

Temperature regulate the seasonal stratification and turnover, thus affects the growth, productivity and cyclization of most aquatic organisms. Changes in temperature may alter or inhibit normal growth and development certain organisms (Hutchinson, 1957).

The oxgen budget in deep lakes depends on oxygen supply from above layers and rate of oxidation of organic carbon. The depletion of oxygen in the hypolimnion depends on the density of bacterial population, as well as, the decomposable matter and / or mineral salts which are necessary for the nutrition of bacteria. Meanwhile the oxygen concentration in water overlying lake sediment is directly correlated to the biological activity in that sediment (El-Wakeel and Wahby, 1970; Brewer et al ., 1977 and Elewa, 1980).

Organic matter is used as energy source for living organisms in aquatic enviroment. Rock (1975) stated that the decrease in organic matter is mainly due to its sedimentation, adsorption onto suspended matter, and /or by complete mineralization to free CO_2 and H_2O.

The aim of this study is to quantify the microbial content and chemical characteristics of the Lake water during the last ten years (1974 - 1984), as affected by drought period started since 1980 up till now which lowered the water level from 178 m. to 157 m. above mean sea level (MSL).

MATERIAL AND METHODS

Sites and Sampling Time:
Four representative sites were chosen in the main stream of the lake namely : High-Dam, Allaqi (100 km.), Amada (200 km), and Abu-Simple (280 km) up stream from the High-Dam.

Two different sets of sampling periods were taken under this study, first set was collected during year 1974, from winter to autumn, while the second set during the drought period from winter to autumn of year 1984.

Subsurface water samples for microbiological analysis were collecteds in duplicates from midstream using sterilized 300 ml sampling bottles. The collected water samples were transported in an ice-box to laboratory to be analysed within 8 hours. Water samples for chemical analysis were collected by Van Dorn bottle. Hydrolab equipements were used for measurring in situ:pH, dissolved oxgyen, temperature and electrical conductance (E.C). Organic carbon, nitrate, orthophosphate and total nitrogen were determined according to APHA (1975).

Bacterialogical Estimations
The standard plate method was used for total countes of bacteria. The collected water samples were shaked for 5 minutes then ten fold serial dilutions were prepared and 1 ml of each dilution plate was used to inoculate 6 plates of nutrient agar medium.

Three plates were incubated at 22°C for 96 hrs and the other 3 plates were incubated at 37° for 48 hrs, APHA (1975).

The most probable number (MPN) technique was used for counting asymbiotic N_2-fixing bacteria (Azotobacter and N_2-fixing clostridia) using Hoskins Tables (1934). Modified Ashby's medium was used for Azotobacter, incubated for 15 days at 30°C (Abdel-Malek and Ishac, 1968). Nitrogen-fixing clostridia were grown on modified Winogradisky's medium (Allen, 1953). The dilutions were pasteurized at 80°C for 15 minutes before incubation. Aerobic cellulose-decomposing bacteria were grown on Dubos'S cellulose medium (Allen, 1953). For nitrifying becteria stephenson's ammonium sulphate medium with $CaCO_3$ was used (Allen, 1953).

RESULTS AND DISCUSSION

The resultes of seasonal variation in the total bacterial counts (TBC_S) at 22 and 37°C as well as the other specific groups of bacteria, during 1974 are showen in tables 1 and 2. The lowest values cf TBC_S at 22 and 37°C were detected in winter as compared with the maximum in Summer. This might be due to the effect of temperature, as the counts tended to increase by the beginning of spring. At Summer the renewal of nutrients carried by flood and/or the recent drowned vegetation and dead phytoplankton might provide becteria with organic matter encouraging their reproduction (Saleh, 1976).

As regards to the effect of location site, there was a gradual decrease in TBC_S from south to north namely from Abu-Simble to Allaqi, then the count tended to increase again near the High Dam. This might be attributed to the decayed materials from fisheries activities.

Acording to APHA (1975), the bacteria developing at 22°C are saprophytic types and their counts would afford some indication of the amount of food substances available for bacterial nutrition and the amount of soil and other extraneous materials that water gained, while the bacteria developing at 37°C are mainly parasitic derived from soil or excretal material. The ratio of colony counts at these two temperatures helps to explian any sudden fluctuation in bacterial counts; the wider the ratio, the more probable is that bacteria are related to soil or water saprophytes, and therefore, of small significance. In unpolluted water, this ratio usually ranges from 1 to 10, while in polluted water, it is generally less than one. The finding of our study showed that the ratios of TBC_S at 22°C to 37°C were over 1. It was narrower at Summer and Autumn while wider at Winter and Spring. The surface water temperature in this area of study reached 30°C at Summer (Table 3). This prevailing temperature would favour the growth of mesophilic microflora.

Studying total bacterial densities in general, and Azotobacter in particular, indicated that **Az. choococcum** which is the predominent soil species, was also present in considerable numbers along the High Dam lake water. Abde-Malek and Ishac (1962) isolated **Azotobacter** from Nile cannal and drain waters. In this study, counts of **Azotobecter** had the same trend of TBC_S as it increased significantly in Summer and Autumn, while clostridial spore counts were generaly much lower in water than **Azotobacter** counts, in contrast to that in soils (Table 2). This might be due to the fact that they are strictly anaerobic and unable to survive in well oxygenated water in Winter and Spring. Thus, the counts of these bacteria were very low at this time of the year as compared to that recorded in Summer and Autumn.

TABLE 1

Seasonal variations in the total bacterial counts at 22° and 37°C/1 mL., during 1974.

Seasons / Stations	Total bacterial counts at 22°C				Total bacterial counts at 37°C			
	Winter	Spring	Summer	Autumn	Winter	Spring	Summer	Autumn
H.D.	187	414	3730	743	73	188	2520	673
Al laqi	175	228	2700	460	63	87	2540	383
Amada	168	322	2680	720	66	90	2400	705
Abu-Simble	172	421	4820	710	68	192	3510	637

TABLE 2

Seasonal variation in counts of Azotobacter, N_2-fixing clostridia and Nitrifiers/1 ml, during 1974.

Seasons / Stations	Azotobacter				N-Fixing clostridia				Nitrifying bacteria			
	W.	Sp.	S.	A.	W.	Sp.	S.	A.	W.	Sp.	S.	A.
H.D.	24	170	260	320	26	58	170	33	6	8	14	12
Allaqi	51	140	270	390	19	45	170	26	5	9	17	6
Amada	53	115	260	330	22	45	92	17	6	7	11	11
Abu-Simble	86	85	280	330	18	90	140	13	5	5	12	6

W. : Winter   Sp. : Spring   S. : Summer   A. : Autumn

These findings are in harmony with the results of dissolved oxygen and temperature (Table 3). Concering nitrifying bacteria (Table 2), their counts were low. On the other hand, the aerobic cellulose decomposers increased and were in parallel with the orgnic carbon content (Table 5). The counts increased markedly at the Summer and Autumn.

TABLE 3

Seasonal variation in temperature (C°), Cissolved Oxygen (mg L^{-1}), Total Nitrogen (μgN/L) and Otherophosphates (μg PO4/L) in High Dam Lake during 1974.

Seasons	Winter				Spring				Summer				Autumn			
Stations	C°	O_2	T.N	PO_4^{-3}	C°	O_2	T.N.	PO_4^{-3}	C°	O_2	T.N.	PO_4^{-3}	C°	O_2	T.N.	PO_4^{-3}
High Dam	18	7.3	550	26	24	8.8	829	12	27	6.2	860	0	19	6.3	820	24
Allaqi	17	9.4	600	18	26	7.8	810	38	30	6.8	900	25	21	6.8	780	18
Amada	17	10.2	510	26	28	7.6	740	18	29	7.6	760	16	23	7.4	760	15
Abu-Simble	18.5	8.5	480	24	28.5	8.6	740	26	29	8.4	7.50	0	24	8.0	920	12

During this study, the temperature increased in Summer and Autumn. It reached a maximum of 30°C during Summer as compared with 17°C in winter. On the other hand, the oxygen concentration decreased in Summer reaching a maximum during winter and spring (10.2 mg L^{-1}), as observed at Amade (Table 3). These marked changes in both temperature and O_2 concentration in Lake water were reflected on the total bacterial counts, as well as, other specific groups of bacteria (Table 1).

The results showed that total nitrogen increased in Summer and Autumn while no marked changes were observed in the concentration of orthophosphate along the lake (Table 3).

Recent Limnological picture of High-Dam Lake

As the drought period had begun since 1980 and water level was lowered from 178 to 158 m above MSL, changes in both microbiological and chemical characteristics of the High Dam Lake, may be expected. The total bacterial counts at both 22 and 37°C relatively increased in comparison to that obtained 10 years ago (Table 4). This might be due to the activity of phyto and zooplankton and/or relative concentration of bacterial densities related to the less water mass flowing from south. This result is going in parallel with organic carbon results abtained (Table 5), and confirmed by Schmidt (1969).

On the other hand, the counts of both asymbiotic-nitrogen fixers the aerobes **Azotobacter** and the anaerobes; N_2-fixing **clostridia** (Table 4), tended to decrease. This might be due to drought and less suspended matter reaching from south and which might carry these organisms in flooding water.

As regard to the nitrifying bacteria (Table 4) their counts were relatively increased in comparison to that data obtained 10 years ago. This might be due to the increase in the nitrifying activity related to the higher activity of the total bacterial load. This is confirmed by the pronounced increase in the nitrate content in the water of the lake after this period of dryness (Table 5). Aerobic cellulose decomposer counts tended to increase specially in summer parallel with total bacterial counts and organic carbon.

As regards to the chemical characteristics of Lake within 1974-1984 (Table 5), data showed that organic carbon increased by storage mainly in summe, due to the biological degradation of orgnic debries in Lake water. In the same line nitrate increased also by storage which reflected eutrophication in the Lake. The zero value recorded in spring 1984, is correlated with the high rate of photosynthesis by phytoplankton. This high activity of phytoplankton is correlated with the increase in nutrients as measured by the increase in the electrical conductivity by summer and autumn. (Table 5).

Upon storage in the resrvoir, the pH values notably increased in spring reached maximum of 8.89, as compared to pH 7.85 in Autumn 1974. This

TABLE 4

Changes in total bacterial counts at 22 and 37°C and the other specific groups of bacteria at the northern part of High Dam Lake during 1974 / 1984.

(Counts 1 ml. water).

Season	Year	Total bacterial counts		Azotobacter	N_2-fixing clostridia	Nitrifying bacteria	Aerobic-cellulose decomposing bacteria
		22°C	37°C				
Winter	1974	187	73	24	26	6	66
	1984	340	290	17	14	22	110
Spring	1974	414	188	170	58	8	130
	1984	750	360	110	46	39	330
Summer	1974	3730	2520	260	170	14	1700
	1984	5100	4400	140	64	120	2200
Autumn	1974	743	673	320	33	12	320
	1984	1800	1200	64	17	84	450

TABLE 5

Seasonal variations of organic Carbon (mgL^{-1}), Nitrate (μgL^{-1}), electrical Conductance μS^{-1} and PH value of the northern part of High Dam Lake during 1974 / 1984.

Year	1974				1984			
Seasons	Organic Carbon	NO_3^-	PH	E.C	Organic Carbon	NO_3^-	Ph	E.C
Winter	5.7	72	7.85	235	12	75	8.7	245
Spring	8.9	69	8.33	220	20	0	8.89	230
Summer	9.5	70	8.62	258	30	210	8.35	265
Autumn	10.2	64	7.85	250	24.3	290	8.26	260

may be attributed to the increasing photosynthetic activity, consuming free CO_2 from CO^{-3} and HCO_{-3} buffer system. Thus, the increase in pH values, increased consequently eutrophication in the Lake. As stated by Hutchinson (1957) who confirmed that pH of the productive lakes, goes parallel with the oxygen, mainly in spring, the decrease in the oxygen related to the decrease of pH. Therefore, the High Dam lake is considered as an eutrophic lake.

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