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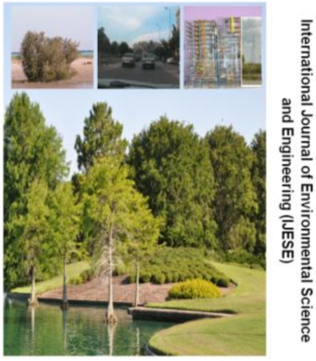

Long - term fluctuations of macrobenthic invertebrates in Aswan Water Reservoir, Egypt.

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ABSTRACT

Long - term fluctuations of macrobenthic invertebrates in Aswan Reservoir were studied monthly during June, 1982 - May, 1983 and seasonally during spring (April), 2008 – winter (January), 2009 and spring (May), 2009 – winter (January), 2010. The standing crop of benthos as well as the number of species showed a remarkable change from one year to another. Clayey silty sand bottom with macrophytes, $CaCO_3$ content, total organic carbon content, temperature, introduction of grass carp to combat aquatic plants and the hydrodynamic regimes seem to be the most important factors controlling the distribution and abundance of the benthic fauna in the reservoir. The sediments detected in Aswan Reservoir have been proved to be mostly derived from Ethiopian sources as indicated by the calculated mineralogic indices of pyroxenes (I_{Pyr}) amphiboles (I_{Amph}) and epidotes (I_{Epd}) where the higher I_{Pyr} values were recorded. Hence, the benthic invertebrates evidently belong to the fauna of the Nile system. This confirms the effect of Nile tributaries on the distribution of both sediments and macrobenthic fauna in Aswan Reservoir.

1. INTRODUCTION

The old Aswan Dam was built in 1902, and updated twice in 1912 and 1934 to increase its storage capacity. The dam is bound within Egypt by a geographic coordinate extending between latitudes 23° 59\ and 24° 03\ N and longitudes 32° 51\ and 32° 55\ E (Fig. 1). The geologic rock units exposed in the eastern and western banks of Aswan Reservoir are represented by Aswan granites & Nubia sandstone, Quaternary old Nile sediments and recent sand sheets (El- Dardir, 1995). The only two studies on the Nile sediments were carried out by El-Dardir (1994 & 1995) who affirmed the relation between geochemical and mineralogical composition with grain size, organic matter and $CaCO_3$. The study of the reservoir benthic fauna has also received a minor interest. The first survey was made by Iskaros (1988) who reported that the main components were molluscs (53.8% by number and 45.0% by weight of the total benthic fauna) and represented by 9 gastropod species and 2 bivalve species, followed by larvae of Chironomidae (9 species), Annelida (4 species) and Platyhelminthes (1 species). This work was undertaken by Iskaros & Gindy (2009) to study the distribution and seasonal variations of the benthic fauna in relation to the prevailing environmental conditions, particularly the substrate status of bottom sediments. The results of this study revealed that the community composition has changed significantly with time during different seasons, where eleven species disappeared, accompanied by the appearance of 4 newly recorded ones.

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The aim of the present work is to assess recent alterations that occurred in macrobenthic invertebrates due to their importance in the food chain, as they constitute one of the main trophic sources for various kinds of fish. We also investigate the influence of different environmental factors affecting benthic fauna, particularly the hydrodynamic regimes of the reservoir and the effect of Nile tributaries, compared to that prevailing in Lake Nasser.

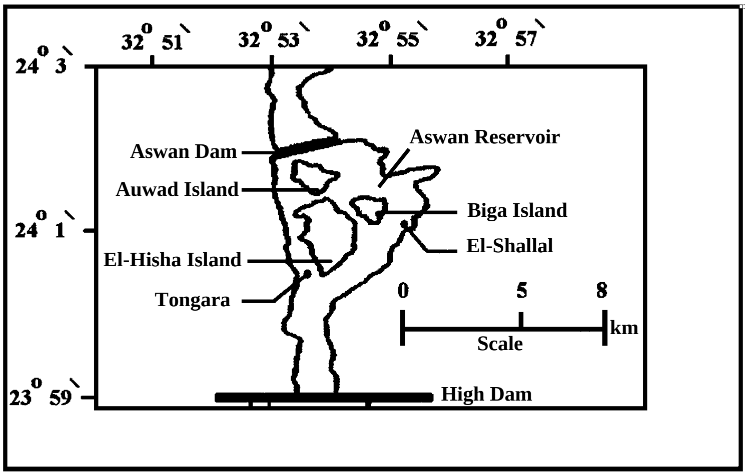

Fig. 1: Aswan Reservoir and location of samples (•)

2. MATERIALS AND METHODS

Aswan Reservoir represents the area between the two dams namely Aswan High Dam and Aswan Dam. It extends for about 6.5 km before Aswan Dam and has an average width of about 1.5 km, The maximum water depth is 18 m at 108 m above mean sea level. Three sampling programs reflecting long – term fluctuations of macrobenthic invertebrates were studied in Aswan Reservoir and these include the following: 1)- Benthos was sampled monthly at Tongara (Fig. 1) during the period June, 1982 – May, 1983 (Iskaros, 1988). A seasonal sampling was carried out at Tongara (western bank) and at El-Shallal (eastern bank) during spring (April), 2008 – winter (January), 2009 (Iskaros and Gindy, 2009). In the present study, two stations were also selected at Tongara and at El-Shallal during Spring (May), Summer (July), Autumn (November) of 2009 and Winter (January) of 2010. Sixteen water samples were collected using Van-Dorn bottle at two levels (surface and bottom). Transparency, water temperature, dissolved oxygen and hydrogen ion concentration were measured according to the procedures described by the American Public Health Association (APHA, 1995). Eight bottom sediment samples were collected using Ponnar bottom grab with an area of 225 cm^2. The bottom sediment samples were mechanically analyzed, using the sieving and pipette techniques (Carver, 1971). The mineralogic indices were calculated by applying the formulae of Hassan (1976). The total organic carbon content was determined, using WR. 112 USA LECO Carbon Analyzer in the Egyptian Ferroalloys Company of Edfu, Egypt. Calcium carbonate content was determined using Collin-Calcimeter. Benthic organisms were collected seasonally with the same grab (1/44 m^2). Usually two samples were taken at each station and the material was separated immediately afterwards, while still alive by a metallic sieve with mesh size of 0.44 mm. The taxa collected were preserved in 5% formalin solution. The annelids, molluscs, insect larvae and decapods were dried on filter paper and weighed. The number and biomass of bottom organisms were calculated per 1m^2. Shells of molluscs were removed as their flesh was only weighed. Correlation coefficient was determined by Minitab 12.21 under Windows XP (2002).

3. Results

3.1. Physico - chemical characteristics

3.1.1. Water temperature

Water temperature in Aswan Reservoir showed clear seasonal variations (Table 1), where the highest value was recorded during summer (27.0 - 27.3 °C) and the lowest in winter (19.8 - 20.7 °C).

Table 1: Physico - chemical parameters in Aswan Reservoir during the study.

Sampling Station	Depth	Secchi disc (cm)				Temperature (°C)				Dissolved oxygen (mg/l)				pH value			
		sp.	su.	au.	w.	sp.	su.	au.	w.	sp.	su.	au.	w.	sp.	su.	au.	w.
East (El-Shallal)	Surface	250	220	325	350	22.0	27.2	23.3	19.8	8.5	4.4	5.8	8.7	8.32	8.05	8.19	8.36
	Bottom					23.1	27.0	23.0	20.2	7.0	4.0	5.4	8.3	8.38	7.98	8.16	8.34
West (Tongara)	Surface	300	320	380	425	20.9	27.3	23.6	20.4	8.8	4.7	6.0	8.6	8.43	7.95	8.49	8.55
	Bottom					22.0	27.0	22.9	20.7	8.6	4.3	6.2	8.8	8.25	7.80	8.17	8.67
Average		275	270	353	388	22.0	27.1	23.2	20.3	8.2	4.4	5.9	8.6	8.35	7.95	8.25	8.48

Note: sp. = spring; su. = summer; au. = autumn & w.= winter

3.1.2. *Transparency*

Transparency in Aswan Reservoir (Table 1) ranged from 425 cm at Tongara during winter to 220 cm at El-Shallal in summer.

3.1.3. *Dissolved* oxygen

The measured values of dissolved oxygen (Table 1) showed that the highest concentrations were observed during winter and spring (7.0 - 8.8 mg/l) while lowest values were in summer and autumn (4 - 6.2 mg/l).

3.1.4. *Hydrogen* - ion concentration (pH)

The pH values of the studied reservoir (Table 1) were on the alkaline side (7.80 - 8.67).

3.2. Characteristics of bottom sediments

Grain size

Grain size analysis (Table 2) showed that the sediment samples investigated in Aswan Reservoir were mainly composed of sand (50.1 - 77.0%) followed by silt (20.2 - 46.2%) and clay (2.6 - 4.3%). During different seasons, these fractions showed low range of variability among stations.

Table 2: Percentages of sand, silt and clay of the analyzed sediment samples in Aswan Reservoir during the study.

Sampling Station	Depth (m)				Sand (%)				Silt (%)				Clay (%)			
	sp.	su.	au.	w.	sp.	su.	au.	w.	sp.	su.	au.	w.	sp.	su.	au.	w.
East (El-Shallal)	5.0	4.0	3.0	5.0	53.7	54.0	50.3	50.1	42.0	41.8	46.0	46.2	4.3	4.2	3.7	3.7
West (Tongara)	4.0	3.0	4.0	4.0	74.5	77.0	74.3	73.0	22.3	20.2	23.1	23.0	3.2	2.8	2.6	4.0
Average	4.5	3.5	3.5	4.5	64.1	65.5	62.3	61.5	32.1	31.0	34.6	34.6	3.8	3.5	3.1	3.9

Note: sp. = spring; su. = summer; au. = autumn & w. = winter

3.2.1. *Mineralogic indices*

The results of mineralogic indices (Table 3) revealed that Aswan Reservoir sediments have higher pyroxene and amphibole indices (52.34 & 53.90, respectively), contrary to epidote index (43.78).

3.2.2. *Calcium carbonate content*

In the studied sediments of Aswan Reservoir, $CaCO_3$ concentrations (Table 4) generally increased during summer and autumn (7.84 - 9.85%), whereas winter and spring sustained the lowest values (4.35 – 4.98%).

3.2.3. *Total organic carbon content*

The highest values of organic carbon in Aswan Reservoir (Table 4) were found during summer and autumn (3.47 – 4.00%), contrary to spring and winter (1.53 – 2.91%). On the other hand, the organic carbon in the studied area indicates that finer sediments contain higher content of organic carbon (Table 2).

3.2.4. Macrobenthic invertebrates

The community composition of macrobenthic invertebrates in Aswan Reservoir included twenty species belonging to Annelida (4 species), Mollusca (8 species), larvae of Chironomidae (7 species) and Decapoda (l species). Besides, one unknown species of

Zygoptera (nymph of Odonata) was also encountered, contributing numerically about 61.1, 22.7, 15.5, 0.6 and 0.1% of the total benthos, respectively.

The highest density and biomass of benthic life in Aswan Reservoir were recorded at Tongara (Fig. 2) (avg. 6322 org./m^2 with 44.9 g/m^2) where there were some patches of macrophytes. On the other hand, the community declined to about the third at El-Shallal (avg. 2217 org./m^2 with 13.3 g/m^2) which was characterized by vegetation - free bottom zone.

The biomass of benthic fauna was nearly proportional to their numerical density except at Tongara in winter due to the increased number of mature forms of oligochaetes (54.7 g/m^2) as observed by the presence of their cocoons. The annual average number and biomass of benthic fauna for all the reservoir amounted to 4270 org./m^2 and 29.1 g/m^2.

Table 3: Mineralogic indices (I_{Pyr}, I_{Amph} & I_{Epd}) of the studied sediments (calculated using the formulae of Hassan, 1976) compared with the main Nile.

	Location	I_{Pyr}	I_{Amph}	I_{Epd}
Hassan (1976)	Main Nile, north of Atbara	83.30	51.60	15.80
	Bahr El-Gebel, total	3.20	97.80	40.50
	Bahr El-Ghazal	13.00	97.60	12.50
	Sobat River, total	8.30	97.80	20.00
	White Nile	4.50	97.20	37.50
	Blue Nile	57.70	78.90	16.40
	Atbara River	99.60	8.00	4.40
	Blue Nile and Atbara	88.20	40.80	16.20
	Average	44.72	71.21	20.41
Present study	East (El-Shallal)	52.76	53.50	43.77
	West (Tongara)	51.92	54.30	43.79
	Average	52.34	53.90	43.78

Table 4: Organic carbon and calcium carbonate contents of the analyzed bottom sediment in Aswan Reservoir during the study.

Sampling Station	**Depth (m)**				**Organic matter (%)**				**Calcium carbonate (%)**			
	sp.	**su.**	**au.**	**w.**	**sp.**	**su.**	**au.**	**w.**	**sp.**	**su.**	**au.**	**w.**
East (El-Shallal)	5.0	4.0	3.0	5.0	2.05	4.00	3.54	1.80	4.35	8.71	7.84	3.70
West (Tongara)	4.0	3.0	4.0	4.0	1.53	3.75	3.47	2.91	4.98	9.85	8.96	4.50
Average	4.5	3.5	3.5	4.5	1.79	3.88	3.51	2.40	4.66	9.28	8.40	4.10

Note: sp. = spring; su. = summer; au. = autumn & w.= winter

Variations in zoobenthos populations during the different seasons are represented in Fig. 2. Their highest density and biomass were reached at Tongara during summer (8371 org./m^2 with 37.8 g/m^2) and winter (7480 org./m^2 with 69.7 g/m^2), as a result of the increased number of molluscs, hirudineas and oligochaetes, respectively. Another increasing density was also recorded at El-Shallal during autumn (6490 org./m^2 with 38.3 g/m^2), mainly formed of oligochaetes. In contrast, the lowest values of benthic fauna were recorded at El- Shallal throughout spring and summer (396 org./m^2 with 3.0 g/m^2 & 484 org./m^2 with 4.3 g/m^2, respectively).

Annelida constituted the main bulk of benthic fauna in Aswan Reservoir. Their annual average numbers and biomass mounted to 2611 org./m^2 and 22.5 g/m^2 with a peak at Tongara (Fig. 2) (avg. 3517 org./m^2 with 33.3 g/m^2). They were represented by 2 Classes, Oligochaeta and Hirudinea. Oligochaetes contributed 49.2 & 80.5% (avg. 2101 org./m^2 with 20.3 g/m^2) of the total benthos and annelids, respectively. They were represented by 3 species namely: *Limnodrilus udekemianus* Claparede, *L. hoffmeisteri* Claparede and *Branchiura sowerbyi* Beddard.

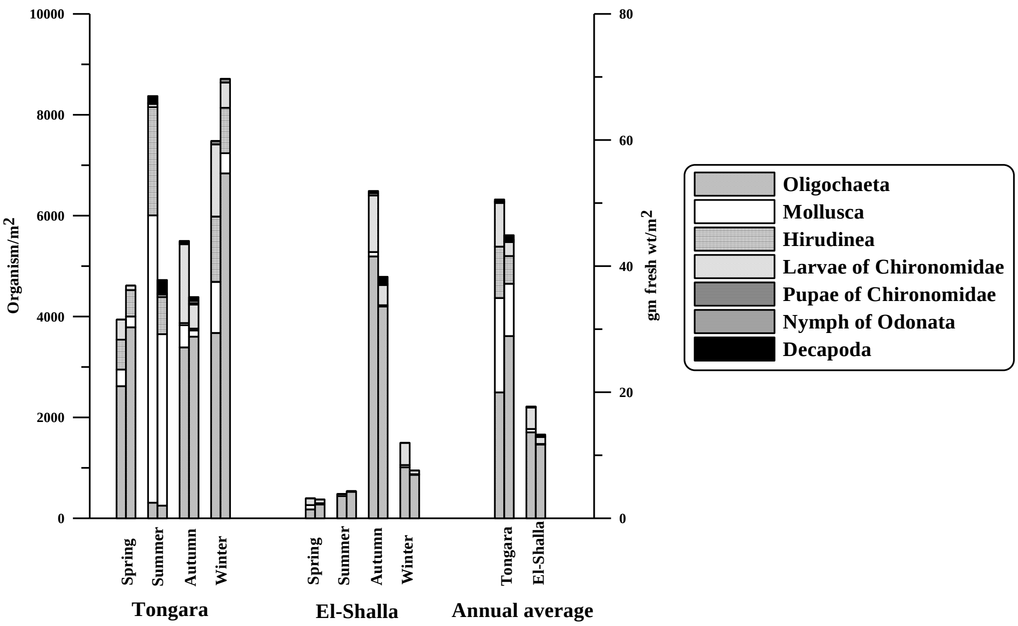

Fig. 2: Distribution and seasonal variations of macrobenthic invertebrstes (org./m^2 & g fresh wt./m^2) in Aswan Reservoir during the study.

They were numerous during autumn (Fig. 1) at Tongara and El-Shallal (3388 org./m^2 with 28.8 g/m^2 & 5192 org./m^2 with 33.6 g/m^2, respectively) and in winter at the former station (3674 org./m^2 with 54.7 g/m^2) where water temperature fluctuated between 19.8 and 23.6°C (Table 1), and mainly consisting of *L. udekemianus* (Fig. 3) which contributed 34.7 and 70.5% (avg. 1482 org./m^2) of total benthos and oligochaetes, respectively. *Limnodrilus hoffmeisteri* contributed 13.5% (avg. 283 org./m^2), while *B. sowerbyi* accounted for 15.9% (avg. 335 org./m^2) with a peak at Tongara during spring (792 org./m^2). On the other hand, Hirudinea were only represented by one species, *Helobdella conifera* Moore, contributing 11.9 and 19.5% (avg. 510 org./m^2 with 2.2 g/m^2) of total benthos and annelids, respectively. The species was confined to Tongara (Fig. 2) with peaks during summer and winter (2145 org./m^2 with 5.9 g/m^2 and 1298 org./m^2 with 7.2 g/m^2) at a wide range of water temperature as shown in Table 1.

Molluscs ranked second in numerical value in Aswan Reservoir with an annual average of 968 org./m^2 and 4.2 g/m^2. Tongara also harboured the highest values (Fig. 2) (avg. 1870 org./m^2 with 8.3 g/m^2) where there is a riverine condition, due to the daily inflow of water from the High Dam to the reservoir (Iskaros & Gindy, 2009). Eight gastropod species namely *Valvata nilotica* Jackeli, *Bulinus truncatus* Audouin, *Gyraulus ehrenbergi* Beck *Biomphalaria alexandrina* Ehrenberg, *Gabbiella senaariensis* Kuster, *Physa acuta* Darparnaud, *Melanoides tuberculata* Müller and *Helisoma duryi* Wetherbg were recorded. Their highest densities were confined to summer (Fig. 2), particularly at Tongara (5698 org./m^2 with 27.2 g/m^2). Similarly, in summer is another peak of high density of *V. nilotica* (Fig. 3) which accounted for 12.6 and 55.7% (avg. 539 org./m^2) of total benthos and molluscs, respectively. *Bulinus truncatus* (Fig. 3) contributed 19.3% (avg. 187 org./m^2), being confined to Tongara during summer, autumn and winter (1254, 66 & 176 org./m^2, respectively). *Gyraulus ehrenbergi* (Fig. 3) contributed 15.1 % (avg. 146 org./m^2). The species was confined to Tongara during the above three seasons (880, 110 and 176 org./m^2, respectively). On the other hand, the other gastropods (Fig. 3) (*G. senaariensis. B. alexandrina, P. acuta, H. duryi* and *M. tuberculata*) were represented by few individuals at Tongara, mainly during summer (44 - 154 org./m^2) except for the latter which was recorded in spring (154 org./m^2).

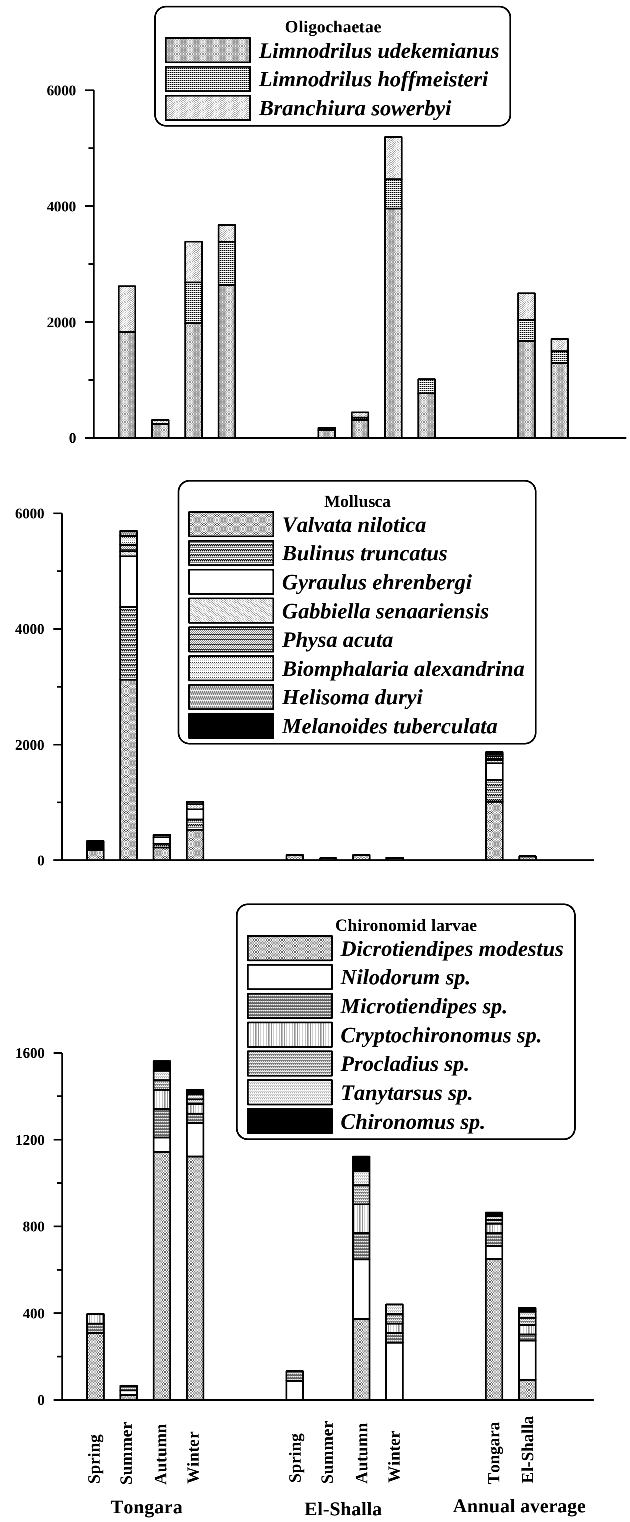

Fig. 3: Distribution and seasonal variations of macrobenthic invertebrates species (org.lm^2) in Aswan Reservoir during the study.

Chironomid larvae ranked third with an annual average of 644 larvae/m^2 and 1.7 g/m^2 where Tongara also sustained the highest values (Fig. 2) (avg. 864 larvae/m^2 with 2.2 g/m^2). They were represented by 7 species, namely; *Dicrotiendipes modestus, Nilodorum* sp., *Microtiendipes* sp., *Cryptochironomus* sp., *Procladius* sp., *Tanytarsus* sp. and *Chironomus* sp. Autumn and winter were the most productive seasons for chironomid larvae (Fig. 3), particularly at Tongara (1562 larvae/m^2 with 3.8 g/m^2 & 1430 larvae/m^2 with 4.0 g/m^2, respectively). It is worthy to note that *Dicrotiendipes modestus* (Fig. 3) predominated the community, contributing 8.7 & 57.6% (avg. 371 larvae/m^2) of total benthos and chironomid larvae, respectively. *Nilodorum* sp. ranked second in importance (18.8% with 121 larvae/m^2) with a peak at El-Shallal (avg. 181 larvae/m^2). On the other hand, the other larvae (Fig. 3) were rarely encountered from one season to another (22-132 larvae/m^2), contributing collectively 23.6% (avg. 152 larvae/m^2). Pupae of Chironomiodae appeared rarely during autumn at Tongara and El-Shallal (22 & 44 pupae/m^2, respectively) and in winter at the former station (66 pupae/m^2).

Other species of rare occurrence (Fig. 2) were recorded in Aswan Reservoir including the crustacean *Cardinea nilotica* Roux which was recorded at Tongara during summer and autumn (avg. 77 org./m^2 with 1.4 g/m^2) and at El-Shallal in the latter season (44 org./m^2 with 1.1 g/m^2) and nymph of Odonata at the former station during the above 2 seasons (avg. 22 nymph/m^2 & 0.3 g/m^2).

4. DISCUSSION

It is well established that the macrobenthic invertebrates are largely influenced by the surrounding environmental conditions, including biotic and abiotic factors and are affected by a complex inter - relationship between these different factors (Hawkes, 1975). Difonzo and Campbell (1988) found that the relative abundance and composition of invertebrates vary depending on the type of microhabitat (aquatic plants, bottom sediments or water column). Similarly, in the present study**,** oligochaetes were more abundant where the decaying macrophytes provide the bottom sediments with nutrients that assures good nourishment. According to Odei (1972 & 1973) and Hann (1995), molluscs and chironomid larvae prefer macrophytes to avoid predators and to feed on epiphytic microorganisms. Those of the Hirudinea live close to the former groups to use them as a source of nourishment (Pennak, 1978). This indicates that macrophytes provide excellent microhabitats of special characteristics that enhance establishment and maintain of many invertebrates (Ali *et al.,* 2007), similar to that observed at Tongara station during the present study.

During different seasons, the water column in the reservoir was isothermic, probably due to its moderate depth (maximum 18 m.) and the daily movements of water which arrives from the Aswan High Dam and enables the water column to be of the same temperature (Iskaros & Gindy, 2009). It is well known that temperature is a critical controlling factor in all aquatic habitats. Changes in temperature can alter or completely inhibit the normal growth and spawning activities of certain organisms (Welch, 1952 & Payne, 1986). Thus, from the correlation coefficient (Table 5), oligochaetes and chironomid larvae reacted negatively to water temperature, contrary to the leeches, decapods and molluscs, except for *Melanoides tuberculata.* However, there is contradiction in the result of the present study with that of Iskaros and Gindy (2009) regarding the chironomid larvae where there was a positive correlation with the water temperature as there was only one peak during autumn. We do believe that the increase in water temperature to about 20°C in winter compared with the same season of the year before (18°C) resulted in the formation of another peak for the chironomid larvae. This is rather in agreement with Iskaros (1988 & 1993) observations on the seasonal variations of molluscs and chironomid larvae of Lake Nasser, where their peaks were observed during summer and autumn and winter, respectively.

Dissolved calcium can be supplied through the encrusting organisms which play the chief role in the accumulation of carbonate as in the case of both Lake Nasser and Nile River sediments (El-Dardir, 1984 & Frahat, 2010). El-Dardir (1984) concluded that the higher water temperature, characteristics of shallow water in Lake Nasser favors the precipitation, through decreased solubility, of both $CaCO_3$ and CO_2, allowing the bottom organisms to flourish. Therefore, a positive correlation stands for the abundance of most bottom fauna species and $CaCO_3$ (Table 5). This clearly indicates that $CaCO_3$ is of marked importance to the population growth of bottom fauna in Aswan Reservoir. The present results confirm those of Brown (1980), Krzyanek (1986) and Ali *et al*. (2007) who stated that the greater the amount of organic matter with Ca increase, the greater the development of detritophages, chiefly the oligochaetes and molluscs.

Organic carbon provides an indication of the amount and type of food settling on the bottom from the water column and it is used as an index of those available for benthic animals (Byers *et al*., 1978). The greatest amount of organic carbon in Aswan Reservoir generally increased in summer and autumn (Table 4) due to the gradual accumulation of phytoplankton on the reservoir bed and its decomposion in the previous seasons. The present results also clarified a positive correlation between organic carbon and most organisms (Table 5).

In the present study, the standing crop of macrobenthic invertebrates in Aswan Reservoir markedly increased to 4270 org./m^2 with 29.1 g/m^2 compared to 2274 org./m^2 with 17.9 g/m^2 which was recorded during the period of June, 1982 - May, 1983 (Iskaros, 1988) and 2858 org./m^2 with 15.4 g/m^2 during spring, 2008 - winter, 2009 (Iskaros & Gindy, 2009). This increase in the standing crop compared to the years before may be attributed to continuous accumulation of detrital particles coming to the reservoir from Lake Nasser and also to changes in the physico - chemical parameters like the increase in water temperature with about 2°C in both winter and summer (Table 1) compared to 18 and 25 °C in the same seasons during the year before (Iskaros & Gindy, 2009).

Table 5: Correlation coefficient between some ecological parameters and macro benthic invertebrates' species during the study.

	T	O.M	$CaCO_3$	Limn. ude.	Limn.	Bran. sow.	Helo. con.	Valv. nil.	Buli. tru.	Gyra. ehr.	Gabb. sen.	Phys. acu.	Biom. ale.	Heli. dur.	Mela. tub.	Dicr. mod.	Nilo. sp.	Micr. sp.	Cryp. sp.	Proc. sp.	Tany. sp.	Chir. sp.
O.M	0.803																					
$CaCO_3$	0.805	0.874																				
Limn. ude.	-0.444	0.106	-0.009																			
Limn. hof.	-0.490	0.248	0.006	0.713																		
Bran. sow.	-0.248	-0.014	0.166	0.761	0.409																	
Helo. con.	0.279	0.207	0.240	-0.119	-0.084	-0.181																
Valv. nil	0.536	0.367	0.499	-0.304	-0.256	-0.283	0.888															
Buli, tru	0.545	0.387	0.511	-0.316	-0.249	-0.304	0.877	0.999														
Gyra. ehr.	0.520	0.408	0.521	-0.286	-0.176	-0.278	0.888	0.995	0.996													
Gabb. sen.	0.129	0.387	0.291	0.037	0.378	-0.121	0.846	0.713	0.713	0.766												
Phys. acu.	0.595	0.365	0.530	-0.366	-0.354	-0.314	0.819	0.989	0.990	0.975	0.606											
Biom. ale.	0.595	0.365	0.530	-0.366	-0.354	-0.314	0.819	0.989	0.990	0.975	0.606	1.000										
Heli. duro.	0.375	0.353	0.340	-0.184	-0.060	-0.325	0.965	0.938	0.936	0.946	0.865	0.882	0.882									
Mela. tub.	-0.196	-0.568	-0.267	0.103	-0.354	0.531	0.042	-0.139	-0.173	-0.194	-0.276	-0.143	-0.143	-0.204								
Dicr. mod.	-0.411	0.167	0.041	0.605	0.891	0.540	0.080	-0.165	-0.170	-0.086	0.499	-0.286	-0.286	0.020	-0.052							
Nilo. sp.	-0.508	-0.055	-0.256	0.624	0.467	0.126	-0.316	-0.302	-0.293	-0.301	-0.213	-0.294	-0.294	-0.232	-0.359	0.065						
Micr. sp.	-0.391	-0.118	0.024	0.176	0.554	0.429	-0.197	-0.185	-0.183	-0.117	0.176	-0.228	-0.228	-0.217	0.000	0.683	-0.078					
Cryp. sp.	-0.429	0.104	0.094	0.899	0.683	0.762	-0.348	-0.362	-0.364	-0.338	-0.146	-0.378	-0.378	-0.359	0.000	0.507	0.696	0.377				
Proc. sp.	-0.393	0.171	0.067	0.761	0.642	0.446	-0.389	-0.319	-0.309	-0.295	-0.174	-0.312	-0.312	-0.313	-0.312	0.311	0.884	0.221	0.917			
Tany. sp.	-0.468	0.127	0.022	0.711	0.700	0.409	-0.399	-0.339	-0.326	-0.303	-0.130	-0.338	-0.338	-0.321	-0.338	0.379	0.855	0.337	0.894	0.984		
Chir. sp.	-0.188	0.406	0.312	0.857	0.750	0.657	-0.254	-0.232	-0.229	-0.193	0.033	-0.260	-0.260	-0.206	-0.260	0.573	0.618	0.346	0.918	0.862	0.821	
Card. nil.	0.579	0.504	0.668	-0.099	-0.175	-0.092	0.702	0.920	0.922	0.912	0.548	0.938	0.938	0.789	-0.216	-0.182	-0.070	-0.153	-0.064	-0.006	-0.057	0.073

T	: Temperature	Biom. ale.	: *Biomphalaria alexandrina*
O.M	: Organic matter	Heli. dur.	: *Helisoma duryi*
Limn. ude.	: *Limnodrilus udekemianus*	Mela. tub.	: *Melanoides tuberculata*
Limn. hof.	: *Limnodrilus hoffmeisteri*	Dicr. mod.	: *Dicrotiendipes modestus*
Bran. sow.	: *Branchiura sowerbyi*	Nilo. sp.	: *Nilodorum* sp.
Helo. con.	: *Helobdella conifera*	Micro. sp.	: *Microtiendipes* sp.
Valv. nil.	: *Valvata nilotica*	Cryp. sp.	: *Cryptochironomus* sp.
Buli. tru.	: *Bulinus truncatus*	Proc. sp.	: *Procladius* sp.
Gyra. her.	: *Gyraulus ehrenbergi*	Tany. sp.	: *Tanytarsus* sp.
Gabb. sen.	: *Gabbiella senaariensis*	Chir. sp.	: *Chironomus* sp.
Phys. acu.	: *Physa acuta*	Card. nil.	: *Cardinea nilotica*

On the other hand, 25 species of macrobenthic invertebrates were recorded in Aswan Reservoir (Iskaros, 1988) (Table 6). Molluscs were the most abundant (53.8% of the total benthos), being represented with 11 species. Chironomid larvae and annelids ranked second and third, being represented with 9 and 4 species, respectively. In addition, Platyhelminthes only embraced one species and nymphs of both Odonata and Ephmeroptera were also recorded.

During the period 2008 – 2009 (Iskaros & Gindy, 2009), species composition and seasonal variations markedly changed. Results of latter work revealed that six mollusc species, 4 chironomid Iarvae species, Platyhelminthes and nymph of Ephemeroptera have disappeared, accompanied by the prevailing of oligochaetes (56.8%), the appearance of one species of both molluscs and decapods in addition to two chironomid larvae species. In the present study, the recorded macrobenthic fauna (Fig. 3), revealed that the hirudineas markedly flourished (11.9%) while they were rather rare during the years before, two new gastropod species were recorded with a marked disappearance of the bivalves (Table 6).

Table 6: Check list of macrobenthic invertebrates species recorded in Aswan Reservoir during the different periods.

Taxa	1982-1983 (Iskaros, 1988)	2008-2009 (Iskaros & Gindy, 2009	2009-2010 The present work
Oligochaeta			
Branchiura sowerbyi Beddard	+	+	+
Limnodrilus udekemianus Claparede	+	+	+
Limnodrilus hoffmeisteri Claparede	+	+	+
Hirudinea			
Helobdella conifera Moore	+	+	+
Platyhelminthes			
Planaria sp.	+	-	-
Chironomid larvae			
Procladius sp.	+	+	+
Ablabesmyia sp.	+	-	+
Dicrotiendipes modestus	+	+	+
Einfeldia sp.	+	-	-
Cryptochironomus sp.	+	+	+
Chironomus sp.	+	+	+
Nilodorum sp.	-	+	+
Tanytarsus sp.	+	-	+
Microtiendipes sp.	-	+	+
Circotopus sp.	+	+	-
Orthocladius sp.	+	-	-
Pupae of Chironomidae*	+	+	+
Nymph of Odonata*	+	+	+
Nymph of Ephemeroptera*	+	-	-
Mollusca			
Theodoxus niloticus Reeve	+	-	-
Bellamya unicolor Olivier	+	-	-
Cleopatra bulmoides Olivier	+	-	-
Valvata nilotica Jickeli	+	+	+
Melanoides tuberculata Müller	+	+	+
Bulinus truncatus Audouin	+	+	+
Bulinus forskallii Ehrenberg	-	+	-
Biomphalaria alexandrina Ehrenberg	+	+	+
Lymnaea natalensis Krauss	+	-	-
Physa acuta Darparnaud	+	+	+
Gyraulus ehrenbergi Beck	-	-	+
Gabbiella senaariensis Kuster	-	-	+
Sphaerium sp.	+	-	-
Pisidium pirothi Jickeli	-	+	-
Corbicula fluminalis Müller	+	-	-
Crustacea			
Cardinea nilotica Roux	-	+	+
Total	25	19	20

* Unidentified species; (+) Present (-) Absent

The macrobenthic invertebrates in Aswan Reservoir were found poor regarding numbers of each species. Compared to that of Lake Nasser and among the marginal vegetations, the diversity markedly increased as a wide variety of insects appear, particularly larvae of

Chironomidae (17 species), nymphs of Odonata (8 species), nymph of Ephemeroptera (1 species), larvae and adult of Coleoptra (1 species for each), adult Hemiptera and larvae of Trichoptera together with Oligochaeta (4 species), Hirudinea (1 species), Crustaceae (3 species), Mollusca (10 species), Hydrozoa (1 species) and Phylactolamata (1 species) (Iskaros, 1988 & 1993 and Fishar, 1995 & 2000). The poverty in the numbers of macrobenthic invertebrates species recorded from Aswan Reservoir is of interest. Actually, it is possible to explain this on the basis of the effect of hydrodynamic regimes in the reservoir, where there is a pronounced diurnal fluctuations in water level with amplitude of about 3 meters related to the daily pattern of water inflow through Aswan High Dam turbines (Iskaros *et al.*, 2008). This creates unstable conditions unfavorable for the development of benthic fauna as it was also observed in the Blue Nile with its strong currents and drastic changes of water level (Rzoska, 1976). Moreover, Wirth and Stone (1968) and Brown (1980) indicated that pulmonates and Chironominids are mainly restricted to aquatic plant substrates. Hence, their distribution in Aswan Reservoir in the present work appears to be reduced due to the marked shortage of suitable substrates, resulting from the introducing grass carps which mainly feed on them (Iskaros & Gindy, 2009).

In the present study, the calculated mineralogic indices revealed that the studied sediments in Aswan Reservoir receive significant contributions from the Ethiopian Plateau and Equatorial regions (Hassan, 1976). This is also in accordance with El-Dardir (1995) who mentioned that the Recent Nile sediments in the area between the High Dam and old Aswan Dam received their sediments from such regions. Consequently, the macrobenthic invertebrates belong to the Nile system fauna. Rzoska (1976) and Brown (1980) expected new establishment of bottom fauna in Lake Nasser after its impoundant in 1969. This really occurred as revealed by the results of Iskaros (1988 & 1993), Fishar (1995 & 2000) and Iskaros and El-Dardir (2010) as well. Entz (1978), also explains that the different species that came from the south through the water flood, the original bottom fauna of the Nile valley reoccupied and established itself after losing its original environments. In the present study, it was clearly noted that some species moved from Lake Nasser and started to accomodate to the reservoir environment. During the period of June, 1982 – May, 1983 (Iskaros, 1988), the total species reached 25 and after the introduction of grass carp that mainly feed on the grass in the reservoir, the number of species decreased to 14 (Iskaros & Gindy, 2009). It is worthy to note that 6 new species were recorded for the first time during the last 2 years (Table 6).

In addition, the highest reading obtained by Secchi disk in Aswan Reservoir during winter may be attributed to slow water speed. On the other hand, the relative decrease in transparency during other seasons may be due to the increasing water discharge from Lake Nasser loaded with more detritus particles which create strong turbulence between bottom and the above layers (Iskaros *et al*., 2008; Iskaros & Gindy, 2009). It was observed that the seasonal peaks of oligochaetes and chironomid larvae (Figs. 2 & 3) coincided mostly with the highst transparency (Table 1). This agrees reasonably well with the results of Lewis (1957) in the Blue Nile at Khartoum and Iskaros (1993) at the littoral stations of Khor Kalabsha in Lake Nasser who noticed that the clear water enables the benthic organisms, particularly the chironomid larvae to fed on both the phytoplankton and zooplankton.

The highest oxygen content recorded in Aswan Reservoir (Table 1) was found in correlation with phytoplankton flourishing during winter and spring (4200-7900 unit $\times$ $10^3 l^{-1}$ & 5306 - 8361 unit x $10^3 l^{-1}$, respectively) compared with summer and autumn (1576 - 2926 unit x $10^3 l^{-1}$ & 3725 - 6174 unit x $10^3 l^{-1}$, respectively) (El-Otify, 1991) and the opposite relation between temperature and DO and its consumption by organic matter decomposition by bacteria (Awadallah *et al*. 1991). Train (1979) mentioned that the amount of oxygen content required for maintenance of healthy freshwater biota must be over 5 mgO_2/l. This also coincides with the present results of most benthos, except for molluscs (Figs. 2 & 3). Iskaros and El-Dardir (2010) found that the main species of molluscs i.e *Valvata nilotica*, reached its peak at the offshore stations of Lake Nasser when the oxygen content varied between 2.28 and 4.02 mgO_2/l.

The alkaline side of the water recorded in Aswan Reservoir (Table 1) may be attributed to the photosynthetic activities of phytoplankton, that led to CO_2 consumption by photosynthetic process and consequently high pH values (El-Otify, 1991). The recorded pH values are more suitable for aquatic freshwater biota as proposed by Train (1979) and Rabeh (2006). This alkaline water habitat is generally found to be favoured by oligochaetes, chironomid larvae and molluscs. Our results indicated that the main species of oligochaetes and chironomid larvae (Fig. 3) were increased accompanied with the increased pH values (Table 1), contrary to molluscs.

It is well known that the zoobenthos population of any water mass, subsisting mostly on detritus including phytoplankton and zooplankton represent the third trophic level in the food chain. These biota form a fovourite diet for fish and therefore control the water's economic production. Thus, these organisms need more study due to their importance in the food chain. Besides, it is of real importance to forbid introducing grass carp to Aswan Reservoir which markedly will affect the environmental balance as the number of species decreased. The existence of such fish will damage the nests of *Tilapia* and use its fry as another choise in its feeding.

In conclusion, the present investigation indicates that the standing crop of benthos as well as number of species in Aswan Reservoir showed a remarkable drastic change from one year to another. The low numbers of macrobenthic invertebrates species in Aswan Reservoir compared to that in Lake Nasser may be attributed to the fact that there is a pronounced diurnal fluctuation in water level which creates severe conditions unfavorable for the development of benthic organisms. Besides, physico-chemical factors, characteristics of bottom sediments, introducing grass carp to control aquatic plants and the effect of Nile tributaries seem to be effective factors that limit the distribution and abundance of the macrobenthic invertebrates in Aswan Reservoir.

5. REFERENCES

Ali, M. M.; Mageed, A. A. and Heikel, M. T. (2007. Importance of aquatic macrophyte for invertebrate diversity in large subtropical reservoir. Limnologica, 37: 155 - 169.

APHA, AWWA and WEF. 1995. Standard methods for the examination of water and wastewater (18 th ed). Washington, DC: APHA, AWWA, WEF., 1042pp.

Awadallah, R. M.; El Haty, M. T.; Soltan, M. E. and Ahmed, L A. 1991. Characterization of the Nile water quality in the zone from Aswan to Giza. Egypt Delta J. Sci. 15(1):84-104.

Brown, D. S. 1980. Freshwater snails of Africa and their medical importance. London and Francis Ltd, 478 pp.

Byres, C.; Mills, E. L. and Stewart, P. L. 1978. A comparison of methods of determining organic carbon in marine sediments with suggestions for a standard method. Hydrobiologia, 58: 43 - 47.

Carver, R. E. 1971. Procedures in sedimentary petrology. John Wiley, London, New York, Sydney, Toronto, 653pp.

Difonzo, C. D. and Campbell, J. M. 1988. Spatial partitioning of microhabitats in littoral cladoceran communities. Journal of freshwater ecology, 4, 303 313.

El-Dardir, M. (1984. Geochemical and sedimentological studies on the sediments of Aswan High Dam Reservoir. Ph. D. Thesis. Faculty of Science, Al Azhar University, Cairo, Egypt, 238pp.

El-Dardir, M. 1994. Mineralogical and geochemical studies on the Recent Nile sediments of the area between the old Aswan Dam and High Dam. Bulletin of Faculty of Science, Menoufia University, 8: 205 - 229.

El Dardir, M. 1995. Trace elements distribution in the Recent Nile sediments between the High Dam and old Aswan Dam, Egypt. Bulletin of Faculty of Science, Al Azhar University, Egypt, 6: 1951 - 1960.

El-Otify, A. M. 1991. Studies on phycoperiphyton of the Nile System at Aswan. Ph. D. Thesis, Faculty of Science, Assiut University, 373 pp.

Entz, B. A. G. 1978. Sedimentation processes in the Reservoir Lake Nasser -Nubia during 1965 -·1974 and future aspects. Symposium of Ecological studies on the Nile River. Egyptian Society of Environment, Cairo.

Fishar, M. R A. 1995. Studies on bottom fauna in Lake Nasser. Ph.D. Thesis, Faculty of Science, Suez Canal University, Egypt, 267pp.

Fishar, M. R A. 2000. Macrobenthic fauna, p. 75 -79. In J.F. Craig (Ed.) Sustainable fish production in Lake Nasser: Ecological Basis and Management Policy. ICLARM Conf. Proc. 61: 184pp.

Farahat, H. I. H. 2010. Particle size distribution and geochemical studies on the recent sediment of Damietta and Rosetta Branches. Ph.D. Thesis, Faculty of Science, Banha University, Egypt, 227pp.

Hann, B. J. 1995. Invertebrates associations with submersed aquatic plants in a prairie wetland. USF (Delta Marsh) Annual report, Vol. 30.

Hassan, F. 1976. Heavy minerals and the evolution of the modern Nile. Quaternary Research, 6:425 - 444.

Hawkes, H. A. 1975. River zonation and classification, 312 - 374. I B.A. Whitton (Ed.), river ecology. University of California.

Iskaros, I. A. 1988. Biological studies on bottom fauna in lake Nasser and adjacent water. M.Sc. Thesis, Faculty of Science, Alexandria University, 184 pp.

Iskaros, I. A. 1993. Ecological studies on the distribution of zooplankton and bottom fauna in Khor Kalabsha in lake Nasser. Ph.D. Thesis, Faculty of Science, Mansoura University, 304 pp.

Iskaros, L A. and Gindy, N. N. 2009. The effect of the substrate status on bottom fauna in Aswan Reservoir. Egyptian Journal of Aquatic Research, 35(2), 137 -148.

Iskaros, L A. and El Dardir, M. 2010. Factors affecting the distribution and abundance of bottom fauna in Lake Nasser. Nature and Scie., 8(7): 95-108.

Iskaros, L A., Bishai, R. M. and Mokhtar, F. M. 2008. Comparative study of zooplankton in Aswan Reservoir and the Nile River at Aswan. Egyptian Journal of Aquatic Research, 34 (2): 260-284.

Krzyanek, E. 1986. Zoobenthos of the small eheolimnic Wilsa-Czarre Dam Reservoir (South Poland) in the period 1975 - 1984. Acta Hydrobiologia, 28: 414 - 427.

Lewis, D. J. 1957. Observations on chironomid at Khartoum. Bulletin of Entomology Research, 48: 155 – 184.

Odei, M. A. 1972. Some preliminary observations on the distribution of bilharzias host snails in the Volta Lake. Bulletin of Institute Fondamental African Noire, 34: 534 - 543.

Odei, M. A. 1973. Observations on some weeds of malacological importance in the Volta Lake. Bulletin of Institute Fondamental African Noire, 35: 57 - 66.

Payne, A. I. 1986. The ecology of tropical lakes and rivers. John Wiley & Sons. Chichester, New York, Toronto, Brisbane and Singapore, 300p.

Pennak, R. W. 1978. Fresh water invertebrates of the United States. 2nd edition. John Willey & Sons. New York, 803 pp.

Rabeh, S. A. 2006. Bacteria as indication of both sewage pollution and trophic level in Abu Zabaal Lakes, Society for Environmental Development (D - Environmental studies), 6(1): 27 - 48.

Rzoska, J. 1976. Notes on the benthos of the Nile system. In. Rzoska (Ed.), The Nile Biology of an Ancient River. W. Junk, The Hague, 345 - 351.

Train, R. E. 1979. Quality Criteria for Water Castle House Publication LTD., London, 256p.

Welch, P. S. 1952. Limnology. 2nd edition. New York, Toronto, London, Mc. Grew, Hillbook Company, Inc., 538pp.

Wirth, W. W. and Stone, A. 1968. Aquatic Diptera, P. 372 - 482. In: R.L. Usinger (Ed.), Aquatic Insecta of California. "Univ. Calif. Pr. Los Angeles.