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SEASONAL VARIATIONS AND COMMUNITY STRUCTURE OF PLANKTON IN RELATION TO SOME ENVIRONMENTAL VARIABLES IN WADI HANEEFAH STREAM, RIYADH, SAUDI ARABIA

SUMMARY

A study on the qualitative and quantitative variations of phytoplankton and zooplankton populations as well as physico-chemical condition of water at three different locations in Wadi Haneefah Stream was carried out. Water temperature fluctuated between 18.0°C and 32.0°C, while pH values ranged from 7.1 to 8.5. Dissolved oxygen concentration reached maximum in May. The contents of chloride, Alkalinity and sulphate were highest in July-August. It is found that most of the parameters studied (turbidity, conductivity, hardness, total nitrogen, total dissolved solids, phosphorus, BOD and COD) have high values in summer months (June – September).

A total of 50 phytoplanktonic taxa representing the families Chlorophyceae, Cyanophyceae, Desmidiaceae and Bacillariophyceae were recorded during the present study. Among all, Bacillariophyceae was the dominating group. The population density of phytoplankton was more prominent in summer. zooplankton community was represented mainly by Protista, Rotifera, and Crustacea. These zooplankton was peaked in July and trough in January. The effects of various physico-chemical quality parameters on the seasonal distribution and succession of planktonic organisms are also discussed

INTRODUCTION

The knowledge of the habitat characteristics, its species composition as well as the physico-chemical and biological factors which directly or indirectly affect to the inhabitants is essential for proper appraisal of the ecology of aquatic animal species (Nikolsky, 1963; Munawar, 1974; Seenayya and Zafar 1979; Shamsi and Jafri, 1979; Smith, 1992; Rask *et al.,* 1992, Lalouie, 1993; Leland and Porter, 2000; Leira and Sabater, 2005; Mageed and Heikal, 2006). The important component of the ecological pyramid of the freshwater ecosystem is plankton. They constitute the basis of the food web and represent one of the most direct and profound response to pollution entering to aquatic environments (Arcifa *et al*., 1986; Basima *et al*., 2006). Changes in the population density of these organisms can potentially alter the entire biomass production (Goldman and Horne, 1983; Huff, 1986; Zafar, 1986). The plankton is supposed to be the first community disturbed by external loading from the surrounding settlement or other anthropogenic activities. Telesh (2004) stated that plankton is an important ecosystem component which response to ecosystem alterations rather rapidly. Hence, the most vulnerable states of the aquatic ecosystem are seen in phytoplankton and zooplankton. Based on the fundamental knowledge on plankton species composition, density and physiological state, it is possible to assess the degree of water pollution (Ivanova and Telesh, 1996). Shamsi and Jafri (1979); Jhingran (1982) suggested that plankton along with other species of animals is the indicators of eutrophication and state of pollution of the aquatic environments. Knowledge of responses of biota to changes in water quality could constitute an important tool to be used by water managers to rapidly and continually assess the quality of waters they are managing.

A considerable amount of literature on the ecological studies of the freshwater ecosystem around the globe are available (Munawar, 1974; Milton and Wayne, 1979; Garcia *et al.,* 1982; Dussart *et al.,* 1984; Tyler, 1984; Tucker and Lloyd 1984; Barnes and Mann, 1991; Smith, 1992; Allanson and Read, 1995; Grange *et al.,* 2000; Arle, 2002; Leira and Sabater, 2005; Basima *et al.,* 2006; Mageed and Heikal, 2006) but very few studies have been made on the freshwater ecosystem of Saudi Arabia (Segars and Dumont, 1993; Al-Ghanim, 2005).

Seasonal variations in both phytoplankton and zooplankton densities in relation to physico-chemical parameters in Wadi Haneefah drainage stream, Riyadh, Saudi Arabia were studied. As far as the authors know, there is very meager scientific published information on this drainage system (Siddiqui and Al-Harbi 1995; Al-Dahmesh 2000). This study might be helpful for regulating the ecosystem and maintaining the aquatic fauna and flora.

Description of the study area

Wadi-Haneefah (Fig.1.) is located between 24° 30'N and 46° 30'E to 24° 45'N and 46° 45'E. This Wadi originated from the North-West of Riyadh, passes through West-South of Riyadh and reaches to East of Al-Hair town. The main sources of water are the seasonal rain fall and sewage water. Some water from sewage treatment plant of Al-Hair Damare, also making way to the stream. It holds a stream with huge amount of water surrounded by abundant vegetation. The depth of water varied at different

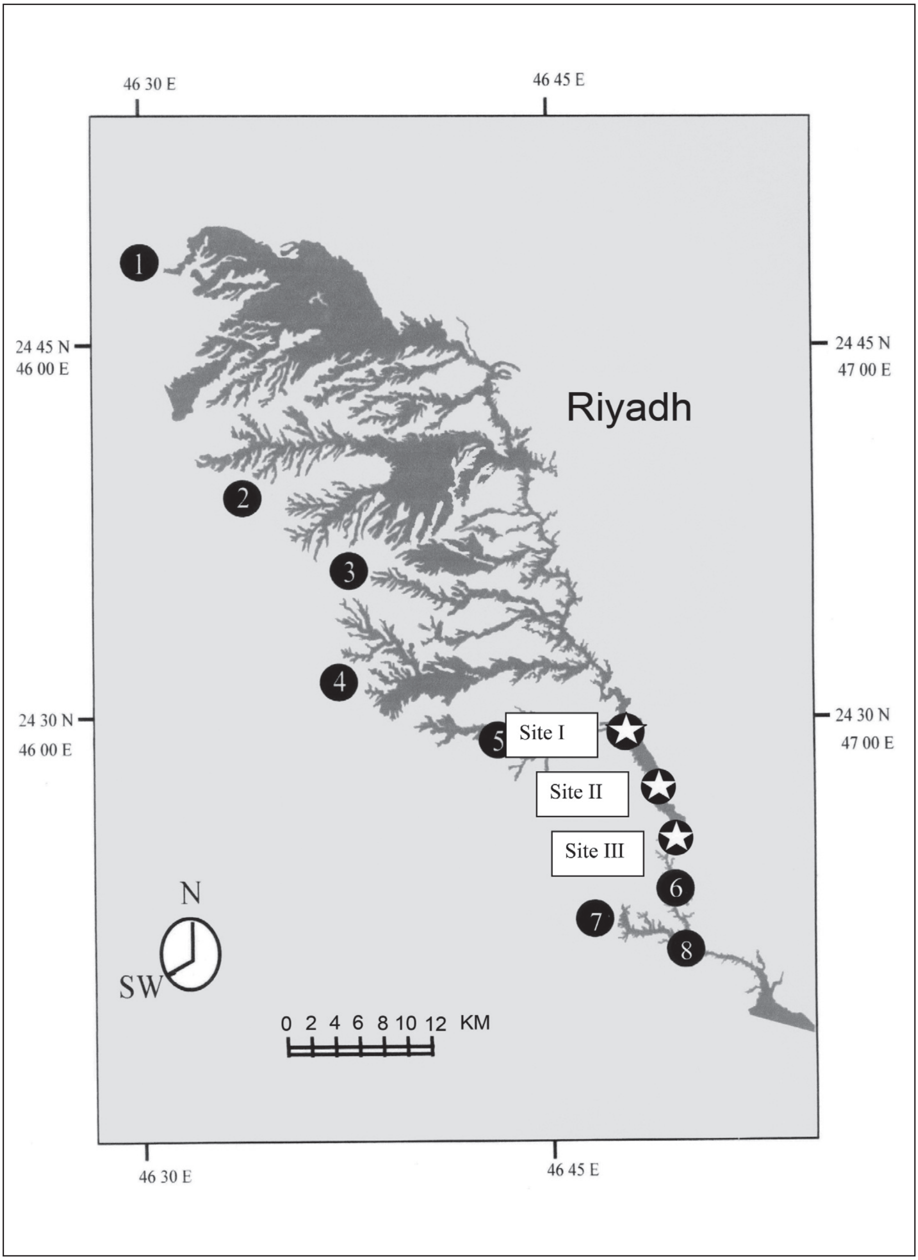

Fig. 1 - Map of wadi Hanifah Channel showing (***) sampling station.
1 - Alelab Dam; 2 - Wadi Safar; 3 - Wadi Ubayr; 4 - Wadi Laban; 5 - Wadi namar; 6 - Al-Hair Dam; 7 - Wadi Liha; 8 - Al-Hair.

areas being approximately two meters. Somewhat irregular shape large shallow patches of water were also formed in some areas. After heavy seasonal rains, however, substantial amounts of runoff water and sewage water increase the catchment's area and water level. The sites with water depth of about two meters selected for the present study have a fine clay bottom structure. Flow of water at site I was faster as compared with site II and III. The shore line is sloppy at all the sites. The difference between the aforesaid sites was the presence of *Chara* spp. and other vegetation which were very dense at site II and III, little at site I. At site III water covers wider area compared to site I and II. Fishes, like *Oreochromis niloticus, Poecilia latipnna,* and *Gumbusia affinis* were found at all sites.

MATERIALS AND METHODS

At each site, physical and chemical properties of water were recorded on monthly basis over a period of one year from January to December 2006. Portable devices from Hanna instruments were used to measure the air and water temperature, pH and conductivity (Model 908) dissolved oxygen (Model HI 9142) and total dissolved solids (Model HI 9034). Samples for other parameters (phosphate, sulphate, nitrate, ammonia, total hardness, total alkalinity, chloride, dissolved oxygen, BOD, COD, Conductivity and turbidity) were kept in amber colored bottled and brought to laboratory for further analysis according to the methods described by Barnes (1959); Sundaresan (1979) and Taras *et al*. (1992).

For phytoplankton analysis, one liter of sub-surface water was collected at each site in the morning hours (between 09:00 and 10:00 hours) and preserved with Lugol's solution immediately. The water samples were left undisturbed for at least 5 days. All the water was siphoned out carefully leaving 10 ml. Three sub-samples of known volumes were used to identify and enumerate the phytoplankton. Samples of zooplankton were collected from the same sites using a conical plankton net made with Organdi cloth with a mesh size of 50 μm. One hundred litters of stream water were filtered through this net. All the samples with a final volume of 25 ml were preserved in 10% formalin solution. Qualitative and quantitative analysis were done in the three sub samples of known volume. The phytoplankton and zooplankton densities were expressed in terms of cell/liter and individuals/m^3, respectively. The following keys were used for plankton identification: Ward and Whipple (1963); Needham and Needham (1964); Tonapi (1980).

Correlation coefficient was preformed at a confidence limit 95% were evaluated to quantify the plankton standing crop and species diversity in relation to the most correlative environmental factors using the parametric Pearson's correlation test using SPSS v.13.

RESULTS

Physical and chemical variables

The hydrographic conditions, chemical parameters and plankton abundance varied widely during the study period. Variations in the physico-chemical variables were shown in Table (1). Water temperature didn't deviate from the normal seasonal fluctuations of Saudi inland waters and coincides with air temperature fluctuating between 18.5°C in January and 32°C in August. Values of pH varied between 7.1 and 8.5 with a peak in summer months (June–September), while dissolved oxygen concentration showed its higher values in late spring (May-June) and fluctuated between 10.8 mg/l at site II in May and 7.2 mg/l at site I in December. Concentration of chloride was generally high in summer months (August) with a mean value of 77.5 mg/l at sites I, II, III, respectively and low in winter (January-February). At all sites, alkalinity, total hardness, TDS and sulphate exhibited higher values in summer months with averages of 1731.3, 240.4, 3586.4 and 145 mg/l respectively, while its minimum values took place in winter (Table 1). At different sampling sites, average values of conductivity were close fluctuating within a narrow range (4804-4882 μS/cm) showing its maxima in June, September and October.

The continuous nutrients enrichment resulting from discharging wastes raised the fertility of Wadi Hanefah to larger extent. During the period of study, high nutrient concentrations were observed at all sites in homogenous manner and the encountered

Table 1 - Monthly variations in the physico-chemical variables recorded at the sampling sites.

Variables	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	Mean±SD
Air Temperature (◦C)	15.5	17.3	21.8	25.5	32.3	37.2	42.7	42.2	37.5	30.8	27.5	14.7	±10.0
Water Temperature (◦C)	18.5	20.7	23.7	29.2	27.5	30.7	30.8	31.7	27.6	25.3	21.5	20	±4.6
Water Level (cm)	128.4	95.1	94.2	89.5	85	83.5	79.2	70.3	77.1	72.3	91.2	125.6	±18.7
pH	7.3	7.2	7.3	7.6	8	8.4	8.5	8.1	8.2	7.9	7.6	7.8	±0.4
Turbidity (NTU)	3.5	4.4	13	12.8	11.7	8.8	6.9	7	3.8	2.8	2.4	2.9	±4.0
Conductivity (µS/cm)	3392	4372	5064	4696	4503	5320	5086	5093	5417	5343	5099	4817	±565
Calcium (mg/l)	797.5	957.3	900.2	1030.5	1001.3	1119.1	962.1	1147.1	1171.6	1156.1	1076.7	998.8	±113.7
Magnesium (mg/l)	267.4	388.4	508.4	470.5	392.5	534.8	763.6	532.7	559.9	498.1	467.3	411.2	±120.6
Total Hardness (mg/l)	1065.2	1345.7	1408.6	1500.6	1393.6	1653.9	1725.6	1679.8	1731.5	1654.2	1544	1410	±13121.2
Total Alkalinity (mg/l)	137.5	212	199.6	197.4	201	203.8	240.4	239.5	236.5	201.7	220.6	210.9	±27.5
Total Dissolved Solids (mg/l)	2309.3	2993.2	3393.1	3224.7	2915.4	3586.4	3452.9	3491	3558.3	3648.1	3434.9	3223.4	±379.0
Ammonia (mg/l)	1.1	2.9	2.6	2.7	4.5	3.2	4.2	2.5	1.2	1.1	1.1	1.5	±1.2
Nitrite) (mg/l)	1.3	2.3	1.2	1.3	4.2	1.1	6.4	1.4	1.2	1.2	1.1	2.4	±1.6
Nitrate (mg/l)	51.3	70.3	115.2	116.9	113.9	250.3	215.6	227.1	134	59.6	80.4	95.8	±67.5
Sulphate (mg/l)	76.5	110.7	105.7	79.5	117.8	135.1	145	133	133.1	132.2	125.9	110.4	±21.7
Orth-Phosphate (mg/l)	1.1	1.7	2.4	2.7	2.9	3.9	3.3	4.8	3.8	3.1	2	1.7	±1.1
Chloride (mg/l)	43.5	25.9	71.3	66.5	62.5	68.2	67	77.5	73.5	69.9	64.8	61.6	±7022.5
Dissolved Oxygen (mg/l)	8.1	8.3	7.7	8.6	10.8	10.2	8.8	7.7	7.6	8.6	9.1	8.1	±1.0
Biological Oxygen Demand (mg /l)	6.1	6.8	9.8	8.6	7.4	7	14.2	15.1	11.7	11	7	7.4	±3.0
Chemical Oxygen Demand (mg/l)	14.6	14.6	19.8	15.5	15	12.1	24.5	35.3	18.2	20.3	14.7	13.3	±6.4

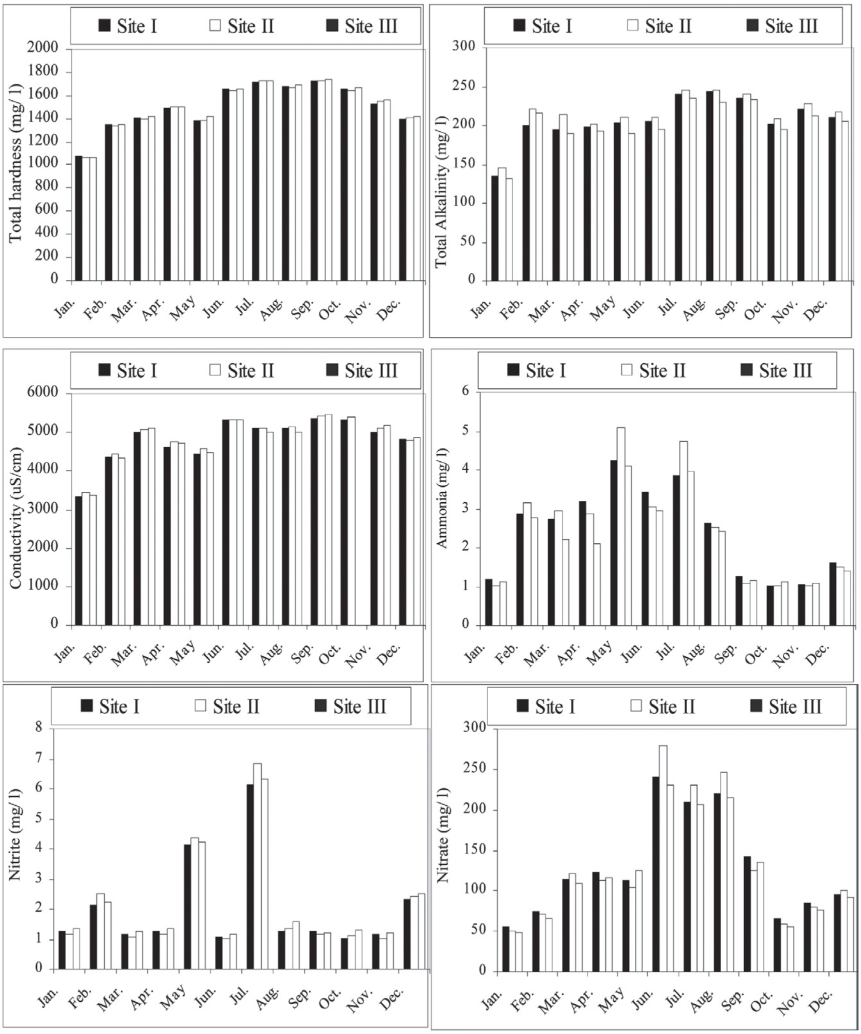

Fig. 2 - Monthly variations of some physical and chemical variables at the studied sites.

variations was insignificant. The average of nutrient salts were fluctuated between minima of 1.05, 1.09, 51.3 and 1.1 and maxima of 4.49, 6.4, 250.3 and 4.8 mg/ l for ammonia, nitrite, nitrate and phosphate, respectively. Seasonally, all nutrient salts showed its minimum concentrations in winter (Table 1 and Fig. 2). The highest concentrations of nitrate and phosphates were recorded in June-July, while ammonia and nitrite showed two peaks in late spring (May) and summer (July).

BOD and COD values showed more or less the same pattern without significant variations between sites (annual averages 9.3 and 18.1 mg/l, respectively). Its maxima were registered from July to October at all investigated sites. (Table 1). High values of conductivity were registered in the dry months and lower values were found in wet colder months. Turbidity values were high from March to May at all sites.

Phytoplankton community

The annual average of phytoplankton standing crop throughout the study area was considerably high (58509 cell/l). The highest count of 74891cell/l was recorded at site III in July, while lowest of 40338 appeared at site I in December. Regarding spatial distribution of total phytoplankton count, considerable high values (62782 and 61229 cell/l) were detected at site II and III respectively, while no significant difference was estimated. Bacillariophyceae constituted the main bulk of the phytoplankton population throughout the whole study area forming 51.2% of the community with an annual average of 29961 cell/l followed by Chlorophyceae which constituted about 23.4% of the total phytoplankton with an annual average of 13699 cell/l. Desmidiaceae and Cyanophyceae came in third and fourth rank each contributing 12.4 % of the total phytoplankton count (Fig. 3).

Seasonally, phytoplankton showed its lowest value of 44855cell/l in January. The phytoplankton showed the outstanding peak in summer with 68139cell/l in July (Fig. 3). In total, 77 *taxa* have been identified during the period of study (Table 2), most of them belongs to Bacillariophyceae (29 *taxa* representing 11 genera). The majority of the recorded species were perennial, except for 5 species (showed seasonal occurrence).

Bacillariophyceae dominated all the year round with its higher abundance in spring and summer while lower values appeared in winter (Fig. 3). Among the most dominant diatom species were *Cyclotella meneghiniana, Synedra ulna, Nitzschia* spp., *Tabellaria fenestrata,, Navicula gracilis* and *Navicula* spp. representing 21.9, 10.5, 9.7, 7.5, and 6.5% of total diatoms count, respectively.

Chlorophyceae constituted the second important group in terms of population density. The maximum population density of this group was recorded in summer (May-October) and the minimum in winter (December-January). The abundant species were *Protococcus* spp., *Ulothrix zonata*, *Ankistrodesmus falcatus* which were found throughout the period of study constituted about 19.4, 17.6, 11.2 and 9% of the total chlorophycaea.

Cyanophyceae were represented by *Merismopedia elegans* and *Oscillatoria princes* (forming 4.5 and 2.5% of the total phytoplankton and 36.3 and 20.1% of the total Cyanophyceae, respectively). First species reached its highest density during summer, while second one peaked in winter. Also *Tetrapedia* spp., *Anabaena constricta* and *Spirulina major* appeared with considerable high numbers (forming

Table 2- List of planktonic species recorded in Wadi Haneefah Stream, during the study period.

Cyanophyceae	*Synedra capitata*
Anabaena constricta	*Synedra fragilis*
Merismopedia elegans	*Synedra* spp
Oscillatoria princeps	*Synedra amphirhncus*
Spirulina major	*Synedra familaris*
Tetrapedia spp.	*Synedra fasciculata*
Chlorophyceae	*Synedra raaiosa*
Ankistrodesmus falcatus	*Synedra radians*
Crucigenia quadrat	*Synedra ulna*
Kirchneriella obesa	*Tabellaria fenestrata*
Microspora spp	*Tabellaria flocculosa*
Ophiocytium parvulum	*Tabellaria* spp.
Protococcus spp.	**Protista**
Scenedesmus microporum	*Dileptus anser*
Scenedesmus spp.	*Frontonia depressa*
Selenastrum microporum	*Paramecium africanum*
Tetradesmus wisconsinensis	*Paramecium* spp.
Ulothrix zonata	*Polytoma tetraolare*
Desmidiaceae	*Trinema acinus*
Closterium spp.	**Rotifera**
Cosmarium laeve	*Brachionus calyciflorus*
Cosmarium margaritiferum	*Brachionus* spp.
Gonatozygon spp.	*Dicronophorus forcipatus*
Penium spp.	*Keratella cochlearis*
Bacillariophyceae	*Keratella* spp.
Amphonema spp.	*Notholca squamula*
Campylodiscus bicostatus	*Ploesoma truncatum*
Cocconies curvata	*Testudinella patina*
Cyclotella comnta	**Crustacea**
Cyclotella spp.	*Cypriodopsis* spp.
Diatoma Vulgare	*Eubranchipus vernalis*
Eunotia sp.	*Mesocyclops* sp
Navicula dicephala	
Navicula gastrum	
Navicula gracilis	
Navicula spp	
Nitzschia amphiina	
Nitzschia frustulum	
Nitzschia plana	
Nitzschia sigma	
Nitzschia spp	
Stauroneis spp	

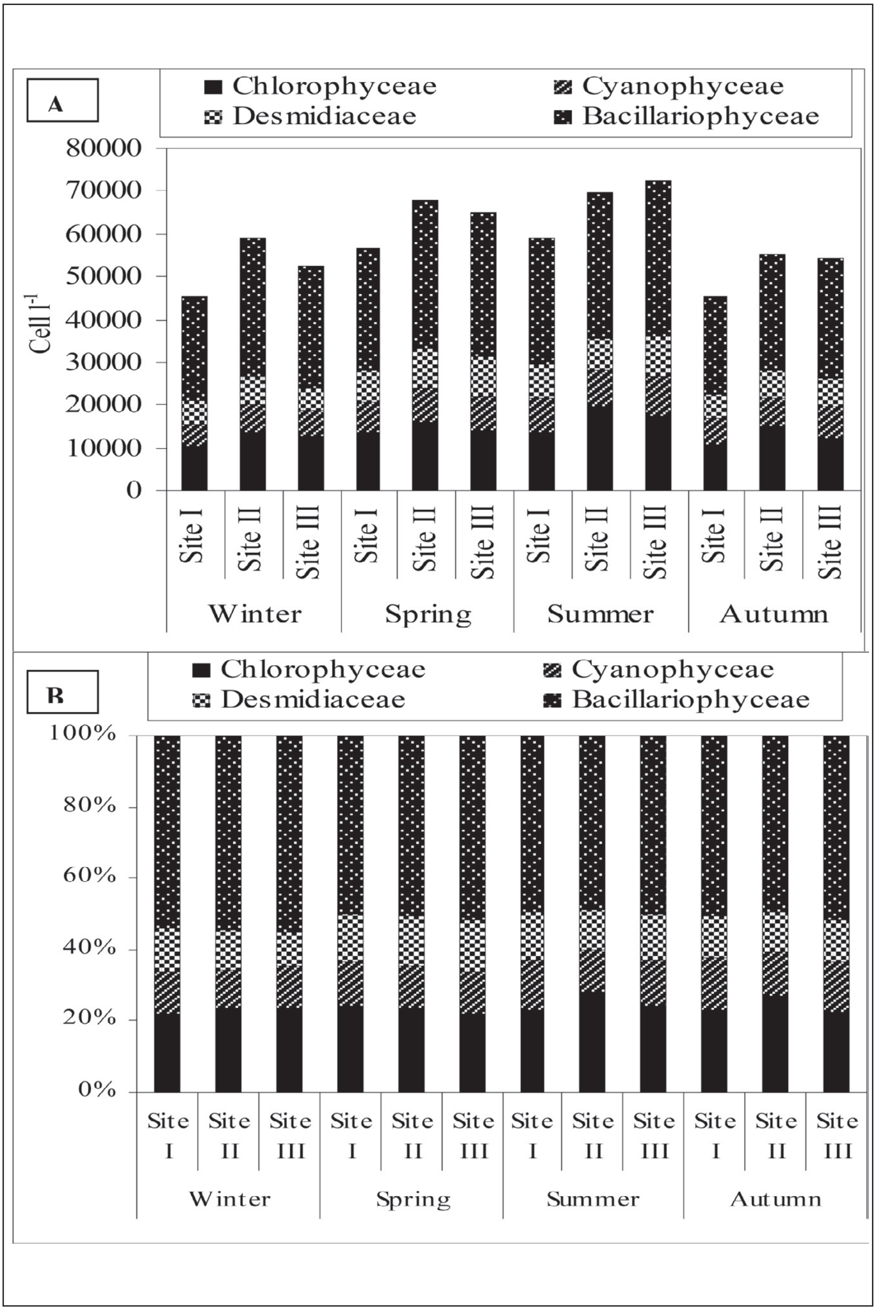

Fig. 3 - Standing crop (A) and percentage composition (B) of the different phytoplankton groups at the studied sites.

17.5, 14.3 and 12.2% of the total Cyanophyceae, respectively). They showed one peak of abundance in spring nevertheless *Tetrapedia* spp. showed anther peak in late summer-early autumn.

Desmidiaceae was represented by four genera namely *Gonatozygon, Closterium*, *Penium* and *Cosmarium*. *Closterium* spp was the dominating genus with a maximum density of 5733 cell/l in August and minmum of 3200 cell/l in October at site I. *Penium* spp and *Cosmarium* spp. representing 11 and 9.5% of total Desmidiaceae showing the same pattern. They disappeared from the plankton samples in winter, while their higher densities were recorded in late spring-early summer.

Zooplankton community

Zooplankton abundance varied from 2259 Ind. m^{-3} at site I in January to 7113 Ind. m^{-3} at site III in September (average 4890 Ind. m^{-3}) over the study period. Total zooplankton community showed consistently high abundance at all studied sites during summer months (July-September) attaining its highest average density of 6582 Ind. m^{-3} in September (Fig. 4). On the other hand, the minimum abundance was recorded in January (average 2742 Ind. m^{-3}). Zooplankton communities were represented mainly by Protista with an average of 3799Ind. m^{-3}, constituting 77.7% of total zooplankton. While the other groups (Rotifera and Crustacea) formed collectively 15.1 and 7.2 % of total zooplankton count.

In the study area, Protista dominated the community all year round and determined the general pattern of zooplankton annual distribution (Fig 4). Limited variations in Protista abundance were encountered between the sampling sites ranging between 3452 and 4160 Ind. m^{-3} at sites I and III, respectively with an annual average of 3799 Ind. m^{-3}. The seasonal cycle of protozoa showed one continuous of abundance in summer (coinciding that of total zooplankton) with maximum of 5056 Ind. m^{-3}, representing 78.1 % of total count in July. On the other hand, minimum abundance was observed in January (Fig 4).

As shown in (Table 2), Protista were represented by six species *(Dileptus anser, Frontonia depressa, Paramecium africanum, Paramecium* spp.*, Polytoma tetraolare* and *Trinema acinus*). All the recorded protistan species exhibited its maximum abundance in summer (July-September) and minima in January except *Frontonia depressa* which dominated in January (average 357 Ind. m^{-3}), continued to May and missed from zooplankton hauls during the rest of the year. *Dileptus anser* , *Frontonia depressa* and *Trinema acinus* were dominated and abundant species.

Rotifera constituted the second important group in terms of abundance comprising about 15.1% of the total zooplankton count (annual average of 739 Ind. m^{-3}) with peak in summer (Fig. 4). The abundance of this group fluctuated between a minimum of 160 Ind. m^{-3} at site III in January and a maximum of 589 Ind. m^{-3} at site II in November. This group was represented by the following species:

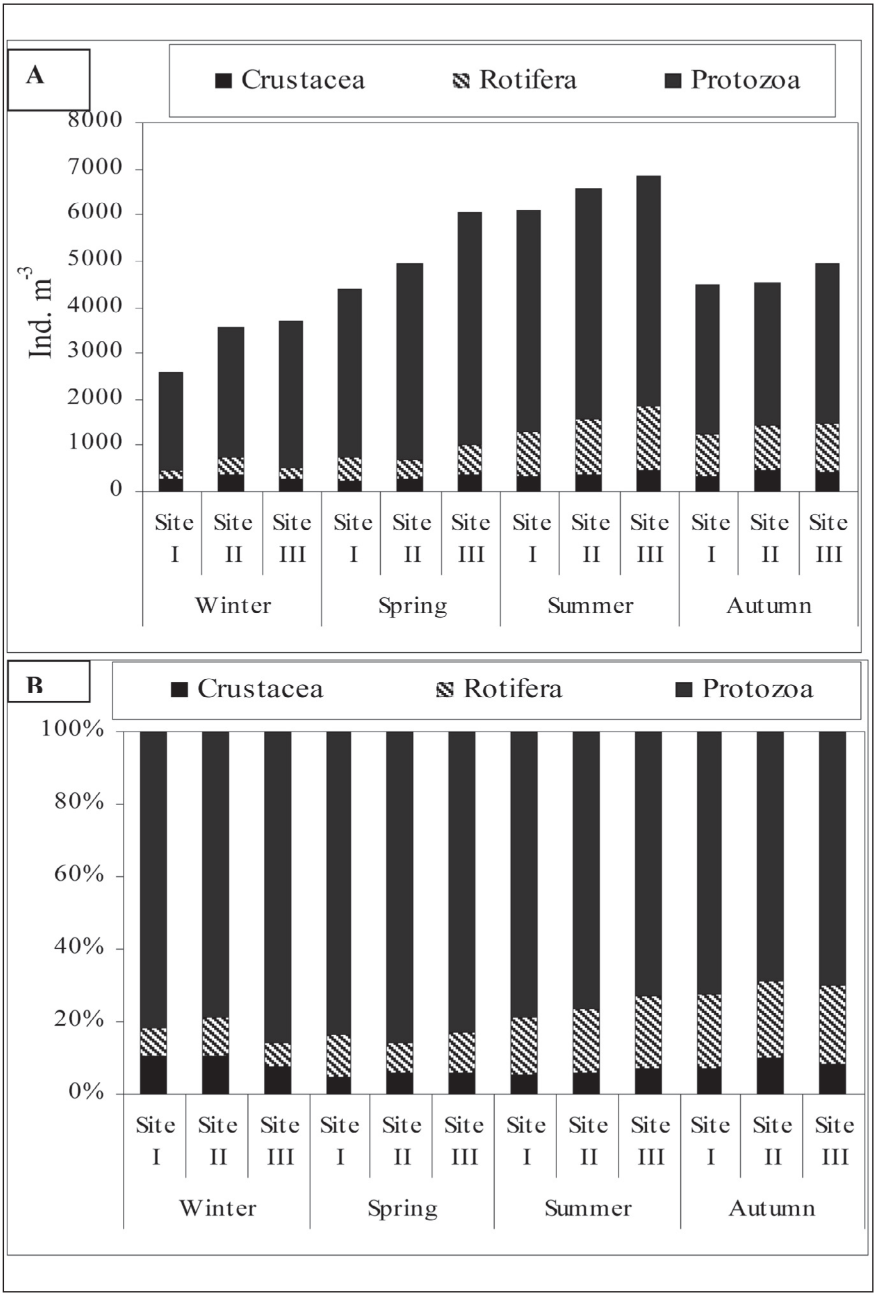

Fig. 4 - Standing crop (A) and percentage composition (B) of the different zooplankton groups at the studied sites.

Keratella cochlearis, Ploesoma truncatum, Testudinella patina, Dicronophorus forcipatus, Brachionus calyciflorus and *Notholca squamula* that form 22.2, 20.1, 19.3, 13.3, 13.2 and 12% of the total rotifer count. All of the above mentioned species showed their highest abundance in summer early autumn (314 Ind. m^{-3} in September, 315 in July, 259 in November, 284 in August, 204 in November and 205 in August, respectively). Where as *Ploesoma truncatum, Dicronophorus forcipatus,* and *Notholca squamula* disappeared from January to May.

Crustacea was less abundant, contributed only 7.2% of the total zooplankton count with an average of 354 Ind. m^{-3}. Crustacea were represented only by *Cypriodopsis* spp. (average 141, forming 39.8% to the total crustaceans), *Mesocyclops* sp (average 110 Ind. m^{-3}, representing 31.1% to the total crustaceans) and *Eubranchipus vernalis* (average101 Ind. m^{-3}, accounting 28.5% to the total crustaceans). *Cypriodopsis* spp. and *Eubranchipus vernalis* showed the same pattern of annual abundance with a higher count in summer months, whereas *Mesocyclops* sp showed its peak in late summer and early autumn.

Statistical analysis

Most of the physico-chemical conditions except for water level, turbidity and ammonia, showed a positive correlation with total and different groups of both phytoplankton and zooplankton. Also, high significant Pearson correlations were obtained between water temperature and both phyto- and zooplankton ($r = 0.93$ and 0.86 respectively).

DISCUSSION

The lakes, ponds and streams, unlike most terrestrial ecosystems, have well defined boundaries- the shoreline, side of the basin, surface of water and bottom sediment (Jhingran, 1982). So, within these limits, the environmental quality and productivity changes in different periods of time depending upon the physical, chemical and biological condition of water (Shamsi and Jafri, 1979; HUFF, 1986). During the period of study, high water temperature recorded in summer period was mainly due to the high intensity of solar radiation and low water level. While low temperature recorded in January were probably due to the prevailing weather experienced in the area during winter (Al- Dahmesh, 2000).

Lower values of DO in winter months (December, January and February) could be attributed to the low phytoplankton production recorded during these rainy months, which reduces the rate of photosynthesis as has been reported by Moulood *et al*. (1978). Turbidity of water is indirectly affects the oxygen level by limiting the photosynthesis through reducing light penetration in water. Trends of variations in the concentration of most chemical parameters such as phosphate, sulfate, nitrate, ammonia and chloride seemed to be identical. High values in summer (May-September) could presumably be the result of higher water evaporation rate as reported by MARTINELLI *et al.* (1999) in Piracicaba River (Brazil) and SWAINE *et al.* (2006) in Ghana.

During the flood season, a great mass of water comes from surrounding areas with low or some times without minerals dominate owing to the velocity of the run off. This causes the dilution of minerals in water bodies. The general decline in chemical concentrations with increasing rainfall is sometimes moderated by other factors like nutrient cycle within the biosphere, land use and soil parent material. SWAINE *et al.* (2006) while working on the river plant and water quality reported a low concentration of the phosphate in wet season. They registered a high level of ammonia through out investigation period. Data similar to these results were reported by BORDALO *et al.* (2001). Liberation weathering and decomposition products in the wet season and flushing of particulate materials may be the reason for elevated concentrations of sulphate, phosphate, calcium and turbidity. ARLE (2002) reported that mineral concentrations and dilution affects the value of conductivity. It also support to present findings as high values of conductivity was registered in summer months during this period the concentrations of most of the micronutrients were at the highest level.

During the period of study, Phytoplankton standing crop did not show significant variations between studied site (p>0.05). The relative variation in phytoplankton count found at site II and III was probably due to water stagnancy and dense vegetation at these sites. High phytoplankton production was recorded in warmer months may be mainly attributed to the high temperature as well documented in the literature (FOGG, 1991; ALAM *et al.*, 2001). Also, seasonal changes in the phytoplankton production can be explained in terms of not only variations in water temperature, but also in relation to competition for nutrients and light as well as biological factor including zooplankton grazing (GRANGE *et al.,* 2000; FRONEMAN, 2002). This is clear in our results since maximum phytoplankton production appeared during warmer months coinciding with high temperature and micronutrients. This finding was supported by high correlation coefficients between temperature, nutrients and both phyto- and zooplankton. Additionally, this high density in summer may be due to the reduction in the water depth due to the loss of water through evaporation and dense vegetation might be responsible for increasing the colonization of phytoplankton as reported by TUCKER and LLOYD (1984); SMITH (1992).

Diatoms dominated the phytoplankton groups in the number of species and individuals. This may be due they triggered by high silicate levels which occurred in concentrations. Most of the abundant species such as: *Cyclotella meneghiniana, Synedra ulna*, *Nitzschia* spp. and *Navicula* spp. which dominated mainly in the study area, were reported as indicator species of high productive and/or waste water polluted water body (MIHNEA, 1985; BIGGS, 1989, ABDALLA *et al.*, 1991; EL-SHERIF, 1994; ZAGHLOUL, 1996, RADWAN, 2005). Also, *Cyclotella* was reported among the governing organisms of the eutrophic lakes and reservoir worldwide (Aykulu *et al*., 1983). Chlorophyceae constituted the second important group in terms of cell number being dominant in summer when the nutrient salts concentrations were high. Most species of Chlorophyceae known to be common in various conditions of sewage ponds (Gray, 1989). The flourishing of diatoms and chlorophytes in high temperature giving the outstanding peak in summer explains the presence of positive correlations with temperature as well as high nutrient concentrations.

Regarding phytoplankton diversity, the low number of species recorded during the present study can be attributed to the inhibitory effects of high nutrient concentrations and high turbidity which leads to the dominance of few species on the expense of the others. This was confirmed by Ludsin *et al*. (2001); Prepas and Charette (2003) who concluded that the biodiversity of most aquatic systems decreases with increasing the load of the nutrients as a result of increasing eutrophication.

The abundance of zooplankton community in any water body may be affected by the density of aquatic organisms. High population density of zooplankton registered coincided with the peaks of phytoplankton in summer suggest that the increase in zooplankton production may be attributed to greater availability of food in form of phytoplankton (Wadajo, 1982; Wadajo and Belay 1984; Webber and Roff 1995; Christou, 1998; Uye *et al*., 2000) ($r = 0.752$) as well as temperature ($r=0.80$). The zooplankton community in the study sites was dominated by Protista. In addition to more favorable conditions in summer including high temperature and high nutrients, the observed range of pH (7.1-8.5) seemed conducive to the blooming of phyto and zooplankton biomass where pH is a regulating factor affect on nutrients uptake processes and on the equilibrium of nutrients as reported by Peterson *et al*. (1984). The dominance of the different protistan species may be referred or correlated to sewage water which is rich by bacteria being bacterial production and other small food items the major factor affecting protistans production (Carwugh and Meyer, 1989).

Other groups such as rotifers and crustaceans were also found but with comparatively low populations. The lower abundance and diversity found in the present study for the larger zooplankton (copepods and cladocerans) community might be explained by the unfavorable conditions such as low light penetration and/or presence of planktivorous fishes (Wetzel, 1983; Arcifa *et al.,* 1986; Basima *et al*. 2006).

It may be concluded that population densities and species composition of plankton communities in Wadi Haneefah Stream depends mainly on physico- chemical and biological conditions of the water. The low species diversity of planktonic organisms may suggest stressful condition which could be represented by waste water and consequently high nutrient load in the stream. Occurrence of organic pollution indicator species of phytoplankton such as *Cyclotella meneghiniana*, *Synedra ulna*, *Nitzschia spp*., and *Navicula spp*. in high densities strengthen on our finding.

The study suggest the need for more comprehensive investigation along the Wadi Haneefah Stream covering the whole stream specially upstream and tributaries to evaluate the possibility of its use for aquaculture purposes (mass culture).

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REFERENCES

Abdalla R.R., Samaan A. A., Ghabrial M. G., 1991- Eutrophication in Lake Mariut Bull. Nat. Ins. Oceanogr. And Fish. ARE 17 (1): 157-166.

Alam M. G. M., Jahan N., Thalib L., Wei B., Maekawa T., 2001- Effects of environmental factors on the seasonally change of phytoplankton populations in a closed freshwater ponds. Environ. Internat. 27:363-371.

Al-Dahmesh B. A. A., 2000 - Karyological studies of some freshwater fishes of Wadi Haneefahf Stream Saudi Arabia. Master Dissertation King Saud University. Pp-210.

Al-Ghanim K. A., 2005 - Ecology of sailfin molly *Poecilia latipinna* (Lesueur 1821) in Wadi Haneefah stream Riyadh Saudi Arabia. Ph. D. Thesis King Saud University Riyadh Saudi Arabia Pp 522.

Allanson B. R., Read G. H. L., 1995 - Further comment on the response of Eastern Cape province estuaries to variable freshwater inflows. South African J. Aquat. Sci. 2:56-70.

Arcifa M. S., Northcote T. G., Froehlich O., 1986 - Fish-zooplankton interactions and their effects on water quality of a tropical Brazilian reservoir. Hydrobiologia 139:49-58.

Arle J., 2002 - Physical and chemical dynamics of temporary ponds on a calcareous plateau in Thuringia Germany. Limnologica. 32: 83-101.

Aykulu G., Obali O., Gonulol A., 1983 - Ankara Cevresindeki Bazi Gollerde Fitoplanktonun Yayilisi. Doga Bilim Dergisi: Temel Bilimler7: 227-288.

Barnes H., 1959 - Apparatus and methods of oceanography Part I. Chemical George Allen Ltd. p. 341.

Barnes R. S. K., Mann K. H., 1991 - Fundamental aquatic ecology. Blackwell Scientific Publication Oxford London Edinburgh Boston Melbourne p. 270.

Basima L. B., Senzanje A., Marshal B., Shick K., 2006 - Impact of land and water use on the plankton diversity and water quality in small man-made reservoirs in the Limpopo basin Zimbabwe: A prelimnary investigation. Phys. Chem. Earth 31: 821-831.

Biggs J. F., 1989 - Biomonitoring of organic pollution using periphyton South Branch Canterbury New Zealand. New Zealand Journal of Marine and Freshwater Research 1989 Vol. 23: 263-274

Bordalo A. A., Nilsumranchi t A., Chalermwat K., 2001 - Water quality and uses of the Bangpakong river (eastern Thailand) Water Res. 35: 3635-3642.

Carwugh L. A., Meyer J. L., 1989 - Protozoans in two southeastern blackwater rivers and their importance to trophic transfer. Limnol. Oceanogr 34: 163-177.

CHRISTOU E.D., 1998 - Interannual variability of copepods in a Mediterranean coastal area (Saronikkos Gulf Aegean Sea) J. Mar. Syst. 15:523-532.

DUSSART B. H., FERNANDO C. H., TUDISI T., SHIEL R. J., 1984 - A review of systematics distribution and ecology of tropical freshwater Zooplankton. Hydrobiologia 113: 77-91.

EL-SHERIF Z. M., 1994 - Effect of sewage on phytoplankton population in East of Alexandria coastal waters (Egypt- Proc. 4th Inter. Conference for Environmental Studies & Research pp. 184-193.

FOGG G. E., 1991 - The phytoplanktonic ways of life. New Phytologist. 118:191-232.

FRONEMAN P. W., 2002 - Response of the biology to three different hydrological phases in the temporarily open/closed Kariega estuary. Estuar. Cost. Shelf Sci. 55:535-546.

GARCIA M. O., EMILIANI R., DEPETRIS P.J., 1982 - A principal components analysis of phytoplankton from a pond in the Parana river Valley Argentina. Hydrobiologia 89: 117-122.

GOLDMAN C. R., HORNE A. J., 1983 - Limnology. McGraw Hill Book Company. U.S.A. p.464.

GRANGE N., WHITEFIELD A. K., DE VILLIERS C. J., ALLANSON B. R., 2000 - The response of two South African east cost estuaries to altered river flow rigimes. Aquat. Cons. Mar. Fresh. Ecosy. 10: 155-177.

GRAY F. N., 1989 - Biology of wastewater treatment. Oxford University Press New York.

HORA S. L., PILLAY T. V .R., 1962 - Hand book on fish culture in the Indopacefic regions. F. A. O. Fish. Biol. Tech. pp. 14.

HUFF D. R., 1986 - Phytoplankton communities in Navigation Pool No.7 of the Upper Mississipi river. Hydrobiologia 136: 47-56.

IVANOVA M. B., TELESH I. V., 1996 - Evaluation of the ecological state of the Neva Bay and water flows in St. Petersburg on the basis of zooplankton data In : Alimov A. F. and Frolov A. K. (Eds.) Ecological state of water bodies and flows of the Neva River Drainage Basin. Scientific Center RAS St. Petersburg pp. 36-52.

JHINGRAN V. G., 1982 - Fish and Fisheries of India. Hindustan Publ. Corp. New Delhi. P.666.

LALOUIE F., 1993 - Hydrobiological survey of Gorgan Bay. Iran. Fish. Bull. 4: 5.

LEIRA M., SABATER S., 2005 - Diatom assemblages distribution in catalan rivers NE Spain in relation to chemical and physiographical factors. Water Res. 39:73-82.

LELAND H. V., PORTER S. D., 2000 - Distribution of benthic algae in the upper Illinois River basin in relation with to geology and land use. Freshwater Biol. 44:279-301.

LUDSIN S. A., KERSHNER M. W., BLOCKSOM K. A., KNIGHT R. L., STEIN R. A., 2001 - Life after death in Lake Erie: Nutrient controls drive fish species richness rehabilitation. Ecol. Appl. 11: 731-746.

MAGEED A. A., HEIKAL M. T., 2006 - Factors affecting seasonal patterns in epilimnion zooplankton community in one of the largest man-made lakes in Africa (Lake Nasser Egypt) Limnologica. 36:91-97.

MARTINELLI L. A., KRUSCHE A. V., VIGORIA R. L., DE CAMARGO P. B., BERNARDES M., FERRAZ E. S., DE MORAES J. M., BALLEATER M. V., 1999 - Effect of sewage on the chemical composition of Piracicaba River. Brazil. Water Air Soil Pollut. 110: 67-79.

MIHNEA P. E., 1985 - Effect of pollution on phytoplankton species. Rapp. Comm. Int. Mer. Medit. 29 (9): 85-88.

MILTON R. S., WAYNE M. C., 1979 - Composition and abundance of phytoplankton in

Tributaries of the lower Colarado river Grand Canyon region. Hydrobiologia 66: 81-93.
MOULOOD B. K., HINTON G. C. F., BONEY A. D., 1978 - Diurnal variation of phytoplankton in Loch Lomond. Hydrobiologia. 58: 99-118.
MUNAWAR M., 1974 - Limonogical studies on freshwater ponds of Hyderabad India. (III-Hydrobiologia 44: 13-27.
NEEDHAM J. G., NEEDHAM R. R., 1964 - A guide to the study of freshwater biology. Holden Day Inc. San Francisco Constable & Comp. Ltd. 5th Edit. p.108.
NIKOLSKY G. G., 1963 - The ecology of fishes. Academic Press London New York.
PETERSON H. G., HEALEY F. P., WAGEMANN R., 1984 - Metal toxicity to algae: a highly pH dependent phenomenon. Can. J. Fish. Aquat. Sci. 41: 974-979.
PREPAS E. E., CHARETTE T., 2003 - Worldwide eutrophication of water bodies: causes concerns controls. Treatize on Geochemistry 9: 311-331.
RADWAN A. M., 2005 - Some factors affecting the primary production of phytoplankton in lake Burullus. Egyptian Journal of Aquatic Research 31 (2): 72-88.
RASK M., ARVOLA L., SALOMEN K., RUUHIJAERVI J., 1992 - Limnological studies on the lakes in Evo-Forest area- a historical perspective. Aqua-Fenn. 22: 185-192.
SEENAYYA G., ZAFAR A. A., 1979 - An ecological study of the Mir Alam lake Hyderabad India Ind. J. Bot. 2: 214-220.
SEGARS H., DUMONT H. J., 1993 - Rotifera from Arabia with description of two new species. Fauna of Saudi Arabia 13: 3-26
SHAMSI M. J. K., JAFRI A. K., 1979 - Environmental characteristics and seasonal distribution of planktonic biomass of a perennial and sewage-fed water body from Northern region of India. German. J. Appl. Zool. 76: 441-456.
SIDDIQUI A. Q., AL-HARBI A. H., 1995 - A preliminary study of the ecology of Wadi Haneefah stream with reference to animal communities. Arab Gulf J. Scient. Res. 13:695-717.
SMITH R. L., 1992 - Elements of ecology. 3rd Edit. Harper Collins Publishers Inc. pp.617.
SUNDARESAN B. B., 1979 - A course of manual water and waste water analysis. Nat. Environ. Eng. Res. Inst. Nagpur India. pp. 340.
SWAINE M. D., ADOMAKO J., AMEKA G., DE GRAFT-JOHNSTON K. A. A., CHEEK M., 2006 - Forest river plants and water quality in Ghana. Aquat. Bot. 85: 299-308.
TARAS M. J., GREEBBERG A. E., HOAK R. D., RAUD M. C., 1992 - Standard methods for the examination of water and waste water 18th Ed. EPS. Group Inc. Hanover Maryland. p.1137.
TELESH I. V., 2004 - Plankton of the Baltic estuarine ecosystems with emphasis on Neva Estuary: A review of present knowledge and research perspectives. Mar. Poll. Bull. 49: 206-219.
TONAPI G. T., 1980 - Freshwater animals of India Oxford & IBH Publishing Comp. pp.-340.
TUCKER C. S., LLOYD S. W., 1984 - Phytoplankton communities in channel catfish pond. Hydrobiologia 112: 137-141.
TYLER P. A., 1984 - Water Chemistry of the river Kwai Thailand Hydrobiologia III: 65-73.
UYE S., SHIMAZU T., YAMAMURO M., ISHITOBI Y., KAMIYA H., 2000 - Geographical and seasonal variations in mezozooplankton abundance and biomass in relation to environmental parameters in lake Shinji-Ohashi River-Lake Nakaumi brackisw water system Japan. Journal of Marine Systems 26 (2): 193-207.
WADAJO K., 1982 - Comparative limnology of lake Abiata and lake Langano in relation to primary and secondary production M.Sc. Thesis Addis Abeda University Ethiopia.

WADAJO K., BELAY S., 1984 - Species composition and seasonal abundance of zooplankton in two Ethiopian Rift Valley lakes- lakes Abiata and Langano. Hydrobiologia 113: 129-136.
WARD H. B., WHIPPLE G. C., 1963 - Freshwater biology 2nd Edit. (Edmondson W.T. Ed.) New York London John Wiley & Sons Inc. pp. 1248.
WEBBER M.K., ROFF J.C., 1995 - Annual biomass and production of the oceanic copepod community off Discovery Bay Jamaica. Mar. Biol. 123:481-495.
WETZEL R. G., 1983 - Limnology. Philadelphia: Saudens College Publishing. Pp.457-767.
ZAFAR A. R., 1986 - Seasonality of phytoplankton in some South Indian lakes. Hydrobiologia 138: 177-187
ZAGHLOUL F. A., 1996 - Further studies on the assessment of eutrophication in Alexandria harbors Egypt. Bulletin Faculty of Science Alexandria University 36 (1): 281-294.