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Spatio-Temporal Distribution and Composition of Zooplankton in Wadi Hanifah Stream Riyadh (Saudi Arabia) and Abu Zabaal Lakes (Egypt)

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Abstract.- Information of biological communities is important to assess the qualities of aquatic systems receiving wastewater. Zooplankton communities have a cosmopolitan distribution, short life cycle and high sensitivity to pollutants, which make them useful as biological indicators of the aquatic environment. In this study, the physico-chemical variables and zooplankton community structure of two different aquatic habitats receiving municipal sewage in Egypt and Saudi Arabia were investigated. Average electrical conductivity was recorded as 8346 and 4398 µS/cm, respectively from Abu Zabaal lakes (AZ lakes) and Wadi Hanifah (WH streams). The highest concentration of total ammonia, nitrite, nitrate and orthophosphate were recorded in WH. A total of 43 and 19 taxa and species of zooplankton were recorded in AZ lakes and WH streams, respectively. The standing crops of total zooplankton were much higher in WH streams (av. 5325 Ind. L^{-1}) as compared with AZ lakes (av. 5325 Ind. L^{-1}). Rotifera dominated amongst the zooplankton in AZ lakes with a contribution of 67.2%, while protozoa was the abundant group at WH streams and contributed 78.9% of the total zooplankton density. *Brachionus plicatilis* and *Synchaeta oblonga* were the most abundant rotifer species at lakes, while *Brachionus calyciflorus, Keratella cochlearis* and *Testudinella patina* were abundant at streams. It is concluded that low / reduced in zooplankton diversity at Wadi Hanifah streams may be induced by sewage and others domestic pollutant discharged in it.

Key words: Physico-chemical parameters, zooplankton, wastewater.

INTRODUCTION

Abu Zabaal Lakes are considered as artificial Lakes, which recently created after stone pits stopped in the quarries and received seepage and ground water from the surrounding area particularly from Ismailia canal, Baher El-Bakar drain and surrounding cultivated land. Wadi-Hanifah had been 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 rainfall and sewage water. Some water from sewage treatment plant of Al-Hair was also making way to the stream. Zooplankton occupies an important trophic niche in the aquatic ecosystem as they constitute the most important link in energy transfer between phytoplankton and higher aquatic fauna (Iloba, 2002; Mahboob, 2010).

Zooplankton makes up an invaluable source of protein, amino acids, lipids, fatty acids, minerals and enzymes and is therefore an inexpensive ingredient to replace fishmeal for cultured fish (Kibria *et al*., 1997; Fernando, 1994). Zooplankton research is becoming more and more important in recent years since these floating animals with a little or no power of independent horizontal migration are the reproductive base for all ecosystems (Mahboob and Sheri, 1993; Mahboob and Zahid, 2002). The study of zooplankton communities seems to be particularly useful for the evaluation of ecosystem condition, even through their passive transportation does not permit the formation of clearly defined units as is possible for the benthic organisms. Distribution of zooplankton is useful for the general monitoring of certain aspects of the environment, such as eutrophication, pollution, warming trends and long-term changes which are sign of environmental disturbance (Rutherford *et al*., 1999; Soberon *et al*., 2000). Zooplankton as bioindicators is very convenient in providing ecological indices. In aquatic environments, their small size favors their distribution by currents easing the recognition of environmental problems, also in adjacent areas (Bianchi and Colwell, 1985). Population size, rather

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than occurrence becomes a key factor (Krivolutzky, 1985). Due to short life cycles, the zooplankton can quickly respond to environmental modifications, being an excellent key group (Boltovoskoy, 1999). Zooplankton community, which is closely related to all others ecosystem components (phytoplankton, bacterioplankton, fish, and benthos), is a sensitive indicator of the state of the aquatic environment, which allows ecologists to include it in the system of monitoring of water objects. Zooplankton is a reliable indicator of changes in water quality, because it is strongly affected by environmental conditions and responds quickly to changes in water quality (Mahboob and Sheri, 1995). Among zooplankton, rotifers with their high population turnover rates are particularly sensitive to water quality changes. Other studies have shown that eutrophication effects zooplankton composition, shifting the dominance from large species (Copepoda) to smaller ones (Rotifera) (Premazzi and Chiaudani, 1992; Miralto *et al*., 1999).

Recently various researchers studied impact of sewage pollutant on circuitous man-made basins environment of the aquatic ecosystem of Abu Zabaal and Waid Hanifah (Abd-Ellah, 2003; Abdo, 2005; Siddiqui and Al-Harbi 1995; Al-Dahmesh 2000; Rabeh and Azab, 2006; Mohammad and Gad, 2005; Elshabrawy *et al*., 2007; El-Ghanim *et al*., 2008). No comprehensive study on the status and temporal distribution and structure of zooplankton and macrobenthos has been conducted so far. There is very meager scientific published information on Wadi Hanifah drainage system (El-Ghanim *et al*., 2008). The present is a pioneer study on the distribution, abundance and community structure of zooplankton, relative to the sewage pollutant poured to these two different aquatic habitats.

MATERIALS AND METHODS

Study area

Abu Zabaal man-made Lakes are located in the north of Qalubia Governorate at Abu Zabaal City, 30 km southwest of Cairo. The Lakes were created owing to fracture and extract the Basalt rocks. They are closed basins and filling during the fifth decade (first Lake), the eighth decade (second Lake) and in the ninth decade (third Lake), besides small Lake in a filling phase.

Recently Abu Zabaal consists of three Lakes and a filling phase. They occupy the area between latitudes 30° 16.62' and 30° 17.58' N and longitudes 31o 20.90' and 31° 21.69' E. The Lake waters cover an area of about 608 X 10^3 m^2 (~ 150 feddan). The water storage in the Lakes are 5234.075 10^3 m^3.There was a great increase in depth of the first Lake northward (0.6-20 m), with an average of 10.2m. The water depth of the second and third Lakes fluctuated between 2.9-7.6 and 0.8-7.1m with an overall average of 6.1and 5.7m, respectively (Abd-Ellah, 2003).

Abu Zaabal Lake (30°17N, 31°20E) (Fig. 1) is located on the perimeter of Cairo in an area where basalt mining was done by blasting in open pits. In 1992, a severe earthquake occurred and the basin began to fill with water, which rose at a rate of 2–3m per year, forming a lake about 3km by 1.5km wide, with a maximum depth of 25m and an average depth of 18m. In this arid environment, the lake does not receive surface inflow. Beside the main lake, three smaller lakes have formed subsequently and the amalgamations of all these lakes are possible n the next few years. Abu Zabaal lakes have a unique ecosystem and they considered as a mesotrophic and oligohaline ponds. These three man-made brackish ponds have created a variety of new habitats and added considerably to the beauty and serenity of the area. It provided a wetland habitat for a variety of resident and transient wildlife. They also allowed various new and is use as farming, and recreation.

Wadi Hanifah is one of the major natural landmarks in the middle part of Najd plateau. It represents the natural drain for the surface water of a very wide area. The Wadi passes through the city of Ariyadh and about 70% of the city is located within its catchment area. It extends from north of Al-Uyaynah to south of Al-Hair city. The watershed area of Wadi Hanifah is estimated to be about 4400 km^2. It flows southward from its source near the town of Al-Uyaynah until it ends into Wadi Sahba, (Fig. 1B). The main Wadi flood-channel is located slightly east of the center of the catchments area and flows northwest to southeast. Most of Arriyadh city (more than 4 million populations) is located in the

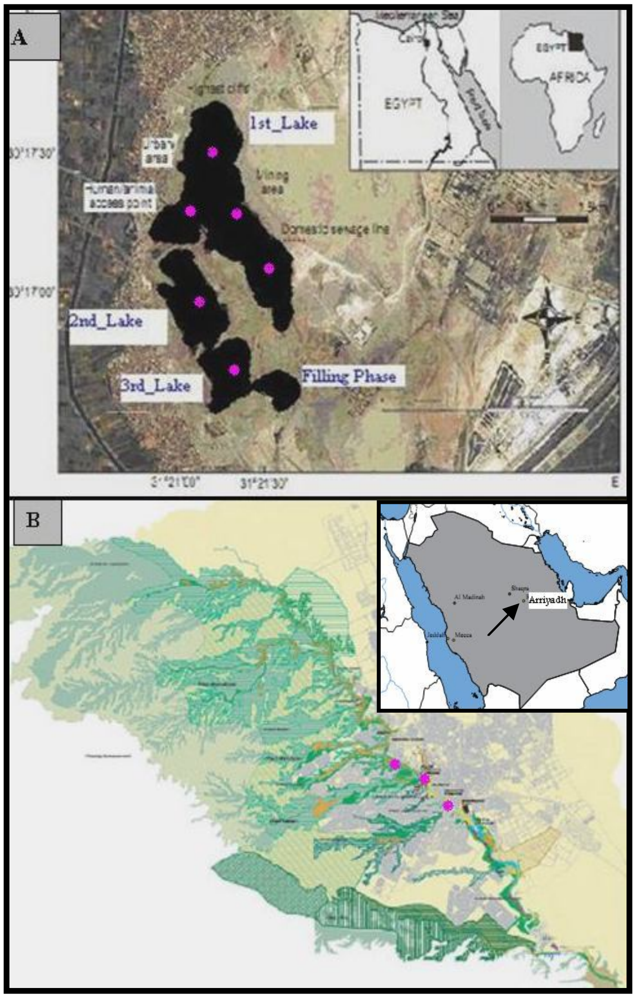

Fig. 1. Maps showing Abu Zabaal lakes (A), and Wadi Hanifah streams (B).

Wadi Hanifah catchment area (ADA, 1994). Wadi-Hanifah (Fig.1) is located between 24° 30'N and 46° 30'E to 24° 45'N and 46° 45'E. The main sources of water are the seasonal rain fall and sewage water. The depth of water varied at different areas being about two meters. Somewhat irregular shape large shallow patches of water were also formed in some areas.

Sampling program

Seasonal water and zooplankton samples were collected from studied Lakes during winter to autumn 2006. The samples were collected from six different stations representing the different microhabitats of Abu Zabaal Lakes and three stations at Wadi Hanifah sreams (Fig. 1).

Physico-chemical studies

The methods discussed in the American Public Health Association (APHA 1992) were used for the determination of the abiotic conditions. Temperatures and pH values were measured during the time of sampling by using pH meter (Jenway model 3150) after calibration. Electrical conductivity was measured using measured, using Hydrolab, Model "Multi 340I/SET". Ammonia was determined by phenate method. Nitrite was determined using colorimetric method. Nitrate was estimated by reduction method as described by Mullin and Riley (1956). Orthophosphate and total phosphorus were determined by using stannous chloride and acid molybdate method.

Zooplankton studies

For quantitative and qualitative study of zooplankton the samples were collected from the different locations. 100 liters of water was filtered using plankton net (20 µm mesh diameter) fitted with a glass bottle of 500 ml capacity. The retenate containing different zooplankton was preserved immediately after collection in four % neutral formalin. A 5 ml portion of the above samples was taken for quantitative and qualitative study of zooplankton. Counting of various zooplankton species was made by using a binocular microscope. Zooplankton species were identified by using Wards and Whipple (1969), Ruttner-Kolisko (1974), Koste (1978) and Einsle (1996).

RESULTS

Physico-chemical studies

Generally, air and water temperature was slightly higher in Wadi Hanifah streams than Abu Zabaal lakes. Average water temperature was recorded as 24.8 and 24.1°C, annual range of 18.5 to 31.7 and 17.6 to 30.6°C for Wadi Hanifah streams and Abu Zabaal lakes, respectively. Annual water temperature in WH streams and AZ lakes were ranged as 18.5 to 31.7 and 17.6 to 30.6°C, respectively. It followed climatic variation with lower values in winter and highest ones in summer (Fig. 2). pH values were slightly alkaline and ranging from 7.3 to 8.5 at WH streams and from 8.2 to 8.8 in AZ lakes (Fig. 2). Electrical conductivity of

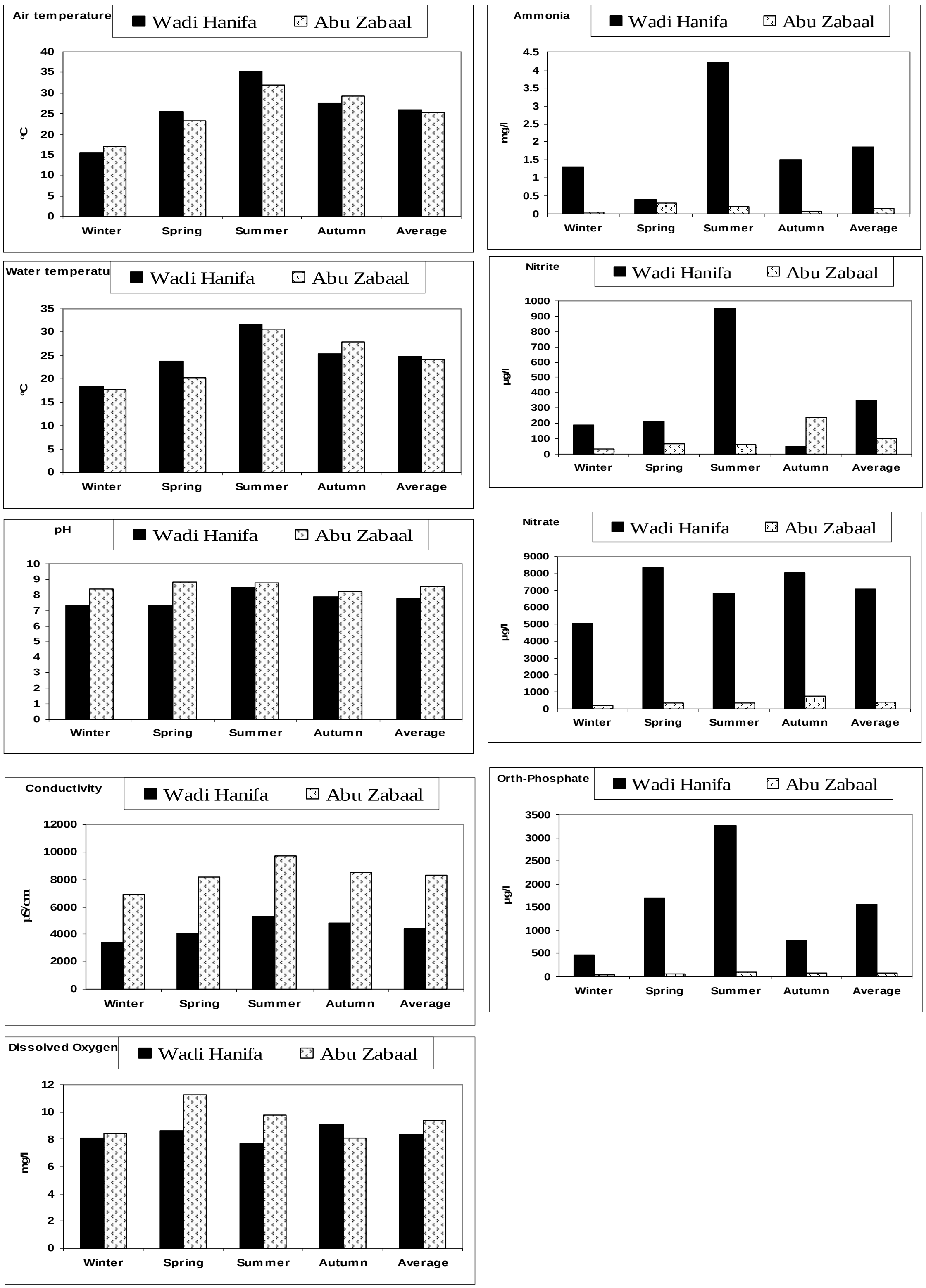

Fig. 2. Some water physical and chemicals features of the studied localities.

AZ lakes was higher as compared to WH streams. It ranged between 6930 and 9750µS/cm with an average of value of 8346 µS /cm (Fig. 2).

Dissolved oxygen is often used as an indicator of water quality, such that high concentrations of oxygen usually show good water quality. The amount of dissolved oxygen gas depends highly on temperature and somewhat on atmospheric pressure. Dissolved oxygen concentration showed that water of AZ lakes (9.4 mg L^{-1}) was more oxygenated as compared to WH streams (8.3mg.L^{-1}). Maximum dissolved contents were recorded as 11.3 and 9.1 in AZ lakes and WH streams during spring and autumn, respectively (Fig.2).

Average concentration of ammonia was much higher at WH streams (1.86 mg L^{-1}) than AZ lakes (0.2 mg L^{-1}). Summer sustained the highest ammonia value at WH streams (4.2 mg L^{-1}), while the highest concentration (0.3 mg L^{-1}) was recorded in AZ lakes during spring months. Nitrite-nitrogen is the intermediate oxidation state between ammonia and nitrate-nitrogen and as such it can appear as a transient in both the oxidation of ammonium-nitrogen and the reduction of nitrate-nitrogen. The maximum and minimum exchangeable NO2-N contents were recorded 52 and 950 µg L^{-1} and 31 and 239 µg L^{-1} in WH streams and AZ lakes (Fig. 2). The highest nitrate values were detected at WH streams with maximum of 8362 µg L^{-1} in autumn. The corresponding values in AZ lakes were much lower with values ranging between 210 and 742 µg L^{-1} during winter and autumn (Fig. 2). Ortho-phosphate concentrations show similar trends as Nitrite in its seasonal variations for both studied localities (Fig. 3).

Zooplankton studies

A total of 43 zooplanktonic species and taxa were recorded in the present study in AZ lakes. Zooplankton population was comprised of 23 Rotifera, 5 Copepoda,4 Cladocera, 9 Protozoa and 2 Meroplankton species and taxa at AZ lakes (Table I). Low zooplanktonic population with only 19 species was recorded at WH streams (9 Rotifera, 4 Copepoda, 5 Protozoa and 1 Meroplankton). Contrarily to diversity, zooplankton abundance was much higher (avr. 5325 Ind. L^{-1}) at WH streams as compared with AZl lakes (avr. 64 Ind. L^{-1}). Maximum zooplanktonic density was recorded in summer months at WH streams (6950) and AZ lakes (84) in summer. On the other hand, winter sustained the lowest density at both localities (Figs. 3, 4.)

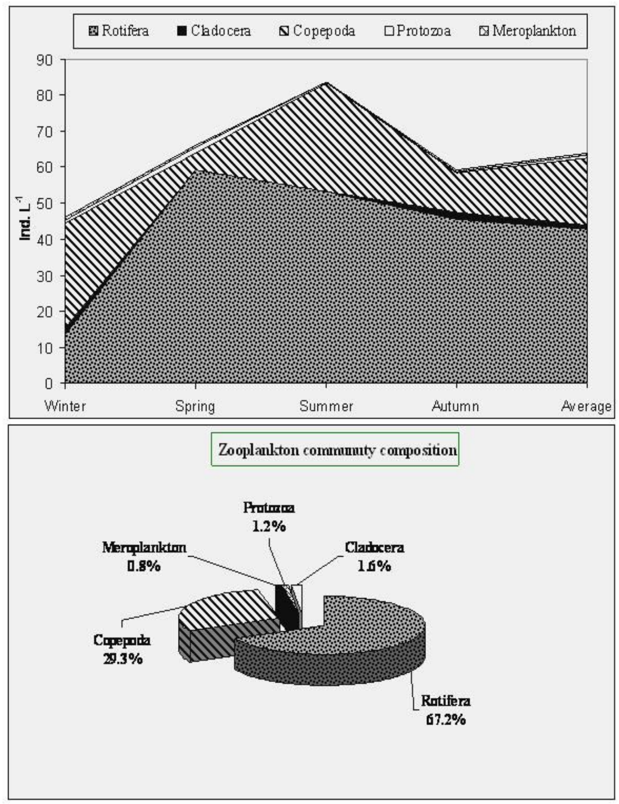

Fig. 3. Seasonal variation and community structure of zooplankton in Abu Zabaal lakes.

Community structure

Rotifera

Rotifers dominated the other zooplankton groups, forming 67.2 % of the total zooplankton density at AZ lakes and came next to protozoa with a percentage of 14.1% at WH streams. The distribution of rotifers follows the same general trends observed for the total zooplankton. The population density of rotifera reached maximum (1100 and 59 Ind. L^{-1}) in summer and spring at WH streams and AZ lakes, estimated in winter. *Brachionus plicatilis* and *Synchaeta oblonga* were the most abundant rotifer species at AZl lakes. The

Table I.- **A list of zooplankton species recorded in Abu Zaabal Lakes and Wadi Hanifah streams.**

	Abu Zabaal lakes	Wadi Hanifa streams
Rotifera		
Anuraeopsis fissa	*	
Asplaknia girodi	*	
Brachionus angularis	*	*
Brachionus calyciflorus		*
Brachionus plicatilis	*	
Collothca pelagica	*	
Colurella obtusa	*	
Dicronophorus forcipatus		*
Filinia longiseta	*	
Hexarthra fennica	*	
Keratella cochlearis	*	*
Keratella quadrata	*	*
Keratella tropica	*	
Lecane bulla	*	
Lecane clostercercoid	*	*
Lecane leontina	*	
Lecane luna	*	
Mytilina ventralis	*	
Notholca squamula		*
Philodina roseola	*	
Ploesoma truncatum		*
Polyarthra vulgaris	*	
Proalides sp	*	
Rotaria rotatoria	*	
Synchaeta oblonga	*	
Synchaeta pectinata	*	
Testudinella patina		*
Trichcerca pusilla	*	
Copepoda		
Nauplius larvae	*	*
Cyclopoid copepodid	*	*
Acanthocyclops robustus	*	
Eucyclops sp	*	
Eubranchipus vernalis		*
Mesocyclops sp		*
Schizopra nilotica	*	
Cladocera		
Coronatella rectangula	*	
Chydoeus sphearicus	*	
Scapholeberis kingi	*	
Bosmina longirostris	*	
Protozoa		
Coleps hirtus	*	
Colpoda cucullus	*	
Didiniu nasutu	*	
Difflugia globulosa	*	
Dileptus sp.	*	*
Euglypha tuberculata	*	
Frontonia depressa		*
Paramecium sp.		*
Polytoma tetraolare		*
Stokesia vernalis	*	
Stylonychia sp.	*	
Trinema acinus		*
Vorticella sp.	*	
Meroplankton		
Chironomus larvae	*	
Ostracod sp.	*	*

first species persisted with a highest density of 51 Ind. L^{-1} in summer while the second ones reached maximum (43 Ind. L^{-1}) in autumn. Population of both species decreased during spring (Fig. 5). *Brachionus calyciflorus, Keratella cochlearis* and *Testudinella patina* were abundant at WH streams. Summer seems to be the season of high production for *Keratella cochlearis*, while *Brachionus calyciflorus* and *Testudinella patina* reached maximum in autumn. Population of all the species remained lowest in winter and spring (Fig. 6).

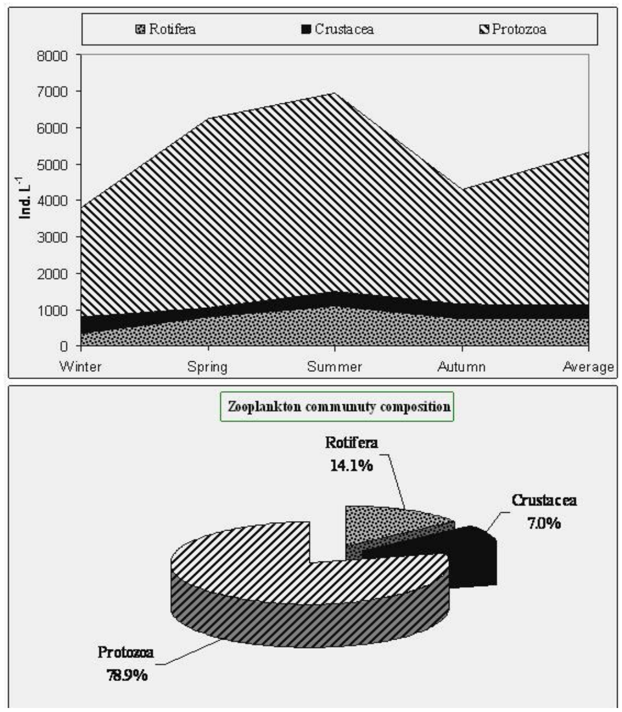

Fig. 4. Seasonal variation and community structure of zooplankton in Wadi Hanifah streams.

Copepoda

Copepoda was represented by 5 and 4 taxa at AZ lakes and WH streams, respectively. The highest density (59 Ind. L^{-1}) of this group was observed at AZ lakes in spring, while the lowest density (13 Ind. L^{-1}) was recorded in winter (Fig. 3). Contrarily to AZ lakes the standing crops of these organisms reached maximum (450 Ind. L^{-1}) in winter at WH streams, while the lowest production was in spring (Fig. 4). Nauplius larvae numerically dominated the copepod with a highest yield of 18 Ind. L^{-1} at AZ lakes in spring (Fig. 5). *Acanthocyclops robustus* and *Mesocyclops* sp were the dominant adult copepods at AZ lakes and WH streams, respectively.

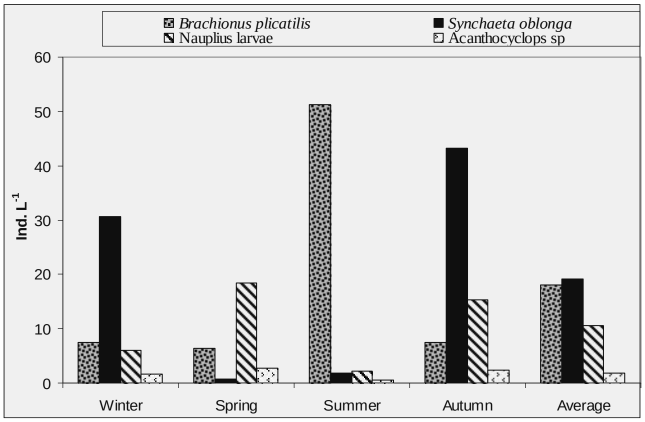

Fig. 5. Seasonal variation of the zooplankton species in Abu Zabaal lakes

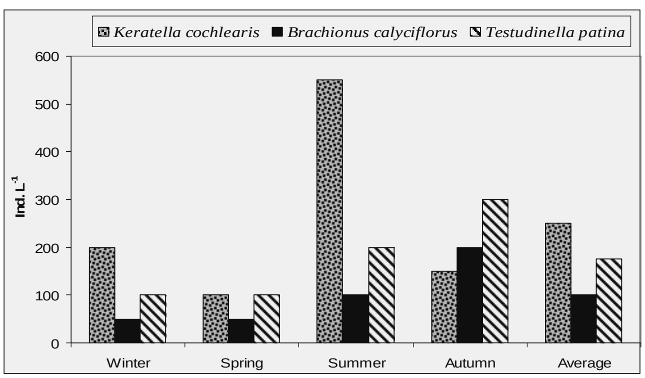

Fig. 6. Seasonal variation of the dominant zooplankton genera in Wadi Hanifah streams.

Cladocera

Cladocera represented only by 4 species, with a contribution of 1.6% in the total zooplankton density AZ lakes. The occurrence of this organisms were restricted to winter and autumn (Fig. 3).

Protozoa

Protozoa was present as dominated group with a contribution of about 78.9% of the total zooplankton density at WH streams. The population density of these unicellular invertebrates reached maximum, 5200 and 5450 Ind. L^{-1} in spring and summer at WH streams. Protozoa was scarcely present at AZ lakes.

DISCUSSION

The long-term monitoring of anthropogenic pollution in aquatic ecosystem is of environmental and human health concern even nowadays, when numerous effective measures were undertaken to reduce the pollution impact of natural water bodies. In these studies aquatic organisms are widely used for biological monitoring of variations in the environmental levels of anthropogenic pollutants (Phillips, 1980; Hellawell, 1986; Mahboob and Zahid, 2002). Among aquatic indicator organisms a significant role is assigned to zooplankton assemblages due to capacity for accumulate heavy metals, and their essential role in the enrichment of anthropogenic compounds in food chains (Stemberger and Chen, 1998). Both ecological and toxicological factors influenced zooplankton assemblages at the studied area. Among ecological factors, dissolved oxygen, ammonia, Nitrite were the most significant variables to explain variation in zooplankton. The concentration of dissolved oxygen is one of the most important key factors in controlling aquatic life (Train, 1979; Mahboob and Sheri, 1993). The low oxygen levels were an important factor in limiting species distribution. In response to decreasing oxygen concentrations, species richness and diversity both decrease, and the species composition is largely determined by the tolerance to oxygen deficiency (Mahboob and Sheri, 1995; Flemer *et al.*, 1999; Wu, 2002). Water of AZ lakes water was more oxygenated as compared to WH streams. This may be one major factor responsible for increasing diversity within zooplankton in these lakes.

Total ammonia nitrogen (TAN) is composed of toxic (un-ionized) ammonia (NH_3) and nontoxic (ionized) ammonia (NH_4). Only a fraction of the TAN exists as toxic (un-ionized) ammonia, and a balance exists between it and the non-toxic ionized ammonia: The proportion of TAN in the toxic form increases as the temperature and pH of the water increase. For every pH increase of one unit, the amount of toxic un-ionized ammonia increases about 10 times (Durborow *et al.*, 1992). Wadi Hanifah streams are characterized by high concentration of ammonia which may result from the large amount of sewage input, which was reflected in the low diversity of their zooplankton communities. Result of present study was substantiated by the findings of Harris *et al*. (1998) and Alabaster *et al*. (1983). They mentioned that, ammonia is toxic, not only to fish but also to all aquatic animals, especially in pond aquaculture at low concentrations of dissolved oxygen. The toxic levels of un-ionised ammonia for short-term exposure usually are reported to lie between 0.6 and 2 mg/l (Pillay, 1993). Ciliates were responding more quickly to environmental contaminants than other organisms (Madoni, 2005), because of their high reproduction rates and sensitivity to pollutants (Decamp and Warren, 1998). The higher ammonia concentration seems to be received from the domestic sewage and agriculture discharge or internally from decayed organic matter in the water body.Ciliates is considered effective biological indicators and an early predictor for the changes in organic pollution in streams and rivers. Protozoa was dominant and most abundant zooplankton group in WH streams, indicator of organic pollution. According to the most recent literature, nitrogen compounds, which are included in artificial fertilizers, are one major factor responsible for accelerating the eutrophication of surface waters (Fairchild *et al*., 2005). This influences the quality of inland waters, which are endangered by the increase of trophic conditions as a result of enrichment from the catchments area (Joniak *et al.*, 2006). Compared to AZ lakes, the water of WH streams showed high enrichment with nutrient and the dominant rotifer species in this stream, Brachionus calyciflorus and *Keratella cochlearis* and *Testudinella patina* are indicators of high trophy (Karabin, 1985). Mass occurrence as well as the high densities of the zooplankton communities suggests a high trophy in these streams. *Brachionus calyciflorus* is considered an indicator for eutrophic water (Guisand and Joja, 1988; Mahboob, 2010), cosmopolitan, eurytherm, eurohaline in alkaline and also polluted shallow waters (Shiel *et al*., 1982).

CONCLUSIONS

Reduction in zooplankton diversity at Wadi Hanifah streams probably was induced by sewage and others domestic pollutant poured to it and may be the main reason for this heterogeneity of zooplankton community. It has been ended zooplankton may be used as bioindicators for water quality to provide early warning mechanisms of possible environmental damage. Impacts of effluents can also be tested and predicted before their discharge. Environmental degradation can be assessed by studying the communities of invertebrate organisms present in the water body, thus showing effects on the aquatic ecosystem.

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