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COMPARATIVE STUDY OF ECOLOGICAL CONDITIONS OF FOUR WETLANDS OF PUNJAB USING MACROINVERTEBRATES AS BIOINDICATORS

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ABSTRACT

A baseline study was conducted from November 2006 to October 2007 to investigate the status of aquatic macro-invertebrates as bio-indicators and their ecological linkages to physico-chemical characteristics of four wetland areas of Punjab namely, Balloki Headworks, Qadirabad Headworks, Rasul Headworks and Kalar Kahar Lake. The sampling points were marked on a map using GPS; Garmen 97. The hydrological parameters such as temperature, pH, LDO, salinity and TDS were recorded to get knowledge of the effect of season on the pond ecosystem. Macroinvertebrate sampling from the pelagic water was done using a dip net of mesh size approximately 0.6 mm, dragged in the water for 15 minutes. These were then preserved and identified up to the order level. The results revealed that Balloki area being under the effect of dry season and agricultural stress had more tolerant species. The presence of pollution sensitive ephemeroptera was justified by low TDS and high LDO at Rasul Headworks. The hydrology and fauna of Kalar Kahar Lake was exclusively different from the other sites. In this case pH, TDS, salinity were highest whereas LDO was the lowest. The relative abundance of sensitive to tolerant species was in accordance with the hydrological data.

Keywords: Macroinvertebartes, Bioindicators, Physicochemical characteristics, Wetlands, Ecological study.

INTRODUCTION

Wetlands play an important role in the water cycle by capturing, holding rainfall and water from the melting snow; retaining sediments and purifying water in the process. In fact wastewater and urban runoff are commonly received by wetlands, which are also an effective filter, sink and transformation system for pollutants. These functions are very important among the other ecological services offered by wetlands (Hansson, 2005).

Freshwater macroinvertebrates are a diverse a group of animals ranging from worms and leeches to crustaceans and insects. These organisms may be very sensitive to changes in the environment such as pollution, habitat fragmentation and other stresses that degrade biodiversity (Gooderham and Tyrslin, 2002). For survival, specific ranges of environmental conditions such as temperature, oxygen levels, pH and salinity, are needed by the macro-invertebrates (Williams, 1987). The macroinvertebrate community is closely linked to habitat conditions for example, detritivores are found in organically rich sediments under macrophytes while Ephemeroptera are characteristic of shallow wave washed smooth habitats (James *et al.*, 1998). Their abundance and diversity is an indicator of the productivity of the ecosystem (Batzer and Resh, 1991). Considering the classification of aquatic macroinvertebrates by Kruger and Lubezenko (1994), daphnia, stone flies and may flies are very sensitive species, freshwater shrimps are medium tolerant, odonates such as damsel flies and dragon flies are tolerant species, whereas, cleopterans, arachanids, and gastropods are very tolerant.

The fish being the major source of income for the local fisherman, feed on the natural fauna in the ponds. The drifting species are the aquatic and fallen taxa also serve as food for fish. The piscivorous birds are attracted to the wetlands, arrive in thousands during the breeding season (Prusty and Azeez, 2007) and roost in the macrophytes (Irshad and Mirza 2011). Macrophytes provide habitat for both macroinvertebrates and epiphytic algae, which in turn forms the basis of the littoral food web (James *et al*., 2000b).

This study aimed to collect baseline information on macroinvertebrates, which are the primary consumers and some decomposers of the pond ecosystem of study area. Also, the ecological linkages of macroinvertebrates were investigated focusing on their relationship with physicochemical and season variations.

MATERIALS AND METHODS

Pakistan has about 225 important wetlands of which four were studied, namely, Balloki headworks, Qadirabad headworks, Rasul headworks and Kalar Kahar Lake, in the province of Punjab. Three of the wetlands mentioned above have two types of ponds, the permanent and the seasonal ones. The fourth wetland Kalar Kahar is a permanent lake.

Abbreviations used for names of study areas:
BA: Baloki Headworks; QA: Qadirabad headworks;
RA: Rasul Headworks; KA: Kalar Kahar Lake

A suitable pond area was selected upstream of the barrage. Two trips were made to the selected pond of each area, one in the winter and the other in summer. The coordinates of the study area were taken by using the GPS model, Garmen 97 and then the values were plotted on map, using Arc View software. The hydrology was determined by an onsite water quality monitoring equipment Hydrolab MS-5 Sonde. Parameters such as temperature, luminescent dissolved oxygen (LDO), salinity, Total dissolved solids (TDS) and pH were recorded. The type of vegetation for every visit was noted. Organisms were collected only from the pelagic waters. Dip net of mesh size, approximately 0.6mm was dragged in the water for fifteen minutes along the boat and the contents of the mesh were emptied into a bottle containing water from the same pond. The water was collected in plastic containers and marked with a waypoint from the GPS receiver. The macroinvertebrates in these sample bottles were then separated, counted and placed in small sized vials containing a preservative. Composition of the preservative; 30% of Glycerin, 20% of Distilled Water, and 50% of 70% Alcohol. The organisms were then carefully photographed, and identified with the help of available guides. (Needham and Needham 1962), (Kruger and Lubezenko, 1994)

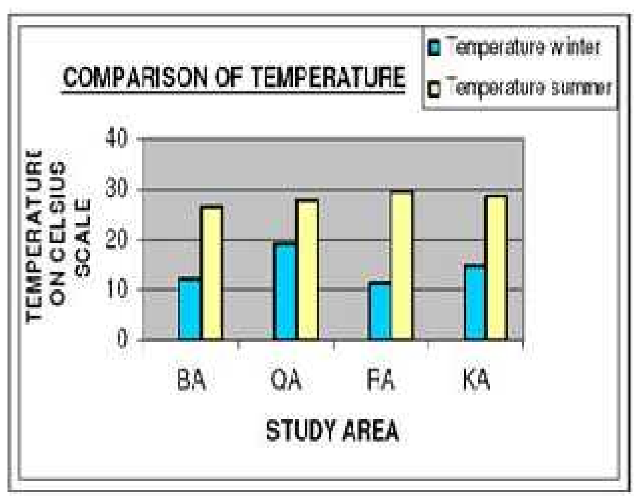
RESULTS AND DISCUSSION

The physical and chemical characteristics of water showed seasonal fluctuations interacting with one another and have combined effect on animals and plants (Odum1971; Jeffries and Mills, 1990). There was no marked difference between the temperatures of all the study areas; however, the temperature of summer was twice that of the winter season (Figure 1). Increased solar radiations lead to rise in the surface water temperatures, which in turn affected the number and diversity of macroinvertebrates (Townsend, 1986). The productivity of the water bodies is directly affected by the intensity and seasonal variations in the temperature of water (Macan, 1980). These factors are extremely varied and control the composition of natural waters.(Boyd, 1981) Similar results have been reported by Shelly *et al.,* (2011), Ali *et al*., (2004), Ali *et al.,* (2007) and Salam *et al.,* (2001).

The concentration of TDS was always higher for winters than in summer. KA had the highest value of TDS; 5.75 g/l and 2.32 g/l for winter and summer, respectively. The LDO was highest in RA with about 10 mg/l in winter and 6 mg/l in summer. KA had the lowest oxygen levels in winter; 3.14 mg/l however, the conditions improved in the monsoons and LDO increased to 4 mg/liter. The LDO of RA was highest possibly because of good water quality and habitat conditions. In fact, the summer values were higher than winters for all areas except RA ponds where the water bodies of ponds were all covered with floating vegetation in summer, reducing light penetration and wave action. Low LDO in the KA during winter might be because, previously the lake had been used as a fish farm and to increase the productivity of the pond organic fertilizers were used whose decomposition lead to reduced oxygen levels. Similar results have been reported by Chugtai (1999) where TDS was inversely related to LDO. In winters, the TDS was higher due to decomposition which had just taken place and the biomass was in the form of dissolved solids. The accumulation of detritus provides a substrate for the matrix of bacteria, algae, and fungi supplying a rich source of organic material for detritivorous macroinvertebrates (Weatherhead and James 2001).

The pH values were relatively higher in winter in the three areas except the KA where the value increased in summer. The pH of KA was the highest; 8.64 in winter and 9.25 in summer, whereas QA had the lowest values of 7.59 and 7.48 in winter and summer respectively. These values fall within the suitable pH range for fish production (Boyd and Tucker, 1998).

At all the study sites the salinity levels were higher in winter season than summer. The salinity levels were lowest in RA being 0.12 ppt in summer and 0.091 ppt in winter. Of all the parameters, the values came out to be strikingly different for KA and RA pond areas. KA being located in the salt range had the highest level of salinity in comparison with the other areas. The salinity of all the areas decreased in summer and for the lake, salinity decrease to 2.82 ppt from 4.77 in winter. The salinity was lowest for RA ponds whereas it was moderate for QA and BA. The hydrology of the wetland of QA was found to be stable where the values came out to be nearly the same for two visits and there was not much difference in the habitat (Figure-1).



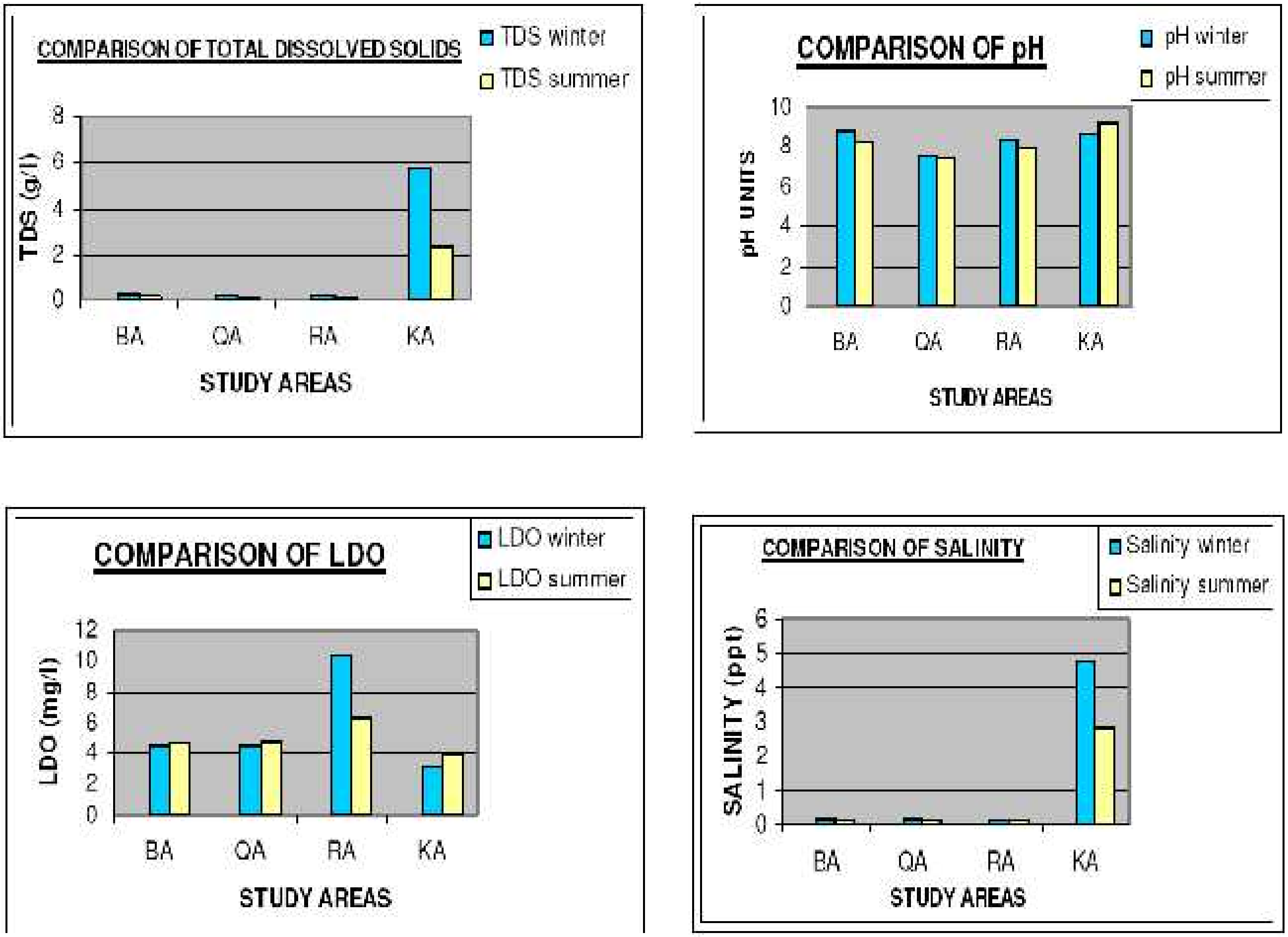


Figure. 1: Water characteristics of the wetlands

Macrophytes: A seasonal observation on macrophytes has been given in table-1 that shows some variations in prominent macrophytes in winter and summer conditions at the four sites.

Table 1: Macrophytes of two seasons

Study Area	Balloki		Qadirabad		Rasul		Kalar Kahar Lake	
Season	Winter	Summer	Winter	Summer	Winter	Summer	Winter	Summer
Aquatic Macrophytes	Lotus	No vegetation	Lotus, Hyacinth, Typha and submerged vegetation	Same as before	Sacchrum at the periphery of ponds	Lotus, Hyacinth and Sacchrum	Phragmitis	submerged vegetation, Typha and algal bloom

Macroinvertbrates: The pond areas go through a cyclic process in which there is a climax situation (Figure-2). The primary producers die and scavengers take over to clean the debris. Low periphyton content was possibly due to the dominance of macrophytes. Pond vegetation supply food in the form of organic material. Removal of this food source does not only affect macroinvertebrates that feed on it, but also increase the amount of light reaching the water (Eliassen, 1952).

BA ponds had more concentration of macroinvertebrates (Figure-3) in the fall possibly as the season changed; the water level in the ponds had already decreased. Due to the drought conditions prevailing (noted in January) the invertebrates of the pond had accumulated in the water that was remaining in the area. Agricultural pressure, evaporation (from the month of January to October) and decrease in the water table had completely dried up the ponds. This is in agreement with the study of Ali *et al*. (2000). Robinson *et al*., (1990) worked on the effect of seasons on animal abundances; he concluded that the overall abundance was three times greater in fall. The difference in the number of organisms could be due to seasonal life cycle of the invertebrates, environmental factors or biotic factors such as competition and predation (Thorson, 1966).

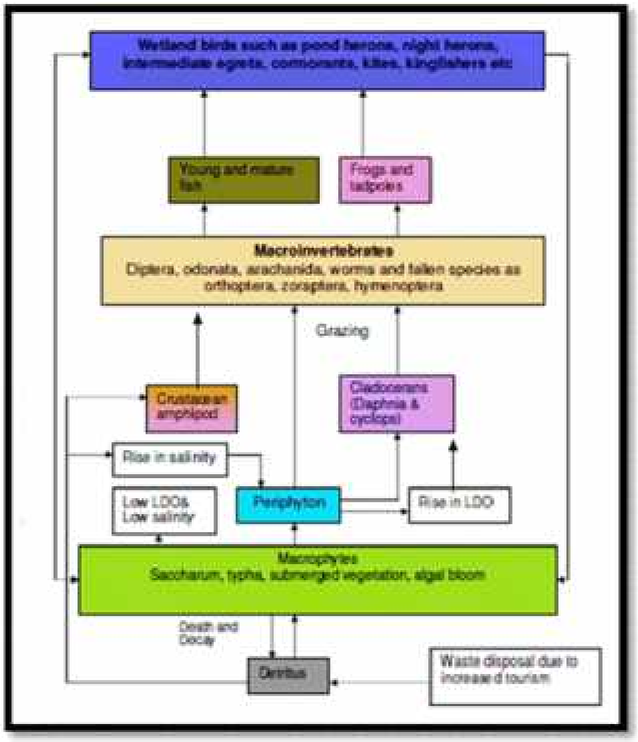


Figure 2. Interaction of biotic and abiotic factors of the wetland ecosystem

In the winter season, the highest numbers of coleopterans were present in the samples collected at QA and were the lowest in KA. Coleoptera were highest in the RA in the summer and the lowest in KA in the winter. This relates to the TDS value which was the lowest for RA and highest in KA. If we compare the abundance of these scavengers with the pH, TDS and LDO, then a direct relationship is observed as these organisms feed on the debris and organic matter clearing the water. Lower the TDS, higher the number of coleopterans, which feed on the debris.

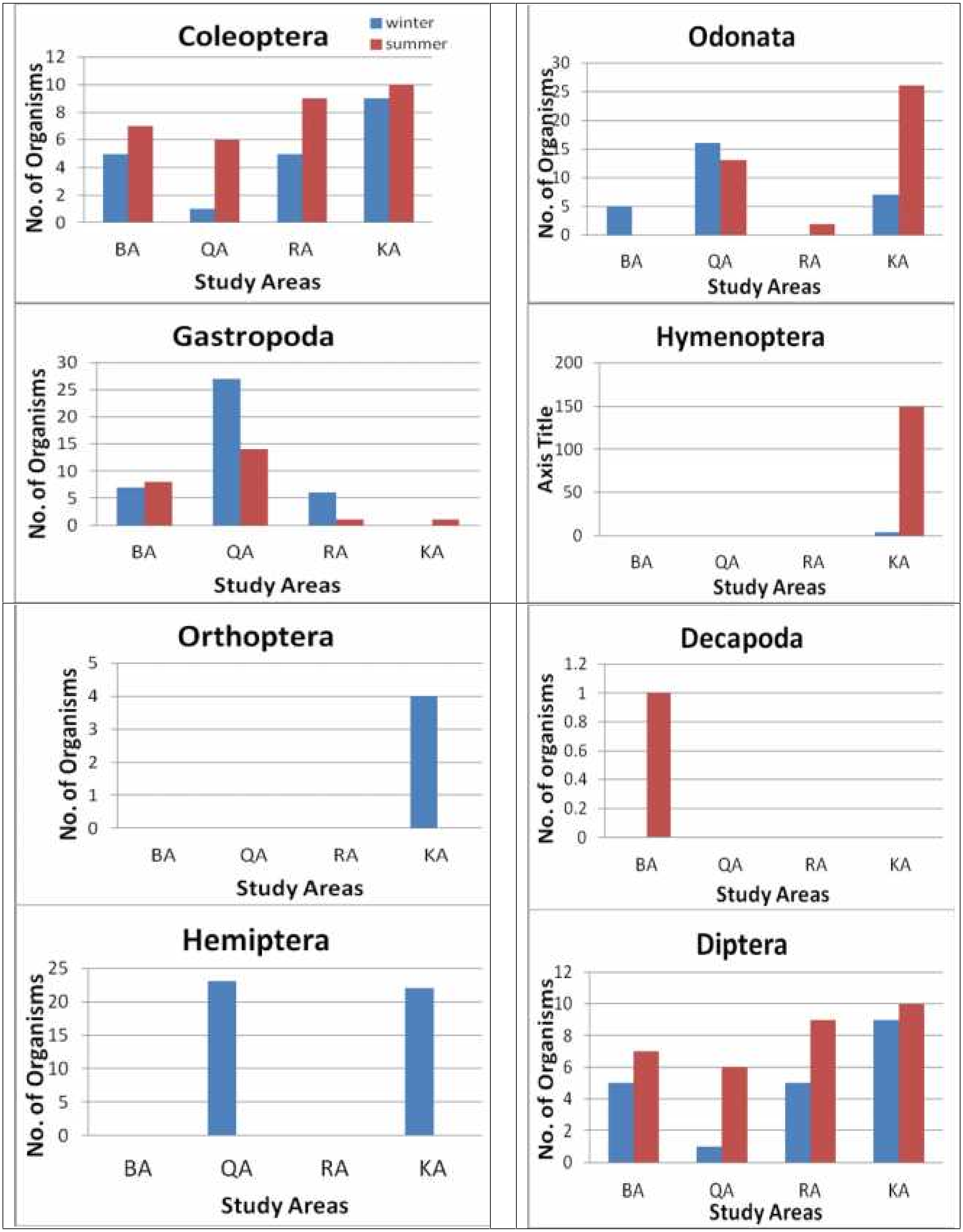
Gastropods were most abundant in BA and QA whereas they were not observed in KA at all, this could be because these taxa inhabit sandy soils whereas, brackish lake had soil with more silt content. Unlike QA and RA, at BA there was no difference in the number of mollusks collected in the two seasons. No odonates were found in the RA and BA in the winter season and the counts were nearly the same for QA during the two visits. Odonates were most abundant in the KA during the summer time, whereas it was comparatively very few in the winter. The odonates such as dragon flies and damsel flies which are the tolerant species were most abundant in the QA and KA, indicating localized and channelized pollution.

The drifting winged insects; zorapterans, orthopterans and hymenopterans such as chalcids were found only in the KA with a great difference in the counts of winter and summer. The hemipterans which are the detritus feeders and were found only in the winter season in QA and KA ecosystem. This might have resulted in an increase in algal growth in KA waters that favored colonization of selected macroinvertebrates.

Memebrs of the order diptera such as chironomids and mosquito larvae become the food fish and many invertebrate groups including odonates such as dragonfly. The dragonfly nymph eats mosquitoes at all stages of development and is quite effective in controlling populations (Singh *et al*, 2003). Dipterans were most abundant in the eutrophic lake KA. Arachanids which included spiders and water striders were most abundant in the BA in winter and then is the numerical value obtained from KA. A large number of spiders observed in the field in the QA but these could not be caught.

Only one member of the class decapoda; freshwater shrimp (medium tolerant species) was included in the summer sample from BA and nowhere else. The crustaceans included daphnia, Cyclops in all areas but gammarus were found only in KA in the winter season. The occurrence of amphipod; gammarus found at KA can be explained by the distribution of some of the tolerant and highly invasive species during different seasons, which invade the ecosystem and dominate others. The sensitive species like mayfly nymphs, observed only in RA pond, indicated good healthy water quality. This was possibly because of high LDO, low TDS and low salinity level.

Sewage and industrial effluents contain many components, including toxic substances such as heavy metals and pesticide that can kill macroinvertebrates, as can treated water by reducing dissolved oxygen levels and disrupting macroinvertebrate metabolism. Severe organic pollution causes depletion of oxygen in the water and invertebrates are largely eliminated except for species such as worms and chironomid larvae which can tolerate low levels of oxygen. This is the reason they are most abundant in winters reflecting their detritivorous behavior (McLachlan, 1970, Van den Berg *et al.*, 1997, Biggs and Malthus, 1982, Quinn and Hickey, 1990). At various points, feedback loops occur, for example snails groom the leaves of the macrophytes, reducing sediment and algal films and improving photosynthetic efficiency (James *et al*., 2000a).


Coleoptera
winter
summer
No. of Organisms
Study Areas
BA QA RA KA
Odonata
No. of Organisms
Study Areas
Gastropoda
No. of Organisms
Study Areas
Hymenoptera
Axis Title
Study Areas
Orthoptera
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Decapoda
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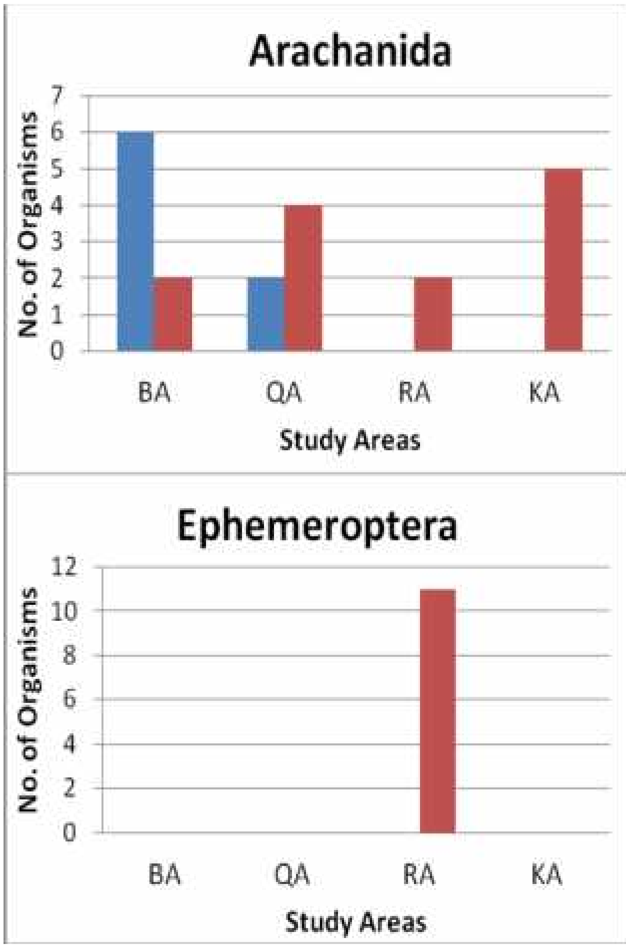

Figure. 3: Macro-invertebrates of the wetlands

Conclusion: The results revealed that water quality of the wetlands has a strong impact on biological components. The diversity of organisms found in these water bodies gives a clear indication of the quality of habitat. Upon comparison of the four study sites it was observed that the abundance and tolerant species such as diptera, gastropoda, coleoptera and odonata indicated the poor quality of ponds at BA. The largest diversity of macroinvertebrates at QA which included both tolerant and sensitive species, showed stable hydrology of the area. Highest level of LDO and lowest level of TDS at RA indicated clear oxygenated water which explained the presence of the very sensitive ephemeroptera. The hydrology and fauna of KA was exclusively different from the other sites showing presence of orthoptera, hymenoptera and comparatively higher number of hemiptera. In this case pH, TDS, salinity were highest whereas LDO was the lowest. The lake was euotrophic in winter but naturally recovered by the onset of monsoon. In the KA tourism had a major effect on the water quality.

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