ABSTRACT

The organisms associated with solid liquid interface are ordinarily termed as Benthos (Haeckel, 1891). The term Benthos is derived from two Greek words “Ben” meaning ‘the collection of organisms living in or on the sea or lakes’ and “Thos” ‘the bottom of sea or lakes’. Hutchinson (1967) defined benthos as an association of species of plants and animals that live in or on the bottom of a body of water. Benthic fauna are especially of great significance for the fisheries that they themselves act as a food of bottom feeding fishes (Walker et al., 1991; Vijaykumar et al., 1991) forming an important part of the food chain. Benthos plays a critical role in the natural flow of energy and nutrients. As benthic invertebrates die, they decay leaving behind nutrients that are reused by aquatic plants and other animals. These animals are widespread in their distribution and can live on all bottom types, even on man made objects. They can be found in hot springs, small ponds and large lakes. Some are even found in the soil beneath puddles. Many species of benthos are able to move around and expand their distribution by drifting with currents to a new location during the aquatic phase of their life or by flying to a new stream during their terrestrial phase. Most benthic species can be found throughout the year, but the largest numbers occur in the spring just before the reproductive period. In colder months, many species burrow deep within the mud or remain inactive on rock surfaces. Many aquatic insects undergo a complete metamorphosis - the transition from egg to larva to pupa and finally to adult. They remain in the water for most of their lives (typically one month to four years). After becoming adults, the majority of insects live for only a brief time, usually a few hours to a few days, while they locate mates and reproduce.

Among the invertebrate taxa, benthos are sensitive to pollutants such as metals and organic waste. Mayflies, stone flies and caddis flies are generally intolerant of pollution but some species can survive in good oxygen concentration in moderately polluted water body. Stream macro invertebrates have been used extensively to bio-monitor numerous environmental stresses (Rosenberg and Resh, 1993). Benthos are sensitive to watershed condition and exhibit sufficient stability in assemblage structure over time to make them
useful as long term monitor of stream health (Richards and Minshell, 1992) and indicator of water quality (Gauffin and Tarwell, 1952; Wilhm and Dorris, 1968 and Resh, 1995). Hynes (1961) reported that the density of benthos in a water body is useful index of water quality although density may fluctuate widely with changes in the seasons and space. Some benthic forms are often considered to be best indicator of organic pollution because of their constant presence, relatively long life span, sedentary habits and different tolerance to stress habitat (Webber et al., 1989). According to Brinkhurst (1974), the community of benthic invertebrate in lake has been used as indicator of lake fertility and even been used as a basis for lake classification (Johnson et al., 1990). Knowledge of littoral benthos also becomes more important because of the increasing human influence on the aquatic ecosystem. Moreover, the effect of pollution or even more the effect of the regulation of water level can not be understood or even can not be predicted without knowledge of the natural state of the littoral zone.

The benthic Cladocera comprise a suite of species that occupy various littoral and profundal habitats. The importance of cladocera in the trophic dynamics of freshwater systems, being the main component of benthos, has long been recognized (Sinha and Khan, 1998). They are the consumers of first order, directly drawing energy from primary producers of the ecosystem viz. phytoplankton. In turn, they form the food for planktivorous fishes and other invertebrates, transferring energy to higher trophic levels. Besides, they have also been reported to be reliable indicator of eutrophic nature of water bodies (Sinha and Khan, 1998; Sharma, 2001).

Copepods are significant primary and secondary consumers in aquatic food chains. Their grazing contributes to the transfer of algal primary production to higher trophic levels. In other words, copepods can make organic material available to higher trophic levels in a larger pellet form thus saving the foraging energy of their predators.

Rotifers are the most important soft bodied invertebrates in the fresh water plankton and benthos and characteristically inhabitants of inland waters (Hutchinson, 1967). Further, the members of this group are known to exhibit worldwide occurrence from the Arctic and Antarctic regions to the tropics. The rotifers occur in an endless variety of aquatic and semi aquatic habitats,
including limnetic and deepest regions of the largest lakes and smallest puddles.

Oligochaetes body is clearly divided into segments which are separated externally by distinct grooves. The red annelids worm has also been reported increasing in number in water polluted with domestic sewage. Oligochaetes are the common inhabitants of polluted waters. Availability of food, polluted environment and absence of predation might be cause of higher numbers of Oligochetes population.

Aquatic Dipterans are the most ubiquitous of the entire macrobenthic invertebrate group in tropics. Due to eutrophic nature of Dipteran larvae, they have been used as reliable indicators of aquatic pollution and related perturbation.

Aquatic Hemiptera holds an important place in the ecology of fresh water ecosystems. They are important food to many organisms including fish, amphibians, water fowl and many other animals. They generally have an intermediate place in the food chain, apart from being eaten, are often important predators too. Hemipterans are exceedingly important in relation to fish production. They are the primary food for many wild and cultivable fishes, which make them valuable predators, are also occasional pests in the manmade nursery ponds for fish culture where they feed on young fish.

Ephemeropterans (mayflies) are considered as “keystone” species and their presence is believed to be an important indicator of oligotrophic to mesotrophic (low to moderately productive) condition in running waters. From an ecological perspective, Trichoptera are important processors of organic matter. Trichoptera larvae, pupae and adults also form an important link in the food chain and they have also been used extensively by trout fishing enthusiasts as models for “flies”. The ability of larval trichoptera to construct cases from silk and surrounding material has led to their ecological diversification and utilization of habitats unavailable to other aquatic macro - invertebrates.

The present study was carried out on three derelict water bodies of Aligarh, namely Medical Pond, Laldiggi Pond and Chautal Pond. The objective of present study includes
1. Study of monthly variations in important physico-chemical factors
2. Study of monthly abundance of benthos, species composition and community structure in selected waterbodies.
3. Study degree of relationship between benthos density and physicochemical factors.
4. Statistical analyses including various measures of diversity and CCA analysis.

These would be helpful in knowing the status of benthic diversity in such waterbodies and their conservation from biodiversity point of view.


Water temperature recorded a very significant positive correlation with Air temperature (Medical Pond: r = 0.996; Laldiggi Pond: r = 0.985; Chautal Pond: r = 0.995) total solids (Medical Pond: r = 0.758; Laldiggi Pond: r = 0.907; Chautal Pond: r = 0.746) and total dissolved solids (Medical Pond: r = 0.542; Laldiggi Pond: r = 0.931; Chautal Pond: r = 0.689) in all the selected water bodies.

**Depth:** Medical Pond showed the minimum depth 41.0 cm in June, 2009 and maximum of 169.0 cm in August, 2009. In Laldiggi Pond, it fluctuated from a minimum of 57.0 cm in June, 2009 to a maximum of 149.0 cm in September, 2009. In Chautal Pond, depth varied from a
minimum of 51.0 cm in June, 2009 to a maximum of 99.0 cm in September, 2009.

Seasonal fluctuations in depth were found to be affected by high rate of evaporation at high ambient temperature and precipitation during rainy season.

**Transparency:** Secchi disc transparency values varied from a minimum of 17.50 cm in June, 2009 to a maximum of 45.0 cm in March, 2009 in Medical Pond. Laldiggi Pond showed a range from 20.0 cm to 57.50 cm with minimum values recorded in June, 2009 and maximum in February, 2009. In Chautal Pond, the transparency values fluctuated from a minimum of 25.0 cm in June, 2009 to a maximum of 47.0 cm in March, 2009. Low values of transparency were recorded in summer and monsoon, which might be due to entry of suspended and colloidal matter, silt and clay into these water bodies along with the rain water from surrounding areas during monsoon and due to evaporation of water, which causes concentration of dissolved solids due to high temperature and production of plankton during summer. High transparency in post monsoon, winter and post winter might be related to low biological activities and settling of suspension Transparency recorded negative correlation with TDS  (Medical Pond: $r = -0.472$; Laldiggi Pond: $r = -0.610$; Chautal Pond: $r = -0.499$) and water temperature  (Medical Pond: $r = -0.768$; Laldiggi Pond: $r = -0.641$; Chautal Pond: $r = -0.745$) in all the three selected water bodies.

**D.O.:** Value of dissolved oxygen fluctuated from a minimum of 3.6 mg/l in July, 2009 to a maximum of 10.0 mg/l in December, 2009 in Medical Pond. Laldiggi Pond, showed variations from a minimum of 3.1 mg/l in October, 2009 to a maximum of 8.0 mg/l in January, 2010. In Chautal Pond, it ranged from a minimum of 3.0 mg/l in July, 2009 to a maximum of 8.2 mg/l in January 2010. The higher values of dissolved oxygen content in winter could be related to high oxygen retention capacity of water at low temperature and reduction in respiratory consumption of oxygen due to reduced metabolic rate, whereas lower values during summer might be due to death and decomposition of organic matter, decrease in oxygen retention by water at high temperature and increase in the respiratory consumption of
oxygen due to increased metabolic rate. Statistically D.O. showed negative and significant correlation with water temperature in all the three selected ponds (Medical Pond: \( r = -0.853 \); Laldiggi Pond: \( r = -0.811 \) and Chautal Pond: \( r = -0.577 \)), indicating temperature as one of the important factors for variations in D.O. concentration in all the water bodies.

**Free CO\(_2\):** Carbon dioxide was found to be absent in Medical Pond during the whole course of study. It might be due to its utilization in photosynthesis. Moreover, phytoplankton and macrophyte combine bicarbonate to form carbon dioxide and carbonates Wurts and Durborow (1992). In Laldiggi Pond, the carbon dioxide was found to be absent in some months viz. September, 2009, November, 2009, December, 2009 and January, 2010 and during rest of the period of study, it fluctuated from a minimum of 18.0 mg/l in March, 2009 to a maximum of 30.0 mg/l in August, 2009. In Chautal Pond, it varied from a minimum of 10.0 mg/l in February, 2009 to a maximum of 45.0 mg/l in August, 2009. The presence of carbon dioxide in these ponds could be attributed to lower rates of photosynthesis and more decomposition of organic matter in these water bodies.

**Conductivity:** It varied from a minimum of 803 µScm\(^{-1}\) in March, 2009 to a maximum of 1789 µScm\(^{-1}\) in July, 2009 in Medical Pond. Laldiggi Pond showed the minimum value 978 µScm\(^{-1}\) in June, 2009 and maximum 1678 µScm\(^{-1}\) in January, 2010. In Chautal Pond, values of conductivity fluctuated from a minimum of 998 µScm\(^{-1}\) in December, 2009 to a maximum of 1691 µScm\(^{-1}\) in May, 2009. Higher values of conductivity in Medical and Chautal Pond were recorded during summer, which might be related to decomposition of organic matter, fecal matter, sewage, leaching of salts etc. from the catchment area, whereas in Laldiggi Pond, lower values during summer might be attributed to increase in the uptake of nutrients by algae and macrophyte in this pond.

**TS:** Medical Pond showed the minimum value 1526 mg/l in January, 2010 and maximum 2900 mg/l in August, 2009. In Laldiggi Pond,
values fluctuated from a minimum of 1400 mg/l in December, 2009 to a maximum of 2970 mg/l in July, 2009. Chautal Pond showed the minimum value 1210 mg/l in December, 2009 and maximum 3050 mg/l in September, 2009. Statistically total solids recorded a very significant positive correlation with water temperature in all the three selected ponds (Medical Pond: \( r = 0.758 \); Laldiggi Pond: \( r = 0.907 \) and Chautal Pond: \( r = 0.746 \)), indicating temperature as one of the important factors responsible for concentration of solids.

**TSS:** Medical Pond showed minimum value 450 mg/l in June, 2009 and maximum 950 mg/l in August, 2009. In Laldiggi Pond, it fluctuated from a minimum of 340 mg/l in November, 2009 to a maximum of 1200 mg/l in August, 2009. Chautal Pond showed minimum value 395 mg/l in February, 2009 and maximum 915 mg/l in September, 2009. Statistically TSS showed negative correlation with transparency (Medical Pond: \( r = -0.187 \); Laldiggi Pond: \( r = -0.262 \); Chautal Pond: \( r = -0.569 \)).

**TDS:** Medical Pond showed minimum value 920 mg/l in December, 2009 and maximum 2010 mg/l in September, 2009. In Laldiggi Pond, TDS values fluctuated from a minimum of 950 mg/l in December, 2009 to a maximum of 2200 mg/l in June, 2009. In Chautal Pond, values varied from a minimum of 700 mg/l in November, 2009 to a maximum of 2135 mg/l in September, 2009. Statistically TDS showed negative correlation with dissolved oxygen in Laldiggi Pond (\( r = -0.631 \)) and Chautal Pond (\( r = -0.446 \)) but in Medical Pond, it showed positive correlation (\( r = 0.510 \)). TDS showed positive significant correlation with water temperature (Medical Pond: \( r = 0.542 \); Laldiggi Pond: \( r = 0.931 \); Chautal Pond: \( r = 0.689 \)). As with the increase in temperature the decomposition and mineralization processes increase thus releasing nutrient in the water.

**pH:** It varied from a minimum of 8.5 in January, 2010 to a maximum of 9.5 in July, 2009 in Medical Pond. In Laldiggi Pond, it fluctuated from a
minimum of 8.0 in April, 2009 to a maximum of 8.9 in December, 2009. In Chautal Pond, it ranged from a minimum of 7.8 in September, 2009 to a maximum of 8.5 in April, 2009. pH of sediment fluctuated from 7.5 to 9.6 throughout the course of study. In Medical Pond, it varied from a minimum of 8.4 in December, 2010 to a maximum of 9.6 in June, 2009. In Laldiggi Pond, it fluctuated from a minimum of 8.0 in July, 2009 to a maximum of 9.2 in December, 2009. In Chautal Pond, it ranged from a minimum of 7.5 in September, 2009 to a maximum of 8.7 in April, 2009. The high pH values in present study could be related to enhanced photosynthesis carried out by phytoplankton and macrophytes, wherein CO₂ is removed and, hence pH is raised. Statistically pH showed positive correlation with total alkalinity in Medical Pond (r = 0.783) and Chautal Pond (r = 0.203) and negative significant correlation in Laldiggi Pond (r = -0.635).

**Total alkalinity:** Total alkalinity of water fluctuated from a minimum of 180.00 mg/l in March, 2009 to a maximum of 590.00 mg/l in May, 2009 in Medical Pond. Laldiggi Pond, showed the minimum value 145.00 mg/l in October, 2009 and maximum 500.00 mg/l in April, 2009. In Chautal Pond, the values varied from a minimum of 250.00 mg/l in September, 2009 to a maximum of 407.00 mg/l in November, 2009. Variations in total alkalinity of sediment ranged from 64.55 mg/l to 228.00 mg/l in the selected water bodies. In Medical Pond, values of total alkalinity fluctuated from a minimum of 84.55 mg/l in November, 2009 to a maximum of 228.76 mg/l in June, 2009. In Laldiggi Pond, it showed the minimum value 73.20 mg/l in September, 2009 and maximum 201.33 mg/l in April, 2009. In Chautal Pond, the values varied from a minimum of 64.55 mg/l in November, 2009 to a maximum of 178.00 mg/l in May, 2009. Statistically alkalinity showed positive correlation with Hardness in Medical Pond (r = 0.447) and Chautal Pond (r = 0.365) and negative correlation in Laldiggi Pond (r = -0.309).

**Carbonate alkalinity:** Medical Pond showed minimum value 100.00 mg/l in October, 2009 and maximum 500.00 mg/l in June, 2009,
whereas in Laldiggi Pond, carbonate alkalinity was recorded in September, 2009, November, 2009, December, 2009 and January, 2010 only. Its values fluctuated from a minimum of 100.00 mg/l in December, 2009 to a maximum of 160.00 mg/l in January, 2010. In Chautal Pond, it was never recorded during the study period.

**Bicarbonate:** The values of bicarbonate alkalinity fluctuated from a minimum of 50.00 mg/l in September, 2009 to a maximum of 110.00 mg/l in May and August, 2009 and in February, 2009 and March, 2009 it was not found in Medical Pond. In Laldiggi Pond, it showed the minimum value 20.00 mg/l in September, 2009 and maximum 560.00 mg/l in April, 2009. In Chautal Pond, it varied from a minimum of 250.00 mg/l in September, 2009 to a maximum of 407.00 mg/l in November, 2009.

**Hardness:** Medical Pond showed minimum value 124.00 mg/l during January, 2010 and maximum 260.00 mg/l in April, 2009. Laldiggi Pond, showed minimum hardness 112.00 mg/l in December, 2009 and maximum 170.00 mg/l in July, 2009. Chautal Pond showed minimum values of hardness 100.00 mg/l during February, 2009 and maximum 240.00 mg/l in November, 2009. Higher values of hardness during summer in these ponds might be attributed to high evaporation of water at high temperature and anthropogenic activities in and around.

**Calcium:** It fluctuated from a minimum of 36.87 mg/l in December, 2009 to a maximum of 64.12 mg/l in May, 2009 in Medical Pond. In Laldiggi Pond, it varied from a minimum of 36.00 mg/l in December, 2009 to a maximum of 89.77 mg/l in February, 2009. In Chautal Pond, it fluctuated from a minimum of 48.00 mg/l in December, 2009 to a maximum of 88.17 mg/l in March, 2009. High values of calcium were recorded throughout the study period which might be attributed to continuous input of sewage from surrounding areas and weathering of calcareous materials.
Magnesium: It fluctuated from a minimum of 19.77 mg/l in October, 2009 to a maximum of 43.51 mg/l in May, 2009 in Medical Pond. In Laldiggi Pond, it varied from a minimum of 18.46 mg/l in January, 2010 to a maximum of 36.92 mg/l in April, 2009. In Chautal Pond, it ranged from a minimum of 15.82 mg/l in January, 2010 to a maximum of 34.28 mg/l in June, 2009. Lower values during winter months might be attributed to higher sedimentation rate leading to settlement in the bottom and utilization by plankton, whereas higher values during summer can be related to higher evaporation leading to concentration and its release from decomposition of organic matter.

Chloride: It fluctuated from a minimum of 127.00 mg/l in the month of January, 2010 to a maximum of 624.0 mg/l in the month of June, 2009 in Medical Pond. It ranged from a minimum of 93.70 mg/l in the month of December, 2009 to a maximum of 244.00 mg/l in June, 2009 in Laldiggi Pond. In Chautal Pond, values fluctuated from a minimum of 135.00 mg/l in February, 2009 to a maximum of 227.00 mg/l in June, 2009. Maximum values during summer might be due to higher rate of evaporation and organic pollution of animal origin, whereas lower values during winter could be related to reduction in siltation or allochthonous import of organic matter from catchment area. Moreover, Medical Pond showed relatively high chloride content than that of Laldiggi Pond and Chautal Pond, which might be due to increased sewage contaminations and public use for washing purposes. Statistically chloride showed positive and significant correlation with water temperature (Medical Pond: $r = 0.550$; Laldiggi Pond: $r = 0.778$; Chautal Pond: $r = 0.546$).

Nitrate-nitrogen: It fluctuated from a minimum of 0.054 mg/l in January, 2010 to a maximum of 0.195 mg/l in August, 2009 in Medical Pond. Laldiggi Pond, showed the minimum value 0.081 mg/l in January, 2010 and maximum 0.195 mg/l in June, 2009. In Chautal Pond, values fluctuated from a minimum of 0.051 mg/l in January, 2010 to maximum of 0.278 mg/l in September, 2009.
Statistically NO$_3$- N recorded a significant positive correlation with water temperature (Medical Pond: $r = 0.915$; Laldiggi Pond $r = 0.754$; Chautal Pond: $r = 0.686$) and with TDS in all the three selected ponds (Medical Pond: $r = 0.528$; Laldiggi Pond: $r = 0.781$; Chautal Pond: $r = 0.809$). Higher values were recorded during Monsoon, which could be related to influx of decaying organic matter along with surface run-off from catchment area. Lower values of NO$_3$-N during winter could be attributed to reduced rate of decomposition and its utilization by macrophytes.

**Phosphate- phosphorus:** It ranged from a minimum of 0.419 mg/l in March, 2009 to a maximum of 1.040 mg/l in June, 2009 in Medical Pond. Laldiggi Pond, showed minimum value 0.226 mg/l in January, 2010 and maximum 0.965 mg/l in June, 2009. In Chautal Pond, it fluctuated from a minimum of 0.240 mg/l in December, 2009 to a maximum of 0.950 mg/l in May, 2009. Higher values of PO$_4$ - P during summer were found to be due to release of phosphates from decomposition at high temperature and evaporation of water leading to its concentration, whereas lower values could be attributed to its utilization by macrophytes and algae for their growth, low calcium level and low temperature.

Statistically PO$_4$-P recorded a significant positive correlation with water temperature in all the three selected ponds (Medical Pond: $r = 0.730$; Laldiggi Pond: $r =0.875$; Chautal Pond: $r =0.739$). It recorded negative correlation with pH in Laldiggi Pond ($r = -0.694$) and Chautal Pond ($r =-0.037$), whereas positive correlation in Medical Pond ($r = 0.492$).

**%Organic carbon:** It varied from 0.516% during May, 2009 to 2.270% during September, 2009 in Medical Pond. In Laldiggi Pond it ranged from 0.766% during January, 2010 to 2.488% during October, 2009, whereas in Chautal Pond the value fluctuated between 0.636% during March, 2009 and 3.375% during November, 2009.

**%Organic matter:** The highest value (5.820%) was observed on clay loam substratum in Chautal Pond and lowest (0.891%) on sandy clay loam substratum in Medical Pond. The organic matter in sediment of
Medical Pond varied from 0.891% during May, 2009 to 3.914% during September, 2009. In Laldiggi Pond it ranged from 1.321% during January, 2010 to 4.290% during October, 2009, whereas in Chautal Pond the value fluctuated between 1.098% during March, 2009 and 5.820% during November, 2009.

On the basis of composition of sand, silt and clay in sediment, the type of sediment is sandy clay loam in Medical and Laldiggi Pond, whereas clay type in Chautal Pond.

**Benthos distribution, abundance and diversity**– The freshwater benthic community of these water bodies comprised of ten groups, namely *Rotifera*, *Oligochaeta*, *Cladocera*, *Copepoda*, *Ostracoda*, *Diptera*, *Hemiptera*, *Coleoptera*, *Trichoptera* and *Ephemeroptera*. They showed wide variations in their densities and occurrence.

**Rotifera** formed the first most abundant group of benthic fauna in three selected water bodies. This group was represented by six genera viz. *Brachionus*, *Keratella*, *Notholca*, *Filinia*, *Hexarthra*, and *Asplanchna*. Total percent contribution of Rotifers ranged from 23.47% during December, 2009 to 35.12% during September, 2009 in Medical Pond, from 22.31% during January, 2010 to 33.73% in August, 2009 in Laldiggi Pond and from 24.83% during September, 2009 to 41.45% in March, 2009 in Chautal Pond.

Statistically Rotifera recorded a significant negative correlation with water temperature (Medical Pond: $r = -0.769$; Laldiggi Pond: $r = -0.618$; Chautal Pond: $r = -0.584$), whereas with D.O., it showed significant positive correlation in all the three selected Ponds (Medical Pond: $r = 0.599$; Laldiggi Pond: $r = 0.631$; Chautal Pond: $r = 0.566$). It showed negative correlation with TDS in all ponds (Medical Pond: $r = -0.171$; Laldiggi Pond: $r = -0.646$; Chautal Pond: $r = -0.782$) and with diversity index in Medical Pond ($r = -0.172$) and Chautal Pond ($r = -0.623$), whereas positive in Laldiggi Pond ($r = 0.243$).

**Diptera** formed the second abundant group of benthic fauna in Medical Pond and Laldiggi Pond and third in Chautal Pond. It was represented by
Chironomus, Helius, Culex and Pentaneura. The percent contribution of Diptera to the total benthos ranged from 8.39% during August, 2009 to 23.31% in May, 2009 in Medical Pond, from 6.52% during June, 2009 to 25.28% in October, 2009 in Laldiggi Pond and from 7.14% during April, 2009 to 22.25% in January, 2010 in Chautal Pond.

Statistically Diptera recorded a significant negative correlation with water temperature (Medical Pond: $r = -0.654$; Laldiggi Pond: $r = -0.716$; Chautal Pond: $r = -0.655$), TDS (Medical Pond: $r = -0.538$; Laldiggi Pond: $r = -0.705$; Chautal Pond: $r = -0.535$) and nitrate (Medical Pond: $r = -0.570$; Laldiggi Pond: $r = -0.676$; Chautal Pond: $r = -0.643$) in all the ponds.

Chironomus is one of the most common indicators of pollution. It can survive in low oxygen as well as polluted condition of water body. Its presence in high number in these water bodies indicated that these water bodies are polluted.

Cladocera formed the third abundant group in Medical Pond and Laldiggi Pond whereas second in Chautal Pond. It was represented by species of Daphnia, Bosmina and Moina. Total percent contribution of cladocera was found to be ranged from 8.06% during January, 2010 to 14.74% in December, 2009 in Medical Pond, from 12.75% during September, 2009 to 18.83% in May, 2009 in Laldiggi Pond and from 10.49% during August, 2009 to 22.63% in April, 2009 in Chautal Pond.

Statistically Cladocera recorded significant negative correlation with water temperature (Medical Pond: $r = -0.610$; Laldiggi Pond: $r = -0.647$; Chautal Pond: $r = -0.503$), whereas it showed significant positive correlation with D.O. in all selected ponds (Medical Pond: $r = 0.698$; Laldiggi Pond: $r = 0.854$; Chautal Pond: $r = 0.627$). A negative significant correlation was obtained with T.D.S in Medical Pond ($r = -0.622$) and in Laldiggi Pond ($r = -0.604$) and insignificant in Chautal Pond ($r = -0.298$) and with diversity index, it showed positive correlation in Medical Pond ($r = 0.464$) and Laldiggi Pond ($r = 0.259$) and negative in Chautal Pond ($r = -0.542$).
**Ostracoda** formed fifth abundant group in Medical Pond; sixth in Laldiggi Pond and fourth in Chautal Pond. It was represented by *Heterocypris*, *Stenocypris* and *Centrocypris*. Its percent contribution varied from 4.78 % during June, 2009 to 11.58 % in November, 2009 in Medical Pond, from 4.11 % during October, 2009 to 9.75 % in June, 2009 in Laldiggi Pond and from 7.01 % during February, 2009 to 15.18 % in March, 2009 in Chautal Pond. Statistically Ostracoda recorded negative correlation with water temperature (Medical Pond: $r = -0.667$; Laldiggi Pond: $r = -0.595$; Chautal Pond: $r = -0.552$) and TDS in selected ponds (Medical Pond: $r = -0.572$; Laldiggi Pond: $r = -0.516$; Chautal Pond: $r = -0.493$).

**Hemiptera** formed sixth abundant group in Medical Pond; fifth in Laldiggi Pond and Seventh in Chautal Pond. Hemiptera was represented by *Notonecta*, *Coroxid*, *Hebrus*, *Sigara*, *Belostoma* and *Hespercorixa*. Total percent contribution of Hemiptera ranged from 4.28 % during October, 2009 to 12.88 % during December, 2009 in Medical Pond, from 4.93 % during October, 2009 to 12.57 % in December, 2009 in Laldiggi Pond and from 2.65 % during March, 2009 to 10.12 % in December, 2009 in Chautal Pond.

Statistically Hemiptera recorded a significant negative correlation with water temperature (Medical Pond: $r = -0.712$; Laldiggi Pond: $r = -0.676$; Chautal Pond: $r = -0.596$), whereas it showed significant positive correlation with D.O. in selected Ponds (Medical Pond: $r = 0.772$; Laldiggi Pond: $r = 0.889$; Chautal Pond: $r = 0.860$). It showed negative correlation with TDS (Medical Pond: $r = -0.350$; Laldiggi Pond: $r = -0.552$; Chautal Pond: $r = -0.450$) in selected ponds and with diversity index it showed insignificant negative correlation in Medical Pond ($r = -0.188$) and Chautal Pond ($r = -0.088$) but significant positive in Laldiggi Pond ($r = 0.675$).

The high or low abundance of Hemiptera in present study can be related to presence of macrophytes in these selected ponds. **Coleoptera** formed fourth abundant group in Medical Pond, eighth in Laldiggi Pond and seventh in Chautal Pond. This group was represented by *Hydrophilus*, *Dysticus*, *Berosus* and *Haliplus*. The total percent contribution of Coleoptera to benthic fauna ranged from 4.00 % during July, 2009 to 12.52 % in October, 2009 in Medical Pond, from 3.10 % during May, 2009 to 9.23 % in June, 2009,
in Laldiggi and from 4.06 % during June, 2009 to 10.12 % during December, 2010 in Chautal Pond. Statistically Coleoptera recorded a significant negative correlation with water temperature (Medical Pond: \( r = -0.721 \); Laldiggi Pond: \( r = -0.741 \); Chautal Pond: \( r = -0.669 \)), whereas significant positive correlation with D.O. (Medical Pond: \( r = 0.667 \); Laldiggi Pond: \( r = 0.825 \); Chautal Pond: \( r = 0.693 \)) in selected ponds. It showed negative correlation with TDS in all selected ponds (Medical Pond: \( r = -0.463 \); Laldiggi Pond: \( r = -0.481 \); Chautal Pond: \( r = -0.328 \)) and with diversity index, it showed positive correlation in Medical Pond (\( r = 0.184 \)) and Laldiggi Pond (\( r = 0.591 \)) and negative in Chautal Pond (\( r = -0.201 \)).

**Copepods** formed seventh abundant group in Medical Pond; fourth in Laldiggi Pond and eighth in Chautal Pond. It was represented by *Cyclops viridis* and *Diaptomus*. Total percent contribution of copepods ranged from 5.11 % during December, 2009 to 9.67 % in January, 2010 in Medical Pond, from 5.16 % during August, 2009 to 14.70 % in May, 2009 in Laldiggi Pond and from 2.82 % during June, 2009 to 7.39 % in October, 2009 in Chautal Pond.

Statistically Copepoda recorded significant negative correlation with water temperature (Medical Pond: \( r = -0.675 \); Laldiggi Pond: \( r = -0.543 \); Chautal Pond: \( r = -0.745 \)), whereas it showed significant positive correlation with D.O. (Medical Pond: \( r = 0.523 \); Laldiggi Pond: \( r = 0.662 \); Chautal Pond: \( r = 0.817 \)) and insignificant negative correlation with TDS (Medical Pond: \( r = -0.306 \); Laldiggi Pond: \( r = -0.473 \); Chautal Pond: \( r = -0.292 \)) in selected ponds. With diversity index, it showed insignificant negative correlation in Medical Pond (\( r = -0.267 \)) and Chautal Pond (\( r = -0.126 \)) whereas insignificant positive in Laldiggi Pond (\( r = 0.213 \)).

**Oligochaeta** formed eighth abundant group in Medical Pond, seventh in Laldiggi Pond and sixth in Chautal Pond. This group was represented by *Tubifex, Chaetogaster, Nais and Aelosma*. The total percent contribution of Oligochaeta to the density of benthic fauna ranged from 4.53 % during February, 2009 to 8.87 % in September, 2009 in Medical Pond, from 4.63 % during February, 2009 to 9.13 % in June, 2009, in Laldiggi and from 4.02 % during December, 2009 to 10.78 % during July, 2009 in Chautal Pond.
Statistically Oligochaeta recorded negative correlation with water temperature (Medical Pond: $r = -0.187$; Laldiggi Pond: $r = -0.180$; Chautal Pond: $r = -0.527$), whereas it showed positive correlation with D.O. in all the three selected ponds (Medical Pond: $r = 0.435$; Laldiggi Pond: $r = 0.678$; Chautal Pond: $r = 0.133$). It showed positive correlation with TDS in Laldiggi Pond ($r = 0.318$) and Chautal Pond ($r = 0.309$) and negative in Medical Pond ($r = -0.457$) and with diversity index it showed positive correlation in all studied ponds.

**Trichoptera** formed ninth and second least abundant group in all the three water bodies. This group was represented by *Limnephilus*, *Phryganaea* and *Polycentropus*. Total percent contribution of Trichoptera was found negligible and ranged from 0.138 % during April, 2009 to 0.350 % during December, 2009 in Medical Pond, from 0.106 % during April, 2009 to 0.347 % in June, 2009 in Laldiggi Pond and from 0.132 % during September, 2009 to 5.76 % in December, 2009 in Chautal Pond.

Statistically Trichoptera recorded a significant positive correlation with dissolved oxygen (Medical Pond: $r = 0.846$; Laldiggi Pond: $r = 0.642$; Chautal Pond: $r = 0.560$), whereas it showed significant negative correlation with water temperature in Medical Pond ($r = -0.757$) and Laldiggi Pond ($r = -0.555$), whereas insignificant negative in Chautal Pond ($r = -0.499$). It showed negative correlation with TDS in all the three selected Ponds (Medical Pond: $r = -0.493$; Laldiggi Pond: $r = -0.380$; Chautal Pond: $r = -0.596$) and with diversity index in Medical Pond ($r = -0.268$) and Chautal Pond ($r = -0.481$) and positive in Laldiggi Pond ($r = 0.354$).

Trichopterans showed low frequency across selected ponds. This clearly indicated that they are sensitive to pollution. It can be further concluded that these insects can live in polluted water which can be related to the availability of food and oxygen in these ponds in addition to other factors.

**Ephemeroptera** formed tenth and least abundant group in all the selected water bodies. This group was represented by *Baetis* and *Caenis*. Total percent contribution of Ephemeroptera was found fractional. It ranged from 0.069 % during April, 2009 to 0.378 % during September, 2009 in Medical Pond, from 0.077 % during March, 2009 to 0.189% in November, 2009 in Laldiggi Pond
and from 0.065 % during March, 2009 to 0.231 % in November, 2009 in Chautal Pond (Table- 7a, b, c).

Statistically Ephemeroptera recorded a significant negative correlation with water temperature (Medical Pond: \( r = -0.670 \); Laldiggi Pond: \( r = -0.647 \); Chautal Pond: \( r = -0.565 \)), whereas with D.O., it showed significant positive correlation in all selected Ponds (Medical Pond: \( r = 0.586 \); Laldiggi Pond: \( r = 0.783 \); Chautal Pond: \( r = 0.761 \)).

Mayfly larvae were present in all studied water bodies. Their presence indicated that these larvae are able to survive in polluted waters provided there is sufficient oxygen (> 2.8 mg/l).

Eggs and Nauplii were found throughout the period of investigation indicating that benthos are prolific and continuous breeders.

The absence of Plecoptera during present study clearly indicates the water quality degradation and physical alteration of these derelict water bodies under study as these are restricted to habitats where there is a little human development, clear water, and high dissolved oxygen content.

The preponderance of saprophilic insects e.g. ‘bloodworm’ midge larva in all the selected water bodies understudy clearly indicate that all these water bodies are organically enriched. This further indicates that these water bodies are grossly polluted with poor water quality characterized by low oxygen and high nutrient concentration (eutrophic). In present study, Ephemeroptera were sparsely represented in all the selected water bodies. The main reasons for their low population density and low diversity in present study could be related to habitat degradation by pollution.

**Diversity Indices**

Benthos species diversity index showed insignificant negative correlation with water temperature in Medical Pond ($r = -0.041$) and Laldiggi Pond ($r = -0.246$), whereas significant positive in Chautal Pond ($r = 0.544$).

Correlation between benthos species diversity and following group density are: Cladocera density, showed insignificant positive correlation in Medical Pond ($r = 0.464$) and Laldiggi Pond ($r = 0.259$) and significant negative in Chautal Pond ($r = -0.542$); Copepoda, insignificant negative correlation in Medical Pond ($r = -0.267$) and Chautal Pond ($r = -0.126$) whereas insignificant positive correlation in Laldiggi Pond ($r = 0.213$); Rotifera, insignificant in all ponds except Chautal Pond where it is insignificant negative (Medical Pond: $r = -0.172$; Laldiggi Pond: $r = 0.243$ and in Chautal Pond: $r = -0.623$); Ostracoda, positive correlation in Medical Pond ($r = 0.282$) and Laldiggi Pond ($r = 0.495$) and negative in Chautal Pond ($r = -0.174$); Oligochaeta showed insignificant positive correlation in all the three ponds in Medical Pond ($r = 0.114$), Laldiggi Pond ($r = 0.403$) and Chautal Pond ($r = 0.223$); Diptera, significant negative correlation in Medical Pond ($r = -0.534$) and insignificant positive in Laldiggi Pond ($r = 0.261$) and insignificant negative in Chautal Pond ($r = -0.378$); Hemiptera, insignificant correlation in all the water bodies except Laldiggi Pond (Medical Pond: $r = -0.188$; Laldiggi Pond: $r = 0.675$; Chautal Pond: $r = -0.088$); Coleoptera, insignificant positive correlation in two ponds except Chautal Pond (Medical Pond: $r = 0.184$; Laldiggi Pond: $r = 0.591$, and Chautal Pond: $r = -0.201$); Trichoptera, insignificant negative correlation in Medical Pond ($r = -0.268$) and Chautal Pond ($r = -0.481$) and positive in Laldiggi Pond ($r = 0.354$); Ephemeroptera, insignificant correlation in all the ponds (Medical Pond: $r = 0.165$; Laldiggi Pond: $r = 0.441$; Chautal Pond: $r = -0.019$).

Menhinicks index of diversity for benthos varied from a minimum of 0.553 in December, 2009 to a maximum of 0.786 in July, 2009 in Medical Pond, from 0.494 in January, 2010 to 0.723 in June, 2009 in Laldiggi Pond and from 0.477 in January, 2010 to 0.7048 in July, 2009 in Chautal Pond. Statistically benthos density showed significant negative correlation with Menhinicks index in all the studied water bodies (Medical Pond: $r = -0.983$; Laldiggi Pond: $r = -0.982$ and Chautal Pond: $r = -0.931$).
The species evenness values varied from a minimum of 0.644 in June, 2009 to a maximum of 0.726 in February, 2009 in Medical Pond, from 0.533 in October, 2009 to 0.668 in January, 2010 in Laldiggi Pond and from 0.544 in February, 2009 to 0.703 in August, 2009 in Chautal Pond. Correlation between species evenness and some Physico-chemical parameters were also determined. Species evenness showed positive correlation with PO$_4$-P in two ponds and negative correlation in one of the ponds (Medical Pond: $r = 0.507$; Laldiggi Pond: $r = -0.184$; Chautal Pond: $r = 0.041$).

The highest similarity 91.67% was recorded between April, 2009 – August, 2009 in Medical Pond followed by 90.49 between July, 2009 – September, 2009 in Laldiggi Pond and 90.12 between February, 2009 and April, 2009 in Chautal Pond. The lowest similarity was 75.96 between March, 2009-January, 2010 in Chautal Pond followed by 78.59 between October, 2009 - January, 2010 in Laldiggi Pond and 79.92 in July, 2009 – December, 2009 in Medical Pond. Overall high Similarity index values suggested that most of the species in these ponds were common during the course of study. This has resulted in overlapping of faunal grouping and predictability of community composition.

Canonical correspondence analysis (CCA): The data of benthos and water and sediment quality variables were drawn up in the form of one matrix and were analysed by canonical correspondence analysis (CCA) using PAST program, version (2.10) by Oyvind Hammer and D.A.T Harper, represented in Medical Pond, Laldiggi Pond and Chautal Pond.