CHAPTER – VI
SUMMARY
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Aligarh is richly supplied with fresh water bodies of various kinds. Due to population growth, economic development, rapid urbanization, large scale industrialization and environmental concerns water stress has emerged as a real threat.

Water temperature varied in accordance with air temperature. It varied from 12°C to 34°C in these selected water bodies. Water temperature ranged from 12°C (January, 2010) to 34°C (June and July, 2009) in pond I, 14°C (January, 2010) to 34°C (June, 2009) in pond II, 13°C (January, 2010) to 34°C (June, 2009) in pond III, 14°C (January, 2010) to 34°C (July, 2009) in pond IV and 12°C (January, 2010) to 32°C (May, June and September, 2009) in pond V. Water temperature recorded a very significant positive correlation with air temperature in all the five selected ponds (pond I: r = 0.997; pond II: r = 0.996; pond III: r = 0.995; pond IV: r = 0.996 and pond V: r = 0.985).


Water colour of the selected ponds varied from green, yellowish, greenish yellow to brownish which might be due to phytoplanktonic bloom, high rate of decomposition of organic matter, turbidity and polluted nature of these water bodies.

Depth values ranged from 40 cm to 149 cm in these water bodies. Pond I, showed the minimum depth of 51 cm in the month of May, 2009 to a maximum of 100 cm in the month of August, 2009. Pond II, it fluctuated from a minimum of 40 cm in the month of June, 2009 to a maximum of 91 cm in the month of September, 2009. Pond III, depth values varied from a minimum of 51 cm in the month of June, 2009 to a maximum of 99 cm in the month of September, 2009. Pond IV, showed the minimum values of 41 cm in the month of June, 2009 to a maximum of 89 cm in the month of August, 2009, whereas in pond V, it varied from a minimum of 77 cm in the month of June, 2009 to a maximum of 149 cm, in the month of September, 2009.
Wide seasonal fluctuations in depth were found to be affected by high rate of evaporation at high ambient temperature and precipitation.

Transparency values ranged from 8.75 to 57.50 cm in the selected ponds. Its values ranged 8.75 cm (August, 2009) to 31 cm (January, 2010) in pond I, 19 cm (May, 2009) to 39 cm (November, 2009) in pond II, 25 cm (June, 2009) to 47 cm (March, 2009) in pond III, 11 cm (May and July, 2009) to 45 cm (March, 2009) in pond IV whereas in pond V, it varied from 19 cm (May and June, 2009 to 57.5 cm (February, 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 and evaporation of water which causes concentration of dissolved solids at increasing temperature and production of plankton. High transparency in post monsoon, winter and post winter might be related to low biological activities and least entry of suspension through soil erosion or surface run-off. Transparency recorded negative correlation with TDS (pond I: r = - 0.668; pond II: r = - 0.576; pond III: r = - 0.507; pond IV: r = - 0.524 and pond V: r = - 0.390) and TSS (pond I: r = - 0.597; pond II: r = - 0.379; pond III: r = - 0.581; pond IV: r = - 0.159 and V: r = - 0.169) in all the five selected water bodies.

Dissolved Oxygen content varied from 3.0 mg/l to 12.0 mg/l. In pond I, it varied from 3.6 mg/l (March, 2009) to 12.0 mg/l (January, 2010), 3.0 mg/l (October and November, 2009) to 8.6 mg/l (January, 2010) in pond II, 3.2 mg/l (April, 2009) to 8.2 mg/l (January, 2010) in pond III, 3.6 mg/l (September, 2009) to 10.0 mg/l (December, 2009), whereas in pond V, it varied from minimum of 3.1 mg/l (October, 2009) to a maximum of 8.0 mg/l (January, 2010). The higher values of dissolved oxygen content in winter could be related to increased oxygen content, oxygen retention capacity of water due to low temperature and reduction in respiratory consumption of oxygen due to reduced metabolic rate. Lower Values during summer might be due to death and composition of organic matter, increasing temperature leading to decrease in oxygen retention capacity of water and increase in the respiratory consumption of oxygen due to increased metabolic rate.
Statistically water temperature recorded negative correlation with dissolved oxygen in all the five selected ponds (pond I: $r = -0.320$; pond II: $r = -0.598$; pond III: $r = -0.622$; pond IV: $r = -0.828$ and pond V: $r = -0.816$).

Carbon dioxide was found to be absent in pond I and IV during the whole course of study. It might be due to release of free carbon dioxide from the water column due to increase in pH and temperature, utilization during photosynthesis and due to conversion of free carbon dioxide into bicarbonates by reacting with carbonates. In pond II, III and V, it fluctuated from 8.0 mg/l (March, 2009) to 45.0 mg/l (July, 2009). In pond II, the values of carbon dioxide fluctuated from a minimum of 8.0 mg/l in the month of March, 2009 to a maximum of 35.0 mg/l in the month of November, 2009. In pond III, it varied from a minimum of 10.0 mg/l in the month of February, 2009 to a maximum of 45.0 mg/l in the month of July, 2009. In pond V, it ranged from a minimum of 18.0 mg/l in the month of March, 2009 to a maximum of 30.0 mg/l in the month of August, 2009, however, it was found absent in the month of September, November and December, 2009 and January, 2010. The presence of carbon dioxide in these ponds could be attributed to lower rates of photosynthesis and higher rates of decomposition of organic matter.

Electrical conductivity varied from 786 $\mu$Scm$^{-1}$ to 1963 $\mu$Scm$^{-1}$ in these selected water bodies. In pond I, it varied from a minimum of 786 $\mu$Scm$^{-1}$ in the month of March, 2009 to a maximum of 1963 $\mu$Scm$^{-1}$ in the month of January, 2010. Pond II, showed the minimum values of 965 $\mu$Scm$^{-1}$ in the month of May, 2009 to a maximum of 1697 $\mu$Scm$^{-1}$ in the month of July, 2009. In pond III, values of conductivity fluctuated from a minimum of 974 $\mu$Scm$^{-1}$ in the month of April, 2009 to a maximum of 1960 $\mu$Scm$^{-1}$ in the month of September, 2009. In pond IV, values of conductivity varied from a minimum of 803 $\mu$Scm$^{-1}$ in the month of March, 2009 to a maximum of 1789 $\mu$Scm$^{-1}$ in the month of July, 2009, whereas it fluctuated from a minimum of 978 $\mu$Scm$^{-1}$ in the month of June, 2009 to a maximum of 1678 $\mu$Scm$^{-1}$ in the month of January, 2010 in pond V. High values of conductivity were recorded during most of the study period which might be related to decomposition of organic matter, faecal matter, sewage, leaching of salts etc. from the catchment area, decrease in phytoplankton population leading to increase in major ion concentration in aquatic
medium. Lower values during summer might be attributed to increase in the uptake of nutrients, locking of nutrients and loss of nutrients into the sediment.

Total solids varied from 1210.0 mg/l to 3050.0 mg/l in the selected water bodies. Pond I showed the minimum value 1400 mg/l in the month of December, 2009 and maximum 2720 mg/l in the month of July, 2009. In pond II, values fluctuated from a minimum of 1230 mg/l in the month of January, 2010 to a maximum of 2590 mg/l in the month of August, 2009. Pond III, showed the minimum value 1210 mg/l in the month of December, 2009 and maximum 3050 mg/l in the month of September, 2009. In pond IV, values ranged from a minimum of 1600 mg/l in the month of March and December, 2009 to a maximum of 2900 mg/l in the month of August, 2009, whereas in pond V, it fluctuated from a minimum of 1400 mg/l in the month of December, 2009 to a maximum of 2970 mg/l in the month of July, 2009.

High values of total solids were recorded during monsoon and summer which could be attributed to inputs through surface run-off, release from autogenic and biogenic sources, discharge from drains, evaporation etc. Statistically total solids recorded a very significant positive correlation with water temperature in all the five selected ponds (pond I: \( r = 0.665 \); pond II: \( r = 0.815 \); pond III: \( r = 0.746 \); pond IV: \( r = 0.681 \) and pond V: \( r = 0.800 \)).

Total dissolved solids in the selected ponds ranged from 700 mg/l to 2135 mg/l. Pond I, showed the minimum values of 900 mg/l in the month of December, 2009 to a maximum of 1870 mg/l in the month of July, 2009. In pond II, TDS values fluctuated from the minimum of 740 mg/l in the month of February, 2009 to a maximum of 1673 mg/l in the month of August, 2009. In pond III, values varied from a minimum of 700 mg/l in the month of November, 2009 to a maximum of 2135 mg/l in the month of September, 2009. Pond IV, showed the minimum values of 920 mg/l in the month of December, 2009 to a maximum of 2010 mg/l in the month of September, 2009 whereas, in pond V, it fluctuated from a minimum of 950 mg/l in the month of December, 2009 to a maximum of 1850 mg/l in the month of July, 2009.

Higher values during monsoon might be due to increase in the load of soluble salts, mud, humus, nutrients in the surface run-off entering these ponds, sewage,
faecal matter, leaching of fertilizers and increased residual load. Lower values of total dissolved salts in winter could be attributed to their utilization by plankton and other aquatic plants and loss of nutrients into the sediment.

Statistically TDS showed positive correlation with total alkalinity (pond I: $r = 0.270$; pond IV: $r = 0.381$; pond V: $r = 0.078$) and negative in II: $r = -0.122$ and pond III: $r = 0.388$ whereas, it showed negative correlation with Diptera at all the five selected water bodies (pond I: $r = -0.384$; pond II: $r = -0.465$; pond III: $r = -0.703$; pond IV: $r = -0.823$ and pond V: $r = -0.559$).

Total suspended solids varied from 290 mg/l to 1200 mg/l in the selected water bodies. Pond I, showed the minimum values of 400 mg/l in the month of January, 2010 and maximum 1000 mg/l in the month of August, 2009. In pond II, it fluctuated from a minimum of 430 mg/l in the month of January, 2010 to a maximum of 1118 mg/l in the month of September, 2009. In pond III, it fluctuated from a minimum value of 395 mg/l in the month of February, 2009 to a maximum of 915 mg/l in the month of September, 2009. In pond IV, values of TSS fluctuated from a minimum of 290 mg/l in the month of January, 2010 to a maximum of 950 mg/l in the month of August, 2009, whereas in pond V, it varied from a minimum of 340 mg/l in the month of November, 2009 to a maximum of 1200 mg/l in the month of August, 2009. Higher values in monsoon might be due to sewage, silt, clay and other particles entering these ponds along with surface run-off, whereas lower values during winter might be due to sedimentation, less human activities and slow decomposition rate during winter.

pH varied from 7.6 to 9.5 in these water bodies. In pond I, it varied from a minimum of 8.5 in the month of October, 2009 to a maximum of 9.4 in the month of June and July, 2009. In pond II, it fluctuated from a minimum of 7.6 in the month of October, 2009 to a maximum of 8.3 in the month of June and August, 2009. In pond III, it ranged from a minimum of 7.8 in the month of May, 2009 to a maximum of 8.5 in the month of April, 2009. In pond IV, it varied from a minimum of 8.5 in the month of January, 2010 to a maximum of 9.5 in the month of July, 2009, whereas in pond V, it ranged from a minimum of 8.0 mg/l in the month of April and June, 2009 to a maximum of 8.9 in December, 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. The wide range of pH is the result of disturbance caused by washer men activities, wind action and cattles in these ponds during the study period.

Statistically pH showed positive correlation with total alkalinity in pond I (r = 0.724), pond II (r = 0.023), pond III (r = 0.110), pond IV (r = 0.784) and negative correlation in pond V (r = - 0.645).

Total alkalinity values ranged between 145 mg/l to 590 mg/l in the selected water bodies. In pond I, values of total alkalinity fluctuated from a minimum of 170 mg/l in the month of December, 2009 to a maximum of 470 mg/l in the month of May, 2009. Pond II, showed the minimum value 172 mg/l in the month of August, 2009 and maximum 350 mg/l in the month of March, 2009. In pond III, the values varied from a minimum of 250 mg/l in the month of September, 2009 to a maximum of 407 mg/l in the month of November, 2009. Pond IV, showed the minimum value 180 mg/l in the month of March, 2009 and maximum 590 mg/l in the month of May, 2009, whereas in pond V, the values varied from a minimum of 145 mg/l in the month of October, 2009 to a maximum of 500 mg/l in the month of April, 2009. The fluctuations in total alkalinity were mainly due to the seasonal effects, planktonic population, bottom deposits and water currents and entry of sewage from the catchment area.

Statistically alkalinity showed positive correlation with Hardness in all the selected ponds (pond I: r = 0.771; pond II: r = 0.248; pond III: r = 0.365; pond IV: r = 0.447) except in pond V (r = - 0.240).

The values of carbonate alkalinity ranged between 10.0 mg/l and 500.0 mg/l in the selected water bodies. Pond I, showed minimum value 10.0 mg/l in the month of March, 2009 and 400.0 mg/l in the month of July, 2009. In ponds II and III, it was recorded absent throughout the study period. In pond IV, it varied from a minimum of 100 mg/l in the month of October, 2009 to a maximum of 500 mg/l in the month of June, 2009, whereas in pond V, carbonate alkalinity was found present in the months of September, November, December, 2009 and January, 2010 only. Its values
fluctuated from a minimum of 100 mg/l in the month of December, 2009 to a maximum of 160 mg/l in the month of January, 2010. Carbonates were completely absent in ponds II and III and for the most of the study period at site V, which could be related to the presence of free carbon dioxide during these periods.

Bicarbonate alkalinity ranged from a minimum of 10 mg/l to a maximum of 500 mg/l in these selected water bodies. In pond I, the values of bicarbonate alkalinity fluctuated from a minimum (10 mg/l) in the month of August and December, 2009 to maximum (240 mg/l) in the month of March, 2009. Pond II, showed the minimum value (172 mg/l) in the month of August, 2009 and maximum (350 mg/l) in the month of March, 2009. In pond III, it varied from minimum (250 mg/l) in the month of September, 2009 to maximum (407 mg/l) in the month of November, 2009. Pond IV, showed minimum value (50 mg/l) in the month of September, 2009 and maximum (110 mg/l) in the month of May and August, 2009, whereas in pond V, it varied from minimum (20 mg/l) in the month of September to maximum (500 mg/l) in the month of April, 2009. Bicarbonate alkalinity was recorded present in all the ponds except in pond IV, where it was found absent during the month of February and March, 2009. The increased or decreased bicarbonate content might be due to rains and surface run-off, photosynthetic and respiratory activity of algae and macrophytes.

The values of hardness fluctuated from 100 mg/l to 262 mg/l the selected water bodies. Pond I, showed minimum value of hardness (110 mg/l) during February, 2009 and maximum (230 mg/l) in the month of June, 2009. Pond II, showed minimum hardness (110 mg/l) in the month of April, 2009 and maximum (262 mg/l) in the month of March 2009. Pond III, showed minimum value of hardness (100 mg/l) during February, 2009 and maximum (240 mg/l) in the month of November, 2009. Pond IV, showed minimum value of hardness (124 mg/l) during January, 2010 and maximum (260 mg/l) in the month of April, 2009, whereas in pond V, the minimum hardness value (112 mg/l) was recorded in the month of April, 2009 and January, 2010 and maximum (170 mg/l) was recorded during July, 2009. Higher values of hardness during summer in all the ponds might be attributed to evaporation of water at high temperature, anthropogenic activities in and around these ponds, addition of sewage and detergents by washer men.
Among ions, two main ions calcium and magnesium were found dominant in these selected water bodies.

The value of calcium ranged from minimum 36.00 mg/l (December, 2009) to maximum 89.77 mg/l (February, 2009) in selected ponds. In pond I, it fluctuated from a minimum of 36.00 mg/l in the month of December, 2009 to a maximum of 80.16 mg/l in the month of August, 2009. In pond II, it varied from a minimum of 36.07 mg/l in the month of May, 2009 to a maximum of 80.16 mg/l in the month of March, 2009. In pond III, it fluctuated from a minimum of 36.00 mg/l in the month of December, 2009 to a maximum of 80.16 mg/l in the month of March, 2009. In pond IV, values of calcium ranged from a minimum of 36.87 mg/l in the month of December, 2009 to a maximum of 64.12 mg/l in the month of May, 2009, whereas it varied from a minimum of 36.87 mg/l in the month of December, 2009 to a maximum of 89.77 mg/l in the month of February, 2009 in pond V. High values of calcium were recorded throughout the study period which might be attributed to heavy input of sewage from surrounding areas, weathering of calcareous materials and domestic effluents.

Values of magnesium ranged from 13.18 mg/l to 44.83 mg/l in these water bodies. In pond I, it fluctuated from minimum (13.18 mg/l) in the month of March, 2009 to maximum (42.19 mg/l) in the month of June, 2009. In pond II, it varied from minimum (17.34 mg/l) in the month of December, 2009 to maximum (44.83 mg/l) in the month of June, 2009. In pond III, it ranged from minimum (15.82 mg/l) in the month of January, 2010 to a maximum (34.28 mg/l) in the month of June, 2009. In pond IV, it fluctuated from minimum (21.09 mg/l) in the month of February, 2009 to maximum (43.51 mg/l) in the month of May, 2009, whereas in pond V, it varied from minimum (18.46 mg/l) in the month of January, 2010 to maximum (36.92 mg/l) in the month of April, 2009. Lower values during winter months might be attributed to higher sedimentation rate leading to settlement in the bottom and utilization of Plankton, whereas higher values during summer can be related to higher evaporation rate, decomposition of organic matter and bathing and washing.

Chloride values varied from 93.7 mg/l to 624.0 in these selected water bodies. In pond I, it fluctuated from minimum (184.0 mg/l) in the month of December, 2009
to maximum (610.0 mg/l) in the month of June, 2009. Pond II, showed variation from minimum (113.6 mg/l) in the month of January, 2010 to maximum (244.0 mg/l) in the month of May, 2009. In pond III, values fluctuated from minimum (135.0 mg/l) in the month of February, 2009 to maximum (227.0 mg/l) in the month June, 2009. In pond IV, it varied from minimum (127.0 mg/l) in the month of January, 2010 to maximum (624.0 mg/l) in the month of June, 2009, whereas in pond V, it ranged from minimum (93.7 mg/l) in the month of December, 2009 to maximum (244.0 mg/l) in the month of 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, Pond I and IV have comparatively high chloride content than that of ponds II, III and V, which might be due to increased sewage contaminations, public use for washing purposes, more contamination by wastes of animal origin and greater deposition of organic matter in these ponds.

Statistically chloride showed positive significant correlation with Coleoptera (pond I: r = 0.762; pond II: r = 0.643; pond III: r = 0.595; pond IV: r = 0.858 and pond V: r = 0.673) and Trichoptera (pond I: r = 0.816; pond II: r = 0.714; pond III: r = 0.579; pond IV: r = 0.820 and pond V: r = 0.763) in all the five selected ponds.

Values of NO\textsubscript{3}-N ranged from 0.050 mg/l to 0.278 mg/l during the course of study in these water bodies. In pond I, it fluctuated from minimum (0.056 mg/l) in the month of January, 2010 to maximum (0.240 mg/l) in the month of July and September, 2009. Pond II, showed the minimum values (0.050 mg/l) in the month of December, 2009 to maximum (0.237 mg/l) in the month of July, 2009. In pond III, values fluctuated from minimum (0.051 mg/l) in the month of January, 2010 to maximum (0.278 mg/l) in the month of September, 2009. In pond IV, it varied from minimum (0.056 mg/l) in the month of February, 2009 to maximum (0.195 mg/l) in the month of August, 2009, whereas in pond V, it ranged from minimum (0.081 mg/l) in the month of March, 2009 and January, 2010 to maximum (0.267 mg/l) in the month of July, 2009.

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 NO₃-N during winter could be attributed to reduced rate of decomposition and its utilization by macrophytes.

Statistically NO₃- N recorded a very significant positive correlation with water temperature in all the five selected ponds (pond I: \( r = 0.816 \); pond II: \( r = 0.742 \); pond III: \( r = 0.686 \); pond IV: \( r = 0.746 \) and pond V: \( r = 0.736 \)), significant negative correlation with Diptera in three ponds (pond I: \( r = -0.694 \); pond II: \( r = -0.637 \); pond III: \( r = -0.734 \)) and negative non-significant correlation in pond IV (\( r = -0.746 \)) and pond V (\( r = -0.736 \)), significant positive correlation with Hemiptera in all the five water bodies (pond I: \( r = 0.915 \); pond II: \( r = 0.785 \); pond III: \( r = 0.861 \); pond IV: \( r = 0.692 \) and pond V: \( r = -0.890 \)), positive non-significant correlation with Coleoptera (pond I: \( r = 0.210 \); pond II: \( r = 0.450 \); pond III: \( r = 0.062 \); pond IV: \( r = 0.524 \) and pond V: \( r = 0.263 \)) and Trichoptera (pond I: \( r = 0.252 \); pond II: \( r = 0.485 \); pond III: \( r = 0.024 \); pond IV: \( r = 0.503 \) and pond V: \( r = 0.309 \)) and positive correlation with Odonata (pond I: \( r = 0.625 \); pond II: \( r = 0.601 \); pond III: \( r = 0.367 \); pond IV: \( r = 0.370 \) and pond V: \( r = 0.658 \)) and Ephemeroptera (pond I: \( r = 0.618 \); pond II: \( r = 0.382 \); pond III: \( r = 0.579 \); pond IV: \( r = 0.741 \) and pond V: \( r = 0.576 \)).

PO₄-P ranged from 0.191 mg/l to 1.425 mg/l in these selected water bodies. In pond I, it ranged from minimum (0.240 mg/l) in the month of January, 2010 to maximum (1.190 mg/l) in June, 2009. Pond II, showed minimum value (0.191 mg/l) in the month of January, 2010 and maximum (1.090 mg/l) in the month of June, 2009. In pond, III, it fluctuated from minimum (0.240 mg/l) in the month of December, 2009 to maximum (0.950 mg/l) in the month of May, 2009. Pond IV, showed minimum value (0.359 mg/l) in the month of December, 2009 to maximum (1.425 mg/l) in the month of April, 2009, whereas in pond V, it fluctuated from minimum (0.226 mg/l) in the month of January, 2010 to maximum (0.965 mg/l) in the month of June, 2009.

Higher values of PO₄-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 PO₄- P recorded a very significant positive correlation with water temperature in all the five selected ponds (pond I: \( r = 0.725 \); pond II: \( r = 0.892 \); pond
III: $r = 0.740$; pond IV: $r = 0.645$ and pond V: $r = 0.743$), whereas, it showed significant positive correlation with Coleoptera, (pond I: $r = 0.713$; pond II: $r = 0.831$; pond III: $r = 0.717$; pond IV: $r = 0.740$ and pond V: $r = 0.802$), Trichoptera (pond I: $r = 0.742$; pond II: $r = 0.730$; pond III: $r = 0.738$; pond IV: $r = 0.807$ and pond V: $r = 0.725$), Odonata (pond I: $r = 0.931$; pond II: $r = 0.917$; pond III: $r = 0.828$; pond IV: $r = 0.621$ and pond V: $r = 0.777$) and Ephemeroptera (pond I: $r = 0.820$; pond II: $r = 0.699$; pond III: $r = 0.696$; pond IV: $r = 0.826$ and pond V: $r = 0.737$) in all the five selected water bodies.

Diptera formed the most abundant group amongst the different groups of aquatic insects in all the five selected water bodies. This group was represented by species of Anopheles larva, Anopheles pupa, Chaoborus larva, Chironomus larva, Chironomus pupa, Chrysops larva, Culex larva, Culex pupa, Dictya pictipes (pupa), Dixa larva, Eristalis larva, Helius larva, Odontomyia cincta, Pedcia larva, Phalacrocorida larva, Pentaneura larva, Pilaria larva, Tabanus larva.

Chironomus sp. was found to be the most abundant species in terms of the total population density amongst Dipterans.

Chironomus sp. were very common and found to be the most abundant species in terms of total population density during the whole period of study, occurring in higher numbers in all the five derelict water bodies throughout the period of study. Its population density varied from a minimum of 274 No./m$^2$ in June, 2009 to a maximum of 635 No./m$^2$ in January, 2010 in pond I, 245 No./m$^2$ in August, 2009 to 467 No./m$^2$ in January, 2010 in pond II, 195 No./m$^2$ in October, 2009 to 545 No./m$^2$ in December, 2009 in pond III, 249 No./m$^2$ in June, 2009 to 510 No./m$^2$ in December, 2009 in pond IV and 306 No./m$^2$ in June, 2009 to 701 No./m$^2$ in January, 2010 in pond V.

The population density of Diptera ranged from minimum (349 No./m$^2$) in June, 2009 to maximum (850 No./m$^2$) in January, 2010 in pond I, (294 No./m$^2$) in June, 2009 to (598 No./m$^2$) in January, 2010 in pond II, (290 No./m$^2$) in October, 2009 to (725 No./m$^2$) in December, 2009 in pond III, (299 No./m$^2$) in June, 2009 to (681 No./m$^2$) in December, 2009 in pond IV and (399 No./m$^2$) in June, 2009 to (881 No./m$^2$) in January, 2010 in pond V.

136
Statistically Diptera recorded a very significant negative correlation with water temperature in all the five selected ponds (pond I: $r = -0.764$; pond II: $r = -0.745$; pond III: $r = -0.761$; pond IV: $r = -0.757$ and pond V: $r = -0.765$) and significant negative correlation with PO$_4$-P except in pond IV (pond I: $r = -0.667$; pond II: $r = -0.756$; pond III: $r = -0.691$; pond IV: $r = -0.520$ and pond V: $r = -0.913$).

Hemiptera formed the second most abundant group of aquatic insects in these derelict water bodies. This group was represented by the genera *Belostoma* sp., *Buenoa* sp., *Coroxid* sp., *Gerris* sp., *Hebrus* sp., *Hesperocorxa* sp., *Mesovelia* sp., *Nepa* sp., *Neoplea striola*, *Notonecta insulate*, *Pelocoris* sp., *Ranatra* sp., and *Sigara* sp.

The population density of Hemiptera ranged from minimum (26 No./m$^2$) during January, 2010 to maximum (190 No./m$^2$) in July, 2009 in pond I, (7 No./m$^2$) during January, 2010 to (81 No./m$^2$) in August, 2009 in pond II, (29 No./m$^2$) during December, 2009 to (162 No./m$^2$) in August, 2009 in pond III, (15 No./m$^2$) during January, 2010 to (156 No./m$^2$) in August, 2009 in pond IV and (25 No./m$^2$) during February, 2009 to (178 No./m$^2$) in July, 2009 in pond V.

Statistically Hemiptera recorded a very significant positive correlation with water temperature (pond I: $r = 0.752$; pond II: $r = 0.744$; pond III: $r = 0.859$; pond IV: $r = 0.830$ and pond V: $r = 0.814$) and TDS (pond I: $r = 0.879$; pond II: $r = 0.876$; pond III: $r = 0.854$; pond IV: $r = 0.758$ and pond V: $r = 0.844$) in all the five selected pond, whereas with PO$_4$-P, it recorded positive but non-significant correlation (pond I: $r = 0.335$; pond II: $r = 0.502$; pond III: $r = 0.510$; pond IV: $r = 0.399$ and pond V: $r = 0.456$).


The population density of Coleoptera ranged from minimum (11 No./m$^2$) during December, 2009 to maximum (85 No./m$^2$) in May, 2009 in pond I, (7 No./m$^2$) during January, 2010 to (45 No./m$^2$) in April, 2009 in pond II, (12 No./m$^2$)
during December, 2009 to (94 No./m²) in June, 2009 in pond III, (8 No./m²) during October, 2009 to (93 No./m²) in May, 2009 in pond IV and (13 No./m²) during December, 2009 to (107 No./m²) in April and June, 2009 in pond V.

Statistically coleoptra recorded a very significant positive correlation with water temperature in all the five selected ponds (pond I: r = 0.661; pond II: r = 0.609; pond III: r = 0.713; pond IV: r = 0.762 and pond V: r = 0.621), whereas it showed positive insignificant correlation with TDS in all the selected ponds (pond I: r = 0.201; pond II: r = 0.407; pond III: r = 0.386; pond IV: r = 0.461 and pond V: r = 0.338).

Trichoptera formed the forth most abundant group of aquatic insects. This group was represented by Leptocella larva, Leucotrochia larva, Limnephilus larva, Phryganea larva, Polycentropus larva, Ptilostomis larval case, Trianodes larva.

The population density of Trichoptera ranged from minimum (4 No./m²) during September and November, 2009 to maximum (57 No./m²) in May, 2009 in pond I, (3 No./m²) during October, 2009 and January, 2010 to (27 No./m²) in May, 2009 in pond II, (5 No./m²) during November, 2009 to (52 No./m²) in June, 2009 in pond III, (4 No./m²) during October, 2009 to (48 No./m²) in April, 2009 in pond IV and (9 No./m²) during October, 2009 to (62 No./m²) in May, 2009 in pond V.

Statistically Trichoptera recorded a very significant positive correlation with water temperature in all the five selected ponds (pond I: r = 0.638; pond II: r = 0.679; pond III: r = 0.682; pond IV: r = 0.593 and pond V: r = 0.670), whereas it showed positive but non-significant correlation with TDS in all the five ponds (pond I: r = 0.166; pond II: r = -0.560; pond III: r = 0.322; pond IV: r = 0.313 and pond V: r = 0.379).

Odonata constituted the fifth most abundant group of aquatic insects. This group was represented by Aeschna nymph, Argia nymph, Coenagrion nymph, Cordulia nymph and Ischurna nymph.

The population density of Odonata ranged from minimum (3 No./m²) during November, 2009 to maximum (63 No./m²) in June, 2009 in pond I, Nil during January, 2010 to (15 No./m²) in April and June 2009 in pond II, (3 No./m²) during December, 2009 to (49 No./m²) in April, 2009 in pond III, (3 No./m²) during
November, 2009 to (54 No./ m$^2$) in May, 2009 in pond IV and (4 No./ m$^2$) during November and December, 2009 to (55 No./ m$^2$) in June, 2009 in pond V.

Statistically Odonata recorded a very significant positive correlation with water temperature in all the five selected ponds (pond I: $r = 0.846$; pond II: $r = 0.748$; pond III: $r = 0.813$; pond IV: $r = 0.699$ and pond V: $r = 0.870$), whereas it showed positive correlation with TDS in all the five selected ponds (pond I: $r = 0.365$; pond II: $r = 0.640$; pond III: $r = 0.557$; pond IV: $r = 0.423$ and pond V: $r = 0.639$).

Ephemeroptera constituted the sixth most abundant group of aquatic insects. This group was represented by *Baetis hiemalis* nymph, *Caenis* nymph, *Ephemera* nymph and *Heptagenia* nymph.

The population density of Ephemeroptera ranged from minimum (3 No./ m$^2$) during December, 2009 to maximum (31 No./ m$^2$) in June, 2009 in pond I, (Nil) during February, 2009 to (13 No./ m$^2$) in August, 2009 in pond II, (3No./ m$^2$) during February, 2009 and January, 2010 to (37 No./ m$^2$) in June, 2009 in pond III, (4 No./ m$^2$) during January, 2010 to (43 No./ m$^2$) in May, 2009 in pond IV and (3 No./ m$^2$) during January, 2010 to (43 No./ m$^2$) in May, 2009 in pond V.

Statistically Ephemeroptera recorded a very significant positive correlation with water temperature in all the five selected ponds (pond I: $r = 0.869$; pond II: $r = 0.701$; pond III: $r = 0.925$; pond IV: $r = 0.892$ and pond V: $r = 0.892$), whereas it showed positive correlation with TDS in all the five selected ponds (pond I: $r = 0.429$; pond II: $r = 0.734$; pond III: $r = 0.559$; pond IV: $r = 0.608$ and pond V: $r = 0.705$).

The values of Shannon-Wiener’s index for insects varied from minimum of 1.534 in January, 2010 to maximum (2.898) in the month of June, 2009 in pond I, 1.210 in February, 2009 to 2.159 in the month of August, 2009 in pond II, 1.521 in February, 2009 to 2.939 in the month of June, 2009 in pond III, 1.494 in January, 2010 to 2.842 in the month of May, 2009 in pond IV and 1.360 in December, 2009 to 2.983 in the month of June, 2009 in pond V. Lowest diversity index for insects i.e. Shannon-Wiener’s index was found in pond II, which indicates that pond II is more polluted than pond I, II, III, IV and V. Since, the Shannon – Weiner diversity index in present study ranged between 1.210 – 2.983 in all selected water bodies, they can be categorized as moderately polluted to highly polluted.
Correlation between species diversity of insects (Shannon- Wiener’s index) and some Physico - chemical parameters was calculated. In case of insects, species diversity showed significant positive correlation with water temperature in all the five selected ponds (Pond I: r = 0.936; pond II: r = 0.852; pond III: r = 0.902; pond IV: r = 0.948 and pond V: r= 0.849) whereas it showed positive correlation with pH in pond I (r = 0.667), pond II (r = 0.336), pond III (r = 0.131) and pond IV (r = 0.648) and negative correlation in pond V (r = - 0.556) whereas, it showed significant positive correlation with NO₃-N (Pond I: r = 0.797; pond II: r = 0.699; pond III: r = 0.712; pond IV: r = 0.693 and pond V: r= 0.655) and PO₄–P (Pond I: r = 0.797; pond II: r = 0.699; pond III: r = 0.712; pond IV: r = 0.693 and pond V: r= 0.655) in all the five selected ponds.

The Menhinick’s index of diversity for aquatic insects varied from minimum of 0.336 in February, 2009 to maximum of 0.684 in January, 2010 in pond I, 0.309 in February, 2009 to 0.505 in January, 2010 in pond II, 0.297 in October, 2009 to 0.529 in December, 2009 in pond III, 0.317 in February, 2009 to 0.590 in December, 2009 in pond IV and from 0.379 in November, 2009 to 0.576 in January, 2010 in pond V.

Menhinick index showed insignificant negative correlation with water temperature in (Pond I: r = - 0.216; pond II: r = - 0.466; pond III: r = - 0.090; and pond V: r = - 0.153) and positive but insignificant in pond IV: r = 0.033. With pH, it showed insignificant positive correlation in all the ponds except pond IV where it was recorded to be negative and insignificant (Pond I: r = 0.187; pond II: r = 0.250; pond III: r = 0.007; and pond IV: r = - 0.180 and pond V: r = 0.464, whereas it showed insignificant correlation with NO₃-N (Pond I: r = - 0.271; pond II: r = - 0.389; pond III: r = - 0.448; pond IV r = 0.274 and pond V: r = 0.076) and PO₄–P (Pond I: r = - 0.246; pond II: r = - 0.501; pond III: r = - 0.169; pond IV r = 0.120 and pond V: r = - 0.548) in all the water bodies understudy.

The Sorenson’s index value (% species similarity) for aquatic insects varied from minimum of 53.57 (December,2009 - January,2010) to maximum of 90.53 (June - July, 2009) in pond I, 48.65 (February, 2009 - January, 2010) to 83.64 (June - July,2009) in pond II, 52.17 (February-March, 2009) to 87.76 (May-June and June - July, 2009) in pond III, 42.31 (February, 2009 - January, 2010) to 86.96 (May-June,
2009) in pond IV and from 53.33 (February, 2009 - January, 2010) to 91.26 (June - July, 2009) in pond V.


Species dominance (Berger-Parker’s index) showed significant positive correlation with water temperature in all the five selected ponds (Pond I: r = 0.925; pond II: r = 0.825; pond III: r = 0.875; pond IV: r = 0.930 and pond V: r= 0.812). With pH, it showed positive correlation in all ponds except pond V, where it showed negative correlation (Pond I: r = 0.659; pond II: r = 0.395; pond III: r = 0.037; pond IV: r = 0.622; pond V: r = - 0.547), whereas, it showed significant positive correlation with NO3- N (Pond I: r = 0.831; pond II: r = 0.712; pond III: r = 0.820; pond IV: r = 0.667 and pond V: r = 0.660) and PO4 – P (Pond I: r = 0.778; pond II: r = 0.712; pond III: r = 0.635; pond IV: r = 0.733 and pond V: r = 0.812) in all the five selected ponds.

The species evenness values varied from minimum 0.238 in January, 2010 to maximum 0.516 in June, 2009 in pond I, 0.199 in January, 2010 to 0.392 in August, 2009 in pond II, 0.248 in December, 2009 to 0.529 in September, 2009 in pond III, 0.241 in January, 2010 to 0.502 in June, 2009 in pond IV and from 0.208 in December, 2009 to 0.454 in May, 2009 in pond V. Moreover, evenness and diversity go hand in hand in all the five selected water bodies. High diversity was always associated with high evenness.

In case of insects, species evenness showed significant positive correlation with water temperature in all the five selected ponds (Pond I: r = 0.939; pond II: r = 0.870; pond III: r = 0.887; pond IV: r = 0.951 and pond V: r = 0.837), with pH, it showed positive correlation in all the selected water bodies except pond V, where it showed negative correlation (Pond I: r = 0.645; pond II: r = 0.348; pond III: r = 0.105; pond IV: r = 0.669; pond V: r = - 0.574), whereas, it showed significant positive correlation with NO3- N (Pond I: r = 0.810; pond II: r = 0.718; pond III: r = 0.770;
pond IV: \( r = 0.671 \) and pond V: \( r = 0.646 \) and \( \text{PO}_4^-\text{P} \) (Pond I: \( r = 0.831 \); pond II: \( r = 0.813 \); pond III: \( r = 0.674 \); pond IV: \( r = 0.756 \) and pond V: \( r = 0.840 \)) in all the selected ponds.

The values of species evenness values indicate that distribution of aquatic insect genera was uneven in all the selected water bodies.

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. The preponderance of saprophilic insects e.g. ‘bloodwarm’ 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).

Chironomid larvae are an important food source for fish and waterfowl. The adults provide food for amphibians, bats and martins and swallows. Chironomids can be important freshwater indicator. Large numbers of pollution tolerant chronomids are often indicative of poor water quality, characterized by low dissolved oxygen and high nutrient concentrations. Chironomids species diversity and their sensitivity to eutrophic conditions have been used in trophic classification of lakes into oligotrophic, mesotrophic and eutrophic. The high abundance of Chironomus sp. in all the selected ponds in present study indicates that these water bodies are highly eutrophic.

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. Certain families of bugs may be utilized in the biological control of mosquito larvae. The species of predatory aquatic bugs (Nepoidea, including
Belostomatidae and Nepidae) have been designated as threatened-vulnerable species in Red Book of Japan and are regarded as effective predators of freshwater snails and mosquito larvae. As these insects are more voracious predators and can fly to different water bodies, thus they are more important mosquito regulator than even the widely used mosquito-fish which cannot move out of one body of water.

Ephemeropterans (mayflies) are one of the most important herbivorous invertebrate aquatic insects. Ephemeroptera larvae are recognized worldwide for their sensitivity to oxygen depletion, and are therefore, commonly used as bioindicators in many monitoring programmes. 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. A high sensitivity of mayfly taxa to oxygen depletion, acidification, and various contaminants including metals, ammonia and other chemicals was demonstrated in both observational and experimental studies. The importance of Ephemeroptera as a part of functioning aquatic ecosystem is recognized worldwide as shown by many food studies. Mayfly nymphs consume epiphytic algae and fine particulate organic matter.

Anglers often use mayflies as bait, or tie “flies” that are made to resemble imagos and subimagos. The larvae, as primary consumers, filter and remove large amounts of nutrients from the water and are important as food for other aquatic organisms. In present study, Ephemeropterans were sparsely represented in all the selected water bodies. The main reasons for their population decline and low diversity in present study can be related to habitat degradation by pollution.

Plecoptera (Stone flies) represent a very important component of ponds both as biomass and as diversity of ecological roles, acting as primary or secondary consumers and as prey for the other macro-vertebrates and fishes, including those of economic importance. From a scientific point of view, they have been used as biogeographical indicators and in evolutionary research. They are used as biological indicators of water quality, especially dissolved oxygen levels, thus deteriorating populations of stoneflies mean that poor water quality threatens the health of aquatic ecosystem.
The absence of plecoptera during present study clearly indicates the water quality degradation and physical alteration of these derelict water bodies under study. Moreover, it is also clear from the study that Plecoptera is a sensitive order of aquatic insects and is restricted to habitats where there is a little human development, clear water, and high dissolved oxygen content.

Amongst aquatic insects Coleopterans are used as food in many countries of the world. The list of the edible insects of the world shows that the number of edible aquatic beetles is not very high (6.58%). However, it has been observed that in some Asian countries, such as Japan, China, Thailand, Indonesia (Java and Bali) and Vietnam, the consumption of aquatic insects is more common.

The genera of aquatic beetles commonly consumed in different countries of the world are *Cybister*, *Dystiscus*, *Hydrophilus*, and *Peltodytes* etc. The presence of all above mentioned genera in present study clearly shows their importance from nutritional point of view. Beetles are highly prized in the kitchen in many countries. They are prepared roasted or smoked and are used in tamales, quesadillas, sopes, etc. Either they are boiled in salt water and then combined with pepper and lemon, or they are dried in the sun. Some people eat them alive.

From an ecological perspective, Trichoptera are important processors of organic matter. As processors of organic matter, collectively known as functional feeding groups (FFG) of animals, they display the full array of feeding modes. 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”. Although a few species have been recorded as pests in rice paddies, most caddisflies have very little economic importance. 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. Although caddisflies recorded during the present course of study are not generally considered to be of great economic importance as pests, they are beneficially important in the trophic dynamics and energy flow in aquatic ecosystems. The larvae are also useful as biological indicator organisms for assessing water quality.
The order Odonata represents one set of insects that is being widely studied for its potential in indicating environmental quality. Studies have included Odonata relationship with water quality, biotope quality, general species richness and use of Odonata as indicators for wetland conservation. As a group of species that are especially sensitive to the changes in their habitat, Odonata population can also be indicative of the richness of other invertebrates and macrophytes. The odonate larva use as energetic source in their diet the *Anopheles* larva, by maintaining the control over their population numbers, which itself are responsible for spreading of the epidemic illness like malaria.

A feature of the odonate species is that they prefer to live in freshwater, non-contaminated and well oxygenated habitats. Hence, they can serve as valuable bio-indicators for environmental contamination. Though odonates were recorded in present study, but they showed least density and were very sparse in distribution, there by indicating their preference for freshwater i.e. non-contaminated and well oxygenated habitats.
CHAPTER – VII
CONCLUSIONS
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- In all the five selected ponds, water temperature was always found to be less than air temperature and follows the trend of air temperature. A positive significant correlation between air and water temperature was observed.
- Wide seasonal fluctuations were recorded in the depth in all the five selected ponds which might be related to evaporation at high temperature and precipitation.
- Water colour of all the five ponds varied (green, brownish yellow and brownish) in different seasons which might be related to phytoplankton bloom, decomposition of organic matter, turbidity and polluted nature of these water bodies.
- Lower values during summer and monsoon might be due to entry of huge amount of suspended and colloidal matter, silt and clay and evaporation of water.
- Higher values of dissolved oxygen content in winter could be related to increased oxygen retention capacity of water and reduction in respiratory consumption of oxygen due to reduced metabolic rate. Lower values during summer might be due to death and decomposition of organic matter, increasing water temperature leading to decrease in oxygen retention capacity of water and increase in the respiratory consumption of oxygen due to increased metabolic rate.
- Carbon dioxide was recorded absent in pond I and IV throughout the study period. The absence of free CO₂ in present study might be attributed to increase values of pH (8.5 or above) and temperature, utilization during photosynthesis and due to conversion of free carbon dioxide into bicarbonates by reacting with carbonates while presence of Carbon dioxide in pond II, III, and V might be related to lower rates of photosynthesis and higher rates of decomposition of organic matter.
- Fluctuations in total alkalinity in the selected ponds were mainly due to the seasonal effects, planktonic populations, bottom deposits and water currents and entry of sewage from the catchment area. Carbonates were completely absent in pond II and III and for the most of the study period at site V, which could be related to the presence of free CO₂ during this period. Bicarbonate alkalinity was
recorded present in all the ponds except pond IV, were it was found absent during the month of February and March, 2009.

- High values of pH (mostly above 8.0) were recorded in all the selected ponds throughout the course of study, which might be related to enhanced photosynthesis carried out by phytoplankton and macrophytes, wherein CO$_2$ is removed, and hence pH is raised.

- Higher values of hardness were recorded throughout the study period in all the five selected ponds, which might be due anthropogenic activities in and around these water bodies, addition of sewage and detergents by washer men.

- High values of calcium were recorded in all the five selected ponds, which might be attributed to heavy input of sewage from surrounding area, weathering of calcareous materials and domestic effluents.

- Lower values of magnesium were recorded during winter in all the five selected ponds, which might be attributed to higher sedimentation rate leading to settlement in the bottom and utilization by plankton. Higher values during summer months were related to higher evaporation rate, decomposition of organic matter and bathing and washing.

- Higher values of chloride during summer in all the five selected ponds might be due to the 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 chloride along with rain from catchment area. Moreover, higher content of chloride was recorded in pond I and IV than pond II, III and V.

- Higher values of NO$_3$-N were recorded during monsoon in the selected ponds which could be related to influx of decaying organic matter, nitrates from the catchment area and sewage contamination, whereas lower values in winter could be attributed to reduced rate of decomposition and its utilization by macrophytes.

- Higher values of PO$_4$-P during summer were related to increased decomposition at higher temperature, release of nutrients and evaporation of water at high temperature, whereas lower values could be attributed to its utilization by macrophytes and algae for their growth, low calcium level and low temperature.
Insect fauna of these water bodies comprised of order Diptera, Hemiptera, Coleoptera Trichoptera, Odonata and Ephemeroptera.


*Chironomus larva* was very common and found to be the most abundant species amongst all recorded genera, occurring in higher numbers in all the selected ponds. Its population density varied from a minimum of 274/ m$^2$ in June, 2009 to a maximum of 635/ m$^2$ in January, 2010 in pond I, 245/m$^2$ in August, 2009 to 467/m$^2$ in January, 2010 in pond II, 195/ m$^2$ in October, 2009 to 545/ m$^2$ in December, 2009 in pond III, 249/ m$^2$ in June, 2009 to 510/ m$^2$ in December, 2009 in pond IV and 306/ m$^2$ in June, 2009 to a maximum of 701/ m$^2$ in January, 2010 in pond V.

*Chironomus* exhibits high tolerance to eutrophic conditions, showing significant increase in abundance in response to anthropogenic organic enrichment and consequent water quality deterioration, being considered a reliable environmental indicator. The presence of *Chironomus* sp. in high number indicates the eutrophic nature of these water bodies.

Hemiptera formed the second most abundant group of insect fauna in the selected ponds. This group was represented by the genera *Belostoma* sp., *Bueno* sp., *Coroxid* sp., *Gerris* sp., *Hebrus* sp., *Hesperocorx* sp., *Mesovelia* sp., *Nepa* sp., *Neoplea striola*, *Notonecta insulate*, *Pelocoris* sp., *Ranatra* sp., and *Sigara* sp.

The high or low abundance of Hemiptera in present study can be related to presence of macro- vegetation /macrophytes in these selected ponds

The dominance of Coleopteran during summer in present study in all the five ponds can be related to the availability of food and vegetation, which enhanced the growth of insects during this period. The findings are in conformity with the findings of Kaur et al. (1995) and Bath and Kour (1998).

Trichoptera formed the forth most abundant group of insect fauna. This group was represented by Leptocella larva, Leucotreochia larva, Limnephilus larva, Phryganea larva, Polycentropus larva, Ptilostomis larval case, Trianodes larva.

Trichopterans showed low numerical abundance; across selected ponds. This clearly indicates 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.

Odonata constituted the fifth most abundant group of insect fauna. This group was represented by Aeschna nymph, Argia nymph, Coenagrion nymph, Cordulia nymph and Ischurna nymph.

The present investigation clearly indicates that Odonatans can live in polluted as well as clean water, but the algal abundance and luxuriant growth of macrophytes are prerequisite.

Ephemeroptera constituted the sixth most abundant group of insect fauna. This group was represented by Baetis hiemalis nymph, Caenis nymph, Ephemerella nymph and Heptagenia nymph.

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

In general population abundance of aquatic insects was quite high in Pond I, III, IV and V which could be related to organically rich waters and thick vegetation in these water bodies, whereas in pond II, insects showed lowest abundance which could be attributed to lack of vegetation in this pond in addition to other factors.

Among the invertebrate taxa, aquatic insects form an important component of food chains and energy flow pathways. Aquatic insects constitute an important part of animal production within wetlands, ponds and are tightly integrated into the structure and functioning of their habitats (e.g. organic matter processing,
nutrient retention, food resources for vertebrates, such as amphibians, fish or birds).

- Aquatic insects are often good indicators because they are present in some capacity in almost every type of habitat and many are habitat specialists.
- Odonate species prefer to live in freshwater, non-contaminated and well oxygenated habitats. Hence, they can serve as valuable bio-indicators for environmental contamination studies.
- Though odonates were recorded in present study but they showed least diversity and were very sparse in distribution, thereby indicating their preference for freshwater, non-contaminated and well oxygenated habitats.
- In addition to the odonates, aquatic insects mostly sensitive to water pollution are the Ephemeropterans (may flies), plecopterans (stone fly) and tricopterans (caddisfly). The sparse distribution, low numerical abundance and low species diversity in present study is therefore, indicative of the ponds that have been severely disturbed. Thus, by cataloguing the number and species composition in these derelict water bodies, it may be possible to determine what type of pollutants may be present and what is the pollution level in water.
- Aquatic Diptera 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 organic pollution and related perturbation. The preponderance of saprophilic insects (insects restricted to heavily enriched habits e.g. ‘bloodworm’ midge larva) at all the selected sites under study clearly indicate that all these water bodies are organically enriched and are grossly polluted.
- The high abundance of *Chironomus* sp. at all the selected sites in present study indicates that these water bodies are highly eutrophic.
- Aquatic Hemiptera holds an important place in the ecology of fresh water ecosystems. 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. Certain families of bugs may be utilized in the biological control of mosquito larvae.
Amongst aquatic insects Coleopterans are used as food in many countries of the world. Beetles are highly prized in the kitchen in many countries. They are prepared roasted or smoked and are used in “tamales”, “quesadillas”, “sopes”, etc.

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.
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