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Original Research Paper

Zoology

# Physico-Chemical and Ecological Assessment and its impact on Periphyton in ponds of Chapra district, Bihar

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**ABSTRACT**

Biomonitoring in conjunction with physical and chemical observation of water quality is potentially useful in characterizing water bodies. Chemical data measure concentration of pollutants, etc. in the water body, and the ecosystem imbalances are measured by biological information. The objective of this study was to assess the physio-chemical and ecological status of two water bodies in Chapra. The study details the water quality aspects of Bazar Samiti pond (Pond A) and Jagdam College pond (Pond B), whose selection was based on their current use and location. The analysis was done based on APHA, standard methods (1985) and NEERI, water and wastewater analysis (1986). Various physical and chemical parameters were analyzed in the current study. The biological methods used for assessing water quality include collection, counting and identification of aquatic organisms; and processing and interpretation of biological data. Analysis of various parameters studied to assess the water quality showed that the water qualities of both the ponds in Chapra district were slightly polluted. Pond B was slightly more polluted than Pond A. The pH of both the ponds were within the range of BIS standard for class A water bodies as well as the tolerance limits as prescribed by ISI. Dissolved Oxygen of both the ponds was slightly higher than BIS standard. Phosphate concentration in both the ponds was much less than the tolerance limits. Calcium and Magnesium hardness in both the ponds were higher than the tolerance level. However, the Total Hardness of the water of the two ponds sampled was less than the tolerance limit prescribed as well as BIS standard. The density and diversity of phytoplanktons in increasing order was as follows: Myxophyceae> Bacillariophyceae>Chlorophyceae>Euglenophyceae. The density of and diversity of zooplanktons in increasing order was as follows: Rotifera>Copepoda>Protozoa>Cladocera. The species diversity of pond A was more than pond B. The various bio-ecological and physico-chemical parameters also indicate that the pond B was slightly more polluted than pond A. The results also revealed that due to anthropogenic activities in the pond water catchment area, the drainage connectivity between wetlands have been lost and heavily altered, resulting in reduced water storage capacity and shrinkage in the wetland area which has also contributed to depletion in the groundwater table. Hence, there is a need to create awareness in public about the loss and to conserve and restore these natural resources.

**KEYWORDS** Physico-chemical assessment, Ecological assessment, Biomonitoring, Ponds in Chapra district

## Introduction

Many methods and criteria are available to assess aquatic ecosystems. A physico-chemical approach to monitor water pollution is most common and plenty of information is available on these aspects[1]. Such data is valuable and necessary but does not provide all the information required in the assessment of water quality of the water body[2]. One of the most striking features of the past water assessment procedures has been the reliance placed upon physical and chemical techniques with relative neglect of biological parameters[3]. Since water pollution in many instances is a biological phenomenon, it would appear logical that it ought to be measured biologically (Ramachandra T.V. Ahalya N., and Rajasekara Murthy C, 2005). Biological monitoring or biomonitoring has proved to be an important tool in assessing the condition of aquatic ecosystems[4][5][6]. Biological methods used for assessing the water quality include the collection, counting, and identification of the aquatic organisms (APHA, 1985)[7].

Biomonitoring in conjunction with physical and chemical observation of water quality is potentially useful in characterizing water bodies. Chemical data measure concentration of pollutants, etc. in the water body, and the ecosystem imbalances are measured by biological information. The objective of the study was to assess the physio-chemical and ecological status of two water bodies in Chapra. The study details the water quality aspects of Bazar Samiti pond (Pond A) and Jagdam College pond (Pond B), whose selection was based on their current use and location. Both pond reservoirs are situated in Chapra city and their water is used for agriculture, daily activities like washing clothes, swimming, bathing and other recreational value with boating and fishing facilities for the public. Construction activities in the catchment area have increased dramatically over the last few decades due the pressure of urbanization and pressure on land. The area has been converted into huge residential and commercial properties without providing for the basic amenities and infrastructure. During the monsoons, the excess storm waters choke the drains and the weir at the outlet is blocked leading to the mixing of the sewage with the storm water, which eventually finds its way into the pond.

## Materials and Methods

An integrated study of physical, chemical and biological components of the two ponds in Chapra district was done to determine the health of the waterbodies. The monitoring was done on a monthly basis for a period of two years, viz: 2010 & 2011.The sub surface water sample were collected between morning hours 08.00 h and 10.00 h, regularly at monthly interval. Triplicate sample were collected at a time. Analysis for a few parameters were done at the site such as temperature, hydrogen ion concentration (pH). Dissolved oxygen (DO2), free Carbon Dioxide (FC02), while for the rest parameter samples were brought to the laboratories with 6 hours of sampling.

The analysis was done based on APHA, standard methods (1985) and NEERI, water and wastewater analysis (1986). The various physical and chemical parameters that were analyzed in the current study are: Atmospheric temperature, Water temperature, PH, DO, FCO2, Calcium, Calcium hardness, Magnesium,

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Magnesium hardness, Total hardness, Phosphate (PO4-)

**Plankton Analysis**

The physical and chemical characteristics of water affect the abundance, species composition, stability and productivity of the indigenous populations of aquatic organisms. The biological methods used for assessing water quality include collection, counting and identification of aquatic organisms; and processing and interpretation of biological data

**Results and Discussion**

**Table 1:**

| Physico-chemical parameters | Pond A mean | | Overall mean | Pond B mean | | Overall mean | Tolerance limits for selected parameters | BIS Standard for Class-A for selected parameters |
|---|---|---|---|---|---|---|---|---|
| | 2010 | 2011 | | 2010 | 2011 | | | |
| Atmospheric temperature | 26.3 | 25.6 | 26 | 25.6 | 25.6 | 25.6 | NA | NA |
| Water temperature | 26.6 | 26.3 | 26.4 | 26 | 25.3 | 25.65 | 40 | NA |
| pH | 6.4 | 6.4 | 6.4 | 6.4 | 6.4 | 6.4 | 5.5-8.5 | 6.5-8.5 |
| DO | 6.9 | 6.9 | 6.9 | 6.7 | 6.8 | 6.75 | >5 | 6 |
| FCO2 | 32.6 | 33 | 32.8 | 30.7 | 31.2 | 31 | NA | NA |
| Phosphate | 0.28 | 0.32 | 0.3 | 0.31 | 0.22 | 0.26 | 5 | NA |
| Calcium | 36 | 36 | 36 | 34.6 | 35.3 | 34.95 | NA | NA |
| Calcium hardness | 86 | 85 | 85.5 | 84.3 | 84 | 84.15 | 75 | NA |
| Magnesium | 20 | 20.6 | 20.3 | 19.3 | 20 | 19.65 | NA | NA |
| Magnesium hardness | 65 | 65.3 | 65 | 63 | 63.6 | 63.3 | 30 | NA |
| Total Hardness | 147 | 146.6 | 146.8 | 145 | 146 | 145.5 | 300 | 300 |

NA=Not available; *Tolerance limit is as prescribed by the Indian Standards Institution (IS 10500-1989).

Table 1 depicts the general status of physico-chemical parameters recorded in the Pond A & Pond B of Chapra district and their comparison with the BIS standard of Class A water as well as tolerance level as prescribed by the Indian Standards Institution (IS 10500-1989). These values were co-related with the presence or absence of periphytons. The average seasonal values of bio-chemical parameters were compared with seasonal variation in periphytons which is shown in the following figures:

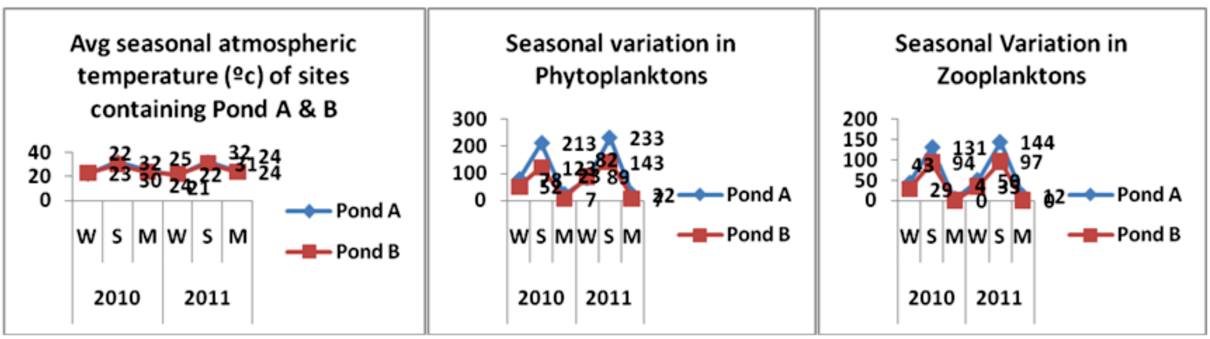


**Figure 1:Co-relation of Average Seasonal Atmospheric temperature with Periphyton Seasonality**

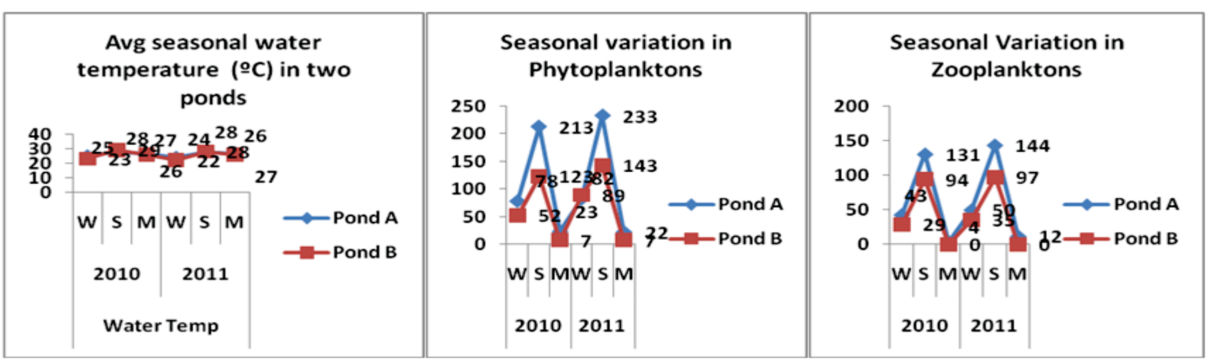


**Figure 2: Co-relation of Average Seasonal Water temperature with Periphyton Seasonality**

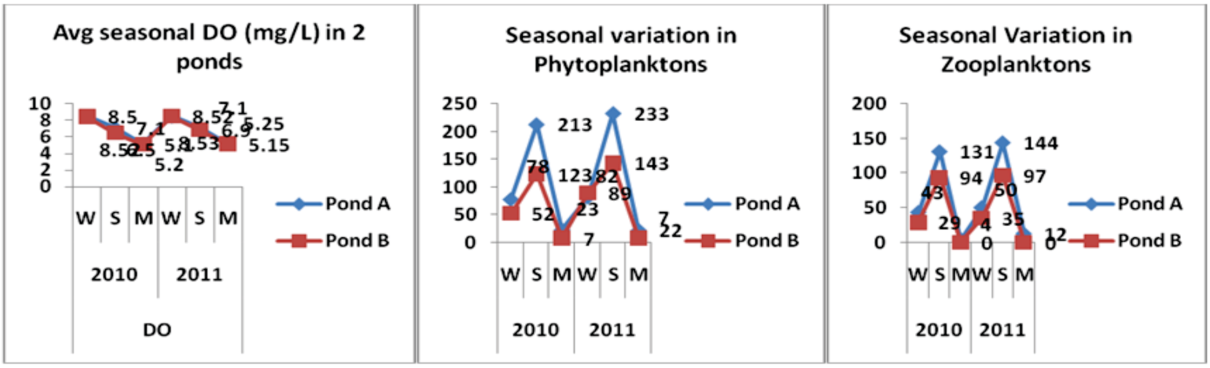


**Figure 3: Co-relation of Average Seasonal Dissolved Oxygen with Periphyton Seasonality**

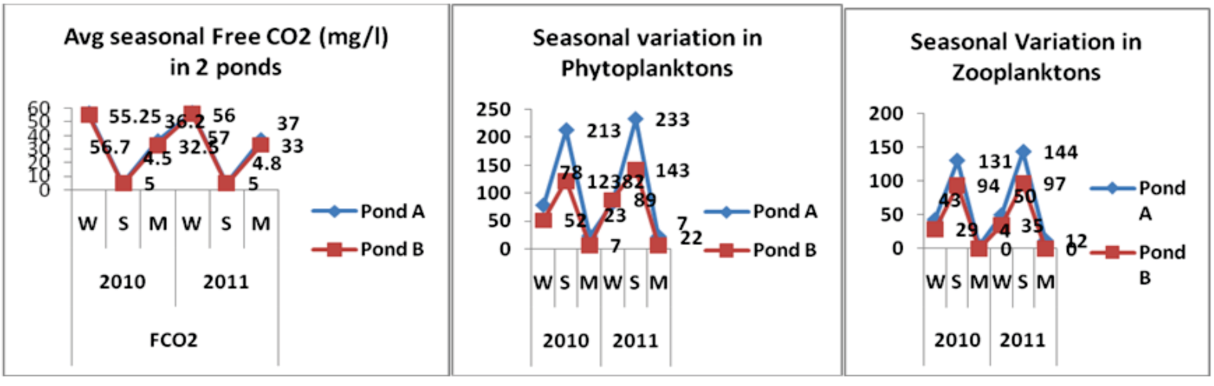


**Figure 4: Co-relation of Average Free Carbon di-oxide with Periphyton Seasonality**

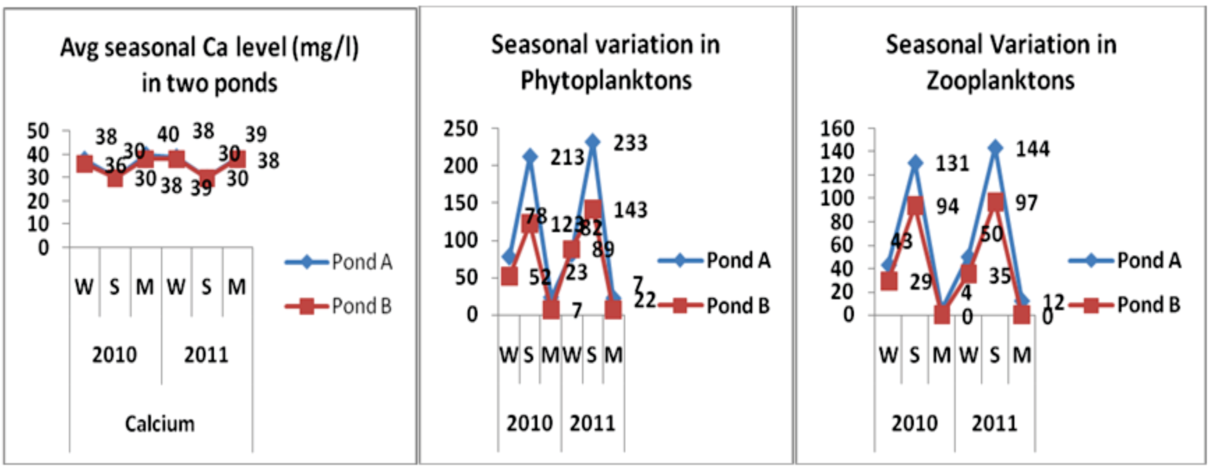


**Figure 5: Co-relation of Average Seasonal Calcium level with Periphyton Seasonality**

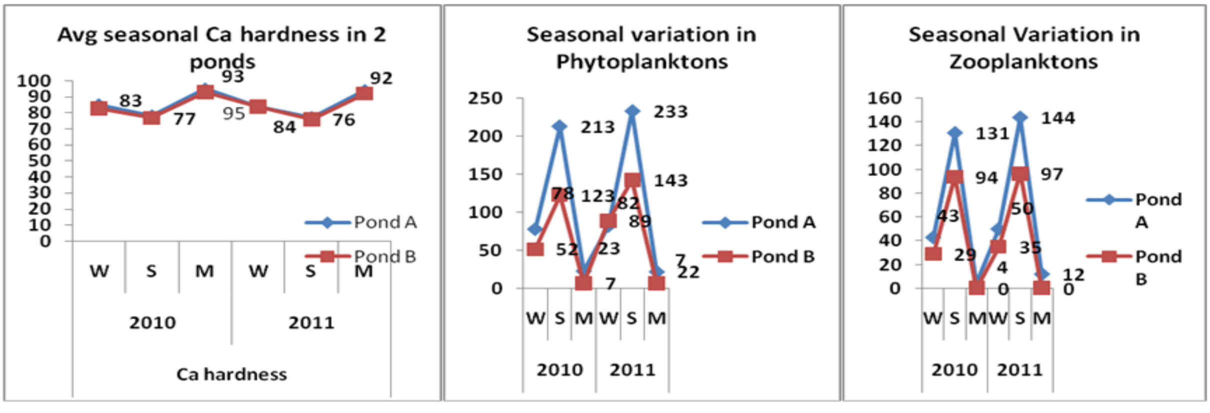


**Figure 6: Co-relation of Average Seasonal Calcium Hardness with Periphyton Seasonality**

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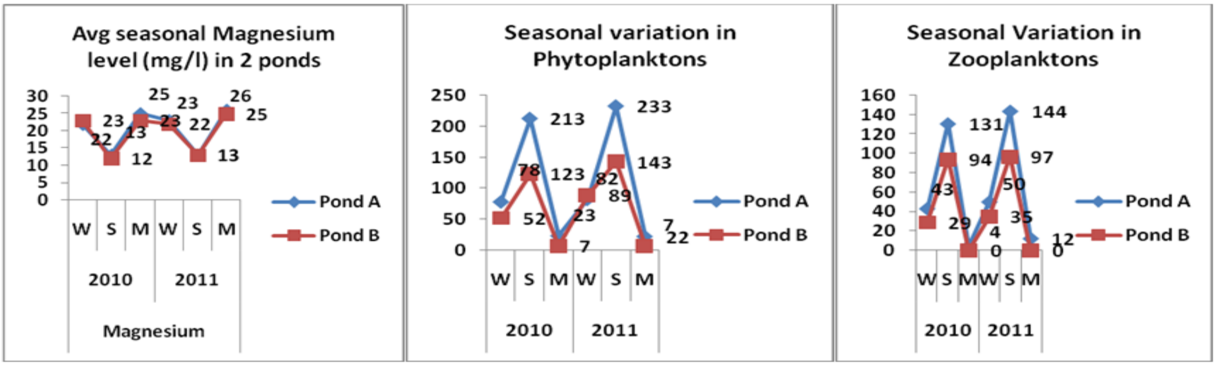


**Figure 7: Co-relation of Average Seasonal Magnesium level with Periphyton Seasonality**

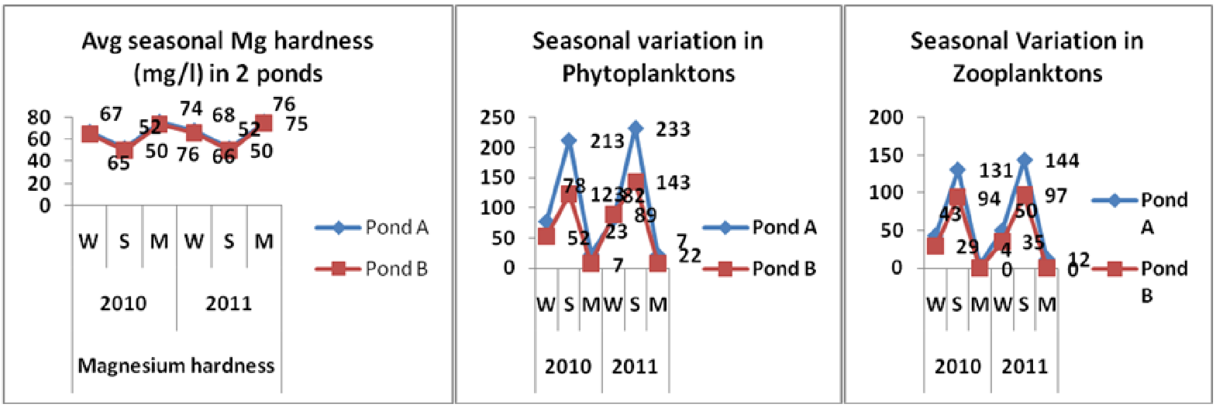


**Figure 8: Co-relation of Average Seasonal Magnesium hardness with Periphyton Seasonality**

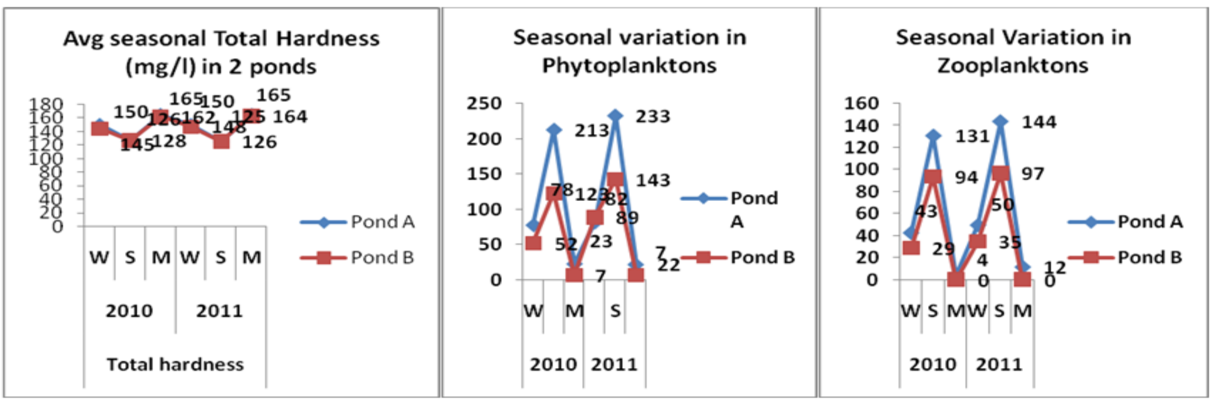


**Figure 9: Co-relation of Average Seasonal Total Hardness with Periphyton Seasonality**

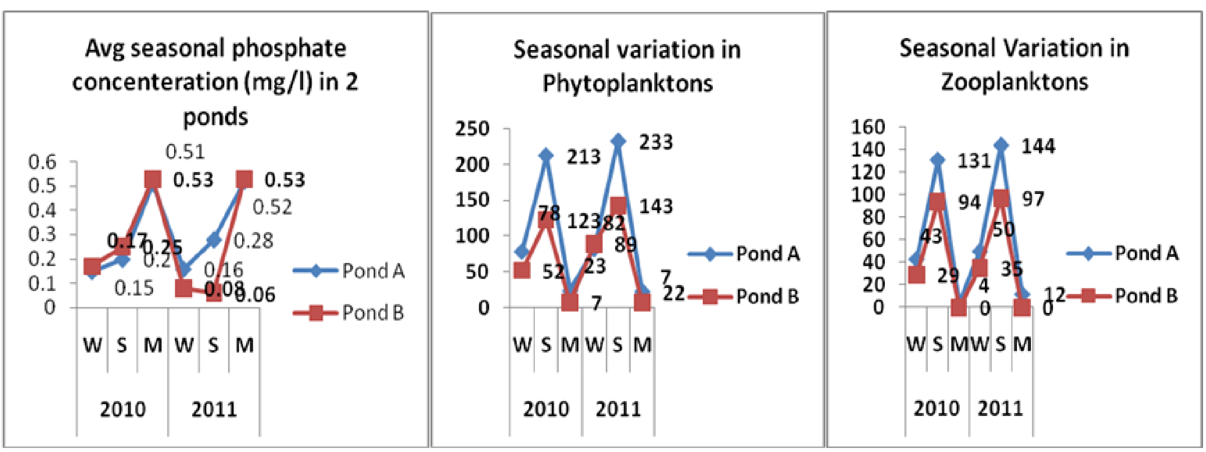


**Figure 10: Co-relation of Average Seasonal Phosphate Concenteration with Periphyton Seasonality**

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The species diversity index calculated for the two ponds were compared to assess the water quality. The same is presented in the Table 2

**Table 2:**

| **Average yearly value of Shannon Weiner Index for periphyton community as a whole in Pond A & Pond B** | **Shannon"s index and pollution levels** | | | |
|---|---|---|---|---|
| | **Pond A** | **Pond B** | **Species** | **Pollution level** |
| **2010** | **6.51** | **4.29** | **3.0-4.5** | **Slight** |
| **2011** | **2.12** | **4.65** | **2.0-3.0** | **Light** |
| **Avg** | **4.3** | **4.4** | **1.0-2.0** | **Moderate** |
| | **0.0-1.0** | **Heavy** | | |

**Atmospheric temperature** in pond A varied from 21-22˚C in winter to 32-33˚C in summer to 24-25˚C in the monsoon season in 2010 & 2011 respectively. Atmospheric temperature in pond B varied from 22-23˚C in winter to 30-31˚C in summer to 24˚C (each) in the monsoon season in 2010 & 2011 respectively.

**Water temperature in pond** A varied from 24-25˚C in winter to 28˚C (each) in summer to 27˚C (each) in the monsoon season in 2010 & 2011 respectively. Atmospheric temperature in pond B varied from 22-23˚C in winter to 28-29˚C in summer to 26˚C (each) in the monsoon season in 2010 & 2011 respectively.

**pH** in pond A varied from 6.2-6.3 in winter to 6.7 (each) in summer to 6.4-6.5 in the monsoon season in 2010 & 2011 respectively. pH in pond B varied from 6.2-6.3 in winter to 6.6-6.7 in summer to 6.4 (each) in the monsoon season in 2010 & 2011 respectively.

**Dissolved Oxygen (mg/l)** in pond A varied from 8.52-8.53 in winter to 7.1 (each) in summer to 5.20-5.25 in the monsoon season in 2010 & 2011 respectively. DO in pond B varied from 8.50-8.52 in winter to 6.5-6.9 in summer to 5.1 (each) in the monsoon season in 2010 & 2011 respectively.

**Free Carbon di-oxide (FCO2) (mg/l)** in pond A varied from 56-57 in winter to 5 (each) in summer to 36.2-37 in the monsoon season in 2010 & 2011 respectively. FCO2 in pond B varied from 55.2-56 in winter to 4.5-4.8 in summer to 32.5-33 in the monsoon season in 2010 & 2011 respectively.

**Phosphate concentration (mg/l)** in pond A varied from 0.15-0.16 in winter to 0.20-0.28 in summer to 0.51-0.52 in the monsoon season in 2010 & 2011 respectively. Phosphate concentration in pond B varied from 0.17-0.08 in winter to 0.25-0.06 in summer to 0.53 (each) in the monsoon season in 2010 & 2011 respectively.

**Calcium concentration (mg/l)** in pond A varied from 38-39 in winter to 30 (each) in summer to 39-40 in the monsoon season in 2010 & 2011 respectively. Calcium concentration in pond B varied from 36-38 in winter to 30 (each) in summer to 38 (each) in the monsoon season in 2010 & 2011 respectively.

**Calcium hardness (mg/l)** in pond A varied from 85-84 in winter to 78-77 in summer to 95-94 in the monsoon season in 2010 & 2011 respectively. Calcium hardness in pond B varied from 83-84 in winter to 77-76 in summer to 93-92 in the monsoon season in 2010 & 2011 respectively.

**Magnesium concentration (mg/l)** in pond A varied from 22-23 in winter to 13 (each) in summer to 25-26 in the monsoon season in 2010 & 2011 respectively. Magnesium concentration in pond B varied from 23-22 in winter to 12-13 in summer to 23-25 in the monsoon season in 2010 & 2011 respectively.

**Magnesium hardness (mg/l)** in pond A varied from 67-68 in winter to 52 (each) in summer to 76 (each) in the monsoon season in 2010 & 2011 respectively. Magnesium hardness in pond B varied from 65-66 in winters to 50 (each) in summer to 74-75 in the monsoon season in 2010 & 2011 respectively.

**Total Hardness (mg/l)** in pond A varied from 150 (each) in winter to 126-125 in summer to 165 (each) in the monsoon season in 2010 & 2011 respectively. Total Hardness in pond B varied from 145-148 in winters to 128-126 in summer to 162-164 in the monsoon season in 2010 & 2011 respectively.

The values of the above parameters were co-related with the periphyton density and diversity. It was found that increase in atmospheric temperature in summer favoured the proliferation of both the phyto and zoo-periphytons. Atmospheric temperature in monsoon was similar to winter temperature in both the ponds but periphyton density was lesser in monsoon than winter. This may be attributed due to excess rain along with pollutants entry into the pond leading to constant turbulence of water and dis favouring the proliferation of periphytons. Increase in water temperature in summer was directly related to increase in periphytons in those months. The pH of both the ponds remained slightly acidic throughout the two years. It was found that a slight increase in pH in the summer favoured the proliferation of periphytons. The concentration of Dissolved Oxygen was also found to be directly associated with the concentration of the periphytons. Increased DO in the summer season favoured an increase in growth of the periphytons. Concentration of DO was found to be minimum in the rainy season which may be co-related to minimum proliferation of periphytons in rainy months. The average value of DO was found to be 6.5-7.1 in the summer season indicating good quality of water. However, DO in the monsoon season declined to 5.0-5.25 indicating moderate pollution of the water bodies. This may be attributed to constant mixing of effluents from washed rain waters into the pond and unfavouring periphytons growth in those months. The concentration of Free Carbon di-oxide was found to be negatively co-related to periphytons concentration. The concentration of FCO2) was found to be minimum in the summer season while maximum values were recorded in the monsoon season when the concentration of periphytons was found to be less. The values of Calcium, Calcium hardness, Magnesium, Magnesium hardness, Phosphate and Total Hardness were recorded to be maximum in the monsoon season when periphytons concentration was minimum while lowest values were found in the summer seasons when the concentration of periphytons were maximum. Thus, all these parameters can be said to be negatively co-related to the presence, growth and proliferation of both the phyto and zoo-periphytons.

**Phyto-periphyton and Zoo- periphyton analysis:** The species distribution of periphytons in the two ponds is represented below:

**Table 3:**

| Species distribution | | | |
|---|---|---|---|
| Pond A | | | |
| **PHYTOPLANKTON** | **ZOOPLANKTON** | | |
| I | **BACILLARIOPHYCEAE** | I | **PROTOZOA** |
| | *Fragilaria Sp.* | | *Centrophyxis Sp.* |
| | *Diatoma* | | *Arcella Sp.* |
| | *Cyclotella* | | |
| | *Cymbella Sp.* | | |
| | *Pinnularia Sp.* | II | **ROTIFERA** |
| | *Navicula Sp.* | | *Brachionus angularis* |
| | *Synedra Sp.* | | *Filinia Sp.* |
| | | | *Monoslala Sp.* |
| II | MYXOPHYCEAE | | |
| | Oscillatoria Sp. | | |
| | Rivularia | | |
| | Nostoc | | |
| | Phormidium Sp. | | |
| | Nodularia | | |
| | Anabaena Sp. | | |
| | Lyngbya Sp. | | |
| III | **CHLOROPHYCEAE** | III | **COPEPODA** |
| | Spirogyra Sp. | | Cyclops Sp. |
| | Scenedesmus Sp. | | Mesocyclops Sp. |
| | Cosmarium Sp. | | |
| | Pediastrum Sp. | | |
| IV | **EUGLENOPHYCEAE** | IV | **CLADOCERA** |
| | Euglena | | Diaphanosoma Sp. |

**Table 4:**

| Species distribution | | | |
|---|---|---|---|
| Pond B | | | |
| | PHYTOPLANKTON | | ZOOPLANKTON |
| I | **BACILLARIOPHYCEAE** | I | **PROTOZOA** |
| | *Fragilaria Sp.* | | *Centrophyxis Sp.* |
| | *Diatoma* | | *Arcella Sp.* |
| | *Cyclotella* | | |
| | *Cymbella Sp.* | | |
| | *Pinnularia Sp.* | II | **ROTIFERA** |
| | *Navicula Sp.* | | *Brachionus angularis* |
| | *Synedra Sp.* | | *Filinia Sp.* |
| | | | *Monoslala Sp.* |
| II | **MYXOPHYCEAE** | | |
| | *Oscillatoria Sp.* | | |
| | *Nostoc* | | |
| | *Phormidium Sp.* | | |
| | *Nodularia* | | |
| | *Anabaena Sp.* | | |
| | *Lyngbya Sp.* | | |
| | | | |
| III | **CHLOROPHYCEAE** | III | **COPEPODA** |
| | *Spirogyra Sp.* | | *Cyclops Sp.* |
| | *Cosmarium Sp.* | | *Mesocyclops Sp.* |
| | *Pediastrum Sp.* | | |
| | | | |
| IV | **EUGLENOPHYCEAE** | IV | **CLADOCERA** |
| | *Euglena* | | *Diaphanosoma Sp.* |

Bacilliariophyceae (Diatoms) were re-pre-se-nted by 7 sps viz: Fragilaria, Synedra, Diatoma, Navicula, Cyclotella, Cymbella and Pinnularia; Myxophyceae/ Cyanophyceae (Blue-Green algae) was again represented by 7 species viz: Oscillatoria, Rivularia, P-ho-rm-idium, Nostoc, Anabaena, Lyngbya & Nodularia; Chlorophyceae represented by 4 species viz: Spirogyra, Scenedesmus, Cosmarium, Pediastrum; Euglenophyceae represented by single species Euglena. Among zooplanktons Protozoans were represented by 3 species viz: Centrophyxis, Arcella & No-th-oica; Rotifera was represented by 3 species viz: Brachionus angularis, Filinia & Monoslala; Copepoda was represented by 2 species Cyclops & Mesocyclops and Cladocera was represented by single species Diaphnosoma. The density and diversity of phytoplanktons in increasing order is as follows: Myxophyceae> B-ac-ill-ar-iop-hyce-ae>-Chl-oro-ph-yce-ae>Euglenophyceae. The density of and diversity of zooplanktons in increasing order is as follows: Ro-ti-fe-ra>Co-pepod-a>Pro-toz-oa>Cladocera. Rotifers form an important cosmopolitan component of the zooplankton and they are one of the principal links in the food chain. Copepods and cladocerons are the principal planktonic groups of mi-cro-crus-taceans present in waterbodies. The species composition of Pond A and Pond B was nearly similar. But Pond B was slightly less in richness when compared to Pond A. Two indicator species viz: Rivularia (Myx-ophy-ceae) and Scendesmus (C-hlor-ophyceae) were found to be completely absent in Pond B in all the seasons. This may be attributed to a variety of factors like predation, sensitivity to various physico-chemical parameters etc. Fishes are important key tone species indicating the quality of the river bodies. Following table depicts the general fishes found in the two ponds sampled in the Chapra district.

**Table 5:**

| Fish observed at the study areas | | |
|---|---|---|
| Sl no | Pond A | Pond B |
| 1 | Wallago attu | Wallago attu |
| 2 | Channa punctatus | Catla catla |
| 3 | Heteropneustes fossilis | Labeo rohita |
| 4 | Labeo rohita | |
| 5 | Catla catla | |
| 6 | Cirrhinus mrigala | |

It is clear from the table 5 that the species diversity of pond A is more than pond B. The various bio-ecological and physico-chemical parameters also indicates that the pond B was slightly more polluted than pond A. The species diversity in pond B was also less than pond B. All these factors may play an important role in regulation of fish breeding in water of the two ponds

**Conclusion:**

The detailed investigations of the parameters, which were well within the tolerance limits, indicated that both the pond reservoirs were fairly unpolluted. The pH of the two pond reservoirs remained slightly acidic throughout. As a major element in aquatic biota, the algal community often exhibits dramatic changes in response to changes in physico – chemical properties of the aquatic environment. The differences in the dominant phytoplankton assemblage of the lakes reflect their trophic levels. Pond A phytoplankton showed a high density and diversity of phyto-periphtons while the density and diversity of zoo-periphytons were nearly similar in both the ponds. Two species of phyto-periphytons viz: Rivularia and Scendesmus were completely absent from Pond B. that was an indication of organic pollution. The results also revealed that due to anthropogenic activities (encroachments, construction activities, waste dumping, sewage disposal, etc.) in the pond water catchment area, the drainage connectivity between wetlands have been lost and heavily altered, resulting in reduced water storage capacity and shrinkage in the wetland area which has also contributed to depletion in the groundwater table. Hence, there is a need to create awareness in public about the loss and to conserve and restore these natural resources. This necessitates the need for restoration and formulation of conservation strategies for sustainable management of ponds. Further research is required towards understanding the role of individual indicator species in an aquatic system, linkages between aquatic ecosystem quality and food chain, interrelationship with other abiotic factors involved and life history, prey predator relationship, inter and intra – specific competition of indicator species the effect of pollution on them

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