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# A comparative hydrobiological study of a few ponds of Barak Valley, Assam and their role as sustainable water resources

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***Abstract:*** *A hydrobiological study conducted in nine different ponds of a rural area of Barak Valley, Assam, showed that the concentrations of chemical parameters like dissolved oxygen, free carbon dioxide, pH, conductivity, alkalinity, nitrate, phosphate, calcium, magnesium, copper and zinc are within the permissible levels of drinking water quality standard of WHO and ISI. However, iron content was higher in most of the ponds. A clear indirect relationship between iron concentration and euglenoids has been observed. Major phytoplankton taxa present in the ponds are Chlorophyceae, Cyanophyceae, Bacillariophyceae and Euglenophyceae. The study reveals that rural ponds can be a very good source of water for drinking, domestic use and fishery and should be conserved at any cost.*

***Key words:*** *Drinking water quality, Iron, Euglenophyceae, Chlorophyceae*
*PDF file of full length paper is available with author*

## Introduction

The world's water resources are under pressure and must be managed for human survival. It is, therefore, necessary to have most relevant information for arriving at rational decisions that will result in the maximum benefit to most people. Accurate and reliable information on the water resource system can, therefore, be a vital aid to strategic management of the resources (Gupta and Deshpande, 2004). Ponds have been used since time immemorial as a traditional source of water supply in India. However, the water of the ponds, lakes and river are polluted mainly due to discharged waste water from residential areas, sewage outlets, solid wastes, detergents, automobile oil wastes, fishing facilities and agricultural pesticides from farmlands (Srivastava *et al.,* 2003; Usha *et al.*, 2006; Hasan *et al.*, 2007). In recent years, their importance has somewhat declined due to technological advancements leading to more centralized water supply systems. There is a relationship among ecologists and microplanners about the importance of conservation of ponds as sustainable source of water for rural communities (Park and Park, 2005). The present study is an attempt to assess the water quality of ponds in a rural area of Barak Valley, Assam so that they may be sustainably exploited for multiple uses like rural water supply, fisheries and even recreation.

## Materials and Methods

The study was carried out in nine different ponds of Airongmara, a village near Silchar, (24°50'N, 92°40'E), Barak Valley, Assam, North East India. Pond 1, 3, 4, 5 and 6 are household ponds while pond 2, 7, 8 and 9 are fishery ponds.

Water samples were collected fortnightly from February to April, 2003 from the sub-surface layer of the ponds in PVC and BOD bottles (for estimating dissolved oxygen). Hydrogen ion concentration and conductivity were measured by a pH and conductivity meter, respectively, while free carbon dioxide, dissolved oxygen and total alkalinity were estimated by standard methods (Michael, 1984; APHA, 1985; Ramesh and Anbu, 1996). Nitrate content was measured by Ion Meter with Ion Selective electrode (Eutech, Germany) while phosphate content was estimated by Ammonium Molybdate-Stannous Chloride method (Michael, 1984). Ca, Mg, Fe, Cu and Zn contents were estimated (Gupta, 1996) by Perkin-Elmer 2380 flame atomic absorption spectro-photometer. The readings were checked with those of standard solutions and procedural blanks, acid washed glassware, analytical grade reagents and double distilled de-ionized water were used to minimize contamination errors. The detection limits for Ca, Mg, Fe, Cu and Zn were 1.0, 0.1, 3.0, 1.0 and 0.8 $\mu gl^{-1}$ respectively. Quantitative sampling of plankton was done by filtering a known volume of water through a plankton net. After fixation in 6 percent formalin and pre-concentration, cell counts were made in a sedgewick rafter (Michael, 1984).Statistical analysis was done by using window based statistical package SYSTAT 10.

## Results and Discussion

Quality of an aquatic ecosystem is dependent on the physico-chemical qualities of water as also on the biological diversity of the system (Ghavzan *et al.*, 2006; Tiwari and Chauhan, 2006; Tas and Gonulol, 2007). Cairns and Dickson (1971), stated that analysis of biological materials along with chemical factors of water forms a valid method of water quality assessment.

Table 1 depicts the chemical variables of the water of nine different ponds selected for the present study. The dissolved oxygen content varied between 5.85 $mgl^{-1}$ in pond 5 to 11.28 $mgl^{-1}$ in pond 8, the value of free carbondioxide ranged from 10.1 $mgl^{-1}$ in pond 6 to 23.47 $mgl^{-1}$ in pond 4. Total alkalinity varied from 11 $mgl^{-1}$ to 47.87 $mgl^{-1}$ in pond 2 and 4 respectively. The pH value ranged from 6.9 in pond 8 to 7.82 in pond 5. The minimum recorded value of conductivity is 29.63 $\mu S/cm$ in pond 2 while maximum value is 182.87 $\mu S/cm$ in

**Table - 1**: Variation of chemical parameters in ponds 1 to 9 (n*= 6)

| Variables | Ponds | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| DO | 6.37 (1.01) | 8.19 (1.07) | 6.55 (2.40) | 5.91 (2.38) | 5.85 (2.2) | 7.57 (0.67) | 7.34 (0.44) | 11.28 (0.029) | 7.29 (0.27) |
| Free $CO_2$ | 12.47 (3.36) | 13.27 (4.68) | 12.53 (0.53) | 23.47 (16.66) | 22.29 (28.37) | 10.1 (1.15) | 17.45 (0.18) | 17.53 (0.50) | 13.39 (0.54) |
| TA | 20.00 (3.60) | 11.00 (3.6) | 17.00 (6.10) | 47.87 (56.23) | 18.37 (24.83) | 22.5 (0.5) | 43.67 (0.38) | 43.8 (2.30) | 37.67 (1.53) |
| pH | 7.40 (0.34) | 7.47 (0.25) | 7.24 (0.14) | 7.5 (0.21) | 7.82 (0.12) | 7.2 (0.02) | 7.18 (0.1) | 6.9 (0.21) | 7.01 (0.07) |
| Cnd. | 123.8 (8.26) | 29.63 (1.7) | 66.4 (9.93) | 114.3 (36.96) | 182.87 (17.4) | 124.2 (3.7) | 177.1 (36.9) | 147.17 (0.47) | 91.3 (1.13) |
| TDS | 56.30 (3.79) | 14.00 (1.0) | 28.90 (7.10) | 52.67 (16.56) | 83.67 (7.77) | 56.5 (2.12) | 82.00 (15.1) | 61.92 (0.38) | 41.00 (1.0) |
| Nitrate | 0.720 (0.38) | 0.210 (0.11) | 01.70 (1.15) | 0.38 (0.32) | 0.63 (0.43) | 0.7 (0.11) | 0.43 (0.06) | 2.2 (0.15) | 0.09 (0.01) |
| Phosphate | 0.850 (0.01) | 0.00 | 0.49 (0.04) | 2.56 (0.25) | 1.22 (0.03) | 0.85 (0.04) | 43.5 (0.78) | 15.2 (0.3) | 3.35 (0.06) |
| Calcium | 0.013 (0.01) | 0.03 (0.01) | 0.70 (0.02) | 0.14 (0.001) | 0.17 (0.002) | 0.012 (0.01) | 1.58 (0.13) | 1.07 (0.01) | 2.6 (0.05) |
| Magnesium | 5.15 (0.05) | 2.05 (0.05) | 04.70 (0.08) | 3.37 (0.01) | 3.66 (0.01) | 2.04 (0.05) | 3.96 (0.86) | 4.3 (0.01) | 4.13 (0.01) |
| Iron | 1.13 (0.01) | 0.71 (0.045) | 01.78 (0.02) | 0.49 (0.01) | 1.23 (0.02) | 0.01 (0.02) | 0.35 (0.57) | 0.02 (0.01) | 0.18 (0.01) |
| Copper | 0.081 (0.01) | 0.07 (0.01) | 0.110 (0.025) | 0.09 (0.02) | 0.11 (0.03) | 0.08 (0.02) | 0.03 (0.01) | 0.02 (0.01) | 0.03 (0.01) |
| Zinc | 0.820 (0.03) | 0.39 (0.02) | 0.300 (0.01) | 0.30 (0.01) | 0.39 (0.02) | 0.2 (0.01) | 0.26 (0.04) | 0.23 (0.00) | 0.34 (0.01) |

*n= number of replicate samples from each pond; all the values are in $mgl^{-1}$ except pH and EC (µS/cm) and phosphate ($\mu gl^{-1}$)
Values in parenthesis are ± SD
DO = Dissolved oxygen, Cnd. = Conductivity, TA = Total alkalinity, TDS = Total dissolved solid

**Table - 2:** Maximum permissible values (WHO and ISI) of some chemical variables estimated in the present study

| Variable | Maximum permissible value (WHO, 1971) | Maximum permissible value (ISI, 1982) |
|---|---|---|
| pH | 6.5-9.2 | 6.5-9.2 |
| Magnesium ($mgl^{-1}$) | 150.0 | 150.0 |
| Iron ($mgl^{-1}$) | 1.0 | 1.0 |
| Copper ($mgl^{-1}$) | 1.0 | 1.5 |
| Nitrate ($mgl^{-1}$) | 45.0 | 45.0 |
| Zinc ($mgl^{-1}$) | 15.0 | 15.0 |

pond 5. The value of nitrate ranged from 0.09 $mgl^{-1}$ to 2.2 $mgl^{-1}$ in pond 9 and 8 respectively. The highest value of phosphate is 43.5 $\mu gl^{-1}$ in pond 7 and not detected in pond 2. Calcium content varied from 0.013 $mgl^{-1}$ in pond 1 to 2.6 $mgl^{-1}$ in pond 9. The value of magnesium ranged from 2.04 $mgl^{-1}$ in pond 6 to 5.15 $mgl^{-1}$ in pond 1. The minimum recorded value of iron is 0.01 $mgl^{-1}$ in pond 6 while the maximum recorded value is 1.78 $mgl^{-1}$ in pond 3. The concentration of copper ranged from 0.02 $mgl^{-1}$ in pond 8 to 0.11 $mgl^{-1}$ in both pond 3 and 5. The zinc content of water varied from 0.2 $mgl^{-1}$ to 0.82 $mgl^{-1}$ in pond 6 and 1 respectively.

Variations in percentage occurrence of major phytoplankton taxa in ponds 1 to 9 are shown in Fig. 1. Major taxa present are Chlorophyceae, Cyanophyceae, Bacillarophyceae and Euglenophyceae. Among the four groups, Chlorophyceae is present in all the ponds. Cyanophyceae is totally absent in pond 3 and 5. Bacillariophyceae is present in pond 1, 3, 7, 8 and 9 in very low percentage and totally absent in pond 2, 4, 5 and 6. Euglenophyceae is present in pond 4, 6, 7, 8 and 9 and totally absent in pond 1, 2 , 3 and 5. Planktonic algae are particularly sensitive to chemical changes and myriad environmental conditions promote the development of the algal spores present in the sediment.(Rodhe,1948). Chlorophyceae is the most common group of phytoplankton in the ponds studied, and its sole presence in pond 5 can be attributed to the fact that this pond is located in the outskirts of Irongmara Township with only one house in its vicinity. The pond is used only for washing and bathing without entry of sewage and domestic waste. Hence the two groups, Cyanophyceae and Euglenophyceae which are generally seen to appear near sewage outfall (Pandit, 2002) are not encountered in the pond.

**Table - 3:** Significant correlations among chemical variables

| Variables | r | p | Variables | r | p |
|---|---|---|---|---|---|
| DO vs. $CO_2$ | -0.365 | ≤0.01 | Ca vs. TA | 0.321 | ≤ 0.02 |
| DO vs. $NO_3$ | 0.561 | ≤0.001 | $PO_4$ vs. TA | 0.350 | ≤ 0.01 |
| Cnd.vs. $PO_4$ | 0.510 | ≤0.001 | pH vs. $NO_3$ | -0.336 | ≤ 0.02 |
| Cnd. vs. Mg | 0.289 | ≤0.05 | Fe vs. Cu | 0.683 | ≤ 0.001 |
| Ca vs. Mg | 0.350 | ≤0.01 | Fe vs. Zn | 0.445 | ≤ 0.001 |

DO = Dissolved oxygen, Cnd. = Conductivity, TA = Total alkalinity

The solubility and availability of nutrients is affected by oxygen content of water and therefore the productivity of aquatic ecosystems (Wetzel, 1984). The highest dissolved oxygen value and nearly neutral pH in pond 8 can be attributed to the diversified nature of the plankton population of the pond where family, Euglenophyceae was the most dominant group followed by Chlorophyceae. As chlorophyll-b is possessed by these two groups only besides possessing chlorophyll-a, they must have transferred an additional amount of light energy to chlorophyll-a for primary photo chemical reactions (Wetzel, 1984). The lowest dissolved oxygen value in pond 5 associated with the highest levels of conductivity, total dissolved solids and pH, as well as high free carbon dioxide and iron values is in agreement with studies conducted at Jaisamand lake, Udaipur, Rajasthan (Sharma and Sarang, 2004) and Naukuchiyatal lake in Kumaon Himalaya (Pandey and Soni, 1993). Algal bloom in pond 5 also confirms the relationship of high pH value with phytoplankton bloom (Sreenivasan, 1965; Mitra and Bhattacharjya, 1965). The chlorophytic algal bloom in this pond might have been instrumental in using up oxygen during the decomposition of the dying bloom

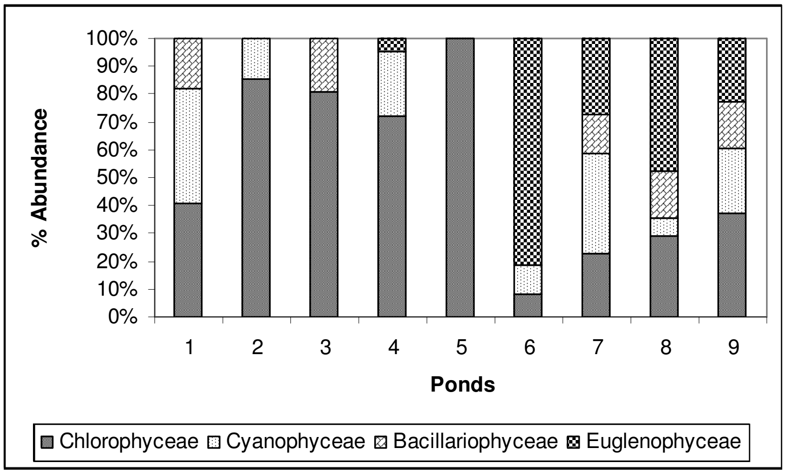


**Fig. 1** : Percentage abundance of major phytoplankton taxa in ponds 1-9

which in turn led to the release of the nutrients, which enhanced the alkalinity and conductivity of pond water (Dutta Gupta *et al.*, 2004).

In lake ecosystems beside the input of nitrate through runoff, decomposition of nitrogenous matter and its further oxidation plays a significant role. Except pond 9, all other ponds have been found to be favourable for fish productivity as nitrate value of these ponds ranged between 0.1-3.0 $mgl^{-1}$ (Verma, 2002). The low range of phosphate value in all the ponds is due to the fact that at high temperature, phosphate is rapidly assimilated by plankton and micro-organisms (Manna and Das, 2004). The highest value of phosphate and the presence of all the four groups of plankton in pond 7 indicate that phosphate regulates the growth of phytoplankton (Welch *et al.*, 1978; Kwang-Guk *et al.*, 2003.)

In this study, we find that concentration of iron is beyond the permissible level of water quality standard in ponds 1, 3 and 5 while other parameters are within the limits in all the ponds. Gobler and Cosper (1996) and several Indian workers (Munnawar, 1970; Khan, 1993 a, b; Choudhury *et al.*, 1998; Khan and Bhat, 2000), have recorded much higher concentration of iron in lake and pond waters and emphasized its role in inducing chrysophyte and euglenoid blooms regularly. In our study, it has been observed that it is totally absent in the ponds where iron level is quite high where as in pond 4, 7 and 9, comparatively lower iron value is associated with moderate abundance of Euglenophyceae. From our study and previous studies, it can be said that as in these types of shallow water bodies boom and bust cycle continues with the entry of nutrients via surface runoff, concentration of iron in the pond 1, 2 and 3 was not conducive for the initiation of the growth of euglenoids while in ponds 4, 7 and 9 with the optimum concentration of iron euglenoids started to develop and spread, thus utilizing and reducing the iron content of water. Further, in ponds 6 and 8 higher growths of euglenoids must have accumulated iron in their body resulting in the lowering of its level in water. Similarly calcium and magnesium are found to be lowest along with lowest iron content and highest percentage occurrence of Euglenophyceae in pond 6. This confirms our previous study, which showed that besides iron, calcium and magnesium also have a great role in stimulating and maintaining *Euglena* blooms (Dutta Gupta *et al.,* 2004). This is possible because calcium increases the availability of other ions and magnesium acts as a carrier of phosphorus (Wetzel, 1984). Lake Manasbal of Kashmir valley of India which is infested by *Euglena pedunculata* also has calcium rich water (Khan and Bhat, 2000). The concentration of copper in all the ponds have been found to be very low compared to other elements and concentration of zinc also has not shown much fluctuation. Though zinc is involved in nucleic acid synthesis and participates in a variety of metabolic processes involving carbohydrates, lipids, proteins and nucleic acid (McDowell, 1992), it can be toxic also when present in excess amount as changes in blood parameters and tissue structures have been reported on exposure to zinc (Gupta and Chakraborty, 1995; Banerjee, 1998). However, in the present study, the highest recorded value of zinc is much below the standards given by WHO (1971) and ISI (1982) (Table 2).

Correlation coefficients computed among the chemical parameters of nine ponds showed a number of significant relationships (Table 3). The classical inverse relationship between dissolved oxygen and carbon dioxide was found to be significant as dissolved oxygen is mainly regulated by photosynthetic activity of algal flora when free carbon dioxide is utilized (Wetzel, 1984). In contrast, positive relationship between dissolved oxygen and nitrate may be explained by the fact that nitrate concentrations in all the ponds were not very high, the maximum value being 2.2 $mgl^{-1}$. The moderate nitrate concentration is likely to have enhanced the growth of phytoplankton which in turn produced more dissolved oxygen. Significant positive correlations of conductivity with phosphate and magnesium indicate that they are the key factors governing the conductivity regimes of the ponds investigated. Phosphate is essential for the growth of organisms and can limit primary productivity (Wetzel, 1984). Again magnesium is required by the chlorophyllous plants as it acts as a micronutrient in enzymatic transphosphorylations by algae. It was also shown that low available magnesium can influence the phytoplankton productivity in oligotrophic Alaskan lakes (Goldman, 1960). Calcium and magnesium are significantly correlated which can be attributed to the fact that both are integral part of plant tissue and contribute to the hardness of water (Wetzel,1984). Further they play an important role in neutralising the excess acid produced in the system (Das, 2002). This also justifies the significant positive relationship of calcium with alkalinity. Inverse relationship of pH with nitrate as recorded in the present study agrees well with the study made in the Maheshkhali Channel, Bay of Bengal, Bangladesh (Ali *et al.*, 1985). Iron showed significant positive correlation with copper and zinc. These are essential micronutrients for plants and many animals, required in trace amounts, and thus vital in the molecular architecture of various proteins, enzymes and vitamins (Giddings, 1973).

The present findings indicate that water quality of all the nine ponds is suitable for drinking and domestic use. Further, they have good potential for fishery except pond 9 where nitrate content is marginally low for fish production. Thus small rural ponds can be a very good source of water for drinking, domestic use and also for generating income from fishery which can be augmented with scientific management as small reservoirs are more manageable and high yielding than larger ones. Hence, it is necessary to protect and conserve these small water bodies. This demands immediate action from ecologists, planners and policy makers.

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