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International Journal For Research in  
Applied Science and Engineering Technology



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# **INTERNATIONAL JOURNAL FOR RESEARCH**

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

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**Volume: 6**

**Issue: II**

**Month of publication: February 2018**

**DOI:**

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# Effect of Brick Kiln Industries on the Community Composition of Plankton in the Lentic Systems of Cachar District in Assam, Northeast India

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**Abstract:** Plankton composition and abundance in aquatic systems is determined and regulated naturally by the prevailing environmental conditions, and are expected to be at equilibrium. However, human induced environmental factors such as land use change putatively disturb such equilibrium leading to change in the composition, abundance and dominance patterns. Therefore, it is important to study how planktonic communities are affected by the change in the aquatic environmental parameters. In the present study, we studied the community composition of plankton in the aquatic bodies formed in agricultural lands as a result of excavation of soil for brick making. We also characterized the aquatic environment through analysis of water properties of selected aquatic bodies. We recorded a total of 48 genera of phytoplankton and 27 genera of zooplankton communities. Amongst phytoplankton, Bacillariophyceae was the most dominant class with 20 numbers of genera, followed by Chlorophyceae (11) and Cyanophyceae (10). Amongst zooplankton, Cladocera was the most dominant group representing 11 genera, followed by Rotifera (6) and Protozoa (5). The present study showed that water properties of the aquatic bodies near brick kiln industry are characterized by typical conditions such as shallow systems with increased water temperature accompanied by lower pH, and available form of nutrients like  $\text{NO}_3\text{-N}$  and  $\text{PO}_4\text{-P}$  that plausibly lead to dominance of few planktonic organisms. The CCA result confirms that plankton communities respond differentially to the aquatic parameters indicating their adaptive capacity to persist in an altered environmental condition. We conclude that the human-induced degraded land modulates the water quality which in turn regulates the community composition and diversity of plankton.

**Keywords:** Lentic system, anthropogenic factor, water properties

## I. INTRODUCTION

Phytoplankton communities are important in environmental impact studies because of their extreme sensitivity to changed conditions (Ingole *et al.* 2010, Zębek 2004). Phytoplankton play an important role in the biosynthesis of organic matter in aquatic body, which directly or indirectly serve all the organisms of a water body as food (Anjana *et al.* 1998). Moreover, number and species composition of phytoplankton serves to determine the quality of a water body (Bahura 1991). Likewise, zooplankton are microscopic, free floating organisms, occupying a middle position between the autotrophs and other heterotrophs in aquatic ecosystems (Ghosh and Biswas 2015). They are used as bioindicators in biomonitoring studies (Sladeczek 1983) and have significant potential for assessing aquatic ecosystem health (Wu. Xia *et al.* 2014).

In nature, the composition and abundance of planktonic communities are mainly regulated through environmental variations in the aquatic systems (Okogwu 2010, Quiroga *et al.* 2013). They are expected to be in equilibrium with the environmental conditions (Petersen 1975, Soares *et al.* 2009). However, anthropogenic disturbances leading to degradation of natural habitats and change in land use have profound impacts on planktonic composition and abundance (Schindler 2001, Buzancic *et al.* 2016).

Brick kiln industries play a major role in unorganized sector of the economy in India, and are restricted mostly to rural and semi-urban areas. These industries profoundly affect the surrounding environment by conversion of wetlands and agricultural lands into degraded wasteland. Several studies have been undertaken on the ecological and environmental impacts of brick industry on soil quality, crop and fruit production, vegetation composition, air pollution, and human health (Naqvi 2004; Vives *et al.* 2007; World Bank 2007; Avitia 2012; Saha and Hosain 2016). However, their impact on the aquatic bodies, particularly the plankton communities have been less studied. Therefore, the present study was undertaken to study the planktonic composition in aquatic bodies near brick kiln industries, and to understand the species response to various water parameters.

We expected that owing to change in water properties, there would be a few typical planktonic organisms that can dominate under that habitat condition.

## II. METHODOLOGY

### A. Study Area

The present study was conducted in brick kiln industry located in the Cachar district of Barak Valley, Assam (Fig. 1). For the present study we selected two sampling stations located within a geographical extent of 60 km<sup>2</sup>, which were situated nearby brick kiln industry.

### B. Water sampling And Analysis

Sampling of water was done at monthly interval from December 2013 to November 2014 from the selected stations. Air and water temperatures were measured in situ with the help of a mercury bulb thermometer (0-100°C). Samples for dissolved oxygen (DO) were collected directly in BOD bottles and were fixed in the field using alkaline iodide and manganous sulphate. For analyzing other chemical parameters, water samples were taken in PVC bottles and were brought to laboratory. pH and conductivity of the water samples were recorded using pH meter (make: Systronics; model: 103621) and conductivity meter (make: Systronics; model: 308 respectively). Other parameters like dissolved oxygen (DO), biological oxygen demand (BOD), free carbon dioxide (CO<sub>2</sub>), nitrate-N (NO<sub>3</sub>-N), and phosphate-P (PO<sub>4</sub>-P) were estimated following Trivedy and Goel (1984) and APHA (2012).

### C. Qualitative and Quantitative Analyses of Plankton

Sampling of plankton samples were done at monthly interval from December 2013 to November 2014 from the selected stations. For this 30 litres of water sample were collected from different areas of each sampling stations and passed through fine mesh (40 µm) plankton net. The water samples after passing through the plankton net were collected and preserved in glass vials using 2ml formalin (4%) which were later on brought to the laboratory. In the laboratory, further concentration of the plankton samples were done by centrifugation at 2000 rpm for 10 minutes which resulted in the settling down of the plankton samples at the bottom of the centrifuge tube. These samples were collected in a separate vial after decanting the supernatant from the centrifuge tube. The volume of the concentrated plankton sample was adjusted to 10 ml by adding distilled water. This was followed by standardization of the plankton sample by finding out the volume of one drop of the concentrated plankton sample. Identification of phytoplankton and zooplankton was done by taking one drop of the concentrated plankton sample on a glass slide and looking through binocular microscope (make: Magnus; model: MLX-i Plus). Likewise a total of 10 drops were considered for the qualitative and quantitative estimations of the phytoplankton and zooplankton taxa from each sampling station after every sample collections. Microscopic identification of phytoplankton and zooplankton was done at 10X and 40X magnifications and were identified up to the genera level.

Identification of phytoplankton was performed using standard keys and monographs of Needham & Needham (1972), Tumer (1978), Biswas and Kalipoda (1980), Pentecost (1984), Anand (1989 and 1998), Edmonson (1992); Tripathi and Pandey (1995), Desikachary (1959) Prasad and Singh (1996), Dutta (2007). Identification of zooplankton was performed using standard keys and monographs of Ward and Whipple (1959), Needham & Needham (1972), Tonapi (1980), Battish (1992), Edmonson (1992), Shiel (1995) and Dutta (2011).

Quantification of the plankton sample was done using Lackey's drop method (Lackey, 1938). The number of phytoplankton and zooplankton present in a litre of water sample has been determined by the using the following formula:

$$\text{Number of individuals of phytoplankton/zooplankton per litre} = \frac{N_1 \times V_1}{N_2 \times V_2}$$

Where,

N<sub>1</sub>=Number of phytoplankton/zooplankton per drop

V<sub>1</sub>=Volume of concentrated sample (ml)

N<sub>2</sub>=Volume of one drop of the sample (ml)

V<sub>2</sub>=Volume of the original sample collected (L)

### D. Statistical Analysis

Univariate and multivariate statistical analyses were done using PAST software (ver. 3.14) (Hammer *et al.* 2011). Principle Component analysis (PCA) for water parameter was done using SPSS software version 20. Canonical Correspondence Analysis (CCA) was done to determine the relationship between plankton communities and the existing water parameter using CANOCO software (version 4.5, Trial version) (Ter Braak 2002).



### III. RESULTS

Table 1 shows the water quality parameter of the aquatic bodies near the brick kiln area. It shows that the aquatic bodies are shallow systems with low water pH and high water temperature. Principal component analyses (PCA) of water properties in aquatic bodies near the brick kiln area rendered five significant PCs with Eigen Values greater than 1 that explained 80% of the total variance of the dataset in the aquatic bodies near the brick kiln area (Table 3). PC1 contributed 24.94% of the total variance and showed high positive loadings for pH, total alkalinity (TA) and total hardness (TH) and negative loading for Phosphate-P ( $\text{PO}_4\text{-P}$ ). PC2 explained 16.12% of the total variance with high positive loadings for water temperature (WT) and water depth (WD). PC3 explained 14.66% of the total variance with high positive loadings for biological oxygen demand (BOD) and free carbon dioxide ( $\text{CO}_2$ ). PC4 explained 13.39% of the total variance with high negative loading for nitrate-N ( $\text{NO}_3\text{-N}$ ). PC5 explained 10.95% of the total variance with high positive loading for electrical conductivity (EC).

In the present study, we enumerated a total of 48 genera of phytoplankton belonging to seven different classes and 27 genera of zooplankton belonging to five different groups (Table 2). Amongst phytoplankton communities, generic richness of Bacillariophyceae was the highest (20) followed by Chlorophyceae (11) and Cyanophyceae (10) (Table 2). Amongst zooplankton, generic richness of Cladocera was the highest (11), followed by Rotifera (6) and Protozoa (5) (Table 2). Class representation of phytoplankton communities in aquatic bodies near the brick kiln area (Fig. 2A) shows that the dominant phytoplankton class is Bacillariophyceae followed by Chlorophyceae and Cyanophyceae. Group representation of zooplankton communities in aquatic bodies near the brick kiln area (Fig. 2B) shows that the dominant zooplankton group is Cladocera followed by Rotifera and Protozoa.

When CCA ordination plotting was done for phytoplankton class the result revealed that Chlorophyceae and Dinophyceae were more associated with WD,  $\text{CO}_2$  and  $\text{PO}_4\text{-P}$ . Cyanophyceae was associated with TA and Zygnematophyceae with water pH while, Chrysophyceae was more associated with  $\text{NO}_3\text{-N}$ . Bacillariophyceae and Euglenophyceae were slightly affected by WT (Fig. 3A). Again, CCA for zooplankton group revealed that Rotifera and Cladocera were associated with  $\text{PO}_4\text{-P}$  whereas Copepod was associated with WT, EC and WD. Protozoa is slightly associated with BOD and  $\text{CO}_2$ . Ostracoda is associated with DO, TH, TA, pH and  $\text{NO}_3\text{-N}$  (Fig. 3B).

### IV. DISCUSSION

The study showed that the habitat of the planktonic communities in the aquatic bodies near the brick kiln industry is mainly characterized by variations in pH, TA, TH,  $\text{PO}_4\text{-P}$ , WT, WD, BOD,  $\text{CO}_2$ ,  $\text{NO}_3\text{-N}$  and EC in the aquatic bodies. These parameters collectively contribute to 80% of the variance in the data set (Tables 1 and 3).

Greater generic richness of Bacillariophyceae followed by Chlorophyceae and Cyanophyceae amongst the phytoplankton class (Table 2) indicates the existence of favorable environmental condition for these genera of phytoplankton in water bodies near brick kiln area. It may be mentioned here that high water temperature favour growth of diatoms (Bacillariophyceae) (Karsten *et al.* 2006). Besides, most of the species under Bacillariophyceae have the ability to multiply by cell division and increase in number, (Veronica *et al.* 2014). Total hardness in the form of calcium carbonates/bicarbonates also promotes the growth of Bacillariophyceae (Patrick 1977). Lower genera of phytoplankton under Chlorophyceae was perhaps due to less availability of nutrients (Mustapha 2009) indicating poor habitat conditions for this class in aquatic bodies near brick kiln industries. Our analyses of the data on water properties and community composition of phytoplankton in aquatic bodies near brick kiln industries through the CCA ordination plots (Fig. 3A) revealed that in aquatic bodies near brick kiln industries the dominance of Bacillariophyceae (Fig. 2A) is not much significantly related with the analyzed water properties which indicates that it might be related with some other parameter of water like silica content of the aquatic bodies for its dominant status, because most of the diatoms required silicon for cell wall formation (Hildebrand *et al.* 1998, 2000) (Fig. 3A). Chlorophyceae (Fig. 2A) was more affected by WD,  $\text{CO}_2$ , and  $\text{PO}_4\text{-P}$  (Fig. 3A). Cyanophyceae (Fig. 2A) was affected by TA and water pH (Fig. 3A).

Similarly greater generic richness of cladocerans followed by rotifers and protozoans indicates the capacity of these genera of zooplankton to tolerate harsh environmental condition in water bodies near the brick kiln industries. The dominance of cladocerans in such water bodies indicates sufficient food availability in that habitat condition as they feed on algae and also on some small sized rotifers and copepod nauplii (Dodson *et al.* 2009). They compete with the rotifers for similar type of food resources and thus large cladocerans limits the growth of rotifers and so competitively they become the most dominant (Herzig 1987, Gilbert 1988) even in aquatic bodies near brick kiln industries. Dominance of Cladocera in the selected water bodies (Fig. 2B) indicates the presence of both the organic and inorganic matters together with phytoplankton and bacteria which all together constituted the food for the cladocerans (Wetzel 2001). Rotifera, the second dominant group of zooplankton indicate the presence of nutrients loading

(Mulani *et al.* 2009; Ezz *et al.* 2014) in the form of organic matters within the system. This might also be attributed to the direct flow due to different anthropogenic activities in the riparian area of the aquatic bodies like grazing by cattle, sometimes fishing, washing utensils and cloths, and taking bath by the labors working in the brick kiln industries (Personal observation). Abundance of Protozoa, the third dominant zooplankton group, indicates greater decomposition of organic matters in such aquatic bodies which facilitates greater accumulation of bacterial population upon which the protozoans feed.

Analyses of the data on water properties and community composition of zooplankton through the CCA ordination plot (Fig. 3B) revealed that in aquatic bodies near brick kiln industries the dominance of Cladocera and Rotifera (Fig. 2B) was related with available phosphorous (Fig. 3B). On the other hand, the dominance of Protozoa (Fig. 2B) was related with high BOD and CO<sub>2</sub> in aquatic bodies near brick kiln industries (Fig. 3B).

## V. CONCLUSION

The study showed that environmental variables play an important role in influencing the plankton community in any aquatic bodies. The plankton communities respond to particular water parameter depending on their capability to cope with the existing environmental condition under that habitat condition. The present study also showed that the water properties in aquatic bodies near brick kiln industry are characterized by certain typical conditions particularly due to its surrounding land use type which facilitated few planktonic organisms to dominate under that habitat condition.

## VI. ACKNOWLEDGEMENT

The authors are thankful to the Head, Department of Ecology and Environmental Science, Assam University Silchar for providing laboratory facilities.

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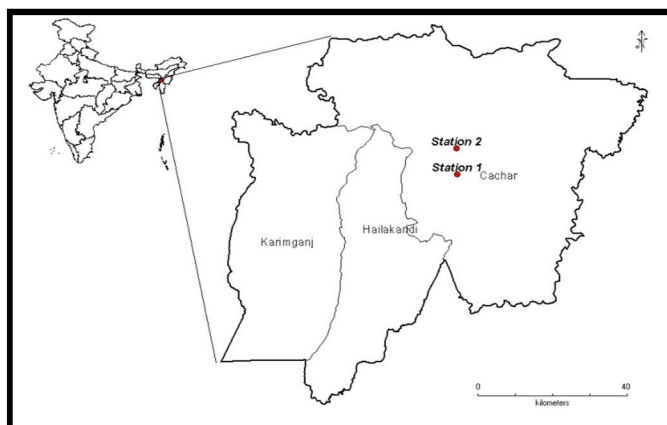


Fig. 1 Map of the study area and sampling stations

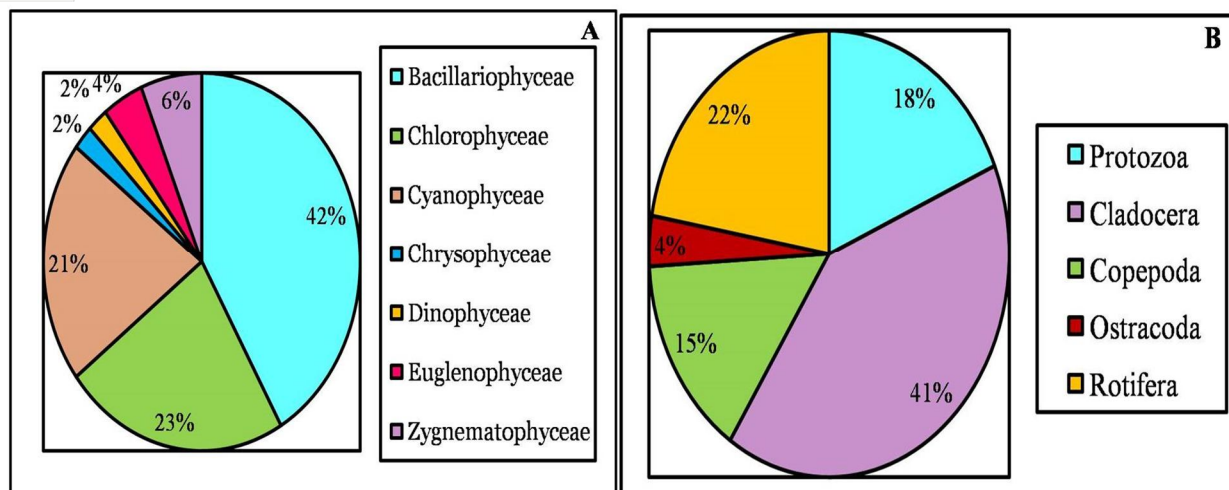


Fig. 2 Class representation of phytoplankton communities (A) and group representation of zooplankton communities (B) in aquatic bodies near the brick kiln area

Table 1. Physico-chemical properties of water in aquatic bodies near the brick kiln area

| Parameter                                   | Mean $\pm$ SD     | Range   |         |
|---|-------------------|---------|---------|
|   |                   | Minimum | Maximum |
| Air temperature ( $^{\circ}\text{C}$ )      | 29.07 $\pm$ 5.13  | 22.50   | 38.08   |
| Water temperature ( $^{\circ}\text{C}$ )    | 29.08 $\pm$ 4.51  | 22.33   | 37.67   |
| Sediment Temperature ( $^{\circ}\text{C}$ ) | 27.80 $\pm$ 4.99  | 22.68   | 34.92   |
| Transparency (m)                            | Turbid            | -       | -       |
| Water depth (m)                             | 0.59 $\pm$ 0.26   | 0.32    | 1.04    |
| pH  | 5.65 $\pm$ 0.66   | 4.57    | 6.37    |
| Electrical conductivity ( $\mu\text{S}$ )   | 92.80 $\pm$ 48.29 | 32.13   | 190.75  |
| Total alkalinity ( $\text{mg l}^{-1}$ )     | 18.50 $\pm$ 9.06  | 5.00    | 32.00   |
| Dissolved oxygen ( $\text{mg l}^{-1}$ )     | 7.09 $\pm$ 1.31   | 4.31    | 8.99    |
| Biological oxygen demand                    | 3.69 $\pm$ 1.70   | 0.94    | 4.50    |
| Free carbon dioxide ( $\text{mg l}^{-1}$ )  | 14.71 $\pm$ 9.16  | 2.66    | 32.44   |
| Total hardness ( $\text{mg l}^{-1}$ )       | 61.10 $\pm$ 33.38 | 23.17   | 106.00  |
| Nitrate-N ( $\text{mg l}^{-1}$ )            | 2.71 $\pm$ 1.95   | 0.32    | 6.51    |
| Phosphate -P ( $\text{mg l}^{-1}$ )         | 0.07 $\pm$ 0.06   | 0.01    | 0.23    |

Mean  $\pm$  SD; n=24

Table 2. List of plankton found in aquatic bodies near the brick kiln area

| Phytoplankton<br>(Total genera=48) | Class             | Genera   |
|------------------------------------|-------------------|--|
|                                    | Bacillariophyceae | Achnanthes spp., Amphora spp., Aulacoseira sp. Cyclotella spp., Cymbella sp., Diatoma spp., Enotia spp., Epithemia spp., Fragilaria sp., Frustulia spp., Gomphonema spp., Gyrosigma sp. Melosira spp., Meridion spp., Navicula spp., Nitzschia spp., Pinnularia spp., Surirella spp, Synedra spp, Tabellaria spp |
|                                    | Total genera      | 20   |
|                                    | Chlorophyceae     | Ankistrodesmus spp, Chlorella spp., Chlamydomonas sp., Docidium sp., Microspora sp., Oedogonium sp., Oocystis sp., Pediastrum spp., Spirogyra spp. , Staurastrum spp., Tetraedron spp.   |
|                                    | Total genera      | 11   |

|                                  |                  |  |
|----------------------------------|------------------|--|
|                                  | Cyanophyceae     | Anabaena sp., Anacystis sp., Nostoc sp., Oscillatoria spp., Lyngbya sp., Hydrodictyon sp., Synechococcus sp., Microcystis spp., Merismopedia spp, Spirulina sp., Cryptomonas sp. |
|                                  | Total genera     | 10   |
|                                  | Chrysophyceae    | Cryptomonas sp.  |
|                                  | Total genera     | 1  |
|                                  | Dinophyceae      | Peridinium sp.   |
|                                  | Total genera     | 1  |
|                                  | Euglenophyceae   | Euglena spp., Trachelomonas spp.   |
|                                  | Total genera     | 2  |
|                                  | Zygnematophyceae | Pleurotaenium sp., Desmidium spp., Zygnema sp  |
|                                  | Total genera     | 3  |
| Zooplankton<br>(Total genera=27) | Group            | Genera   |
|                                  | Protozoa         | Arcella sp., Diffugia spp., Centropyxis spp., Trinema spp., Euglypha sp.   |
|                                  | Total genera     | 5  |
|                                  | Cladocera        | Alona sp., Alonella sp., Bosmina spp., Diaphanosoma sp. , Ceriodaphnia sp., Simocephalous sp., Nauplius larva, Macrothrix sp., Chydorus spp., Diaptomus spp., Moina sp.          |
|                                  | Total genera     | 11   |
|                                  | Copepoda         | Cyclops spp., Copepod nauplii, Calanus sp., Bryocamptus sp.  |
|                                  | Total genera     | 4  |
|                                  | Ostracoda        | Cypris sp.   |
|                                  | Total genera     | 1  |
|                                  | Rotifera         | Lacane spp., Monostyla sp., Asplanchna spp., Brachionus spp., Plationus sp., Filinia sp.   |
|                                  | Total genera     | 6  |

Table 3. Principal component analyses showing rotated component matrix for physico-chemical properties of waterIn aquatic bodies near the brick kiln area

| Rotated component matrix |                          | PC1   | PC2   | PC3   | PC4   | PC5   |
|--------------------------|--------------------------|-------|-------|-------|-------|-------|
| Loading score            | Water temperature        | 0.05  | 0.84  | 0.13  | 0.37  | 0.15  |
|                          | Water depth              | -0.03 | 0.84  | 0.03  | -0.09 | -0.05 |
|                          | pH                       | 0.70  | -0.28 | 0.12  | -0.14 | -0.11 |
|                          | Electrical conductivity  | -0.26 | 0.10  | -0.07 | -0.19 | 0.87  |
|                          | Total alkalinity         | 0.78  | 0.28  | 0.15  | -0.09 | -0.12 |
|                          | Dissolved oxygen         | 0.62  | -0.12 | 0.00  | 0.36  | 0.55  |
|                          | Biological oxygen demand | 0.03  | 0.21  | 0.92  | -0.09 | -0.10 |
|                          | Free carbon dioxide      | 0.05  | -0.11 | 0.82  | 0.46  | 0.04  |
|                          | Total hardness           | 0.79  | 0.24  | -0.05 | 0.18  | -0.24 |
|                          | Nitrate-N                | 0.18  | -0.15 | -0.13 | -0.91 | 0.14  |
|                          | Phosphate-P              | -0.76 | 0.18  | 0.10  | 0.23  | -0.10 |
| Eigen value              |                          | 2.74  | 1.77  | 1.61  | 1.47  | 1.20  |
| % of Variance            |                          | 24.94 | 16.12 | 14.66 | 13.39 | 10.95 |
| Cumulative %             |                          | 24.94 | 41.05 | 55.71 | 69.10 | 80.06 |



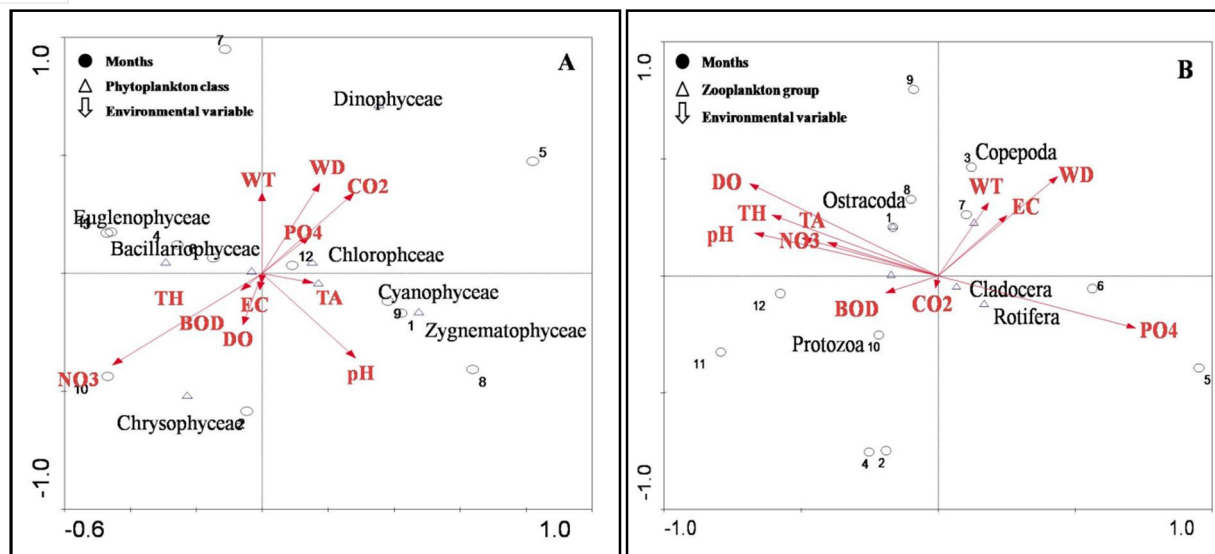


Fig. 3 Canonical correspondence analysis (CCA) based on environmental variables with phytoplankton (A) and zooplankton (B) communities in aquatic bodies near the brick kiln area.

WT- Water temperature; WD-Water depth; EC-Electrical conductivity; DO- Dissolved oxygen; BOD- Biological oxygen demand; TA-Total alkalinity; TH-Total hardness; CO<sub>2</sub>-Free carbon dioxide; NO<sub>3</sub>-N-Available nitrogen; PO<sub>4</sub>-Available phosphorous



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