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Assessing the feasibility of converting waterbodies in abandoned brick kiln industry areas into culture fishery systems

Tapati Das*, Poppy Rajbongshi and Prema Khan

Department of Ecology and Environmental Science, Assam University, Silchar 788 011, India

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ABSTRACT

Population growth and increasing affluence and the resultant demand for more building materials such as bricks is negatively affecting our environment. Brick industries affect the productivity of agricultural lands through extraction of huge amount of top soil for making bricks. In Asian countries like India and Bangladesh, agricultural land is generally given on lease by poor farmers to the brick manufacturers for a particular duration of time, generally 5 to 10 years. After the lease period, the used land is returned to the farmer in a deformed and unproductive state with numerous holes and pits. During rainy season, these depressions accumulate runoff water. Such waterbodies may be converted into productive ecosystems, which can perform important ecological functions and contribute to livelihood and income generation for the poor farmers. With this contention the present study was undertaken to assess the feasibility of converting aquatic bodies in abandoned brick kiln industry into culture fishery system. For the study, we selected a total of six ponds. Of these, four ponds were in abandoned brick kiln industry areas and two fish ponds were near human settlement. Standard methods for analysis of physico-chemical and biological parameters of water in such ponds followed by standard statistical analyses of the collected data were adopted for the study. The study showed that water properties in aquatic bodies in abandoned brick kiln industry are characterized by certain typical conditions particularly due to their surrounding land use type. The study revealed that such waterbodies may be utilized as fish ponds with appropriate management interventions. The study indicates the necessity for long-term and detailed ecological studies of such abandoned systems. The study also recommends investigation on prospects of aquaculture particularly, culturing air breathing fishes.

***Key words**: Restoration, Brick kiln industry, Water bodies, Fish ponds*

Introduction

Population growth and increasing affluence and urbanization demand for building materials such as bricks. It may be noted here that mostly fertile topsoil of agricultural land is used for making bricks (Jeet *et al*., 2021). This lead to change in the land use pattern from productive agricultural land into unproductive degraded lands, and in extreme cases, generation of waste lands (Kathuria and Balasubramanian *et al*., 2013). In context of Asian countries like India and Bangladesh, it may be mentioned here that agricultural land is generally given on lease mostly by the economically weak section of farmers to the brick manufacturers for a particular duration of time, generally 5 to 10 years, (Biswas, 2018). It has been observed that after completion of the lease period, the land is returned to the farmer in a deformed and unproductive state with numerous holes and pits. During rainy season, these depressions accumulate runoff water and get converted into small aquatic systems. We hypothesize that such water bodies in the abandoned brick kiln industries may be converted to productive ecosystems, which can perform important ecological functions and at the same time contribute to livelihood and income generation for the poor farmers. With this contention, the present study is undertaken to assess the feasibility of converting such waterbodies in the abandoned brick kiln industries into culture fishery system. By evaluating the potential of these waterbodies as fish ponds, the study aims to provide a sustainable solution for rehabilitating degraded land and supporting the livelihoods of farmers in the region.

Materials and Methods

Study area

The study area is located in Cachar district, Assam, North-east India. Three distinctive aquatic systems viz., (i) water bodies in abandoned brick kiln area with human settlement (2 nos.), (ii) water bodies in abandoned brick kiln area without human settlement (2 nos.) and (iii) fish ponds located near households with different disturbances/human interventions (2 nos.) were selected for sample collection (Figure 1 and, Tables 1 and 2).

Collection and analysis of water sample

Water samples were collected from the sampling stations (ponds) during dry phase (before the onset of monsoon) comprising the months, February and March of 2018, at fortnightly intervals (n=24). Sampling was done during the dry phase in order to identify the dominant characteristics of the selected ponds after the runoff from their respective catchments is retained in such systems for a considerable period. Air (AT), water (WT) and sediment (ST) temperatures were measured in situ with the help of a mercury bulb thermometer (0-50°C). In situ measurement of transparency (Trans) was done using Secchi disk. Measurement of water depth (WD) was done using a measuring pole. 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 of the pond water, the samples were taken in PVC bottles and were brought to laboratory. pH, electrical conductivity (EC) and total dissolved solid (TDS) of the water samples were recorded using pH meter (make: Systronics; model: 103621), conductivity and TDS meter (make: ESICO; model: 1601) respectively. Other parameters like total hardness as $CaCO_3$ (TH), total alkalinity (TA), free carbon dioxide (FCO_2), dissolved oxygen (DO), biological oxygen demand (BOD), nitrate-nitrogen (NO_3-N), and phosphate-P (PO_4-P) were estimated following APHA (2012).

For estimating the phytoplankton biomass (PB), 30 liters of water were collected from different regions of each of the selected ponds (sites) and passed through plankton net (mesh size of 40µm) which were immediately brought to the laboratory for the determination of chlorophyll-a following standard method (APHA, 2012). Later, the phytoplankton biomass was estimated using the following formula:

Phytoplankton biomass (mg l^{-1}) = Chlorophyll-a x 67 (APHA, 2012)

Collection and analysis of zooplankton sample

For analyzing the zooplankton communities in the sampling stations, 30 liters water sample were taken from different areas of each sampling stations (ponds) 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 2 ml formalin (4%) which were later brought to the laboratory. In the laboratory, further concentration of the plankton samples was done by centrifugation at 2000 rpm for 10 minutes which resulted in the settling down of the plankton at the bottom of the centrifuge tube. These samples were collected in a separate vial after carefully 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 count by finding out the volume of one drop of the concentrated plankton sample. Identification of zooplankton was done by taking one drop of the concentrated plankton sample on a glass slide and looking through binocular microscope (Olympus, Model B-2). Likewise, a total of 10 drops were considered for the qualitative and quantitative estimations of the zooplankton from each sampling station after every sample collection. Microscopic identification of zooplankton was done at 10X magnification. Identification of zooplankton was performed using standard keys and monographs of Ward and Whipple (1959), Needham and Needham (1972), Tonapi (1980), Battish (1992), Shiel (1995), and Dutta (2011). Quantification of the zooplankton was done using Lackey's drop method (Lackey, 1938).

Statistical analysis

Data obtained were tested for normality by means of Shapiro-Wilk Test (Shapiro and Wilk, 1965) using SPSS software version 20. As the data obtained for water parameter showed normal distribution, one-way analysis of variance (one-way ANOVA) and Principal component analysis (PCA) was performed using SPSS, version 20 (Nie *et al*., 2011). Biplot showing group wise PCA for water parameters was performed using PAST, ver. 4.10 (Hammer *et al*., 2012). As the data for zooplankton communities was not normally distributed, Kruskal-Wallis test was performed using SPSS, version 20. Canonical correspondence analysis (CCA) was done using CANOCO, Trial version 4.5 (Ter Braak, 2002).

Results and Discussion

The geographic coordinates and morphometric parameters of different ponds in three distinctive lentic systems of the study area showed that the parameters varied from one sampling station to the other (Table 1). Human interferences like bathing, washing clothes, fishing etc. were observed in all the systems which varied from one station (pond) to the other and it was found to be highest in sampling stations under system 3 (Table 2).

Disturbances can radically alter trajectories of ecosystem function which might lead to unpredictable ecosystem responses (Buma, 2015). In context of brick kiln industry, it may be mentioned here that in the process of making bricks the otherwise productive agricultural land gets converted into degraded land due to removal of the fertile top soil required for brick making. Moreover, quarrying of soil lead to formation of depressions of different sizes and depths which get filled-up with rain water through runoff during the rainy season. When we analyzed the various properties of the accumulated water in such man-made water bodies (comprising the water bodies in the abandoned brick kiln area and the nearby fish ponds) we observed significant variations in water depth, total dissolved solid, electrical conductivity, and dissolved oxygen amongst the three distinctive types of the selected lentic systems (Table 3). These variations were characterized by heterogeneous environment of the study area which has been due to diverse human activities in and around such systems (Table 2).

PCA for the physico-chemical properties of water in ponds under three distinctive lentic systems depicted 4 significant principal components for each system where, 96.26% of the total variance was explained in system 1, 97.81% in system 2 and 95.12% in system 3 (Table 4). The PCA results showed that in system 1, the characteristics of the water properties were mainly due to the dominant role of WD, TDS, EC, FCO_2, NO_3-N followed by ST, TH, TA, DO, pH, BOD, PO_4-P, WT and Trans. In system 2, the characteristics of the water properties were mainly due to the dominant role of WT, ST, TDS, EC, TH, BOD followed by WD, pH, NO_3-N, Trans, and PO_4-P. In system 3, the dominant characteristics of its water were due to WD, TDS, EC, DO followed by WT, TH, BOD, ST, TA, FCO_2, NO_3-N and PO_4-P.

Group-wise PCA (Figure 2) revealed that water pH was closely associated with the first axis and AT and BOD were closely associated with the second axis which all together explained 99.99 percent of the total variance in the dataset thereby indicating that these environmental factors played significant

Table 1. Geographic coordinates and morphometric parameters of different ponds under three distinctive lentic systems in the study area

Parameters	Ponds near brick kiln area 1 (System 1)		Ponds near brick kiln area 2 (System 2)		Fish ponds near human settlement (System 3)	
	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6
Latitude	24°44.687′N	24°44.697′N	24°43.197′N	24°43.300′N	24°41.427′N	24°41.105′N
Longitude	92°47.731′E	92°47.916′E	92°48.101′E	92°48.216′E	92°44.610′E	92°44.513′E
Length (m)	25.42	22.12	24.35	29.48	19.67	20.86
Breadth (m)	19.05	19.87	18.72	18.58	15.89	17.32
Area (m^2)	484.25	439.52	455.83	547.74	312.56	361.29

role in creating the overall variations amongst the selected aquatic systems. There was overlapping of the polygons for system 1 and system 2 while, the polygon related to system 3 was located separately in the ordination plot (Figure 2). Partial overlapping of the polygons for system 1 and system 2 indicates some similarity in the water properties of these ponds/waterbodies as these ponds are located in abandoned brick kiln area while a separation of the polygon related to system 3 indicate a different habitat condition as the ponds under this system are located near human habitation which were undergoing various human interventions including fish culture. All these observations therefore reveal that

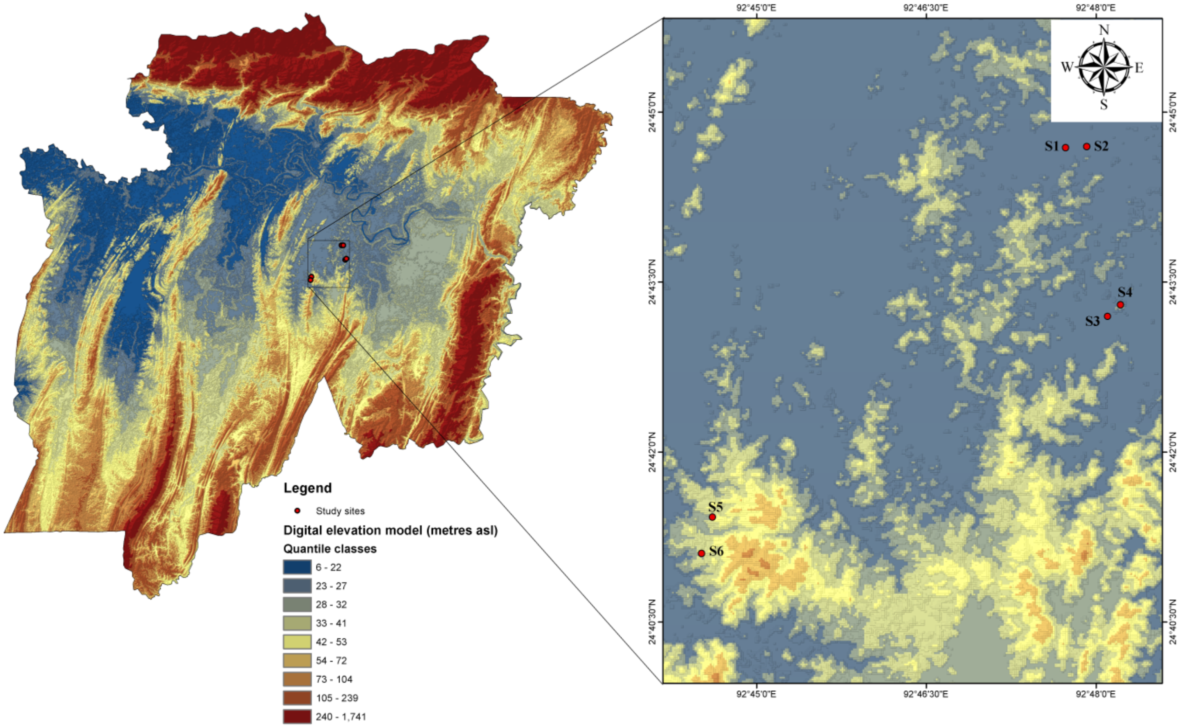

Fig. 1. Map of study area and sampling locations in Barak valley, Assam (S1 and S2 - Ponds near brick kiln area 1 (System 1); S3 and S4 - Pond's near brick kiln area 2 (System 2); S5 and S6 - Fish ponds near human settlement (System 3)

Table 2. General features and/or disturbances in the study area

Common features and/or disturbances	Ponds near brick kiln area 1 (System 1)		Ponds near brick kiln area 2 (System 2)		Fish ponds near human settlement (System 3)	
	Site 1 (Pond 1)	Site 2 (Pond 2)	Site 3 (Pond 3)	Site 4 (Pond 4)	Site 5 (Pond 5)	Site 6 (Pond 6)
Vegetation around the riparian zone of the selected pond	***	**	**	**	**	***
Human settlement near the pond	*	*	-	-	***	***
Presence of aquatic macrophytes	**	***	**	**	***	**
Human bathing	**	*	-	-	-	*
Washing clothes, utensils, and vehicles in the pond	***	**	-	**	**	**
Cattle grazing in the riparian zone	***	*	-	-	*	-
Fish stocked	-	-	-	-	**	***
Supplementation of fish feed	-	-	-	-	**	***
Applying fertilizer in the pond for fish culture	-	-	-	-	**	***

Disturbance score: '-' indicates absence, '*' indicates less, '**' indicates moderate, '***' indicates high following Sunil *et al.*, 2011 aquatic bodies are impacted by the surrounding catchment area and the adjacent riparian region (Rajbongshi *et al.*, 2018). However, the direct effect of anthropogenic intervention within the systems like bathing, washing clothes and utensils, and culture of fish also play a major role in impacting the aquatic environment (Figure 2), and the existing aquatic communities (Table 5).

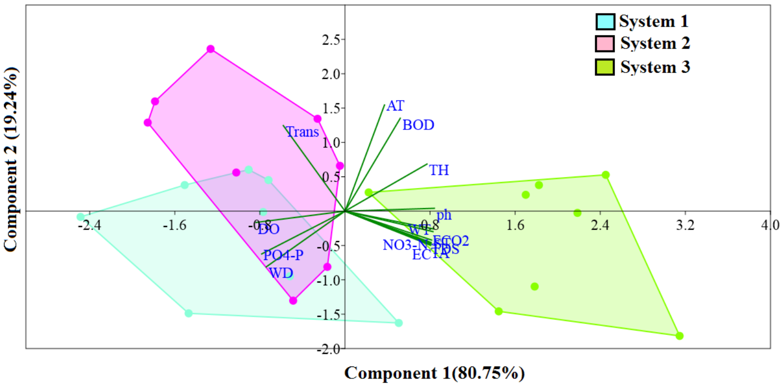

Fig. 2. Group-wise PCA for water parameters in ponds under three distinctive lentic systems of the study area
System 1- Ponds near brick kiln area 1; System 2-Ponds near brick kiln area 2; System 3- Fish ponds near human settlement
AT- Air temperature; WT- Water temperature; WD- Water depth; Trans- Water transparency; TDS- Total dissolves solid, pH- pH of water; EC-Electrical conductivity; TA- Total alkalinity; FCO$_2$- Free carbon dioxide; TH- Total hardness; DO- Dissolved oxygen; BOD- Biological oxygen demand; NO$_3$-N-Nitrate-N; PO$_4$-P- Phosphate-P;PB- Phytoplankton biomass

Table 3. Physico-chemical and biological properties of water in ponds under three distinctive lentic systems of the study area and one-way ANOVA with systems as the main effect variables and the various standards of water properties for freshwater fishery

Parameter	Ponds near brick kiln area 1 (System 1)	Ponds near brick kiln area 2 (System 2)	Fish ponds near human settlement (System 3)	F-ratio	Standard water properties for fresh water fishery (Das *et al.*, 2015)
AT (°C)	22.99±2.91	24.90±5.91	24.53±4.97	0.362^{ns}	-
WT (°C)	22.96±2.73	22.88±2.00	25.08±3.40	1.633^{ns}	25°-32 °C
ST (°C)	23.30±2.67	22.88±1.85	25.46±3.33	2.128^{ns}	-
WD (cm)	84.17±27.93	57.29±28.32	37.33±12.03	7.677*	-
Trans (cm)	31.56±7.20	37.81±15.47	28.14±7.96	1.220^{ns}	-
TDS (mg^{-1})	210.30±31.84	196.07±38.00	297.75±96.03	6.230*	-
pH	5.95±0.45	6.03±0.60	6.45±0.94	1.211^{ns}	6.5-8.5[a]5-9 ([a]Alabester *et al.*, 1980)
EC (μScm^{-1})	401.93±73.57	369.35±92.72	545.22±127.71	6.929*	-
TH (mgl^{-1})	111.67±21.41	118.58±38.68	125.42±30.59	0.392^{ns}	-
TA (mgl^{-1})	29.50±19.05	26.42±12.98	44.42±22.00	2.191^{ns}	-
FCO$_2$ (mgl^{-1})	8.03±1.87	7.73±3.20	12.35±6.06	3.184^{ns}	-
DO (mgl^{-1})	2.33±0.43	2.32±0.39	5.86±0.43	192.780*	5.0-10.0
BOD at 20 °C For 3 days (mgl^{-1})	3.86±4.75	4.87±5.69	4.90±4.38	0.114^{ns}	<10
NO$_3$-N (mgl^{-1})	0.15±0.18	0.11±0.08	0.32±0.32	1.940^{ns}	0.1 to 3.0
PO$_4$ –P (mgl^{-1})	0.07±0.07	0.06±0.03	0.04±0.02	0.870^{ns}	0.05 to 2.0
PB(x10^{-4}mgl^{-1})	15±18	29±30	16±18	0.932^{ns}	-

Mean ± SD; n=24; Degree of freedom (n-1) =2;* $p<0.01$; ns=non-significant
WT- Water temperature; WD- Water depth; Trans- Transparency; TDS- Total dissolve solid, EC-Electrical conductivity; TA-Total alkalinity; FCO$_2$-Free carbon dioxide; TH-Total hardness as CaCO$_3$; DO-Dissolved oxygen; BOD-Biological oxygen demand; NO$_3$-N-Nitrate-N; PO$_4$-P-Phosphate-P; PB-Phytoplankton biomass

Analyses on the distribution and density of zooplankton in the selected systems revealed a total of 19 genera of zooplankton belonging to 6 groups viz., Bryozoa, Protozoa, Cladocera, Copepoda, Ostracoda and Rotifera (Table 5). Generic richness of the existing zooplankton was highest in system 2 (19) followed by system 1 (17) and system 3 (15). Cladocera and Copepoda were the dominant zooplankton groups in system 1. Amongst the zooplankton genera, *Chydorus*, *Diaptomu*s, *Moina*, and *Limnocalanus* were significantly more in the ponds/ water bodies located in the brick kiln areas (system 1 and system 2) while, *Lacane* showed significantly greater density in the fish ponds (system 3) (Table 5). All the zooplankton genera were not uniformly distributed across all the selected aquatic bodies which can be attributed to differences in physico-chemical properties of water across the selected aquatic bodies (Crevecoeur *et al*., 2015). Few zooplankton genera were exclusively present/absent in the selected aquatic systems (for example, presence of *Alona* and *Diaphanosoma* in system 2; absence of *Simocephalous and Asplanchna* in system 3). This suggests that the various zooplankton genera respond differently based on differences in internal ecological conditions, predation effects, trophic levels, and abiotic factors in the systems (Sgarzi *et al*., 2019). Phytoplankton biomass and most of the zooplankton genera were dominant either in system 1 or system 2, which are the ponds located in the brick kiln industry. This indicates presence of favorable food and organic matters and inorganic substances for certain zooplankton group to flourish (Sterner, 2009; Sipaúba-Tavares *et al*., 2011; Wilk Wozniak *et al*., 2014; Gayosso-Morales *et al*., 2017; Yin *et al*., 2018) in such systems. This also indicate the availability of live fish food in water bodies located in abandoned brick kiln industry much like in nearby fish ponds.

CCA revealed that relationship between zooplankton community and the micro-environmental variables varied across the three distinct lentic systems (Figure 3). In system 1, WD, PO_4-P and DO were closely associated with the dominance of zooplankton belonging to the group Copepoda. In system 2, Trans. showed closed association with Ostracoda. In system 3, pH, TH, BOD, TA, NO_3-N, TDS, and ST showed close association with Rotifera and Bryozoa. On the other hand, WT, FCO_2, and EC of water showed close association with Protozoa and Cladocera in general across the three distinctive lentic systems (Figure 3).

Table 4. Loading of variables on principal components rotated according to the varimax method for physico-chemical properties of water in ponds under three distinctive lentic systems of the study area

Water properties		System 1				System 2				System 3			
		VF1	VF2	VF3	VF4	VF1	VF2	VF3	VF4	VF1	VF2	VF3	VF4
Loading scores	Water temperature (WT)	0.03	-0.22	-0.24	**0.85***	**0.73***	0.63	-0.13	-0.07	0.20	**-0.88***	0.32	0.29
	Sediment temperature (ST)	0.09	**-0.97***	-0.16	0.13	**0.74***	0.66	-0.06	-0.12	-0.03	-0.17	**0.90***	0.37
	Water depth (WD)	**0.92***	0.37	-0.02	-0.10	0.12	**-0.92***	0.12	0.15	**-0.73***	0.65	0.05	-0.11
	Transparency (Trans)	-0.30	-0.15	-0.13	**-0.88***	0.16	0.10	-0.13	**0.97***	**-0.71**	0.61	0.17	-0.12
	Total dissolved solid (TDS)	**0.94***	0.01	0.02	0.30	**0.96***	-0.26	-0.10	0.01	**0.99***	0.03	0.05	-0.03
	pH	0.11	-0.15	**-0.96***	0.12	0.09	**0.93***	0.23	0.27	-0.43	-0.63	0.02	0.35
	Electrical conductivity (EC)	**0.97***	-0.15	0.04	0.12	**0.97***	-0.14	0.10	-0.11	**0.99***	-0.04	0.13	-0.07
	Total hardness (TH)	0.19	**0.97***	-0.11	0.09	**-0.95***	-0.29	-0.12	0.06	0.06	**0.76***	-0.64	0.10
	Total alkalinity (TA)	-0.18	**0.98***	-0.04	-0.08	-0.64	-0.19	0.67	-0.27	0.08	0.48	**-0.85***	0.20
	Free carbon dioxide (FCO_2)	**0.80***	-0.19	0.05	0.43	0.60	-0.38	0.65	-0.16	0.06	0.06	**0.86***	-0.39
	Dissolved oxygen (DO)	-0.57	**0.74***	0.37	-0.02	-0.55	0.42	-0.44	0.57	**0.98***	0.05	-0.13	-0.03
	Biological oxygen Demand (BOD)	0.11	0.69	**0.70***	-0.01	**-0.98***	-0.13	0.06	0.03	-0.09	**0.84***	-0.32	0.34
	Nitrate-N (NO_3-N)	**0.88***	-0.24	0.42	-0.01	-0.04	0.20	**0.97***	-0.12	0.36	0.19	-0.48	**0.77***
	Phosphate-P (PO_4-P)	0.42	-0.15	**0.87***	0.03	0.50	0.32	0.16	**-0.77***	-0.18	-0.16	0.03	**0.95***
Eigen value		4.80	4.23	2.60	1.85	6.19	3.24	2.18	2.09	4.36	3.58	3.19	2.19
% of variance		34.27	30.21	18.55	13.23	44.23	23.11	15.54	14.93	31.18	25.54	22.79	15.61
% of Cumulative variance		34.27	64.48	83.03	**96.26****	44.23	67.34	82.88	**97.81****	31.18	56.72	79.51	95.12**

VF, Variance factor; bold values with * indicate strong loading and bold values with ** indicate total variance in the data set

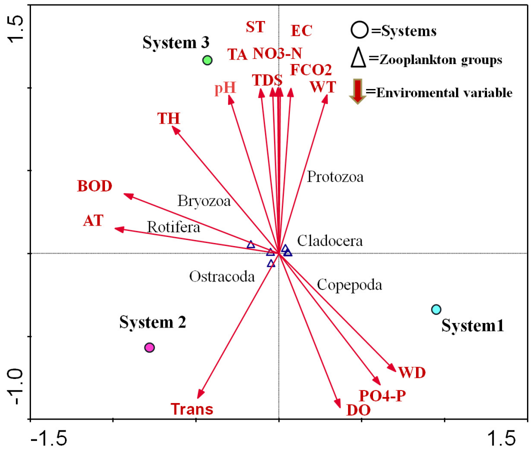

Fig. 3. Canonical correspondence analysis (CCA) based on environmental variables and zooplankton communities in three distinctive lentic systems of the study area

System 1- Ponds near brick kiln area 1; System 2- Ponds near brick kiln area 2; System 3- Fish ponds near human settlement WT- Water temperature; WD- Water depth; Trans-Transparency of water; TDS- Total dissolve solid; pH- pH of water; EC- Electrical conductivity; TA- Total alkalinity; FCO_2- Free carbon dioxide; TH- Total hardness; DO- Dissolved oxygen; BOD- Biological oxygen demand; NO_3-N-Nitrate-N; PO_4-P-Phosphate-P

When we compared the water properties of the ponds located in the abandoned brick kiln areas with standard water properties for fresh water fishery (Alabester *et al.*, 2013; Das *et al.*, 2015), we observed that the water parameters, apart from dissolved oxygen (DO), were within the acceptable range for fish culture. Nevertheless, culture of locally available air-breathing fishes like *Anabas testudineus*, *Clarias batrachus*, *Clarias magur*, *Channa orientalis*, and *Heteropneustes fossilis* can serve as a viable option for effective management of such aquatic bodies characterized by low dissolved oxygen levels and converting such deformed systems into high-output productive systems. In this context, it may be mentioned here that some aquaculture experts suggested that the minimal requirement of DO in aquaculture systems for raising air breathing fishes should be 3 mg l^{-1} (Boyd *et al.*, 2018). However, other group of aquaculture experts suggested that certain air breathing fishes can be raised in aquatic environment with DO much below 3 mg l^{-1} (Torrans *et al.*, 2015). In context of the present study, it may be mentioned here that as the present observation is based on a short-term analysis, a more de-

Table 5. Distribution and density of zooplankton (number of individuals l^{-1}) in ponds under three distinctive lentic systems of the study area and Chi square values with systems as the main effect variables

Group	Taxa	Ponds near brick kiln area 1 (System 1)	Ponds near brick kiln area 2 (System 2)	Fish ponds near human settlement (System 3)	Chi-square value (χ^2)
Bryozoa	*Plumatella*	1.04±2.95	3.47±7.08	3.125±6.20	2.038^{ns}
Protozoa	*Arcella*	12.19±15.42	4.17±11.79	15.14±15.61	1.21 ^{ns}
	Difflugia	6.34±7.02	10.82±15.03	6.34±5.42	1.76 ^{ns}
	Mean	**9.26±4.14**	**7.50±4.71**	**1.74±6.22**	
Cladocera	*Alona*	-	1.74±4.91	-	1.00 ^{ns}
	Bosmina	107.38±162.51	54.97±58.45	97.38±165.68	2.55 ^{ns}
	Diaphanosoma	-	2.08±5.89	-	1.00 ^{ns}
	Ceriodaphnia	3.13±6.20	4.17±7.72	1.04±2.95	0.89 ^{ns}
	Simocephalous	1.04±2.95	7.29±20.62	-	0.91 ^{ns}
	Chydorus	5.73±8.61	15.35±22.26	6.56±8.05	3.28*
	Diaptomus	29.32±19.53	19.27±16.13	23.33±22.55	4.50**
	Moina	60.10±129.07	23.75±36.24	25.52±20.60	3.21*
	Mean	**33.78 ±43.66**	**19.39 ±19.34**	**24.03±32.32**	
Copepoda	*Cyclops*	97.34±99.52	45.88±57.70	62.41±41.52	2.66 ^{ns}
	Limnocalanus	6.56±11.24	9.20±8.56	7.08±10.76	3.04 *
	Nauplii larvae of *Cyclops*	31.11±24.72	17.20±10.23	24.76±16.40	1.37 ^{ns}
	Mean	**25.12 ±16.40**	**17.60 ±8.61**	**21.23±12.75**	
Ostracoda	*Cypris*	9.03±9.90	20.59±34.60	9.03±8.27	1.80 ^{ns}
Rotifera	*Lacane*	3.39±6.29	2.43±4.56	5.47±7.63	4.86**
	Asplanchna	10.94±18.46	9.38±15.71	-	1.70 ^{ns}
	Brachionus	11.28±11.13	5.82±7.12	11.55±7.71	0.02 ^{ns}
	Keratella	2.34±4.38	7.92±9.36	2.08±3.86	2.52 ^{ns}
	Mean	**6.99 ±4.78**	**6.38 ±3.01**	**4.77±5.05**	
Total density	**398.26±32.25**	**265.49±14.54**	**300.82±24.77**	0.102^{ns}	

mean ± SD; n=24; Degree of freedom (n-1) =2; ** $p<0.01$; '-' indicates absence of the concerned genus in respective system tailed and prolonged ecological investigation of such human-made aquatic systems is required to gather a more comprehensive information on such aquatic systems and determine the optimal approach for their management; for example, providing artificial aeration to increase the DO, and transform such degraded systems into functional and productive ones.

Conclusion

The study showed that water properties of aquatic bodies in abandoned brick kiln industries are characterized by typical conditions due to surrounding land use type. Greater phytoplankton biomass and abundance of cladocerans such as *Chydorus*, *Diaptomus*, and *Moina*, and copepods such as *Cyclops* and *Limnocalanus*, in the aquatic bodies of abandoned brick kiln industry, indicate the potential of such systems to act as fish ponds as these planktonic organisms serve as source of live fish food. Such waterbodies may be utilized as fish ponds particularly for culturing air-breathing/cat fishes with appropriate management interventions, which can perform important ecosystem service and contribute to livelihood and income generation for the poor farmers. The study highlights the need for conducting ecological investigations over an extended period to obtain a more complete understanding of these systems. To establish suitable aquaculture systems in abandoned areas of brick kiln industry, it is necessary to conduct more extensive pilot studies. These studies should aim to determine the most effective management approach, including the selection of compatible fish species, appropriate stocking density, optimal duration of culture period, and consideration of various environmental factors in such systems. Additionally, management interventions should be explored and evaluated to gather the necessary information to initiate such sustainable aquaculture systems.

Conflict of interest statement

The authors declare no conflict of interest.

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