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Autochthonous origin of phosphorus in natural pen culture and artificially managed aquaculture pond of Guwahati, Assam

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Abstract
Seasonal variation of phosphorus was studied in two perennial aquaculture ponds of the Aquaculture and Biodiversity Campus of Zoology Department, Gauhati University, Guwahati, Assam, India. One of the experimental ponds is manually managed with the application of lime and other inorganic and organic fertilizer and the other is a naturally maintained pen culture pond, which is recovered from a part of reed swamp and maintained without addition of any fertilizer. The reclaimed zone of the pen culture pond is separated from the perennial swamp by bamboo screens. The unrecovered zone of pen culture pond is infested with *Phragmites karka.* The pen culture pond is dominated by *Eichhornia crassipes*, which is a free floating macrophyte. In comparison to manually managed pond, macrophytic growth is more and phytoplankton density is less in the natural pen culture pond. Both the ponds maintain acidic profile in soil phase; but manually managed pond maintains higher profile than natural pond. The total and available forms of soil phosphorus of the two ponds show similar trend of seasonal fluctuation with higher profile in natural pond. In water phase, however, it is interesting that the artificial pond maintains higher profile in both the form of phosphorus. Major portion of Phosphorus, which is not available for the water phase especially in natural pond are found to be in bounded form mainly with iron, calcium and aluminium.

Keywords: Total phosphorus, available phosphorus, bound form of phosphorus, artificially managed aquaculture pond, natural pen culture pond.

1. Introduction
The proper growth and survival of an aquaculture system, autotroph (phytoplankton and macrophytes) requires proper nutrients from the pond environment. Occurrences of nutrients in pond water largely depend on the nature and properties of the bottom soil, and hence soils are the most important medium for productivity of a fish farm acting as chemical laboratory of the fish pond (Hickling, 1971) [9]

The primary factors that limit the productivity capacity of a fish pond are the quantity of available nutrients, which are used by the living organism for maintenance and growth of the water body. There are two types of nutrients that are used by photosynthetic organisms. The first one is the non-mineral nutrients, which include carbon (C), Hydrogen (H) and oxygen (O). The second one is mineral nutrients, which are again of two types- macronutrients and micronutrients. Macronutrients are further divided into two categories which include Primary nutrients and Secondary nutrients. On the basis of bio limiting nutrient elements present in fish pond, nitrogen, phosphorus and potassium are regarded as primary nutrients owing to their major role in plant nutrition (Dev, 1995) [4]. Of these phosphorus is considered to be the most important single factor for maintenance of pond fertility (Jhingran, 1975) [10] due to its utmost importance to primary fish food organism and also for occurrence in scanty amount in available form. Phosphorus is important as it helps in the transformation process of solar energy to chemical energy. Moreover, Schindler (1974) opined that phosphorus (P) is the limiting nutrient in freshwater ecosystem.

2. Material and Methods
2.1. Study area
The present work has been conducted in two types of ponds – an artificially managed aquaculture pond (Pond A) and a natural pen culture pond (Pond B) located at Gauhati University Campus, Guwahati, Assam, India ($26\ ^{0}09^{/}26^{//}$ N and longitude of $91\ ^{0}40^{/}21^{//}$ E).

Pond A is triangular in shape with a surface area of 1.4 ha. The Pond A was dewatered in March 2006. After dewatering the Pond A, 40 kg urea, 2500 kg organic manure (wet cowdung) and 50 kg lime were added. The Pond B is rectangular naturally maintained pen culture pond, which is recovered from a part of reed swamp and maintained without addition of any fertilizer. The reclaimed zone of the pen culture pond is separated from the perennial swamp by bamboo screens making the ponds into two parts- a recovered zone, which is 0.5 ha area and an unrecovered zone having a surface area of 2.5 ha. The unrecovered zone of pen culture pond is infested with *Phragmites karka.* In comparison to Pond A, macrophytic growth is more and phytoplankton density is less in the Pond B. Both the ponds are rain fed and perennial.

2.2 Sampling

The present work is based on the studies carried out for a period of 2 years, commencing from Nov, 2007 to Oct, 2009. The water and soil phosphorus were analysed at UGC-SAP (DRS) Phase II water and soil analysis laboratory of the Zoology department of Gauhati University. The literatures followed for analysis were A.P.H.A (1988) and N.E.E.R.I. (1989) [14]. p^H was measured with the help of Ecoscan digital p^H meter. Available phosphorus of water in the form of phosphate was estimated spectrophotometrically after development phosphomolybdic blue colour (Dickman and Bray, 1940) [7]. Stannous chloride was used as the reducing agent in this reaction. This colour was measured at 690 nm using standard solution phosphate of known strength.

All forms of phosphate are converted to soluble inorganic orthophosphate by digestion with perchloric acid and oxidation with sodium hydroxide. In the present investigation a known volume of sample water was evaporated to dryness in 100 ml conical flasks. After cooling 1 ml perchloric acid was added and heated on a hot plate till the residue was colourless. The residue was allowed to cool. After cooling 100 ml distilled water was added. The solution was titrated against 8% NaOH until slight pink colour was restored using phenolphthalein as indicator. With these treatments all forms of phosphate were converted into orthophosphate which was estimated as described earlier in available phosphorus.

Soil available phosphorus was measured after Truog's method using 0.002 N H_2SO_4 as extracting medium. In this process 1.0 gm of soil sample was shaking with 200 ml extracting medium (0.002 N H_2SO_4) for half an hour Total phosphorus was estimated by HCl extraction method after Piper, 1967 [15]. In this process 200 ml concentrated HCl was added to 20 gm soil sample in a conical flask. The mixer was then boiled for an hour on a hot plate. After cooling the mixture was filtered into another conical flask. The residual mixture was then washed a few times with hot 0.5 N HCl. The extract so obtained was made up to 500 ml. Now 5 ml aliquot was taken for estimation of total phosphorus.

3 Result

The total phosphorus (ppm) concentration in the bottom soil of two ponds has been depicted in **Figure-1.** The total phosphorus ranges from 28.57 to 64.29 ppm ($\bar{x}$=41.55±8.94) in Pond A and from 60.71 to 85.71 ppm ($\bar{x}$=72.08±6.99) in Pond B. It is also observed that the concentration of available phosphorus fluctuates between the minimum and maximum from 7.0 to 32.0 ppm ($\bar{x}$=18.07±4.55) and 10.4 to 58.34 ppm ($\bar{x}$=34.89±13.66) in the bottom soil of Pond A and Pond B respectively, which are depicted in Figure-2.

The p^H (H^+ ion concentration) of soil fluctuates between 4.93 and 6.04 in Pond A with an average of 5.4±3.1 and 3.58 and 4.94 in Pond B with an average of 4.34±0.30 (Figure-3).

The available phosphorus in water phase of the two ponds has been depicted in Table-4. The available phosphorus shows a moderate range for both the ponds. The range of available phosphorus of Pond A is almost similar (with an average of 0.045 ± 0.013 having a range of 0.0188 to 0.071 $mg.l^{-1}$) with Pond B (with an average of 0.041 ± 0.0126 and range between 0.0186 and 0.058 $mg.l^{-1}$). The available phosphorus of two ponds shows a similar trend of fluctuation in both the ponds exhibiting an exceptional peak in the month of July, 2008 during experimental period. Indeed, a prominent lean period is observed during late monsoon to early autumn of second year of investigation period.

The phosphorus remains in bound form with metal like iron, calcium and aluminium, which is observed from 10.47 to 40.59 ppm **(**$\bar{x}$=23.48±7.51**)** in Pond A; 16.66 to 63.21 ppm ($\bar{x}$=37.19±14.19) in Pond B (Table-1). However, in Pond A the iron bound phosphorus is 13.24±4.04 and in Pond B, it is 24.19±8.35. The calcium bound portion of phosphorus is 3.58±1.10 and 4.57±1.90 in Pond A and Pond B respectively.

The total phosphorus of water in the studied ponds fluctuates between 0.028 $mg.l^{-1}$ and 0.074 $mg.l^{-1}$ in Pond A and 0.021 $mg.l^{-1}$ and 0.061 $mg.l^{-1}$ in Pond B. The average value of total phosphorus in Pond A and Pond B are 0.051 ± 0.013 and 0.046 ± 0.012 respectively (Figure-4).

Table 1: Nutrients of water and Soil of Pond A and Pond B showing the ranges, averages and Standard Deviation (SD) studied during Nov 2007-Oct 2009

Parameters	Year	Pond	Range	Yearly Average	SD
Total Phosphorus (ppm)	2007-2008	Pond A	28.57 to 64.29	42.85	10.55
	2008-2009		21.43 to 60.71	37.75	10.05
	2007-2008	Pond B	60.71 to 85.71	71.72	7.05
	2008-2009		60.71 to 85.71	72.44	7.22
Available phosphorus (ppm)	2007-2008	Pond A	7 to 32	19.05	5.76
	2008-2009		14.2 to 23.37	17.10	2.84
	2007-2008	Pond B	18.6 to 58.34	37.35	15.44
	2008-2009		10.4 to 55.5	35.77	14.95
Bound Phosphorus in soil (ppm)	2007-2008	Pond A	10.5 to 40.59	24.63	9.02
	2008-2009		15.7 to 37.34	22.32	5.79
	2007-2008	Pond B	16.7 to 63.21	37.71	16.88
	2008-2009		23.07 to 57.43	36.67	11.66
Iron bound Phosphorus in soil (ppm)	2007-2008	Pond A	5.82 to 22.55	13.40	5.06
	2008-2009		8.72 to 20.23	13.08	2.92

	2007-2008 2008-2009	Pond B	13.00 to 41.28 16.29 to 33.49	24.93 23.46	10.30 6.21
Calcium bound Phosphorus in soil (ppm)	2007-2008 2008-2009	Pond A	1.98 to 5.38 1.89 to 6.05	3.75 3.41	1.12 1.11
	2007-2008 2008-2009	Pond B	2.18 to 8.84 2.83 to 7.23	4.76 4.39	2.25 1.55
p^H	2007-2008 2008-2009	Pond A	5.04 to 6.04 4.93 to 5.89	5.47 5.34	0.32 0.29
	2007-2008 2008-2009	Pond B	3.9 to 4.94 3.85 to 4.78	4.4 4.29	0.31 0.29
Total phosphorus of water ($mg.l^{-1}$)	2007-2008 2008-2009	Pond A	0.032 to 0.074 0.028 to 0.071	0.052 0.051	0.013 0.013
	2007-2008 2008-2009	Pond B	0.029 to 0.061 0.021 to 0.061	0.044 0.047	0.01 0.014
Available phosphorus of water ($mg.l^{-1}$)	2007-2008 2008-2009	Pond A	0.0266 to 0.071 0.0188 to 0.065	0.0464 0.045	0.0127 0.0141
	2007-2008 2008-2009	Pond B	0.020 to 0.056 0.0186 to 0.058	0.039 0.043	0.0113 0.014

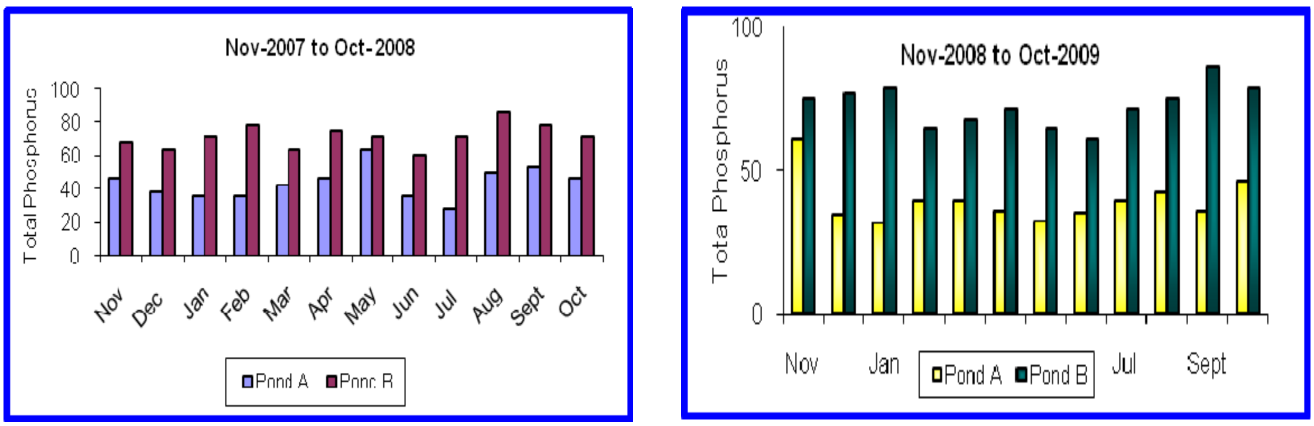


Fig 1: Monthly variation of Total Phosphorus (ppm) of soil in Pond A and Pond B

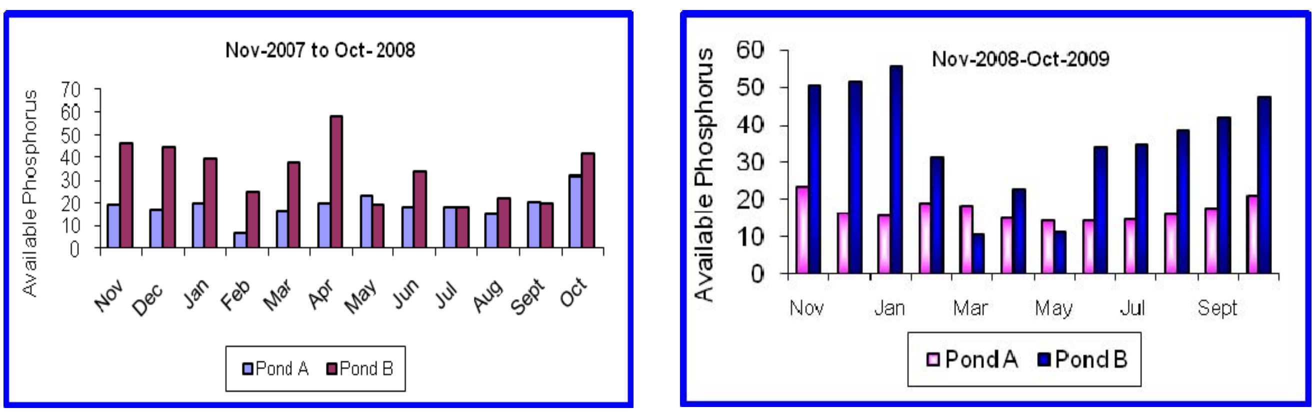


Fig 2: Monthly variation of Available Phosphorus (ppm) of Soil in Pond A and Pond

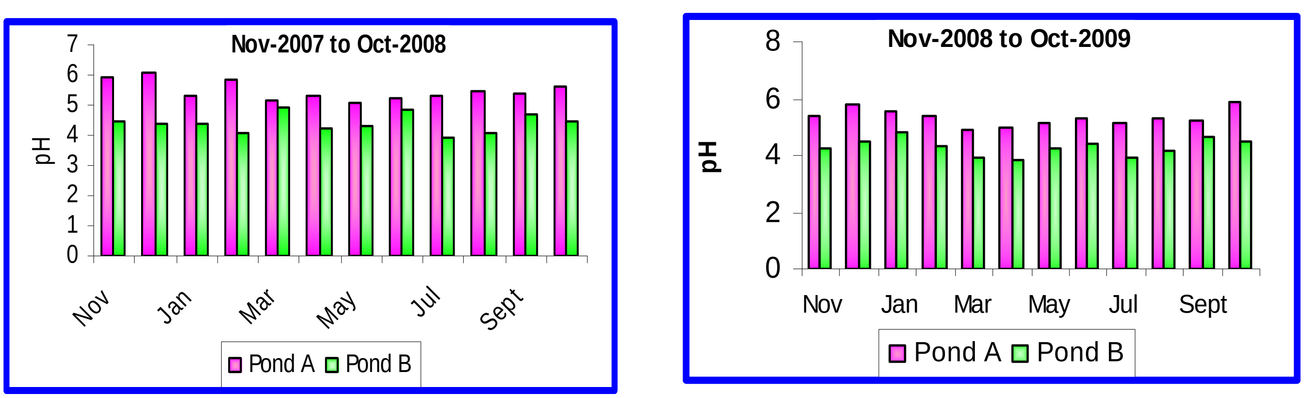
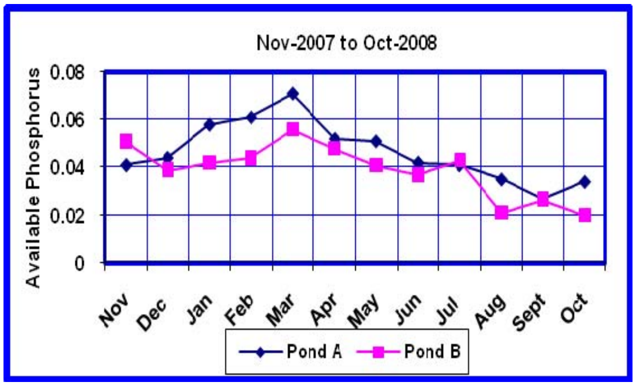


Fig 3: Monthly variation of p^H of soil in Pond A and Pond B



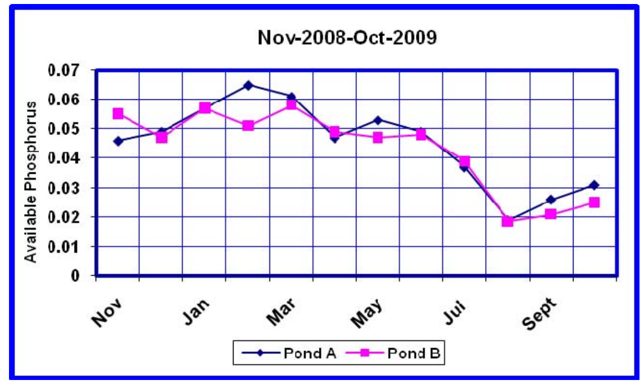


Fig 4: Monthly variation of Available Phosphorus (mg.l^{-1}) of water in Pond A and Pond B

4 Discussion

The exchange of phosphorus between sediments and overlying water is a major pathway of the phosphorus cycle in a natural aquatic ecosystem (Wetzel, 2001) [19]. Phosphorus as orthophosphate ($PO_4^{///}$) in water is one of the major nutrient required by phytoplankton, which is estimated to be less than the normal range (0.1 mg.l^{-1} to 0.2 mg.l^{-1}) as suggested by Sreenivasan, 1965 [17], inspite of enough total phosphorus in soil. The low phosphorus so observed in water (Table-1) is the result of locking up of phosphorus in soil phase at its acidic p^H range (Banerjea and Ghosh, 1970) [3]. Compared to Pond A, the Pond B exhibits the higher value of total phosphorus in soil and the lower ratio of available phosphorus in overlying water. This indicates that there is higher concentration of bound phosphorus of soil in Pond B in comparison to Pond A. The higher concentration of bound phosphorus in Pond B is the result of locking up of phosphorus with iron (Banerjea and Ghosh, 1970) [3] at lower p^H than Pond A. In water phase the available phosphorus content is, however, found to be higher during the month January to May (Figure-4), which may be due to pre monsoon shower (Yadava, 1986; Goswami, 1985) [20, 8] and concomitant release of $PO_4^{///}$ during conversion of insoluble to soluble salts from soil colloids and decomposed organic matter (Saha *et al*., 1971) [16]. Indeed, lower phosphate concentration during the post monsoon period is the result of dilution of waters (Mathew, 1972; Goswami, 1985) [13, 8].

The soil quality of the studied ponds are acidic of which p^H ranges from 4.93 to 6.04 in Pond A and 3.85 to 4.94 in Pond B (Table-1). The ranges of p^H recorded in the studied ponds can be considered at per the normal feature of acidic soil reported from the wetlands of Assam (Banerjea, 1967; Dey 1981; Kar, 1984; Goswami, 1985; Kalita and Goswami, 2006) [2, 6, 8, 11, 12] which is attributed to the production of organic acids from the decomposed organic matter into the basin soil of the ponds.

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