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Changes in sediment chemistry of the *Pangasius* fish ponds in an existing culture system in Mymensingh district, Bangladesh

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Abstract

This investigation was carried out on changes in sediment chemistry of *Pangasius* ponds under existing farming practices in Mymensingh district. The studies were conducted at 15 *Pangasius* ponds on a number of sediment chemistry, over a period of three months from July to August. Sediment chemistry parameters i.e. pH, organic carbon, organic matter, total nitrogen and available phosphorus were analyzed within this period. Sediment chemistry of pond varied with pond age and sediment frequency of removal. It was found that pH value of sediments ranged from 5.92 to 6.76 whereas the concentration of organic carbon fluctuated from 0.86 to 2.52%. Organic matter varied from 1.48 to 3.75%, for total nitrogen concentration from 0.08 to 0.19%, and for phosphorus concentration from 17.58 to 82.9%.Inferentially, apart from phosphorus, others sediment chemistry varied significantly ($p<0.01$) with pond age and frequency of sediment removal. But significant variation was observed in phosphorus only with frequency of sediment removal. Phosphorus value was greater in new pond indicating that primary productivity might be higher. It is concluded that sediment chemistry varied with pond age and sediment removal having wider impacts on primary productivity, pond managementas well as fish production.

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Introduction

Bangladesh is highly populated country; the water resources influence its development and economy. Total amount of fish production is about 25,63, 296 MT whereas aquaculture contributes 10,05,542 MT which is 39% of total production. Now-a-days, *Pangasius* farming is becoming most popular to the farmers and its annual production is 85,869 MT which represent about 5.2% of aquaculture production (DoF, 2009). Aquaculture production has been recognized as the fastest growing animal food production. Aquaculture fulfills 60% of total animal protein of national demand. As Bangladesh achieved the sixth highest position in total inland fish production of the world, this trend will greatly influence the aquaculture practices here (FAO, 2008).Growth and survival, which together determine the ultimate yield, are influenced by a number of ecological parameters and managerial practices. High stocking density of fish in ponds usually exacerbates problems with sediment deterioration. Various waste materials from aquaculture activities (faces and unconsumed feed) first settle in the bottom as a consequence of organic waste and metabolites of degraded organic matter is accumulated in sediment.

Part of the waste is flushed out of the ponds immediately or late after the organic matter has been degraded. This is because large qualities of feed are loaded in ponds, excess feed, fecal matter and then metabolites can cause drastic changes in sediment chemistry which may affect the growth. *Pangasius* farming needs great attention to overcome its difficulties for development and existence of these practices by improving management techniques and by regulating indiscriminate uses of chemical and feeds throughout culture period. If it is possible then these farming practices will be expanded among all area of Bangladesh. Moreover, the sustainable aquaculture particularly for international trade of aquaculture products, sediment chemistry need be maintained at a recommended level (Haque, 2009). Chemistry of bottom sediment is most important factor for farming practices. Sediment has potential impact on production, it is necessary to find out the relationship among them and also with pond age and culture period. Sediment deposit on bottom after a certain period of culture in which decomposed organic materials converted into gases and mineral. Without that, primary production of pond might be hampered. But excess of those matters cause deterioration of pond water quality. It is only the reason for that, measurement of water quality parameters and sediments chemistry are mandatory task for aqua culturist/farmers. The aims of the study were to understand changeability of sediment parameters in terms of pond age and culture period and their interaction.

Materials and methods

The present study, assessment of water quality parameters and sediment chemistry of *Pangasius* ponds under existing farming practices in Mymensingh, Bangladesh was conducted at 15 fish ponds of farmers during the period of three months from May to July.

Locale of the study

The study was carried out at the farmer's ponds which were located at the Trishalupazila in Mymensingh. For the convenience of the study, fifteen ponds were selected randomly. The area of each pond was about 800 m^2 with more or less 1.5-2 meters depth.

Pond description

The ponds were free from aquatic vegetation and well exposed to sunlight. The ponds were rain fed and the actual depth of the water was depending on rainfall. The pond had no inlet facilities but facilities were available to supply water from deep tube-well. Plate 1 shows that pond of the study area with 800 m^2 area is used for *Pangasius* culture.

Collection and treatment of pond sediment

Samples of bottom sediment was collected from each pond with the help of an Ekman Dredge (covering an area of 225 cm^2), which was designed to trap normally a sediment column of 5-10 cm depth from the sediment water interface area. Triplicate sediment samples from different locations were collected from each pond. Plate 12 shows that sediment sample of *Pangasius* pond in polythene bag for chemistry determination.

Preparation of sediment samples

Each sediment sample was put in a labeled plastic bag and carried to the laboratory. In the laboratory, the sediment samples were thoroughly mixed up, stretched out on polythene papers and left for air drying at room temperature. The dried sediments were ground finely, sieved through a 0.03 mm meshed brass sieve and kept properly in labeled polythene bag for chemical analysis.

Chemical analysis

Sediment pH was measured by a glass electrode pH meter (Model No. REX PHS-25) using sediment: distilled water suspension of 1:2:5 (w/v) proportion (Jackson, 1986). Total nitrogen of sediment was determined by the common kjeldhal digestion method. Digestion was made with H_2O_2, concentrated H_2SO_4 and catalyst mixture (K_2SO_4, $CuSO_4$, $5H_2O$; SeF 10:1:1). Nitrogen in the digestion was estimated by distillation with 40% NaOH followed by titration of the distillances trapped in $H_3BO_3$with 0.01 N H_2SO_4 (Page *et al.*, 1989). Sediments organic carbon was measured by the walkley black dichromate oxidation technique (Nelson and Sommers, 1982). The organic matter content was calculated by multiplying the percent organic carbon with the van Bemmelen factor of 1.73.

Available phosphorus was analyzed calorimetrically by 0.5 M $NaHCO_3$ extraction and ascorbic acid reduction method (Matt, 1970).

Data analysis

For statistical analysis of data one way analysis of variance (ANOVA) was carried out to test the significant variations between the cases. For analysis of relationships, co-relation analysis was done to determine the positive or negative relationships between the quality factor of water and sediment of *Pangasius* ponds. Significance was assigned at the probability of 0.01 to 0.05%. Statistical test were performed by computer based statistical software SPSS (Statistical Package for Social Science) version 11.5. The findings of the research work were presented in text visual methods including tables and graphs.

Results

Sediment chemistry

Pond sediments chemistry is another important factor for aquaculture production and productivity of pond. The sediment chemistry plays a significant role in proper aquaculture pond management. The data, collected from study area on pH, organic carbon, organic matter, total nitrogen and available phosphorus was examined statistically and the observed value are shown (Table 1) and described below.

Table 1. Mean value (±SE) of sediment chemistry of old and new ponds.

Parameters / Pond age	pH	Organic carbon (%)	Organic matter (%)	Total Nitrogen (%)	Available phosphorus (%)
10 years (old pond)	6.4±0.09	1.43±0.12	2.52±0.21	0.13±0.01	45.94±8.45
3 years (new pond)	6.67±0.03	1.84±0.22	3.02±0.31	0.15±0.02	48.19±5.93

Soil pH (HydrogenIon Concentration).

The ranged of pH varied from 5.92 to 6.66 in old pond, where the mean value was found 6.40±0.09but the mean was comparatively higher in new pond and that was 6.67±0.37with a range of 6.56 to 6.76 (Table 1).

The value of pH was also varied in three ponds of old age, which termed as regular removal pond, irregular removal pond and not removal pond, and the mean value was 6.64±0.009, 6.53±0.012 and 6.03±0.06 respectively.

The highest (6.76) pH was in regular removal in new pond and the lowest (5.92) was in not removal in old pond. Correlation matrix showed that there was no significant correlation with pond age and sediment removal. However, there was negative significant ($P<0.01$) correlation with available phosphorus and it indicated that the phosphorus content increased with decreasing sediment pH.

Table 2. Correlation matrix of sediment chemistry with pond age

Sediment chemistry	pH	Organic carbon (%)	Organic matter (%)	Total Nitrogen (%)	Available phosphorus (%)
pH					
Organic carbon	-.154				
Organic matter	-.188	.949(**)			
Total nitrogen	-.184	.949(**)	.999(**)		
Available phosphorus	-.749(**)	.645(**)	.658(**)	.649(**)	
Pond age	-.509	-.435	-.362	-.351	-.054

** Correlation is significant at the 0.01 level.

Both Tables 2 and 3 (water quality parameters and sediment chemistry) of correlation matrix shows that the value of correlation is measured at 1 and 5% level of probability indicating no correlation among sediment chemistry and pond age but except pH, other sediment chemistry of *Pangasius* pond closely correlated with frequency of sediment removal, which are also correlated each other.

Table 3. Correlation matrix of sediment chemistry with sediment removal

Sediment chemistry	pH	Organic carbon (%)	Organic matter (%)	Total Nitrogen (%)	Available phosphorus (%)
pH					
Organic carbon	-.154				
Organic matter	-.188	.949(**)			
Total nitrogen	-.184	.949(**)	.999(**)		
Available phosphorus	-.749(**)	.645(**)	.658(**)	.649(**)	
Sediment removal	.051	.683(**)	.621(*)	.608(*)	.530(*)

** Correlation is significant at the 0.01 level.

* Correlation is significant at the 0.05 level.

ANOVA showed that there was a significant difference between old and new pond whereas the difference was greater among regular, irregular and not removal pond, which denoted mean difference was higher or lower in ranged test. It implied that regular removal pond had less difference with irregular removal pond but the mean difference was higher between regular removal pond and not removal pond. It was also found that significant difference remained in not removal old pond and not removal new pond. It might be for that new pond contain small amount of wastes and higher management practices compared to old pond. Tables 4 and 5 shows that F-value and significance value with degree of freedom (df) are represented in table for different sediment chemistry where F-value indicates significant difference between different types of pond.

Organic carbon

The value of organic carbon content of pond sediment ranged from 0.97 to 2.17% in the old pond, and 0.86

to 2.52% in new pond, where the mean value of old pond was 1.43±0.12%. On the other hand, in new pond, it was 1.84±0.22%. The highest and lowest value was observed in new pond (Table 1). The organic carbon content varied from 0.86 to 2.52% with the mean value 1.60±0.12%, where the maximum was in not removal new pond and the minimum was in regular removal new pond in different types of ponds i.e. regular removal pond, irregular removal pond and not removal pond of both old and new ponds (Figure 1).

Correlation matrix showed that there was negative trend of insignificant correlation between pond age and organic carbon content.

However, there was a positive significant correlation of organic carbon with sediment removal, which indicated that, the greater the sediment removal, the lower the organic carbon (Table 2 and 3).

ANOVA showed that there was significant difference between old and new pond, and ranged test showed that the difference was higher between regular removal old pond and not removal new pond. There was also difference between regular removal old pond and not removal old pond (Table 4 and 5).

Table 4. ANOVA table of sediment chemistry along with pond age.

Sediment chemistry	df	F-value	Sig.
pH	1	4.549	0.053
Organic carbon	1	3.026	0.106
Organic matter	1	1.967	0.184
Total nitrogen	1	2.048	0.176
Available phosphorus	1	0.038	0.849

Table 5. ANOVA table of sediment chemistry along with sediment removal.

Sediment chemistry	df	F-value	Sig.
pH	4	99.850	0.000
Organic carbon	4	3.725	0.042
Organic matter	4	2.748	0.089
Total nitrogen	4	2.759	0.088
Available phosphorus	4	44.677	0.000

Organic matter

Organic matter content ranged from 1.48 to 3.61% with a mean of 3.02±0.31% in new pond and 1.69 to 3.75% with mean of 2.52±0.21% in old pond, where the maximum and minimum was found in not removal old pond and regular removal new pond respectively (Table 1).

Correlation matrix showed that there was negative insignificant trend of correlation with sediment removal, which meant if sediment removal reduced, the organic matter content increased.

There was also positive significant correlation with organic carbon, total nitrogen and available phosphorus (Table 2 and 3).

ANOVA showed that there was no significant difference between old and new pond, but there was significant difference among regular removal pond, irregular removal pond and not removal pond. However, the difference was found between regular removal old pond and not removal new pond and regular removal old pond and not removal old pond (Table 4 and 5).

Total nitrogen

The value of total nitrogen varied from 0.08 to 0.19% whereas 0.08 to 0.18% with the mean of 0.15±0.02% in new pond and 0.09 to 0.19% with the mean of 0.13±0.01% in the old pond. The highest and the lowest value were found is not regular removal old pond and regular removal new pond respectively (Table 1).

Correlation matrix showed that there was negative insignificant trend of correlation with pond age, but positive significant correlation with sediment removal, organic carbon, organic matter and available phosphorus, which indicated that total nitrogen content increased with increasing organic matter, organic carbon and available phosphorus (Table 2 and 3).

ANOVA showed no significant difference between old and new pond, but there was significant difference between regular removal pond, irregular removal pond and not removal pond, The mean difference was found among regular removal old pond with not removal old pond and not removal new pond (Table 4 and 5).

Available phosphorus

The value of available phosphorus ranged from 17.58 to 82.91% where 31.27 to 61.81% with the mean of 48.19±5.93% in new pond and 17.58 to 82.91% with the mean of 45.94±8.45% in old pond (Table 1). The maximum and the minimum level of phosphorus were found in not removal old pond and regular removal old pond respectively.

Bar diagram Figure 1 shows the value of sediment chemistry with frequency of removal where the maximum value was represented by not removal old pond for phosphorus whereas the least value was in total nitrogen for all types of frequency of sediment removal.

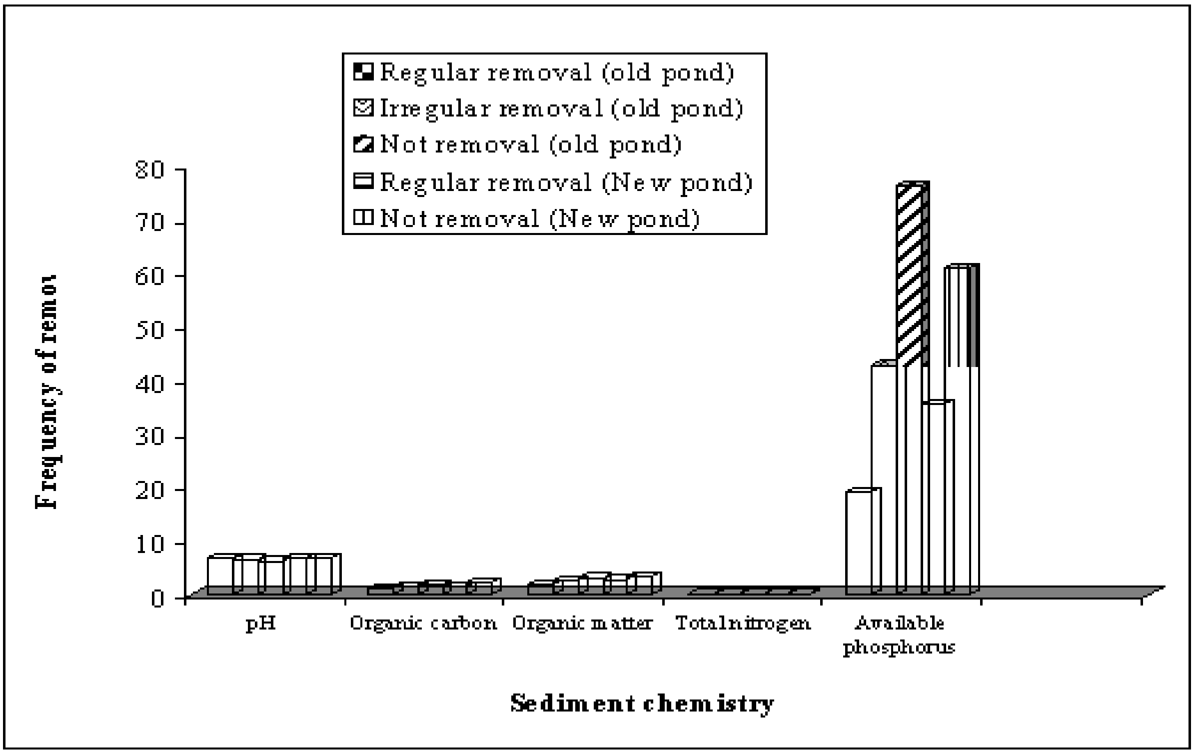

Fig. 1. Variation of sediment chemistry according to frequency of removal

Correlation matrix showed that there were no significant ($P<0.01$) relationships with pond age but positive significant trend of correlation with sediment removal, organic carbon, organic matter and total nitrogen. The correlation was negatively significant with sediment pH, which indicated that the available phosphorus decreased with increasing sediment pH (Table 2 and 3).

ANOVA showed there was no significant difference between old and new ponds but there were significant differences between regular removal pond, irregular removal pond and not removal pond. The multiple comparisons found that the mean difference was significant among regular removal old pond with irregular removal old pond, not removal old pond and regular removal new pond with not removal new pond. However, there were no mean difference between irregular removal old pond and regular removal new pond (Table 4 and 5).

Discussion

Sediment chemistry of Pangasius pond

The water in the fish pond is a complicated chemical system of equilibrium where bottom sediment plays a vigorous role in containing nutrients that released into waterbodies as dissolved materials under different mechanism.

Soil pH

The highest pH was found in new pond where pH ranged from 5.92 to 6.76 which is the more or less similar to the findings of Monir (2009) reporting that the pH concentration varied from 6.82 to 6.90 in different treatments. The findings of the present study do not differ from the finding of Mukta (2008), who observed that the pH value of Ghatail soil was 6.20 and that of Hossain *et al.,* (2003) who reported that the pH value ranged from 6.02 to 7.10 in old Brahmaputra floodplain soil. It could be argued that the value of pH of bottom sediment of the present study is within the suitable range for primary productivity.

Organic carbon

The organic carbon of sediment in the present study ranged from 0.86 to 2.52% with mean value of 1.84±0.22% in new pond and 1.43±0.12% in old pond in which the highest and the lowest value were observed in new pond. This result was consistent with the result of Begum (2003) reporting that organic carbon ranged from 0.80 to 2.86% in different treatments. This finding has a significant importance because organic carbon can play a potential role in buffering systems which may regulate pH value, available phosphorus, organic matter and total nitrogen.

Organic matter

It has been found in this study that the organic matter content of new and old ponds ranged from 1.48 to 3.61% and 1.69 to 3.75% with mean value of 3.02±0.31% and 2.52±0.21% respectively. The higher value was observed in old pond and the lower value was in new pond which was slightly higher than the findings of Karim (2009), reporting that organic content of Ghatail soil ranged from 0.33 to 1.96%. This variation might be due to addition of huge feed in the pond and decomposition of faces and aquatic vegetation. However, it is commonly regarded that organic matter has a close relationship with organic carbon, total nitrogen and available phosphorus suggesting that organic matter may be helpful for increasing available phosphorus and total nitrogen which are limiting factor for floral growth and development.

Total nitrogen

The highest nitrogen was measured in old pond and the lowest value was in new pond whereas the value ranged from 0.08 to 0.18% and 0.09 to 0.19% in the new and old pond respectively. This value was comparatively lower than the value observed by Begum (2003) ranging from 0.04 to 1.36% in different treatment. The findings of present study were higher than the study of Karim (2009), who denoted the range of total nitrogen from 0.043 to 0.096%. This result indicated that decomposition of organic matter might be enhancing the level of total nitrogen, together with available phosphorus.

The critical ranged of nitrogen for production is about 0.12% which is lower than the result of present study. So, it can be said that new pond is more productive than the old pond because the mean value of new pond (0.15±0.02%) was slightly higher than the old pond (0.13±0.01%). It could be it is suggested that total nitrogen is decreased with increasing pond age.

Available phosphorus

Phosphorus is generally considered as the second most limiting nutrient besides nitrogen. Mukta (2008) reported that he optimum range of available phosphorus is 7.38% y and the findings of Chowdhury (1992) stated that the available phosphorus content of Old Brahmaputra floodplain soil varied from 7.0 to 20%, which are much lower than the findings of present study, which was 48.19±5.93% and 45.94± 8.45% in new and old pond respectively. The result also indicated that the available phosphorus is decreased with increasing the sediment pH and increased with increasing organic carbon, organic matter, and total nitrogen and also with removal of sediment, suggesting that, if sediment is removed from bottom, the content of phosphorus is decreased.

Conclusion

Sediment chemistry of pond also varied with pond age and sediment removal. It was found that pH value and organic carbon of sediments were increased chronologically from old pond to new ponds. The variation (new ponds>old ponds)found for organic matter content, for total nitrogen concentration and for available phosphorus concentration. It is suggested that the above parameters should be maintained in their recommended range for proper management and development of *Pangasius* farming. Nitrogen and available phosphorus are limiting factors for plant growth, which are prerequisite for fish farming. Available phosphorus value was greater in new pond indicating that primary productivity might be higher due to the presence of huge amount of phosphorus. It may be concluded that sediment chemistry vary with pond age and sediment removal having wider impacts on primary productivity and fish production. Finally, it could be recommended that to obtain a better performance from farming practices, all aspects of sediment chemistry must be maintained at suitable level. Besides this, excessive feeding, indiscriminate use of chemical and fertilizer should be optimized.

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