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Sources of off-flavor in pangasius catfish (*Pangasianodon hypophthalmus*) ponds

Abstract

With the intensification of aquaculture system, off-flavor in cultured pangasius catfish (*Pangasianodon hypophthalmus*) has become a problem in Bangladesh, resulting in poor acceptability and reduced market price. Since water quality parameters and sediment have greater implications on fish quality, studies were undertaken to identify potential off-flavor agents by investigating water temperature, dissolved oxygen (DO) pH, phytoplankton diversity and sediment organic carbon in 3 randomly selected ponds of 3upazilain Mymensingh district viz., Sadar, Trishal and Muktagachha. Water temperature and DO was found to be significantly different in ponds of Trishalupazila along with significantly high sediment organic carbon ($p<0.05$). Correspondingly, the Algal Genus Pollution Index (AGPI) estimated to study the water quality revealed that ponds in this upazila has the highest organic nutrient level (25.33±3.21). These values, along with strong positive correlation of cyanobacteria abundance and water temperature, sediment organic carbonindicate higher risk of off-flavor production in pond water. Adoption of proper management strategies need to taken immediately so that off-flavor producing organisms can be minimized. This will ensure higher acceptability of pangasius catfish produced in this region and safeguard livelihoods of the fish producers.

Keywords: off-flavor, cyanobacteria, pangasius catfish, *pangasianodon hypophtalmus*, fish breeding pond

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Introduction

Aquaculture is one of the fastest growing food-production sector in the world and currently serves to meet majority of the demand for animal protein.[1] With the growing world population in one hand and depleting stock of marine water bodies on the other, freshwater and marine aquaculture has contributed to the impressive growth in the seafood supply for human consumption.[2] However, due to intensification of the culture systems, objectionable odors or tastes, sometimes referred to as 'off-flavor', are detected in aquaculture products that develop in fish before harvest.[3] It reduces taste and palatability of the fishery products.[4] Such off-flavors are mainly related to the diet of the cultured animal, particularly in catfish farms, environmental and/or caused by inadequate management strategies.[5] It was reported that off-flavor in fish results from two compounds, geosmin [trans-1, 10,-dimethyl-trans-(9)-decalol] and 2-methylisoborneol (exo-l, 2, 7, 7-tetramethyl-[2.2.1] heptan-2-ol), and these compounds are attributed with having an 'earthy' and 'musty' odor, respectively.[6] In aquaculture systems, earthy and musty off-flavors have been detected in common carp,[7] catfish,[8] shrimp[9] and tilapia.[10] Some pre-harvest off-flavors are caused by substances in the diet that are absorbed across the gastrointestinal tract.[11] Although diet-related off-flavors are rare in fish fed, pond-raised catfish occasionally eat other foods, and some of those may cause flavor problems. Other pre-harvest flavor problems are caused by odorous compounds produced by naturally occurring aquatic primary producers like microphytes, microorganisms like cyanobacteria.[12,13] The compounds are synthesized by algae or bacteria, released into the water, and then absorbed through the gills, skin or gastrointestinal tract of fish.[14] The resulting off-odors/flavors decrease profit margins for producers because processing must be delayed until the off-odor/flavor is absent.

During the last couple of decades, fish production from freshwater aquaculture sector in Bangladesh has been gradually increasing. The annual growth rates of production indicate that inland aquaculture grew fastest, followed by the marine sector.[15] It is estimated that roughly equal quantities of fish are produced in three culture systems - around 395,000 tonnes each from traditional homestead ponds, commercial semi-intensive culture of carps, and pellet-fed intensive systems (mainly pangasius catfish and tilapia). Sometimes the ponds are rainfed and their sizes vary depending on areas. In Bangladesh, there are 4.65million ha inland water whereas 528,390 ha closed water which are used for fisheries production.[15,16] Among total inland open water, most of the water bodies are taken under farming practices and aquaculture currently fulfills 60% of total animal protein of national demand. Fish farming especially pangasius catfish farming is adopted throughout the region not only for suitable environmental condition for farming but also for its benefits and demand in the market. Now-a-days, pangasius catfish farming has become most popular among the farmers and its annual production is 453,383 tonnes, which represent about 12.52% of aquaculture production.[15] Mymensingh district is the most prominent area among the fish producing areas of Bangladesh and popularly called 'Mecca of Aquaculture in Bangladesh'. The sub-districts (officially known as 'upazila') of Mymensingh alone produces some 40% of aquaculture product of Bangladesh.[15] However, due to the unawareness among the farmers about the effect of water quality in terms of pollution and sediment chemistry, consumers are complaining about that fish produced in Trishalupazila and its vicinity possess off-flavor. Therefore, it became essential to identify causative agents of such off-flavor so that the farmers can take necessary steps to minimize such problems in pangasius catfish ponds. The present study was, therefore, conducted for addressing the above existing problems with the following objectives: (i) collect information on the physico-chemical parameters of water and sediment in pangasius catfish ponds; (ii) identify the probable causes of water quality deterioration; and (iii) suggest guidelines for preventing the off-flavor problem in catfish ponds.

Materials and methods

Study site

The study was carried out at the farmer's ponds located at 3 upazila (Sadar, Trishal and Muktagachha)in Mymensingh district during May-June 2013 (Figure 1). These upazila were purposively selected as they produce the largest share of pangasius catfish of the country. Area of each pond was about 800m^2 with an average depth of 1.8±0.1m depth with a stocking density of 400-450/decimal with a feeding frequency of three. The ponds were rain fed and had facilities to supply water from deep tube-well.

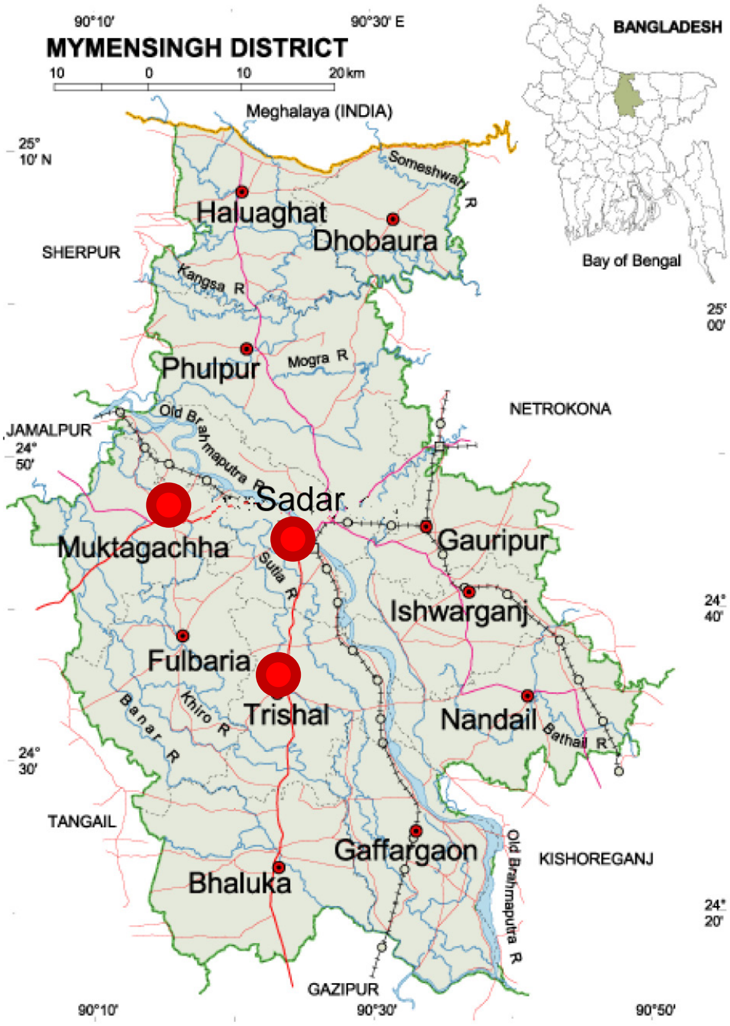

Figure 1 Map showing location of the study area at Sadar, Muktagachha and Trishalupazilas of Mymensingh district (Source: Banglapedia).

Determination of water quality variables

Water sample collection were made between 9.00 and 11.00am, on each sampling day. For this purpose, a number of clear 500ml black bottles marked with pond number and sampling date were used for collection of water samples. Water samples were collected from all layers (upper, middle and bottom) of the water column. Then, samples were taken in the vial immediately at the site. Temperature (T°C; thermometer, div., 0.1°C),dissolved oxygen (DO), nitrate–nitrogen (NO_3-N), ammonia–nitrogen (NH_4-N) and pH (pH-meter Hanna Instruments, Germany)from each pond were recorded. DO, NO_3-NandNH$_4$-Nweremeasured using HANNA Test kit, Hanna Instruments.

Collection of microphytes and preservation in formaldehyde solution

Microphytes, the primary producers suspended in the pelagic zone of the pond were collected from each pond and used for plankton monitoring as described elsewhere.[7] 5L of surface water was taken from different places of the pond and passed through fine mesh (25µm) plankton net. Filtered samples were taken into a measuring cylinder and carefully made up to a standard volume of 50ml. The collected plankton samples were preserved in 5% buffered formalin and brought to the Pond Dynamics Laboratory, Department of Fisheries Management, Bangladesh Agricultural University (BAU), Bangladesh. From each 50ml preserved sample, 1ml sub-sample was examined by using a Sedge Wick-Rafter cell (S-R cell) and a biological microscope (Model CH40, Olympus Optical Co. Ltd., Tokyo, Japan) with phase contrast facilities. For each pond, mean number of plankton was recorded and expressed numerically per liter of water. The quantitative estimation of the planktons was done by using the following formula and expressed numerically per liter of water.

$$N = \frac{A \times 1000 \times C}{V \times F \times L}$$

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where: N, number of plankton cells or units per liter of original water, A, total number of plankton counted; C, volume of final concentrate of the sample in ml; V, volume of field in cubic mm; F, number of field counted; L, volume of original water in liter.

Calculation of algal genus pollution index (AGPI)

Algal genus pollution index (AGPI) is a useful parameter that shows organic pollution level of a water body. Palmer[18] assigned a pollution index factor of 1 through 5 to each of the 20 types of algae that are most tolerant to organic pollution. Based on this, pollution index was assigned to each phytoplankton genera (considering>50 cells/ml)to calculate the AGPI for pangasius catfish ponds.

Collection, treatment and analysis of pond sediment

Samples of bottom sediment was collected from each pond with the help of an Ekman Dredge (covering an area of 225cm), which was designed to trap normally a sediment column of 5-10cm depth from the sediment water interface area. Triplicate sediment samples from three locations were collected from each pond. Each sediment sample was put in a labelled plastic bag and carried to the laboratory at BAU. In the laboratory, the sediment samples were thoroughly mixed up, stretched out on polythene papers and left for air drying for overnight at room temperature. The dried sediments were ground finely, sieved through a 0.03mm meshed brass sieve and kept properly in labelled polythene bag. Organic carbon analysis of sediment samples was conducted at BAU Humboldt Soil Test laboratory, Department of Soil science, BAU.

Data analysis

One-way ANOVA was carried out to test the significant variations between the cases. Correlation analysis was done to determine the positive or negative relationships between the quality factor of water and sediment of fish ponds. All data were analyzed by SPSS version 11.5 (Chicago. USA). Significant differences were determined among treatments at the 5% level ($p<0.05$).

Results

Physico-chemical variables of pond water

The variation of pond water temperature at three upazilain Mymensingh districts showed the highest temperature for ponds located at Trishal upazila (27.7±0.6°C) and lowest in Sadar upazila (24.7±1.0°C). According to statistical analysis, Sadar upazila ponds had significantly low temperature compared to other ponds, in Trishal and Muktagachha upazila ($p<0.05$). DO level was recorded that varied from 2.5 to 5.8mg/l in 9culture ponds with significantly lower levels in Trishal upazila ponds. During the study period, the values of pH ranged from 6.6 to 6.8 with highest in Trishal upazila and lowest in Sadar. These values did not vary significantly, indicating a homogeneous level of alkalinity across ponds in Mymensingh district.

Organic carbon in pond sediment

In the present study, sediment organic carbon range was 1.07to2.35% for ponds located at Sadar, Trishal and Muktagachha upazila (Table 1). The highest organic carbon was recorded in the ponds of Trishal upazila (2.35±0.14%)and the lowest was recorded in the ponds of Muktagachha upazila (1.07±0.41%) with significantly high concentration in ponds of Trishal upazila ($p<0.05$).

Microphyte populations in pond water

Microphytes of a fish pond represent the primary production of the water body, contributing substantially towards the succession and dynamics of zooplankton and fish. Table 2 shows the microphyte genera observed in 9pangasius catfish ponds in Mymensingh district. During the study, four major classes were identified with most of them to be common in all the ponds. In Sadarupazila, the most common genera were *Anabaena*, *Euglena*, *Closterium*, *Cyclotella*, *Tetraedon*, *Phacus* etc. In Trishal, the most common phytoplankton were *Volvox*, *Aphanizomenon*, *Ankistrodesmus*, *Chlorella*, *Scenedesmus*, *Euglena* and *Anabaena*, while in Muktagachha upazila, *Spirulina*, *Cosmarium*, *Cyclotella, Scenedesmus*, *Tetraedon*, *Microcystis*, *Stichococcus*, *Tabellaria*, *Chlorella*, *Cyclotella* and *Closterium* were dominant.

Table 1 Physico-chemical parameters of water and sediments of pangasius catfish ponds at three upazila in Mymensingh

Parameter	Sadar	Trishal	Muktagachha	Level of Significance
Water parameter				
Temperature (°C)	24.7±1.0^{b}	27.7±0.6^{a}	27.0±1.0^{a}	*
DO	5.8±0.1^{a}	2.5±0.4^{b}	4.8±0.2^{a}	*
pH	6.6±0.1	6.8±0.0	6.8±0.1	NS
Sediment parameter				
Organic carbon (%)	2.0±0.53^{a}	2.35±0.14^{a}	1.07±0.42^{b}	*

*Significantly different ($p<0.05$); NS, non-significant

Table 2 List of phytoplankton genera observed in water of pangasius catfish ponds at three upazila in Mymensingh

Upazila	Pond no.	Phytoplankton genera
Sadar	1	*Cyclotella*, *Tetraedon*, *Anabaena*, *Aphanizomenon*, *Ankistrodesmus*, *Chlorella*, *Scenedesmus*, *Volvox*, *Nitszchia*, *Oscillatoria*, *Surirella*
	2	*Cyclotella*, *Euglena*, *Anabaena*, *Tetraedon*, *Soirulina*, *Ankistrodesmus*, *Chlorella*, *Cosmarium*, *Scenedesmus*, *Pediastrun*, *Nitszchia*, *Surirella*
	3	*Stichococcus*, *Tabellaria*, *Euglena*, *Cyclotella*, *Nitszchia*, *Cosmarium*, *Cyclotella*, *Ankistrodesmus*, *Anabaena*, *Surirella*, *Hildenbnandia*, *Oscillatoria*

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Table Continued...

Upazila	Pond no.	Phytoplankton genera
Trishal	1	*Actinastrum, Anabaena, Ankistrodesmus, Aphanizomenon, Chorella, Closterium, Cosmarium, Cyclotella, Euglena, Gomphosphaeria, Hildenbrandia, Nitszchia, Oscillatoria, Scenedesmus, Stichococcus, Surirella, Volvox*
	2	*Pediastrun, Cosmarium, Ankistrodesmus, Chlorella, Tetraedon, Cyclotella, Euglena, Nitszchia, Phacus, Closterium, Anabaena, Scenedesmus, Tetraedon, Navicula, Oscillatoria, Hildenbnandia, Pleurococcus*
	3	*Anabaena, Cosmarium, Closterium, Euglena, Chlorella, Scenedesmus, Soirulina, Oscillatoria, Tetraedon, Phacus, Trachelomonas, Stichococcus, Nitszchia, Hildenbrandia, Pleurococcus*
Muktagachha	1	*Euglena, Flagellaria, Stichococcus, Chlorella, Microcystis, Ankistrodesmus, Closterium, Spirulina, Volvox, Surirella, Oscillatoria, Cosmarium, Aphanizomenon, Pediastrun, Cyclotella, Anabaena, Phacus*
	2	*Cosmarium, Cyclotella, Chlorella, Oscillatoria, Euglena, Scenedesmus, Tetraedon, Closterium, Microcystis*
	3	*Stichococcus, Tabellaria, Chlorella, Cyclotella, Closterium, Oscillatoria, Tetraedon, Euglena, Microcystis, Spirulina, Nitszchia, Ankistrodesmus, Anabaena, Cosmarium*

Table 3 shows the abundance of these microphytepopulations. The abundance of the group Cyanobacteria ranged from $13.69\pm1.5\times10^4$ to $10.23\pm2.5\times10^4$cells/lof water with highest in Trishal and lowest in Sadar upazila. The abundance of Bacillariophyceae, Chlorophyceae and Euglenophyceae were $5.51\pm2.3\times10^4$ to $9.49\pm2.5\times10^4$ cells/l, $6.61\pm1.5\times10^4$ to $10.19\pm3.5\times10^4$ cells/land $5.48\pm1.5\times10^4$ to $7.11\pm1.5\times10^4$ cells/l, respectively. These results suggest that the density of microphytesis variable among aquaculture ponds. When the differences in their abundance was considered, the group Cyanophyceae was found to be significantly higher in ponds of Trishal compared to Sadar and Muktagachha upazilas ($p<0.05$). Bacillariophyceae, on the other hand,weresignificantly lower in ponds of Trishal upazila compared to other locations ($p<0.05$). Chlorophyceae werealso found to be significantly lower in Sadar upazila compared to other two upazilas. However, there was no significant variation in Euglenophyceae among the ponds located at three upazillas.

Table 3 Abundance of phytoplankton genera observed in water of pangasius catfish ponds at three upazila in Mymensingh

Area	Plankton abundance ($\times10^4$cells/L)			
	Cyanophyceae	Bacillariophyceae	Chlorophyceae	Euglenophyceae
Sadar	10.23 ± 2.5^a	8.89 ± 2.5^a	6.61 ± 1.5^a	7.11±1.5
Trishal	13.69 ± 1.5^b	5.51 ± 2.3^b	9.27 ± 2.5^b	6.92±1.5
Muktagachha	12.00 ± 1.3^a	9.49 ± 2.5^a	10.19 ± 3.5^b	5.48±1.5

Values are mean (± SD), n=3; Means within each column sharing different upper case were significantly different ($p<0.05$)

Relationship between physico-chemical parameters of water-sediment and microphyte groups

In the present study, high abundance of *Anabaena*, *Aphanizomenon* was observed across all pangasius catfish ponds studied. We tried to correlate the abundance of microphyte groups with physico-chemical parameters of water and organic carbon of sediment. It was found that the abundance of Cyanophyceae was correlated well with water temperature ($r=0.89$, $p=0.01$). On the other hand, the abundance of Cyanophyceae showed slight correlation with sediment organic carbon ($r=0.61$, $p=0.02$) (Table 4).

Relationship between water-sediment parameters and AGPI

Table 5 shows the AGPI values of pangasius catfish ponds in three upazila ponds. It was revealed that pollution index scores for catfish ponds in Sadar, Trishal and Muktagachha were 17.33, 25.33 and 19.33 with lowest in ponds located at Sadar and highest in those located at Trishalupazila. The latter ponds fall into 'high organic pollution' category (AGPI=25.33±3.21) while ponds in Sadar (17.33±1.15) and Muktagachha (19.33±0.58) were judged to be in 'probable high organic pollution' category.

Table 4 Correlation coefficient between physico-chemical parameters of water-sediment and abundance of Cyanophyceae in pangasius catfish ponds for three ponds of Trishalupazila in Mymensingh

Parameter	Plankton abundance
Water temperature	0.89 (p=0.01)
Sediment Organic carbon	0.61 (p=0.02)

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Table 5 Pollution index of algal genera observed in water of pangasius catfish ponds at three upazila in Mymensingh according to Palmer (1969)

Algal genus	**Pollution index**	**Sadar**			**Trishal**			**Muktagachha**		
		Pond 1	**Pond 2**	**Pond 3**	**Pond 1**	**Pond 2**	**Pond 3**	**Pond 1**	**Pond 2**	**Pond 3**
Cyanophyceae										
Oscillatoria	5	5		5	5	5	5	5	5	5
Chlorophyceae										
Ankistrodesmus	2	2	2	2	2	2		2		2
Chorella	3	3	3		3	3	3	3	3	3
Closterium	1				1	1	1	1	1	1
Scenedesmus	4	4	4		4	4	4		4	
Bacillariophyceae										
Nitszchia	3	3	3	3	3	3	3			3
Cyclotella	1	1	1	1	1	1		1	1	1
Navicula	3					3				
Euglenophyceae										
Euglena	5		5	5	5	5	5	5	5	5
Phacus	2					2	2	2		
Score (Average±SD)		**17.33±1.15** [a]			**25.33±3.21** [b]			**19.33±0.58** [a]		

[*]Pollution classification: 0–10, lack of organic pollution; 10–15, moderate pollution; 15–20, probable high organic pollution; 20 or more, high organic pollution; Means within each row sharing different upper case were significantly different ($p<0.05$)

Discussion

One of the most important sources of off-flavor in fish is the surrounding environment in which fish is being cultured. These pre-harvest flavors develop during the grow-out period Multitude of biological processes in the pond water are responsible for development of these objectionable flavor, making the fish less acceptable to the consumer. Generally, the physico-chemical parameters of water greatly influence fish health and overall production in aquaculture systems. It closely interacts with the sediment properties as well. It is, therefore, important to determine temperature, DO, pH of water, organic carbon of the sediment and odor producing microphytes to identify the sources of off-flavor in catfish pond.

P. hypophthalmus is generally considered as a hardy fish that can tolerate a wide range of environmental conditions. Temperature between 28-32°C is considered optimal for the species, with 34°C being the best culture temperature.[19] In culture ponds, temperature greatly influences the growth and survival of all organisms including microphytes and various microorganisms. Since the average water depth of pangasius catfish ponds in Mymensingh region is 1.8±0.1m, it is expected that a steady temperature would remain in the pond during different phases of the day. In the present study, we recorded a temperature range between 24.7±1.0 and 27.7±0.6°C in ponds of 3 upazila in Mymensingh district where ponds in Sadarupazila had significantly low temperature compared to other ponds. Still, these values were more or less similar to Roy.[20] This last study recorded some physico-chemical parameters in nine experimental ponds of Fisheries Faculty, Bangladesh Agricultural University, Mymensingh during November, 2000 to October, 2001. He stated that water temperature varied from 22 to 32°C, DO from 5.0 to 7.5mg/l and pH from 7.5 to 8.5. Usually, water temperature is lower in culture ponds during the early morning that gradually increases at noon throughout the afternoon.[21] In the present study, water temperature was measured in the morning period of early summer. It may be expected that temperature would rise to an addition of 3 to 5°C during the later parts of the day. These results due to diurnal temperature variation and caused by multiple reasons including cloud cover, land use change, aerosols, water vapor and greenhouse gases.[22] In case of DO, the values ranged between 2.5±0.4 and 5.8±0.1mg/l, with significantly lower levels in ponds at Trishal upazila. The low DO values in ponds at Trishal upazila may be related to higher water temperature of the pond water. As solubility of O_2 decreases as water temperature increases, indicating an inverse relationship between DO and water temperature, there is a high risk of stress for pangasius catfish with a low level of DO in pond water. At the same time, all living organisms in the pond might be influenced greatly due to such low DO level. In culture ponds, pH may vary between 6.5 to 8.2 due to environmental factors, such as breathing and photosynthesis, or pollution. The level of pH observed in the present study ranged between 6.6±0.1 and 6.8±0.1 that showed no significant difference among ponds of 3 upazila. Although the pH level slightly below 7.0 is considered unfavorable for many aquaculture species, tropical fishes like tilapia and pangasius catfish can tolerate and grow ideally between 6 and 9,[23] indicating suitable water chemistry for optimal fish growth.

It is well known that water quality is directly related to sediment chemistry. Attempts were, therefore, made to determine the organic carbon content in pond sediment which is thought be formed due to decomposition of pond elements like macroalgae and/or microorganisms, dejections of farmed fish, etc.

In the present study, sediment organic carbon ranged between 1.07 to 2.35% for ponds located at 3 upazila where significantly high concentration was observed in ponds of Trishal upazila ($p<0.05$). This higher accumulation of organic carbon in the sediment can be attributed to high nutrient concentrations, comparably high levels of soil particulate transfer from adjacent land, and high rates of preservation due to nearly continuous sediment anoxia.[24,25] Generally, pangasius catfish are cultured at a high density in Mymen singh district where as high as 400-450 individuals/decimal are reared in earthen ponds. An estimation of total nitrogen utilization by this fish species showed that nearly 70% of total nitrogen supplied through the feed remains unused and gets deposited at the bottom[26] and dissolved in the water column. This increases the chance of increased deposition of organic matter in the pond sediment. Boyd[27] stated that pond sediment was not only source of nutrient but also had biological filtering ability, by adsorbing organic residues of feed, fecal matters of fish and algal metabolites which were generally toxic for fish, while Mayer and Telford[28] reported that aerobic decomposition of organic matter for nutrient generation was the dominant mechanism, which released nutrient to the water column. It is, therefore, predicted that the relatively faster deposition of organic matter at the bottom was going through slow decomposition since DO levels were relatively low in water. Thisresulted in differences in the carbon capture function of different ponds.[29]

Among the various groups of primary producers in a fish pond, the small planktonic organisms suspended in the upper zone, i.e., microphytes show changes according to the environmental variables and pollution[18,31] reported that a number of microphyte species is unable to tolerate slightest of pollution while few species may able to persist or even attain greater abundance under same situation. Attempts were, therefore, made to identify these assemblages up to genus level using microscopic observations. Overall, under 4 classes, 28 genera were identified, of which *Anabaena*, *Ankistrodesmus*, *Chlorella*, *Euglena*, *Closterium*, *Cyclotella*, *Nitszchia*, *Oscillatoria*, *Scenedesmus* and *Tetraedon* were the most common. Cyanobacteriaand Bacillariophyceae were also abundant andsignificantly higher in Trishal upazilaponds, while only Chlorophyceae showed high concentrationsin Muktagachha. The changes in distribution and abundance are thought to be linked to alteration of physico-chemical factors of pond water.[32] Previous studies showed that species of *Aphanizomenon, Oscillatoria,* and *Pseudanabaena* from catfish aquaculture ponds produce 2-methylisoborneol.[33] Geosmin and 2-methylisoborneol are also responsible for many of the off-flavor episodes/problems in municipal drinking water systems worldwide.[13] Due to significantly higher abundance of cyanobacteria and a number of off-flavor producing plankton in pangasius catfish ponds of Trishal upazila, it is plausible that catfish grown in these ponds would possess off-flavor. This has created an environment favorable for off-flavor development in catfish ponds particularly in Trishal upazila. However, several phytoplankton genera like *Chlorella*, *Closterium*, *Nitszchia* and *Phacus* were found to be least affected by the variation of measured physico-chemical factors. Off-flavor during pre-harvest does not pose a direct threat to fish health but adversely affects the acceptability of fish. This eventually causes delays in harvesting and increases production cost as depuration might be required to reverse the process of deposition of flavor compounds in fish body. Cyanobacteria have been reported to cause off-flavors and cannot be seen with the unaided eye. The cyanobacterial genera that have been associated with geosmin-related off-flavor in catfish aquaculture are *Anabaena, Aphanizomenon* and *Lyngbya.*[34] Also in trout farming systems in UK, a geosmin-producing species of *Oscillatoria* has been associated with an earthy taint in cultured pangus.

Based on the distribution and abundance of microphytes, AGPI values of pangasius catfish ponds in three upazila were calculated. AGPI is also known as algal palmer index that is established as a rapid, reliable and inexpensive method to evaluate the organic pollution level of a water body.[35] The AGPI values ranged from 17.33 to 25.33 with lowest in ponds located at Sadar and highest in those located at Trishal upazila. Therefore, ponds in Trishal upazila fall into 'high organic pollution' category while ponds in Sadar and Muktagachha were in 'probable high organic pollution' category. Khan et al.[36] reported that several contiguous ancient ponds in Noakhali district of Bangladesh had AGPI values as high as 27, while Das et al. reported high values for wastewater fed urban fish ponds in Bankura, India. These results together with water-sediment parameters suggest that pangasius catfish ponds has high supply of nutrients, probably arising from un-used feed and fish feces deposited at the bottom, resulting in heightened level of pollution.[37]

Conclusion

Major water quality parameters and sediment organic carbon in intensive pangasius catfish culture areas of Mymensingh area of Bangladesh were studied to correlate them to off-flavor producing phytoplankton. It revealed culture ponds under investigation in Trishal upazila had significantly higher level of nutrient compared to Sadar and Muktagachha upazila. These ponds were also judged to be the ponds with 'high organic pollution', based on Algal Genus Pollution Index (AGPI). It may be predicted that the risk of off-flavor production in these ponds was very high. Fish farmers can, therefore, easily use this tool to calculate AGPI of their culture ponds and take appropriate steps like increased water exchange, artificial oxidizing of the sediments to minimize off-flavor in fish before they are harvested. This would ensure profitability of fish farmer in one hand, and benefit the consumers on the other.

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Conflicts of interest

The author declares that there are no conflicts of interest.

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