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Managing water quality and fish health in aquaculture: Farmer's traditional practices in west Bengal

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Abstract
The present study was conducted to know the fish health management practices and adaptations prevailing in the dominant fish producing state of India. Primary data was collected from the small and marginal fish farmers of West Bengal by personal interview. Literature review was also done to collect secondary information. The study reveals that though West Bengal is a dominant fish producing state of India, yet the farmers are lacking scientific knowledge on fish health management and overall aquaculture practices. Scientific intervention is a felt need to enhance their knowledge and to formulate effective management strategies for aquaculture.

Keywords: Health, management, practices, knowledge

1. Introduction
Aquaculture is the fastest-growing food production sector. India is the second largest inland fish producer in the world. West Bengal is one of the leading producers of freshwater fish and the largest producer of fish seeds in the country, contributing 30% of the total fish production and 62% of the total fish seed production in the country. Total fish production in the state has increased from 14.72 lakh tonnes in 2011-2012 to 16.17 lakh tonnes in the year 2014-2015 and fish seed production has increased from 13,846 million in 2011-2012 to 17,521 million in 2015-2016 (Handbook of fisheries statistics, 2016) [1]. In spite of the tremendous potential production, fishery sector has been suffering from outbreak of several diseases. Fish farmers of West Bengal have been experiencing about 26% production loss due to diseases and poor management in freshwater aquaculture sector. The aquaculture sector in India in general and West Bengal in particular is still deprived of the developments in fish health and disease management practices. The traditional practices by the fish farmers in effective health management is quite appreciating. The aim of the present review study is to highlight the age old practices and adaptations by the fish farmers of West Bengal to maintain fish health and maximise the production. The information will not only provide an account of the present scenario of fish health management by Bengal fish farmers but also give an account about the same in India. The present study is based on literature searches and analysis of secondary and primary data gathered through personal contacts with experts and the experiences gained by the authors during interaction with aquaculturists as a part of extension service.

2. Aquaculture practices prevailing in West Bengal
The aquaculture sector in West Bengal is highly diverse in terms of species, culture systems, culture environment, operation type, intensity of practice etc. Water-based culture systems (cages), landbased culture systems (rain-fed ponds), irrigated or flow-through systems, tanks, reservoirs, lakes, recycling culture systems (high control enclosed systems), monoculture and polyculture systems, integrated fish base agri-livestock farming systems existed in this state. Fish culture are practiced starting from small-scale dug-out backyard ponds of less than a hactre to commercial hatcheries, which includes large broodstock holding unit, seed production unit, nursing systems and grow-out. The fertility status and the production level of the aquaculture systems in West Bengal vary widely depending upon the soil types, intensity of practice i.e. extensive, semi-intensive, intensive and the management i.e. family to corporate ownership. According to Abraham *et al.* (2010) [2], out of the total respondents from 78 farms

about 64% of the farmers in West Bengal, practise semi-intensive or intensive aquaculture with very high stocking density (>7.5 lakh hatchlings per acre, >1.5 lakh fry per acre and >10,000 fingerlings per acre). Despite of all the variations, the technologies of seed production and rearing (spawn to fry in nursery and further fry to fingerlings in rearing ponds) have been accepted as economically viable activities at farmer's level in the state (Planning Commission Report, Govt. of India, 2011) [3]. The small and marginal farmers of Bengal practise aquaculture in traditional way, based on the inherent natural productivity of the ponds. By virtue of their learning aquaculture in own traditional way, they take advice from other farmers, friends and neighbours but rarely from Govt. officials and scientific personnels. The farmers lack knowledge and awareness in removing weed and intermediate hosts of parasites from ponds or regular monitoring of soil and water quality for enhancing the carrying capacity. The freshwater aquaculture production is dominated (90%) by Indian major carps viz., *Catla catla*, *Labeo rohita* and *Cirrhinus mrigala*. Exotic carps viz., *Cyprinus carpio, Ctenopharyngodon idella, Hypophthalmichthys molitrix, Oreochromis* sp., catfish viz. *Pangasius* sp., *Clarias* sp., *Heteropneustes fossilis* and perch viz. *Anabus testudineus*. Sewage fed aquaculture is also practised by the farmers in West Bengal (mainly in the Ramsar conservation site at East Kolkata Wetland). Polyculture along with integration with livestock and agriculture is the most common practice. Majority of the farmers do not exchange water or maintain feeding schedule, regular health and water quality monitoring, and are away from adopting scientific fish farming. Seed rearing and grow-out cultures are the two main components of carp culture technology, which have undergone several modifications and refinements over the years to evolve to the present day package of farming practices. Only few farmers take help from Government extension workers at hours of need. Farmers are much dependent on information provided by fish traders and business personnel (feed and drug sales persons), who basically suggests their own company products. The involvement of NGOs in imparting knowledge on aquaculture to the farmers was found negligible (Abraham *et al*., 2010) [2]. A shift in behaviour of farmers towards adopting new scientific technologies for sustainable fish production has also been reported.

Disease is the major problem, jeopardising culture was also reported in the present study as reported by Abraham *et al.* (2010) [2], among the different problems faced by West Bengal freshwater fish farmers, disease (82%), inundation due to flood (51%), financial problem (50%), poaching (48%) and market price fluctuation (30%) were the major ones. Disease problem was however, regarded as a third ranked problem, as diseases, except EUS, caused very negligible mortality and affected only a smaller portion of the stock (Abraham *et al*., 2010) [2]. Mondal and Das (2005) [4] also reported disease as the third ranked problem in the hatcheries of West Bengal. Lack of technical expertise on fish farming management was reported to be a common problem in India (Mondal and Das, 2005) [4] like several other Asian countries (Chinabut *et al*., 2002; Hasan and Ahmed, 2002; Jeney *et al*., 2002; Phan *et al.*, 2002) [5-8].

3. Health: A constraint to aquaculture

The current trend in aquaculture is to become self-sufficient in fulfilling the demand and food security of the population. To meet the goal, massive intensification and commercialization of aquatic production has been taken place, which has created immense pressure on the environment resulting in disease outbreak. Now-a-days, disease has become a primary constraint to the culture of many aquatic species, impeding both economic and social development. The disease situation in aquaculture is also changing rapidly in an unpredictable way due to the current period of rapid change in the international trading environment—affected by globalization, increasing aquaculture production and microbial adaptation (Subasinghe *et al.,* 2004) [9]. This situation can be attributed to a multitude of interconnected factors which has contributed to the health problems currently faced by aqua culturists such as the increased globalization of trade in live aquatic animals and their products; the intensification of aquaculture through the translocation of broodstock, postlarvae, fry and fingerlings; the development and expansion of the ornamental fish trade (Subasinghe *et al*., 2001) [10]; the misunderstanding and misuse of specific pathogen free (SPF) stocks (e.g. shrimps); unanticipated negative interactions between cultured and wild fish populations (Olivier, 2002) [11]; poor or lack of effective biosecurity measures; less and slow awareness on emerging diseases; climate change; other human mediated movements of aquaculture commodities. Interactions between wild and cultured fish populations are an important concern for both aquaculturists and natural resource conservation officers. Disease is a result of the complex interaction between the host, the pathogen and the environment (Snieszko, 1974) [12]. In order for a disease to spread from either cultured fish to wild fish or vice-versa, though certain criteria are essential, yet once a pathogen or disease agent is introduced and becomes established into the natural environment, there is little or no possibility for either treatment or eradication. While consequences of ‘‘trickle’’ infections from wild to cultured populations have predictable consequences due to accessible hosts under cultured conditions, the consequences of culture-borne transmission to wild stocks are harder to predict. Precise per annum figures of consequences of disease losses in this area are difficult to pin-down, but some estimates are available. Average expected and actual fish production of West Bengal farmers revealed that the fish farmers of West Bengal has been experiencing about 26% production loss due to diseases and poor management in freshwater aquaculture (Vineetha and Abraham, 2009, Dash *et al*., 2014) [13, 14].

In addition to the obvious effects of large scale aquaculture losses on rural communities, diseases also cause considerable financial impact on investor confidence. These losses are even more alarming where the success or failure of a harvest determines the raising of families above or below the Indian poverty threshold. Moreover, changes in community structure through changes in predator-prey dynamics; changes in host energetic demands, behaviour, mortality, fecundity or susceptibility to predation; changes in genotypic/phenotypic variation; possible species extinctions also have a significant importance in this context.

4. Management practices adopted by farmers

4.1. Water Quality Management: Traditional practices

4.1.1. Dissolved oxygen deficiency

Dissolved oxygen is one of the crucial factor in water quality management and fish culture. Dissolved oxygen depletion can occur for several naturally occurring reasons, most of which are highly preventable or treatable. The primary cause of oxygen depletion in a water body is from excessive algae and phytoplankton growth. During the night, the photosynthetic organisms consume oxygen through respiration. Additionally, as algae and phytoplankton die, the process of decomposition also requires significant amounts of dissolved oxygen. Temperature also plays a prominent role in dissolved oxygen levels. High water temperatures above 30 ^{O}C reduces the dissolve oxygen level. On cloudy days even, the production of oxygen through photosynthesis is slowed down. Additionally, without wind circulation of the water also stops preventing the surface diffusion of atmospheric oxygen. Oxygen deficient water harm fish populations, even causing die-offs. In general, most fish species grows within a range of 5–12 ppm dissolved oxygen. However, when the level drops below 4 ppm they stop feeding, become stressed and begin to die. During morning hours, depletion of dissolved oxygen is managed by farmers through indigenous methods like channelizing fresh water, beating water with bamboo pole, spraying water with open containers and bamboo baskets. The farmers often make children swim in ponds and use ducks to swim in pond and aerate the water, apart from operating aerators.

4.1.2. Turbidity management

Turbidity describes the "cloudiness" or "muddiness" of water. It can be caused by many substances, including microscopic algae, dissolved organic substances, suspended clay particles, and colloidal solids. Though moderate level of phytoplankton turbidity is desirable for aquaculture, turbidity caused by clay particles is generally undesirable, as it keeps light, required for algal growth, from penetrating the water and can also clog fish gills. Flocculating substances like alum @ 15 to 25 mg/L or gypsum @ 100 to 300 mg/L are very effective for controlling clay turbidity. But these chemicals are not always easily available to many farmers site or may be not affordable economically to many. So, for controlling clay turbidity many farmers in West Bengal use organic matters like chopped paddy straw or pieces of banana stem and periodically remove the same from the pond, in addition to lime, to reduce clay turbidity. Clay particles may get attached to the straw and their settlement at the pond bottom causes correction of turbidity. Banana stem actually binds dissolved and suspended particles in the water column and thus clear water by coagulating the particles. But large amounts of organic material must be added to the pond to reduce turbidity, which can deplete dissolved oxygen to critically low levels and produce toxic gases as the organic matter decomposes. But the problem of deposition and decomposition of straw at the pond bottom in producing toxic gas and adding organic load to the culture system is unkown to them. The application of lime to ponds to clear unclean water and addition of pieces of banana stem was also recorded.

4.1.3. PH control

PH is approximately the negative of the base 10 logarithm of the activity of the hydrogen ion. Water with pH less than 7 are acidic and greater than 7 are basic. The optimal range of pH in water for fish culture is 6.5 to 8.5 ppm. Scientific fish culture prefers a neutral to slightly alkaline water pH for better growth of fish. Farmers hardly have laboratory facility to check it out. The experienced farmers mainly taste the water to check water pH. Although this technique doesn't provide very specific measure of water pH, but it provides the information whether the water is acidic or alkaline. Based upon this crude observation, farmers decide to take required action to correct water pH suitable for fish culture. Apart from using lime, farmers use ash of banana plants to increase the water PH. The banana trees are rich in potassium and are alkaline in nature, which actually helps in pH correction. Goswami *et al.* (2006) [15] have also reported that banana pseudo stem can be used to increase pH through their alkaline secretion by cutting them into pieces and immersing in pond water.

4.1.4. Aquatic weed control

Aquatic plants are natural and important components of the aquatic environment. Among different aquatic plants the microscopic plants (algae) form the base of the aquatic food chain. Larger algae and plants when present in limited number provide habitat for fish and food organisms, and all plants produce oxygen by virtue of their photosynthesis during the day. But excessive growth of the plants can have a detrimental effect on a water body and its inhabitants. Aquatic weeds can cause fish mortality due to the oxygen depletion during night. Moreover, decrease in dissolved oxygen level also occurs due to die-off and decomposition of the plants in water body, which also turn the water polluted. The presence of large aquatic plants limits the space for free movement of fish and block light penetration which prevent photosynthesis by microscopic plants and cause fish kill. Farmers of West Bengal are practising age old traditional method to get rid of excess aquatic weed. Fine mesh nets and bamboo poles are used to drag algae, macrophytes and aquatic weed from one end of the pond to other for removal. Farmers often beat the water with bamboo poles to break the continuity of the algal mat and control the spreading of the weeds over the pond surface. Grass carp (*Ctenopharyngodon idella*), silver carp (*Hypophthalmichthys molitrix*), black carp (*Mylopharyngodon piceus*), common carps (*Cyprinus carpio*) and Puntius (*Puntius sarana*) are introduced by the framers in the culture system to feed upon and counteract weed problem. Goswami *et al.* (2006) [15] have observed the use of bamboo poles with toothed prongs or coir rope to remove aquatic weed from water bodies. The farmers reported that algae can be controlled convincingly within one to two weeks using cattle urine. Das *et al*. (2013) [16] in their study in Tripura also documented the application of cattle urine to control the problem of algal bloom formation in pond water. Algal bloom were also controlled by keeping few floating water hyacinth (*Eichhornia crassipes*), locally known as *Kochuri pana* which absorb nutrient and heavy metals, making them limited for the growth of algal bloom.

4.1.5. Control of tadpoles and snails in ponds

Many aqua-culturists have reported economic loss due to the presence of the snails and tadpoles in ponds by competing for food and habitat in pond ecosystem and effecting fish growth. Sorting and removing tadpoles and snails from harvest nets affects production quantification and is time consuming. Moreover it subjects fish to severe mechanical injury and stress. Tadpoles and snails may also substantially reduce primary production, effectively compete for space and artificial feed and serve as vectors for fish disease and as parasites in fish. Current methods used to control tadpoles include using chemicals. The chemical methods are costly, not affordable by the poor farmers, often haphazard, and not highly effective. Farmers of Bengal were reported to apply ash @ 40-45kg/ ha pond or lime @ 20-25 kg/ha around pond periphery for two consecutive weeks to remove tadpoles (Das *et al.*, 2013) [16]. The farmers also remove submerged substrates from water to avoid hatching of adhesive tadpoles eggs deposited in the substrate. To control over population of snails that created hindrance in fish culture, farmers use banana leaf, coconut leaf, palm leaf and bamboo baskets, which are thrown in the pond for a period of 15 – 20 days. Snails use those materials as substratum. Then those materials were removed from ponds along with attached snails [16]. Use of formalin has also been reported for the same reason.

4.1.6. Removal of poisonous gas

Farmers often face problem of toxic gas formation at pond bottom sediment due to over loading of manures. Moreover, leaves from trees often fall on to the pond and sink to the bottom, get rotten and produce a high concentration of poisonous gases dissolved in the water. In such cases, fish get stressed due to water quality deterioration and often kills fish. Farmers usually identify the situation by observing the air bubbles and often foaming formed in pond surface water. Banana stem in considerable quantities are used to manage such problems. Manually raking the pond bottom by dragging tree-branches and bamboo poles horizontally at the pond bottom to release out the humus gas from sediment was observed in West Bengal and same practice has also been reported from Tripura by Das *et al.* (2013) [16]. Hollow bamboo poles are also placed vertically from the mud of the pond bottom upto surface water level to release gas through the pole from the pond bottom.

4.1.7. Feed management

Fish feed is a major expenditure for fish farmers. A balanced fish feed may provide optimum growth of fish and help to fight disease outbreak. Good fish feed management can reduce overall culture cost, improve fish farm environment and ensure healthy growth of fish stock. The proper storage of feed, feeding time, frequency of feeding are the essential component for optimum fish production. Fish farmers of Bengal usually keep feed in gunny bags with small perforations and immerse the same at the corners of the pond tying it in bamboo poles. Mainly farmers are reported to feed partially fermented rice, kura (red powdery coating of rice under the husk), mustard oil cake, bhushi (the remains of wheat grains) as feed ingredient. Substrate such as bamboo, wood, stem and branches of plants are put in the pond bottom for plankton growth. Poultry offal and tannery wastes are also used as feed to catfish for higher growth. The actual dose, rate and feeding interval was unknown to the majority of the farmers interviewed.

4.2. Fish Health management

Fish health management are mainly the management practices which are designed to prevent fish diseases. Disease pose a major threat to aquaculture. Successful fish health management starts with prevention of disease rather than treatment. Prevention of fish disease is accomplished through good water quality management, nutrition, and sanitation. Farmers of West Bengal don’t have thorough knowledge about diagnosis of disease, prevention, treatment and control measures. But some indigenous methods are followed by them to combat disease outbreak and at the initial stage of disease outbreak, success is also achieved in treating the diseases.

4.2.1. Control of external infection

External infection generally occurs due to bacteria, parasites and fungi. Mainly the reasons of any external infection are poor water quality and physical injury, which creates a portal of entry for the pathogens. For any external infection and abnormality in fish like haemorrhages, ulcers etc. the farmers use salt bath. Farmers generally use salt dip or potassium permanganate dip for 1-2 minutes to get rid of any infection. The doses vary widely due to the unawareness of the farmers which sometimes lead to deterioration of the prevailing pathological condition.

4.2.2. Control of *Argulus*

Argulosis in fish cause serious damage. *Argulus* are visible in naked eye. The lice lives in the body surface and fins of fish creating small wounds and reducing the growth of fish. The affected fish suffers from anaemia. Preventative methods and regular monitoring are rarely applied, so that chemical interventions become necessary during Argulosis. Normally *Argulus* infected fish rub their body near the pond dyke or in any hard substratum. So, farmers conventionally keep bamboo poles in bottom sediment in such a way that it can remain vertically throughout the water column. Farmers believe that the fish can get rid of *Argulus* by rubbing their bodies against the bamboo pieces (Kalitha *et al.*, 2004; Goswami *et al.*, 2006) [17, 15]. But in reality, bamboo poles serve as good substrates for *Argulus* to breed, lay eggs and colonize on them. Some farmers also keep old gunny bags submerged in pond water and remove them periodically to kill eggs of the *Argulus* deposited over them.

Some chemicals including pesticides and insecticide (trichlorfon, dermeton, malathion, dichlorvos, ronnel, rulene, parathion, diazinon etc.) are also widely used by farmers of West Bengal. The doses of the application vary depending on the intensity of the infestation. Farmers’ have misconception of using more pesticide to achieve better result, which often causes fish kill.

4.2.3. Control of epizootic ulcerative syndrome (EUS)

Epizootic ulcerative syndrome (EUS) has caused severe damage to aquaculture of India. It appeared for the first time in India and in West Bengal in the year 1988 and has now covered almost every state of the country. It commonly occurs during and before the onset of winter season. At first, fish develop red spots on the skin. The lesions expand to form ulcers followed by the development of granulomas on the internal organs and death. Ulceration in fish body is the first symptom the farmers used to identify. Several traditional practices were recorded from farmers field to control this disease. Application of a paste of turmeric powder and ash of hay or bamboo to control EUS has been practiced by fish farmers. Some farmers even apply branches of Neem plant into fish ponds Kalitha *et al.* (2004) [17]. The degree of recovery of the disease is depended on the degree of spread. According to Goswami *et al.* (2006) [15], the hatchery owners of Bengal control EUS by making paste from garlic and salt @ 2kg each along with 20gm Copper sulphate and potassium permanganate, and mixing it with 30-50 L of water and sprayed over pond water to control EUS. Application of a solution of rotten jaggery on fish for controlling ulcers has also been reported. Mixture of raw turmeric paste (100 gm.) and banana stem juice (2 L) per 0.16 ha pond was applied and found effective to control EUS within an approximate duration of 15 days. Application of turmeric with lime at 3:7

ratio in curing EUS has also been reported by Devi *et al.* (2014) [18]. Application of ash or banana leaf @ 40 kg/0.16 ha water area was found effective within two weeks to control EUS disease. Besides, application of raw garlic paste @ 20kg/ 0.16 ha water area also cured EUS within 15 days.

5. Conclusion

The aquaculture system of West Bengal is closely associated with indigenous traditional knowledge of the farmers. Lack of technical expertise and scientific knowledge on fish farming is reported as a common problem in the present study like other Asian countries (Chinabut *et al.*, 2002; Hasan and Ahmed, 2002; Jeney *et al.,* 2002; Phan *et al.,* 2002) [5-8] and India (Mondal and Das, 2005) [4].The study is also in line with the findings of Rajput (2005) [19] and Devi *et al.* (2014) [18] who observed that lack of knowledge for development of suitable dosage hinders wider use of the indigenous techniques in field. Small and marginal fish farmers of West Bengal cannot easily afford to adopt modern technologies. If the traditional knowledge may be used in farming systems along with frontier technologies developed by agricultural scientists, it would be more practical and will be quickly adapted by the farmers and lower their tendency towards commercial chemotherapeutants, which will in turn increase the benefits, practicability and acceptability of the technology. Though the farmers have a wealth of knowledge in solving their own problems, yet scientific intervention is a felt need to enhance their knowledge and to formulate effective management strategies for aquaculture. Suitable modifications of the local practices, through R&D will help to develop appropriate and acceptable methodologies, suited to the region specific farming situations. The farmers practicing indigenous techniques may also collaborate with research scientists in refining the knowledge for evolving appropriate technologies.

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