Mussel farming: alternate water monitoring practice

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Mussel ecology

Understanding the function of freshwater mussels within aquatic ecosystems is vital for successful management. The Indian freshwater mussel fauna comprises two genera that are abundantly found in most of the freshwater bodies. The genus Lamellidens is represented by nine species and two sub-species, while the genus *Parreysia* is represented by 35 species and 6 sub-species under two sub-genera (Subba Rao, 1989). These bivalves typically live partly buried in the sand or mud and leave characteristic furrows on the substratum due to the sloughing movements of the wedge-like powerful foot during restricted locomotion. They are encountered in greater abundance in waterways located in alluvial soil areas with soft soil substrate harboring green algae. It may be said that *Lamellidens marginalis* (Fig. 1a) is a typical pond species, while L. corrianus (Fig. 1b) is often encountered in shallow habitats including paddy fields during inundation. The species of the genus *Parreysia* (Fig. 1c) are more frequent in flowing habitats like irrigation canals, streams and rivers. Species of the genus *Lamellidens* are normally distributed in stagnant to slow flowing habitats like ponds, tanks, lakes and reservoirs at a depth of 0.5 m (Fig. 2) and beyond (Misra et. al. 2000; Misra, G. 2005). Neutral to slightly alkaline waters are in general conducive for mussel colonization.

Efficacy of freshwater mussels

Freshwater pearl culture

Mussels had been largely ignored by the aquaculture sector since their practical utility was limited. However, in recent times, role of freshwater bivalves in producing an aquatic gem cannot be ruled out. Cultured pearls are produced both in marine and freshwater environments. Possibly, the genesis of modern freshwater pearl culture can be traced back to the traditional practice from the 12th century in producing pearl-coated Buddha images in the mussel Cristaria plicata in lake Tahu in China. The conventional method of production of cultured pearls in vivo involves huge risk. In India, marine pearl culture had its beginning in the early seventies by the efforts of the Central Marine Fisheries Research Institute and the theory of natural and culture pearl formation in marine oysters is now fairly established. Freshwater pearl culture, on the other hand, remained as an unexplored area despite vast freshwater resources and abundant natural stocks of freshwater mussels in the country. Realizing the scope and importance of inland pearl culture, an indigenous system of culturing pearls from common freshwater mussels, *Lamellidens marginalis*, *L. corrianus* and *Parreysia corrugata* has evolved (Janakiram 1989) producing conventional regular round, mabe (half round and design), small round, oval to irregular pearls of assorted colour and luster. Traditionally in the fisheries sector, freshwater mussel fauna are in great demand because of their requirements in diverse fields viz. shell button industry, lime and handicrafts. Mussel meat, an affluent source of protein, is conventionally used as feed in shrimp and catfish hatcheries and is also eaten in some tribal belts of India, such as West Bengal, Bihar, North Eastern States and Orissa. Their task in maintaining the water body as a natural cleanser is a boon to the aqua-industry.

Water body monitoring process

Water quality monitors often look for benthic macro invertebrates to evaluate water quality. These include aquatic insects, worms, shellfish, crustaceans and other animals that are large enough to see without magnification and live at the bottom of a water body. Increasing effort has been devoted towards the selection of appropriate biomonitors. Quite a few such studies specify that molluscs can endure persistent toxins to a greater extent than other organisms and serve as effective biomonitors or indicators (Fang et al, 2001; Salanki et. al. 2003 and Somoldes et. al. 2003). Bivalves have been used for decades as sentinel organisms to monitor pollution in aquatic environment as they are an important indicator of water quality, including waters used for drinking, irrigation and recreational purposes as their community responds to changes in water or habitat quality. The advantages of molluscs over other organisms for biomonitoring studies are their large size as macro-invertebrates and their restricted mobility. Their abundance in diverse types of aquatic bodies and their trouble-free collection is an added benefit for such studies.

Figure 1. Commonly available mussel species in India.

a. *Lamellidens marginalis*.

b. *Lamellidens corrianus*.

c. *Parreysia corrugate*.

The abiotic and biotic factors of an aquatic ecosystem are interdependent and the fluctuations of abiotic factor frequently affect the biotic factors (flora & fauna) changing their quality and variety. The abundance of this benthic fauna greatly depends on physical and chemical property of the substratum

Figure 2. Collecting freshwater mussels from the peripheral pond area.

and can be employed as a barometer of over all biodiversity in aquatic bionetworks. The widespread reduction in density and diversity of freshwater mussels in aquatic ecosystems suggests that insubstantial changes in water quality characteristics can have pervasive effects. Species of commercially obtained freshwater mussel *Elliptio complanata*, a native of Canada, have been shown to actively filter, concentrate, and retain fecal coliform bacteria from a variety of freshwater stream environments (Beth et. al. 2004).

The advantage of using bioindicators over chemical and physical tests to evaluate water quality is that the presence of living organisms inherently provides information about water quality over time. The lack or poor conditions of bioindicators might provide a clue of adverse consequence. The presence of a mixed population of healthy, mussels along with aquatic insects or fish usually indicates that the water quality has been good for some time. The absence of bioindicators at a site that appears good according to chemical and physical sampling might demand further investigations of water quality. Each species of mussel has different environmental requirements. Some species like *E. complanata*, are more pollution tolerant than species like *Margaretifera margaretifera*, the pearl shell mussel. However, since freshwater mussels are hardy creatures, their presence or absence can provide even more information about the history of water quality at a site.

Bioaccumulation

Mussels are sedentary, benthic and gregarious invertebrates. They filter water continuously and feed on phytoplankton. The water current is taken through the inhalant siphons that passes through the gills, labial palps, mantle of the mussels and is finally ejected through the exhalent siphon. During such processes the suspended soil particles, excess algal blooms and metal ions (Cu, Zn, Ni etc.) are removed from the water. In addition to the gills, the mantle, kidney, foot and hepatopancreas are anticipated to be major sites of metal uptake because of their large surface area, thus clearing the aquatic habitat. They accumulate both essential (Na, Ca, Mg) and non essential (Hg, Cd, Pb) metals in higher concentrations than the ambient water. Through their filter feeding and respiratory mechanisms mussels also take up other pollutants such as hydrophobic organic contaminants, poly aromatic hydrocarbons, metallothionein and organochlorines. The accumulation of contaminants from the water column by bivalves is referred to as 'bioconcentration', a property that makes bivalves potentially useful as 'biomonitors' for water quality monitoring programmes, and also for bioremediation to improve the quality of polluted waters.

Bioaccumulation of toxins is one of the many possible tools that can be employed in bio monitoring. In the United States, hanging culture of Dreissena polymorpha is used to reduce suspended matter loads, toxins and especially organic pollutants. *Mytilus edulis*, the blue mussel have been used traditionally in the marine sector for environmental monitoring due to concern for pollution in coastal and estuarine areas. *Anodonta cygnea* when exposed to toxin strain of cyanobacterium, accumulated huge quantity of the peptide oscillatoria toxin that was present in low concentrations within the cyanobacterial cells. Pollutants or chemicals enter the mussels system as they filter water through their gills for respiration and feeding or in case of inorganic contaminants such as metals, through facilitated diffusion, active transport or endocytosis. Moreover some bivalve species are exposed to pollution through pedal feeding or gill ingestion of sediment. Accumulation occurs in tissues e.g. heavy metals will accumulate primarily in muscles and organ (soft) tissues and organic pollutants accumulate in the lipid. Bivalves

Figure 3. Pearl culture ponds.

have been known to metabolize certain classes of compounds better than others controlling ecotoxicity. Mussels possess only minimal ability to bio-transform poly aromatic hydrocarbon (PAH) and are therefore good sentinels of the accumulation of PAHs. More recently freshwater bivalves have been utilized to assess the quality of lakes, rivers and streams.

Plankton control

For upkeep of water systems in aquaculture practices it is can be useful to include freshwater mussel fauna or follow an integration practice. In freshwater pearl farming mussels can plan a very significant role in water quality management through their control of plankton population as a result of filter feeding. Mussels consume both green and blue-green algal cells (Misra et. al. 1998; Wood et. al. 2006). Freshwater mussels can affect phytoplankton populations in two ways; by direct consumption and indirectly by altering nutrient cycles that may favour undesirable algal species. Pearl farming ponds are provided with floating rafts made up of PVC or bamboo in which the operated mussels are hung in the water column at a depth of 60cm. The stocking density of mussels can be 20,000-30,000 in a 0.4 ha pond. Mussels can also be used for bioremediation or as natural biofilters in prawn farming or simply to control excess algal blooms that may pose a risk of eutrophication. The filtration rate can be accelerated by selecting larger individuals that are likely to be more effective than the smaller ones in accumulating phytoplankton.

Future thrust

In recent times mussels are widely used as indicators of water quality or for remediation purposes, even in water treatment plants. Conserving the mussel fauna will ensure that our river and lakes are clean enough to perform aquaculture and other related activities. Easy dissemination techniques for use mussels is these contexts need to be developed. The reproduction system and gonadal behavior of mussel in particular needs attention. Globally substantial work has been done in relation to conservation of mussel fauna, especially of the endangered species such as *Lampsilis* and *M. margaretifera*. In India as well as in the adjoining countries like Bangladesh, Sri Lanka, and Myanmar the bivalves, Lamellidens marginalis and L. corrianus are known to be distributed in the perennial and artificial freshwater bodies (Subba Rao, 1989). Conservation of these species is of prime importance and thus their culture and maintenance is to be emphasized for uninterrupted accessibility of these species to the concerned sector.

Issues that require further study include the endurance of mussels in eutrophic waterways, the quantity of vigorously feeding mussels required to effectively control algal growth under different ecological conditions, and whether it is possible to rear mussels in adequate numbers for their eventual introduction into water bodies with algal problems. In future a holistic approach is needed to quantify mussel filtration rate along with the propagation experiments to establish their role in water quality management. Establishing water quality criteria that includes freshwater mussel response requires an understanding of conventional assessment approaches and scientific considerations.

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References

Beth, C., Michael, S., Mac, L., Robin, O. and Jay, L. 2004. Evaluation of potential health risks to Eastern Elliptio (Elliptio complanata) (Mollusca: Bivalvia: Unionida: Unionidae) and implications for sympatric endangered freshwater mussel species. Journal of Aquatic Ecosystems Stress and Recovery 9: 35-42.

Fang, Z. Q., Cheung, R. Y. H. and Wong, M. H. 2001. Heavy metal concentration in edible bivalve and gastropods available in major market of the Pearl River Delta. Journal of Environmental Science 13: 210-217.

Freshwater Pearl Culture. Training Bulletin, Gayatri Misra, Maharathy, C., Mohanty, P., Pattnaik, S., Ghadai, K., Bhanot, K.K. and Janakiram, K. 2000. Central Institute of Freshwater Aquaculture, Bhubaneswar. 37pp.

Misra, G. 2005. Pearl farming – Avenue For Women Entrepreneurship. In Ninawe, A.S and Diwan, A.D. (eds.) Women Empowerment in Fisheries. Narendra Publishing House, Delhi, pp.201–212.

Misra, G. Kumar K. and Janakiram K. 1998. Role of selected feeds in captive culture of Indian pearl mussel *Lamellidens marginalis* (Lamarck). Current and Emerging Trends in Aquaculture. Ed. P. C. Thomas. Daya Publishing House, New Delhi. pp. 241 –243.

Naimo, T. J., A review of the effects of heavy metals on mussels. 1995. Ecotoxicology 4: 341 – 362.

Salanki, J., Farkas, A., Kamardina,T. and Rozsa, K. S. 2001. Molluscs in biological monitoring water quality. Toxicology Letters 11: 403 –410.

Smolden, R., Bervoets, L.,Wepenser, V. and Blust, R. 2003. A conceptual frame work of using mussels as biomonitors in whole effluent toxicity. Human Ecology. 9(3): 741 –760.

Subba Rao, N. V., 1989. Handbook on freshwater molluscs of India. Zoological Survey of India. Calcutta, India, 289 pp.

Janaki Ram, K., 1989. Studies on culture pearl production from freshwater mussels. Current. Science 58 (8): 474-476.

Wood, S. A., Briggs, L. R., Sprosen, J., Ruck, J. G., Wear, R. G., Holland, P. T., Bloxham, M. 2006. Changes in concentration of microcystis in rainbow trout, freshwater mussels and cyanobacteria in lakes Rotoiti and Rotochu. Environmental Toxicity 21: 205 – 222.