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Freshwater Mussels (Bivalvia: Unionoida) as a biological and water quality indicator: A review

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ABSTRACT

Urbanization is the important contribution to the environmental pollution especially freshwater habitat. Water pollution is a primary reason for the pollution of environment, ecosystem and human health. Molluscans are most important groups of invertebrates in an ecosystem with regard to biomass, diversity, spatial or tropic relationships. Freshwater mussels (Bivalvia: Unionoida) are important component of ecosystems and used as a biological indicator for water pollution. This is due to the special characteristic features that makes as a good biological indicator. There are more sensitive to the toxins and heavy metals such as, copper, zinc, cadmium etc. the accumulation toxins and heavy metal in the shell and organs of freshwater mussels indicating the contaminant nature of the water bodies.

Key words : *Water pollution, Heavy metals, Bioaccumulation, Mollusca, Bio-indicator, Chemical parameters.*

Introduction

Freshwater mussels (Bivalvia: Unionoida) are a group of invertebrate live in freshwater such as lakes and streams. Freshwater mussels are key components of freshwater ecosystems, and have worldwide ecological and economic significance. Freshwater mussels are bivalve molluscs and as such have characteristics common with marine species such as the quahog, oyster and blue mussel. They are distributed nearly worldwide, inhabiting every continent on Earth except Antarctica. Approximately 780 species belonging to 140 genera have been identified, with species diversity maximized in the creeks, rivers, and lakes of North America (Graf and Cummings, 2007).

Six families of freshwater mussels are known as worldwide, although only two families occur in North America (Unionidae and Margaritiferidae). Freshwater mussels play an important role in aquatic ecosystems. As sedentary suspension feeders, unionoids remove a variety of materials from the water column, including sediment, organic matter, bacteria, and phytoplankton. Siphoned material is either transferred to the mouth for digestion or sloughs off the gills and exits via the ventral margin of the shell (pseudofeces). Digested material is either used as fuel for various life processes or excreted as feces. (Vaughn and Hakenkamp, 2001). While the siphoning activities of mussels are often overlooked, they provide an integral resource link between pelagic and benthic habitats (Nelapa *et al.*, 1991; Howard and Cuffey, 2006). Juvenile mussels have demonstrated the ability to pedal feed by sweeping their foot to collect food particles from sediments.

Freshwater Mussels as Biological Indicators

Freshwater mussels possess special characteristics feature that make them as a biological indicator (Bedford *et al.*, 1968; Simmons and Reed, 1973; Imlay, 1982; Neves, 1993; Naimo, 1995). This attribute is allowed individuals to function as "environmental logbooks," effectively record the changes in water habitat over time.

Freshwater mussels are commonly known as "good" indicators of biological integrity and water quality by scientists. Kearns and Karr (1994) used mussels from the genus *Epioblasma* and three snail genera as an intolerant metric when developing a B-IBI (Benthic Index of Biotic Integrity) for the Tennessee Valley. Pip (2006) evaluated water quality and mollusc communities in southern Lake Winnipeg, Manitoba, Canada and reported that mussel richness was positively correlated with total dissolved solids and negatively correlated with lead. She also reported that significant reduction in mussel species diversity in water bodies and it was suggested that this change was due to oxygen depletion, algal toxins, sewage and agricultural spills and habitat changes.

Sensitivity to Toxic Contaminants

The concentration and exposure of toxic contaminant from a particular species may vary from pollutant to pollutant. Additionally, the toxicity of a particular pollutant may be influenced by a number of variables, including concentration and exposure route, frequency, and duration.

Mussel population are severely reduced or destructed due to the toxic contaminants throughout the world (Baker, 1928). Early of the 20th century, industrial stream pollution tells dyestuff discharges from knitting mills causing widespread destruction (Clark and Wilson, 1912) and rivers acting as a sole material of sewage and manufacturing waste. More recently, assessments of unionoid populations have cited toxic contaminants as a contributor to widespread faunal declines (Havlik and Marking, 1987; Bogan, 1993; Neves *et al.*, 1997).

Freshwater mussels exhibit a variety of sensitivities to toxic contaminants based on species, life stage (glochidium, juvenile, or adult), and environmental conditions. For example, Wang *et al.*, (2007a) reported that glochidial Oyster Mussel (*Epioblasma capsaeformis*) and Scaleshell (*Leptodea leptodon*) were far more sensitive to copper than glochidial Dwarf Wedgemussel (Alasmidonta heterodon).

Shells as Indicators

Freshwater mussel shells used as an indicators of ecological integrity and environmental stress since the early 1900s (Coker *et al.*, 1921). However, recently, researchers have started to collect quantitative information from the shell material (Imlay, 1982; Ravera *et al.*, 2005; Brown *et al.*, 2005).

Mussel shells consist of five primary layers: the periostracum, prismatic layer, peripheral layer, laminar layer, and inner nacreous layer (Imlay, 1982). The periostracum is mainly proteinaceous in nature. Other four layers are comprised of calcium carbonate, in the form of calcite or aragonite.

Metals may be present in shell material due to surface adsorption or as metabolic analogues of calcium. The metal content of shell material often varies greatly from what is found in soft tissues. For example, Anderson (1977) reported that the metal concentrations were higher in soft tissues compared to the shell material. In particularly zinc concentration was accumulated to level of 10-40 times found in shell material. Ravera *et al.*, (2003) reported shells contain higher concentrations of Ca, Cr, Mn, Ni, and Mo than the soft tissues, however, concentrations of As, Cd, Cu, Ni, and Pb was lower in shells than soft tissues. Considerable variation was also observed in heavy metal concentrations between different species.

Ravera *et al.*, (2005) analyzed shell material from a pair of Italian lakes to document the changes in the metal concentrations over two distinct time periods. Using recently collected shells and preserved valves from a museum, researchers were able to analyze metal concentrations from 1928-1934 and 1995-2000. Several metals significantly differed in concentration between the two periods, which also varied greatly between the two lakes.

Biological Indicator of freshwater Molluscs

Some of the molluscan species such as *Alasmidonta Sp. EpioblasmaSp, Fusconaia Sp, Lampsilis Sp, Lasmigona, Pleurobema, Quadrula, Medionidus conradicus* are worked as a valuable indicators of habitat and water quality and indicating the toxic and other biological contaminant in water bodies (Grabarkiewicz and Davis, 2008).

Water and sediment quality

Because of filter feeders' adult mussels are sensitive to water borne contaminants such as those carried in agricultural runoff and in municipal and industrial wastewater. On the other hand, Juvenile mussels may be particularly sensitive to the chemistry of the sediments in which they live and feed. Thus, possible influences on mussel communities might include not only the chemical quality of stream water but also the chemical quality of streambed sediments, which is particularly prone to storing trace metals and organic chemical compounds. Water and sediment quality can be evaluated from a combination of onsite measurements of water quality and collection of water and sediment samples for laboratory analyses (Beth *et al.,* 2004).

Water body monitoring process

The large size of as macro-invertebrates and restricted mobility are more important advantageous over the other organisms for biomonitoring. The reduction in density and diversity of freshwater mussels suggests that insubstantial changes in water quality characteristics can have pervasive effects (Beth *et al.,* 2004). The advantage of using bio indicators over chemical and physical tests to evaluate water quality is that the presence of living organisms inherently provides information about water quality over time.

Bioaccumulation

Fresh water mussels are sedentary, benthic and gregarious invertebrates. They filter water continuously and feed on phytoplankton. The water current is taken by the inhalant siphons that pass through the gills, labial palps, and mantle, and is finally ejected by the exhalent siphon. During this process the suspended soil particles, excess algal blooms and metal ions (Cu, Zn, Ni etc.) are removed from the water. 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, they are also take up other pollutants such as hydrophobic organic contaminants, poly aromatic hydrocarbons, metallothionein and organochlorines (Ravera *et al.,* 2003). 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. Hanging culture of *Dreissenapo lymorpha* 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 coastland 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. 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 have been known to metabolize certain classes of compounds better than others controlling ecotoxicity. More recently freshwater bivalves have been utilized to assess the quality of lakes, rivers and streams (Misra and Mukhapadhyay, 2008).

Conclusion

Ecosystem services are benefits to humans. Freshwater mussels performed important role in aquatic ecosystems, which may in turn be framed as the ecosystem services that they contribute to or provide. These include services such as nutrient recycle and storage, structural habitat, substrate and food web modification, and use as environmental monitors; regulating services such as water purification (biofiltration); and provisioning and cultural services including use as a food source, as tools and jewelry, and for spiritual enhancement. Mussel-provided ecosystem services are declining because of large declines in mussel abundance. Mussel propagation could be used to restore populations of common mussel species and their ecosystem services.

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