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Review : Gastropods as A Bioindicator and Biomonitoring Metal Pollution

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Abstract

Andi Nur Samsi, Ruzkiah Asaf, Sahabuddin, Andi Santi, and Muhammad Ikhsan Wamnebo. 2017. Review: Gastropods as A Bioindicator and Biomonitoring Metal Pollution. *Aquacultura Indonesiana, 18 (1): 1-8*. Water pollution effect on aquatic organisms and if consumed can affect people's health. These pollutants can be heavy metals such as Cd, Pb, Cr, Hg, and others. Heavy metals have high levels will cause disorders of the kidneys, brain, severe irritation to the skin, can cause diarrhea and even death. The purpose of this paper is to explain physiological mechanisms that occur in the body of gastropods are linked to pollutants in the water environment. Therefore, monitoring the level of pollution a body of water that is alleged to have suffered contamination is very important. Gastropods are one of the aquatic animals (Class) used as bioindicators and biomonitoring for this group of animals has a high ability to accumulate heavy metals in their bodies compared to other aquatic animals. Gastropods is one bioavailability against metal pollution so that it can be used for environmental monitoring. *Littoraria scabra*, *Nassarius reticulatus*, *Nerita albicilla*, *Nucella lapillus*, *Gibberulus gibbosus*, *Terebralia palustris*, and *Telescopium telescopiun* always use as biomonitoring metal pollution. The main indicator that can be shown by gastropods is declining abundance and body size. Other indicators are as bioavailability of heavy metals in the soft tissues and shells. The ability of the heavy metal deposits is influenced by environmental factors, body size, weight, and gender. Heavy metals can affect hard, thickness, volume, and color of the shell.

Keywords*:* Bioindicator; Gastropods; Heavy metal; Human health; Pollution

Introduction

Water pollution affects human health because it can cause typhoid, hepatitis, diarrhea, cholera, malaria, blindness, paratyphoid, polio, and cryptosporidiosis. Akhtar *et al*. (2005) also added that water pollution can cause stomach disorders, kidney disorders, toxic food, and skin problems. Additionally, it can cause diarrhea that leads to death (Carr, 2001).

Gastropod is also used extensively as bioavailability (Rainbow *et al*., 1993, 2000; Bebianno *et al*., 2003). Bioavailability is the discovery of Cd in the form of nanoparticles (Khan *et al*., 2013). Bioavailability also means finding an element in the body of an organism. Gastropods are used for monitoring pollution in the waters and used in the environmental monitoring program to transformation heavy metal temporally and geographically which threatening to health (Amin *et al*., 2009). Amin *et al*. (2009) found that anthropogenic activity in Dumai strongly associated with the level of heavy metals in sediments and this is a negative impact on the community structure of gastropods. Biomonitoring can be defined as the use of organisms to determine environmental change conditions (Gerhardt, 1999; Oertel and Salanki, 2003) whereas the bioindicator is an organism or part of an organism or a community that provides information about environmental quality (Markert *et al*., 1999; Markert *et al*., 2003).

In this paper, will be discussed in more detail how gastropods can be used as bioindicators and biomonitoring metal pollution in water. Biomonitor or bioindicator using indicator taxa that examined the impact of environmental changes such as change of habitat, fragmentation, and climate change (McGeoch, 1998, in Markert *et al*., 2003) in the spatial and temporal scales. Pollution can be interpreted as contaminants in the water that comes from industrial activity and human activity such as heavy metals, pesticides, fluoride, phenol, insecticides and detergents (Reddy and Lee, 2012). The discussion will focus on the physiological mechanisms that occur in the body of gastropods are linked to pollutants in the water environment. This has induced to the introduction and supervision of water is very important.

Water Pollution

Water is an important part of the life cycle. Water must be preserved and protected from all types of pollutants. The human body and other living organisms need water but in a pure form free of various types of contamination. However, human intrusive bodies of water those rivers, wells, and sea. On land, natural water systems polluted by industrial waste, urban sewage, pesticides, and pollutants associated (Pathak, 2013).

In a scientific sense, water pollution is a distortion of aquatic ecosystems. Therefore, water pollution is a change that affects the aquatic ecosystem of living organisms, in particular, the oxygen content, the presence of toxins and so on (Thakur, 2005). Water pollution comes from a variety of forms, including (Pathak, 2013):

1. Deoxygenating material, for example, household waste and other organic waste, such as silage, agricultural waste from a number of heavy industrial processes (e.g. food processing and production of smokeless fuels, textiles, paper and dairy products);
2. Fertilizers such as manure, which can cause eutrophication, causing acceleration of the growth of plants and algae and cause a decrease in water quality;
3. Solid materials, which can inhibit or block the flow of light for growth;
4. Toxic material: some materials, such as heavy metals, pesticides or nitrates, which are toxic to humans, animals and plants;
5. Disease-carried away by agents, such as bacteria;
6. The heat, which can affect biological conditions and also deoxygenates water.

The effect of any pollutant varies according to the size, temperature; flow rate and oxygen content of the water, as well as the local geology and the presence of other pollutants and produced a synergistic effect. It is not enough if only to see water pollution because about 30% of water supply is taken from groundwater. As a result, water pollution control includes control fluid drainage into the ground (Bell and McGillivray, 2004).

Pollution has been entered into the aquatic environment, rivers, swamps, sea, estuary, and others. Pollution or contamination of the environment generally in the form of chemicals and even heavy metal. Disruptions caused chemicals to be dangerous and can affect the organism either directly or indirectly. Anthropogenic disruptions will directly affect the organism and indirectly affect species interactions (Pinto *et al*., 2015).

Increased human activity in the household led to the growing volume of waste generated from time to time. The volume of household waste increased by 5 million m^3 per annum, with an increase in the average content of 50% (Haryoto, 1999). The consequence is that the burden of the body of water that had been used as a household waste disposal is becoming increasingly severe, including the disruption of other components such as waterways, marine life, and the water source population. The situation is causing a lot of pollution that cause harm to humans and the environment (Yusuf, 2008).

The community macroinvertebrates are very important in describing biodiversity, ecosystem health and play an important role as a component of trophic important in the food web (Coull *et al*., 1995; MacFarlane and Booth, 2001; Yap *et al*., 2003; Azrina *et al*., 2006). Benthic communities are often affected by the waste. The main source of contaminants derived from urban and agricultural runoff, industrial, boats, and recreational aspects of the use, discharge of oil and chemicals and "dumping pollutants" (Harty, 1997; Birch *et al*., 1998). Heavy metals are typically stored in intertidal sediments that have an organic material and high pH (Luoma *et al*., 1990; Sadiq, 1992).

Gastropods

Community macrozoobenthos invertebrates important in demonstrating biodiversity, ecosystem health and play an important role as a component of trophic important in the food web (Coull *et al*., 1995; MacFarlane and Booth, 2001; Yap *et al*., 2003; Azrina *et al*., 2006). One group of invertebrates, which are often used in environmental monitoring are gastropods.

Shell of gastropods is twisted, mollusks asymmetrical, usually with a circular spiral shell (Figure 1). Their soft body is divided into four main parts: the head, which is usually prominent in the anterior of the shell; legs, stomach muscular organ with the essentially flat part that is used to move (creeping or burrowing); visceral mass, that fills the back of the spire shell, and contains important organ systems; coat, a tegumen such as lines and produce shells, and formed the mantle cavity which is usually where the gills. Gastropods rotate through 180° so-called "torque", which occurs in the first few hours of larval development. Most gastropods have a single circular shell, and the gill cover operculum. In some species, shells may be just as simple cone or dish upside down, or maybe even no shell (FAO, 1998).

Prosobranchia as the majority group gastropods. Shells of gastropods Prosobranchia usually consists of a circular and spiral tube increases with diameter growth, and opening only at the end of the growing ventral, called aperture. The axis may be hollow shells or columella, forming the opening of the shell, umbilicus. Basic shell formed by the largest spiral or body whorl, while the other whorls, which closer to the top or apex, is spire. The continuous line where two adjacent helices and joined known as suture. The aperture may be simple, rounded lines eggs, or can be transformed anteriorly by siphonal canal. Margins are close to columella forming an inner lip, while the opposite margin of the outer lip; Last margins sometimes show posterior canal. Shell surface is usually smooth, but usually also look chiseled, sculptured. A sculptural elemen in the form of a spiral else (follow the arc of a helix), or axial (transverse to the whorls and approximately parallel to the axis of the circular or axis) (FAO, 1998).

The majority Prosobranchs are carnivores, herbivores, using a radula, cuticle ribbon in the form of rows of teeth, to eat. Is generally separate sexes, although some species may be hermaphrodites. In Prosobranchs primitive, external fertilization; species with eggs to internal fertili-zation covered by a protective layer of mucus jelly or capsules corneous. Embryos can hatch as planktonic larvae swim freely, or crawling on young stages (after metamorphosis) (FAO, 1998).

There are various kinds of gastropods that can be used to determine the presence of pollutants in the environment (Figure 2). *Littoraria scabra*, gastropods kind used in the study of heavy metal accumulation in mangrove ecosystems (Wolf, *et al*., 2001; Wolf and Rashid, 2008). Lopes, *et al*. (2010) using *Terebralia palustris* to determine the direct and indirect effects of contaminant waste to it. *Nucella lapillus* and *Nassarius reticulatus* used to determine the pattern of bioaccumulation butyltin (Ruiz, *et al*., 2008; Ruiz, *et al*., 2010). In addition, shells *Nerita albicilla* and *Canarium (Gibberulus) gibbosus* used as an indicator of pollution in the Red Sea, Egypt (El-Sorogy, *et al*., 2013).

Gastropods types *Telescopium telescopium* also used in biomonitor Cd, Cu, Pb, Fe, Ni and Zn in Sungai Sepang Besar, Malaysia. Metal contamination found in tissue and soft tissue gastropod shells. Body parts such whorl shell, the shell middle, and part of apex. The soft tissue covering the legs, tentacles, gills, muscles, coat, digestive tract and other tissues (Yap and Noorhaidah, 2012).

The concentration of Cd, Cu, Pb, Fe, Ni, and Zn on the network shell found at the highest concentrations of Fe body whorl with an average value of 153 mg/g (dry weight) and the lowest Cd concentration in apex with an average rating of 2.97 ug/g (dry weight). On the soft tissue found in the gills highest concentrations of Fe with an average value of 1,536 mg/g (dry weight) and the concentration of Cd in the legs with an average value of 0.01 ug/g (dry weight) (Yap and Noorhaidah, 2012).

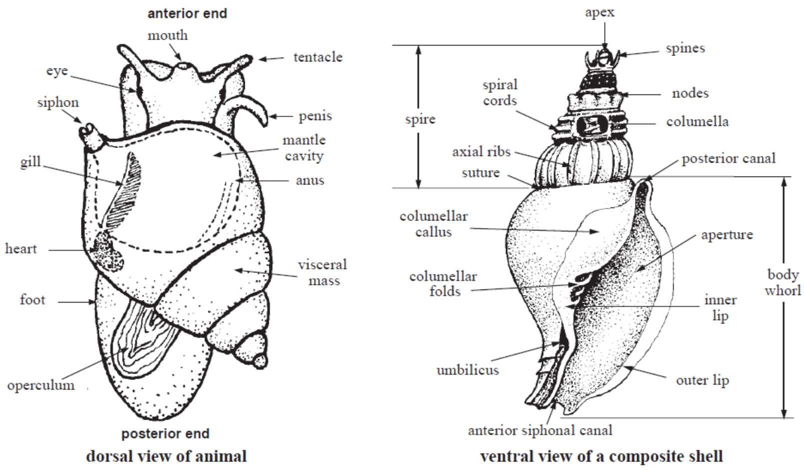

Figure 1. Morphology Gastropoda (Source: FAO, 1998)

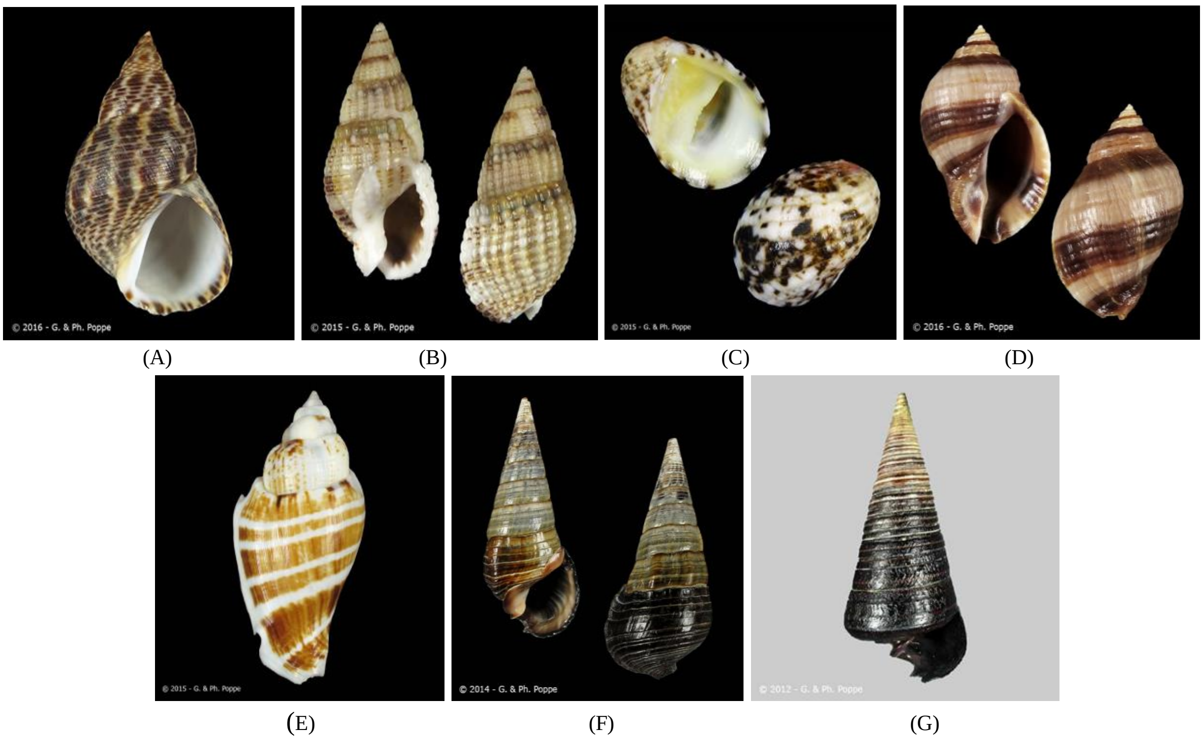

Figure 2. A. *Littoraria scabra*; B. *Nassarius reticulatus*; C. *Nerita albicilla*; D. *Nucella lapillus*; E. *Gibberulus gibbosus*; F. *Terebralia palustris*; G. *Telescopium telescopium* (Source: www.conchology.be)

Mechanism Bioavailability

The mechanism of heavy metal bioavailability is mass transport through the plasma membrane. According to Figure 3, three exposure scenarios must be considered: the free metal ions, metal complexes, and particle-bound metals. The results of toxicity when levels of metal absorption from all sources exceeds the combined level of detoxification and excretion of the metal in question.

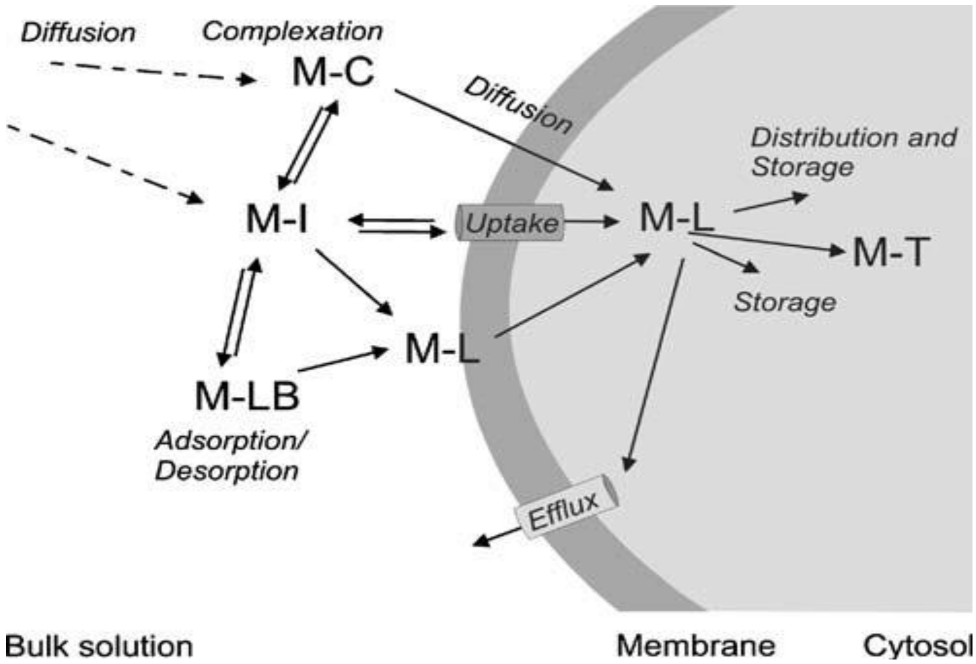

Figure 3. The conceptual model of the main process and the source for uptake of metals in biological membranes. (M-C metal complexes, M-I metal ion, MLB metal particles labile bond, M-T metal targets sites, metal M-L bound with a ligand biological), (redrawn and modified after Worms *et al*., 2006).

Bioavailability is the result of a complex contaminant/particle interaction and dense strongly influenced by the activities of organisms such as eating or digging behavior. This makes it unlikely that a simple chemical fractionation, methods will be developed, which mimic the bioavailability of metals for various organisms (Ahlf and Forstner, 2001). Thus, as discussed in Meyer (2002), the bioavailability of metals may be more of a conceptual term of the exact parameters measured.

After crossing the plasma membrane, which is included in the metal bound by the ligand and distributed among the storage section, efflux, or toxic action. The relationship between metal accumulation and toxicity is affected by physiological activity and the determination of the stage of an accurate understanding of the impact of the concentration of metals in aquatic organisms (Rainbow, 2007).

Effect of Metal Against Gastropods

Studies on a macrobenthic community which shows that concentrations of heavy metals in sediments correlate strongly with the composition of biological communities (Sommerfield *et al*., 1994; Warwick, 2001; Mucha *et al*., 2005). The benthic community has been frequently used in environmental monitoring and assessment of heavy metal contaminants and organic material in the estuary and often show changes in community structure and composition macrobenthic as the impact of pollutants (Gray *et al*., 1990; Warwick, 1993). Stark (1998) found a correlation between the concentrations of heavy metals and patterns in the collection of benthic Sydney, Australia. Ward and Hutchings (1996) also found a characteristic pattern of species associated with pollution gradient that consists of various types of heavy metals in various habitats around Port Pirrie, Northern Australia. Morrisey (1996) also found changes in abundance and taxonomic composition of fauna in the sediment which affected by Cu in Botany Bay, Australia.

Teles (1994) adds that the diversity index can provide better information about the condition of the environment as a living organism rather than just looking at the taxonomy. Clements (1991) explains that the metal impact on benthic communities is characterized by lowering the abundance, diversity index decreased, and the shift in the composition of the sensitive communities become tolerant taxa. Reynoldson (1987) adds that the clearest effects of contaminated sediments on benthic marine invertebrates will directly cause the death of the organism. Warwick (1993) also mentions that invertebrates macrobenthic continuous direct contact with sediment will be caused them to be immobile to avoid the impact of pollutants and limited their capability.

Gastropods also are used as an indicator of metal contaminants in sediments of mangrove Dumai, Sumatra, Indonesia (Amin *et al*., 2009). In general, if the concentration of Cd, Cu, Pb, Zn, Ni and Fe increased, the abundance of gastropods and species diversity will decline. The link between the concentration of heavy metals in sediment with a number of species of gastropods are found to be negative (Amin *et al*., 2009). Wolf and Rashid (2008) found that the opposite is Littoraria scabra density is higher in areas that are not polluted than the polluted area.

Much research has been done and showed that gastropods can be used biomonitor or bioindicator. Biomonitor or bioindicator using indicator taxa that examined the impact of environmental changes such as change of habitat, fragmentation, and climate change (McGeoch, 1998, in Markert *et al*., 2003) in the spatial and temporal scales. Indicator species may act as a representative of a group of organisms or the larger community (Meffe and Carrol, 1994 in Markert *et al*., 2003). Lawton and Gaston (2001) proposed that the indicator species (bio-indicators) used in the three objectives; (A) describe the state of biotic and abiotic environment; (B) disclose the facts about the impact of environmental change; or (c) shows the diversity of other species, taxa, or communities that exist within it.

Marine gastropods abundant along the coast in the world, easily be identified, and arrested all the time every year, and can tolerate a wide range of concentrations of contaminants and physicochemical variables such as salinity (Langston and Spence, 1995). Marine gastropods most ideal as biomonitor (Phillips, 1990).

Bioavailability is found the Cd in the form of nanoparticles (Khan *et al*., 2013). Gastropods are also used extensively as bioavailability (Rainbow *et al*., 1993, 2000; Bebiano *et al*., 2003). Aluminium, copper, manganese, tin, and zink is found in the soft tissues *Littoraria scabra* which living in polluted mangrove area (Wolf and Rashid, 2008). *L. scabra* may accumulate heavy metals derived from the water or the food (Bryan *et al*., 1983).

The heavy metal accumulates in the body of the soft parts of the animal, as well as in the shell Gastropoda (Krolak, 1998). Large heavy metal content in each of the soft tissues and shells of gastropods will be different. Distribution of heavy metals in body tissues gastropods are influenced by physiological tissue and metal bonding, storage and detoxification strategies (Yap and Cheng, 2013).

Shell of *Nerita albicilla* can accumulate Cu, Pb, Zn, Ag, Th, Ba, Ti, S, Sc, Se and *Canarium (Gibberulus) gibbosus* can accumulate Mo, U, Au, and K (El-Sorogy *et al*., 2013). In addition, changes in the size of *Littoraria scabra* were found in the area of non-polluting has a total weight, shell length and shell width greater than those found in the polluted area (Wolf and Rashid, 2008). Correlation between Zn content with hardness, thickness, and volume Cepaea nemoralis shell in the polluted area (Jordaens *et al*., 2006). Additionally, Jordaens *et al*. (2006) also found a significant correlation between the strength of the shell with pollution and shell color (F: 3.90, df: 1).

Bioaccumulation of heavy metals by gastropods are influenced by environmental factors such as water flow, water availability, pH, sediment, salinity, and other (Williamson, 1980). In addition, body size, weight, and gender have an important role in the accumulation of heavy metals (Gupta and Singh, 2011).

Conclusions

Gastropods can be used as bio-indicators and biomonitor heavy metal pollution. Gastropod response to polutant indicated by the decrease in the abundance, size changes and can affects the community structure. Environmental factors, body size, weight, and gender influence in the accumulation of heavy metals. Heavy metals can affect hardness, thickness, volume, and color of the shell.

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