

## **Bioaccumulation of inorganic and organic mercury and organolead compounds in marine organisms**

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### **INTRODUCTION**

An important factor in understanding the metal biogeochemical cycles is the knowledge on the bioavailability and trophic transfer of metals in the marine food chain. Recent research in the area demonstrated that numerous factors influence bioaccumulation of particular metals into marine organisms (Fisher and Reinfelder, 1995). One of the most important factors is the chemical characteristics of metals which regulate their speciation in different environmental compartments. Of special interest are metals which form organometal compounds stable under environmental conditions, as are Hg, Sn and Pb. Due to their more covalent nature and thus higher lipophilicity, organometal compounds usually accumulate more efficiently and are more toxic than inorganic forms of the same metal (Pelletier, 1995). Among the metals Hg represents a special case, as it is the only metal for which widespread methylation (formation of mono- and dimethyl mercury) in aquatic systems (primarily sediments) is recognised and whose elemental form ( $\text{Hg}^0$ ) exists in nature. In addition, the behaviour of inorganic mercury differs from other Group IIb metals because of the covalent nature of its compounds with halides ( $\text{HgCl}_2$ ) and sulfide ( $\text{HgS}$ ), which are thus non-polar and have a relatively high octanol-water partition coefficient (Wright and Mason, 2000). Lead also forms organometal compounds relatively stable under environmental conditions (ethyl and methyl derivatives of tetra, tri- and dialkyl lead), which are however, in contrast to organic mercury, not formed in the environment, but introduced to it by the anthropogenic activity (use of tetraalkyllead as additive in gasoline). The bioaccumulation and biomagnification of organic and inorganic mercury, as well as organolead compounds in the marine organisms will be briefly presented here.

### **BIOACCUMULATION OF MERCURY COMPOUNDS**

Mercury is accumulated by aquatic plants and organisms and the concentration tends to increase with increasing trophic level (mercury biomagnifies). The form of mercury which is actually biomagnified is methylmercury, whose percentage increases from phytoplankton (<10%) and invertebrates (generally <20%) to fish (>90%). Both inorganic and organic mercury are taken up easily and quickly by organisms, but methylmercury depurates much more slowly than inorganic mercury (Mikac *et al.*, 1996a). Recent research by Mason and co-workers (Wright and Mason, 1995; Mason *et al.*, 1995; Lawson and Mason, 1998) offers basic explanations of the preferential bioaccumulation of organic over inorganic mercury. They showed that passive uptake of lipophilic complexes (primarily  $\text{HgCl}_2$  and  $\text{MeHgCl}$ ) is the controlling accumulation mechanism for phytoplankton and microorganisms (Fig. 1). Differential bioaccumulation of

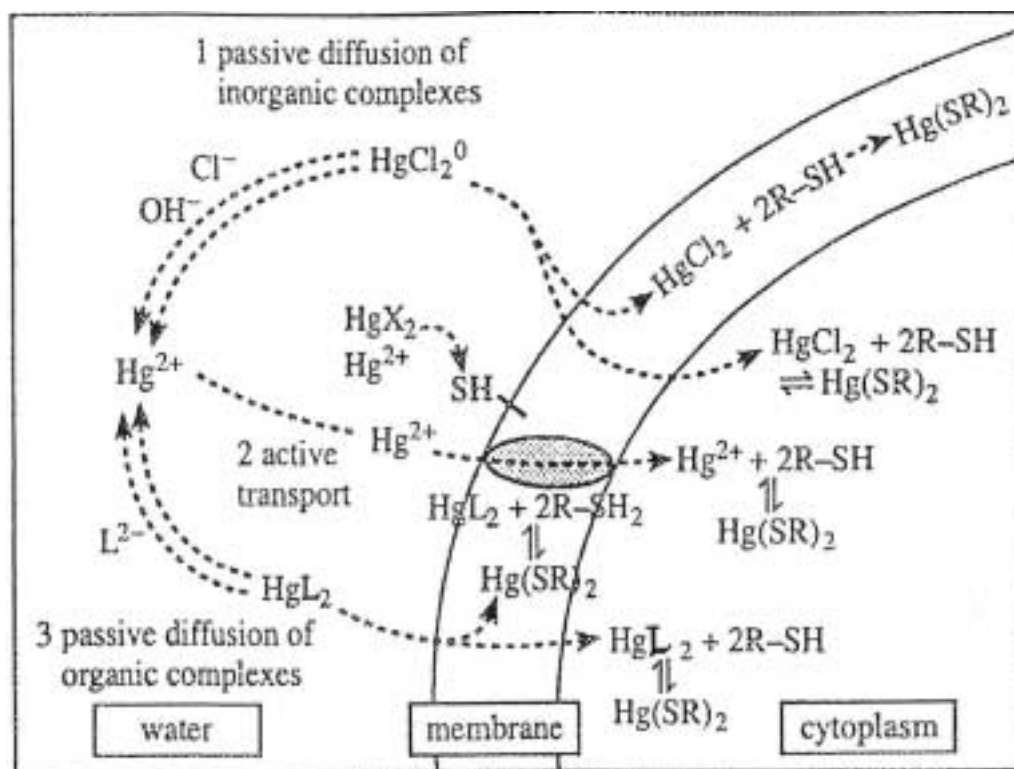


Fig. 1. Scheme describing factors influencing the bioaccumulation of inorganic and organic mercury (from Wright and Mason, 2000).

organic and inorganic mercury is explained by different proportion of each that are present as neutral complexes (in seawater nearly 100 % of methylmercury is as  $\text{MeHgCl}$  while only 3% of the inorganic mercury is  $\text{HgCl}_2$ ) and by the greater assimilation efficiency of methylmercury over inorganic mercury by zooplankton (due to preferential partitioning of methylmercury into the cytoplasm of phytoplankton cells). Fish assimilate methylmercury more efficiently than inorganic mercury owing to larger fraction of methylmercury in the soft tissue of zooplankton, leading to further discrimination up the aquatic food chain (Lawson and Mason, 1998; Mikac *et al.*, 1985). However, our knowledge of the fundamental physiological and biogeochemical mechanisms of mercury uptake and excretion is still inadequate, making it very difficult to set up predictive models of methylmercury bioaccumulation as a function of environmental factors.

### BIOACCUMULATION OF ORGANOLEAD COMPOUNDS

The occurrence of organolead compounds in the environment has received much less attention than organomercury and organotin species, and many aspects of their occurrence and their fate in aquatic systems are still largely unknown (Pelletier, 1995). Especially data on occurrence of alkylleads in living organisms and trophic transfer of organolead compounds through aquatic ecosystems are scarce. It was shown that fish living in the vicinity of alkyllead manufactures could accumulate high concentrations of ethyllead compounds comprising up to 75 % of the total lead (Pelletier, 1995). Data for marine organisms not directly exposed to alkylleads are very limited. The accumulation of lead compounds into marine organisms was studied in the mussel *Mytilus galloprovincialis* and different fish species from the Adriatic sea (Mikac *et al.*, 1996b; Mikac *et al.*, 2001). The presence of all alkyllead species in mussels tissues was established, with a dominance of ethyl derivatives (Fig. 2). The target organs for accumulation of organic lead in mussels were viscera and mantle and for inorganic lead just viscera. Distribution of lead compounds in fish demonstrated that organic lead was more equally distributed between muscle and intestine, compared to the total lead which was accumulated primarily in the intestine. Bioconcentration factors between mussels and seawater were lower for alkyllead compounds than those for the total lead, indicating less efficient bioaccumulation of organic lead. For both

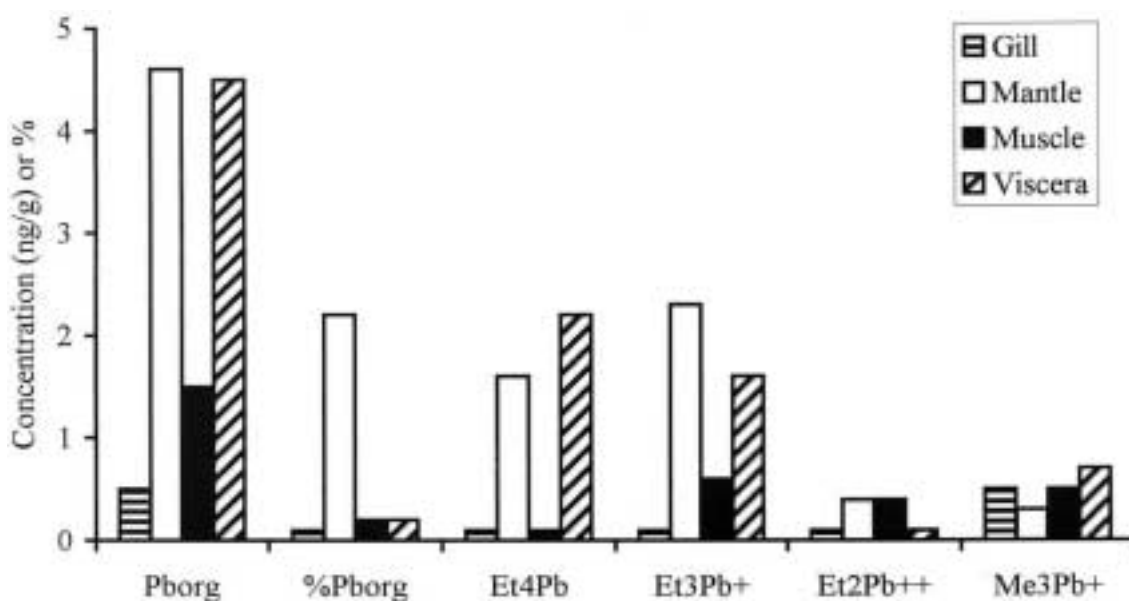


Fig. 2. Distribution of organic lead in mussels *Mytilus galloprovincialis* from the Adriatic Sea.

total and organic lead, concentrations in organisms and bioconcentration factors between organisms and seawater were much higher in mussels than in fish, indicating the absence of biomagnification for both lead species.

### CONCLUSION

These two examples demonstrate that the lipophilic nature of organometal compounds does not necessarily lead to higher bioaccumulation of these compounds in marine organisms, compared to the inorganic metal forms. For each organometal species stability and reactivity under environmental conditions, as well as biotransfer and recycling mechanisms in the marine trophic network, should be known in order to understand the environmental fate and behavior of these compounds and establish appropriate water and sediment quality criteria.