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Zebra Mussel Research Technical Notes

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Bioaccumulation of Contaminants by Zebra Mussels

Background An important issue in zebra mussel control is the contaminant status of populations. Prior to development of procedures to dispose of large numbers of zebra mussels, data on bioaccumulation of contaminants and the concentrations that might be expected in field populations are necessary.

Purpose The purpose of this technical note is to summarize recent information on the potential of zebra mussels to accumulate contaminants and the possible problems associated with their disposal.

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Bioaccumulation Bioaccumulation is the accumulation of contaminants by aquatic organisms from sources such as water, food, and in the case of zebra mussels, suspended sediment particles. Zebra mussels appear to be uniquely positioned to bioaccumulate contaminants and to be a serious problem if found to be highly contaminated. These animals usually attach themselves in large numbers to available hard substrate and filter the water for food and oxygen. Recent studies in North America have demonstrated high levels of contaminant bioaccumulation in zebra mussels. They also have been studied in northern Europe, primarily in the Netherlands, as potential indicators of contaminant concentrations of various water bodies (de Kock and Bowmer 1993) and have been compared to the marine biomonitoring organism *Mytilus edulis* (Fisher 1993). These studies have demonstrated that zebra mussels can accumulate contaminants because of their unusually high lipid content, reported to be as high as 15 percent (Fisher and Landrum 1992). Contaminants measured in laboratory and field populations include pentachlorophenol, DDE, and hexachlorobenzene. It seems clear from analyses of zebra mussels from Netherlands lakes that these animals can accumulate cadmium (Cd), mercury, lead, copper, and organic contaminants such as polychlorinated biphenyls (PCBs), pesticides, and petroleum hydrocarbons (Reeders and Bij de Vaate 1992). In addition, zebra mussels have been reported to increase contaminants in sediments (Howell 1993).

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Field studies

Zebra mussels have been studied in the Netherlands in relation to toxicological field studies since 1976. They are being used as a biomonitoring animal, for other toxicological studies of contaminants, and in food chain studies. They are useful as biomonitors because of their ability to rapidly accumulate a variety of aquatic contaminants.

De Kock and Bowmer (1993) studied *Dreissena polymorpha* after exposure to Cd in the field and estimated the time to reach steady state as 40 to 60 days. These authors also discuss the harmful effects of Cd on zebra mussels and describe experiments in which Cd has been transferred from contaminated mussels to ducks. De Kock and Bowmer (1993) also indicate that data are available which allow calculation of water concentrations of contaminants based on tissue analyses. Organochlorine contaminants in relation to bioaccumulation are also discussed. De Kock and Bowmer (1993) concluded that zebra mussels are good bioaccumulators of aquatic contaminants and are important food chain organisms.

Bioaccumulation and lipids

Laboratory tests conducted on North American populations of zebra mussels have demonstrated the ability of adults to accumulate hydrophobic aquatic contaminants from algae and sediments. Uptake from these sources was slower than uptake from water (Bruner, Fisher, and Landrum 1992). Contaminants not retained by the zebra mussel are deposited in mussel feces and pseudofeces, where they can affect invertebrate surface feeders. One hydrophobic contaminant studied was pentachlorophenol (PCP). Fisher and Landrum (1992) used PCP to show that zebra mussel bioaccumulation is related to temperature and pH, and reported that *D. polymorpha* are well suited for contaminant bioaccumulation because they have a relatively high lipid content, 9 to 15 percent. The animals can also avoid temporary adverse physical or chemical conditions by closing their valves and can thus survive short periods of low water quality.

Studies of the effects of temperature on bioaccumulation kinetics have shown that bioaccumulation is more likely and more dramatic at temperatures of 20°C compared to temperatures of 4°C (Landrum and Gosslaux 1992). Additional details and data relating to laboratory bioaccumulation by zebra mussels can be found in the collection of papers on zebra mussels edited by Nalepa and Schloesser (1993). Specific filtering rates were related to algal concentration and were as high as 2.65 L of water per gram dry weight per hour. Contaminant elimination from tissues was relatively slow, taking 2 to 7 days to depurate one-half the contaminants accumulated. These studies, then, indicate that zebra mussels are able to create dense populations at locations where contaminants are available and filter the water to accumulate and retain contaminants, especially hydrophobic or lipophilic compounds. Although bioaccumulation is greater at higher temperatures, the relative body burden of contaminants may also be high at low temperatures because whatever contaminants are accumulated are released very slowly at temperatures >10°C.

Bioaccumulation testing in the Netherlands

Zebra mussels have been investigated in the Netherlands as natural biofilters because of their habitat requirements and filtering abilities (Reeders and Bij de Vaate 1992). Field experiments showed that zebra mussels produced pseudofeces that were slightly more contaminated than the suspended particles in the water column. Zebra mussels tend to concentrate contaminants and were shown to be efficient bioaccumulators of organic contaminants and pollutants such as polycyclic aromatic hydrocarbons (PAHs) that were present on sediment particles. Reeders and Bij de Vaate (1992) presented data which showed

that a variety of aquatic contaminants (such as metals, pesticides, and PAHs) are concentrated by zebra mussels exposed at a field location.

Impact of zebra mussels on sediments

Howell (1993) reported that zebra mussels are colonizing fine-grained sediments at an area where eastern Lake Erie flows into the Niagara River, and that this colonization has had an effect on sediment quality. The sediments have become more silty, with increased organic carbon levels, and PAH compounds have been found to increase. The benthic community has also changed as a result of zebra mussels.

Disposal of zebra mussels

Currently, zebra mussels are disposed of at municipal landfills that will accept them. The most obvious problem associated with zebra mussel disposal is the characteristic odor that results from their rapid decomposition. However, large quantities of mussels from the field have not been analyzed for contaminants systematically. It is entirely possible that, in some cases, decomposing zebra mussels could be a contaminant source. Studies of zebra mussels for use as a soil amendment are under way (Banks and others 1993). The composted mussels are being analyzed for metal and organic contaminants.

Additional recent information concerning contaminants and disposal problems is available (Secor and others 1993). Secor and others (1993) report chemical analyses of mussels from known contaminated areas in New York. The mussels were found to contain high levels of Cd, selenium, and PCBs. This kind of information should be carefully considered prior to decisions about disposal of dead mussels and their use as food for farm animals or as a fertilizer.

Summary

Zebra mussels can bioaccumulate a variety of aquatic contaminants in laboratory and field situations. However, it is not clear whether zebra mussels can be considered a contaminant source after their disposal. It is unclear whether disposal of dredged material containing zebra mussels should be handled differently from normal dredged material disposal or whether zebra mussels always should be placed at landfills or at other, more regulated, disposal sites. Studies of the contaminant status of North American zebra mussel populations and composted remains are presently under way and are expected to provide additional information in the next 1 to 2 years.

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