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Zebra Mussel Research Technical Notes

Section 1 — Environmental Testing Technical Note ZMR-1-26

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Toxicity and Environmental Effects of Disposal of Contaminated Zebra Mussels

Background and purpose

The successful spread of the zebra mussel, *Dreissena polymorpha*, in North America has resulted in its disposal becoming a potential concern. Zebra mussels are similar to other mussels in that they filter water for food and oxygen and are known to accumulate contaminants. Laboratory tests as well as field data have shown that zebra mussels can readily accumulate metals, polychlorinated biphenyls (PCBs), and petroleum hydrocarbons. The unique problem with zebra mussels and contaminants is that zebra mussels can build up large populations at locations where contaminants may be present, and the organisms must be periodically removed.

Contaminants and test results

Recent laboratory studies and data from field populations show that while zebra mussels do bioaccumulate contaminants, tissue levels from field populations are only somewhat elevated in relation to background concentrations. Testing of zebra mussels using the Toxicity Characteristic Leaching Procedure (TCLP) and the Leachate Toxicity Test (LTT) has indicated that zebra mussel waste should not be considered hazardous based on U.S. and Canadian regulations. Currently, large volumes of zebra mussels are being disposed of at approved landfills, generally without chemical analyses.

Additional information

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Bioaccumulation and zebra mussel disposal

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

Bioaccumulation is simply the accumulation of contaminants by aquatic organisms from sources such as water, food and, in the case of zebra mussels, suspended sediment particles. Recent studies have demonstrated that these mussels are well equipped to accumulate contaminants because of their relatively high filtration rates and lipid content. These studies include toxicological field studies by de Kock and Bowmer (1993) and laboratory bioaccumulation

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studies by Bruner, Fisher, and Landrum (1992) and Landrum and Gossiaux (1992). These papers are reviewed and summarized in Tatem (1994).

In preparing this technical note, recent literature on contaminants and zebra mussels, and on contaminant concentrations in field populations, was reviewed. This information, from 1992 to 1994, primarily concerns North American *D. polymorpha* populations. Summary tables of information from some of these sources are also presented. Field data reported in Reeders and Bij de Vaate (1992), Mills and others (1993), Secor and others (1993), and Kreis and others (1991, 1994) are discussed. Doherty, Evans, and Neuhauser (1993), an important source, presents data from leachate tests of zebra mussels and compares results with disposal criteria concentrations for the United States and Canada.

Results

Zebra mussels can accumulate contaminants because of their high filtration rates and lipid content (Fisher and others 1993). Contaminants measured in laboratory and field populations include metals, pentachlorophenol, DDE, hexachlorobenzene (HCB), and other organic contaminants. Analyses of zebra mussels from the Netherlands show that these mussels can accumulate contaminants including cadmium, mercury, lead, and copper, and organic contaminants such as PCBs, pesticides, and petroleum hydrocarbons (Reeders and Bij de Vaate 1992). Zebra mussels have been studied in the Netherlands since 1976 in relation to toxicological field studies. They are useful as biomonitors because of their ability to rapidly accumulate a variety of aquatic contaminants, as reported by de Kock and Bowmer (1993). The important point in relation to this discussion is that zebra mussels are recognized as good bioaccumulators of aquatic contaminants.

The field studies indicate that *D. polymorpha* 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. Fisher and others (1993) describe the toxicokinetics of organic contaminants in zebra mussels, including pesticides and polycyclic aromatic hydrocarbons (PAHs), one class of petroleum hydrocarbons. They also compared the zebra mussels to the well-known marine mussel bioaccumulator *Mytilus*. Fisher (1993) discusses the effects of zebra mussels on overall contaminant cycling in Lake Erie. Tables 1-4 summarize the contaminants that have been identified in zebra mussel populations and the concentrations that can be expected.

TCLP and LTT results

Doherty, Evans, and Neuhauser (1993) tested zebra mussels from two power plants on Lake Erie for contaminants and for leachable contaminants using the Toxicity Characteristic Leaching Procedure for the United States and the Leachate Toxicity Test for Canada (Table 5). The mussels from these two facilities would not be classified as hazardous waste according to the U.S. criteria (USEPA 1990) and the Canadian criteria (Ontario regulation 309, schedule 4).

Data presented by Kreis and others (1994) show that contaminants are primarily associated with zebra mussel tissues rather than with the shells (Table 6). This has also been observed by Secor and others (1993) and Van der Velde and others (1992). Disposal of zebra mussels involves whole mussels and includes both tissues and shells. The shells effectively dilute contaminant concentrations in relation to disposal of zebra mussels. Different size classes of *D. polymorpha* reveal varying concentrations of contaminants; the data suggest that contaminant concentrations generally decrease with increasing size of individuals due to increased shell mass.

Kreis and others (1994) also discuss some of the problems associated with the use of zebra mussels for contaminant biomonitoring and state that their data strongly support the conclusion that whole zebra mussel contaminant concentrations are relatively low and the contaminant concentrations would be considered nonpolluted if compared with the U.S. Environmental Protection Agency's sediment guidelines. These data do not indicate that normal zebra mussel populations require any special disposal practices.

Conclusions

The data and information summarized in this technical note show that zebra mussels are well equipped and likely to accumulate contaminants such as metals, PCBs, and petroleum hydrocarbons from water and suspended sediments; however, tissue concentrations of whole mussels are generally low. Contaminant bioaccumulation by zebra mussels has been demonstrated in both laboratory studies and in field populations. Periodic removal of *D. polymorpha* populations from facilities may help prevent tissue concentrations from becoming excessive.

The data show that contaminant concentrations do not exceed criteria in leachate tests with field populations of zebra mussels. There is no reason, therefore, to consider zebra mussel waste (whole mussels) as hazardous, and in the absence of additional data, no special precautions are necessary for their disposal. Periodic chemical analyses or leachate tests of mussels removed from facilities are recommended, especially at locations having any history of contamination. Large volumes of zebra mussels generally should not be disposed at aquatic sites or used as animal feed. Zebra mussels can be composted to increase disposal options; disposal at approved landfills is recommended.

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Table 1. Inorganic and Organic Contaminants in Suspended Sediment and Zebra Mussel Pseudofeces from the Netherlands

Contaminant	Suspended Sediment	Pseudo Feces	Background *Dreissena*	*Dreissena* at 271 days
Metals	mg/kg dry	mg/kg dry	mg/kg dry	mg/kg dry
Cadmium	9.2	9.6	2.3	2.6
Mercury	1.7	1.6	0.2	0.3
Lead	183	207	2.1	5.2
Copper	111	107	21.4	29.3
Chromium	128	144	3.5	7.7
PCBs and pesticides	μg/kg OC[1]	μg/kg OC	μg/kg fat	μg/kg fat
PCB-153	778	952	591	1,214
Other PCBs	3,187	3,786	1,596	3,186
HCB	423	520	59.1	214.3
Dieldrin	220	267	77	56
DDT	437	338	45	44
DDE	194	228	127	164
Petroleum PAHs	mg/kg OC	mg/kg OC	μg/kg fat	μg/kg fat
BaP	28	31	318	3,214
Other PAHs	95	107	3,727	18,214

Source: Reeders and Bij de Vaate (1992).
Note: Background tissue concentrations (zebra mussels from Lake Ijsselmeer) were compared to zebra mussels exposed for 271 days at a contaminated location.
[1]Organic carbon.

Table 2. Organic and Metal Contaminants in Zebra Mussel Tissues from Western Lake Erie (N = 4)

Contaminant	Concentration	
Organics	μg/kg wet	ppm dry
PCBs	520	4.0
HCB	0.83	0.0065
DDTs	22	0.180
Chlordanes	14	0.111
Metals	ppm dry	
Cadmium	3.4 to 5.3	
Chromium	<0.8 to 3.2	
Copper	13 to 15	
Lead	2.2	
Mercury	0.02	
Nickel	19	
Zinc	160	

Source: Kreis et al. (1991).

Table 3. Concentrations of Elements, DDE, and PCBs (ppm dry weight) in Zebra Mussel Tissues and Shells from New York State Waters

Contaminant	Location[1]				
	Gen/U	Hud/A	Nia/A	Oneida	Ont/A
Cadmium					
Tissue	3.0	1.7	5.0	0.7	0.6
Shell	0.6	0.4	0.9	0.3	0.6
Chromium					
Tissue	5.0	2.7	5.0	1.6	1.9
Shell	9.8	9.0	10.1	9.0	8.0
Mercury					
Tissue	0.38	0.06	0.08	0.05	0.7
Shell	ND[2]	ND	ND	ND	ND
Nickel					
Tissue	13.5	5.7	18.9	4.2	7.3
Shell	9.0	4.7	8.5	3.2	3.2
Lead					
Tissue	4.4	2.2	3.4	1.0	1.8
Shell	1.8	ND	9.6	9.4	ND
Selenium					
Tissue	3.8	3.0	2.7	2.6	2.9
Shell	—	—	—	—	—
Zinc					
Tissue	191	138	160	99	124
Shell	9.6	7.8	13.5	4.5	4.5
DDE - tissue	ND	ND	ND	0.02	0.04
PCBs - tissue	0.6	5.7	0.9	0.5	1.04

Source: Secor and others (1993).

[1]Location descriptions are as follows:

Gen/U = Genesee River between Erie Canal and Lake Ontario
Hud/A = Hudson River between Hudson and Catskill, NY
Nia/A = Niagara River hydroelectric power reservoir
Oneida = Oneida Lake-Sylvan Beach (relatively pristine site)
Ont/A = Lake Ontario-Oswego Harbor

[2]Not detectable.

Table 4. Metal Concentrations in Zebra Mussel and Quagga Mussel Soft Tissues

Contaminant	Concentration Range, ppm dry weight
Cadmium	4.5-11.9 4.8-8.7 3.1-6.6
Chromium	2.6-18 3.0-5.2 2.3-7.4
Mercury	0.09-0.28 0.09-0.27 0.08-0.55
Nickel	4.6-12.1 3.6-12.6 3.9-17.3
Lead	1.8-7.9 2.1-4.0 1.9-6.3
Selenium	3.4-4.4 3.1-4.5 3.3-5.3
Zinc	71.8-300 75.2-390 64.5-192

Source: Mills and others (1993).
Note: Concentration ranges at depths of 25 to 85 meters at Oldcott, 30 Mile Point, and other locations in Lake Ontario.

Table 5. Regulatory Action Levels for Leachable Contaminants in United States and Canada

		Canada	
Contaminant, mg/L	United States	Leachate Toxicity	Registration Limit
Cadmium	1.0	0.5	0.05
Chromium	5.0	5.0	0.5
Lead	5.0	5.0	0.5
Mercury	0.2	0.1	0.01
Selenium	1.0	1.0	0.1
PCB	—	0.3	0.03
Aldrin/dieldrin	—	0.07	0.007
Chlordane	0.03	—	—
DDT	—	3.0	0.3
Endrin	0.02	0.02	0.002
HCB	0.13	—	—
Lindane	0.4	0.4	0.04
Toxaphene	0.5	0.5	0.05

Source: Doherty and others (1993).

Table 6. Summary of Organic and Metal Contaminant Concentrations and Percent Lipids for Zebra Mussel Shell, Whole Animals, and Tissue

Contaminant	Shell (N = 1)	Whole (N = 3)	Tissue (N = 3)
Organics	µg/kg (ppb) dry weight		
Total PCBs	7.9	48	1,070
DDT analogs	0.2	1.2	27
HCB	0.02	0.05	0.8
G-chlordane	<0.01	0.08	1.9
(Lipids, percent)	(0.05)	(0.26)	(6.9)
	Shell (N = 3)	**Whole (N = 3)**	**Tissue (N = 2)**
Metals	mg/kg (ppm) dry weight		
Cadmium	0.1	0.5	4.1
Chromium	0.5	0.9	2.7
Copper	2.1	4.9	24
Nickel	0.5	1.5	14
Lead	0.3	0.6	1.8

Source: Kreis and others (1994).
Note: Zebra mussels of size class 16-19 mm, from western Lake Erie.