UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 5
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CHICAGO, ILLINOIS 60604

Date: July 30, 2004

Subject: (1) Health Risk Analysis of Tittabawassee Fish with Dioxin
(2) Recommendations for Risk Evaluation

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Summary

Tittabawassee River Fish data collected by DEQ in 2003 and made available to U.S. EPA in June 2004, was analyzed to assess risks to fish consumers. Dioxins in river fish present unacceptable risks to public health. Cancer risks to a frequent (high-end) fish consumer are as great as one in a 1,000 exceeding U.S. EPA cancer risk management guidelines of one in 10,000 to one in 1,000,000. Non-cancer risks (e.g, reproductive and congenital defects) are up to 10 times acceptable exposure values for adults and 25 times above safe levels for children. There is particular concern of risks to women of childbearing age and to the developing fetus.

In addition to unacceptable human health risks from dioxin in fish there is also unacceptable risks to wildlife (Tittabawassee Ecological Assessment Report, DEQ, Galbraith Environmental Services, 2003). The assessment concluded that dioxin and dibenzofurans are at levels posing Aserious@ reproductive impairment to fish, fish eating birds and mammals. Furthermore, dioxin levels are elevated in area turkey, deer and other game (Dow Chemical, July 2004) indicating terrestrial food chain contamination due to contamination of flood plain soils, posing potential public health risks. Dioxin contamination of sediments and flood plain soils appears to extend over 50 miles, into Saginaw Bay (DEQ November, 2003 update). The site has similar characteristics regarding levels of risk and area affected as the Kalamazoo and Fox Rivers, which are currently a focus of U.S. EPA remediation plans.

In spite of active involvement by EPA in the 1980s to reduce dioxin emissions from Dow Chemical, it is clear that the persistent, un-addressed dioxin problem exists. A complete multimedia exposure and risk analysis, consistent with state and U.S. EPA guidelines is needed before any final risk management conclusions and decisions can be drawn. Given the situation, particularly the contamination of the Tittabawassee and Saginaw rivers, a prominent role by U.S. EPA to protect public health and reduce risks is indicated.

Background

Beginning in the late 1970s, U.S. EPA began an evaluation of dioxin emissions from the Dow Chemical facility in Midland Michigan and concluded that a substantial risk of injury to human health or the environment existed as defined under Section 8(e) of the Toxic Substances Control Act (Awidespread and previously unsuspected distribution in environmental media@). Dow Chemical was identified as the primary, if not sole contributor to dioxin contamination in Midland, the Tittabawassee River, Saginaw River, and Saginaw Bay (August 8, 1978, communication to J. Merenda, Director, Assessment Division, OTE/OTS from F. Kover; September 6, 1978, communication to Ethyl H. Blair, Dow Chemical from Warren R. Muir, OTS, EPA; February 8, 1979, communication to J. Merenda from F. Kover; EPA Oversight on Dioxin Contamination, Hearing, Committee on Science and Technology, U.S. House of Representatives, No.68, March 23, 1983).

In 1983, as part of a National Dioxin Strategy, U.S. EPA Region 5 characterized dioxin emissions from Dow Chemical=s wastewaters as well as from hazardous waste incineration (EPA-905/4-88-003; EPA-905/4-88-004). A comprehensive, multi-pathway risk assessment was completed in 1988 to characterize risks from all exposure routes and communicate these findings to the public. U.S. EPA determined that dioxin contamination of fish represented substantial risks to fish consumers, including the developing child (EPA-905/4-88-005). Cancer risks were found to be as high as one in a 100 for cancer while non-cancer risks were up to 50 times acceptable levels, indicating Asignificant risks from consumption of game and sport fish@, particularly to Achildren and women of child bearing age, related to possible reproductive effects, teratogenic effects, liver damage, and cancer@ (pg. 31 (EPA-905/4-88-008).

As a result of these studies, EPA recommended that Dow Chemical undertake actions to reduce active dioxin emissions from their operations (EPA-905/4-88-008). Many of these recommendations were acted upon by Dow Chemical; others were not (e.g., characterization of sediment contamination). U.S. EPA believed that changes in plant operations, particularly regarding reductions in wastewater discharges of dioxins, which Dow undertook, would yield substantial reductions in fish dioxin levels. Based upon limited sediment data of only tetra dioxins (TCDDs), we concluded that sediment contamination by dioxins was not likely to be significant (EPA-905/4-88-003; EPA-905/4-88-008). It is now clear, based upon recent data, which evaluated all key dioxins (CDDs) and dibenzofurans (CDFs), that our original conclusion regarding dioxin in sediments was not correct. Nevertheless, our risk management recommendations in 1988 were as follows:

ATittabawassee River sediments and the river flood plain, from downstream of Dow Chemical to about five miles downstream from outfall 031, should be thoroughly surveyed, evaluated, and classified in order to locate any pockets of organic contamination or deposition zones containing clay, silt, or other fine particles of a type with the potential to absorb CDDs/CDFs@ (EPA 4-88-008, page 34). AIf significantly contaminated sediments were found and confirmed, serious consideration would be given to removal by dredging or excavation@(Appendix A, page 22).

DEQ=s subsequent evaluation of flood plain soils, sediments, and fish indicate that significant dioxin levels remain in the Tittabawassee and Saginaw Rivers system requiring a new risk assessment and risk management evaluation. Major flooding of the Tittabawassee River, subsequent to EPA=s findings in the 1980s, appears to have disturbed contaminated sediments, causing wider re-distribution of dioxin contamination. DEQ has determined that dioxin sediment contamination extends into Saginaw River and Bay. The current situation is sufficiently different, and over a wider area than known in 1988, to warrant another comprehensive look at the dioxin issue, using a multi-media risk approach, which is standard federal and state methodology.

Risks from Dioxin Contamination of Fish

Dioxin contamination (as Toxic Equivalent Factors) in Tittabawassee fish fillets, as reported by DEQ in 2004, was evaluated for human health risk following techniques and parameters used for the Fox River Baseline Risk Assessment (EPA, 2001).

To evaluate the high-end, low income (RME) consumer, the upper 95th percentile of fish intake (110g/day) from the West 1993 study was applied, a 50% reduction from cooking an cleaning, a 50 year exposure duration, and consumption of 50% sport fish and 50% bottom feeders. For the RME sport fisher (59 grams per day) the average of the West 1989 and 1993 studies were applied and 100% sport fish consumption. Central tendency intakes of 43 g/day of fish and 15 grams/day were used to assess, average high-end and sport fish consumer and a 30 year exposure duration. U.S. EPA=s cancer potency factor of 1.56 E5 $(mg/kg/day)^{-1}$ was applied. To evaluate non-cancer risks EPA=s historical RfD of 1E-9 mg/kg-bw-day was used. (EPA is currently evaluating procedures to assess non-cancer risks and these may deviate from conventional RfD approaches). The risk assessment presented below is a screening level analysis and is not intended as a comprehensive risk analysis. Nevertheless, the results are sufficient to demonstrate excessive risks and initiate procedures to reduce exposures to dioxin via fish consumption. Average TEQ (Great Lakes Initiative TEF) levels as weighted means (see table at the end) were used, which are as follows: 50% Sport fish + 50 % Bottom Feeder = TEQ mean of 14.1 ppt and 100% Sport fish = 8.5 ppt

Group	**Cancer Risks**	**Hazard Index****
high-end, RME* consumer	1.2 E-3 (one in a thousand)	11 (26)
RME* sport fisher	4.0 E-4 (4 in 10,000)	3 (8)
Average high-end	2.8 E-4 (3 in 10,000)	3 (10)
Average sport fisher	5.9 E-5 (5 in a 100,000)	0.6 (2)

*Reasonable Maximum Exposure

**Hazard Indices for children, given in parentheses, are 2-3 times higher for children

Exposure methodology from Fox River Baseline Risk Assessment (EPA, 2001); Risk Assessment for Dioxin Contamination Midland Michigan (EPA-905/4-88-005). Note 1988 Midland risk assessment for fish assumed lifetime exposure and no reductions in dioxin from cooking and cleaning.

Discussion

With the exception of the average sport fisher, cancer and non-cancer risks are outside acceptable risk ranges. Of particular concern is the high-end, low income fish consumer which has cancer risks as great as one in a 1,000 and that of the high-intake (RME) sport fisher, which has risks over one in 10,000. Considering the most recent human and animal cancer risk data on dioxin, these risks could be up to an order of magnitude higher, yielding cancer risks in the one in a 100 range (Fingerhut et at., 1991; Aylward et al., 1996; Becher et al., 1998; Manz et al, 1991; Flesch-Janys et al., 1995, 1998; Zober et al., 1990; Ott and Zober, 1996; Portier and Koln, 1996). These risks are in the same range and possibly exceed (considering EPA=s proposed dioxin cancer potency factor, under review by the National Academy of Sciences) those found for the Fox and Kalamazoo Rivers, which are now the focus of remediation by EPA Superfund and State agencies. Cancer risks of one in a 1,000 are often considered as posing substantial endangerment to public health.

Non-cancer risks are also elevated and unacceptable, being up to 25 times safe levels for children and up to 10 times for women of child bearing age and other adults. (Note: TEQs follow Great Lakes Initiative TEF approach. WHO TEQs may yield higher hazard indices). A number of studies in both animals and humans indicate that dioxin and dioxin like compounds are capable of eliciting a variety of adverse impacts at very low doses including reproductive, teratogenic, neurobehavorial, immunologic, and hormonal (e.g., thyroid) effects (Sweeney, 1984; Peterson et al., Kimmel, 1998, Huisman et al, 1995; Koopman-Esseboom et al, 1994, Patandin et al, 1999). There is particular concern regarding maternal exposures (before or during pregnancy) and exposures to the fetus or nursing infant, when dioxin dose per body weight is considerably higher than in later life stages. This screening level assessment did not attempt evaluate risks in these early life stages. However, as done for the Fox River evaluation, infants and children eating fish from ages one through seven would have non-cancer risks about 2.5 times greater than an adult.

These risks findings are consistent with State of Michigan fish consumption advisories issued for the Tittabawassee River, which recommend that no persons consume carp, catfish, and white bass while women and children are not to consume smallmouth bass. Fish advisories due to dioxin and PCB contamination also have been issued for Saginaw River and Bay. (General Motor facilities were known PCB contributors to Saginaw River and Bay).

Public health risk exists from fish consumption, because surveys have shown that people are either unaware of advisories or do not follow them. For instance, a 1988 creel survey (Smith and Enger) found that 10% of 360 Tittabawassee River fisherman processed (clean and freeze for later consumption) more than 50 pounds of fish per year, with a portion of fish being those in the do not eat categories. Three persons reported processing more than 50 pounds of carp and catfish a year from the river. More public outreach is needed to warn Tittabawassee and Saginaw River fish consumers.

Dioxin levels in fish have declined very slowly or not at all over time. For instance,

levels of dioxin in walleye averaged (weighted) 3.6 ppt in the 1983-1988, while 2003 samples 15 to 20 years later are 3.4 ppt. More significant reductions were found in carp and catfish, although carp have dioxin levels more than twice the State of Michigan=s health criteria of 10 ppt. (An EPA derived risk criteria might result in a dioxin value under 10 ppt for fish consumption). Dioxin contamination of sediments and flood plain soils are the most likely source of the dioxin contamination in fish, as Dow has greatly reduced direct water discharges and dioxin sediment levels downstream of Dow outfalls average 780 ppt, over 200 times upstream dioxin values.

It is also important to note that dioxin sediment contamination extends over the entire Saginaw River and into the Bay, although General Motors facilities were historical contributors due to PCB use and discharge. About 40 miles of river and flood plains have dioxin contamination, similar in area to the Fox and Kalamazoo Rivers.

Comparison of sediment or flood plain levels to either EPA or DEQ residential dioxin cleanup levels is inappropriate, since residential cleanup values do not consider food chain exposures and biomagnification (Kimbrough, et al.,1984; U.S. EPA, OSWER Directive 9200. 4-26, April 13, 1998; David Cooper, OSWER, EPA e-mail, June 21, 2004). As early as 1984, dioxin assessments recognized that other risk-based approaches were needed for terrestrial or aquatic exposures. For example, CDC determined that soil dioxin levels as low as 6-20 ppt in soils would be needed to protect persons consuming agricultural products such, as milk or beef (Kimbrough, et al, 1984). More advanced techniques (e.g., modeling) are required, such as that used on the Fox River and now underway for the Kalamazoo River, which can determine the relationship between dioxins in sediments and levels in fish.

Conclusions and Recommendations

1. Unacceptable, elevated (cancer risks as high as one in a 1,000) to public health exist to the frequent consumer (2 pound meal per week or greater) of Tittabawassee River fish. Although U.S. EPA was heavily involved in addressing dioxin problems from the Dow Chemical facility in the 1980s, it is clear that significant risks to public health still remain. More extensive outreach is needed to warn consumers of risks associated with the consumption of fish from the Tittabawassee River, Saginaw River, and Saginaw Bay.

2. Potential health risks, which need quantification, exist to persons consuming game in the Midland area. Dioxin contamination of game (turkey and deer), indicate contamination of the terrestrial food chain.

3. Unacceptable, serious aquatic ecological risks, associated with dioxin exposure, exist to fish, fish eating birds, and mammals.

4. Given substantial risks to public health and wildlife, strong consideration should be given to remediation (e.g., removal) of dioxin contaminated sediments and flood plain soils most proximal to the rivers. Such actions would be consistent with those

underway or planned for the Fox and Kalamazoo rivers.

5. Multi-media risk evaluation of all exposure pathways (residential soils, flood plain soils, fish, and wild game) are needed before final conclusions are drawn regarding risks to human health and ecology. Such approaches are consistent with approaches historically undertaken for the site, recent complex sites such as the Fox River and Hudson River, as well as U.S. EPA guidance for Superfund and RCRA sites. Comparison of sediment or certain flood plain data to either EPA or state dioxin criteria, which are based only on direct contact (e.g., ingestion) with residential soils, cannot be directly applied (as determined by U.S. EPA and CDC) to assess risks and determine cleanup options for aquatic and terrestrial food chain exposures.

6. Based upon current data and estimated risks, priorities for additional data collection, risk evaluation, and remediation should be established. For instance, it appears that risks to fish consumers are substantially higher than persons exposed to dioxin via direct ingestion of soils. Of those exposed to dioxin contamination in soils, those immediately adjacent to the flood plain appear to be a higher risk as compared to other areas in Midland.

7. Data collection, risk assessment, and modeling, as done for the Fox River and underway for the Kalamazoo, should be employed to determine risks and develop appropriate remedial actions, particularly for sediments and flood plain soils.

8. U.S. EPA, working closely with Michigan Departments of Environmental Quality and Community Health, needs to becomes engaged in the dioxin contamination problem and to re-enforce existing risks to public health and wildlife. There is particular concern regarding distortions of risk information (including findings by U.S. EPA) which are causing inaccurate risk messages to the public.

Dioxin levels in 2003 Tittabawassee River fish fillets (DEQ, 2004). TEQs determined by

TEF approach as specified in the Great Lakes Initiative.

Class/Species	N	TCDD ppt		TEQ ppt	
		Range	Mean	Range	Mean
Bottom Feeders					
Carp	10	0.5-23.4	7.2	3.1-81.2	26.5
Catfish	9	0.7-4.5	1.9	4.0-31.1	12.1
Weighted means			4.7		19.7
1983-1987	32	3.8-530	45	5.0-690	58
Game fish					
Smallmouth bass	10	0.9-2.6	1.4	5.3-14.5	8.5
Walleye	10	0.4-1.5	0.86	1.9-5.7	3.4
White Bass	10	1.6-4.9	3.2	6.8-20.3	13.5
Weighted means			1.8		8.5
1983-1987	41	1.8-15	5.0	4.1-39	13

50% Game + 50 % Bottom Feeder (TEQ mean of 14.1 ppt)
100% Game (8.5 ppt)

Toxicity Equivalency Factors and BEFs for CDDs and CDFs (State of Michigan)

Congener	TEF	BEF
2,3,7,8-TCDD	1.0	1.0
1,2,3,7,8-PeCDD	0.5	0.9
1,2,3,4,7,8-HxCDD	0.1	0.3
1,2,3,6,7,8-HxCDD	0.1	0.1
1,2,3,7,8,9-HxCDD	0.1	0.1
1,2,3,4,6,7,8-HpCDD	0.01	0.05
OCDD	0.001	0.01
2,3,7,8-TCDF	0.1	0.8
1,2,3,7,8-PeCDF	0.05	0.2
2,3,4,7,8-PeCDF	0.5	1.6
1,2,3,4,7,8-HxCDF	0.1	0.08
1,2,3,6,7,8-HxCDF	0.1	0.2
2,3,4,6,7,8-HxCDF	0.1	0.7
1,2,3,7,8,9-HxCDF	0.1	0.6
1,2,3,4,6,7,8-HpCDF	0.01	0.01
1,2,3,4,7,8,9-HpCDF	0.01	0.4
OCDF	0 .001	0.02

History: 1997 MR 7, Eff. July 28, 1997.