

Summary of Epidemiological and Environmental Toxicology Research in the Great Lakes

Goal of Toxicology Research – To measure and understand the links between exposure and effect related to a chemical, biological, or physical agent.

Epidemiological (Human Health) Studies - Summarized from ATSDR's "The Effects of Great Lakes Contaminants on Human Health" Report to Congress, <http://www.epa.gov/glnpo/health/index.htm>

Several epidemiologic investigations have been conducted to investigate the association between persistent toxic substances (PTSs) in the Great Lakes and the health of people in the Great Lakes states. These studies have demonstrated increased tissue levels of toxic substances (body burdens) in these populations that may be associated with or potentially result in reproductive, developmental, behavioral, neurologic, endocrine, and immunologic effects.

Epidemiologic studies of exposed human populations provide the most convincing evidence of human health effects. Of the three major routes of human exposure in the Great Lakes -- air, drinking water, and fish consumption -- fish consumption is generally thought to present the greatest risk of exposure. The most direct evidence for adverse human health effects from environmental pollution is found in a series of studies linking PCB exposure to consumption of contaminated fish (Fein *et al.* 1983, 1984; Jacobson 1984a; Jacobson and Jacobson 1988, Swain 1991, Mergler *et al.* 1997, Johnson *et al.* 1998). Linking human health effects to exposure to PTSs has provided a dilemma to public health officials because there is often conflicting information between studies (Johnson *et al.* 1998). Perhaps the most compelling finding of late is that, despite limitations and weaknesses in individual studies, the collective weight of evidence indicates that PTSs found in fish in the Great Lakes basin and elsewhere can cause neurobehavioral problems (Johnson *et al.* 1998).

The following research has been or is being conducted to clarify the relationships among exposure, contaminant levels in human biological tissues and fluids, and human health effects. Below are specific research data gaps that are in the process of being filled, which will provide necessary information for assessing human risk from exposure to Great Lakes contaminants.

2. **Some Past Great Lakes Studies** – most focused on chlorinated organics (i.e. PCBs, DDT & isomers, and general exposure due to proximity to the Great Lakes)
 - a. Health Canada/IJC Report on Canadian Great Lakes Areas of Concern (see Elliot *et al.* 2001)
 - b. Michigan Sport Fishermen Cohort Study (Humphrey 1976-1989, 5 papers)
 - c. Wisconsin Sports Fish-Consumers Study (Fiore *et al.* 1989; Sonzogni *et al.* 1991)
 - d. Minnesota Ecologic Epidemiologic Study (Schuman *et al.* 1982)
 - e. Michigan Maternal and Infant Study (Many related papers, 1980s)

- f. Effects of OC chemicals on reproductive outcomes of humans who consumed contaminated Great Lakes fish: an epidemiologic consideration (Swain 1991)
- g. Wisconsin Maternal and Infant Study (Smith 1984, Dar *et al.* 1992)
- h. New York Ecologic Epidemiologic Study (Kagey and Stark 1992)
- i. Effects of maternal exposure to Lake Ontario contaminants on their newborns (Lonkey *et al.* 1996)

3. Current Program Areas of Research

- a. Characterization of exposure and determination of the profiles and levels of Great Lakes contaminants in human biologic tissues and fluids
- b. Identification of sensitive and specific human reproductive end points
- c. Determination of the short- and long-term risk(s) of adverse health effects in the children of exposed parent
- d. Feasibility of Establishing registries and/or surveillance cohorts in the Great Lakes

Environmental Toxicology Research

The challenge faced by environmental toxicologists in general is trying to estimate the extent of contaminant/s exposure to specific populations over a certain time period that may lead to some measured effect. This often occurs with limited information, particularly about the environmental behavior of the contaminant/s. Environmental toxicology research is a combination of knowing the properties and environmental fate and transport routes of a contaminant or a mixture of contaminants to determine potential exposure and the dose of contaminant/s that leads to some measure of effect. How these factors link to human health has become increasingly important. Research in the past focused on measuring environmental effects in the field and measuring toxicity in a laboratory situation and trying to extrapolate to what is going on in the environment. Today, increasing effort is being done to link exposure and effect from a molecular basis up to individual and population levels. Linking ecological health to human health and being able to predict potential problems to human health from environmental contaminants by measuring or modeling effects in the environment are important challenges being focused on in current environmental toxicology research both in the Great Lakes and elsewhere. Below is a brief summary of past findings and an outline of some of the current research focus in environmental toxicology in the Great Lakes region:

- 1. Past Great Lakes Studies** – Studies that have observed effects from PTSs in wildlife (both field and lab) from the Great Lakes region are numerous. Effects have been observed from the cellular/sub-cellular level on up to individuals and populations. Observed effects include, but are not limited to: population declines, reproductive effects, developmental toxicity, behavioral abnormalities, target organ toxicity, biochemical changes, and metabolic abnormalities (Johnson *et al.* 1998).

- 2. Current Program Areas of Research**

- a. Measuring exposure to environmental estrogens (laboratory and field)
- b. Measuring exposures to polybrominated diphenyl ethers and fluorinated surfactants (laboratory and field)
- c. Research related to chemical risk assessment such as determining toxicological pathways for use in developing Quantitative Structure Activity Relationships (QSARs).
- d. Research related to developing and improving mechanistic models of water, sediment, biota interactions.
- e. Research to determine the fate, transport, and food web accumulation of contaminants
- f. Development of quantitative relationships between chemical and non-chemical stressors and the responses of freshwater ecosystems and aquatic life and wildlife species.

2. Some Current and Recent Research Projects

- a. NOAA GLERL, http://www.glerl.noaa.gov/res/by_subject.html#toxic
 - i. Contaminant Effects: Investigations on the Utility of Body Residue as the Dose Metric (Peter Landrum)
 - ii. Bioavailability of Sediment-Associated Toxic Organic Contaminants (Peter Landrum)
- b. NOAA Sea Grant, <http://www.nsgo.seagrant.org/roe/research.html>
 - i. Using Fathead Minnows to Screen for Estrogens and Androgens in Rivers.
 - ii. Effects of Polyhalogenated Aromatic Hydrocarbons on Estrogen Metabolism in Lake Trout.
 - iii. Methylmercury Production and Transfer to Benthic Food Webs in Nearshore and Wetland Environments of Southern Lake Superior.
 - iv. Disposition and Metabolism of Polybrominated Diphenyl Ethers in Fish.
 - v. Laboratory Studies to Investigate Reduction/Removal of Sediment Toxicity Caused by Organic Toxicants.
- c. US EPA Mid-Continent Ecology Division, http://www.epa.gov/med/research_topics.html#ecotoxicology
 - i. Assessment of the Effects of Persistent Bioaccumulative Toxic Chemicals in Aquatic Ecosystems (Cook *et al.* 2003)
 - ii. Development Of An Amphibian Model For Assessing Thyroid Axis Disruption (Degitz and Tietge)
 - iii. Development of Methods for Assessing Contaminated Sediments: TIE (Mount *et al.*)
 - iv. Evaluation of Toxicity and Accumulation of PFOS by *Rana pipiens* (Ankley, Kuehl)
 - v. Methods for Estimating Methylmercury Effects on Avian Species and Extrapolation of Effects Among Species (Bennett)
- d. Environment Canada
 - i. Fish and Wildlife Health Effects and Exposure Study, http://www.on.ec.gc.ca/wildlife/factsheets/fs_fish_and_wildlife-e.html#coverstory

- e. National Wildlife Research Centre, Wildlife Toxicology Division – Canada, http://www.cws-scf.ec.gc.ca/nwrc-cnrf/toxic/index_e.cfm
 - i. Egg Viability in Great Lakes Fish-eating Birds
 - ii. Toxicology of Environmental Mercury in Fish-Eating Wildlife
 - iii. Develop methods to measure gene expression in wildlife using techniques such as quantitative PCR (Q-PCR), serial analysis of gene expression (SAGE), DNA microarrays, and differential display PCR to examine the effects of environmental contaminants in wild birds
 - iv. Stable Isotopes as Research Tools in Ecology/Toxicology

3. Available Toxicology Resources

- a. EPA's ECOTOX Database - source for locating single chemical toxicity data for aquatic life, terrestrial plants and wildlife. Maintained by Office of Research & Development, <http://www.epa.gov/ecotox/>
- b. ATSDR ToxFAQs – a series of summaries about hazardous substances and potential effects of exposure on human health developed by the ATSDR Division of Toxicology. <http://www.atsdr.cdc.gov/toxfaq.html>
- c. Toxicological Effects of Methylmercury – National Research Council (2000), http://books.nap.edu/catalog/9899.html?onpi_newsdoc071100