Fact Sheet Date: March 12, 1998

NEW YORK STATE
- HUMAN HEALTH FACT SHEET -

Ambient Water Quality Value
Based on Human Consumption of Fish

SUBSTANCE: Heptachlor **CAS REGISTRY NUMBER:** 76-44-8

AMBIENT WATER QUALITY VALUE: 2×10^{-4} ug/L

BASIS: Bioaccumulation

INTRODUCTION

This value applies to the water column and is designed to protect humans from the effects of waterborne contaminants that may bioaccumulate in fish; it is referred to as a Health (Fish Consumption) or H(FC) value. The H(FC) value is based on three components, the toxicity of the substance to humans, the extent to which it bioaccumulates in fish, and the rate of fish consumption.

SUMMARY OF INFORMATION

A. Toxicity

The toxicity of heptachlor relevant to human health is described in a separate fact sheet (NYS, 1997). That fact sheet, which supports an ambient water quality value for protection of sources of potable water, derives a human dose of 1.27×10^{-3} ug heptachlor/kg/day, corresponding to an excess lifetime cancer risk of one-in-one million.

B. Bioaccumulation

A measurement of bioaccumulation is necessary to derive a value to protect human consumers of fish. Bioaccumulation is the process by which a substance becomes concentrated in an organism through the organism's exposure to the contaminant in food and water. Bioaccumulation is represented numerically by a bioaccumulation factor, or BAF, which is the ratio of the concentration of a substance in the organism to that in the water column.

The term bioconcentration also describes the concentration of a substance in an organism relative to the concentration in the water column. A bioconcentration factor (BCF), however, is measured with exposure to the contaminant by water only. A BCF may be equal to the BAF for many substances, but can underestimate it for others.

U.S. EPA (1995a) has promulgated, as final Federal regulations, procedures for deriving bioaccumulation factors. The procedures are believed appropriate for deriving statewide values and are being used in this fact sheet.

A key aspect of this procedure is that bioaccumulation is believed to be related to the concentration of freely dissolved substance. Hydrophobic organic substances are considered to exist in water in three phases: freely dissolved, sorbed to dissolved organic matter and sorbed to suspended solids (U.S. EPA, 1995b). Because BAF determinations are often based on measurements of total or dissolved substance, a measured BAF must be adjusted based on the estimated fraction of freely dissolved material. In addition, because measured BAFs are determined based on the percent lipid in the species studied, they are adjusted, or normalized, to 100% lipid to allow comparison of BAFs derived from species with different tissue lipid fractions. A BAF adjusted for both fraction freely dissolved and normalized to 100% lipid is referred to as a "baseline BAF."

Although bioaccumulation is related to the freely dissolved substance, water quality criteria are based on total substance. A baseline BAF, therefore, is readjusted to a final BAF by the expected fraction freely dissolved and fish lipid content for the waters for which criteria are established. The relationship of field-measured or final BAF to the baseline BAF is shown in equation 1:

(Eq. 1) $$\text{Baseline BAF} = \left[\frac{\text{Field or Final BAF}}{f_{fd}} - 1\right]\left[\frac{1}{f_l}\right]$$

where f_l = fraction of tissue that is lipid and f_{fd} = fraction of substance that is freely dissolved.

U.S. EPA (1995b) presented the following equation for estimating f_{fd}:

(Eq. 2) $$f_{fd} = \frac{1}{1 + \frac{(DOC)(K_{ow})}{10} + (POC)(K_{ow})}$$

where K_{ow} is the n-octanol-water partition coefficient of the substance in question, and DOC and POC are concentrations of dissolved and particulate organic carbon, respectively, in kg/L. The basis for this equation is described by U.S. EPA (1995b).

When deriving a baseline BAF from a field-measured BAF, DOC and POC levels under which the field BAF was determined are used to calculate a f_{fd}. When the baseline BAF is readjusted to yield a final BAF, the DOC and POC levels appropriate for the applicability of the criterion are used.

Derivation of Baseline BAFs

The procedures (U.S. EPA, 1995a,b) provide a hierarchy of methods to calculate a baseline BAF. A field-measured BAF for heptachlor, preferred under the procedures, was not found (U.S. EPA, 1993, 1995b). Therefore, a predicted baseline BAF from a laboratory-measured BCF, is calculated, using the following equation:

$$\text{Predicted Baseline BAF} = (\text{FCM}) \left[\frac{\text{Measured BCF}}{f_{fd}} - 1\right]\left[\frac{1}{f_l}\right]$$

where FCM is a Food-Chain Multiplier, f_{fd} is the fraction of freely dissolved substance, and f_l is the fraction of lipid.

U.S. EPA (1993) presents a geometric mean normalized (to 1% lipid) BCF of 1,469 L/kg, based on Schimmel et al. (1976), Goodman et al. (1978) and Veith et al. (1979). U.S. EPA (1993) also presents a "typical log P" (log K_{ow}) for heptachlor of 5.02. From Table B-1 (U.S. EPA, 1995a) this corresponds to FCMs of 3.273 for trophic level 3 and 2.722 for trophic level 4. As the f_{fd} would be close to 1 for a K_{ow} in this range, this fact sheet will use a value of 1 for f_{fd}. The value for f_l is 0.01 as the BCF was normalized to 1% lipid. Predicted baseline BAFs are calculated for trophic levels 3 and 4 below.

$$\text{Predicted Baseline BAF}_{TL3} = (3.273)\left[\frac{1{,}469\text{ L/kg}}{1} - 1\right]\left[\frac{1}{0.01}\right] = 480{,}500\text{ L/kg}$$

$$\text{Predicted Baseline BAF}_{TL4} = (2.722)\left[\frac{1{,}469\text{ L/kg}}{1} - 1\right]\left[\frac{1}{0.01}\right] = 399{,}600\text{ L/kg}$$

The readjustment of these baseline BAFs to final BAFs is described below.

DERIVATION OF WATER QUALITY VALUE

As required by 6 NYCRR 702.8(a) the water quality value must equal the acceptable daily intake from fish consumption divided by a bioaccumulation factor and by a fish consumption rate of 0.033 kg/day.

A. Acceptable Daily Intake From Fish Consumption

As required by 6 NYCRR 702.8(b), the most stringent acceptable daily intake from fish consumption is the human dose for oncogenic effects, as determined from 6 NYCRR 702.4. This value is 1.27×10^{-3} ug heptachlor/kg/day from NYS (1997) as described above.

B. Final BAFs

As described above, a baseline BAF is adjusted by the fish lipid fraction and the fraction freely dissolved to yield a final BAF for the substance. Equation 1 (above) is rearranged to solve for final BAF:

Final BAF = [(baseline BAF)(f_l) + 1](f_{fd})

where values for f_l and f_{fd} are appropriate to criteria for New York State. Because, as described below, humans are exposed to fish from two trophic levels, this calculation is performed to generate final BAFs for trophic levels 3 and 4.

A fish lipid content of 3% had previously been used when calculating BAFs for deriving criteria for New York State. U.S. EPA (1995a) apportions daily fish consumption between fish of trophic levels 3 and 4. Specifically, 24% is assigned to trophic level 3 fish, with a standardized lipid fraction of 0.0182 (1.82%), and 76% to trophic level 4 fish, with a standardized lipid fraction of 0.0310 (3.1%). The weighted average lipid fraction of trophic level 3 and 4 fish is thus 0.028 (2.8%), which is very close to the value of 3% that had been used in New York State. U.S. EPA's apportionment approach is believed to be protective of human consumers of fish statewide, and will be used in the derivation of the water quality value in this fact sheet to achieve consistency with requirements for the Great Lakes System.

As in the derivation of the baseline BAFs, a value of 1 for f_{fd} will be used to calculate the final BAFs.

As described above, the baseline BAFs for heptachlor for trophic levels 3 and 4 are 480,500 and 399,600 L/kg respectively.

The final BAF for trophic level 3 is calculated as:

Final BAF_{TL3} = [(baseline BAF_{TL3})($f_{l\ TL3}$) + 1](f_{fd}) =

Final BAF_{TL3} = [(480,500)(0.0182)+1](1) = 8,750 L/kg

The final BAF for trophic level 4 is calculated as:

Final BAF_{TL4} = [(baseline BAF_{TL4})($f_{l\ TL4}$) + 1](f_{fd}) =

Final BAF_{TL4} = [(399,600)(0.0310)+1](1) = 12,400 L/kg

C. Human Exposure (Fish Consumption)

6 NYCRR 702.8 requires that H(FC) values be based on a fish consumption rate of 0.033 kg/day.

D. Calculation of Water Quality Value

The water quality value (WQV) is derived using a human body weight of 70 kg and a daily fish consumption rate of 0.033 kg as shown below. The fish consumption is apportioned as 24% trophic level 3 and 76% trophic level 4.

$$WQV = \frac{\text{Acceptable Daily Intake from Fish Consumption x 70 kg}}{[(BAF_{TL3})(0.24) + (BAF_{TL4})(0.76)] \text{ x } 0.033 \text{ kg/day}}$$

$$WQV = \frac{1.27 \times 10^{-3} \text{ ug heptachlor/kg/day x 70 kg}}{[(8{,}750 \text{ L/kg})(0.24) + (12{,}400 \text{ L/kg})(0.76)] \text{ x } 0.033 \text{ kg/day}}$$

$$= 2.34 \times 10^{-4} \text{ ug/L, rounded to } 2 \times 10^{-4} \text{ ug/L}$$

REFERENCES

Goodman, L.R., D.J. Hansen, J.A. Couch, and J. Forester. 1978. Effects of heptachlor and toxaphene on laboratory-reared embryos and fry of the Sheepshead Minnow. Proceedings of the Thirtieth Annual Conference (1976), Southeastern Association of Fish and Wildlife Agencies, pp. 192-202. [Note: The value used for percent lipids is from Moore (1981).] [As cited in U.S. EPA (1993)].

Hansen, D.J. 1980. Memorandum to C.E. Stephan. August 25. [As cited in U.S. EPA (1993)].

Moore, J.C. 1981. Memorandum to D.J. Hansen. April 7. [As cited in U.S. EPA (1993)].

6 NYCRR (New York State Codes, Rules and Regulations). Water Quality Regulations, Surface Water and Groundwater Classifications and Standards: Title 6 NYCRR, Chapter X, Parts 700-705. Albany, NY: Department of Environmental Conservation.

NYS (New York State). 1997. Human Health Fact Sheet. Ambient Water Quality Value for Protection of Sources of Potable Water. Heptachlor. Albany, NY: Department of Environmental Conservation.

Schimmel, S.C., J.M. Patrick, Jr., and J. Forester. 1976. Heptachlor: Uptake, depuration, retention, and metabolism by Spot, *Leiostomus xanthurus*. J. Toxicol. Environ Health 2:169-178. [Note: The value used for percent lipids is from Hansen (1980).] [As cited in U.S. EPA (1993)].

U.S. EPA (Environmental Protection Agency). 1993. Derivation of Proposed Human Health and Wildlife Bioaccumulation Factors for the Great Lakes Initiative. By: Charles E. Stephan, Environmental Research Laboratory, Office of Research and Development, Duluth, MN: U.S. Environmental Protection Agency. Draft, March 3, 1993.

U.S. EPA (Environmental Protection Agency). 1995a. Final Water Quality Guidance for the Great Lakes System. 60 Federal Register: 15366-15425. March 23, 1995.

U.S. EPA (Environmental Protection Agency). 1995b. Great Lakes Water Quality Initiative Technical Support Document for the Procedure to Determine Bioaccumulation Factors. Office of Water. EPA-820-B95-005.

Veith, G.D., D.L. DeFoe, and B.V. Bergstedt. 1979. Measuring and estimating the bioconcentration factor of chemicals in fish. J. Fish. Res. Board Can. 36:1040-1048. [As cited in U.S. EPA (1993)].

New York State Department of Environmental Conservation
Division of Water
SJS
January 29, 1997