Fact Sheet Date: March 12, 1998

NEW YORK STATE
- HUMAN HEALTH FACT SHEET -

Ambient Water Quality Value
Based on Human Consumption of Fish

SUBSTANCE: alpha-Hexachlorocyclohexane **CAS REGISTRY NUMBER:** 319-84-6

AMBIENT WATER QUALITY VALUE: 0.002 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 alpha-hexachlorocyclohexane (alpha-HCH) 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 2.94×10^{-4} ug alpha-HCH/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 substantially 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

U.S. EPA (1995b), as part of the documentation for the Great Lakes Water Quality Initiative, presents baseline BAFs for a number of substances. For alpha-HCH, these values are presented in Table 1 and are based on a study by Oliver and Niimi (1988).

Table 1

Baseline BAFs for alpha-HCH (U.S. EPA, 1995b)

Trophic Level	Baseline BAF (L/kg)
3	56,890
4	48,980

The Department is concerned about the accuracy of the water column concentration (2.8 ng/L) used to calculate these BAFs and the concentration (0.3 ng/L) used to calculate the BAFs for gamma-HCH. A paper by Biberhofer and Stevens (1987) shows an average concentration of 6.87 for alpha-HCH in Lake Ontario. These measurements were taken six months prior to the Oliver and Niimi water column data and are also considered representative for the calculation of the BAF. The Department is also concerned with the significant departure of the Oliver and Niimi BAFs from the value of about 6,500 L/kg predicted by K_{ow}s and FCMs for each isomer of HCH.

The Department received and reviewed data for young-of-the-year spottail shiner submitted by the public. The data indicate a BAF (100% lipid) of about 5,000 L/kg, but the Department does not believe it is valid to select a BAF based on this fish. The BAF is expected to be understated because of “growth dilution,” and adult fish should be used to derive a BAF for calculating a standard.

The Department also reviewed a data set submitted by the public for food fish (rainbow trout, white sucker, lake trout and smelt) collected in the Niagara River in 1986 and 1988. The data are unpublished fish data from the Canadian Ministry of the Environment (MOE). This data set shows a wide range of BAFs (2,230 to 210,860 L/kg) and a geometric mean of 9,200 L/kg. The wide variation in BAFs results from wide variation in tissue concentrations of the MOE data set. The MOE data set does not include the size of the fish, which might explain the variations in concentrations. It is also noted that while the fish were caught in the Niagara River, they would have spent a significant portion of the time in Lake Ontario. The Niagara River water column concentrations, therefore, might not represent the proper exposure concentrations for calculating a BAF. Although the Department did not use this data set for the reasons described, it did yield a BAF for alpha-HCH that is in very close agreement with the BAF calculated below.

Alternatively, BAFs for alpha-HCH have been calculated using fish tissue data collected by the Department in the Niagara River in 1981 and water column concentrations from a paper by Kuntz and Warry (1983). The water column concentrations represent samples collected in the lower Niagara River from April 1979 through December 1981 at approximately two week intervals (75 samples). The mean concentration is 10.5 ng/L on total sample and 10.2 ng/L dissolved. The freely dissolved concentration of alpha-HCH, which has a Log K_{ow} of 3.776 (U.S. EPA, 1995b), will be assumed equal to the dissolved concentration of 10.2 ng/L.

The Department's fish tissue data are presented in Table 2 (next page). The data were collected in 1981 in the Niagara River below Buffalo and at Fort Niagara and in the Lower Niagara River. The samples are standard fillet. The BAFs in Table 2 are calculated using the water column value of 10.2 ng/L described above. The geometric mean of the separate data sets for each species is also presented in Table 2. Baseline BAFs for trophic levels 3 and 4 are the geometric means of the species mean BAFs for the respective trophic levels and are presented in Table 3. These values will be used in the calculation of final BAFs.

TABLE 3

Baseline BAFs for alpha-HCH

Trophic Level	Baseline BAF (L/kg)
3	7,408
4	9,602

Table 2

Field BAFs for Alpha-HCH
Niagara River

Species (Trophic Level)	Number of fish	Length mm	Weight grams	% lipid	A-HC ug/g	A-HCH ng/glipid	BAF (L/kg)	G-Mean BAF (L/kg)
AMEL	13	706.1	747.4	26.76	0.02398	89.61	8,785	
AMEL (3)	10	891.2	1864.0	31.25	0.03394	108.61	10,648	9,672
CARP	12	560.8	2766.6	9.66	0.00997	103.21	10,119	
CARP	6	608.8	3214.0	10.24	0.00963	94.04	9,220	
CARP	9	395.1	922.2	8.55	0.00997	116.61	11,432	
CARP (2)	15	518.1	2359.7	8.13	0.00718	88.31	8,658	9,803
RB	16	214.6	205.8	1.44	0.00112	77.78	7,625	
RB	32	177.7	123.1	1.61	0.00102	63.35	6,211	
RB	15	197.4	178.7	2.08	0.00308	148.08	14,517	
RB (3)	36	160.4	86.9	0.93	0.00029	31.18	3,057	6,771
SMB	8	318.9	492.6	4.42	0.00522	118.10	11,578	
SMB	13	341.2	637.9	3.93	0.00433	110.18	10,802	
SMB	8	301.0	459.5	2.44	0.00198	81.15	7,956	
SMB (4)	4	293.2	357.5	3.19	0.00278	87.15	8,544	9,602
YP	12	186.9	73.3	1.11	0.00089	80.18	7,861	
YP (3)	18	209.6	109.4	1.00	0.00050	50.00	4,902	6,208

BAFs are based on water concentration of 10.2 ng/L

AMEL = American Eel
CARP = Carp
RB = Rock Bass
SMP = Small Mouth Bass
YP = Yellow Perch

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 2.94×10^{-4} ug alpha-HCH/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:

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

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.

For deriving f_{fd} values for the Great Lakes, U.S. EPA (1995a) procedures use DOC and POC values of 2 and 0.04 mg/L respectively. The POC level of 0.04 mg/L is on the low end for the Great Lakes but U.S. EPA selected it to ensure protection throughout the System.

Data on levels of DOC and POC were examined for fresh and marine waters in New York State. Levels of DOC vary somewhat through the State but are fairly close to 2 mg/L. The f_{fd} is not very sensitive to changes in concentration of DOC. Levels of POC in New York State range from zero to several mg/L, but a sufficient number of near-zero values were found such that the level that EPA uses for the Great Lakes System seems appropriate for statewide standards and at the same time provides consistency with the federal requirements for the Great Lakes System.

Using these values for DOC and POC, equation 2 (above) becomes:

$$f_{fd} = \frac{1}{1 + (0.00000024\ \text{kg/L})(K_{ow})}$$

With a K_{ow} of 5,970, the fraction freely dissolved is calculated to be 0.999.

As described above, the baseline BAFs for alpha-HCH for trophic levels 3 and 4 are 7,408 and 9,602 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} = [(7,408)(0.0182)+1](0.999) = 136 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} = [(9,602)(0.0310)+1](0.999) = 298 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.

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

$$WQV = \frac{2.94 \times 10^{-4} \text{ ug (alpha-HCH)/kg/day x 70 kg}}{[(136 \text{ L/kg})(0.24) + (298 \text{ L/kg})(0.76)] \times 0.033 \text{ kg/day}}$$

= 0.00241 ug/L, rounded to 0.002 ug/L

REFERENCES

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