# Canadian Water Quality Guidelines for the Protection of Agricultural Water Uses

# CHLORINATED BENZENES
## hexachlorobenzene

Hexachlorobenzene (CAS 118-74-1) is a white needle-like crystalline solid with a low water solubility of 5 $\mu g \cdot L^{-1}$, a vapour pressure of 0.0023 Pa, a Henry's law constant of 131 $Pa \cdot m^3 \cdot mol^{-1}$, and a log octanol–water partition coefficient of 5.50 (Mackay et al. 1992).

Hexachlorobenzene has been used as an agricultural fungicide and a wood preservative. It is also used in industrial applications as an aluminium fluxing agent, as a porosity control agent in graphite anode manufacturing, as a peptizing agent in nitroso and styrene rubber production, and in the production of pyrotechnics and tracer bullets (Mumma and Lawless 1975). With the elimination of the use of hexachlorobenzene as a fungicide in the 1970s, the major Canadian use appears to be organic chemical synthesis (CIS 1991).

Hexachlorobenzene can be found ubiquitously in the environment due to its past commercial applications with dissipative use patterns, long environmental persistence, and long-range atmospheric transport. It is not produced or widely used in Canada. The principle sources of environmental contamination are losses associated with the manufacture and use of chlorinated solvents, application of hexachlorobenzene-contaminated pesticides, incineration of hexachlorobenzene-containing wastes, and long-range transborder transport and deposition. It is estimated that releases of hexachlorobenzene to the Canadian environment are likely in excess of 1000 kg per year (Government of Canada 1993).

There is also only sparse information about hexachlorobenzene in groundwater and surface water; reported levels range from 0.018 to 3.0 $\mu g \cdot L^{-1}$ and from 0.000 012 to 0.087 $\mu g \cdot L^{-1}$, respectively. Levels near the upper part of the range are usually near known sites of contamination, and higher levels have been reported in industrial effluents (Government of Canada 1993).

Mackay et al. (1992) have modelled the environmental fate of hexachlorobenzene using several versions of a fugacity-based model and available information. Modelled behaviour is generally consistent with field observations and demonstrates that hexachlorobenzene tends to partition primarily into soils and, to a lesser extent, bottom sediments (long-term sinks/storage sites), with transfer between media being slow. Nevertheless, about 10% ends up in the atmosphere, as it has a relatively high vapour pressure and extremely low water solubility. The primary removal process in air is by advection (e.g., deposition and sedimentation) and, to a much smaller extent, by chemical reactions. Movement in the environment is largely by long-range airborne transport and atmospheric deposition. Photodegradation is very slow. In water, hexachlorobenzene is found mostly in organic phases (organisms, sediments) or associated with suspended/dissolved organic material rather than dissolved in the water phase. Organism residues may reach toxicologically significant concentrations because of the partitioning characteristics (direct and via the foodchain) and persistence. Biotransformation is minor, with biodegradation in soil by microbes requiring years. The modelled mean environmental half-lives range from 1.1 to 3.4 years for air, water, and soil and over 3.4 years for sediments.

## Water Quality Guideline Derivation

The interim Canadian water quality guideline for hexachlorobenzene for the protection of livestock water was developed based on the CCME protocol (CCME 1993).

For more information. see the Canadian Environmental Protection Act (CEPA) assessment report and its supporting document (Government of Canada 1993) and the supporting document (Environment Canada 1997).

**Table 1. Water quality guidelines for hexachlorobenzene for the protection of agricultural water uses (Environment Canada 1997).**

| Use | Guideline value ($\mu g \cdot L^{-1}$) |
|---|---|
| Irrigation water | NRG* |
| Livestock water | 0.52† |

*No recommended guideline.
†Interim guideline.

## Livestock Water

No previous guidelines have been developed for livestock water supplies. Recent reviews (Government of Canada 1993; Environment Canada 1997) have shown that only a limited amount of toxicity data suitable for guideline development, are available. For hexachlorobenzene, an interim water quality guideline for the protection and maintenance of livestock water supplies of 0.52 $\mu g \cdot L^{-1}$ is recommended.

The oral toxicity of hexachlorobenzene is low, probably due to its low vapour pressure and limited solubility. The $LD_{50}$s range from approximately 1000 to 10 000 $mg \cdot kg^{-1}$ bw and effects (growth, neurological effects, and liver damage) are found with repeated exposures of 30–250 $mg \cdot kg^{-1}$ bw per day in exposed guinea pigs and rats. The LOECs for monkeys, pigs, mink, mice, and rats range from 0.1 to 0.7 $mg \cdot kg^{-1}$ bw per day. Hexachlorobenzene is considered to be an animal carcinogen in the United States and is classified as a Type II carcinogen by Health Canada.

Japanese quail, *Coturnix japonica*, exposed to 100 $mg \cdot g^{-1}$ of hexachlorobenzene in their diet for 90 d exhibited an increase in mortality. Hatchability of eggs was reduced after exposure to 20 $\mu g \cdot g^{-1}$ of hexachlorobenzene (approximately 11.3 $mg \cdot kg^{-1}$ bw per day, ww) for the same duration (Vos et al. 1971, 1972). At 5 $\mu g \cdot g^{-1}$ of hexachlorobenzene (2.8 $mg \cdot kg^{-1}$ bw per day), increased liver weight, slight liver damage, and increased fecal excretion of coproporphyrin were observed.

The most sensitive livestock species tested was the mink (Rush et al. 1983; Bleavins et al. 1984), with a LOEC of 0.16 $mg \cdot kg^{-1}$ bw per day. Following the protocol (CCME 1993), a NOEC of 0.029 $mg \cdot kg^{-1}$ bw per day (LOEC ÷ 5.6) and a TDI (i.e., geometric mean of the LOEC and NOEC, divided by an uncertainty factor of 100) of 0.000 68 $mg \cdot kg^{-1}$ bw per day were derived. The uncertainty factor of 100 was chosen instead of the default value of 10 to account for the bioaccumulation potential of hexachlorobenzene. Since only the minimum data for an interim guideline were available, the most conservative estimates of body weight (bw) and daily water intake rate (WIR) (i.e., 2.3 kg and 0.61 $L \cdot d^{-1}$ for the white leghorn chicken) were used to calculate the reference concentration (RC = [TDI · bw] ÷ WIR) of 0.0026 $mg \cdot L^{-1}$. To account for exposure to hexachlorobenzene from sources other than water, the lowest RC is multiplied by an apportionment factor of 0.2 to give an interim water quality guideline of 0.52 $\mu g \cdot L^{-1}$ for the protection of livestock.

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Excerpt from Publication No. 1299; ISBN 1-896997-34-1

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