This fact sheet provides soil quality guidelines for ethylene glycol in Canada for the protection of environmental health (Table 1). A supporting scientific document is also available (Environment Canada 1996).

**Background Information**

Ethylene glycol (C₂H₆O₂; CAS 107-21-1) is an aliphatic alcohol characterized by two hydroxyl functional groups attached to methyl subunits in an aliphatic chain. Ethylene glycol is a clear, colourless, odourless, relatively nonvolatile, viscous liquid with a melting point of -13°C, a boiling point of 197.6°C, and a flash point of 111–115°C. It has a sweet taste and imparts a warming sensation to the tongue when swallowed. Ethylene glycol has a low vapour pressure of 6.7 Pa (0.05 mm Hg) at 20°C, a low Henry’s law constant of $6 \times 10^{-8}$ atm·m³·mol⁻¹, and a very low octanol–water coefficient (log $K_{ow}$ 4.36). It is miscible in water and in solvents such as acetone, formaldehyde, glycerol, and acetic acid. It is sparingly soluble in ether and insoluble in benzene, chlorinated hydrocarbons, and oils. It is very hygroscopic and will absorb up to 200% its weight in water at 100% relative humidity. In 1991, total consumption of ethylene glycol in Canada was 135 kt, of which about 60% was used in the production of deicing fluids and antifreeze mixtures (Chinn 1993). An additional 11% was used in the production of polyethylene terephthalate (polyester). Minor uses are in the processing of oil and gas and in the production of solvents, explosives, cellulose film, and glycol esters (Chinn 1993; CPI Product Profiles 1994).

**Table 1. Soil quality guidelines for ethylene glycol (mg kg⁻¹).**

<table>
<thead>
<tr>
<th>Guideline</th>
<th>Agricultural</th>
<th>Residential/ parkland</th>
<th>Commercial</th>
<th>Industrial</th>
</tr>
</thead>
<tbody>
<tr>
<td>SQGRH</td>
<td>960&lt;sup&gt;a&lt;/sup&gt;</td>
<td>960&lt;sup&gt;a&lt;/sup&gt;</td>
<td>960&lt;sup&gt;a&lt;/sup&gt;</td>
<td>960&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Limiting pathway for SQGRH</td>
<td>NC&lt;sup&gt;b&lt;/sup&gt;</td>
<td>NC&lt;sup&gt;b&lt;/sup&gt;</td>
<td>NC&lt;sup&gt;b&lt;/sup&gt;</td>
<td>NC&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Provisional SQGRH</td>
<td>NC&lt;sup&gt;c&lt;/sup&gt;</td>
<td>NC&lt;sup&gt;c&lt;/sup&gt;</td>
<td>NC&lt;sup&gt;c&lt;/sup&gt;</td>
<td>NC&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>Limiting pathway for provisional SQGRH</td>
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<td>ND</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td>SQGE</td>
<td>NC&lt;sup&gt;d&lt;/sup&gt;</td>
<td>NC&lt;sup&gt;d&lt;/sup&gt;</td>
<td>NC&lt;sup&gt;d&lt;/sup&gt;</td>
<td>NC&lt;sup&gt;d&lt;/sup&gt;</td>
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<td>ND</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td>Provisional SQGE</td>
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<td>960</td>
<td>960</td>
<td>960</td>
</tr>
<tr>
<td>Limiting pathway for provisional SQGE</td>
<td>Aquatic life</td>
<td>Aquatic life</td>
<td>Aquatic life</td>
<td>Aquatic life</td>
</tr>
<tr>
<td>Interim soil quality criterion (CCME 1991)</td>
<td>No value</td>
<td>No value</td>
<td>No value</td>
<td>No value</td>
</tr>
</tbody>
</table>

Notes: NC = not calculated; ND = not determined; SQGE = soil quality guideline for environmental health; SQGRH = soil quality guideline for human health.

<sup>a</sup>Data are sufficient and adequate to calculate only a provisional SQGE.

<sup>b</sup>There is no SQGRH for this land use at this time.

<sup>c</sup>There is no provisional SQGRH for this land use at this time.

<sup>d</sup>Data are insufficient/inadequate to calculate an SQGE. However, data are sufficient and adequate to calculate a provisional SQGE.

The guidelines in this fact sheet are for general guidance only. Site-specific conditions should be considered in the application of these values. The values may be applied differently in various jurisdictions. The reader should consult the appropriate jurisdiction before application of the values.

Canadian Environmental Quality Guidelines
Canadian Council of Ministers of the Environment, 1999
No information was found on levels of ethylene glycol in Canadian soils. Data on ethylene glycol levels in other environmental media are limited to areas near airports. Percy (1992) reported air concentrations of ethylene glycol of 3.2 and 4.1 mg·m\(^{-3}\) at an Ontario airport. In surface water, the highest reported ethylene glycol concentration (up to 13 200 mg·L\(^{-1}\)) was measured in a drainage ditch carrying runoff from a Quebec airport in 1974. More recent measurements, however, suggest that contamination levels at that site have declined since 1974 as concentrations of ethylene glycol ranged from 4.5 to 552 mg·L\(^{-1}\) in 1987 (Transport Canada 1988). Other Canadian airports have reported similar concentrations of ethylene glycol ranging from <10 to 643 mg·L\(^{-1}\) (Transport Canada 1989a, 1989b, 1990). In groundwater samples collected at one Canadian airport in 1985 and 1986, the maximum recorded ethylene glycol concentration was 415 mg·L\(^{-1}\) (Transport Canada 1985, 1987).

**Environmental Fate and Behaviour in Soil**

The major processes that determine the mobility and distribution of ethylene glycol in the terrestrial environment are leaching, biodegradation, and photolysis.

The low vapour pressure and relatively low Henry’s law constant of ethylene glycol suggest that volatilization is not an important fate process in most circumstances (Howard 1990; MacDonald et al. 1992; Nielsen et al 1993). Also, the low K\(_{ow}\) and high water solubility of ethylene glycol indicate a low potential for soil and sediment adsorption (Lokke 1984; Abdelghani et al. 1990; Howard 1990; MacDonald et al. 1992; Nielsen et al 1993).

Ethylene glycol is miscible in water and thus is subject to surface transport with surface water and storm water and has a high potential to leach into groundwater (Lokke 1984; Nielsen et al. 1993). Field studies by Transport Canada (1987) showed that a solution of 10% ethylene glycol moved through a silt sand at an average rate of 0.6 m·d\(^{-1}\). Of particular concern is the potential for oxygen depletion in water bodies receiving ethylene glycol-contaminated surface waters, storm water, or groundwater. The biodegradation of ethylene glycol can be sufficiently rapid that dissolved oxygen could be depleted in receiving waters to levels that may threaten oxygen-dependent aquatic biota.

Ethylene glycol is known to be susceptible to phototransformation, which is thought to be proportional to light intensity (Atkinson 1985; Cunningham and Others 1985; Freitag et al. 1985).

Biodegradation of ethylene glycol has been reported under aerobic and anaerobic conditions in soils, sediments, and sludge (Gaston and Stadman 1963; Haines and Alexander 1975; Means and Anderson 1981; Willetts 1981; Dwyer and Tiedje 1983; Howard 1990). Under aerobic conditions, ethylene glycol is degraded by species such as *Pseudomonas* sp. and *Flavobacterium* sp. to glycolate and eventually to carbon dioxide (Haines and Alexander 1975; Willetts 1981). Under anaerobic conditions, it is degraded by anaerobic bacteria such as *Clostridium glycolicum* and converted to ethanoic acid and ethanol (Gaston and Stadman 1963).

**Behaviour and Effects in Biota**

**Soil Microbial Processes**

Few data were found on the effects of ethylene glycol to microbes and microbial processes in soil, but there are several studies carried out in other media. Khoury et al. (1990) reported an average toxic endpoint, IC\(_{50}\) (50% reduction in optical density), of 114 300 mg·L\(^{-1}\) on heterotrophic soil microorganisms.

Daugherty (1980) reported that the *Pseudomonas aeruginosa* is capable of degrading ethylene glycol, in culture medium, up to 1000 mg·L\(^{-1}\), and concentrations >2000 mg·L\(^{-1}\) were found to be inhibitory. Stahl and Pessen (1953) reported the inhibitory effect for the same organism at 20 000 mg·L\(^{-1}\).

Kilroy and Gray (1992) reported 50% reduction of respiration at 202.36 mL·L\(^{-1}\) in a mixture of municipal sludge and synthetic sewage and at 154.79 and 196.65 mL·L\(^{-1}\) in factory sludge/synthetic sewage and factory sludge/factory feed, respectively. Klecka and Landi (1985) reported a 50% reduction in microbial respiration at >1000 mg·L\(^{-1}\) in incubated activated sludge.

**Terrestrial Plants**

In an attempt to establish phytotoxic levels of ethylene glycol in soil, Environment Canada conducted seedling emergence tests for both radishes (*Raphanus sativa*) and lettuce (*Lactuca sativa*). The lowest concentrations at which adverse effect occurred were 5300 and 9000 mg·kg\(^{-1}\) soil, resulting in a 25% reduction in seedling emergence for radishes and lettuce, respectively (Environment Canada 1995). Unresolved problems associated with the recovery of ethylene glycol allow these results to be used for calculating provisional soil quality guidelines only.
Reynolds (1977) reported a 50% inhibition of germination of lettuce at 55 mg·L⁻¹ in nutrient solution.

**Terrestrial Invertebrates**

The only available information on the toxic effects of ethylene glycol on terrestrial invertebrates is from Environment Canada. The lowest reported ethylene glycol concentration resulting in adverse effects in the earthworm (*Eisenia fetida*) is 20 000 mg·kg⁻¹ soil. At this concentration the earthworm suffered 25% mortality. The same unresolved problems associated with the phytotoxicity tests were encountered, and the results are used for deriving provisional soil quality guidelines only (Environment Canada 1995).

**Livestock and Wildlife**

Ethylene glycol itself is not toxic, however, its intermediary oxidation products are active toxicants (Black 1983). Ethylene glycol is metabolized by alcohol and aldehyde dehydrogenases in the liver, and the main metabolites are glycoaldehyde, glycolic acid, glyoxylic acid, and glycolate. Chou and Richardson (1978) observed a direct correlation between urinary glycolate levels and mortality. It is thought that glycolate is the primary toxic metabolite of ethylene glycol.

Symptoms of ethylene glycol toxicity may include weakness, depression, metabolic acidosis, coma, cardiopulmonary collapse, and death in mammals (Environment Canada 1996). In poultry, Riddell et al. (1967) reported drowsiness, ataxia, dyspnea, and torticollis followed by watery droppings, ruffled feathers, recumbency, and death. Ethylene glycol poisoning in cattle has been reported by Crowell et al. (1979). The toxic dose was reported at 2 mL·kg⁻¹ bw, and the symptoms were increased respiration, staggering gait, paraparesis, depression, and, later, recumbency and death.

Ethylene glycol poisoning in polar bears has been reported by Amstrup et al. (1989). Soil, snow, and urine sampled under the dead animal contained high quantities of ethylene glycol (200 mg·kg⁻¹ soil) and rhodamine B, a mixture commonly used to mark roads and runways during snow and ice periods. It was concluded that there was enough ethylene glycol in the body to cause the bear’s death.

**Guideline Derivation**

Canadian soil quality guidelines are derived for different land uses following the process outlined in CCME (1996a) using different receptors and exposure scenarios for each land use (Table 1). Detailed derivations for ethylene glycol soil quality guidelines are provided in Environment Canada (1996).

**Soil Quality Guidelines for Environmental Health**

Environmental soil quality guidelines (SQGs) are based on soil contact using data from toxicity studies on plants and invertebrates. In the case of agricultural land use, soil and food ingestion toxicity data for mammalian and avian species are included. To provide a broader scope of protection, a nutrient and energy cycling check is calculated. For industrial land use, an off-site migration check is also calculated.

In the case of ethylene glycol, there are insufficient data to derive any of the environmental health guidelines or check values. However, there are sufficient data to derive a provisional SQGe based on soil contact of plants and invertebrates (Table 2).
Table 2. Soil quality guidelines and check values for ethylene glycol (mg·kg$^{-1}$).

<table>
<thead>
<tr>
<th>Guideline</th>
<th>Land use</th>
<th>Agricultural</th>
<th>Residential/parkland</th>
<th>Commercial</th>
<th>Industrial</th>
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<td></td>
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<td>Human health guidelines/check values$^b$</td>
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<td>SQG$_{HH}$</td>
<td>NC</td>
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<td>NC</td>
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<td>NC</td>
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<tr>
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<td>Inhalation of indoor air check</td>
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<tr>
<td>Off-site migration check</td>
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<td>Produce, meat, and milk check</td>
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</tr>
<tr>
<td>SQG$_{E}$</td>
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<td>2000$^a$</td>
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<td>NC$^d$</td>
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<td>960$^e$</td>
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<tr>
<td>Limiting pathway for provisional SQG$_{E}$</td>
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<td>Aquatic life</td>
<td>Aquatic life</td>
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<td>Aquatic life</td>
</tr>
<tr>
<td>Interim soil quality criterion (CCME 1991)</td>
<td>No value</td>
<td>No value</td>
<td>No value</td>
<td>No value</td>
<td>No value</td>
</tr>
</tbody>
</table>

Notes: NC = not calculated; ND = not determined; SQG$_{E}$ = soil quality guideline for environmental health; SQG$_{HH}$ = soil quality guideline for human health. The dash indicates guideline/check value that is not part of the exposure scenario for this land use and therefore is not calculated.

$^a$Data are sufficient and adequate to calculate only a provisional SQG$_{E}$.

$^b$There are no human health guidelines/check values at this time.

$^c$There is no provisional SQG$_{HH}$ for this land use at this time.

$^d$Data are insufficient/inadequate to calculate this value for this land use.

$^e$Because of the known fate and behaviour of ethylene glycol in the environment, the groundwater check (aquatic life) value has been applied in the determination of the environmental soil quality guideline. This check should be applied to all sites regardless of site-specific characteristics.
The environmental groundwater check has been used to derive an ethylene glycol soil concentration that is protective of freshwater aquatic life associated with groundwater recharge to surface water. Because of the known fate and behaviour of ethylene glycol in the environment, this groundwater check value is applied in the determination of the environmental soil quality guideline. This check should be applied to all sites regardless of site-specific characteristics (Table 2).

Soil Quality Guidelines for Human Health

There are no human health guidelines or check values available at this time (Table 2).

Soil Quality Guidelines for Ethylene Glycol

The soil quality guidelines are the provisional SQGs.

CCME (1996b) provides guidance on potential modifications to the final recommended soil quality guideline when setting site-specific objectives.

References


This fact sheet was originally published in the working document entitled “Recommended Canadian Soil Quality Guidelines” (Canadian Council of Ministers of the Environment, March 1997, Winnipeg). A revised and edited version is presented here.

Reference listing:


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