

Soil vulnerability to losses from leaching into groundwater

Groundwater pollution results from the more or less rapid leaching of nutrients in the surface layer (A) down to lower layers (subsoil (B) and substratum (C)). Leaching occurs during water runoff from soil by gravitation, when the field's capacity is exceeded, until the profile is completely saturated. Quantities of water and leached elements depend on the soil's capacity to hold the latter, the height of the water table, the soil's moisture balance, rainfall, density of vegetation cover and mineral or organic fertilizer spreading practices (Lavoie et al. 1995).

The leaching vulnerability assessment model (Lavoie and Nolin 1997) uses the soil characteristics that affect the movement of water in soil: profile permeability, available water (in the topmost 100 cm of soil) and water saturation risk as derived from the degree and frequency of saturation (flood risk and drainage class). The most vulnerable soils are those that are highly permeable, very well drained and with low water-holding capacity. Soils that are very poorly drained or in flood-prone areas are also highly vulnerable, owing to the fact that the soil is frequently water-saturated.

While soil moisture balance is a determining factor for groundwater pollution risk assessment, there are other factors that also play a role in natural groundwater quality and the protection of that quality: these include geology and geomorphology, the presence of macropores and/or shrinkage cracks, which are difficult to estimate in a general model, and rainfall.

Table 1. Assessment model for soil vulnerability to losses as a result of leaching

Flood risk	Drainage	Profile permeability	Available water (100 cm soil depth)	Vulnerability
Present	---	---	---	High
	Very rapidly drained to well drained	Slow	---	Nil to low
		Moderate	<10 cm	Moderate
		Rapid	≥10 cm	Nil to low
		Rapid	<10 cm	High
Absent	Moderately well drained to imperfectly drained	Slow	≥10 cm	Moderate
		Moderate	<10 cm	High
		Moderate	10-20 cm	Moderate
		Rapid	≥20 cm	Nil to low
	Poorly drained	Rapid	<20 cm	High
		Rapid	≥20 cm	Moderate
		Slow	<15 cm	High
		Slow	≥15 cm	Moderate
		Moderate	<20 cm	High
		Moderate	≥20 cm	Moderate
Very poorly drained	---	---	High	

Lavoie and Nolin 1997

The map shows the areas that are most vulnerable to losses as a result of leaching for farmland with improved drainage. According to the assessment model, 20.8% of the total study area appears to be characterized by high vulnerability to groundwater pollution, where subsurface drainage is in place (e.g. Joseph series). A number of these soils are flood-prone. These soils occur mainly in Richelieu and Saint-Hyacinthe Counties and along the St. Lawrence, rivers and creeks, and on the sandy terraces of the bois de Verchères. Vulnerability increases to 56.1% if the soils are not drained, owing to the risk of prolonged periods of water saturation, which is an important factor in this classification. The same applies to the other vulnerability classes. Soils classified as being moderately vulnerable (e.g. Sainte-Julie series) account for 34.8% of the total area if they are drained, and 43.4% if they are not drained. The least vulnerable soils account for 44.9% of the study area on the assumption that they are drained, and 0.5% if they are not (e.g. Saint-Blaise series).

It is noteworthy that the risk of groundwater pollution, no less than the risk of surface water pollution, is closely associated with rainfall, since water acts as a carrier and solvent. However, that risk may be reduced by adequate tillage and spreading practices.