NELSON EDUCATION | Canada's Learning Advantage

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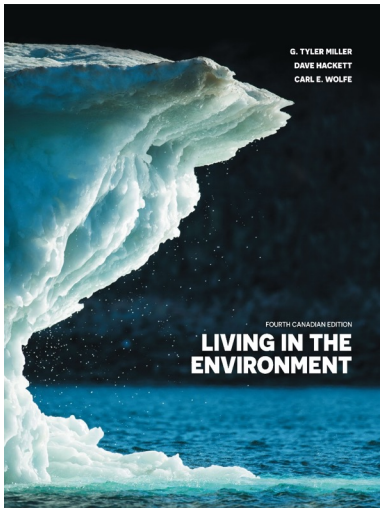


prepared by

Ian Dawe

Chapter 22

Water Pollution

Key Concepts

Types, sources, and effects of water pollutants
Measuring water quality
Major pollution problems and solutions in
- Freshwater streams and lakes
- Groundwater
- Oceans
- Surface water

Drinking water quality

Major Categories of Water Pollutants

Infectious agents
Oxygen-demanding wastes
Inorganic chemicals
Organic chemicals
Plant nutrients
Sediment
Radioactive materials
Heat (thermal pollution)

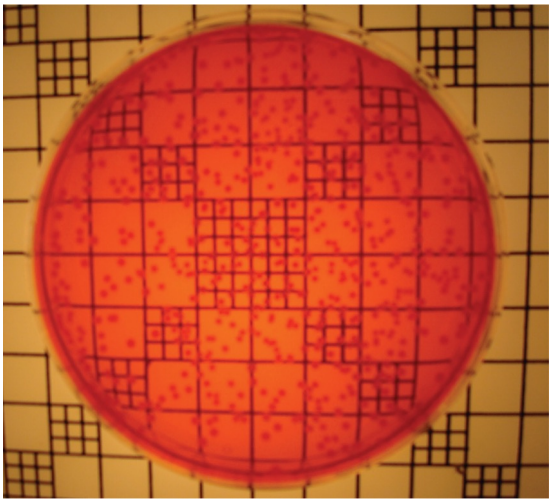
Common Diseases Transmitted Through Contaminated Drinking Water

- Bacteria
  - Typhoid fever
  - Cholera
  - Dysentery
- Viruses
  - Infectious hepatitis
- Parasitic protozoa
  - Amoebic dysentery
- Parasitic worms
  - Schistosomiasis

How Do We Measure Water Quality?

- Bacterial count
  - Bacterial source tracking
- Dissolved oxygen (DO)
- Biological oxygen demand (BOD)
- Chemical analysis
- Sediment: Evaporation or turbidity
- Indicator species
- Biomonitoring or biosensors

Bacterial Count



Dave Hackett

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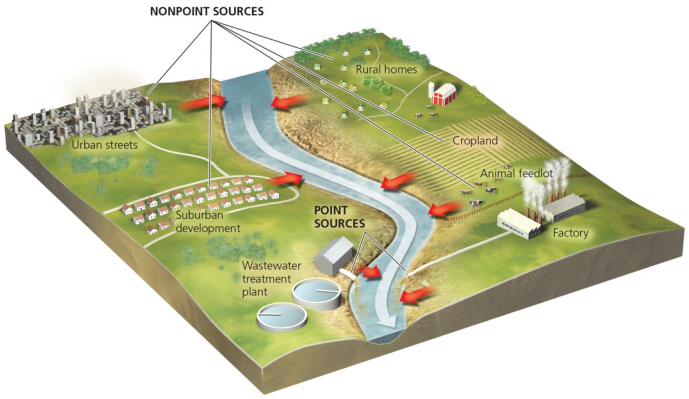
Point and Nonpoint Sources of Water Pollution



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What Are Major Sources of Water Pollution?

Agricultural

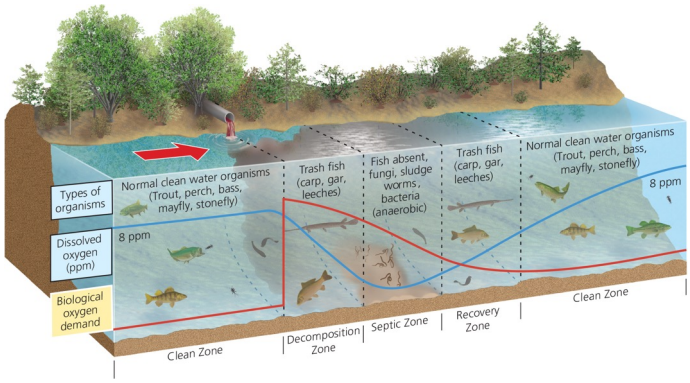
– Leading cause of water pollution

Industrial

Mining

– Toxic chemicals released

Pollution of Freshwater Streams



Steps Toward Reduction of Stream Pollution

Developed Countries

- Most have sharply reduced point-source pollution
- Nonpoint sources/toxic chemicals still a problem

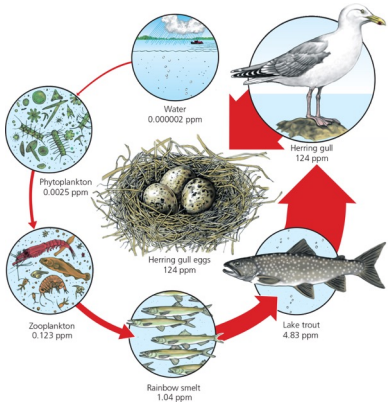
Developing Countries

- Serious and growing problems
- Religious beliefs and cultural traditions
- Poverty, economic development, population

Pollution of Freshwater Lakes

Lakes more vulnerable to pollution due to low mixing and low flow

Concentrations of chemicals can be biomagnified



What Is Cultural Eutrophication?

Excessive nutrients from human activities accelerate the input of plant nutrients to a lake.

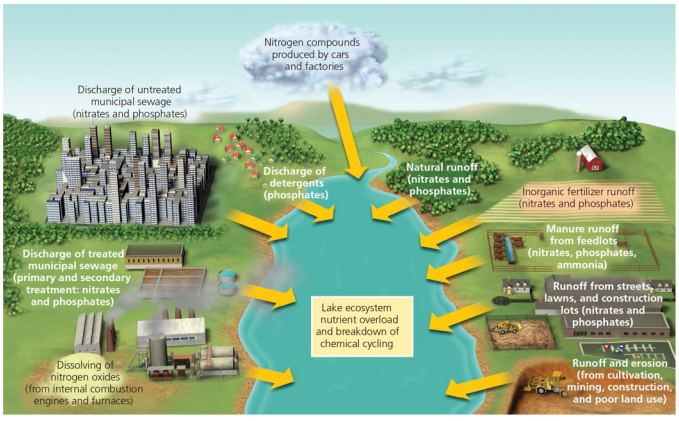
Mostly nitrate- and phosphate-containing effluents

Can also occur in coastal marine environments

Prevention

- Waste treatment
- Banning or limited phosphates
- Soil conservation and land-use control
- Remove excess weeds
- Herbicides and algicides
- Pumping air

What Is Cultural Eutrophication?
Continued



Case Study: Canada's Experimental Lakes Area (ELA)—A Famous Outdoor Laboratory

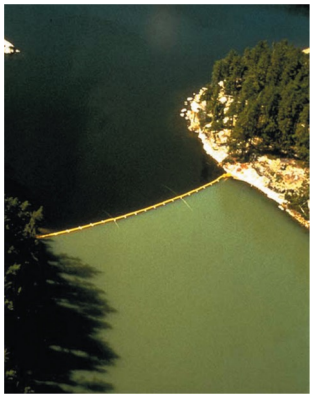
Established near Kenora, ON, in 1967

- Scientific study area aimed at determining causes of lake death
- Long-term ecosystem research

Led to controls of phosphorus in Canada, the United States, and Europe

Re-balanced pH of lakes with calcium carbonate

Government funding pulled in 2012, project taken over by international institute



David Schindler

Case Study: Pollution in the Great Lakes—Hopeful Progress

Source: Adapted from Environment Canada; Ontario Ministry of Environment and Climate Change. "Map Illustrating Great Lakes Areas of Concern" from Canada-Ontario Agreement on Great Lakes Water Quality and Ecosystem Health (2014), p. 34.

Pollution of Groundwater

Challenges

- Extremely slow flow
- Low oxygen levels
- Minimal bacteria
- Low temperatures

Extent uncertain

- High concentrations of nitrates in Ontario and Prairie province wells
- Walkerton resulted in increased awareness and better facilities Canada-wide

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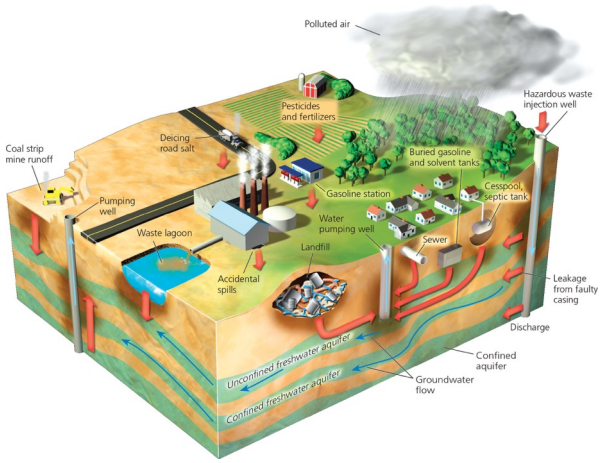
Sources of Groundwater



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Groundwater Pollution: Solutions

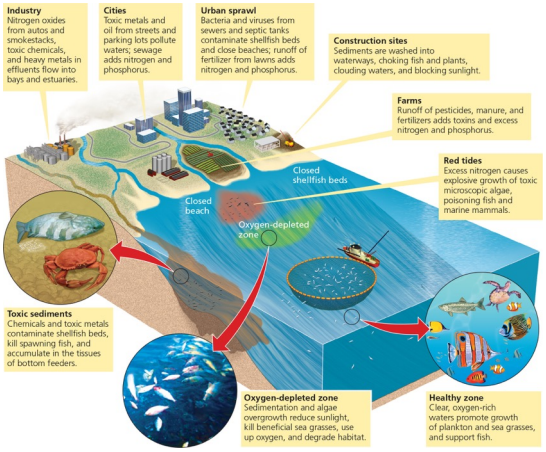
Prevention

- Find substitutes for toxic chemicals.
- Keep toxic chemicals out of the environment.
- Install monitoring wells near landfills and underground tanks.
- Require leak detectors on underground tanks.
- Ban hazardous waste disposal in landfills and injection wells.
- Store harmful liquids in aboveground tanks with leak detection and collection systems.

Cleanup

- Pump to surface, clean, and return to aquifer (very expensive).
- Inject microorganisms to clean up contamination (less expensive but still costly).
- Pump nanoparticles of inorganic compounds to remove pollutants (may be the cheapest, easiest, and most effective method but is still being developed).

Ocean Pollution: Sources



Controlling the Dumping of Pollutants in the Ocean

Legal dumping of **dredge spoils**

Canada banned radioactive waste dumping (1997)

London Dumping Convention (1972)

Difficulties in enforcement

Sources and Effects of Oil Spills in the Ocean

Sources

- Offshore wells
- Tankers
- Pipelines
- Storage tanks

Most oil pollution has land-based origin

Effects

- Death of organisms
- Loss of animal insulation and buoyancy
- Smothering
- Economic losses for coastal communities

How Well Can We Clean Up Oil Spills?

Mechanical
- Floating booms
- Skimmers
- Absorbent devices

Chemical
- Coagulants
- Dispersants

Biological
- Bacteria

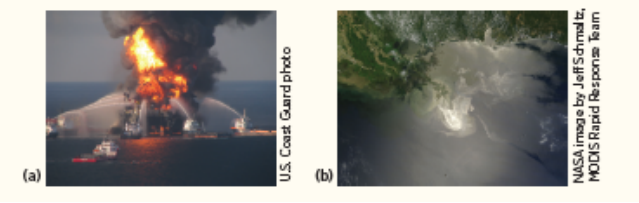
Combined maximum recovery of only 15%

Spotlight: The Deepwater Horizon Blowout

Blowout of methane gas and oil that escaped from offshore well in Gulf of Mexico

Minimum 5 million barrels spilled
- Exxon Valdez only 0.75 million max

First-time addition of dispersants directly to well



How Can We Protect Coastal Waters?

FIGURE 22-16 **SOLUTIONS**

Coastal Water Pollution

Methods for preventing and cleaning up excessive pollution of coastal waters. Which two of these solutions do you believe are the most important?

Prevention

- Reduce input of toxic pollutants.
- Separate sewage and storm lines.
- Ban dumping of wastes and sewage by maritime and cruise ships in coastal waters.
- Ban ocean dumping of sludge and hazardous dredged material.
- Protect sensitive areas from development, oil drilling, and oil shipping.
- Regulate coastal development.
- Recycle used oil.
- Require double hulls for oil tankers.

Cleanup

- Improve oil-spill cleanup capabilities.
- Sprinkle nanoparticles over an oil or sewage spill to dissolve the oil or sewage without creating harmful by-products (still under development).
- Require at least secondary treatment of coastal sewage.
- Use wetlands, solar-aquatic, or other methods to treat sewage.

(Left): © StacieStauffSmith Photos/Shutterstock;
(Right): © Ben Osborne/Getty Images

Preventing and Reducing Surface Water Pollution: Nonpoint Sources

Reduce agricultural and industrial runoff

Buffer zone vegetation

Reduce soil erosion

Slow-release fertilizer

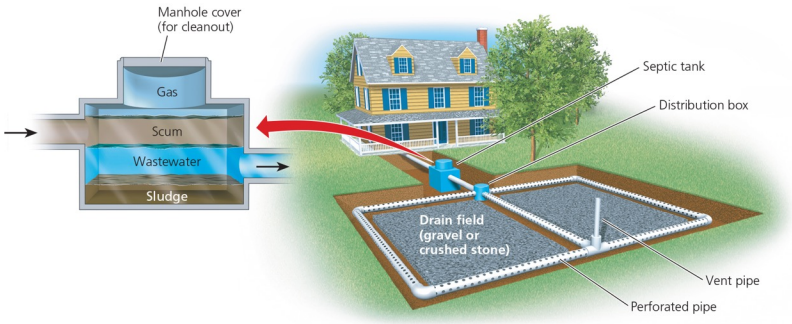
Preventing and Reducing Surface Water Pollution: Point Sources–Legal and Market Approaches

Canada
- Fisheries Act
- Canadian Environmental Protection Act
- Canadian Water Act
- Great Lakes Water Quality Agreement

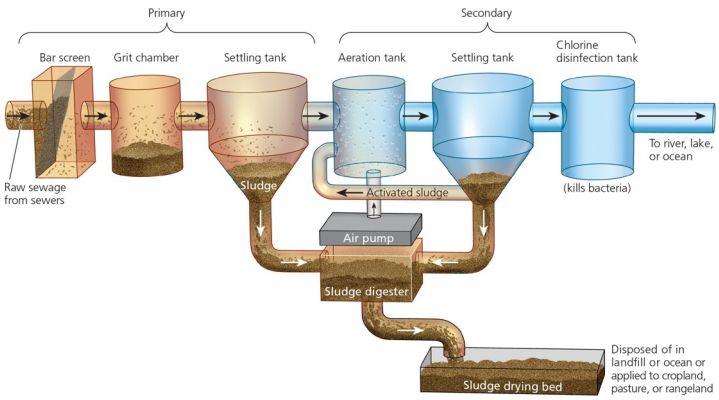
United States
- Clean Water Act and Water Quality Act

Market solution? **Discharge trading**

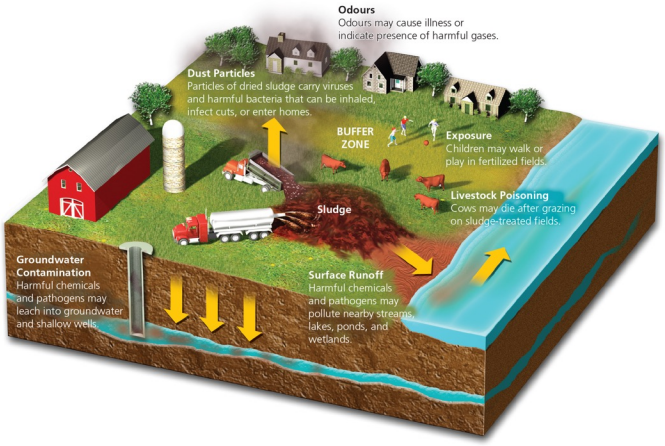
Preventing and Reducing Surface Water Pollution: Point Sources–Technological Approach I



Preventing and Reducing Surface Water Pollution: Point Sources–Technological Approach II



Preventing and Reducing Surface Water Pollution: What Should We Do With Sewage Sludge?



Preventing and Reducing Surface Water Pollution: Advanced (Tertiary) Sewage Treatment

Removes **specific** target pollutants

– Uses both physical and chemical processes

– Most commonly used for NO_3^- and PO_4^{3-}

Expensive

Only 5% of North American wastewater

Preventing and Reducing Surface Water Pollution: Last Steps in Sewage Treatment

Bleaching

– To remove any colouration

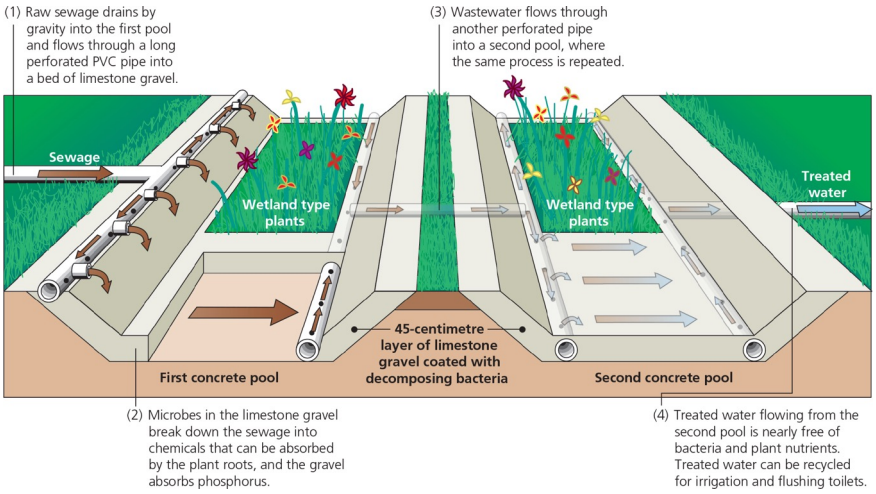
Disinfection

– Removal of bacteria, protozoa, some viruses

– Chlorination (most popular)

– UV light or ozone

Preventing and Reducing Surface Water Pollution: Can We Treat Sewage by Working with Nature?



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Drinking Water Quality

Purification of urban drinking water

– High-tech and central

Purification of rural drinking water

– Low-tech and individual

Standards for safe drinking water

Is bottled water worthwhile?

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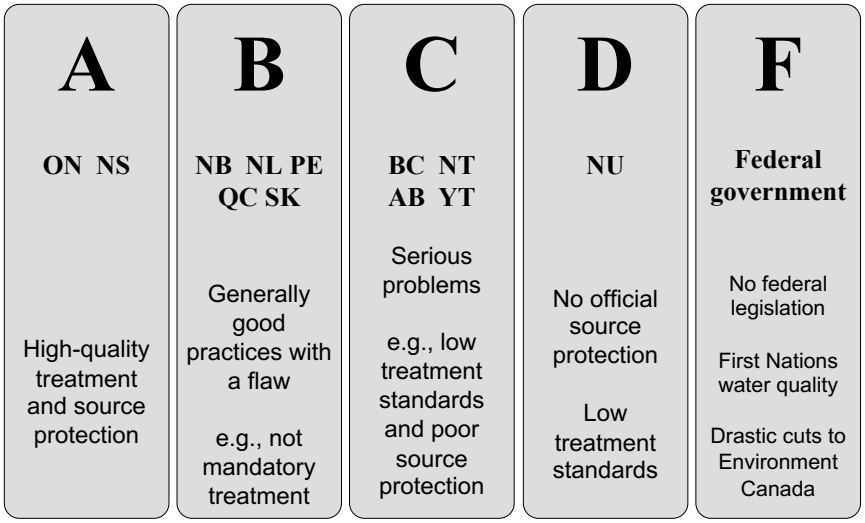
Drinking Water Report Card



Water Pollution: Solutions

- Prevent groundwater contamination.
- Greatly reduce nonpoint runoff.
- Reuse treated wastewater for irrigation.
- Find substitutes for toxic pollutants.
- Work with nature to treat sewage.
- Practise five R's of resource use (refuse, reduce, recycle, reuse, and rethink).
- Reduce resource waste.
- Reduce air pollution.
- Reduce poverty.

Conclusion

- Water pollution takes several forms.
- Addressing both marine and freshwater systems requires a multifaceted approach.
- Sewage and industrial runoff is an issue.
- Solutions are imperfectly (and inconsistently) applied nation-wide.