The Insidious Nature of Groundwater Contamination – The Great Need for Protection

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Fresh Water Supply

- **Availability of and access to freshwater are among the most critical natural resources issues facing the world**
- **2 billion people in 40 countries are currently affected by inadequate water supply**

***2nd UN World Water Development Report*, March 2006**

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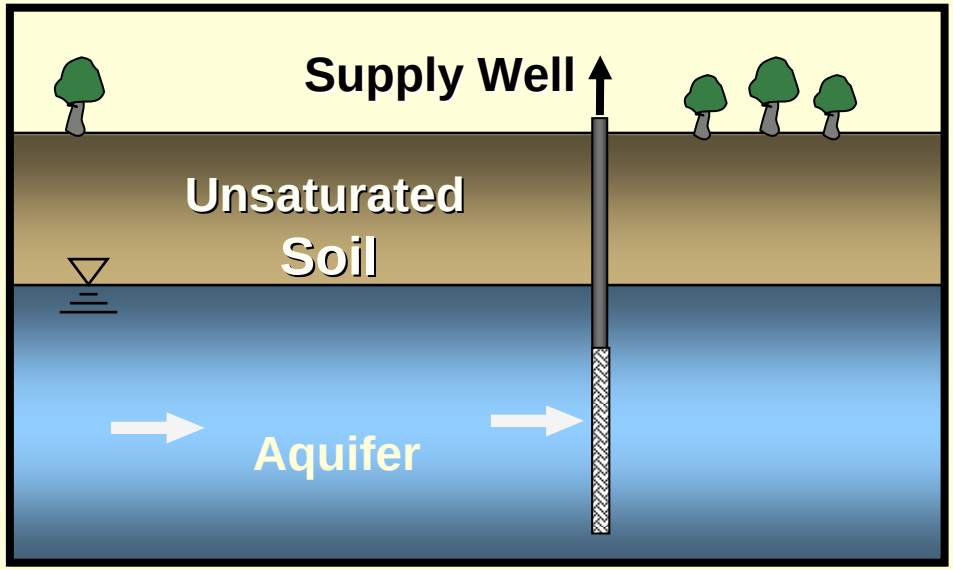
- **Groundwater is a critical part of this resource**

***2nd UN World Water Development Report*, March 2006**

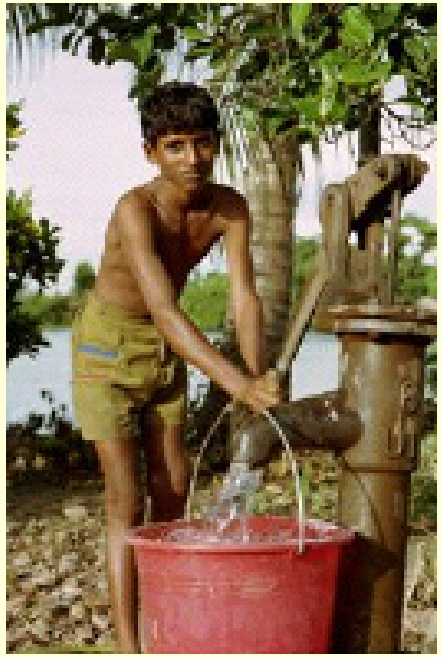
Value of Groundwater (when you have it)



- Inexpensive source of safe water
- Generally does not require treatment
- Long-distance transport not necessary
- Not lost through evaporation or runoff
- Reservoir to buffer against extended drought

Groundwater

- Represents 98% of world's liquid freshwater supply
- Provides:
  - 50% of world's potable water supply
  - 40% of industrial demand
  - 20% of water used in irrigated agriculture



http://www.banglabangla.org/kyag/images/BOY%20AT%20WATER%20PUMP%20DHAKA.jpg

UNESCO Water Portal Weekly Update No. 103: Groundwater 22 July 2005

*Groundwater in Percent of Total Public Water Supply**

Percent	European Countries
80 - 100	Austria, Denmark, Italy, Iceland, Switzerland
60 - 80	Germany, Luxembourg, Netherlands, Portugal
40 - 60	Belgium - Flanders, Finland, France, Greece, Ireland, Sweden, Czech Republic
20 - 40	Spain, United Kingdom
0 - 20	Belgium - Brussels, Norway

***EEA, *Groundwater Quality and Quantity in Europe* (1999)**

Groundwater Facts for U.S.

- **Source of drinking water for 50% of total population and 95% of rural population**
- **Decentralized wastewater treatment systems (septic tanks) used in 25% of U.S. homes**
- **168,000 viral illnesses and 34,000 bacterial illnesses estimated to occur each year from drinking groundwater contaminated from septic systems**

EPA 832-8-03-001 (March 2003)

Groundwater Facts for U.S. (Continued)

- **Prevention requires properly designed and operated septic systems with adequate horizontal setback from drinking water supply wells**
- **EPA permits states to regulate setbacks. (States generally recommend safe horizontal distance to be 20 to 60 meters)**
- **Properly constructed wells that prevent seepage of surface waters**

EPA 832-8-03-001 (March 2003)

Groundwater in Mexico

- 75% rely on groundwater for drinking and other domestic needs
- 57% rely on for agriculture
- Virtually all aquifers subject to qualitative degradation
- Overdraft and quality decline could render substantial portions unusable in future
- In Merida, the upper 20 m is unfit for human consumption
- Yucatan Peninsula has heavy contamination from human, solid, and animal wastes

U.S. National Research Council, 2007

UN Division for Sustainable Development
Agenda 21: Chapter 18

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UN Division for Sustainable Development
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- **The extent and severity of contamination of unsaturated zones and aquifers have long been underestimated owing to the relative inaccessibility of aquifers...**
- **The protection of groundwater is …an essential element of water resource management.**

Sanitation

"the science and practice of effecting **healthful** and hygienic conditions"

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WHO Guidelines for drinking-water quality:

"Drinking-water quality is an issue of concern for **human health** in developing and developed countries world-wide. The risks arise from **infectious agents, toxic chemicals** and radiological hazards."

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WHO Guidelines for drinking-water quality:

"Drinking-water quality is an issue of concern for **human health** in developing and developed countries world-wide. The risks arise from **infectious agents, toxic chemicals and radiological hazards**. Experience highlights the value of **preventive management** approaches spanning from water resource to consumer."

Nitrate in Drinking Water

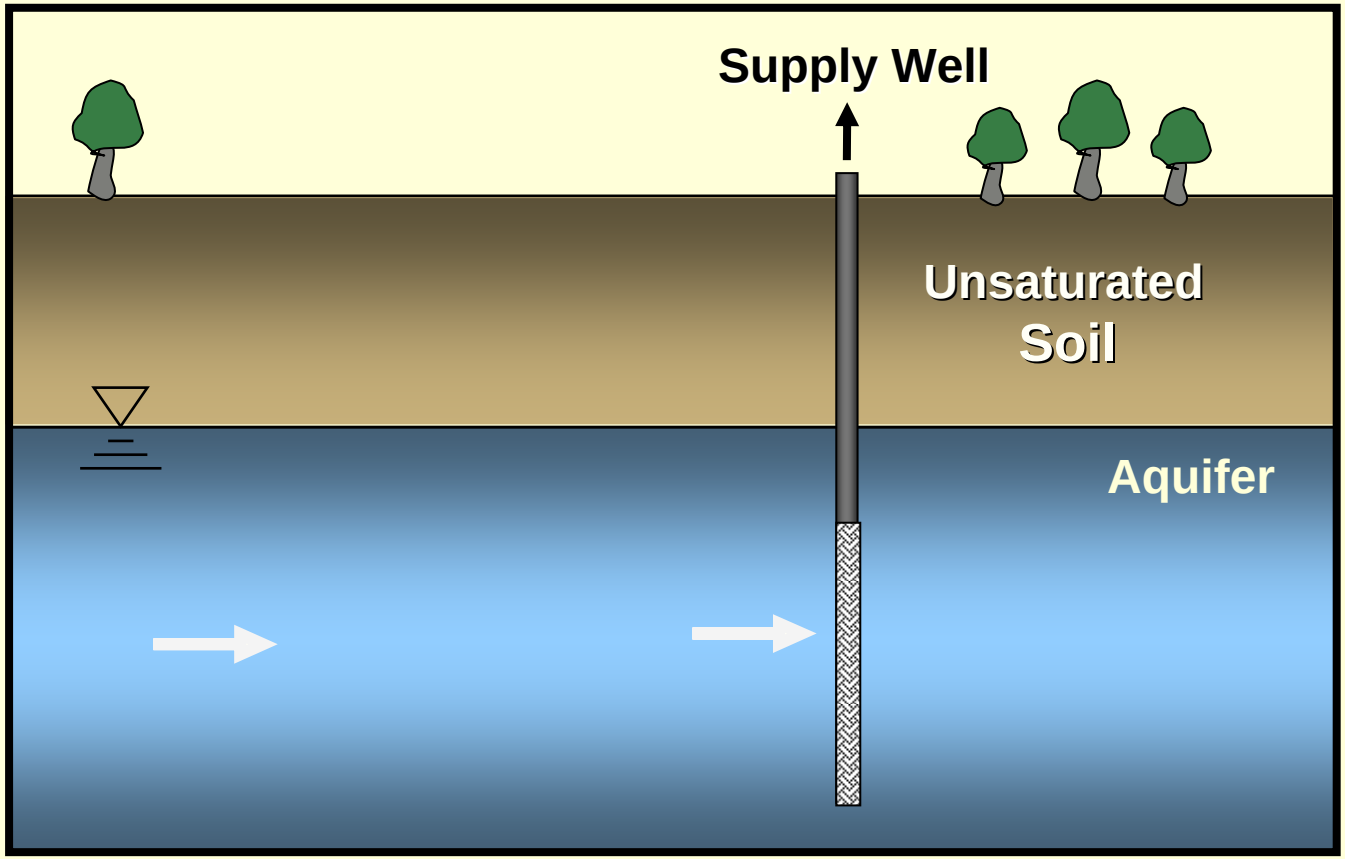
- **EPA also recognizes nitrate contamination of groundwater as a problem in the U.S.**
- **An estimated 9.4% of private wells exceed nitrate-nitrogen drinking water standard of 10 mg/L**
- **High nitrate results from fertilizer application and animal feed lots as well as from septic systems**

EPA 832-8-03-001 (March 2003)

Chemical Contaminants in Groundwater

Contaminant	Source
Nitrate	Fertilizer, manure, human wastes
Salinity	Sea water intrusion, irrigation return flow, saline aquifers
Pesticides	Use in agriculture
Volatile Organic Compounds (VOCs)	Petroleum usage, cleaning of laundry, engines, electronic parts
Heavy Metals	Manufacturing processes, aquifer minerals, mineral/wastewater interactions

Groundwater Contamination with Biological and Chemical Contaminants



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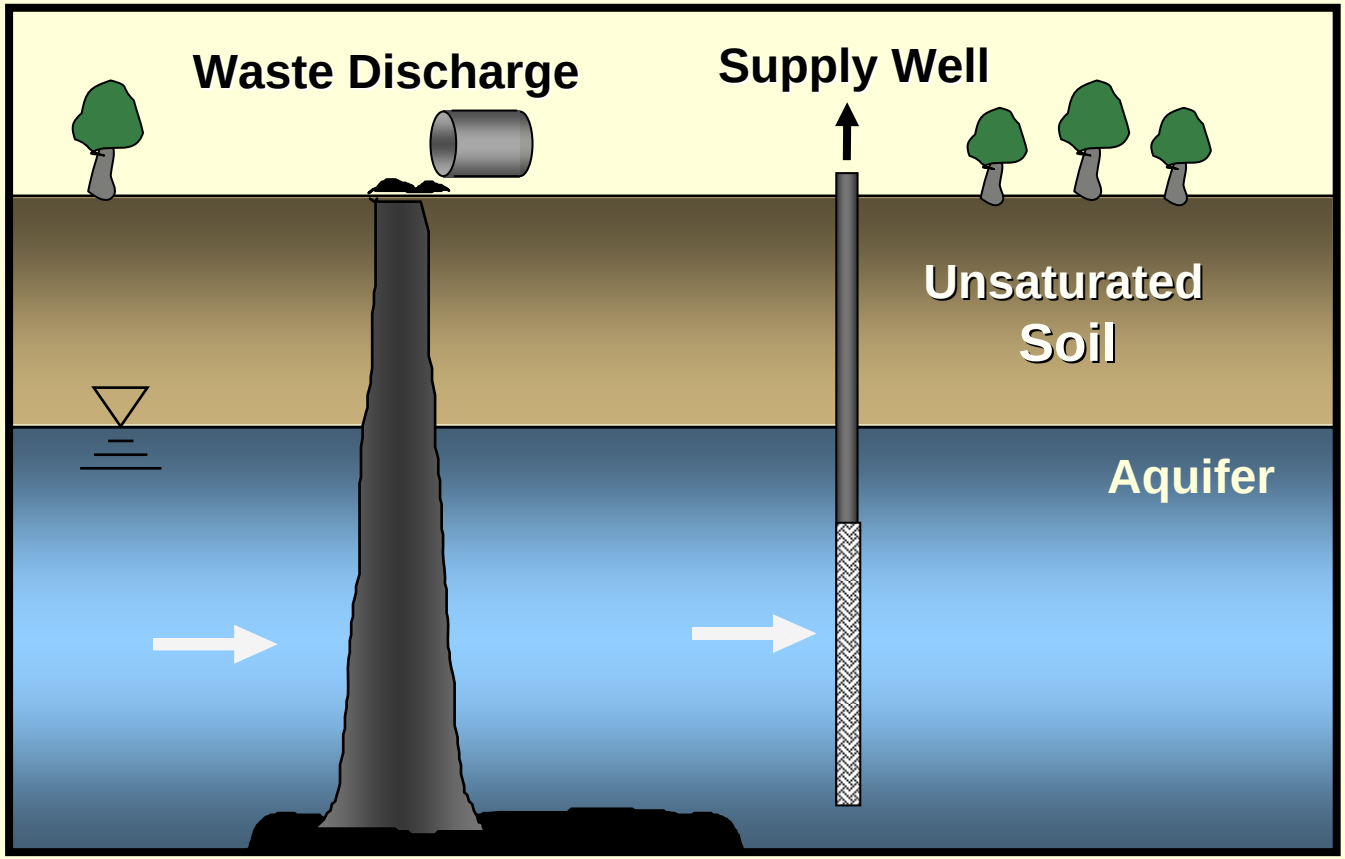

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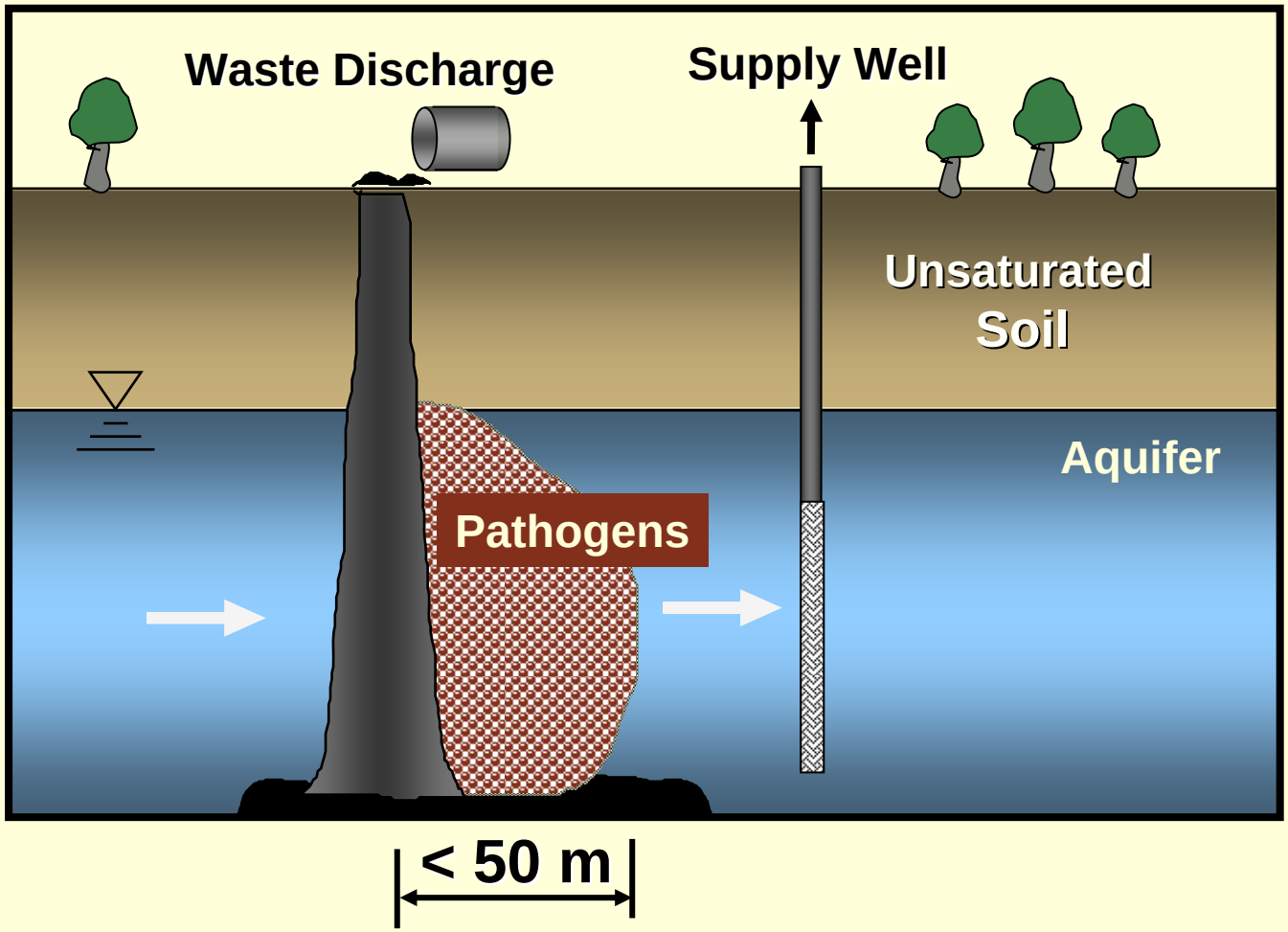

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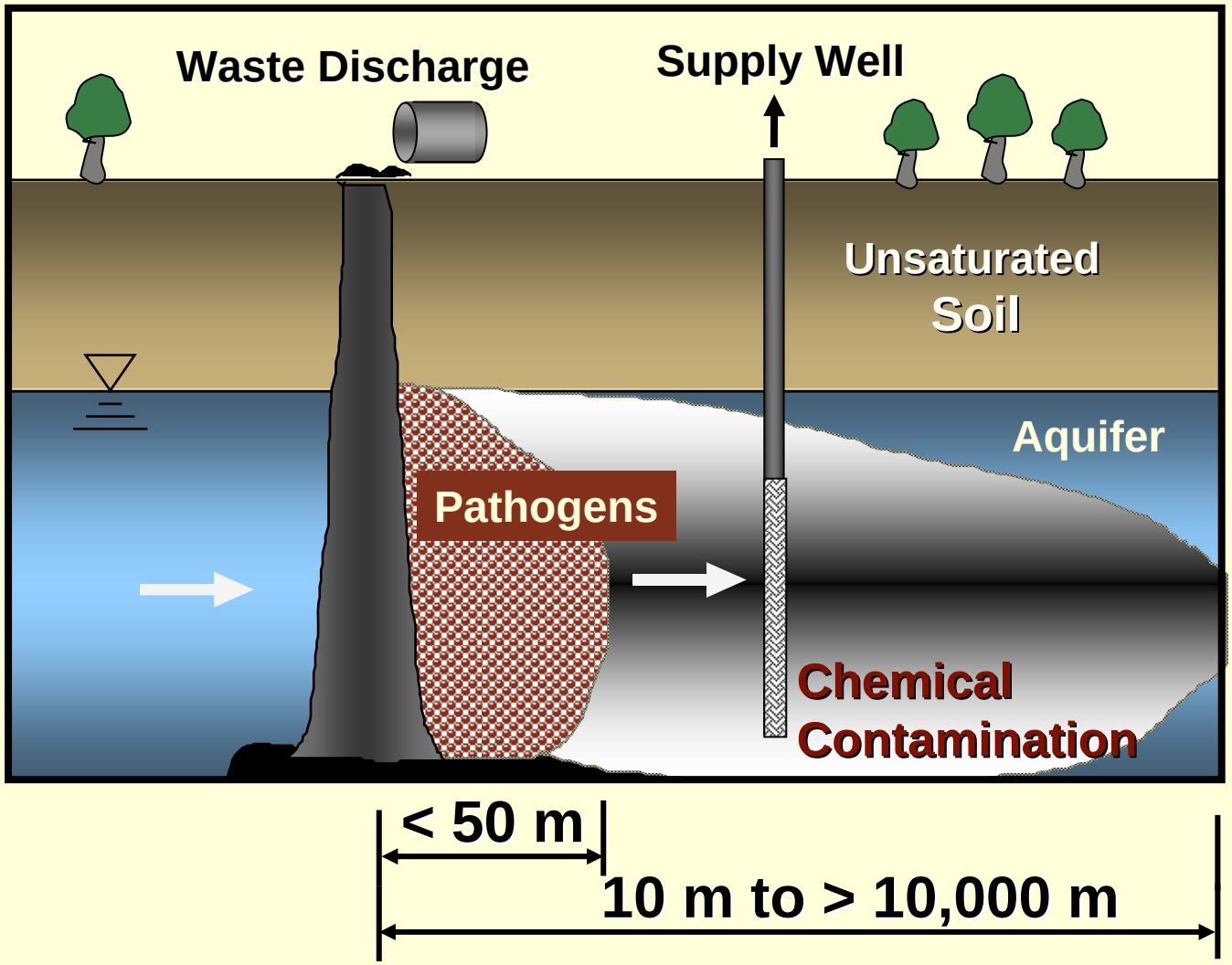
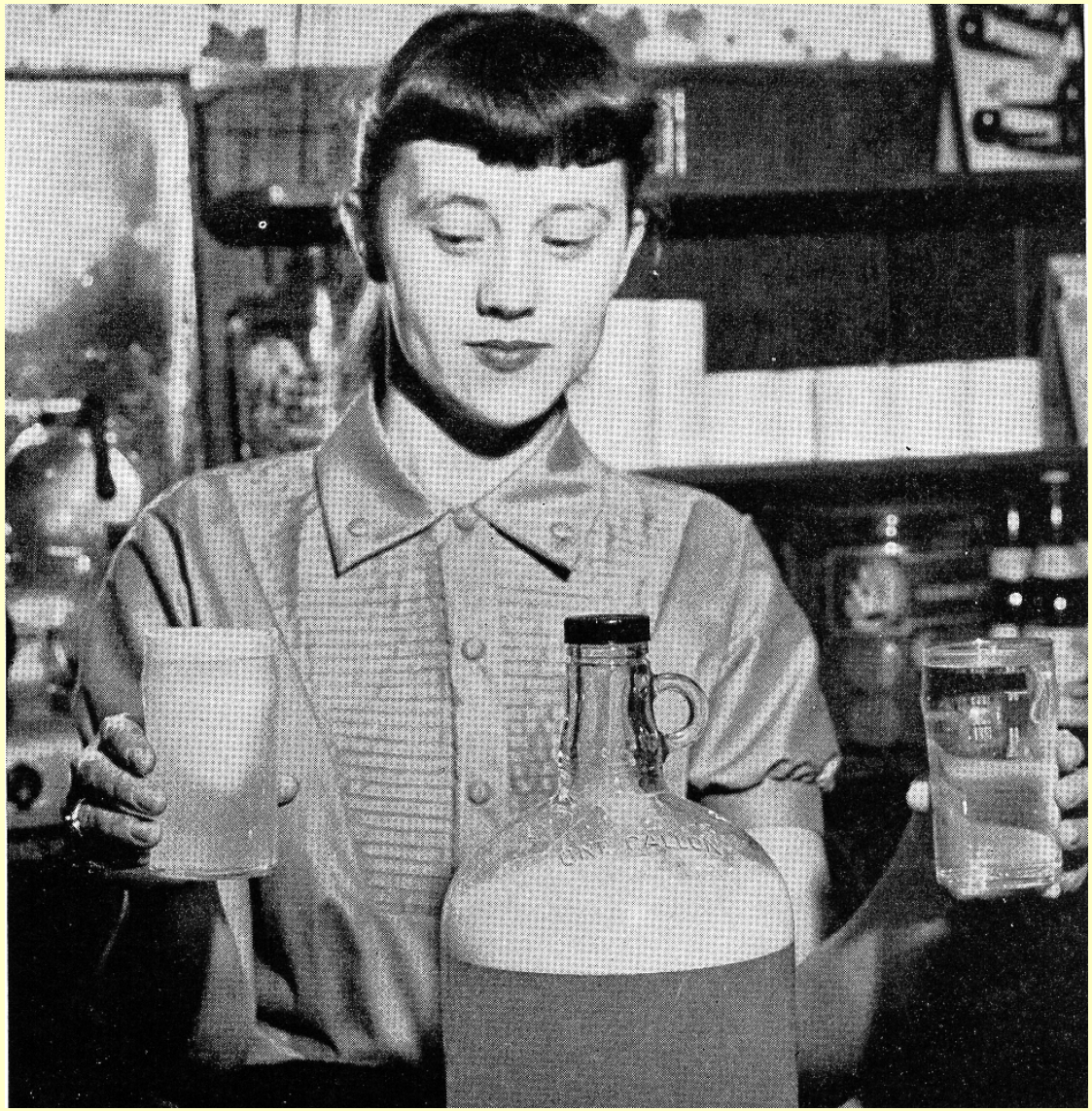



ONE GALLON

Biological vs. Chemical Contamination of Groundwater

Biological	Chemical (persistent soluble)
Disappears quickly	Disappears slowly
Filtered easily	Not filtered easily
Travels short distance	Travels long distance
Short term problem	Long term problem
Acute onset	Chronic onset
Easily monitored	Difficult to monitor

Contaminant Flushing Related to Turnover Time

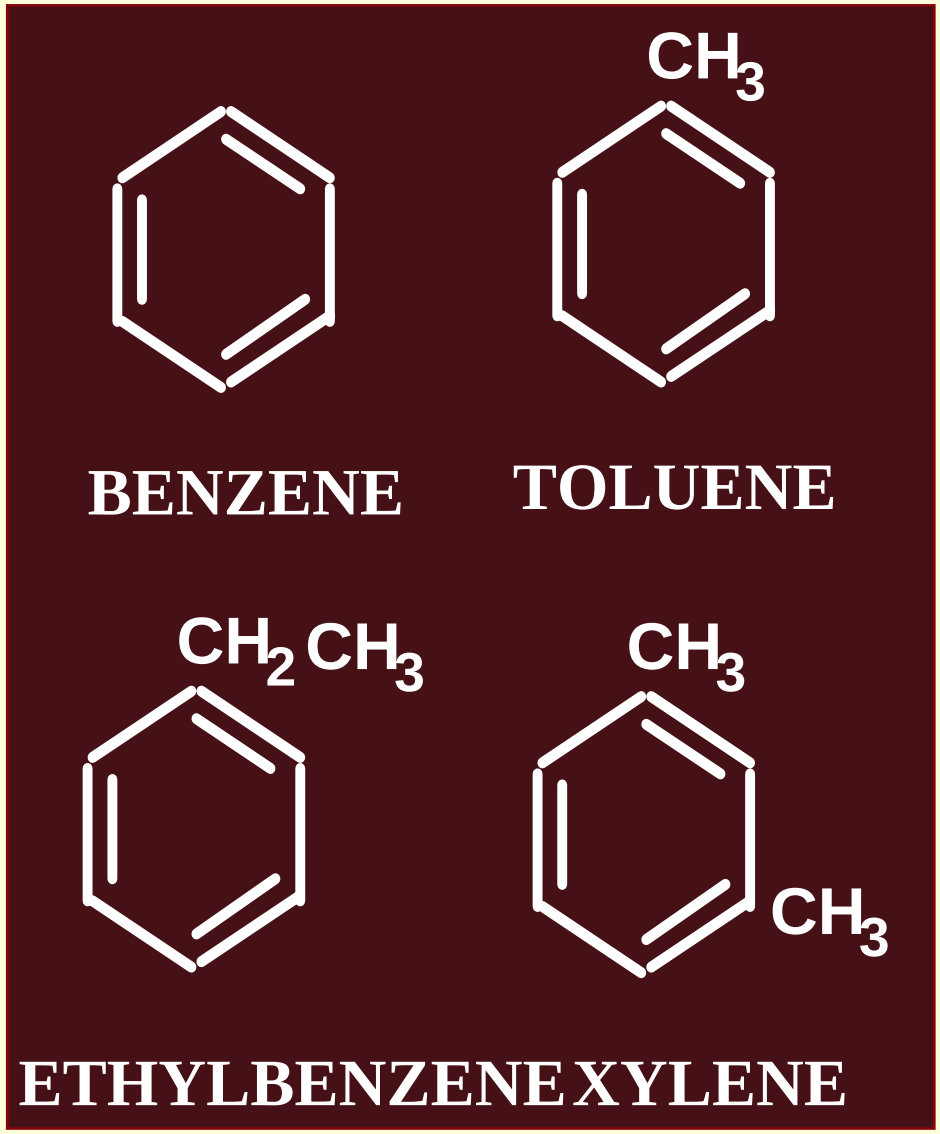
- **Rivers - days to years**
- **Lakes - years to centuries**
- **Groundwater - centuries to millennia**

*Volatile Organic Compounds in U.S. Groundwater**

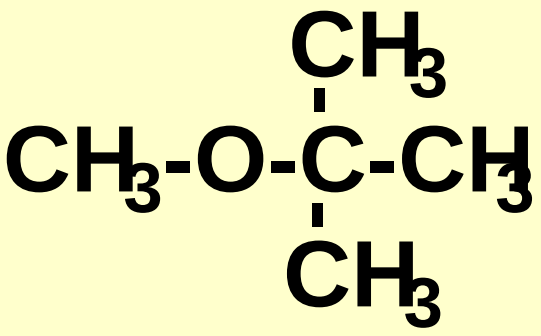
- **Factors associated with VOCs in GW**
  - **Septic tanks**
  - **Urban land usage**
  - **Hazardous waste facilities**
  - **Gasoline storage and release facilities**
- **Most prevalent VOCs**
  - **Chloroform**
  - **Trichloroethene and tetrachloroethene**
  - **MTBE**

***USGS Circular 1292 (2006)**

BETX Compounds are Anaerobically Biodegradable

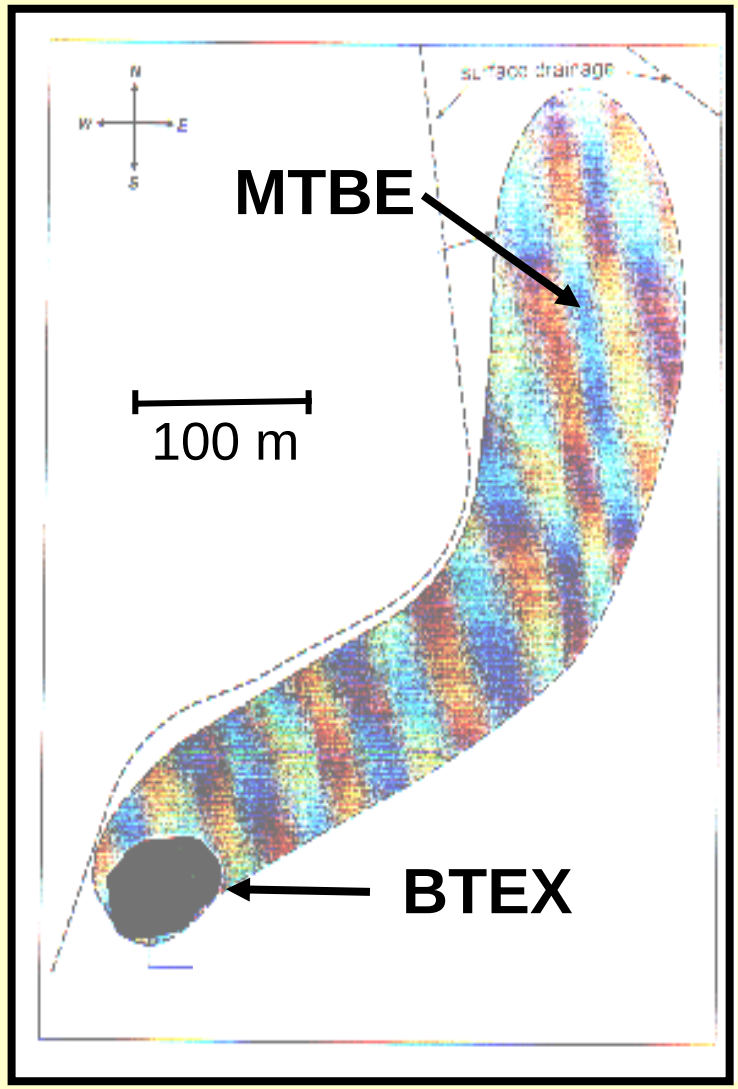


Methyl Tertiarybutyl Ether Plume from Gasoline Spill



MTBE

Vandenberg
Air Force Base
November 1997



CHLORINATED SOLVENTS

$CHCl=CCl_2$

TCE

$CCl_2=CCl_2$

PCE

CCl_3CH_3

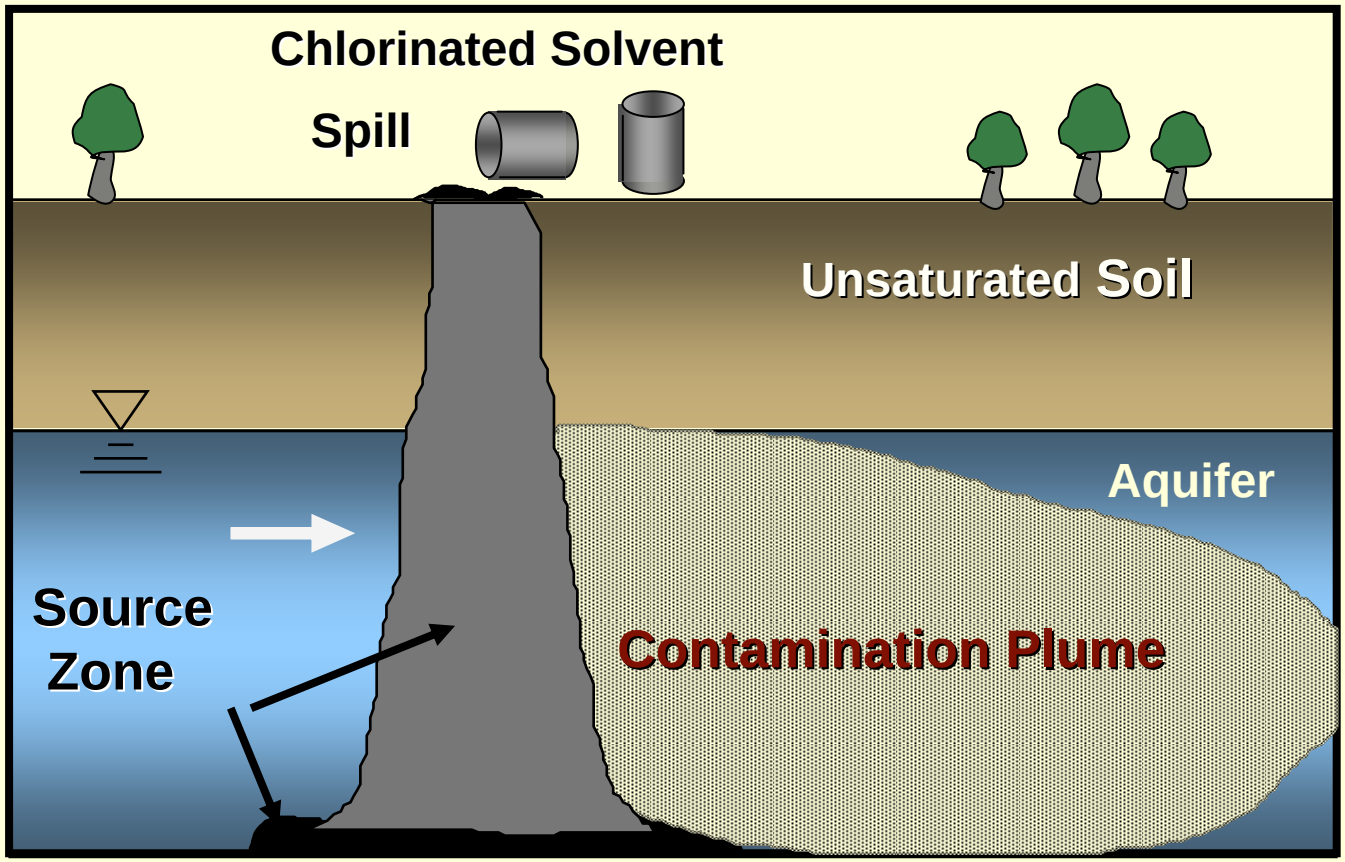
TCA

CCl_4

CT

Groundwater Contamination with Chlorinated Solvents

- Denser than water
- Penetrate groundwater surface



Impact of TCE on Groundwater

- **3.84 liters of TCE can contaminate 80,000 m^3 of groundwater to above WHO standard of 70 µg/L**
- **One years supply for 1000 people at 200 L/d**

Groundwater Contamination from Chemicals in the United States

- **300,000 to 400,000 sites**
- **$750 billion - Estimated cleanup cost**
- **Most frequently detected organic contaminants are chlorinated solvents**
  - **First: Trichloroethene (TCE)**
  - **Second: Tetrachloroethene (PCE)**
  - **Sixth: 1,1,1-Trichloroethane (TCA)**

(National Research Council, *Alternatives to Ground Water Cleanup* (1994)

Prevention Using Properly Designed Chemical Storage Tanks

Boremco.com
Beldingtank.com
Baxterplastics.com

Arsenic in Bangladesh Groundwater

- **Arsenic in groundwater poses a health risk to 57 million people in Bangladesh**
- **Arsenic in surface soil can be converted to a soluble form by anaerobic bacteria, allowing it to leach down to contaminate groundwater***

Science and Development Network, 20 April 2006

***Polizzotto et al., *Proc. National Academy of Science*, 102:18819 (2005); *Chemical Geology*, 228:97 (2006); *Nature*, 454:505 (2008).**

Summary

- **Groundwater is a most valuable resource that is greatly in need of protection**
- **Procedures for protection from pathogens are well known, relatively economical, and generally applied**

Summary (Continued)

- **Chemical contamination is widespread, insidious, long lasting, and exceedingly expensive to cleanup**
- **Protection from chemical contamination is seldom addressed nor is the need to do so widely recognized**
- **Protection from chemical contamination is relatively easy and inexpensive**
- **Greater action by governments is here needed as is education of the public about the need**


Thank you