PHYTOREMEDIATION OF CONTAMINATED GROUNDWATER USING *POPULUS* TREES

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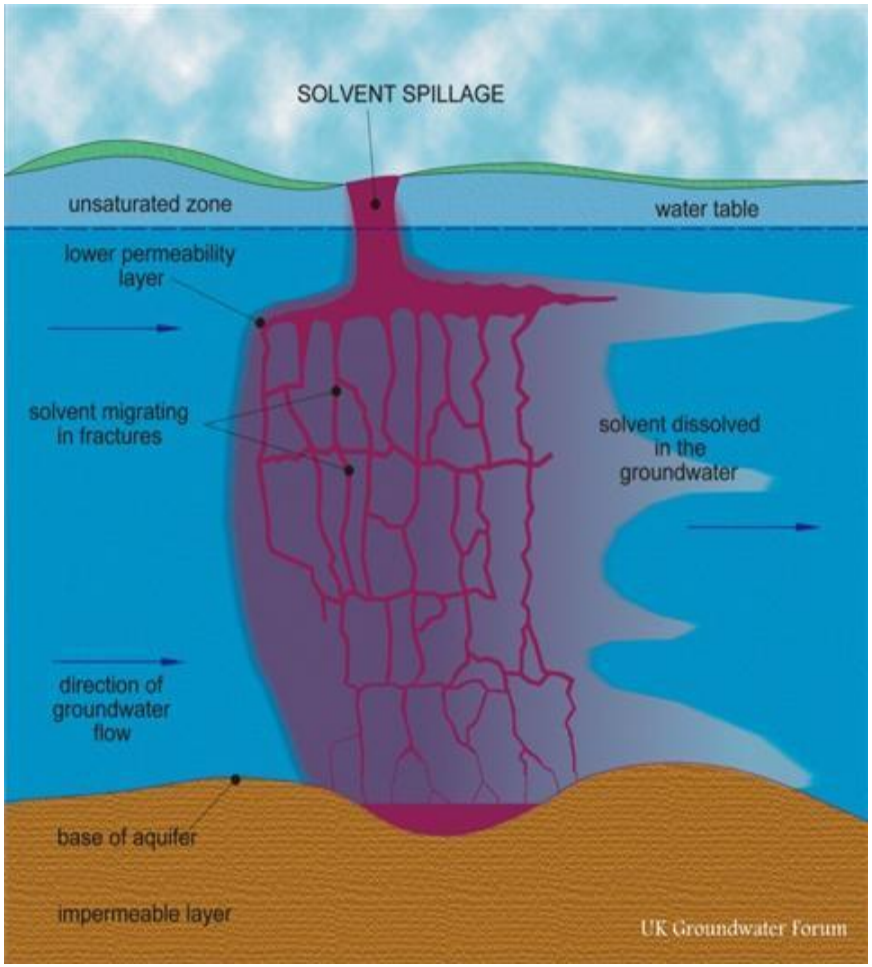
Outline

- Introduction to contaminated groundwater and how *Populus* trees are used in the process
- Characteristics of TCE
- Relevant *Populus* traits
- Metabolism and uptake of TCE
- The setup
- Limiting Factors
- Conclusion and questions

Groundwater Contamination and Phytoremediation

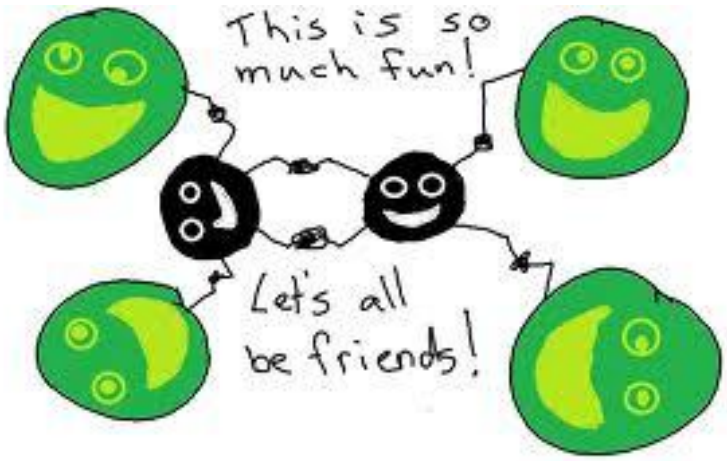
- Tetrachloroethylene (TCE) is one of the most common groundwater contaminants
- *Populus* species can be effective pump and treat systems for groundwater contamination
- Hydraulic control, buffer strips, and riparian corridors are three ways to mitigate contaminated groundwater plumes



Characteristics of TCE

- Organic compound, logKow of 2.29

- Industrial degreasing agent, also used as a solvent in dry cleaning and as an ingredient in paints, inks, and disinfectants



- Tends to exists in undissolved pools at the bottom of aquifers

- Dissolves from non-aqueous phase liquid to aqueous phase

(Chappell 1997)

Toxicity of TCE

- Clean Air Act of 1970
- Kidney, neural, and dermatological reactions have been documented in animals
- In 2000, the National Cancer Institute found evidence that TCE caused cancerous tumor growth in mice
- EPA standards for drinking water is 5 ppb; has also reported that "drinking one ppm TCE in water over a lifetime will cause 32 people out of 100,000 to be at risk for cancer."

Question no. 1

Does the logKow of TCE fall within the appropriate range for phytoremediation of organic compounds?

Why *Populus* Trees?

- *Populus* includes poplars, cottonwoods and aspen
- High rates of transpiration
- Pump 100 to 200 L/day/tree (about 26 to 53 gallon/day) for 5 year old trees
- Grow quickly
- High potential for hybridization because they are able to cross breed within the genus in the wild
- *P. deltoides x P. trichocarpa* popular cross in phytoremediation

(Chappell 1997)

Metabolism and Processing of TCE

- Metabolites detected in hybrid poplars exposed to TCE similar to those found in but has been found to be similar to TCE degradation pathway in mammals
- One suggested pathway is the TCE-oxygen-p450
- Phytomineralization by microorganisms, phytostabilization, phytovolatilization, and sequestration have been observed
- Exact fate of TCE unknown

(Bankston, et. al. 2002; Strycharz & Newman, 2010; Chappell 1997)

Hydraulic Control – The Setup

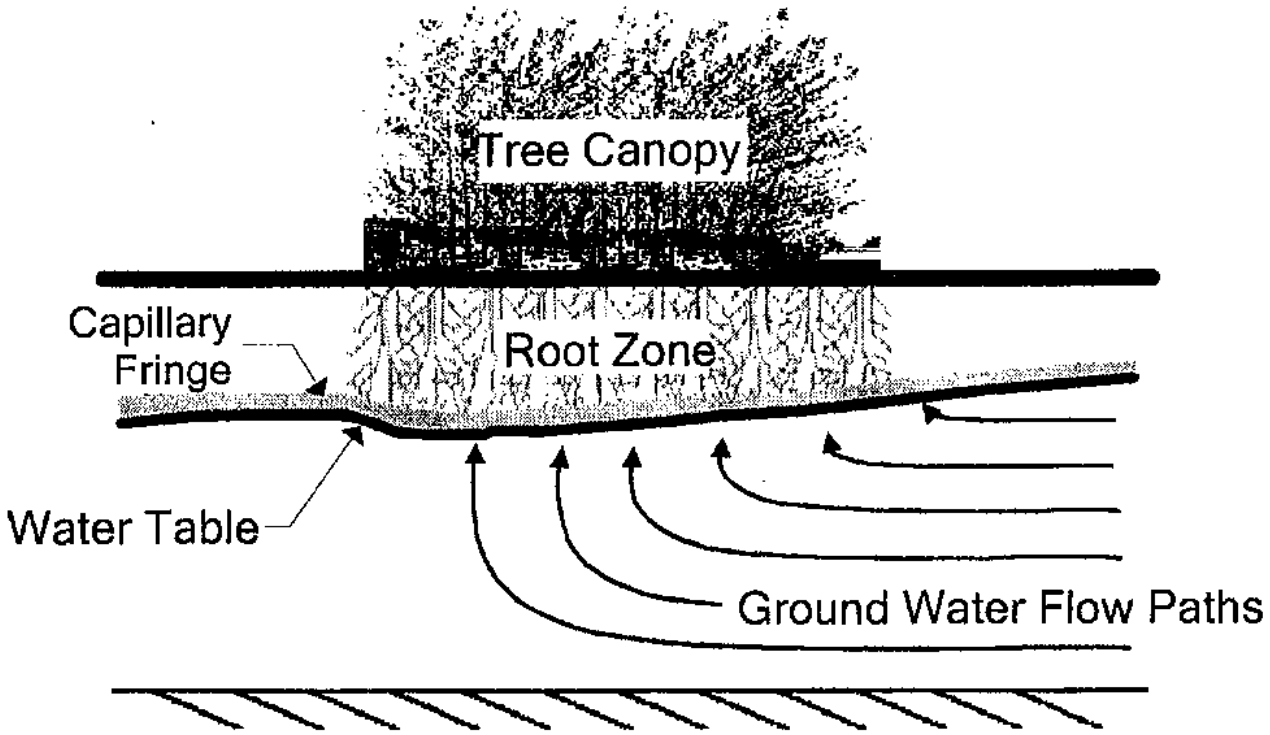


Figure 1. Phytoremediation plantation operation schematic.

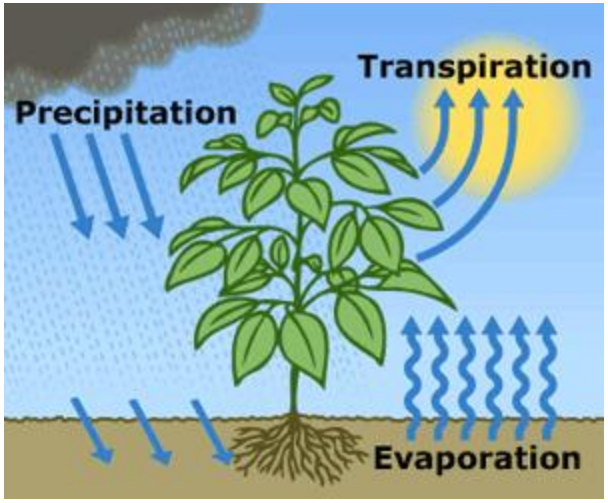
(Matthews et. al. 2003)

Site Setup Continued

- Must be shallow enough for roots to reach (one study cited 2.75 to 8.2 meters)
- Groundwater contamination must be fully intercepted (current standard is 5 ug/L for drinking water)
- Planting sites usually less than or equal to one acre
- Costs 10%-20% of mechanical operations
- Consider land use implications- tree plantation may limit land use until remediation is complete
- Tree plantations may also benefit surrounding habitat

Limiting Factors

- Evapotranspiration and growing season
- Trees' use of precipitation instead of groundwater as water source
  - Pave the area?
- Deciduous trees cease ET in the winter, running the risk of allowing migration of the contaminated plume



Question no. 2

How can lack of transpiration by *Populus* during winter months be mitigated in the context of remediation site design?

Conclusion

Using *Populus* species to remediated contaminated ground water is a viable method of phytoremediation.

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Answers to Questions

Number 1: Yes

Number 2: Plant the site with conifers as well, which transpire during winter months.