Re-greening of Murdock wetlands is joint effort

In Murdock, Neb., a small village south of Omaha, Argonne planted more than 2,000 trees in 2005. These new flora not only improve the wildlife habitat and provide aesthetic recreational value, but they also play a key role in an integrated plan to take up and degrade the carbon tetrachloride that has contaminated the community's water.

During the 1950s and '60s, the U.S. Department of Agriculture (USDA) applied fumigants containing carbon tetrachloride to grain in storage facilities at Murdock.

Carbon tetrachloride is a toxic pollutant that is a probable human carcinogen. The clear liquid is moderately soluble in water and evaporates readily from surface water. It is moderately mobile in most soil and can seep into groundwater.

The U.S. Environmental Protection Agency (EPA) determined that the fumigants containing carbon tetrachloride had migrated through the near-surface and unsaturated vadose zone soils into groundwater at Murdock, because of either spillage or application methods.

In 1991, the USDA's Commodity Credit Corporation directed Argonne to perform a series of technical investigations to determine the distribution and monitor the extent of contamination caused by the carbon tetrachloride. Sampling in 2004 found a maximum concentration of 281 µg/L at the headwaters of Murdock's tributary creek. Under Nebraska regulations, the limit for carbon tetrachloride in surface water is 44.2 µg/L. However, the findings did not indicate any unacceptable health risks associated with vapor intrusion or direct exposure to near-surface soils at Murdock.

A few of the 2,000 trees Argonne planted in Murdock, Neb., as part of a carbon tetrachloride bioremediation plan. These new flora not only improve the wildlife habitat and provide aesthetic recreational value, but they also play a key role in an integrated plan to take up and degrade the carbon tetrachloride that has contaminated the community's water.

Prior to the recent work at Murdock, no active measures had been taken to reduce the toxicity or volume of the existing carbon tetrachloride. However, since it was determined that this passive approach would take more than 80 years to be effective, an integrated remediation system was designed and installed in 2005 to boost the reduction of the pollutant. Researchers used computer flow-and-transport modeling to develop the integrated system, which minimizes interference from clean surface water and soil water while maximizing benefits to the community and ecosystem.

The integrated remediation system involves three components:

- Hot-spot control through extraction of water from the contaminated aquifer and

treatment with a modified spray irrigation system;
- Phytotechnology, which uses plants to reduce contaminant concentrations; and
- Supplemental treatment by engineered wetlands downgradient of the contaminated zone.

The first components of the system, the groundwater extraction well and modified spray apparatus, apply a light spray to the local school's athletic fields near the contaminant source. Since carbon tetrachloride is highly volatile, exposure of the fine mist to air and sunlight results in an almost immediate reduction in contaminant levels. Consequently, this system successfully treats an area of elevated carbon tetrachloride levels within the existing plume and captures some of the contaminant emanating from the source area.

Second, the phytotechnology portion of the treatment system addresses the portion of the contaminant plume that has migrated toward the creek in the area. The more than 2,000 trees (six species) planted were selected for disease tolerance and rapid growth. The deep-rooting species were planted in wells to focus their roots toward direct uptake of contaminated groundwater. Native prairie plants were planted for surface cover between the trees to prevent clean surface water from mixing with the contaminated groundwater. A vegetation buffer along the creek banks controls erosion.

Third, researchers set up engineered wetlands where the contaminated groundwater flows from the phytoremediation area. The overall basin design incorporates an undulating bottom that increases residence time of water and fosters biodiversity in the wetlands. The basin increases water surface area and contaminant evaporation and decreases the risk of flooding.

Baseline sampling of the integrated system in July 2005 indicated that the project's goals are achievable. Carbon tetrachloride levels had already risen in the tree tissues, and the spray system had reduced contamination to a more acceptable level.

Evaluation of the system's performance through the end of 2006 showed that

- The groundwater extraction-spray irrigation component is effectively decreasing contaminant concentrations and improving the quality of the school's athletic fields;
- The planted trees have flourished and weathered a temporary outbreak of a fungal infection, and the effectiveness of the phytoremediation zone has increased;
- The carbon tetrachloride concentrations in surface water of the wetlands decrease dramatically along the flow path, so that the final discharge has been free from the contaminant or has contained only a trace;
- The air in the phytoremediation zone remains safe for visitors and workers.

Researchers also prepared and installed a set of 19 informational signs, including technical illustrations and photographs, along a nature trail that winds through the phytoremediation and wetlands areas at Murdock. In March 2007, these signs and a companion visitor guide won a distinguished award in the annual Society for Technical Communication competition for the Chicago chapter. In June 2007, the signs and visitor guide won a distinguished award in the technical art category of the STC international competition.

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