Enhanced Bioremediation of Chlorinated Solvents in Groundwater Using Mulch Derived from Waste Organic Material Cape Canaveral Air Force Station, Florida

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Abstract: The use of mulch as a media for the treatment of contaminated groundwater has received increased attention in recent years. For instance, mulch has been used as a sorptive media for the removal of chromium from acid mine drainage; surface amendments using wood mulch have been used to treat contaminated soil; and mulch has been used to remove nitrate from framing runoff, sewage systems and landfill leachate. Recent studies have suggested that mulch can also aid in the remediation of solvent contaminated groundwater. The organic mulch may serve as an inexpensive source of fermentable organic matter to produce hydrogen (an electron donor) required to promote reductive dechlorination (Aziz, 2000). Chlorinated hydrocarbons such as trichloroethene (TCE), dichloroethene (DCE), and vinyl chloride have been shown to degrade via reductive dechlorination under anaerobic conditions. The anaerobic decay of mulch may increase reducing conditions in groundwater, potentially stimulating reductive dechlorination.

Two in-situ methods are being developed for the use of mulch in the remediation of contaminated groundwater: 1) permeable reactive barriers and 2) surface amendments. Both methods are being implemented on a pilot scale at Cape Canaveral Air Force Station (CCAFS), Florida. Permeable reactive barriers rely on natural or induced groundwater gradients to carry contaminated groundwater through a permeable membrane (i.e. mulch layer). A surface amendment using mulch relies on the contact of groundwater with leachate generated within the decaying organic material. Permeable reactive barriers do not perform well in areas where there is only a slight groundwater gradient. Surface amendments would be less effective with increase plume depths due to the inability to adequately stimulate reducing conditions.

A surface amendment is currently being implemented at Space Launch Complex 15 (L15) at CCAFS, and a mulch barrier wall may be implemented at Facility 1381 at CCAFS. L15 is located off Intercontinental Ballistic Missile (ICBM) Road, approximately 0.5 miles west of the Atlantic Ocean and 1.75 miles east of the Banana River. The site is bordered on the north and east by drainage canals, on the south by Launch Complex 14, and on the west by ICBM Road. L15 was constructed in 1957 for the United States Air Force (USAF) Titan I Missile Program. However, L15 was never used for active launch of space vehicles or missiles. L15 was utilized as a waste burning facility from 1958 to 1972. Static testing of launch vehicles may have occurred at L15 prior to 1958. During its operation as a waste burning facility fuels, solvents and other liquids from various CCAFS and Kennedy Space Center (KSC) operations were openly incinerated in the concrete flume trench north of the launch stand. Waste burning operations

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were abandoned in 1972. However, storage of liquid contaminants appears to have continued for several years following 1972.

Topography at L15 is characterized by little relief with ground surface elevation ranging from approximately 5 to 12 feet above mean sea level (msl). The site is predominately overgrown and remains for the most part inactive. The surficial aquifer extends to a depth of approximately 100 feet below land surface (bls). Intermittent clay stringers divide the surficial aquifer into several flow zones. The most significant clay layer exists at approximately 50 feet, and it serves as a retarding unit that has limited the vertical migration of contaminants. Groundwater beneath L15 flows north and east toward man-made drainage canals located a few hundred feet beyond the central facility. In the vicinity of the deluge basin, groundwater flow is predominately to the north. The canals collect surface water runoff from the site and are potentially impacted by shallow groundwater flow. Surface water in the canals flows westward and ultimately discharges to the Banana River. The horizontal groundwater gradient within the uppermost unit of the surficial aquifer is approximately 0.0007 ft/ft to the east and 0.0011 ft/ft to the north based upon June 1994 and May 1998 potentiometric data. The hydraulic conductivity within the shallow groundwater zone ranges between 5 to 100 feet per day.

Two large source areas of chlorinated hydrocarbon contamination have been identified in the shallow aquifer. The largest source is in the vicinity of the abandoned launch stand. The majority of the contamination in this area ranges from 20 to 50 feet below land surface. The second source is located to the north beneath the deluge basin which remains connected to the launch via a concrete narrow flume trench designed to deflect heat from launches. The depth of contamination in this area is more shallow and extends from the top of the surficial aquifer to about 25 feet bls. The highest concentrations of chlorinated solvents observed at the site are located near the launch stand. However, concentrations as high as 10,000 micrograms per liter (ug/L) of TCE have been observed in the vicinity of the deluge basin. The pilot study being conducted at L15 focuses on the contaminated area downgradient of the deluge basin, since contamination from beneath the basin has the potential to impact the surface water canal to the north.

A surface amendment was selected for L15 based upon the slight groundwater gradient and relatively shallow depth of contaminated groundwater. Construction of the surface amendment began in March 2001 and will be completed by the end of April 2001. The surface amendment consists of three adjacent cells covering a total area of 0.4 acres. Each cell is approximately 40 feet wide and 160 feet long. The easternmost cell serves as a control and is left undisturbed. Data from this cell will serve as a baseline and will be compared with the active treatment cells to determine the net dechlorination attributed to the surface amendment. The other two cells are being used for active treatment. These two cells were excavated to approximately one foot above the water table. These two cells will be back-filled with mulch and a mulch sand blend, respectively. Sand is being added to one of the cells in order to evaluate its effect on permeability and the impact this may have on treatment.

The mulch used during this pilot test will be generated from the removal of nuisance vegetation present at CCAFS and from off-site sources. The mulch will consist primarily of Florida hardwoods such as scrub oak and Brazilian pepper. Mulch placement will be completed by the end of April 2001. Mulch is being imported in order to expedite the performance of the pilot test.

If the pilot test proves successful, then all of the mulch may be generated from an on-site source for future applications.

Prior to placement of the mulch, baseline sampling for volatile organic compounds (VOCs) and natural attenuation parameters (oxidation-reduction potential, dissolved oxygen, et al.) will be conducted. Seven multi-chamber monitor wells have been installed and will serve as the primary monitoring network. This network will be supplemented by several micro-wells that are to be installed directly into the mulch treatment area. Each multi-chamber well consists of seven monitoring ports at five foot intervals from 5 to 35 feet bls. The micro-wells will be installed at depths of 5, 10, and 15 feet bls. Performance assessment will be on going throughout an 18-month period following mulch placement and will be updated continually. The results of this pilot test will be evaluated to determine the applicability of using mulch as a supplement to bioremediation at CCAFS.

References:

Aziz, Carol E., Hampton, Schipper, Haas, and Cork. "Treatment of Chlorinated Solvent-Impacted Groundwater Using an In Situ Organic Mulch Biowall." Partners in Environmental Technology, 2000.