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Project Summary

Assessing UST Corrective Action Technologies: Lessons Learned about In Situ Air Sparging at the Denison Avenue Site, Cleveland, Ohio

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In situ air sparging (IAS) has been used at an increasing number of sites to address groundwater contamination. Because of the lack of substantive performance data, however, the actual effectiveness of this system is not known. The EPA Office of Research and Development Risk Reduction Engineering Laboratory (ORD RREL) with the EPA Region 5 Office of Underground Storage Tanks, the Ohio State Fire Marshal, and BP Exploration & Oil, Inc. (BP) participated in a field evaluation of an IAS system at a petroleum leaking UST site in Cleveland, OH. The purpose of this study was to provide performance data that will be independently evaluated by EPA to better understand IAS effectiveness.

This report presents the site and monitoring data provided by BP over a 2-yr period. The chemical data indicated an overall decrease of BTEX concentrations in groundwater to nondetectable levels shortly after startup of the IAS system. Some of the IAS system chemical data were collected before the Quality Assurance Project Plan (QAPP) was developed, however, and did not meet Quality Control (QC) criteria. Variability in the chemical and process data also precludes making any definitive link between the decrease in contaminant concentrations and IAS performance at this site. Although these data did not allow a definitive evaluation of IAS system performance, they provided valuable information used to develop lessons learned that should be considered when system parameters are evaluated.

This Project Summary was deveoped by EPA's Risk Reduction Engineering laboratory, Cincinnati, OH, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

In situ air sparging (IAS) in combination with soil vapor extraction (SVE) is being proposed and used at an increasing number of underground storage tank (UST) sites across the nation as an alternative groundwater treatment technology; however, the applicability and effectiveness of IAS is not known. Claims have been made that IAS can be used to successfully remediate hydrocarbon contamination in both the saturated and unsaturated zones. Unfortunately, there is a lack of substantive peer-reviewed performance data to support the claims of practitioners who propose using these systems. Consequently, independently reviewed performance data are needed to evaluate the effectiveness and limitations of IAS systems at leaking UST sites. These data are also needed to provide a comparision with conceptual and laboratory models that are used to better understand the processes that determine the performance of IAS systems.

In response to this need, the U.S. Environmental Protection Agency (EPA) Office of Research and Development (ORD) Risk Reduction Engineering Laboratory (RREL) UST Research Program has provided technical support to EPA regions for evaluating selected technologies while they are being used to remediate actual UST sites. Under this program, RREL worked with the EPA Region 5 Office of Underground Storage Tanks, the Ohio State Fire Marshal, Bureau of Underground Storage Tank Regulations (BUSTR), and BP to identify a site at which an IAS system was being operated. RREL provided assistance to BP and its contractor, Engineering-Science, in developing a site-specific quality assurance project plan (QAPP) to define the quality of data required and to describe the sampling and analytical methodologies to be used in evaluating the performance of the system installed at this site at West 65th and Denison Avenue in Cleveland, OH. Interim site and operational data generated at this site were provided by BP. The EPA RREL then examined and evaluated the data generated during operation of the IAS system at this site. These data provided the basis for developing the lessons learned about evaluating IAS at this site.

Purpose

The original purpose of this report was to evaluate the impact and performance of the IAS system installed at the site in Cleveland, OH. A tremendous amount of data were collected at this site. However, the comparability and quality of some of the chemical data (BTEX, TPH) did not meet the QC criteria established in the QAPP. In addition, the low initial contaminant concentrations in groundwater and the large variability in the chemical and process data that were noted over the course of this study (approximately 2 yr) prevented a definitive evaluation of the performance of the IAS system at this site. Although these data could not be used to evaluate the performance of the IAS system, they can be used to develop lessons learned for evaluating IAS systems. Therefore, the purpose of this report is to present the lessons that were learned from the data collected at this site.

Technology Description

The in situ air sparging system at this site involves injection of clean air directly into the porous medium below the water table in an attempt to remove organic contaminants by a combination of volatilization and oxygenation to enhance aerobic biodegradation processes. Hydrocarbon vapors are then recovered by use of soil vapor extraction (SVE).

At this site, an oil-free air compressor is used to inject atmospheric air into vertical sparging wells in the subsurface. Contaminant vapors are removed via soil vapor extraction wells manifolded to a blower. Water present in the extracted vapor stream is removed in an air/water separator. The off-gas from the SVE wells did not require treatment at this site. The well configuration used for the IAS system examined in this study consists of two "remediation cells," each consisting of three vertical air sparging or injection wells with a central SVE well. The IAS system design and operation are presented as well as the monitoring program for examining this IAS system.

Site Characteristics

The BP Oil Site (No. 04216) is an active gasoline retail service station located on the southwest corner at the intersection of West 65th and Denison Avenue in Cleveland, OH. Petroleum products had been released at this site, but the source of this release is not known. Surrounding properties are largely residential, with light commercial development along Denison Avenue and private residences on the side streets. Potable water for the immediate area surrounding the site is provided by the City of Cleveland.

This site, which is located on the eastern lake and till plains of the Central Lowland Province, is characteristic of a remnant beach ridge on the lake plain bordering the southern shore of Lake Erie. The soil texture of subsurface soils varies widely throughout the site in the horizontal direction and even more significantly in the vertical direction. In general, discontinuous and interfingered silt and silty clay lenses are shown from the ground surface to a depth of approximately 15 ft. Interbedded and discontinuous low permeability silts and silty clays overlie and in certain locations partially confine the more permeable sands and silty sands that constitute the main water-bearing zone. A continuous clay layer underlies the entire site at a depth of over 22 to 25 ft from the surface.

Based on the regional topography, the predominant direction of groundwater movement on a regional scale is to the north toward Lake Erie. Reported groundwater elevations taken at the site, prior to start-up of the IAS system, indicate that groundwater movement is to the north, which is consistent with regional trends. Groundwater can be found at an average depth of 19 ft. The water-bearing zone is a semiconfined aquifer comprising predominately sands or sandy silt that ranges from approximately 4 to 7 ft thick across the site. As mentioned, silts and silty clays overlie these sandy soils and, at certain locations on the eastern part of the site, semiconfine portions of the aquifer. Over much of the site, these sandy soils extend above the groundwater table. In the southeastern part of the site, the silty clay above the aquifer is breached by silt. A clay aquitard underlies the aquifer across the entire site.

An Evaluation of Parameters for Monitoring Performance of In Situ Air Sparging

An evaluation of parameters that are used as indicators of IAS performance is first presented before the discussion of the lessons learned from the data generated at the Denison Avenue site. Two general types of parameters are discussed. The first are soil and groundwater quality parameters including dissolved hydrocarbon concentrations, dissolved oxygen, dissolved metals, and hydrocarbon concentrations in soils. The second are vadose zone parameters including soil gas pressure, hydrocarbon and oxygen concentrations in the soil gas, and hydrocarbon concentrations in the soil vapor extraction off-gas. The significance and limitations are discussed for each of these parameters.

In reviewing the importance of the performance parameters, it is important to understand the critical role of the placement of the monitoring points within the context of the stratigraphy of a site. The placement of monitoring points for representative data collection are at least as important as the actual parameters used in the analysis of system performance.

Lessons Learned About In Situ Air Sparging at the Denison Avenue Site

The primary lesson learned from the monitoring data at the Denison Avenue site is that it is very difficult to evaluate the performance of in situ air sparging. A tremendous amount of data was collected during the study. Even so, the data do not provide a clear picture of how well the IAS process was working.

Based on these data, however, the following lessons were learned: (1) A significant contribution to the difficult interpretation of the data is the fact that relatively minor changes in horizontal, and especially vertical, placement of wells and monitoring points in the complex stratigraphy at this site can have a major impact on the performance data collected. (2) Contaminant indicators such as BTEX are often used as the primary indicators of system performance. Based on the data from this site, however, BTEX cannot be solely used to indicate system performance. (Low and variable concentrations may reflect “naturally-occurring” changes in concentration over time.) (3) Other system parameters measured, such as dissolved oxygen and pressure, can be used along with contaminant indicators to provide additional insight as to the impact of IAS on the site. (At this site, however, these parameters are influenced by processes that are not well understood at this time.)

Recommendations

Based on the lessons learned in an attempt to evaluate the performance of the IAS system at the Denison Avenue site, the following recommendations should be considered in the experimental design for future technology applications of IAS systems: (1) Whenever possible, a full year of background data (e.g., BTEX in groundwater, dissolved oxygen) should be reviewed before the IAS system is started up to better understand any trends or natural variations in concentrations. This is often difficult because either the data do not exist or the data quality is inconsistent over time. Alternatively, in the absence of historical data, wells within the zone of contamination, but outside the zone of active remediation, can be used as a “control.” (2) Defining the vertical and horizontal zone of contamination in soil and groundwater as well as the hydrogeologic characteristics of the site is necessary to determine proper well and monitoring point placement. (3) To ensure that samples collected from the monitoring wells reflect the general water quality, the IAS system should be shut down prior to each sampling event. The period of IAS system shutdown will usually be site-specific based on the parameter being measured and the hydrogeologic characteristics of the site. (4) System design diagnosis can be performed using tracer tests to determine if the injected air from the IAS system is being captured by the soil vapor extraction system and if the vapor monitoring points reflect the influence of the IAS system. (5) An additional test that can be used to assess system performance is routine shutdown/in situ respiration tests. These in situ respiration tests can be used to assess bioactivity and microbial oxygen uptake rate changes over time for inferring the contribution of biodegradation to changes in contaminant concentration. (6) The parameters that will be used to monitor performance, the appropriate methods for obtaining these parameters, and method performance criteria need to be established prior to the start-up of the system and used throughout the technology application since the field evaluation may be several years in duration.

In general, the best indicator of system performance or the effectiveness of an IAS system is the long-term improvement in soil/groundwater quality after the air sparging system has been shut down. As part of evaluating the application and performance of IAS, the final sampling and analysis should be conducted after a period of system shutdown.

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The complete report, entitled "Assessing UST Corrective Action Technologies: Lessons Learned About In Situ Air Sparging at the Denison Avenue Site, Cleveland, OH," (Order No. PB95-188082; Cost: $27.00, subject to change) will be available only from:
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