APPLICATION OF PASSIVE SOIL GAS SAMPLING TO DETERMINE THE PRESENCE OF PETROLEUM HYDROCARBONS IN GAS STATION SUBSURFACE: TWO CASES IN THE CENTRAL VALLEY OF COSTA RICA

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INTRODUCTION

Monitoring groundwater pollution around commercial gas stations requires non-invasive methods to identify the extent of any pollution, sources of spills, or leaks from storage tanks, dispensers or pipes because the facilities are generally operating at the time and fear loss of business with too much disruption onsite by consultants and contractors.

METHODS

Passive soil gas sampling is an excellent tool that can identify quickly and directly the presence of volatile organic compounds in the subsurface, both in the unsaturated zone and VOCs volatilizing from groundwater plumes. In the case of fuel dispensing stations, pipelines or refineries, it provides for rapid determination of source areas and contamination plumes originating from hydrocarbon releases, such as diesel and / or gasoline. Volatile organic compounds (VOC) including petroleum hydrocarbons migrate through the vadose zone as a free phase liquid that forms an equilibrium between liquid phase, adsorbed phase, vapor phase and dissolved phase. The vapor phase equilibrium radiates from the source area to the surface where the passive soil gas samplers are installed in order to capture the equilibrium concentration at the time of sampling. Similar phase condition equilibrium is achieved once the non aqueous phase liquid (NAPL) reaches groundwater, however, the vapor phase is only at the surface of the water table. The dissolved phase hydrocarbons generate a plume spreading away from the point of entry into the groundwater and or location of NAPL or residual NAPL but does not always move linearly in the direction of groundwater flow.

The passive soil gas sampling approach is based on the capture of vapor phase molecules of volatile or semi-volatile organic contaminants, that have radiated from the source of the contamination whether in the vadose zone or groundwater table. The passive soil gas samplers are placed at approx 10cm beneath the surface in holes that are typically 25mm in diameter and 90cm deep. Sampling locations are generally evenly spaced at 7, 10, 15, or 30 meter grid spacing depending on the area of investigation and detail or resolution desired. Sampling exposure periods range from 1 to 4 weeks depending on the project objectives, soil types (longer for clay soils), and the volatility of the target compounds. The sorbents inside the passive soil gas samplers adsorb the organic compounds in the soil vapor to maintain an equilibrium concentration at the location and time without forcing the movement of subsurface vapors. The samples are analyzed in the laboratory with the technique of thermal desorption-gas chromatography / mass spectrometry (TD-GC/MS). The analysis is based on U.S. EPA Method 8260C to target approximately 40 compounds ranging from MTBE to 2-Methylnaphthalene and includes QA/QC procedures appropriate to the method. Additional compounds can be targeted including chlorinated hydrocarbons. The results are provided in units of mass in nanograms (ng) and can report with high confidence each individual compound down to 5 ng. The resulting data are provided in tabular format as well as on color isopleth maps to show the distribution of compounds across the area of interest.

RESULTS

In the Central Valley of Costa Rica, the method of passive soil gas sampling was applied at two gas stations to determine the presence of contamination in the ground (diesel and gasoline). The first phase of monitoring was to deploy 3 sampling points in each gas station near the storage tanks, at a midpoint of the fuel line, and near the dispenser site. In Site #1 only 40 ng of MTBE was detected

in one sampling point near the dispenser area, suggesting that the subsurface had not been significantly impacted and resulted in no further testing or investigation, figure 1 shows the contour map of vapor gas identify.

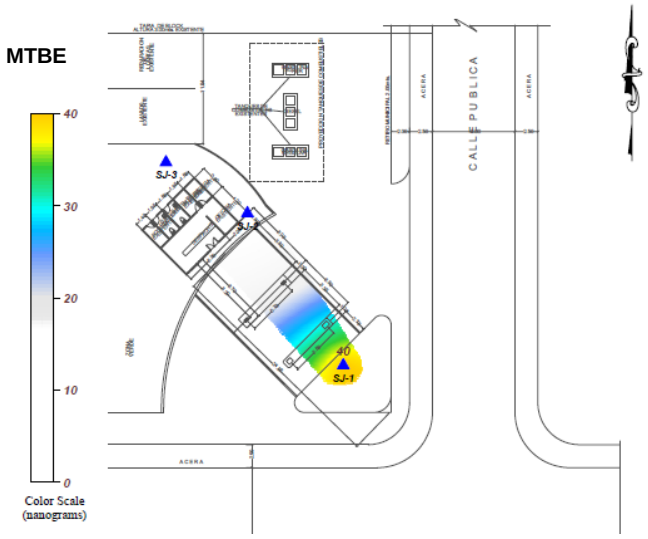

Figure 1. Site #1 map contour showing MTBE gas concentration only in 1 sampling point.

The Site #2 reported compounds associated with petroleum hydrocarbons in quantities of 18,923 ng of MTBE by the dispenser area and 143,741 ng BTEX and 1,168,996 ng TPH C5-C15 next to Super gasoline tank, figure 2 shows the map results.

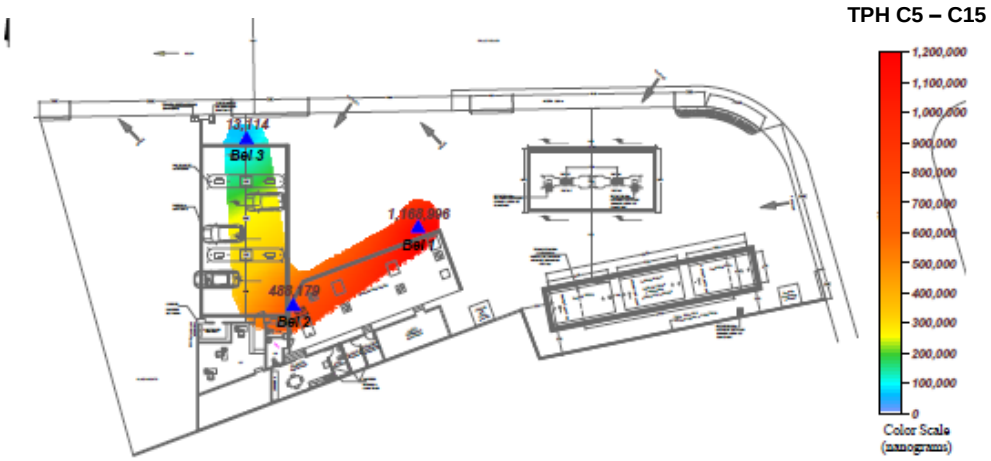

Figure 2. Map showing the results for Total Petroleum Hydrocarbons in Site #2 after first approach.

Therefore the gas station #2 required additional investigation to delineate the impacts across the property. A second passive soil gas investigation was deployed which consisted of placing 20 sampling points separated by 8m each. Isopleths distribution maps were generated from the data, which showed that MTBE, benzene, naphthalene grease traps, BTEX and Total Petroleum Hydrocarbons (TPH) were present in the subsurface of the gas station. Also it was detected the most affected, it is located next to the unleaded gasoline tank, where the mass of TPH was 2,037,641 ng. Based on the results of the investigation, the contaminant plume appears to be moving westward in the direction of groundwater flow, figure 3 shows the final map results for the second passive soils gas survey at the entire site.

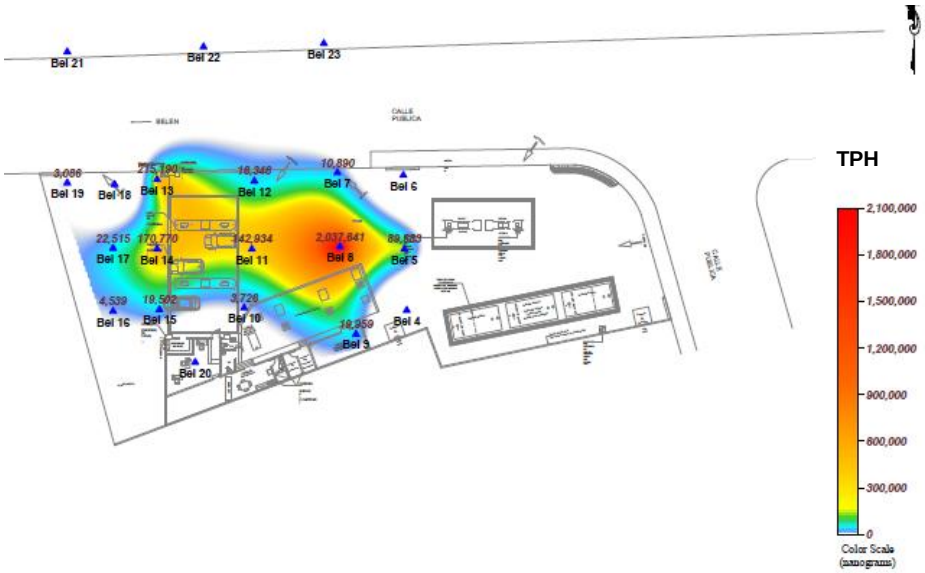

Figure 3. Map of results from the second approach at Site #2. Map shows the results for TPH.

To verify the concentration in the groundwater, a soil boring were advanced, located in the most critical point of contamination adjacent to the USTs. Another boring was advanced up gradient to confirm no offsite source and to obtain background water level parameters. Each soil boring was converted to a groundwater monitoring well for future testing. Soil collected at the capillary fringe was analyzed and revealed TPH concentration of 15.35 mg / kg at 6 m deep in a volcanic tuff. The water table depth was 7m with semiconfined conditions. Additional soil borings will be advanced across the site to further assess the impacts and to confirm the plume delineation already inferred by the passive soil gas sampling investigation.

CONCLUSIONS

-The passive soils gas sampling method was able to identify petroleum contamination at a depth of up to 7m in very low permeability materials, such as tuff clay.
-There is now accurate data of the plume location, its size and the total hydrocarbon concentration in the most critical point.
-The source of the leak in the premium gasoline tank was located, as was the possibility for diesel leakage in the grease traps (because of the presence of naphthalene).
-Further investigation is desired to delineate the impacts to vadose zone and to perched groundwater at 7m. The wells will be constructed for dual use as soil vapor extraction and multiphase extraction wells to remove the majority of the petroleum from the subsurface.

Passive soil gas sampling is a rapid screening tool for initial site investigations of contaminant impacts and for improving the site conceptual model prior to implementation of a remediation approach.

The passive soil gas sampling method is a low-cost tool to identify contamination from spills of volatile organic compounds in gas stations, chemical plants, refineries, tankers, dry cleaners and more. It also offers significant improvements to the placement of soil borings to perform soil sampling and drilling for vertical delineation of impacts and for remediation plan design with high accuracy and savings in time and money.

References

O'Neill, H., 2011: Passive Soil Gas Testing: A Standard for Site Characterization. Beacon Environmental Services. Bel Air, Maryland, USA. (www.beacon-usa.com)