One Year Study of Natural Source Zone Depletion (NSZD) at a Paved Former Service Station Site in Spain

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Background/Objectives. An investigation was carried out to evaluate different surface and sub-surface methods for determining the rate of NSZD at a former service station site in Spain. The site is considered typical of many services stations in Europe, as a paved asphalt surface is present and extends beyond the boundaries of the site. Below the asphalt and surface fill, relatively coarse-grained soil extends down to a perched water table at 8 to 12 m depth. Two plumes exist at the site: a dissolved phase gasoline plume and a diesel light non-aqueous phase liquid (LNAPL) plume, both extending in a south-easterly direction. The site was chosen to investigate NSZD as high groundwater temperatures were observed during site assessment, indicative of biodegradation. Based on the API (2017) guidelines for NSZD, a number of methods are available for use but only three were considered well documented: two surface methods (chamber and trap) that measure the rate of CO_2 efflux from the soil; and one sub-surface method using soil gas probes to determine O_2/CO_2 gradients with depth. The temperature gradient method was considered promising but needed further evaluation. Other methods recommended in the literature include shallow soil gas measurements, and the use of existing monitoring wells for temperature and O_2/CO_2 measurements. Since NSZD is a new technology in Europe, this site was chosen to demonstrate NSZD to Spanish regulators before proposing wider implementation in the country. This ongoing work is a collaboration involving BP and Concawe.

Approach/Activities. Five NSZD monitoring locations were chosen to include one in the background area and two each over the gasoline and diesel plumes. At each location, semi-annual CO_2 trap (trap method for paved sites) and quarterly O_2/CO_2 gradients measurements (soil gas probes) were collected for one year. In addition, quarterly O_2/CO_2 /temperature gradients were measured in 15 nearby monitoring wells. Temperature sensors were used to monitor temperature changes with depth in monitoring wells in the background, gasoline and diesel areas. Additional measurements were made to help evaluate data collected during the study.

Results/Lessons Learned. The multiple measurement methods provided insights in the site conceptual model. Complex O_2/CO_2 profiles at both soil probe and monitoring well locations indicated the presence of lateral flow of vapor through the soil underneath the pavement. CO_2 and temperature patterns were consistent in indicating ongoing biodegradation at depth near the LNAPL and water table. Lateral flow, along with contribution of near-surface CO_2 from shallow contamination or fill material, meant that several measurement methods depending on a one-dimensional model could not easily provide an NSZD rate, including the CO_2 traps. The results from the various measurement methods and various interpretation models and their applicability at this site will be discussed. In addition, a method to estimate the thermal diffusivity based on thermal recordings versus depth ('Tmax' method), will be presented.