H126-014 Room: 301A Time: May 23 14:15-14:30

Two-dimensional numerical study for preliminary risk assessment of contaminated groundwater under natural and man-made effect

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Subsurface contamination by chlorinated hydrocarbons is common throughout many areas of North America, Europe, and Asia. Most of these compounds, which are classified into alkyl halides-aliphatic and aryl halides-aromatic, are categorized as persistent organic pollutants (POPs). Risk assessments are routinely performed at sites contaminated by POPs as a means of quantifying the potential threats to the public health and to ecosystems.

Subsurface contaminant transport models which simplify complex processes are commonly used for exposure assessment (pathway analysis) to determine the concentrations of contaminants that reach the exposed receptors. Practitioners and scientists have recently paid much attention on this tool for supporting an appropriate monitoring and remediation works. This is because of a variety of inherent uncertainties pertaining to hydraulic properties, and contamination mechanisms and behaviors frequently involved in contaminated sites throughout the world. It is noted as well that the related data and information are commonly insufficient.

The two-dimensional flow and transport model is designed in the present study to support the pathway analysis of chlorinated hydrocarbons pollution. The transport of chlorobenzene (CB) carrying dioxins comprises the processes of advection, dispersion, adsorption and degradation. The modeling approach employing various hypothetical scenarios is expected to narrow down the uncertain occurrences in the site and reveal the role of the occurring processes on the contaminant distributions.

The result of the modeling approach demonstrated that the comparison between CB distribution in the absence (the first scenario) and the presence of the river (the second scenario) examined in the two observation wells indicate that in average 50 and 70 % of concentration is seeped out to the river. It may lead to the contaminant spreading to the greater distance downstream of the river.

It was revealed that the flow and transport of contaminants in the site have been affected by pumping work (the third scenario). In addition, the hypothetical well pumping rate and duration were also estimated by comparing the numerical solution with the measured piezometric head of groundwater. More than 90 % of the contaminant concentration observed in three wells was reduced after 3 year operation at the four pumping wells since 2001 until 2003, suggesting that high efficiency of multiple pumping techniques is able to impede further mobilization of contaminants. In contrast, the plume already extended more than 130 m downstream of the contaminant source can not be captured by the current pumping work since the predicted path is out of those well capturing zones. Its results suggest that aquifer located in that predicted area should be subjected to an appropriate intensive monitoring and remediation work.

The results of simulated model confirm that the numerical approach is capable of recreating the natural processes (i.e. the presence and absence of river) and man induced effect (pumping efforts) on the distribution and behavior of the contaminant. It can be useful as the preliminary attempt for reconstructing the history of release and estimating the future plume of the contaminants, particularly under insufficient data availability.