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Use of compound specific isotope analysis (CSIA) on investigation of soil and groundwater contamination

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In order to consider the effectiveness of CSIA on investigation of soil and groundwater contamination, stable carbon isotope ratio ($d^{13}C$ value) of each CVOC product that becomes potential source contaminant was measured and the effectiveness of CSIA on investigation of soil and groundwater contamination was examined by investigating the $d^{13}C$ value distribution about each CVOC on a soil and groundwater contaminated site.

In this analysis, experimental reagents and the industrial reagents of CVOCs produced in Japan about CVOCs products that become potential source contaminants were collected and the $d^{13}C$ values of these products were measured using Elemental Analyzer/Isotope Ratio Mass Spectrometer (EA/IRMS).

As the result of measuring the $d^{13}C$ values about four tetrachloroethene (PCE) products and four trichloroethene (TCE) product, $d^{13}C$ values of PCE were -37.29 to -29.77 permil and that values of TCE were -33.49 to -27.18 permil. The range of the $d^{13}C$ values on PCE products was greater than that on TCE products.

The $d^{13}C$ values of CVOC increase by the isotopic fractionation according to the degradation process by the microorganism and hardly change in a physical process such as the dilutions and volatilizing. Therefore, there is a possibility to be able to specify the contaminant source based on the result of CSIA of the contaminant.

On the groundwater investigation in a soil and groundwater contaminated site by PCE as a primary source, The $d^{13}C$ values of each CVOC in groundwater were measured by CSIA using Gas Chromatograph/Combustion/Isotope Ratio Mass Spectrometer (GC/C/IRMS), and two dimension distributions of the $d^{13}C$ values in aquifer were estimated about each CVOC. It is reported that the uncertainty of the $d^{13}C$ value is within the plus or minus 0.5 permil under the ideal condition, though the problem remains in the reliability of low concentration samples. The groundwater investigations were done in August and December, 2007.

In August, the $d^{13}C$ values of PCE in the monitoring well of RW-C which installed into the source area was -27.03 permil and the value in the monitoring well of A-3.0 which is located 40.4 m downstream side of RW-C was -23.10 permil. The $d^{13}C$ values of cis-1,2-dichloroethene (cis-1,2-DCE) was the lowest in A-3.0 with -25.60 permil and increased toward the downstream and lower side. From these data, the situation in which cis-1,2-DCE were produced by degradation of PCE from RW-C and moved to each depth on the downstream side was estimated. From the groundwater quality data such as DO, ORP and sulfur, it was thought that the cause of the increase of $d^{13}C$ value on cis-1,2-DCE is a reductive dechlorination by microorganism.

In December, contamination mechanism which was estimated from the $d^{13}C$ values data was same with the one in August. Therefore, it was estimated that the movement mechanism of contaminant is steady. The $d^{13}C$ values of PCE in December increased 2.67 to 3.36 permil compared with August in RW-C and A-3.0, and the $d^{13}C$ values of cis-1,2-DCE in December increased 0.18 permil compared with August in RW-B which located 33.6 m upstream side of RW-C. On the other hand, the $d^{13}C$ values of cis-1,2-DCE in each depth of each point on downstream side of RW-C in December decreased 0.11 to 0.59 permil compared with August. It is important to accumulate the knowledge about the seasonal change of $d^{13}C$ values of CVOCs in soil and groundwater. These results show that there is a possibility to estimate the contamination mechanism from the situation of $d^{13}C$ values distribution of CVOCs measured by CSIA if the reliability of the $d^{13}C$ value measured by CSIA can be secured.

Keywords: soil and groundwater contamination, stable carbon isotope, compound specific isotope analysis, chlorinated volatile organic compound