TITLE: **Use of Literature Degradation Rates in a Property-Specific Fate and Transport Modeling Evaluation**

DATE EFFECTIVE: January 2003

HISTORY: Update of VA30007.03.015 - Revision was necessary to reflect changes in rule citations that became effective in March 2009.

KEYWORDS: Biodegradation, fate and transport modeling, modeling, passive remedy, natural attenuation

RULE/ AUTHORITY: OAC 3745-300-07(G)(4) and 3745-300-07(I)(2)

QUESTION: How should degradation rate(s) based on values from literature (e.g., published studies from scientific or engineering journals) be utilized when conducting a property-specific fate and transport evaluation under the Voluntary Action Program (VAP)?

ANSWER: Degradation rates based on values from literature can be used as part of an overall fate and transport assessment of contaminants in ground water as long as appropriate site characterization determines that the use of such values is justifiable (refer to OAC 3745-300-07(G)(4) and 3745-300-07(I)(2)). In addition, the modeling evaluation should be coupled with a sensitivity/uncertainty analysis using a range of values from different literature sources in accordance with OAC 3745-300-07(G)(4).

BACKGROUND: Scientific literature has documented several important degradation pathways for chemicals in the environment. These degradation processes are being incorporated more often into passive remedies or natural attenuation remedies of ground water plumes. The degradation of contaminants in the environment can be biotic (biologically mediated) or abiotic (chemical reaction). It is essential to identify the pathway or mechanism by which a contaminant degrades when including degradation as a component in the analysis of the fate and transport of contaminants. A degradation pathway is defined as a mechanism that produces a known by-product from a “parent” chemical through a known reaction or process. Determining which degradation pathway(s) are likely to occur at a property can often be

achieved through (1) an understanding of the scientific research documenting various pathways and (2) an evaluation of whether the property-specific environmental conditions are favorable for degradation via a specific pathway.

The demonstration that a particular degradation pathway is occurring at a property, or that conditions are at least favorable, is probably the most important step in the natural attenuation evaluation. There are several technical guidance documents available to assist in this important step of the evaluation. Some of these include:

- ASTM, 1998. "Standard Guide for Remediation of Ground Water by Natural Attenuation at Petroleum Release Sites," American Society for Testing and Materials, E1943-98, August, 1998.
- US EPA, 1998. "Technical Protocol for Evaluating Natural attenuation of Chlorinated Solvents in Ground Water," Office of Research and Development, EPA/600/R-98/128, September 1998.
- ITRC, 1999. "Natural Attenuation of Chlorinated Solvents in Groundwater: Principles and Practice," Interstate Technology Regulatory Cooperation, May 1999.
- NRC, 2000. "Natural Attenuation for Groundwater Remediation," National Research Council, National Academy Press, 2000.

In general, each of these protocols indicates that natural attenuation is most appropriately documented through a weight-of-evidence approach that includes: (1) evidence of contaminant mass loss and (2) screening for geochemical "footprints" of degradation. Evidence of contaminant mass loss can be as simple as documenting decreasing concentrations of a parent compound and increasing concentrations of its daughter products, or as complex as calculating a property-specific degradation rate through a rigorous analysis of the fate and transport of the contaminant plume. Screening for the "footprints" of degradation includes measuring the concentration of various important geochemical indicator parameters, such as:

Dissolved Oxygen (DO)	Ferrous Iron
Nitrate	Sulfate
Nitrite	Sulfide

Carbon Dioxide	Methane
Chloride	Alkalinity
Temperature	Total Organic Carbon (TOC)
pH	Chemical Oxygen Demand (COD)
Hydrogen	Oxidation Reduction Potential (ORP)

The level or degree to which mass loss is documented and the "footprints" of degradation are evaluated is property-specific and depends on a number of factors including:

- The concentration and extent of contamination on the property and the ratio of the concentration of parent compounds to daughter products present within the ground water;
- The level of uncertainty in the scientific literature about the reliability of the mechanism responsible for the degradation pathway;
- The level of risk to receptors identified during the assessment of exposure pathways;
- The strength of the weight-of-evidence used to document that property-specific environmental conditions are favorable for degradation via a specific pathway; and
- The reliability of the method or data used as evidence of contaminant mass loss at the property.

If the data collected as part of the site characterization include sufficient evidence that degradation is occurring or the pathway is well recognized, it is justifiable to use degradation rates based on values found in the literature (refer to OAC 3745-300-07(G)(4) and 3745-300-07(I)(2)). Literature rates derived from field studies are generally preferred over literature rates derived from laboratory studies. Evidence of microbes that are capable of degrading the COCs also may be used to document biodegradation potential. This evidence is generally derived through a laboratory microcosm study using contaminated media from the property.

In general, the use of literature-based values in a modeling analysis should be coupled with a sensitivity/uncertainty analysis using a range of values from different literature sources in accordance with OAC 3745-300-07(G)(4). If the modeling analysis demonstrates that receptors could be at risk because either (1) the concentrations of COCs in exceedance of applicable standards may reach the point of compliance or (2) the sensitivity/uncertainty analysis indicates a large

degree of uncertainty in the risk to the receptor, then the calculation of a property-specific degradation rate may be warranted (refer to OAC 3745-300-07(G)(4)). If further analysis demonstrates that receptors are still at risk, then an active remedy or an engineering control is likely necessary and a remedy would need to be implemented in accordance with OAC 3745-300-11.

SUMMARY: The degradation rate, especially as it compares to the rate of contaminant transport, is an important parameter that determines whether natural attenuation is a viable remedial option. It is, however, appropriate to use degradation rate values found in the scientific literature as part of a fate and transport analysis provided that appropriate site characterization has determined that the use of such values is justifiable for a particular degradation mechanism or pathway (refer to OAC 3745-300-07(G)(4) and 3745-300-07(I)(2)). The level of appropriate site characterization is property-specific and depends on a number of factors. These factors should be considered as part of the overall fate and transport analysis and the property-specific risk assessment. Several technical protocols are available as guidance on documenting evidence of natural attenuation. Finally, the use of literature values in any modeling analysis should be coupled with a sensitivity/uncertainty analysis using a range of values found in the literature in accordance with OAC 3745-300-07(G)(4).

OHIO EPA CONTACT: For any questions concerning this issue, please contact the VAP central office at (614) 644-2924.