The Role of Air-Water Gas Exchange in the Source Apportionment of Volatile Organic Compounds in Streams

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The National Water-Quality Assessment (NAWQA) Program of the U.S. Geological Survey seeks to understand the sources and processes that determine the concentrations and behavior of contaminants in the natural waters of the United States [Gilliom et al., 1995]. Contaminant groups of interest include volatile organic compounds (VOCs), pesticides, nutrients, trace elements, and major ions. For perennial urban streams, NAWQA results indicate the frequent presence of multiple dissolved VOCs [Gilliom et al., 1995; Lopes and Price, 1997]. An adequate understanding, however, does not exist of the identities and relative roles of the typical contaminant sources that lead to the observed VOC concentrations, or of the coupled manners in which physical, chemical, and biological processes in streams act on those contributions to yield observed position- and time-dependent concentrations. The NAWQA Program is interested in the continued development of “source apportionment” (SA) models for use in tracking how multiple VOC sources and sinks can combine to yield a given observed concentration at some stream point (x,y,z,t). Reasons for interest in the relative and absolute contributions of different sources to VOC concentrations include the need to apportion: 1) the origins/responsibility for observed contamination; and 2) the associated human and ecosystem risks posed by various sources.

This study describes the development and testing of a model to predict the time- and position-dependent concentrations of volatile organic compounds (VOCs) in streams as well as the SA of those concentrations. The model estimates the relative contribution of sources and sinks to a given observed VOC concentration. For VOCs, sources include the atmosphere (by absorption), as well as point and non-point inflows of VOC-containing water. Loss processes include volatilization to the atmosphere, degradation, and outflows of VOC-containing water from the stream to local groundwater. This paper presents: 1) the details of StreamVOC, a SA model for VOCs in streams; and 2) comparison of model output with measured concentrations for eight VOCs found in the Aberjona River (Winchester, Massachusetts). Input data for the model were obtained during a synoptic study of the stream system conducted July 11-13, 2001 as part of the NAWQA Program. The input data included a variety of basic stream characteristics (e.g. flows, temperature, and VOC concentrations). The StreamVOC model output agreed moderately well with the measured concentration data for a number of the VOCs, and provided compound-dependent SA estimates as a function of longitudinal distance down the river. For the compounds where the stream was a source of the VOC to the atmosphere, the quality of the agreement between the predicted and observed concentrations could be improved by simple adjustments of the model input parameters. Furthermore, these adjustments were the same for all VOCs in this class, demonstrating the need for careful characterization of the sources when using the StreamVOC model.

References