Isotope Hydrology Investigation of the Pawcatuck Watershed

Principle Investigators

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Introduction

There are three new research projects for the FY1999 annual research program for the Water Resources Center at the University of Rhode Island. Two of these projects apply isotope hydrology and application of Ra-223 as a tracer for the study of groundwater in Rhode Island watersheds. As groundwater is the main source of water supply in southern Rhode Island, there is a continuous need of study of hydrologic relations between surface water, surficial-material groundwater and bed rock groundwater, and nutrient input via groundwater and exchange with coastal waters. The third project studies the phosphorus activity in riparian forest soils so that a best management practice of nutrients in runoff can be determined.

Problem and Research Objective

This research applies environmental isotope techniques to the investigation of hydrologic relations between surface water, surficial-material groundwater and bedrock groundwater in Pawcatuck Watershed of southwestern Rhode Island and southeastern Connecticut. This 300-square mile watershed is experiencing rapid population growth, increasing from ~100,000 in 1970 to over 140,000 by 1990 and is the focus of an interagency and interstate effort to collect and disseminate information on the natural resources of the watershed for the purpose of fostering effective resource management. In Rhode Island, total public-supply withdrawals have decreased from 116 million gallons per day in 1985 to 114 million gallons per day in 1995, groundwater withdrawals by rural self-supplied domestic users, however, have increased by 30% over the same period, from 5.6 Mgal/d to 7.3 Mgal/d. Developers, farmers and conservation groups in these rural areas are often at odds over what constitutes a "safe yield" and what the environmental impacts of a proposed withdrawal or development will be. Because the surface-water and groudwater systems form an integrated hydrologic unit, withdrawals from aquifers affect not only water table elevations, but stream flows and wetland habitat as well. Environmentally sound resource management must be based on detailed information about the interaction between surface water and groundwater, and the dynamics of recharge/discharge relationships in complex aquifer systems. Acquisition of these data requires a more detailed investigation of watershed hydrology than has typically been conducted in many watersheds. An isotope hydrology investigation is conducted herein to address these issues.

Methodology

This project is designed to assess the hydrologic relations between precipitation, surface water, wetlands, glacial aquifer groundwater and fractured bedrock groundwater using isotopic and hydro-geochemical indicators. To this end, samples of groundwater, surface water and precipitation were collected over a 6-month period from sampling stations located throughout the watershed. Surface water samples were collected monthly from a network of ponds and streams. Streams were sampled at USGS gauging stations to permit correlation with stream discharge rates. Groundwater samples were collected from existing domestic supply wells. A well survey was sent to homeowners in the study areas to identify wells suitable for sampling as part of the study. Only those wells for which depth and aquifer material information are available were used. Precipitation samples were collected in rain gage located in Richmond RI. Although, determination of average annual isotopic composition of precipitation requires a long term record, these data will mark the start of such a data-collection effort. Water samples were collected for laboratory analysis of inorganic constituents including: calcium, magnesium, sodium, potassium, manganese, iron, chloride, sulfate, nitrate, orthophosphate, alkalinity, and dissolved silica. Appropriate sample preservation techniques were used in accordance with Standard Methods for the Examination of Water and Wastewater, 1989. Field data collected include temperature, electrical conductivity, dissolved oxygen, and pH. Water samples were analyzed for delta-18-O and delta-D under at the Environmental Isotope Laboratory at the University of Arizona. Chemical analyses of all water samples are being completed in the Department of Geoscience at the University of Rhode Island. Sampling site locations have been used to generate a geographic information system database which includes all site-specific information. Upon Completion of the study these data will be made available to the public through the Rhode Island State Geological Survey.

Principal Findings and Significance

All sampling has been completed for this one-year project. Stable isotope analyses have been completed and the remaining chemical analyses will be completed over the next two months. The following summary of findings to date current presents results of the stable isotope analyses. Isotopic Composition of precipitation: The isotopic composition of precipitation was measured in samples collected from a rain gage in Richmond, RI from 7/1/1999 to 1/20/2000. All events yielding more than 5 mm (1/4 inch) of water equivalent precipitation were sampled. Smaller precipitation events were not sampled due to difficulties obtaining a sample sufficiently large for analysis. A total of 480 mm (20.1 inches) of precipitation was collected during the study period, representing 84% of the total of 570 mm (23.8 inches) reported by the National Weather Service for Rhode Island. The stable isotopic composition of precipitation ranged from delta-18-O =-31.0%, delta-D = -226% for a snow sample collected on 1/20/2000, to delta-18-O = -2.0 %, delta-

D = -8 % for a rain event on 9/6/1999. The volume weighted mean for the study period is delta-18-O = -6.4 %, delta-D = -36 %. The local meteoric water line derived from these data is delta-D = -6.6 and delta-18-O +4.2 with R-square = 0.96. The data show that isotopically heavy precipitation falls during the summer months, with enrichment likely due to higher temperatures in both the atmosphere and the vapor source. Isotopically lighter precipitation was measured during the fall and early winter with an extremely light measurement for snowfall on 1/20/2000. Isotopic Composition of Surface Water and Groundwater: A total of 112 groundwater and surface-water samples were collected during the study period. Surface water samples were collected from 17 sampling stations throughout the Pawcatuck Watershed. Samples were collected approximately monthly with increased intervals at certain sites following large precipitation events. Groundwater samples were collected at 20 sampling sites in the watershed. Analyses of these data are ongoing. Both spatial and temporal variations in isotopic composition are being addressed. Ponds show the greatest temporal variability in isotopic composition. Samples from Worden's Pond for example, varied from delta-18-O = -1.2%, delta-D = -17 during July, 1999 to delta-18-O = -5.5 %, delta-D = -31 % during November, 1999. In contrast, some of the river segments have yielded relatively constant values. The Usquepaugh River, sampled at the Rte 2 USGS gauging station, yielded values consistently near delta-18-O = -6.6 %, delta-D = -40%. Isotopic enrichment in the ponds is associated with evaporative enrichment during the summer months. The relatively stable isotopic composition of the rivers suggests a strong groundwater component with little impact from evaporation and summer storms. Preliminary analysis of these data is encouraging and shows that isotopic hydrology will provide new insights into the flow dynamics of this watershed.

Descriptors

Groundwater, Geochemistry, Isotopes, Water Quality, Water-Use, Water Supply.

Articles in Refereed Scientific Journals

N/A. This is an on-going project to be completed in October, 2000.

Book Chapters

Dissertations

Water Resources Research Institute Reports

Conference Proceedings

Other Publications