

Water Resources Center

Annual Technical Report

FY 1999

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.

Research Program

Basic Project Information

Basic Project Information	
Category	Data
Title	Isotope Hydrology Investigation of the Pawcatuck Watershed
Project Number	B-02
Start Date	03/01/1999
End Date	10/31/2000
Research Category	Ground-water Flow and Transport
Focus Category #1	Groundwater
Focus Category #2	Geomorphological and Geochemical Processes
Focus Category #3	Hydrology
Lead Institution	University of Rhode Island

Principal Investigators

Principal Investigators			
Name	Title During Project Period	Affiliated Organization	Order
Anne I Veeger	Associate Professor	University of Rhode Island	01

Problem and Research Objectives

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 groundwater systems form an integrated hydrologic unit, withdrawals from aquifers affect not only watertable 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 hydrogeochemical 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 gaging 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 $\delta\text{-}^{18}\text{O} = -31.0\%$, $\delta\text{-D} = -226\%$ for a snow sample collected on 1/20/2000, to $\delta\text{-}^{18}\text{O} = -2.0\%$, $\delta\text{-D} = -8\%$ for a rain event on 9/6/1999. The volume weighted mean for the study period is $\delta\text{-}^{18}\text{O} = -6.4\%$, $\delta\text{-D} = -36\%$. The local meteoric water line derived from these data is $\delta\text{-D} = -6.6$ and $\delta\text{-}^{18}\text{O} +4.2$ with $R\text{-square} = 0.96$. 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 $\delta\text{-}^{18}\text{O} = -1.2\%$, $\delta\text{-D} = -17$ during July, 1999 to $\delta\text{-}^{18}\text{O} = -5.5\%$, $\delta\text{-D} = -31\%$ during November, 1999. In contrast, some of the river segments have yielded relatively constant values. The Usquepaugh River, sampled at the Rte 2 USGS gaging station, yielded values consistently near $\delta\text{-}^{18}\text{O} = -6.6\%$, $\delta\text{-D} = -40\%$. 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

Basic Project Information

Basic Project Information	
Category	Data
Title	Application of Ra-223 as a Tracer of Groundwater in Southern Rhode Island Watersheds
Project Number	B-03
Start Date	03/01/1999
End Date	10/31/2000
Research Category	Ground-water Flow and Transport
Focus Category #1	Groundwater
Focus Category #2	Radioactive Substances
Focus Category #3	Hydrogeochemistry
Lead Institution	University of Rhode Island

Principal Investigators

Principal Investigators			
Name	Title During Project Period	Affiliated Organization	Order
Bradley Moran	Associate Professor	University of Rhode Island	01

Problem and Research Objectives

The key research question addressed is the magnitude and seasonal variability of submarine groundwater discharge (SGWD) on a regional basis and its impact on the ecology and biogeochemistry of coastal waters. It has become increasingly evident that groundwater represents a significant, though poorly constrained, source of dissolved nutrients and contaminants to coastal watersheds. Quantifying the flux of groundwater is therefore of significant economic and environmental importance, particularly given the potential for transporting nutrients in groundwater into coastal waters without the filtering effect of estuaries as in the case of riverine transport. The application of Ra-223, Ra-224, Ra-226, and Ra-228 provides a large-scale measure of the diffuse input of groundwater and associated nutrients and contaminants to coastal watersheds of southern Rhode Island. The objectives of the proposed research are to: 1. develop a Ra-223 tracer analytical capability to assess the impact on salt marsh hydrology and ecology of nutrient input via groundwater and exchange with coastal waters. 2. quantify seasonal changes in the magnitude of groundwater input on a regional basis to southern Rhode Island salt ponds using a combination of Ra-223, Ra-224, Ra-226 and Ra-228 tracers.

Methodology

Ra-224, Ra-226 and Ra-228 have been determined in groundwater, salt ponds, and adjacent shelf

waters of Rhode Island using existing techniques in the principal investigator's laboratory. Samples will be analyzed for Ra-223 using a delayed coincidence counting system. We have acquired the components to build a delayed coincidence counting system for the analysis of short-lived Ra-223 (half-life = 11.4 d) and Ra-224 (half-life = 11.4 d). This detection system has only recently been made commercially available, and consists of a data acquisition board, amplifier, PMT's, software, HV supply, preamplifier and counting cells. The time required to acquire the components to build the delayed coincidence counter was considerably longer than anticipated (~8 months), primarily due to delays beyond our control with University of Rhode Island Purchasing. The system is now fully operational.

Principal Findings and Significance

We are accomplishing the primary objectives of this project. Specifically, we have measured the concentrations of Ra-226 in groundwater, shelf water, and coastal ponds of southern Rhode Island. Our work has indicated enrichments of Ra-226 observed in these coastal-zone systems, with the values of approximately 2 dpm /100L for inner shelf waters and ranging from 19-44 dpm/100L for the four coastal ponds examined (point Judith, Potter, Green Hill, and Ninigret Pond). For these salt ponds, estimated groundwater flows of 0.007-0.077 ml/sq.cm-d were calculated. These inputs correspond to ~1-4200000 L/d. which are 4-60 times less than estimates of stream and river flow to these ponds. An important question that we are currently investigating is the magnitude of seasonal variations in groundwater flux in such coastal environments; we have almost completed a seasonal study of groundwater flow in the Pettaquamscutt River-Estuary. We are attempting to use our radionuclide tracer results to estimate the flux of nutrients, particularly nitrogen, in groundwater to the coastal ponds of southern Rhode Island.

Descriptors

Groundwater, Watershed, Radionuclides, Radium, Pollutants, Nutrients

Articles in Refereed Scientific Journals

Scott M.K., and S. B. Moran (2000) Groundwater input to coastal salt ponds of southern Rhode Island estimated using Ra-226 as a tracer, *Journal of Environmental Radioactivity* (submitted 12/99) Moran, S.B., S.W. Nixon, M.K. Scott, and L. Ernst (2000), Groundwater nitrogen in southern Rhode Island: concentrations and fluxes, *Estuaries* (in preparation) Kelly, R.P., and S.B. Moran (2000) Seasonal changes in groundwater input and mixing within the Pettaquamscutt Estuary estimated using Ra-224, Ra-226 and Ra-228 as tracers. *Oceanography: The making of a Science*, WHOI, March 30-31 Kelly, R.P. and S.B. Moran (2000) Seasonal changes in groundwater input and mixing within the Pettaquamscutt Estuary estimated using Ra-224, Ra-226 and Ra-228 as tracers, *Estuarine, Coastal and Shelf Sciences* (in preparation)

Book Chapters

Dissertations

Kelly, R.P., (2001) Seasonal changes in groundwater input and mixing within the Pettaquamscutt Estuary estimated using Ra-224, Ra-226 and Ra-228 as tracers, M.Sc Thesis, Graduate School of Oceanography, University of Rhode Island (anticipated Spring 2001)

Water Resources Research Institute Reports

Conference Proceedings

Moran, S. B., and M. K. Scott (1999) Ra-226 as a tracer of groundwater input to coastal waters of southern Rhode Island. Conference on Technologically Enhanced Natural Radiation (TENR), Rio de Janeiro, September 13-17

Other Publications

Basic Project Information

Basic Project Information	
Category	Data
Title	Acid phosphatase activity as an indicator of phosphorus status in riparian forest soils
Project Number	B-04
Start Date	03/01/1999
End Date	10/31/2000
Research Category	Water Quality
Focus Category #1	Nutrients
Focus Category #2	Non Point Pollution
Focus Category #3	Management and Planning
Lead Institution	University of Rhode Island

Principal Investigators

Principal Investigators			
Name	Title During Project Period	Affiliated Organization	Order
Jose A Amador	Associate Professor	University of Rhode Island	01
Josef H Gorres	Assistant Professor	University of Rhode Island	02

Problem and Research Objectives

Riparian wetland areas tend to accumulate sediment-bound P that originates from upland areas. In addition to sediment trapping, P removal in riparian areas occurs via plant and microbial uptake and adsorption to soil particles. There is a need for sensitive, fast, and inexpensive method to evaluate the performance of riparian forest soils with respect to P status. The national Research Council's committee on Long-Range Soil and Water Conservation has identified the long-term effectiveness of riparian zones in nutrient and sediment removal as a major concern. Soil acid phosphatases catalyze the hydrolysis of organic phosphate esters to orthophosphate, and thus constitute an important link between biologically unavailable and bioavailable P pools in the soil. This research addresses Research Priority Area A--- Watershed/ Ecosystem Management, and specifically Subsection d: Effective management strategies for

riparian zones and wetlands protection and assessment of their role in the retention and recycling of nutrients and toxicants. The results of this study will be of use to land and water managers and land-use planners in monitoring the performance of riparian areas and in assessing their role in water quality enhancement.

Methodology

The study is being conducted in moderately well drained and somewhat poorly drained soils in a riparian forest within the Peckham Farm research area of the University of Rhode Island in Kingston, RI. The soil in the upland portion of the catena is mapped as a Hinckley sandy loam, whereas the soils in the lower portions of the catena are mapped as Walpole sandy loam and Scarborough mucky sandy loam. There are four nutrient treatments being applied as 1 cm of simulated runoff to 1 m x 1 m square plots: (i) unamended control; (ii) control amended with water; (iii) simulated runoff containing P only; and (iv) simulated runoff containing P and N. Nutrients concentrations are applied at a rate of 0.75 kg Phosphate-P/ha (treatment iii) or 0.75 kg phosphate-P/ha and 3 kg Nitrate-N/ha (treatment iv) on every application. Application of simulated runoff has been made in October, and November 1999 and April 2000. Soil cores (5-cm length) have been bulked, sieved and sampled on those dates and in December 1999 and March 2000. Phosphatase activity is assayed twice for each sampling time: once using field-moist soil samples immediately after collection and a second time using soil samples that were air-dried for two months. In addition to phosphatase activity measurements, soil moisture content, bulk density, pH (using a 1:10 soil/water (wt:wt) ratio), and bicarbonate-extractable inorganic P are determined.

Principal Findings and Significance

Soil phosphatase activity in both somewhat poorly drained (SPD) soil and moderately well drained (MWD) soil increased in the autumn and remained high in the spring. However, activity was much greater in the SPD soil than MWD soil. Phosphate concentrations are also much higher in the SPD soil than the MWD soil. However, if the data are normalized to soil organic matter content, the phosphatase activity in the both drainage classes is similar in the winter and spring. Normalization to soil organic matter is justified because of the great differences in organic matter between these two soils and by the known association of phosphatase activity with organic matter content. Our data showed statistically significant differences in acid phosphatase activity per unit of soil mass among drainage classes within a soil catena, with activity decreasing as drainage improves. Furthermore, acid phosphatase activity in each drainage class showed a statistically significant, positive, and different linear relationship with soil organic matter and moisture. Phosphate levels were fairly constant in the autumn in the MWD soil in all three treatments, but increased in the spring. In SPD soil, the trend was different, with phosphate levels increasing in the autumn in all three treatments, decreasing in the spring in the control and P addition treatment, but increasing in the N + P treatment. Despite the difference in phosphate levels in the SPD soil and the fact that inorganic N additions have been shown to increase phosphatase activity in soils, we still have not observed significant differences in phosphatase activity among treatments in either MWD or SPD soil. Phosphatase assays conducted on field-moist soil are more representative of activity under field conditions and thus are representative of short-term changes in the enzyme pool, such as those resulting from recent changes in enzyme production. By contrast, air-drying has been shown to reduce acid phosphatase activity in soils, apparently as a result of degradation of recently-produced enzyme. The enzymatic activity of air-dried soil is associated with protected, particle-bound enzyme and represents long-term changes in phosphatase activity. Much of the total activity in our study is attributable to the labile fraction and not the recalcitrant (dry soil) fraction. Our data indicate that short-term changes (activity in wet soil minus activity in dry soil) in phosphatase levels may be detectable; however, to date, the nutrient additions in this experiment have not resulted in significant differences in phosphatase

activity relative to control plots. The results of this study are important for determining (a) whether response of soil acid phosphatase to P and N and P in runoff can be detected against seasonal variations and (b) whether landscape position within a riparian forest influences the ability of acid phosphatase to respond to nutrient disturbances.

Descriptors

Phosphorus, Soil Biochemistry, Runoff, Riparian Forests, Acid Phosphatase

Articles in Refereed Scientific Journals

Book Chapters

Dissertations

Water Resources Research Institute Reports

Conference Proceedings

Other Publications

Information Transfer Program

USGS Internship Program

Student Support

Student Support					
Category	Section 104 Base Grant	Section 104 RCGP Award	NIWR-USGS Internship	Supplemental Awards	Total
Undergraduate	0	0	0	0	0
Masters	3	0	0	0	3
Ph.D.	0	0	0	0	0
Post-Doc.	0	0	0	0	0
Total	3	0	0	0	3

Awards & Achievements

Publications from Prior Projects

Articles in Refereed Scientific Journals

Book Chapters

Dissertations

Water Resources Research Institute Reports

Conference Proceedings

Other Publications