Tennessee Water Resources Research Center

Annual Technical Report

FY 1999

Introduction

Water Resources Issues and Problems of Tennessee

Tennessee is fortunate to have what many consider to be an abundant and good quality water supply. Historically, federal government agencies, such as the Tennessee Valley Authority (TVA), Corps of Engineers, Soil Conservation Service, U.S. Geological Survey and others, have been the primary contributors to the management and monitoring of water resources. In recent years, however, the State, through the Tennessee departments of Environment and Conservation, Wildlife Resources, Agriculture and others, have begun to develop a more active and aggressive role in the management and protection of these resources. The State has moved to establish an integrated and coordinated policy and administrative system for the management of water resources in Tennessee.

While the situation is improving, there remain many of the raditional types of water problems. Although the overall supply of water is adequate, the distribution is still not optimal. Local shortages occur during dry periods. The summer of 1980 was a particularly hot and dry one. During this period over 35 water districts out of a total of 671 public systems in Tennessee experienced lesser degrees of difficulty in supply water. The situation continued to worsen in the late 1980's. Beginning in 1985 and continuing on through the summer of 1988, Tennessee experienced another major drought period which severely strained the water supplies of many communities across the state. In recent years, many of the small municipal water suppliers and utility districts that rely on wells, springs, or minor tributaries for their water sources continue to face severe water shortage problems. All across the state many private, domestic, and commercial use wells have become severely strained, forcing users to seek alternative sources of water. Providing an adequate supply of water for industrial, commercial, and domestic uses and the protection of these surface and groundwater resources are of major concern in all regions of the state and vital to the economic development and growth of the state.

Groundwater presents a particular challenge in Tennessee. Over 50% of the population of Tennessee depends on groundwater for drinking water supply. In West Tennessee, nearly all public suppliers, industries, and rural residents use groundwater. However, not enough is known about the quality and quantity of groundwater in the state, and consequently, maximum benefit from and protection of this resource cannot be easily accomplished. More information about the quality of the state's groundwater, particularly about the potential impact of recharge areas, is needed in order to develop an effective management and protection program for this valuable resource.

There is also the problem of potential contamination of groundwater from agricultural and urban non-point sources. The "fate and transport" of agricultural chemicals (herbicides and pesticides)and toxic substances in groundwater is a problem area that must be addressed if the state's groundwater protection strategy is to be effective in protecting this vital resource.

Although the danger of large-scale, main-stem flooding is controlled by mainstream and tributary dams that have been constructed by TVA and the Army Corps of Engineers, localized flooding and even general flooding in

unregulated watersheds remain substantial problems across the state. A lack of effective local floodplain management land-use controls is apparent in West Tennessee, where related problems of excessive erosion, sedimentation, drainage, and the loss of wetlands constitutes what many consider to be the greatest single water resource issue in the state from an economic and environmental point of view. Effective regulation of private levee design, construction, maintenance, and safety is needed.

Water quality problems continue to persist from past industrial practices, from the surface mining of coal and other minerals (especially from abandoned mines), from agricultural and urban nonpoint sources and from improperly planned, designed and operated waste disposal sites. As has been the situation in the past, the state program for the construction of municipal wastewater treatment facilities and improved operation and management of the facilities have experienced numerous set-backs due to shortfalls in funding and administrative delays. In major urban areas that have combined storm and sanitary sewers, urban stormwater runoff causes increased pollution and, during periods of wet weather, bypasses treatment facilities, which allows raw sewage to enter receiving waters untreated. Tennessee cities, both large and small, are concerned about current (and future) impacts of the new NPDES stormwater discharge permit requirements on clean up needs and costs. In certain regions of the state, failing septic fields and the practice of blasting bedrock for new septic fields are serious threats to surface and groundwater resources.

There are existing programs which can address many of these problems. However, some problems do not have easy solutions. Additional research can also play a role in understanding and solving these problems, but the greatest impediments are the lack of agreement between competing interests and a shortage of financial support for existing programs. From the viewpoint of the State government, the legal, institutional, and administrative aspects of water management are major concerns. The state is still working to develop new policy and to refine administrative structure for the effective management of its water resources.

To address the problems and issues of effective water resources management in the state of Tennessee, a truly interdisciplinary and well-coordinated effort is necessary. The Tennessee Water Resources Research Center has the capability and organization that can call upon the diverse set of disciplinary expertise necessary to address the key water issues of the state and region.

The Tennessee Water Resources Research Center: Overview of Program Objectives and Goals:

The Tennessee Water Resources Research Center serves as a link between the academic community and water-related organizations and people in federal and state government and in the private sector, for purpose of mobilizing university research expertise in identifying and addressing high-priority water problems and issues and in each of the respective state regions.

The Tennessee Water Resources Research Center, located at the University of Tennessee, is a federally-designated state research institute. It is supported in part by the U.S. Geologica] Survey of the U.S. Department of Interior under the provisions of the Water Resources Research Act of 1984, as amended by P.L. 101-397 and 101-147. The Act states that each institute shall:

1. plan, conduct or otherwise arrange for competent research that fosters the entry of new research scientists into the water resources fields; the training and education of future water scientists, engineers and technicians; the preliminary exploration of new ideas that address water problems or expand understanding of water and water-related phenomena, and the dissemination of research results of water managers and the public.

2. cooperate closely with other colleges and universities in the state that have demonstrated capabilities for

research, information dissemination, and graduate training, in order to develop a statewide program designed to resolve state and regional water and related land problems.

In supporting the federal institute mandate, the TWRRC is committed to emphasizing these major goals:

1. To assist and support all the academic institutions of the state, public and private, in pursuing water resources research programs for addressing problem areas of concern to the state and region.

2. To provide information dissemination and technology transfer services to state and local governmental bodies, academic institutions, professional groups, businesses and industries, environmental organizations and others, including the general public, who have an interest in water resources matters.

3. To promote professional training and education in fields relating to water resources and to encourage the entry of promising students into careers in these fields.

4. To represent Tennessee in the Universities Council on Water Resources, the American Water Resources Association (including Tennessee Section), the Ohio River Basin Consortium for Research and Education, the Clinch-Powell River Basir Consortia, the South Atlantic-Gulf regional grouping of state water resources research institutes, the ORNL-TVA-UT Research Consortium and the National Institutes for Water Resources (NIWR) Directors. To work with these and other associations and with state, local and federal government agencies dealing with watt resources in identifying problems amenable to a research approach and in developing coherent programs to address them. Particularly, to cooperate with the other state institutes and their regional groupings for assisting the U.S. Geological Survey in developing a national water resources strategy.

   In fulfilling the Center's major goals indicated previously, TWRRC emphasizes the application of Section 104 grant and required matching funds for primarily supporting the research and training/education needs of the state. While the information dissemination and technology transfer portion of the Center's overall program does not receive direct or significant section 104 funding, this is accomplished primarily from the research and training activities of the Center from other funding sources--state, private, or non-profit. The Center recognizes that education and training, research, and information transfer are not independent objectives or are not mutually exclusive. Instead these goals are achieved through the administration of a coordinated, fully-integrated program within the limitations of the resources available to the Center.

Research Program

Basic Project Information

Basic Project Information	
Category	**Data**
Title	High-rate anaerobic pretreatment of animal wastewater:colon;colon
Project Number	TN-02
Start Date	01/01/1985
End Date	01/01/1985
Research Category	Water Quality
Focus Category #1	Agriculture

Focus Category #2	Treatment
Focus Category #3	Water Quality
Lead Institution	The University of Tennessee, Knoxville

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
D. Raj Raman	Associate Professor	The University of Tennessee	01
Robert T. Burns	Associate Professor	The University of Tennessee	02

Problem and Research Objectives

Due to the large volume of concentrated organic waste generated at modern animal production facilities, and the high cost of traditional wastewater treatment systems, land application of animal waste is the primary disposal method used by U.S. producers. Earthen lagoons are commonly used for storage of the waste and all associated flush water and storm water until land application. Throughout much of the United States, and especially in the warmer southern and island regions, these lagoons can function as anaerobic treatment systems and provide significant reductions in both the oxygen demand and nitrogen content of the wastewater. To achieve these benefits, lagoon organic loading rates must not be excessive or anaerobic treatment will be inhibited; large lagoon volumes have traditionally been used to provide non-inhibitory organic loading rates. However, many animal waste lagoons are overloaded organically, causing minimal (or partial) anaerobic treatment to occur. When waste from a poorly functioning lagoon is land-applied, the risk of surface and groundwater contamination increases because of its high organic content (such waste is also an odor nuisance). Protection of surface and groundwater is a Southern and Island Region priority; the proposal addresses this priority through the development of an innovative wastewater treatment method for agriculture.

There are two distinct methods of reducing lagoon organic loadings: enlarge the lagoon or decrease the mass loading of organic matter through pretreatment. The goal of this work is to explore two promising pretreatment strategies in a series of lab-scale experiments and to use standard engineering-economic principles to compare pretreatment methods with lagoon enlargement. The two pretreatment strategies of interest are both high-rate, retained-biomass anaerobic digestion processes: the anaerobic filter (AF) and the anaerobic sequencing batch reactor (ASBR). The ASBR is more complex, but will not require that solids be removed from the incoming waste stream; the AF is relatively simple, but will require that solids be removed from the influent waste stream to prevent plugging the unit. Although literature reports suggest that either of these technologies might work as pretreatment reactors, explicit comparisons of the two technologies on similar waste streams have not been conducted, nor have engineering-economic analyses. Both are necessary for the development and realistic evaluation of the technologies. If such work is carried out successfully, it will provide design engineers, regulators, and producers a much-needed tool for improving traditional animal waste management systems. Anaerobic filters are continuous-flow fixed-film anaerobic digesters in which the majority of waste-degrading microorganisms are attached to a packing material inside the digester.

Constraining the microbes in this manner leads to greatly increased waste treatment capacity and shock loading resistance. This technology is approximately 30 years old1, and several studies have shown that AFs operated at short-retention times can greatly reduce the organic content of animal wastewater. However, most development work on the AF has involved high-strength industrial and food-processing wastewaters rather than animal waste.

As their name implies, ASBRs operate in a fill–react–settle–decant mode, and retain biomass through settling prior to the decant phase11. This technology is approximately a decade old, and as with the AF, treatment performance is enhanced through biomass retention. Several reports have examined the potential of ASBRs to treat animal waste.

Several investigations demonstrate the potential of AF and ASBR technologies to significantly reduce organic loadings in animal wastewaters3,4,5,13,14,15. However, none have explored the potential of using very short retention time systems for lagoon pretreatment, and no single study has made direct comparisons between the AF and ASBR. Furthermore, no economic analyses have been reported comparing the two technologies or examining the potential cost savings of combined high-rate and lagoon treatment.

Methodology

Study the kinetics of organic matter removal in 25-L ASBR and downflow anaerobic filter (DFAF) reactors at ambient and mesophilic temperatures. Perform an engineering-economic analysis to estimate the economic feasibility of using full-scale versions of these processes to enhance wastewater treatment in lagoons. Specific objectives are: (A) Develop kinetic data for AF and ASBR systems operated at 25 and 35°C treating dairy wastewater. Measure organic removal rate as a function of organic loading rate, and calculate treatment efficiency as a function of organic loading rate. Gather ancillary operating data while performing the kinetic tests, including biogas composition and production. (B) Use the data gathered in (A) to develop an engineering-economic model of high-rate anaerobic systems. Incorporate the model into a spreadsheet so that total system cost (the sum of the high-rate system plus the lagoon) can easily be computed for a variety of scenarios (e.g., varying land costs, liner costs, desired overall volatile solids (VS) removal, desired VS loading to lagoon).

Principal Findings and Significance

Results indicated that negligible biodegradation was occurring at the 0.5-d hydraulic retention time. Although other workers have shown that longer-retention time reactors can treat dairy waste8, the project goal was still to explore the viability of short retention time – and therefore potentially low-cost – reactors for reducing volatile fatty acid (VFA) accumulation in overloaded lagoons. Therefore, the decision was made to explore the performance of the reactors to remove VFA from VFA-enriched dairy wastewaters, such as might occur in overloaded lagoons. In this model, the high-rate anaerobic digesters treat supernatant from the lagoon, rather than screened wastewater. In so doing, the lagoon serves as a settling tank and as a hydrolysis and fermentation reactor, while the primary function of the high-rate digester is to support a large methanogenic population capable of converting VFAs to biogas. The critical parameter in such a configuration is the maximum volumetric VFA removal rate achievable in the high-rate anaerobic digesters; knowledge of

this parameter would facilitate a preliminary economic analysis. To estimate this parameter, the reactors were fed dilute (5 g COD L-1) dairy waste spiked with acetic acid at concentrations of 0.5, 1.5, and 3.0 g L-1, and operated at a 0.5-d hydraulic retention time. After each change in influent VFA concentration, reactors were operated for at least three hydraulic retention times prior to the beginning of data collection, to allow steady-state conditions to develop within the reactors.

All reactors achieved statistically significant VFA removal at influent VFA concentrations of 0.5 and 1.5 g L-1 ($P < 0.0001$). However, at an influent concentration of 3.0 g L-1, ASBR reactors achieved only moderate treatment. At an influent VFA concentration of 0.5 g L-1, VFA reduction was slightly – though not statistically significantly – greater in the ASBR reactors than in the DFAF reactors. Under these conditions there was no statistically significant difference in the effluent concentrations between reactor types at 25°C ($P = 0.65$) or at 35°C ($P = 0.34$).

At an influent VFA concentration of 1.5 g L-1, VFA treatment efficiency in all the ASBR reactors dropped below 51%. This decrease suggested that the ASBR reactors had reached their maximum removal potential. The DFAF reactors at the same 1.5 g VFA L-1 feed concentration achieved >65% removal, except for one reactor, which achieved 45%. Interestingly, three DFAF reactors achieved greater VFA treatment efficiencies at the increased loading rate perhaps reflecting recruitment of more organisms in the reactor. Reactor type significantly affected treatment efficiency at this VFA concentration, with DFAF reactors outperforming the ASBR systems at both 25°C ($P = 0.017$) and 35°C ($P < 0.0001$).

At the highest VFA concentration tested, 3.0 g L-1, no ASBR reactors attained treatment efficiencies greater than 20%. In contrast, DFAF reactors, with the exception of R7, had treatment efficiencies greater than 80%. As with the 1.5 g L-1 feedstock, there was a statistically significant difference in performance between reactor types at both at both 25 and 35°C ($P < 0.0001$).

The 80% VFA treatment efficiency observed in DFAF reactors receiving VFA loadings of 6.0 g L-1 d-1 translate into a volumetric VFA removal rate of 4.8 g L-1 d-1. To put this number into perspective, it can be expressed as 70 x the design loading of an anaerobic lagoon in Tennessee.

Descriptors

System engineering, anaerobic treatment, wastewater, animal waste, lagoons, benefit-cost analysis, anaerobic-filter, anaerobic sequencing batch reactor

Articles in Refereed Scientific Journals

Book Chapters

Dissertations

(Dissertation in Progress, expected completion date 8/00)Hawkins, G.L. 2000. Reducing Organic Loading Rates of Anaerobic Lagoons with High-Rate Anaerobic Digestion:

Reactor Performance and Economic Analysis.

Water Resources Research Institute Reports

Conference Proceedings

Hawkins, G.L., D.R. Raman, R.T. Burns, R.E. Yoder, and T.L. Cross. 2000. Reducing Dairy Lagoon Organic Loading Rates with High-Rate Anaerobic Digesters. In: Proceedings of The Eight Internatinal Symposium on Animal, Agricultural And Fod Processing Wastes, pages unknown. Des Moines, Iowa, 9-11 October.

Hawkins, G.L., D.R. Raman. 1999. Kinetic Study of Anaerobic Filter and Anaerobic Sequencing Batch Reactor For Design of a Pretreatment System for Dairy and Swine Wastewater. ASAE Paper No. 994061. ASAE, St. Joseph, MI.

Hawkins, G.L. 2000. Reducing Organic Loading Rates of Anaerobic Lagoons with High-Rate Anaerobic Digestion: Reactor Performance And Economic Analysis. The University of Tennessee, Knoxville.

Other Publications

(Presentation and Paper)
Hawkins, G.L., D.R. Raman, R.T. Burns, R.E. Yoder, and T.L. Cross. 2000. Reducing Dairy Lagoon Organic Loading Rates with High-Rate Anaerobic Digesters. In: Proceedings of the Eighth International Symposium on Animal, Agricultural and Food Processing Waste, pages unknown. Des Moines, Iowa, 9-11 October.

(Poster and Paper)
Hawkins, G.L., and D.R. Raman. 1999. Kinetic Study of Anaerobic Filter and Anaerobic Sequencing Batch Reactor for Design of a Pretreatment System for Dairy and Swine Wastewater. ASAE Paper No. 994061. ASAE, St. Joseph, MI.

Basic Project Information

Basic Project Information	
Category	**Data**
Title	Field-Testing of Krypton-85 as an Emerging Tool for Age-Dating Groundwater, I : II
Project Number	TN-03
Start Date	09/01/1997
End Date	08/31/2000
Research Category	Water Quality
Focus Category #1	Groundwater
Focus Category #2	Hydrology

Focus Category #3	Methods
Lead Institution	The University of Tennessee, Knoxville

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
Norbert Thonnard	Professor	The University of Tennessee	01
Larry D. McKay	Associate Professor	The University of Tennessee	02
Randall W. Gentry	Assistant Professor	The University of Memphis, Memphis	03
Jerry L. Anderson	Professor	The University of Memphis, Memphis	04

Problem and Research Objectives

Two recurring research needs in the management of water resources are the development of better methods to assess Water Quality and Water Quantity. When these resources are predominantly obtained from groundwater, such as from the Memphis Aquifer in the northern part of the Lower Mississippi Embayment, it becomes critical to understand surface water infiltration and groundwater flow, which permits determination of recharge rates (water quantity) and the potential for contaminant transport and infiltration into the aquifer (water quality).

Reliable, accurate measurements of aquifer recharge and groundwater flow are needed for water resource planning in many areas, but conventional measurement methods often involve a high degree of uncertainty. Physically-based methods using Darcy's Law and values of hydraulic conductivity and hydraulic gradient are strongly influenced by small and large-scale variations in hydraulic conductivity. For example, the presence of thin silt layers, or buried clay-rich soil horizons, can greatly impede downward flow, but it is often difficult to detect or measure the properties of such features. Topography, vegetation and climate factors can also greatly influence groundwater flow and recharge, and again it is difficult to evaluate their influence on how much infiltration actually reaches the water table.

Environmental tracers can play a major role in quantitative assessment of the hydrology of aquifer-aquitard systems. For example, tritium and CFCs are present at very low, but measurable levels in the atmosphere (and hence, in precipitation) due to release from anthropogenic sources such as atmospheric testing of thermonuclear devices and industrial or commercial activities. As precipitation containing these tracers infiltrates into the ground, it carries with it chemical or isotopic signatures related to atmospheric conditions at the time of recharge. The concentration of these tracers along a groundwater flow path will vary, (usually decreasing along the flow path) and measurement of concentrations can be used to determine groundwater age and infiltration rates.

Tracers can also be used to quantitatively investigate many other aspects of groundwater flow systems including: discrimination between recharge and discharge zones, leakage through aquitards, measurement of dispersion or mixing rate between older and younger groundwaters, significance of fracture flow, investigation of groundwater-surface water interactions, and can act as a surrogate for assessing transport rates of contaminants.

However, measurements of groundwater ages and recharge rates based on the most widely used environmental tracers, tritium and CFCs, are problematic because of a variety of factors related to either historic variations of their concentration in the atmosphere (in the case of 3H), or biogeochemical reactions in the subsurface (in the case of CFCs). As a result, groundwater ages and infiltration rate measurements based on these methods contain a lot of uncertainty, or require detailed hydrogeochemical studies utilizing nests of many wells installed at different depths. What is needed is an environmental tracer that can provide an accurate groundwater "age" utilizing samples from a few wells at a specific location, or perhaps even a single well. With such a method it would become feasible to map groundwater ages over large areas, preferably using existing wells, so that variations in groundwater flow and infiltration rates could be used to assess the potential for contaminant transport, and explicitly included in water balance and aquifer utilization models.

Characteristics of an ideal groundwater tracer are: 1) its input concentration history should be known and not sensitive to local or seasonal variation; 2) it should be non-degradable or should decay at a known rate; 3) it should be unaffected by interaction with the aquifer and have no subsurface sources; 4) collection and analysis of samples should be practical, and 5) interpretation of results should be simple and unambiguous. Tritium and CFCs fail to meet several of these criteria. Krypton-85 promises to avoid many of the problems inherent in tritium and CFCs.

Krypton-85 has great potential for use as a groundwater tracer because it is not affected by many of the factors (declining source concentration, reaction with soil or groundwater, temperature-dependence) that limit the present or future usefulness of tritium or CFCs. Although both tritium and Kr-85 are radioactive with approximately the same half-life, in contrast to tritium, the monotonic increase in krypton-85 level in the atmosphere since 1945 results in a direct relationship between measured krypton-85 level and age. Hence, a single measurement represents a unique age. As krypton-85 measurements provide the isotopic ratios of Kr-85 to the stable krypton isotopes in the sample, changes in solubility and recovery or processing losses cancel and do not effect the accuracy of the measurement. The biggest drawback to the use of krypton-85 has been the large groundwater samples (120-250 liters) required for decay-counting methods. The recent development of the resonance ionization spectroscopy (RIS) methodology for krypton-85 analyses reduces the water requirement to less than 20 liters at a cost feasible for use as an investigative tool, making it a potentially viable tracer for hydrology.

The objectives for this research are: a) Development and testing of improved groundwater sampling, degassing, and krypton separation methods. b) Field demonstration of the applicability of krypton-85 and the RIS-based method by age-dating groundwaters in a well-characterized, hydrologically simple aquifer, and comparison with conventional age-dating or physical measurement methods. c) Identification of a specific aquifer sub-systems

for follow-on study using Kr-85 that will advance ground water resource management in the northern part of the Lower Mississippi Embayment.

Methodology

The research being reported here, sponsored in part by the TNWRRC with FY97 and FY98 funding, is the first application of the RIS-based analytical technique for Kr-85 to groundwater problems. The principles of the methodology were developed earlier at Oak Ridge National Laboratory and Atom Sciences, Inc., and since 1994, further developed for earth and planetary sciences at The University of Tennessee with NSF, DOE and NASA funding.

Methodology:
The large reduction in sample size with the RIS-based technique compared to decay counting results from counting almost all of the Kr-85 atoms in the sample (only 400 per liter of water in a 40-year old sample) rather than waiting for a very small fraction (typically less than 0.5%) to decay. In addition to the Kr-85 atoms, there are 1011 to 1013 times as many stable Kr atoms, which must be reduced by a factor of 109 before the Kr-85 atoms can be counted in the ultra-sensitive RIS-based mass spectrometer. This is accomplished by processing the sample with two specialized mass spectrometers before the final counting step.

Before proceeding with the above steps, groundwater has to be collected, dissolved gases stripped from it, and krypton separated from the gases, all of which has to be done with high efficiency and no contamination from atmospheric gases. Development and implementation of these hydrology-specific steps was a major component of this TNWRRC-sponsored research.

In summary, the overall sequence of events required for a Kr-85 determination is as follows:

1. Flow-controlled collection of water for minimal disturbance to aquifer into 20-liter glass carboys with no loss of dissolved gases or atmospheric contamination. Miniature packers, all-metal sampling and transfer lines, and less than 20% head draw-down was employed.

2. Contamination-free and efficient stripping of all dissolved gases from sample and transfer to reliable long-term storage bottles. Stripping was by repeated spaying of water into evacuated stainless steel tank, trapping of water vapor and transfer to evacuated Al storage cylinder. Final stripping included He purge, which raised storage pressure above ambient.

3. Efficient separation and recovery of the typically ~1 ppm Kr from the stripped gases with less than 20% remaining of the other gases. Four-step cryogenic gas chromatography with Ti gettering.

4. Removal of unwanted Kr isotopes by five decades while retaining 50% of the Kr-85 atoms using a miniaturized plasma ion source, gas recirculation, velocity filter mass separation and collection of separated Kr-85 in aluminized sapphire.

5. Removal of remaining unwanted Kr isotopes by four more decades while retaining 50% of the Kr-85 from step 4 in a static electron-ionization quadrupole mass filter and high-voltage implantation into aluminized sapphire.

6. Counting 90% of the few thousand remaining Kr-85 atoms in a static time-of-flight mass spectrometer using resonance ionization and photo-cryogenic sample concentration.

Accomplishments:

- Equipment for Steps 1., 2., and 3., above, was designed, implemented and tested. Upper limits to atmospheric contamination are below 0.1%, while overall Kr recovery is >92%.

- A collaboration was established with the Waterloo Centre for Groundwater Research, Ontario. In addition to providing us with data and access to their Sturgeon Falls field site, an ideal aquifer for qualifying a new groundwater age-dating technique due to its simple and well-characterized morphology, near-constant infiltration rate, and vertical flow, they are providing tritium analyses from aliquots of the Kr-85 samples for comparison, and from other samples collected to evaluate sampling methods.

- Collaboration was established with the Ground Water Institute of the University of Memphis. From information in their data bank and recent tritium data, a site was selected at the Shelby County Landfill where follow-on Kr-85 measurements would be valuable in confirming suspected “windows” in the confining layer of the Memphis Sand Aquifer, a potential contamination pathway to this major regional water resource.

- Water samples were collected at the Sturgeon Falls site, 22 for Kr-85 analysis and 21 for tritium. Processing of samples from the flow-divide has been completed through Steps 2. and 3., while a subset thereof, and numerous calibration standards, have also been processed through Steps 4. and 5. Because of the delays mentioned earlier, Step 6. (being developed with NSF, DOE and NASA funding) is just now coming on-line. Resonance ionization of Kr and the time-of-flight mass spectrometer are operating and undergoing its final tests and adjustments. We anticipate processing the remaining Kr-85 samples through this last step in the next couple of months.

Principal Findings and Significance

Although this work is still in progress, and final numbers are not yet available, no insurmountable “hitches” have been discovered in technical aspects of making the analyses. In fact, a pleasant surprise has been that a conservative, worst-case upper limit to atmospheric contamination in the collection, degassing and krypton separation steps is less than 0.1%, implying that it should be feasible to extend Kr-85 dates to 1960, in which, due to decay and lower atmospheric concentration at that time, the anticipated Kr-85 level in the sample whould be only 1% of modern. The reproducible and high efficiency of the degasing and krypton separation process makes it feasible to determine recharge

temperatures from noble gas solubilities. Naturally, the “proof” will be when we match our Kr-85 results to other groundwater “age” indicators.

Significant, and somewhat unexpected, is the strong interest expressed by hydrogeologist in our work, and the many collaborative oportunities that have opened up. Clearly Kr-85 is an isotope that is percieved by many professionals of providing more reliable age-dating once the analytical methodology is proven.

Initially, krypton-85 will primarily be a research tool until its applicability and limitations have been tested in a variety of hydrogeologic settings. The first “practical” application will likely be in a sedimentary aquifer in the northern part of the Lower Mississippi Embayment, a region under active study by one of the CoPIs at the Ground Water Institute of the University of Memphis. Other likely users may be the US Geological Survey for their ongoing research on hydrology of aquifer systems and DOE and related national laboratories for use in contaminant fate and transport studies at sites such as Savannah River or Oak Ridge. In the long term, krypton-85 measurements may become a widely used investigative tool for researchers and practitioners working on a variety of topics, including assessing aquifer or basin yields, and examining the integrity of clay-rich confining layers below contaminated sites.

Descriptors

Groundwater Hydrology, Groundwater Movement, Age Dating, Groundwater Recharge, Solute transport, Contaminant Transport, Waste Disposal, Hydrogeology

Articles in Refereed Scientific Journals

Book Chapters

Dissertations

Water Resources Research Institute Reports

Conference Proceedings

Gentry, R.W., L.D. McKay, D. Larsen and N. Thonnard. 2000. An Examination of the Influence of Recharge through Confining Layers Overlying the Memphis Aquifer in Western Tennessee. Hydrogeology Journal in press.

Thonnard. N., C.F. Joyner, W. Dong and L.D. McKay. 1999. Application of Emerging New Environmental Tracers, 85Kr and 3H/3He, to Age-Dating of Young Groundwater in an Investigation of Recharge and Non-Point Source Pollution Potential of the Memphis Aquifer. 51st Annual NGWA Convention and Exposition, December 6, 1999, Nashville, TN.

Dong, W., C.F. Joyner and N. Thonnard. 2000. Low-Blank and Efficient Groundwater Sampling and Gas Separation for Krypton-85 And Krypton-81 Analyses. 2000 South-Central Section Meeting of the Geological Society of America, April 4, 2000, Fayetteville, Arkansas.

Thonnard, N., L.D. McKay, D.H. Cumbie and C.F. Joyner, 1997. Status of Laser-Based Krypton-85 Analysis Development for Dating of Young Groundwater. 1997 Annual meeting of the Geological Society of America, October 20, 1997, Salt Lake City, UT., GSA Abstracts with Prog., 29, No.6, A-78, 1997.

Other Publications

Information Transfer Program

Basic Project Information

Basic Project Information	
Category	**Data**
Title	Tennessee Water Resources Research Center Information Transfer Program
Description	Information/Technology Transfer Activities
Start Date	03/01/1999
End Date	02/28/2000
Type	Conferences
Lead Institution	The University of Tennessee

Principal Investigators

Problem and Research Objectives

The major emphasis of the information transfer program during the FY 1999 grant period focused on technical publication support, conference planning/development, and improvement in the information transfer network. The primary purpose of the program was to support the objectives of the technical research performed under the FY 1999 Water Resources Research Institute Program.

The primary objectives, as in previous years, of the Information Transfer Activities are:

- To provide technical and structural support to water researchers performing research under the WRRIP.
- To deliver timely water-resources related information to water researchers, agency administrators, government officials, students and the general public.
- To coordinate with various federal, state, and local agencies and other academic institutions on program objectives and research opportunities.

During the FY 1999 grant period, a major focus of the information transfer activities was on the participation of the Center staff in the planning and implementation of several statewide conferences and workshop.

- To increase the general public's awareness and appreciation of the water resources problems in the state.

- To promote and develop conferences, seminars and workshops for local and state officials and the general public which address a wide range of issues relating to the protection and management of the state's water resources.

Methodology

As co-sponsor, the Center was involved in the planning and implementation of the Ninth Tennessee Water Resources Symposium, which was held on April 12-14, 1999 in Nashville, Tennessee. The purposes of the symposium are: (1) to promote communication on water resources research and management, and (2) to encourage cooperation among the diverse range of water professionals in the state. As with previous symposia, the ninth symposium was very successful with over 225 attendees and approximately 68 papers being presented in the two-day period. The event received a good deal of publicity across the state.

The Center also participated in several meetings and workshops across the state that were held to address water related problems and issues such as stormwater management, water quality monitoring, non-point source pollution, water supply planning, multiobjective river basin management and lake management issues in Tennessee.

Other principal information transfer activities which were carried out during the FY 1999 grant period focused on the dissemination of technical reports and other water resources related reports published by the Center as well as other types of information concerning water resources issues and problems. A majority of the requests for reports and information have come from federal and state government agencies, university faculty and students, and private citizens within the state. The Center also responded to numerous requests from across the nation and around the world.

Principal Findings and Significance

The following is a brief listing of formal meetings, seminars and workshops that the Center actively hosted, supported and participated in during FY 1999:

- State of the Rivers Conference, World Wildlife Fund, March 15-17, 1999, Chattanooga, TN.

- Tennessee Water Resources Research Center Statewide Advisory Committee annual meeting, interaction among researchers and researcher users, March 29, 1999, Knoxville, TN.

- Tennessee Wetlands Technical Advisory Task Force meeting, April 15-16, 1999,

Nashville, Tennessee. Meeting of government agency staff and technical experts to advise to the State on issues related to the Tennessee Wetlands Management Plan.

- WaterFest, April 24, 1999, Knoxville, TN. An annual community-wide event sponsored by the Water Quality Forum that highlights the importance of our water resources and the activities of the WQF partners to protect and manage those resources.

- Sediment and Erosion Control Best Management Practices Workshop, April 28, 1999, Knoxville, TN. A workshop sponsored by the Tennessee Dept. of Transportation and TNWRRC for contractors of TDOT road projects.

- The A B C's of Stormwater Management for Local Officials, June 24, 1999, Nashville, TN. A one day workshop put on by TNWRRC and the Tennessee Nonpoint Source Program targeted at non-technical local officials from Tennessee's county and municipal governments, who are responsible for developing and implementing EPA's NPDES Phase II stormwater management programs.

- Adopt-A-Watershed Teacher Training Workshop, July 26-29, 1999, Knoxville, TN.

- A workshop to train high school and middle school teachers the AAW science based curriculum program that utilizes the local watershed as a living laboratory.

- The Southeast Watershed Roundtable, August 23-24, 1999, Knoxville, TN. The Roundtable was sponsored by the Southeast Watershed Forum and TNWRRC. It is an annual regional Roundtable convened to assess watershed restoration progress in the Southeast. It is a key element of the President Clinton's Clean Water Action Plan.

- Watershed Monitoring Workshop, September 11, 1999, Brookhaven Farms Knoxville, TN. A workshop sponsored by Tennessee Valley Authority and TNWRRC. The objective of the workshop was to train members of local watershed associations in monitoring and assessment techniques.

- Urban Runoff Working Group, September 22, 1999, Nashville, TN.

- Knox County Soil Conservation District BMP Tour, October 14, 1999, Knoxville, TN. TNWRRC staff made presentations on streambank restoration demonstration projects in Knox County.

- Tennessee Nonpoint Source Partnership Conference, October 27-28, 1999, Knoxville, TN. TNWRRC hosted the conference and staff made several presentations and lead the field day tour which focused on urban BMP projects in Knoxville.

- Tenth Annual SAMAB Conference, November 1-3, 1999, Knoxville, TN. Sponsored by the Southern Appalachian Man and the Biosphere. TNWRRC staff made several presentations on watershed assessment projects.

- Southeast Water Supply Roundtable, November 8-10, 1999, Wyndam Peachtree Executive Conference Center, Peachtree City, GA. TNWRRC was one of the sponsoring organizations for the Roundtable and staff actively participated in the Roundtable.

- Erosion Control BMP Workshop. December 1, 1999, Ijams Nature Center, Knoxville, TN.

- National Conference on Tool for Urban Water Resources Management and Protection, February 7-10, 2000 Chicago, IL.

- Designing and Implementing and Effective Storm Water Management Program, February 15, 2000 Nashville, TN.

- Knoxville Water Quality Forum, Quarterly meetings, May, July and October 1999 and January 2000. Meeting of government agencies and other organizations to share information and discuss water quality issues in the Tennessee River and it's tributaries in Knox county.

- Little River and French Broad Watershed Associations, monthly meetings. Agency staff and community leaders working towards protection of the Little River and lower French Broad watersheds.

- Joint UT-TVA-ORNL Water resources Consortium Seminar Series on timely water resources topics, issues and projects of common interest to the three organizations.

Articles in Refereed Scientific Journals

Book Chapters

Dissertations

Water Resources Research Institute Reports

Gangaware, T.G., J. Smoot, K. Thomason, B. Tschantz, L. Wilks, and B. Woodile, 1999. Stormwater Quality and Quantity Management: A Primer for Local Government Officials. The University of Tennessee, Knoxville, TN., 61pp.

Conference Proceedings

Other Publications

Wanger, C.R. and B. Tschantz, 2000, Evaluation of Stormwater Quality Performance of Catch Basin Filter Inserts. IN: Proceeding of the Tenth Annual Tennessee Water Resources Symposium. Nashville, TN., pp.2A-29-34.

Jones, R.E., B. Marshall,. R. A. Hanahan, T.Gangaware and D. Feldman, 2000. Public Views on Local Watershed Issues: Survey Results of Residents Living in First and Beaver

Creek Watersheds of Knox County, Tennessee. IN: Proceeding of the Tenth Annual Tennessee Water Resources Symposium. Nashville, TN., pp.2A-43-48.

USGS Internship Program

Student Support

Student Support					
Category	**Section 104 Base Grant**	**Section 104 RCGP Award**	**NIWR-USGS Internship**	**Supplemental Awards**	**Total**
Undergraduate	0	3	0	0	3
Masters	1	3	0	0	4
Ph.D.	0	2	0	0	2
Post-Doc.	0	0	0	0	0
Total	1	8	0	0	9

Awards & Achievements

None resulting from work supported by Section 104 awards.

Publications from Prior Projects

Articles in Refereed Scientific Journals

Book Chapters

Dissertations

Water Resources Research Institute Reports

Conference Proceedings

Other Publications