Iowa State Water Resources Research Institute

Annual Technical Report

FY 1999

Introduction

June 30, 2000 John E. Schefter, Chief Office of External Research MS 424, Water Resources Division US Geological Survey 12201 Sunrise Valley Drive Reston VA 20192 Dear Mr. Schefter: Attached is the 1999 Iowa State Water Resources Research Institute Annual Report, Grant No. 1434-HQ-96-GR-02670. As you can see, we have had a very productive year. I hope you will find our report informative and acceptable. Please feel free to contact me if you need any additional information. Sincerely, Ramesh Kanwar Director RS:jas FISCAL YEAR 1999 PROGRAM REPORT Iowa State Water Resources Research Institute Iowa State University Iowa June 2000 Report No. GR-02670 Fiscal Year 1999 Program Report Grant No. 1434-HQ-96-GR-02670 For U.S. Department of the Interior Geological Survey by Iowa State Water Resources Research Institute Iowa State University Ames IA 50011 Ramesh Kanwar, Director June 2000 The activities on which this report is based were financed in part by the U.S. Department of the Interior, Geological Survey, through the Iowa State Water Resources Research Institute. The contents of this publication do not necessarily reflect the views and policies of the Department of the Interior, nor does mention of trade names or commercial products constitute their endorsement by the United States Government. ABSTRACT ISWRRI was created by the Iowa Board of Regents at Iowa State University as a cooperative institute representing the faculties at Iowa State University, the University of Iowa, and the University of Northern Iowa. Policy recommendations governing the operations of ISWRRI are made to the director, the Dean of Agriculture and the Vice Provost for Research and Advanced Studies by the ISWRRI Faculty Council. The ISWRRI Faculty Council includes faculty from Iowa State University (10 members), the University of Iowa (2 members) and the University of Northern Iowa (2 members). ISWRRI is supported by funds from the State Water Institute program within the U.S. Department of the Interior, Geological Survey. Supporting funds for major project staff and indirect costs are provided by the university budgets provided by the Iowa Legislature. In order that the research supported in related directly to the solution of Iowa's water resources problems, a State Research Advisory Panel, whose members are listed at the end of this report, was created. These members were selected as representatives of state agencies with a major role in development and protection of Iowa's natural resources. The Iowa State Water Resources Research Institute (ISWRRI) FY 1999 research program was funded by Iowa State University and the U.S. Department of the Interior, Geological Survey. The request for proposals for the ISWRRI 1999 grant program was sent to all water resources faculty at Iowa State University, the University of Iowa, and the University of Northern Iowa, and to all departmental executive officers of academic departments offering graduate degree programs in water related fields at state universities in Iowa. Proposals were solicited in three priority areas identified by the ISWRRI State Advisory Panel: 1) newly emerging water contaminants (bacteria, pathogens and antibiotics) in surface and groundwater systems from animal waste, food and meat industry, or municipal systems; 2) effects on surface and groundwater quality from earthen manure storage sites; and 3) monitoring studies to identify/quantify nutrient loads entering the Mississippi River from major Iowa streams/distributories. Seventeen proposals were received for consideration by ISWRRI in 1999. Each proposal was sent to reviewers from various state agencies having a mission in water resources of Iowa, including the Iowa Department of Natural Resources and the Iowa Department of Agriculture and Land Stewardship. In addition, the proposals were reviewed by the district office of the U.S. Geological Survey. Proposals were evaluated according to the evaluation sheet provided by each reviewer. The State Advisory Panel met twice (first on January 24, 2000, and again on March 7, 2000) to rank and recommend proposals for ISWRRI funding. Eight new projects were selected for funding. In addition, two ongoing ISWRRI projects were approved for one more year of funding. An additional project on wetland research was funded through a partnership with the Leopold Center for Sustainable Agriculture. Eight graduate students are being supported on FY 2000 funded projects compared with only three graduate students in FY 1999 who were supported on ISWRRI projects. In addition, ISWRRI awarded 10 scholarships to graduate students to attend the annual state water quality conference on agriculture and environment in March 2000. ISWRRI has initiated a new program to encourage undergraduate and high school students to become interested in graduate degree programs in water resources. Under this program, two undergraduate students and one high school student were funded for FY 2000 summer research internships. To expand outreach activities, ISWRRI was a co-sponsor with Iowa State University and the Iowa Department of Natural Resources of the state annual water quality conference which was held on March 6-7, 2000 in Ames. ISWRRI is developing similar partnerships with other organizations in the state to co-sponsor water related conferences in the coming year as well. Water Problems and Issues of Iowa About 125 years ago, less than 3% of Iowa's land was under production agriculture. With the installation of an extensive network of subsurface drains, open ditches, and straightening of many perennial streams between 1910 to 1930's, much of Iowa's land was converted to agricultural use. Although this brought production benefits, modification of the local and regional hydrology contributed to increased occurrences of peak flows from agricultural lands, resulting in direct transfer of nonpoint source pollutants to the Missouri and Mississippi Rivers. Nonpoint source pollution has become Iowa's number-one priority. In addition, the impact of nonpoint source pollution on the quality of surface and groundwater resources in Iowa and the Midwest has been enormous. The Iowa State Water Resources Research Institute will have to develop some major research programs in the area of nonpoint source pollution. We will attempt to address technical issues to reduce the transport of nutrients to river water systems and other water bodies in the rural Iowa watersheds. Nonpoint source nutrient pollution is recognized as an important environmental and social issue in Iowa and the Midwest for several reasons. First, excessive use of nutrients in agricultural watersheds can have serious impacts on the quality of surface and ground water resources. Second, several states, including Iowa, are in the process of creating laws to reduce nitrate-nitrogen (NO_3-N) and phosphorus (P) loading from mineral fertilizers and manure to soil and water resources. Third, pollution of water resources from nutrients supplied by manure to croplands will determine environmental indicators for developing public policies on the management of manure. Efficient use of livestock manure can be a sustainable practice for many farmers; for example, an average of 73% of Iowa farms have livestock. Livestock production systems in Iowa have changed significantly in recent years. Today's animal production systems are becoming larger, and the public is concerned about the effects of animal production facilities on surface and groundwater quality. Of particular concern are surface runoff losses of N in the forms of NH_4-N, NO_3-N and organic-N, runoff losses of and phosphorus as phosphate-phosphorus (PO_4-P) and organic-P, and leaching losses of NO_3-N, PO_4-P, silica, and bacteria to ground water. Silica loss from manure fields to water bodies is becoming an area of interest to researchers around the country as it is considered a source of pollution. The NH_4-N at concentrations of > 2.0 mg/L can result in fish kills, and PO_4-P at levels as low as 0.05 mg/L can promote the growth of algae and speed up the process of eutrophication in lakes and reservoirs. Organic forms of N and P can reduce oxygen levels in surface water resources and further "enrich" the supply of nutrients causing nuisance aquatic plant growth, resulting in a "hypoxia zone" in larger water bodies. Another water quality issue is the potential of pathogenic bacteria being transported from the land receiving animal manure to drinking water sources. Although on-farm research has shown that animal manure can provide all the nutrients needed for continuous corn, only 49% of the farmers studied reported taking fertilizer credit for the manure they applied to their fields. This shows the need for more research projects in Iowa to show the economic and environmental benefits of using manure in agricultural watersheds. Recently, reports of the Long-Term Resource Monitoring Program (LTRMP) of the Iowa Department of Natural Resources (DNR) have raised concerns that current nutrient and management practices allow river waters to carry abnormally high levels of runoff-related pollutants such as sediments, nitrogen, phosphorus, and pathogen bacteria. Also, nutrient, silica, and sediment loading to several Iowa rivers threaten the economic vitality of their recreation use and impairment of the rivers' fish population. Therefore, applied research and demonstration studies on manure and fertilizer management are needed to control, retain, and monitor nutrients in the Mississippi River Basin lands of Iowa. Developing and implementing management strategies in watersheds to control water pollution efforts require two things: (1) development and evaluation of on-the-farm management systems that have the potential to maintain economic yields and reduce pollution, and (2) large-scale hydrologic/landscapes implementation of structural best management practices or integrated farming systems that reflect significant reductions in N and P loadings in the water bodies. Previous strategies for addressing water quality problems from livestock production systems have focused primarily on preventing point discharges of animal waste pollutants from confinement areas to water bodies. But more evidence is coming that animal manure applied on land has much broader water quality implications. The Environmental Protection Agency (EPA), under the Clean Water Act, has the statutory authority and responsibility to help states implement the Total Maximum Daily Load (TMDL) program for impaired water bodies in all state waters. This is another major issue facing Iowa. It will require a close partnership among several state agencies, citizen groups, producers, and NRCS and extension staff to implement best management practices in watersheds to control the release of nutrients to surface water bodies. To develop and implement TMDL compliance in agricultural and rural watersheds, watershed-scale models could be an economic and effective means to accomplishment this goal. Also, the use of computer models needs to be evaluated to develop management scenarios to control nonpoint source pollution at the watershed scale by relating hydrologic and water quality functions. Several watershed scale models are available to simulate hydrology and water quality of drainage/runoff from complex agricultural watersheds with differing landscape activities. The use of GIS and modeling studies offer another opportunity for the ISWRRI to help the state fulfill its obligations under the Clean Water Act. Several other water quality problems are emerging in Iowa. The potential implications of endocrine and pharmaceutically active chemicals in drinking water supplies and waste water pose new challenges in Iowa. Potential contributions of organic material to nitrate contamination of rivers and streams is another challenge. This will require the prioritization of research needs and developing a practical agenda for the ISWRRI. The expansion of ISWRRI program would permit the Institute to participate in finding solutions to some of Iowa's emerging water quality and quantity problems. Program Goals and Priorities The major goal of the ISWRRI for the FY 2000 was to expand the competitive research grants program. The ISWRRI received some additional matching funds for the FY 2000 from the Iowa State university. The State Advisory Panel developed a list of several topics to be included in the request for proposals for the competitive grants program. Out of a list of several topics, the following priority areas were identified for the FY2000: i) Newly emerging water contaminants (bacteria, pathogens, and antibiotics) in surface and groundwater systems from animal waste/food and meat industry/ or municipal systems. ii) Effects on surface and groundwater quality due to earthen manure storage sites. iii) Monitoring studies to identify/quantify nutrient loads entering the Mississippi river from major Iowa streams/distributaries. The request for proposals was sent to all researchers across the state to solicit submission of proposals. A total of seventeen proposals were received and were reviewed by the State Advisory Panel. The proposals were then ranked on the criteria decided earlier in the proposal review for and discussions by the members of the Panel. The State Advisory Panel recommended that 10 proposals be funded for the FY2000 program. Two out of the ten proposals were up for renewal for the second year. The summary report of these proposals is given in the following sections. The ISWRRI has set up a new web site (address: www.water.iastate.edu) to promote outreach/information transfer programs. ISWRRI sponsored the State Water Quality Conference and offered an Iowa State University Provost's water Conference in 1999. ISWRRI has awarded two undergraduate student and one high school student research internships.

Research Program

Projects approved for funding in 2000 Potential Pathogen Movement with Seepage from Earthen Waste Storage Structures Used for Liquid Manures 3/1/2000-2/29/2001 $19,800 James L. Baker, Thomas Glanville and Stewart Melvin Ag & Biosystems Engineering 219 Davidson Hall Iowa State University Ames IA 50011 Phone:515-294-4025 Fax: 515-294-2552 jlbaker@iastate.edu Sampling and pathogen and chemical analysis of shallow groundwater over a 12-month period in the vicinity of an Iowa State University earthen lagoon (utilized for storage of liquid swine manure) will be used to assess the potential of pathogen movement with seepage from the lagoon. Based on these preliminary results, if warranted, a more detailed, expanded research program (in terms of additional EWSS sites and more extensive sampling) will be planned and initiated. Construction of a soil pit for natural resource education for school children, field day participants, and research farm visitors 3/1/2000-6/30/2000 $1,650 Ken Pecinovsky ISU NE Research and Demonstration Farm 3321 290th St. Nashua, IA 50658 Phone:515-435-4864 Fax: 515-435-2009 Email: kennethp@iastate.edu This soil pit will be an excellent method for teaching any visitors to the research farm about water quality, underground ecological activity, and potential for contamination of our environment. The soil and water viewing pit will be constructed with glass walls, cement floors, and reinforced walls for safety. The structure will provide students and visitors with an "eye level" learning tool to understand various soil and water quality issues and provide a season-long view of plant, animal, and mineral life in the soil. Visitors can view root growth of various crop species, water movement through a tile line, earthworm activity, different soil horizons, etc. Overall, this innovative project will educate people of all ages in the wise use of our natural resources and how to preserve the quality of our environment. Effect of Swine Waste Effluent Field Application on Tn916 Content of Surface Waters 3/1/2000-2/28/2002 $14,900 Robert E. Andrews, Jr. Department of Microbiology 207 Science I Iowa State University Ames, Iowa 50011 Phone:515-294-8988 Fax: 515-294-6019 E-mail:randrews@iastate.edu Our previous work has shown that (i) Tn916 may be introduced into the soil by application of manure-containing wastes, (ii) that Tn916-mediated genetic exchange occurs in the soil, and (iii) that members of the normal soil microflora may receive Tn916. The experiments in this project are designed to provide evidence that Tn916-containing enterococci appear in the surface waters after application of manure-containing wastes. The results will substantially "close the loop" by showing that fecal enterococci the water supply, which would then provide a mechanism by which these may be taken up by animals and humans. The strength of the current approach is that the analysis will depend on detection of the specific DNA sequence responsible for gene mobilization as well as the presence of the specific antibiotic resistance gene. Characterizing Gene Expression in a Water-Borne Bacterial Pathogen 3/1/00-2/29/01 $7,340 Gregory J. Phillips, Ph.D. James Dickson, Ph.D. Department of Microbiology Iowa State University 207 Science I Building Ames IA 50011 Phone: 515-294-1525 Fax: 515-294-6019 e-mail: gregory@iastate.edu It is our expectation that at the completion of these studies we will have identified a number of genes, including virulence factors, whose expression changes in aquatic environments. These insights will indicate how E. coli responds to aquatic environments and will be useful to identify new intervention strategies to prevent the growth and survival of pathogens in water facilities. In addition to offering a better understanding of the nature of aquatic environments that may trigger unwanted proliferation of E. coli O157:H7, the data obtained from these studies will also be essential to compete for extramural funds for using the breaking microarray technology. Evaluating the Effectiveness of Restored Wetlands for Reducing Nutrient Losses from Agricultural Watersheds 3/1/00-2/29/01 $13,000 Arnold G. van der Valk, Director, Iowa Lakeside Laboratory William G. Crumpton Botany Department 141 Bessey Hall Ames, IA 50011 Phone: 515-294-4374 Fax: 515-294-9777 Email: valk@iastate.edu This will be the first quantitative analysis at the watershed level of the effectiveness of actual wetland restorations for reducing nonpoint pollution resulting from agricultural activities. This project has three major goals: (1) to examine the effectiveness of restored wetlands within agricultural watersheds for reducing nutrient losses; (2) to determine if nutrient exports from particular watersheds could be further reduced by altering the location and/or size of restored wetlands or by improving the establishment and management of their vegetation; and (3) to recommend workable guidelines for siting, sizing, establishing, and managing restored wetlands within watersheds to minimize nutrient losses and to maximize the amount of land that can be kept in agricultural production. A Prediction System for Transport and Fate of Toxic Substances in Surface Waters 3/1/00-2/28/01 $7,400 Roy Gu Civil & Construction Engineering Town Engineering Building Iowa State University Ames IA 50011 Phone:515-294-4534 Fax: 515-294-8216 E-mail:roygu@iastate.edu The objectives of the proposed research are (1) to develop and validate an integrated 2-D mathematical model that simulates and predicts the fate and transport of toxic chemical spills and runoff in rivers and reservoirs or lakes; (2) to develop a real-time prediction and analysis computer program for emergency responses and remediation management; and (3) to incorporate the prediction system into an existing regional contingency plan or a toxic contamination control program at the state level. The menu-driven computer simulation and analysis program to be developed will include a data entry module, an integrated spill model, and a visualization/output data presentation module. The program can yield travel times and concentration curves versus time at various locations and provide timely information by forecasting the location and distribution of toxicants in the event of a toxic spill or runoff. Field Assessment of Groundwater Quality Beneath Cracking Soil with Surface-Applied Hog Manure 3/1/00-2/28/01 $11,258 Robert Horton Agronomy Department 2543 Agronomy Building Iowa State University Ames IA 50011 Phone:515-294-7843 Fax: 515-294-3163 E-mail:rhorton@iastate.edu No study on hog manure transport in cracking soils by using time domain reflectometry (TDR) has ever been reported. This relatively new method for gathering water content and bulk electrical conductivity data has shown applicability in a number of solute transport experiments and even for cattle manure transport. Yet, none of the research publications have ever dealt with manure transport in cracking soils. Thus, research efforts geared towards the use of TDR for monitoring manure transport in cracking soils is deemed an important research strategy toward fulfilling the overall goal of investigating and characterizing manure impacts on groundwater quality, particularly in cracking field soils in Iowa. The general objectives of this study are (1) to obtain field-measured data on water, manure, and crack dynamics in cracking soils; and (2) to apply a numerical model to simulate water flow and manure transport through dynamically changing soil cracks. Microcystin-LR: A Potential Contaminant of Concern for Iowa Surface Waters 3/1/00-2/28/01 $16,246 Maureen E. Clayton Department of Biology University of Northern Iowa Cedar Falls IA 50614-0421 Phone:319-273-7125 Fax: 319-273-7125 E-mail:maureen.clayton@uni.edu The quality of Iowa surface waters is endangered by nonpoint source (NPS) pollution. The traditional threat to lakes from NPS contaminants is eutrophication. Microcystin-LR, a cyanobacterial hepatotoxin, may, however, be a newly emerging contaminant of concern. Toxin concentrations in the water column are related to cyanobacterial population density and the concentration of toxin within the cell, which are both influenced by ambient nutrient concentration. We therefore propose to investigate microcystin-LR concentrations, cyanobacterial species composition and abundance, and nutrient concentrations in two Iowa lakes. The objective of the proposed research is to define the degree of risk to water quality and human, wildlife, and ecosystem health posed by microcystin-LR. Effect of Liquid Swine Manure Application to Water Quality from Soil Infiltration Areas and Wetlands 3/1/2000-2/28/2001 $9,194 Jeffery Lorimor Agricultural and Biosystems Engineering Iowa State University Ames IA 50011 Larry Halverson Agronomy Department Iowa State University Ames IA 50011 Phone:515-294-9806 Fax: 515-294-9973 E-mail:jclorimo@iastate.edu Recent research has shown that soil filtration of liquid swine manure through infiltration areas and subsequent wetland treatment of filtrate effluent from infiltration areas is very effective at removing waterborne nutrients. However, bacterial movement to surface and groundwater from areas receiving manure applications is also of concern. This project will examine bacterial movement through the soil in manure application areas to determine whether the bacteria in the effluent from application areas and wetlands used for treatment are from the applied manure or from the soil itself. Occurrence and Formation of Nitrosamines in Drinking Water Distribution Systems 3/1/00-2/28/01 $23,902 Richard L. Valentine Department of Civil and Environmental Engineering University of Iowa Iowa City IA 52242 Phone:319-335-5653 Fax: 319-335-5660 E-mail:richard-valentine@uiowa.edu Many nitrosamines, especially N-dimethylnitrosamine (NDMA), are potent carcinogens. A number of studies and observations, as well as consideration of processes that may occur in water distribution systems, support the hypothesis that nitrosamine (NA) occurrence and formation could be an especially important problem in some midwestern drinking water distribution systems. Although the exact conditions and mechanisms leading to nitrosamine formation in the environment are not well understood, it is known that they are formed by reaction of nitrite with certain organic nitrogen-containing (amine) compounds. These precursors to nitrosamine formation are ubiquitous in many Midwest drinking water sources or can actually be formed in distribution systems thus making these supplies particularly susceptible to nitrosamine formation. Additionally, recent observation in California suggests that NDMA formation may be related to disinfection practices, suggesting that at least this nitrosamine should also be considered a "new" disinfection by-product. Little is known, however, about the occurrence and formation of nitrosamines in potentially susceptible midwestern drinking water distribution systems. To date, no systematic studies have considered the potential for formation in distribution systems. No studies have investigated the relationship of nitrosamine formation to disinfection, or the role of the pipe-water interface and the presence of deposit material. The proposed study will assess the extent of this potential problem in several distribution systems believed to be "susceptible" to nitrosamine formation and will determine how water quality, treatment, and distribution system characteristics influence this. Laboratory based studies will examine reaction mechanisms and kinetics and will explore several hypotheses that cannot be investigated in the field. These include the role of disinfection and the presence of pipes and attached deposit material. The information obtained in this study will be used to propose strategies to minimize exposure such as modifying treatment, changing source water, or perhaps instituting waste and agricultural management practices that minimize inorganic and organic nitrogen discharges to potential drinking water supplies. SYNOPSIS Project Number: B-04 Start: 3/99 End: 2/01 Title: Field assessment of groundwater quality beneath cracking soil with surface-applied hog manure Principal Investigator: Dr. Robert Horton Department of Agronomy Iowa State University Congressional District: Iowa Third Focus Categories: AG, GW, NPP Descriptors: Agriculture, Animal Waste, Contaminant Transport, Groundwater Quality, Hydrology, Infiltration, Mathematical Models, Soil Physics, Surface- Groundwater Relationships, Unsaturated Flow, Water Quality Modeling Problem Statement and Research Objectives: The potential impact of swine manure application in the farm on groundwater quality continues to be a major concern, particularly in Iowa where numerous large hog confinement facilities exist. While a number of studies have been done on groundwater contamination by livestock manure and on methods to reduce manure impact on both surface and groundwater resources, studies on manure transport in cracking soils have received little attention. In order to develop appropriate swine manure application strategies that will reduce groundwater quality degradation, detailed studies of preferential transport through dynamically changing cracks need to be conducted. Furthermore, no study on swine manure transport in cracking soils by using time domain reflectometry (TDR) has ever been reported. This relatively new method for gathering water content and bulk electrical conductivity data has shown applicability in a number of solute transport experiments and even for cattle manure transport. Research efforts geared toward the use of TDR for monitoring manure transport in cracking soils is, therefore, deemed an important research strategy toward fulfilling the overall goal of investigating and characterizing manure impacts on groundwater quality, particularly in cracking field soils in Iowa. The main objectives of this research are: 1. To obtain field-measured data on water, manure and crack dynamics in cracking soils; and 2. To apply a numerical model to simulate water flow and manure transport through dynamically changing soil cracks. Methodology: This study was conducted at the Agronomy and Agricultural Engineering Research Center of Iowa State University, about 7 miles west of Ames, where soils exhibit various degrees of cracking. Laboratory soil column and lysimeter studies using both direct effluent and time-domain reflectometry measurements were performed to examine the transport of swine manure in this soil. Effluents were tested for electrical conductivity and chloride concentrations to serve as basis for comparing with TDR results. The breakthrough curves obtained from both direct effluent and TDR measurements were then compared to evaluate the feasibility of the TDR method for predicting swine manure transport. Additional experiments are planned. The effluent samples will be tested not only for electrical conductivity and chloride but also for orthophosphate and ammonium-nitrogen. The soil transport characteristics will be evaluated with $CaCl_2$ used as a tracer and a horizontal TDR probe to serve as a basis for modeling manure transport in these soils. The adequacy of the contaminant transport model to predict the various manure chemical constituents will then be examined. Principal Findings and Significance (3/1/99 – 2/29/00): Before the field experiments, a soil column study was performed using manure as tracer at the Soil Physics Laboratory of the Agronomy Department to test the applicability of TDR for manure transport experiments. An 8.5-cm diameter and 20-cm long soil column and a vertical TDR probe connected to a Tektronix 1502B cable tester were used for this purpose. A pulse of swine manure tracer was applied over the surface of the saturated soil column, and the effluent was collected at regular time intervals. The effluent electrical conductivity (EC) breakthrough curve compared well with the TDR breakthrough curve, indicating the feasibility of using TDR for manure transport studies. Four field experiments have been conducted in the lysimeters at the Agronomy and Agricultural Engineering Research Center of Iowa State University. The experimental setup included a 1000-gal water tank with built-in flow regulator as the water source for ponding the lysimeter and an impeller pump for collecting effluent samples from lysimeter bottom. Sixteen (16) TDR probes ranging in length from 15 cm to 60 cm were installed vertically in the lysimeter and were connected to a multiplexer. A Tektronix 1502B TDR cable tester was connected to the multiplexer and a laptop computer to form the TDR data collection system. The first two experiments were performed under saturated flow conditions in early fall of 1999. Swine manure was applied uniformly over the surface of the lysimeter at a rate of 5000 gal/acre, and the surface was ponded at a constant head of about 6.5 cm. after the manure had infiltrated. Effluent samples were collected at regular intervals until about 1 to 2 pore volumes were collected and were analyzed for EC and chloride concentrations. In the first experiment, analysis of the TDR data showed that the plot of the reciprocal of the resistive impedance load R, a representation of the bulk electrical conductivity, against time exhibited a high degree of noise. This is evidently due to the usage of electric power for both the TDR cable tester and the computer and also to the interference of other existing electromagnetic waves in the lysimeter area. The use of an optical isolator as an interface between the cable tester and the laptop computer did not solve the problem. The noise in the TDR waveform was finally eliminated in the second experiment by using an electric generator and car battery to power the laptop computer and the TDR cable tester, respectively. Data analysis showed that the plots of 1/R against time for most of the probes became nearly smooth. These findings are significant in dealing with future field experiments using TDR in areas where possible electrical interference exists. The third and fourth experiments were performed in late fall of 1999 under unsaturated flow condition. A lysimeter with soil exhibiting an appreciable number of cracks was chosen for this experiment. The geometrical configuration of the cracks was photographed and also traced on plastic sheets to capture the relative location of the probes and cracks. The basic experimental setup employed in the previous experiments was used in these two experiments. The appropriate noise-eliminating power supplies were similarly used. Swine manure was applied uniformly over the dry soil surface of the lysimeter at a rate of 5000 gal/acre. After infiltration, the surface was ponded with water at a constant head of 6.5 cm. Effluent samples were then collected until 1 to 2 pore volumes were discharged and were analyzed for EC and chloride concentrations. In all four experiments, saturated or unsaturated soil conditions, the effluent data showed an early breakthrough of swine manure in terms of EC and chloride, with the effluent EC and chloride peaking from 0.1 to 0.25 pore volumes. The resulting breakthrough curves generally followed the typical behavior of breakthrough curves although a double hump was exhibited in the lysimeter experiments on soils with cracks. These findings further demonstrate the major role contributed by preferential flow resulting from soil cracks in the leaching of swine manure in soils. The TDR results did not prove to be highly promising, with only 6 out of 16 probes and 4 out of 16 probes yielding the expected impedance load behavior for the saturated soil experiments, respectively. Of the probes that seemed to work, the TDR data obtained did not provide a good match of the relative residual mass with those obtained from direct effluent EC measurements, particularly at the initial stage of the experiment, i.e., up to 0.5 pore volumes. Although these results may indicate a possible limitation of the TDR method for predicting manure transport in cracking soils, more experiments may be necessary for these results to be conclusive. Future Plans: Additional soil column studies will be performed to examine the transport of swine manure in cracking soils by using TDR and direct effluent measurements. Aside from electrical conductivity and chloride, the effluents from the column studies will also be tested for orthophosphate and ammonium-nitrogen. The feasibility of the TDR method in predicting manure transport will be further examined with a vertical probe. The soil transport characteristics of the columns used for manure transport studies will then be determined for using a conservative tracer (CaCl2) and a horizontal TDR probe. The applicability of the mobile-immobile model to predict the various manure chemical constituents will then be evaluated. SYNOPSIS Project Number: R-0007 Start: 09/01/98 End: 02/28/01 Title: Treatment of nitrate-contaminated groundwater using fe(0) and autotrophic denitrifiers Investigator: Pedro J. Alvarez Department of Civil & Environmental Engineering The University of Iowa Congressional District: Iowa First Focus Categories: GW, NC, TRT, WQL. Descriptors: Biological Treatment, Groundwater, Indigenous Microorganisms, In Situ Remediation, Nitrate, Nitrite, Reactive Barriers. Problem and Research Objectives: Nitrate is a priority pollutant because of its potential to cause methemoglobinemia. There is also circumstantial evidence linking nitrate ingestion to gastric cancer and birth defects (Mirvish, 1985). Nitrate contamination is a major water quality problem in the United States, especially in the North Central Region (Nolan et al., 1997). In Iowa alone, 1 million tons of nitrogen are applied each year, and 18% of the private wells contain nitrate above the drinking water standard of 10 mg/l as N. Another 37% of the wells have levels greater than 3 mg/l as N, typically considered indicative of anthropogenic pollution (Kross et al., 1993). The ubiquity of the nitrate contamination problem is reflected in a 1985 AWWA survey, which found that 23% of all primary drinking water standard violations in the United States were due to high nitrate concentrations (Kapoor and Viraraghavan, 1997). Without appropriate cleanup measures, nitrate can persist in subsoils and endanger groundwater resources and public health. Therefore, there is considerable public interest and regulatory pressure to clean up nitrate-contaminated aquifers. Several physical-chemical and biological processes have been proposed for this purpose (e.g., reverse osmosis and ion exchange). Traditional treatment processes, however, are relatively expensive to operate and are limited by the production of nitrate-concentrated waste streams that may pose a disposal problem. This provides a strong motivation to explore novel nitrate-removal alternatives that address both physical-chemical and microbiological advantages and constraints. The general goal of this project is to exploit favorable biogeochemical interactions in Fe(0) barriers to enhance the remediation of aquifers contaminated with nitrate and nitrite. Laboratory experiments that address critical knowledge gaps will be performed during two years. Specific objectives include: 1) To delineate the applicability and limitations of biologically active semipermeable Fe(0) barriers to intercept and remove nitrate and/or nitrite from groundwater plumes and to obtain basic criteria for the design and operation of biologically active Fe(0) barriers. 2) To determine the effect that Fe(0) has on the activity of denitrifying bacteria and to evaluate the effect that the bacteria have on the abiotic reduction of nitrate by Fe(0). 3) To determine how environmental factors and substrate interactions affect the efficiency of bioaugmented Fe(0) barriers to attenuate nitrate migration under various hydraulic regimes and to evaluate the effect of microbial growth on the permeability of the barrier. Methodology: Electrochemical experiments were conducted to determine whether mass transport to the iron surface or the chemical reaction at the iron surface controls the overall reduction rate of nitrate and nitrite by iron metal. These experiments were conducted in a custom three-electrode glass cell apparatus equipped with a rotating disk electrode (RDE) as described in Jennifer Ginner's thesis. In addition, batch experiments were used to determine the effect of temperature on the rate of nitrate and nitrite reduction by iron metal. Batch experiments also investigated the effect that microbes have on the system and measured the corresponding activation energy. Principal Findings and Significance: Experiments were conducted to determine whether the rate of nitrate reduction by iron metal is controlled by mass transport to the iron surface or the chemical reaction at the iron surface. An oxide-free rotating disk electrode (RDE). The rate of nitrate reduction by this electrode was limited by the chemical reaction at the bare iron surface, and not by mass transfer limitations associated with transport from the bulk liquid to the iron surface. In contrast, the reduction of nitrite at an oxide-free RDE is influenced by mass transport to the bare iron surface. Mass transport may have a larger influence in the field because the iron surface is covered with iron oxides and impurities. Note that these experiments do not imply that the kinetics of nitrate reduction by iron would necessarily be controlled by the chemical reaction in full-scale applications, where the iron surface may be covered with iron oxides and impurities. Iron oxides present a physical barrier that may increase the size of the diffusion layer between the bulk solution at the pure iron metal surface. This larger diffusion layer may cause the reduction of nitrate to be controlled by mass transport to the iron surface rather than the chemical reaction at the iron surface. Results showed also that the kinetics of nitrate reduction by iron metal is first-order with respect to the amount of iron available to serve as a reductant (Figure 1). The strong influence of Fe availability on reduction rates suggests that the presence of multiple contaminants may inhibit individual contaminant reduction rates. Fig. 1. Effect of Fe metal surface area concentration on kinetics of nitrate reduction. The linear increase in the zero-order rate coefficient suggests that the kinetics of nitrate reduction are first-order with respect to iron metal surface area concentration. The slope of the line provides a surface area normalized rate coefficient that is useful for predicting reduction rates at different iron loadings. We also investigated how temperature affects the removal rate of nitrate and nitrite. Temperature had a significant effect on the removal rate of both nitrate and nitrite by iron metal in batch systems. The removal rate of nitrite was much faster than the removal rate of nitrate at all temperatures tested. Consistent with the observations in the RDE experiments described, the activation energy for nitrate removal by iron metal in batch systems was 36.3 ± 9.08 kJ mol-1, which is slightly indicative of surface-reaction control. The activation energy of nitrite removal by iron metal in batch systems was 23.8 ± 3.95 kJ mol-1, which is slightly indicative of mass transport control or mixed control. The batch temperature study indicated that nitrate removal by iron metal requires greater activation energy than does nitrite removal. These batch experiments also showed that cells can enhance nitrate-removal kinetics not only because they increase the flow of electrons through cathodic depolarization (see last-year report), but also because cells can lower the activation energy of the reaction. This leads to faster reaction rates, as illustrated in Figure 2. This is not surprising, inasmuch as cells contain catalysts like enzymes whose purpose is to decrease the activation energy and make the reaction go faster. These experiments also helped delineate the applicability of the iron-supported denitrification at different temperatures. The data showed that this process can work within the temperature range of 5 to 50 C. Figure 2. Decrease in activation energy for nitrate removal in batch reactors amended with 70 g/L Masterbuilder® Fe(0) filings, with and without Paracoccus denitrificans (100 mg/l) SYNOPSIS Project Number: 04 Start: 10/97 End: 09/00 Title: Watershed level approach to siting wetlands for hydrologic and water quality functions Investigators: William G. Crumpton, Thomas M. Isenhart, Richard C. Schultz, Steven E. Jungst Iowa State University Ames IA 50011 Congressional District: Iowa Third Focus Categories: MOD, HYDROL, NPP Descriptors: Agriculture, Baseflow, Denitrification, Ecosystems, Flood Control, Hydrologic Models, Landscape Management, Land-Water Interactions, Model Studies, Nitrogen, Pollution Control, Water Quality Modeling, Watershed Management, Wetlands Problem and Research Objectives: Although the north central region was historically a landscape rich in wetlands, over the past century most of the region's wetlands have been drained for agricultural use. In Iowa for example, fewer than 30,000 acres remain of several million original acres of prairie pothole wetlands. We now recognize the important functions that wetlands had served in this landscape, and there is considerable interest in recovering these lost functions. Since the mid-1980s, a variety of state and federal programs have been used to promote wetland restoration, and over the next few years, thousands of acres of Iowa wetlands will be restored under the Wetland Reserve Program alone. These continuing efforts provide a unique opportunity to increase the quality and quantity of Iowa's wetland resource base and improve the quality of Iowa's watersheds. However, wetland restorations have been motivated primarily by concern over waterfowl habitat loss, and site selection criteria for wetland restorations have not adequately considered hydrologic and water quality functions. As a result, restoration efforts may not be achieving the hydrologic and water quality benefits for which they are frequently credited. For example, of more than 500 wetland restorations in the southern prairie pothole region surveyed by Galatowitsch (1993), most drain very small areas and intercept insufficient contaminant loads to significantly affect water quality. This does not, however, lessen the promise of properly sited and designed wetlands for water quality improvement and peak flow attenuation in agricultural watersheds. In fact, wetland restoration is one of the most promising strategies for reducing nonpoint source pollution in the prairie pothole region (Crumpton 1996, Crumpton et al. 1995, van der Valk and Jolly 1992) and may be among the more effective approaches for flood control (Ogawa and Male 1986). However, a series of technical issues need to be resolved before this strategy is implemented on a regional scale, among the most critical of which are wetland siting and design criteria. From a water resources perspective, siting and design criteria for wetland restoration and construction require watershed-scale approaches. There is, however, surprisingly little quantitative information on the effectiveness of wetland restoration as a means of improving the hydrology or water quality of agricultural watersheds. The principal objective of the project is to develop and apply a watershed-scale approach to planning wetland restorations for hydrologic and water quality benefits in a typical agricultural watershed in the corn-belt ecoregion. We will explicitly evaluate the importance of the extent and location of wetlands in the watershed on two primary end points: peak flow attenuation and stream nitrate loads. Methodology: This project draws heavily upon the results of ongoing research of the Wetlands Research Group at Iowa State University. This group has combined experimental studies in wetland mesocosms and microcosms with field studies in natural and restored wetlands to develop general models of contaminant fate in wetland ecosystems (Crumpton and Baker 1993, Crumpton et al. 1995). Based on these results, we have developed a general transport limitation model for nitrate and pesticide fate in emergent wetlands in which surfaces such as litter and sediment provide most of the active sites for contaminant sorption or transformation and in which loss rates are limited by contaminant transport to these sites. This model has been calibrated for nitrate and subsequently validated (Crumpton and Phipps in prep.) against two separate sets of field data for restored wetlands at the Des Plaines River Wetlands Demonstration site (Phipps and Crumpton 1994). In this project, the wetland nitrate model is linked to a continuous hydrologic simulation model to estimate hydrologic and nitrate dynamics for a variety of wetland restoration scenarios in Bear Creek Watershed, a small (26.8 mi2) drainage basin located within the Des Moines Lobe subregion of the Western Corn Belt Plains ecoregion. We have incorperated a stream flow separation procedure (Nathan and McMahon 1990) for distinguishing between baseflow (which usually has a high nitrate concentration) and quickflow (which usually has a much lower nitrate concentration). We have established a continuous hydrologic monitoring network in the watershed and are conducting detailed monitoring of stream nitrate dynamics. Measured water quality and hydrologic data are being used to validate model predictions for the current status of the watershed and to evaluate the effects of potential wetland restorations. Principal Findings and Significance: In model simulations, we are primarily interested in the concentrations and loads of contaminants in water exiting the watershed. Although wetlands have significant nitrate removal capacity, our model simulations suggest that commonly used site selection criteria for wetland restorations may be inadequate for water quality purposes. However, our preliminary results suggest that properly sited wetlands could significantly reduce nitrate exports from the watershed, even under high flow conditions. Wetlands can provide significant water quality benefits only if properly sited. Water quality is best viewed from a watershed perspective, and selection of sites for wetland restoration should be made at this scale.

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SYNOPSIS Project Number: 02 Start: 10/96 (actual) End: 10/99 Title: Effectiveness of a constructed buffer strip in capturing nitrogen in the Midwestern agricultural landscape Investigators: Schultz, Richard C., Thomas M. Isenhart, and William W. Simpkins Iowa State University Ames, IA Congressional District: Iowa Third Focus Categories: NC, NPP, WQL, HYDGEO Descriptors: Agriculture, Denitrification, Ecosystems, Hydrogeology, Land-Water Interactions, Nitrogen, Pollution Control, Riparian Vegetation, Vadose Zone, Water Quality, Watershed Management Problem And Research Objectives: The midwestern United States is an agriculturally productive region where intense production has been possible because of the quality and availability of the natural resources and suitable topography. Modification of the local and regional hydrology has been an essential part of this conversion. Creation of extensive networks of subsurface tile drains, excavation of surface drainage ditches, and channelization of many perennial streams has facilitated the conversion of nearly all the land to agricultural uses and has provided direct conduits for nonpoint source pollutants to surface waters. The resulting impact on the quality of surface and groundwaters of the region has been profound. A challenge for resource managers in such landscapes is the development and implementation of restoration-based management approaches that build upon traditional pollution control efforts. One promising approach to increase the effectiveness of efforts to protect soil and water quality while also enhancing the physical, chemical, and biological integrity of the terrestrial and aquatic systems is the creation or restoration of landscape buffer zones. Few models exist, however, for landscape restoration within intensively modified agricultural ecosystems. The riparian management system model for reestablishing healthy riparian systems is being developed for the midwestern region. The model is unique in that it provides three subsystems to treat the three major sources of nonpoint source pollutants. The three systems include a multispecies riparian buffer strip, bioengineering techniques to stabilize streambanks, and constructed wetlands to intercept and process tile water before it enters the stream. The model is flexible in design depending on landowner objectives, cost-share opportunities, and hydrologic linkages in the landscape. Present application of this system is envisioned in the headwaters reaches of most agricultural streams. However, major questions exist about the total length and width of the buffer strips that would be needed to achieve target reductions in nonpoint source pollution loadings within a given landscape and watershed. An explicit goal of this work is to refine the riparian management system design developed by researchers at Iowa State University to provide broad scale applicability to watersheds in the midwestern agroecosystem. To accomplish this, we need to identify the pathway and process variables involved in nitrogen movement through the buffer zones. By constructing a detailed water budget to accurately model water fluxes and by monitoring the flow of nitrogen within groundwater and vadose zone water moving through the buffer strip a clearer picture of the fate of the most prevalent chemical nonpoint source pollutant will be developed. Integrating these results by using the Riparian Ecosystem Management Model (REMM) will provide researchers, planners, and field professionals a tool for making credible recommendations regarding buffer strip widths, compositions of plant species, etc. to accommodate site-specific conditions. At present most of these recommendations are based on intuitive and subjective estimates based on limited field demonstration sites. County, state, and national governmental and nongovernmental organizations are requesting better tools for making riparian best management practices recommendations. The proposed work will help provide such tools. Specific objectives for the project are to: 1. Construct a detailed water budget to accurately model water fluxes through a multispecies buffer strip. 2. Monitor the flow of nitrogen within groundwater and vadose zone water. 3. Integrate the results by using the Riparian Ecosystem Management Model (REMM) Methodology: This research represents an expansion of ongoing initiatives in the Bear Creek Basin and takes advantage of unique opportunities at the project site. The initial buffer strip project site established in 1990 is 1 km long and consists of 15 plots with single tree species plus cool season grass control plots. This site is the focus of research sponsored by the USDA National Research Initiative Competitive Grants Program. Data from this project are being used to expand the capabilities of this research support. The current project site is located on a private farm along Bear Creek in northern Story County in central Iowa and is immediately upstream from the initial project site. The multispecies buffer strip was planted in 1994 and consists of four rows of trees planted close to and parallel to the creek. The tree rows contain several different species ranging from willow (Salix) to upland red oak (Quercus rubra), planted according to site characteristics. Upslope from the trees are two mixed rows of seven different shrub species. Finally, a 7.3 m wide strip of switchgrass (Panicum virgatum) was planted upslope from the shrubs and is the interface with the cropped fields. The planting borders fields in a corn-soybean rotation, which receive annual inputs of fertilizer and herbicides. The owner-operator utilizes many conservation best management practices. Specific methods being used for each of the project objectives are as follows. 1. Construct a detailed water budget to accurately model water fluxes through a multispecies buffer strip. Each experimental unit consists of a 20 m wide transect that runs perpendicular to the stream and extends from inside the crop field through the buffer strip to the stream edge. Each of three transects is fully instrumented for water sampling at four stations: at the grass-crop field interface, at the shrub-grass interface, at the tree-shrub interface, and in the tree strips along the stream - buffer strip interface (streambank). These positions allow us to identify the role of the vegetation zones in improving water quality. Each water-sampling station includes: 1. Porous cup tension lysimeters for sampling nitrate concentrations in the vadose zone at four depths: 15 cm, 45 cm, 90 cm, and 150 cm. 2. Soil tensiometers for monitoring soil moisture tension at the same four depths. 3. A single piezometer (monitoring well) located in the shallow groundwater. In addition, two piezometers (5.5 m and 10 m) have been installed at the distant crop field edge upslope of the buffer. A stilling well has also been installed and equipped with a continuously recording pressure transducer to measure stream stage. Tensiometers within one of the transects are equipped with transducers, and the tension data are continually recorded (Soil Measurement Systems, Tucson, AZ). In the other two transects, tensiometers are equipped with septa to facilitate tension measurement using a tensicorder (Soil Measurement Systems, Tucson, AZ). These instruments are read on a predetermined schedule and at regular intervals after each major precipitation event. Soil tension will be used to predict the soil moisture content from characteristic moisture curves that will be developed for each site by using the pressure membrane plate and pressure cooker method. This information will provide a real-time measure of changes in soil moisture and will allow the modeling of the wetting front of a precipitation event as it moves through the soil profile. Piezometers within transects with the recording tensiometers are equipped with continuously recording pressure transducers to provide real-time data on groundwater fluctuations. A weather station at the adjacent research site is used for monitoring air and soil temperature, relative humidity, wind speed, solar input, rainfall and wet- and dry-fall. Integrating all this information, a water balance for each water-sampling station is being developed based on measured rainfall inputs, observed changes in soil moisture, and potential evapotranspiration as calculated from our weather-station data. This will allow for the evaluation of vegetation effects on the site water balance and will be used as input data for the hydrology component of the REMM model. 2. Monitor the flow of nitrogen within groundwater and vadose zone water moving through the buffer strip. The nests of lysimeters and piezometers are being used to measure the flux of nitrate-nitrogen in the subsurface water. Water samples are analyzed for NO_3^--N, Cl^-, N_2O and O_2. Samples for nitrogen analysis are preserved with H_2SO_4. NO_3^--N is analyzed using UV second derivative spectroscopy, and Cl^- is analyzed using ion-selective electrodes. The ratio of nitrate to chloride is calculated to reflect changes in total nitrate movement. 3. Integrate the results by using the Riparian Ecosystem Management Model (REMM) Results are integrated by using the Riparian Ecosystem Management Model (REMM) being developed by researchers at the Southeast Watershed Research Laboratory, USDA Agricultural Research Service, Tifton, GA. This model is being developed to evaluate management alternatives in riparian areas for mitigating nonpoint source pollution. It is a process-based model, simulating surface and subsurface hydrology, nutrient dynamics, and plant growth on a daily time-step. This model offers great promise for researchers, planners, and field professionals as a decision tool to aid in the design of buffer strips for effective management of riparian ecosystems for the amelioration of nonpoint source pollution. Although the REMM model has not yet been released for distribution, it has been extensively tested and validated within the Southeastern Coastal Plain (Altier et al. 1994). Before its wide-scale distribution, the developers are seeking partners in several regions to test the model and to assemble regional databases of model input variables. Our research group is the major midwestern cooperator for this work. Results are being used to refine the model to allow its application to established buffer strips in the Midwestern United States and the regionally applicable database of model input variables will be made available to interested researchers and resource managers. Principal Findings And Significance: Geology of the Buffer Sites Bear Creek is a tributary of the Skunk River that drains approximately 7,656 ha of gently rolling agricultural land. The Bear Creek Watershed lies within the glacial deposits of the Des Moines Lobe – the last major advance of ice into Iowa during late Wisconsin time from 12,500 to 14,000 years ago (Prior, 1991). The Altamont moraine, one of three major end moraines (Bemis, Altamont, and Algona) associated with the Des Moines Lobe in Iowa, bounds the watershed on the east. The loamy till of the Dows Formation is the primary surficial unit in the watershed. Basal till of the Alden Member averages about 48 percent sand, 37 percent silt, and 15 percent clay in central Iowa (Kemmis et al., 1981). The presence of large amounts of glacially derived sand and gravel within till, its lack of compactness, and the proximity of this study site to the Altamont moraine suggest that the shallow till and sand belong instead to the Morgan Member. This supraglacial till unit, more properly a resedimented till or diamicton, is associated with subglacial channel development and the so-called "linked depression" topography of central Iowa. Some basal till of the Alden Member is present beneath the Morgan Member. Alluvial deposits found immediately adjacent to Bear Creek are of Holocene age and record extensive erosion and deposition along the creek during the last 10,000 years. The deposits are grouped within the DeForest Formation, and the most probable units at the site are the Gunder (3,000 to 10,000 years old), Roberts Creek (500 to 4,000 years old), and Camp Creek (400 years ago to present) Members (see Bettis et al., 1992 for descriptions). The Coland soil, a poorly drained, moderately permeable soil found in bottomlands and in the drainage ways of some upland areas has formed primarily in the loamy alluvium at the site. It has slopes ranging from 0 to 2 percent and the solum ranges from 0.9 to 1.2 m thick. The bedrock at the site consists of limestone, dolomite, sandstone, and shale of Mississippian age. The uppermost limestone unit lies stratigraphically within the St. Louis Formation. The bedrock surface is surprisingly shallow in the study area and ranges from 6.7 m deep at the entrance to the Risdal farm, 3.7 to 4.6 m deep beneath the alluvium, and is less than 1.5 m below the channel itself. The Mississippian aquifer is a regional aquifer that supplies potable water for municipalities and private farms in this area and throughout north-central Iowa. Previous investigations at the site indicate strong upward gradients near the creek and suggest that groundwater flow from this aquifer may discharge into Bear Creek (Simpkins, 1993). Hydrogeology Water-table monitoring wells were installed in June and July 1996 and again in May 1997 to: 1) determine the direction of groundwater flow and the magnitude of the hydraulic gradient, 2) estimate the hydraulic conductivity of the sand aquifer beneath the buffer, and 3) estimate the residence time of groundwater in the buffer (Figure 1). Cores were obtained and described during well installation to help interpret the geology. A sand aquifer occurs at the Risdal North and Strum site that we interpret as the Gunder Member (Figure 2). In some cases, this sand may be in connection with sands of the Morgan Member, particularly at Risdal South. The till and shaly limestone beneath the Gunder Member sands acts as a confining unit throughout all three sites, thus forcing groundwater laterally into the creek and preventing upward discharge and mixing of waters from the limestone aquifer. Measurements of the hydraulic heads indicate that groundwater is generally directed toward the creek and that most of the flow is lateral (Figure 3). Mean hydraulic gradients during that period were 0.02 (Risdal, N=107) and 0.003 (Strum, N=41). Brief gradient reversals occur during times of high creek stage allowing for creek water to invade the aquifer. Slug tests were performed in each of the wells to determine the hydraulic conductivity (K) of the geologic units. Results of slug tests show a lognormal distribution of K values and an overall geometric mean K of 1.7 x 10-5 m/s (N=35). Lower mean values occur at the Risdal site (K = 1 x 10-5 m/s), and slightly higher mean values occur at the Strum site (K = 3 x 10-5 m/s). The K values at Risdal North have a bimodal distribution, which suggests some heterogeneity within the alluvium that is not apparent in the boring logs. In contrast, K values at the Strum site are quite uniform. Figure 1. Site map of the Strum farm showing location of buffer study site and monitoring wells. Field slope is 0.15. Figure 2. Fence diagram showing geographic relationships at Strum site. Figure 3. Hydraulic heads measured by pressure transducers in four monitoring wells at the Strum site between May 28, 1999 (150 days) and July 17, 1999 (200 days). A consistent hydraulic gradient toward the creek throughout this period indicates that groundwater flows from the field toward the creek. Three recharge events occurred at or near 155, 162, and 174 days. The decline in hydraulic heads shown here marks the beginning of an extended dry period. Groundwater velocities and residence times were calculated with the average linear velocity equation, and these were used to estimate the groundwater residence time in the buffers. The estimated groundwater residence time is 3.5 to 4 months for the Risdal sites and 9 months for the Strum site. Using Darcy's Law and the Dupuit equation, we estimate that the three buffers contributed about 11 m3day-1 of groundwater to the creek during the study period. An additional array of 15 multilevel piezometers with sampling ports at 0.3 m intervals was installed in 1997 and 1998 to perform forced-gradient tracer tests. The array is within the cool-season grass riparian buffer (Risdal North). By comparison with values estimated from the monitoring wells, results of the initial tracer test suggested a K of 1.8 x 10-4 m/s, a longitudinal dispersivity of 0.07 m, and an average linear velocity of 0.38 m/d. A second tracer test was performed with an injection rate of 200 L/d, an average hydraulic gradient of 0.02, and an initial concentration of 4 mM Br. Modeled results of the second tracer test show a K of 3.8 x 10-5 m/s, a longitudinal dispersivity of 0.05 m, and an average linear velocity of 0.27 m/d. These values suggest a groundwater residence time of only 60 to 80 days in the buffer. Water movement through the unsaturated zone is being characterized and used to estimate the flux of agrichemicals, primarily NO3-N, in the unsaturated zone of the three instrumented buffers. Soil tension measurements have been made on a weekly to bimonthly basis and after precipitation events since Spring 1997 (Figure 4). Measurements are made using porous-cup tensiometers and a tensiometer from Soil Measurement Systems, Inc. Figure 4. Pressure head (soil moisture potential) data from three tensiometers (depths of 0.30, 0.91, and 1.5 m) as measured by pressure transducers at the Strum site. Data are for the period of May 9, 2000 (130 days) through June 6, 2000 (158 days). Upward moisture gradients dominated at all depths during this period. Decline in moisture potential at 150 days is the result of precipitation. Data from all three sites suggest both vertical and horizontal components of flow. Within Risdal North, upward hydraulic gradients dominated the unsaturated zone from May 1997 through June 1998, especially during periods of low precipitation and high evapotranspiration. As indicated by data collected on 26 May 1998, water may move upward and toward the field edge, which could be the result of high evapotranspiration demand by a lush band of cool-season grass growing at the field edge. A low matric potential zone (indicated by the lower hydraulic head) in the center of the transect on this date may reflect a change in soil morphology and a path for water movement not characteristic of the entire buffer. The decline in the water table about 6 meters from the field edge may be due to the water that accumulates and mounds near the crop field/buffer border where the eroded topsoil has created a small (< 0.2 m) berm. The flow direction in the unsaturated zone reverses during periods of high precipitation and winter thawing events, resulting in a net downward movement of water (recharge) and a hint of a lateral hydraulic gradient to the stream (interflow). Transducer data from tensiometers taken during a ten-day period in June 1998 also suggest a rapid response of the system to precipitation events. The tensiometer and monitoring well data together indicate that such infiltration events can result in a rapid water-table rise (recharge) of 1.3 m. A weather station at the adjacent research site is used for monitoring air and soil temperature, relative humidity, wind speed, solar input, rainfall and wet- and dry-fall. Integrating all this information, a water balance for each water-sampling station is being developed based on measured rainfall inputs, observed changes in soil moisture, and potential evapotranspiration as calculated from our weather-station data. This will allow for the evaluation of vegetation effects on the site water balance and will be used as input data for the hydrology component of the REMM model. Hydrogeochemistry and Water Quality Groundwater from the monitoring wells have been sampled and analyzed for NO3-N, NH4-N, dissolved O2 (DO), temperature, specific conductance, chloride, N2O and N2 gas on a bimonthly to monthly basis, and dissolved organic carbon, pH, and alkalinity on a quarterly basis since summer 1996. Groundwater samples are obtained by using low-flow purging techniques at or near the water table. NO3-N concentrations in groundwater show well-defined decreases at two of the three sites, in particular at Risdal North (Figure 5). Mean NO3-N concentrations from the edge of the field to the creek during the study period were as follows: Risdal North decreased from 13.2 mg/L to 3.2 mg/L; Strum decreased from 11.3 mg/L to 6.8 mg/L; and Risdal South did not show a well defined decrease. An increase in N2O and a decrease in dissolved O2 concentrations generally accompany the decrease in NO3-N concentrations. These relationships, along with fairly constant Cl concentrations across the buffer, suggest that denitrification is involved in attenuating NO3-N near the water table. The fact that the trends are less clear at sites like Risdal South attests to the inherent spatial variability of processes in this system. Figure 5. NO3-N concentrations from four monitoring wells at the Strum site from January 1, 1999 (0 days) to May 10, 2000 (500 days). Concentrations were generally highest at the field edge and declined toward the creek, with the exception of well S28 near the creek. Anomalously high concentrations in S28 may be the result of bank storage caused by beaver dam construction. Data from the multilevel piezometers show a general increase in NO3-N concentration with depth from 1.3 to 14.3 mg/L NO3-N. In this same interval, the concentration of Cl, a conservative anion, varies only from 16.4 to 16.9 mg/L. This suggests that NO3-N concentrations are not decreased by dilution from another groundwater source. In addition, the concentration of N2O, a byproduct of denitrification, peaks at 2.1 m (0.29 µmol/L) and decreases to 0.09 µmol/L at 2.7 m. The coupling of NO3-N concentration decrease with N2O production again suggests that denitrification is causing the decrease in NO3-N concentration at the top of the water table. Dissolved organic carbon (DOC) concentrations at the water table range from 0.2 to 6.0 mg/L; these values suggest that there is sufficient carbon for denitrification. The data from the vertical profiles also suggest that a significant amount of NO3-N is transported near the base of the aquifer. Subsequent tracer tests used both Br and NO3-N as tracers to estimate the rate of NO3-N loss at various depths in the buffers. Nitrate leaching losses in the buffers are determined from pore water NO3-N concentrations obtained with the suction lysimeters positioned at four depths. Results indicate that nitrate concentrations in the vadose zone are much lower across the buffer than within the adjacent, cultivated field. Although concentrations of nitrate-nitrogen within the vadose zone of the cropped field will vary from year to year depending upon crop rotation, average concentrations measured within the unsaturated zone nearest the stream have never exceeded 3 mg L-1. In contrast, concentrations of nitrate-nitrogen measured in the vadose zone within a field cropped to the stream edge showed no reduction nearer the stream (data not shown). Evaluation of Nitrate Sinks Denitrification: Intact rates of denitrification and denitrification potential within the vadose zone are estimated by the intact soil core - acetylene block technique. Both intact rates and denitrification potential were higher within soils under trees and switchgrass than under crops. There is also an effect of time since establishment of buffer vegetation, because intact and potential rates were higher under buffer vegetation eight years of age than under the same vegetation four years of age. Both sampling sites were located on the same soil type and were in row crops before buffer establishment. These data are in agreement with other studies demonstrating the importance of a continuous supply of carbon as an energy source for sustained nitrate removal by denitrification and the linkage between vegetation and denitrification and imply that riparian buffers will become more efficient in retaining nitrate as they mature. These carbon inputs from surface vegetation are also likely to be very important in providing energy for denitrification in shallow groundwater. Soil Respiration/Root Distribution: Studies have been conducted on the oldest buffer site, established in 1990. In the seventh growing season, in situ soil respiration was significantly greater in the buffer soils than in the crop field soils. Live fine root biomass also was greater in the MRB zones than in the crop fields and fine root production ranged from 1700 kg/ha in the soybean field to 5800 kg/ha in the switchgrass. Average end-of-season above ground detritus in the different systems ranged from 19 Mg/ha in the switchgrass to 7.9 Mg/ha in the corn fields to 0.8 Mg/ha in the soybean fields. Differences in fine root production, in situ soil respiration rate, and fine root biomass are all consistent in suggesting greater C availability in the soils of the buffers than in the crop fields. Switchgrass and poplar have deeper rooting systems than do the crops or cool-season grasses, suggesting a potential for C inputs throughout the soil profile. Soil Quality: In the seventh growing season, total soil organic C (SOC) was also significantly greater in the buffer soils than in the crop field soils. Mean SOC content in the buffer soils and cropped soils were 136 MG ha-1 and 70 Mg ha-1, respectively. Total organic C increases since the buffer was established seven years ago were 123% for poplar, 85% for switchgrass, and 61% for cool-season grass. Total particulate organic matter (POM) carbon comprised 16-23% of the SOC in the buffer soils and only 9-18% in the cropped soils. When the cropped plots are used as a baseline, POM C increased 255% in the poplar, 178% in the cool season grass, and 156% in the switchgrass since the buffer was established seven years ago. Infiltration: A soil water infiltration study conducted in 1995 (sixth growing season of the MRBS) found that cumulative infiltration rates under the buffer were five times greater than under the cultivated fields. Within the buffer infiltration rates were silver maple > cool season grass > switchgrass. Soil bulk densities in the buffer were also significantly lower than in the cropped fields. These improvements in soil quality serve as an indicator of the soil's structural and biological integrity, which in turn is related to the status of certain degradative processes and to environmental and biological plant stress. As these preliminary responses become more quantified they will provide input to the unanswered questions about the effectiveness of a multispecies restored riparian buffer model in the midwestern United States agricultural landscape. Such data presently do not exist outside of our studies and their lack is hindering the development of design and management strategies for these landscape buffers. Modeling: The Riparian Ecosystem Management Model was made available for testing in June 1999. We are in the process of parameterizing the model by using data collected at the research site. This information will be utilized to validate the model which will then be used to evaluate management alternatives in riparian areas for mitigating nonpoint source pollution and for simulating the changes in buffer function over time since establishment. Literature Cited: Altier, L.S., R.R. Lowrance, R.G. Williams, J.M. Sheridan, D.D. Bosch, R.K. Hubbard, W.C. Mills and D.L. Thomas. 1994. An ecosystem model for the management of riparian areas. Pages 373-387. In: Riparian ecosystems in the humid U.S.: functions and values. Nat. Assoc. Conserv. Districts, Washington, D.C. Bettis, E.A., Baker, R.G., Green, W.R., Whelan, M.K., and Benn, D.W., 1992, Late Wisconsinan and Holocene alluvial stratigraphy, paleoecology, and archaeological geology of east-central Iowa: Iowa Geological Survey Bureau Guidebook no. 12, 82p. Kemmis, T.J., Hallberg, G.R., and Lutenegger, A.J., 1981, Depositional environments of glacial sediments and landforms on the Des Moines Lobe: Iowa Geological Survey Guidebook Series no. 6, 132 p. Prior, J.C., 1991, Landforms of Iowa: University of Iowa, Burr Oak Press, 153 p. Simpkins, W.W., 1993, Hydrogeology and hydrogeochemistry of the CRMBS site in W.W. Simpkins, ed., Water, Water, Everywhere....: Guidebook for the 57th Annual Tri-State Geological Field Conference and Geological Society of Iowa Guidebook no. 58, p. 111-132. SYNOPSIS Project Number: 425-17-01 Start: June, 1999 End: February 28, 2001 Title: Pilot study of bio-markers for evaluation of water quality in Iowa streams Investigators: George M. Breuer, Ph.D., CIH, Periyasamy Subramanian, Ph.D., CIH, and Stephen J. Reynolds, Ph.D., CIH, University of Iowa, Iowa City, Iowa; Amadu Ayebo, Indiana University of Pennsylvania, Indiana, Pennsylvania Congressional District: Iowa First Focus Category: MET Descriptors: Animal Waste, Streams Problem and research objectives: The goal of this pilot study is to identify sterol based biomarkers useful in evaluating and monitoring Iowa streams with respect to human and animal waste pollution. The sterols are involved in physiological processes in animals, with related but different compounds being produced in plants and fungi. Thus such compounds present promise as indicators of animal-derived pollution. Methodology: The essence of this work as a pilot study is divisible into two portions. The first essential is development and validation of methods for the matrices of importance for stream evaluation. Once such methods are established in laboratory work, it is essential to evaluate their applicability in actual environmental measurements, preferably in situations that are well defined in terms of pollution input. Principal findings and significance: Both water and sediment methods have been developed for sterols in environmental samples, based on an adaptation of the standard USEPA method 8270, a GC/MS method with both aqueous and solid sample options. To optimize sensitivity, a derivatization step to form the trimethyl silyl esters of the sterols is advantageous, adding complexity to the method but proving to be fairly straightforward. Deuterated cholesterol was found to work well as a surrogate, and this quality control feature has been incorporated into the methods to reduce variability, especially for sediment samples where the derivatization may be matrix dependent. Preliminary field samples showed correlation with the amount of sediment in the sample, with essentially no detectable sterols in clear water samples, so the original proposed method development—involving only an aqueous method—was modified. This is consistent with the sterols being fused ring hydrocarbons with few attached functional groups and with carbon numbers in the 20 or higher range, thus having very limited water solubility. It also suggests that the sterols may tend to accumulate in the sediment in streams so that the sterol concentration in the sediment may act as an integrating exposure index of animal and/or human impact. The grant award in midsummer along with a somewhat longer method development process following award (owing to the need for a sediment procedure as well as an aqueous procedure) and the extremely dry fall weather in 1999 leaving some small case-study streams dry has hampered the field aspect of this study. An extension of the grant period has been obtained to complete a reasonable field effort. However, several preliminary environmental samples were collected to ensure applicability of the methods developed to real environmental matrices. A lake sediment was used initially as a convenient matrix because of its high sterol content. To begin assessment of the ability to distinguish species, sterols in fecal material from four species (chicken, bovine, equine, and swine) were also run, showing some promise of distinguishing species although ratios are different in some respects to those of Leeming et al. (R. Leeming, A. Ball, N. Ashbolt and P. D. Nichols, "Using faecal sterols from humans and animals to distinguish faecal pollution in receiving waters", Water Research, 30, 2893-2900 (1996)). Other field data show good surrogate percentage recovery, which averages 74 +/- 10 % for sediment samples and 74 +/- 8 % for water samples. Sampling in field situations represented four basins with intensive animal husbandry, based on IDNR figures on animal waste permits, two comparable agricultural basins with little animal husbandry but typical agricultural and wastewater discharges, a "control basin" in notheast Iowa, and some remote samples from a co-investigator at Indiana University of Pennsylvania. The final report will cover the field sampling work and a discussion of the interpretation of results. An interim progress report was submitted to the Iowa State Water Resources Research Institute on December 17, 1999. SYNOPSIS Project Number: 03 Start: 03/01/1999 End: 02/28/2001 Title: A prediction system for transport and fate of toxic substances in surface waters Investigator: Ruochuan Gu, Associate Professor, Ph.D., P.E. Dept. of Civil and Construction Engineering Iowa State University Congressional District: Iowa Third Focus Categories: TS, MOD, WQL Descriptors: Water Quality Modeling, Toxic Substances, Contaminant Transport, Rivers, Reservoirs, Water Quality Control Problems and research objectives: Toxic substances from chemical spills and nonpoint source runoff into rivers, reservoirs, or lakes pose a potential risk to human health and aquatic lives. Accidental spills can be caused by train derails and truck collisions during ground transportation, leaking from factories and storage tanks, and obsolete navigation (barges in the Midwest waterways and tankers in other regions). Toxic contaminants from spills and runoff have a significant impact on the environment and continue to be a serious threat to watersheds and water resources. The inevitability of toxic spills and runoff points to the need for a full understanding of the behavior (transport and fate) of toxic chemicals in surface waters and an effective tool for prediction to assist contamination control, remediation management, and watershed protection. On the other hand, lack of understanding of toxic substance behavior in a reservoir can hamper effective implementation of spill control measures. The objectives of the research are (1) to develop and validate an integrated 2-D mathematical model that simulates and predicts the fate and transport of toxic chemical spills and runoff in rivers and reservoirs or lakes, (2) to develop a real-time prediction and analysis computer program for emergency responses and remediation management, and (3) to incorporate the prediction system into an existing regional contingency plan or a toxic contamination control program at the state level. Methodology: This research project will develop and validate an integrated 2-D mathematical model and a real-time computer program that predicts the fate and transport of toxic substances in rivers and reservoirs or lakes, investigates the flow behavior and mixing processes in various flow regimes, and evaluates their effects on the dilution of spilled or runoff-carried chemicals and water quality conditions in a stratified reservoir or lake. The three components and interactions of toxic substances in a stream and reservoir system (flow of water, transport of sediments, and fate and transport of toxic chemicals) will be formulated and integrated. The physical and biochemical processes will be internally linked by coupling the unsteady equations for flows, sediments, and toxic contaminants. The model simulating the fate and transport of spilled or nonpoint source toxic chemicals will be incorporated into a computer prediction and analysis program consisting of the following three modules for ease and quickness: (1) a menu-based pre-processor for interactive data preparation and execution of other modules, (2) the spill model for prediction, simulation, and analysis, and (3) a post-processor that provides a graphic interface for visualizing the results of the spill model to keep track of a spill in a waterbody. The model to be developed will be tested and validated against the field data of past spills into the Sacramento River and Shasta Reservoir and the observations of contaminated density currents (carrying toxic chemicals) in the Des Moines River and Saylorville Reservoir, Iowa. This test will focus on the fate and transport of pesticides, including atrazine, alachlor, and dieldrin. Project Progress Report: This project has supported one graduate student. Progress in this research during the first year of the award period has been made on Tasks 1 and 2 as planned in the original proposal. Task 1, formulation of the 2-D toxic substance model and numerical solutions, has been completed. The model (TOXIC-W2 Version 1.0) has been developed by formulating and integrating the three components and interactions of toxic substances in a stream and reservoir system. The physical and biochemical processes were internally linked by coupling the unsteady equations for flows, sediments, and toxic contaminants. The model incorporated the kinetics of physical processes, chemical reactions, and biological transformations. The numerical solutions to the model have been obtained. The FORTRAN computer code for the model has been written and tested. The result of this task has generated a part of a Ph.D. dissertation and a peer-reviewed journal paper (submitted to Water Research, published by International Association on Water Quality). Task 2, development of the real-time prediction and analysis program incorporating the 2-D model and establishing a data base module and a graphics visualization module for the program, has been carried out in part with primary progress in program development. A Visual Basic computer prediction and analysis program, TSPS Version 1.0, has been developed. The development of the program was done by incorporating the FORTRAN model (TOXIC-W2 Version 1.0) produced by Task 1, establishing an interface for the Visual Basic program and the FORTRAN model, and using a menu-based pre-processor module for interactive data preparation and execution of other modules. The other modules include the FORTRAN model and the output display or graphics visualization module. The first manual for the FORTRAN model (TOXIC-W2 Version 1.0) and a preliminary description of the Visual Basic program (TSPS Version 1.0) have been drafted. Task 2 will continue, including completion of the pre-processing module, the execution of the FORTRAN model within the Visual Basic program, and development and execution of the output-displaying module. Task 3 (model test and validation against field data) will be performed during the second year as the project is to be continued. Future Work: Future work will proceed according to plans in the proposal. From now to the end of the project (February 28, 2001), we will wrap up task 2 "Development of the real-time prediction and analysis program using Visual Basic" and complete task 3 "Test the model against field data and observations." SYNOPSIS Project Number: C - 03 Start: 9/97 End: 8/00 Title: Enhancing the Abiotic Degradation of Trichloroethylene with Bimetals Investigators: Say Kee Ong Iowa State University Congressional District: Iowa Third Focus Category: TS, WQL, TRT Descriptors: Hazardous Waste, Organic Compounds, Water Quality Control, Groundwater Quality Problem and Research Objectives: A remedial treatment technology currently under development for the treatment of contaminated groundwater is the reductive dehalogenation of chlorinated solvents by using zero-valent iron. With zero-valent iron, the reduction of C1 chlorinated compounds such as carbon tetrachloride is rapid with half-lives in the order of several hours, but for C2 chlorinated compounds such as trichloroethylene (TCE), the degradation rates are slow with half-lives in the order of one to two days. The objectives of the research are to enhance the degradation rates of TCE by coating the zero-valent iron with noble metals such as copper and nickel (called bimetals) and to investigate the mechanism of enhanced degradation of bimetals. Methodology: The research methodology includes: (i) using the cold electrodeless plating method to prepare copper and nickel coated-iron (bimetals), (ii) conducting batch degradation experiments with bimetals and aqueous solution of TCE, and (iii) elucidating the probable degradation process with bimetals. Cold plating of copper on zero-valent iron was accomplished by adding zero-valent iron to copper sulfate solution. Similar nickel plating was conducted using nickel sulfate solution. Batch degradation experiments were used to study the degradation rates and the degradation mechanism. The headspace method using 60 mL vials was used. Twenty mL of TCE-contaminated water and 10 gms of bimetals were mixed in the vial. The headspace and the liquid samples were analyzed to determine the degradation rates of TCE and the production of byproducts. Principal Findings and Significance: Preparation of bimetals was accomplished by using the cold electrodeless plating method. Copper plating was rapid and was completed in a few minutes whereas nickel plating was slower, taking about one to two hours for the reaction to be completed. The results showed that bimetals can be prepared in a simple and inexpensive way by the cold electrodeless method. However, work is currently being conducted to assess the stability and leaching of copper and nickel during the dehaolgenation reaction. Batch degradation experiments were conducted using copper-coated iron and nickel-coated iron. These experiments showed that the degradation rates of TCE were enhanced by at least 50 times more than the rates from using zero-valent iron only. The optimum concentrations of copper and nickel needed to maximize the reaction were found to be 8% and 1.5%, respectively. The significance of this research is that bimetals may be used to enhance the reductive dehalogenation of TCE. In addition, less byproducts were formed when bimetals were used than when zero-valent iron only was used. The dominant byproducts formed using bimetals were ethene and ethane, which are innocuous compounds. Dissolution of copper and nickel from the reductive reaction had minimum impact.

Information Transfer Program

ISWRRI co-sponsored an "ISU Provosts' Conference on Water." This conference was held in Ames, Iowa, on March 24, 2000 and was organized in partnership with four states (Iowa, Nebraska, Missouri, and Kansas) and EPA Region VII. The purpose of the ISU Provosts' Water Conference was to: 1) create awareness of diversity in water related research at ISU, 2) promote research collaboration teams, and 3) identify global opportunities for research. Four broad themes were identified relating to water issues: water quality, water quantity, water demand, and water management. Each theme discussed opportunities in the areas of research, education, outreach, and global collaborations. At the follow-up two-day conference (March 25 and 26) of the four states and EPA Region VII discussion covered several topics related to the Clean Water Action Plan that each state is responsible for developing. Two international speakers were invited to make keynote presentations at the Provost's Water Conference. Mr. Wulf Klohn, Senior Water Resources Officer, Food and Agriculture Organization (FAO) of the United Nations gave a presentation on "Food for all – Is there enough water to make it possible?". The First Secretary of the Turkish Embassy gave a presentation on "Water Projects in Turkey," which are funded for about $22 billion. About 200 people attended this conference. ISWRRI co-sponsored another conference on "Agriculture and the Environment: A wake up call for Iowans". This conference was held on March 7-8, 2000 in Ames, Iowa. The propose of this conference was to 1) provide a forum for awareness and discussion of critical issues affecting water resources, 2) address federal and state nonpoint source pollution policies that will potentially have an impact on land management in agricultural watersheds, and 3) address specific topics that focus on total maximum daily loads, nutrient criteria, animal feeding operations, and source water protection. Mr. Charles Fox, Assistant Administrator, U.S. EPA; Dr. Paul Johnson, Director of the Iowa Department of Natural Resources; Dr. Stanley Johnson, Vice-Provost, Iowa State University Extension; Catherine Kling, Professor of Economics; and Susan Brown, Iowa State University Extension, made keynote presentations at this conference. ISWRRI awarded ten scholarships to graduate students to pay their registration fees to attend the conference. Another ISWRRI activity on information dissemination is to participate in field days organized by the Iowa Agriculture and Home Economics Experiment Station. The water resources faculty at Iowa State University participated in numerous field days in 1999. Drs. James Baker, Jeff Lorimor, Bill Crumpton, John Downing, Stu Melvin, and Ramesh Kanwar shared results of their research projects (on poultry and swine manure effects on water quality, role of wetlands to mitigate water quality, and BMP's to reduce water quality implications) with more than 300 farmers/producers/stakeholders at a field day on September 6, 1999. Mr. Carl Pederson made a presentation to more than 150 farmers at the Northeast Research Center near Nashua, Iowa, on the impact of swine manure, late spring nitrate test, alfalfa, and strip cropping on water quality in September 1999. The ISWRRI has set up a new web site (address: www.water.iastate.edu) to promote outreach/information transfer programs. ISWRRI has awarded two undergraduate student and one high school student research internships. ISWRRI HELPED CONDUCT THESE TOURS OF THE BEAR CREEK WATERSHED: Jan. 21, 2000 Operations Manager and Regional Forester from the Minnesota Department of Natural Resources. Sept. 16, 1999 Bear Creek Watershed Project Cooperators Appreciation Day. (100 attendees). Sept. 15, 1999 USDA Farm Services Agency State office employees and State Commissioners. (35 attendees). Sept. 10, 1999 Attendees of the IA Environmental Council Annual Meeting. (26 attendees). Sept. 2, 1999 Team of South African Conservation Professionals (8 attendees). Sept. 1, 1999 Soil and Water District Commissioners from across IA as part of their annual meeting. (45 attendees). Aug. 24, 1999 Julie Elfving (USEPA Region 7) and members of the Federal Coordination Team of the Clean Water Action Plan (7 attendees). Aug. 11, 1999 Members of NCT-179 as part of a meeting being held in Ames organizing an NC project entitled Integrating biophysical functions of riparian systems with management practices and policies. (20 attendees). July 14, 1999 Tour as part of the Annual Northeastern Nurserymen conference - Nursery challenges for the new millennium (65 attendees). July 13, 1999 Story County Master Conservationist class. (25 attendees) July 13, 1999 Chris Hoag, wetland ecologist with USDA-NRCS Interagency Riparian/Wetland Plant Development Team. July 12, 1999 Videographers from the Egyptian Ministry of Water filming a documentary on water quality (8 attendees). June 30, 1999 Natural resource professionals from Kansas (NRCS, K. State, KDNR, etc.) who are working to implement a Kansas buffer initiative (20 attendees). June 29, 1999 Jerry Perkins, Farm and Country Page Editor of the Des Moines Register which resulted in an article in the Sunday Register on July 18, 1999. June 10, 1999 Delegation from IL Farm Bureau and commodity organizations in IL working with Trees Forever to implement an Illinois Buffer Initiative. (12 attendees) June 6, 1999 Attendees of the North Central 1876 College Teaching Symposium (20 attendees). June 4, 1999 Delegation of four senior scientists from the Indian Council of Agricultural Research. (8 attendees) May 28, 1999 Farmer from Wales being hosted by the Leopold Center for Sustainable Agriculture. May 27, 1999 Water quality field day for grade school students from Fellows Elementary School of the Ames School District, organized by Murphy Family Farms (60 attendees). May 17, 1999 Anne Sansom, Rural Land Use Officer, Environment Agency, United Kingdom. May 10, 1999 Visiting scientists from the US Forest Service/USDA National Agroforestry Center, Lincoln NE. (6 attendees) ISWRRI HOSTED THE FOLLOWING WORKSHOPS: Iowa Society of American Foresters Annual Conference – Bridges to the 21st Century ISU Field Extension Education Laboratory October 21, 1999 (60 attendees) Riparian Buffers for Water Quality and Wildlife Farm Progress Show Exhibit, Amana, IA September 28-30, 1999 Bear Creek Watershed Project Cooperators Appreciation Day Ron Risdal Farm September 16, 1999 (100 attendees) Alternative Riparian Assessment Procedures Workshop Rathbun Rural Water Association, Centerville IA. Co-hosted with Chariton Valley RC&D May 26-27, 1999 (20 attendees) Workshop designed to train natural resource managers and researchers on current alternative riparian assessment methodologies. Trees, Trees, Trees Iowa State University May 3, 1999 Workshop for nearly 140 (six groups of 24) first to fourth graders from Nevada Elementary School. Riparian Management Systems Workshop Fayetteville, AK April 12, 1999 (40 attendees) Workshop held in conjunction with the USEPA Region 6 Nonpoint Source Watershed Conference: Innovative Strategies for the New Millennium. PRESENTATIONS Role and functions of wetland, Importance to Clean Water Action Plan. (W.G. Crumpton). Presentation at the EPA Region 7 Seventh Annual Nonpoint Source Conference. Ames IA March 1999. Dynamics of Nitrate Loss in Emergent Wetlands. Presentation at the Sixth Symposium on Biogeochemistry of Wetlands, Ft. Lauderdale, FL, July 1999. Dynamics of Nitrate Loss in Emergent Wetlands: Wetlands as Sinks for Non-Point Source Nitrate Loads. Invited presentation as part of the Duke University Wetland Center's Distinguished Speaker Series, Duke University, December 3, 1999. Watersheds. Invited presentation by T.M. Isenhart at the Winterfest 2000 – 29th Annual Meeting of the Iowa Association of County Conservation Employees. Marshalltown, IA. February, 2000. The Bear Creek Watershed Project: riparian management systems for water quality and wildlife. Invited presentation by T.M. Isenhart to the Winter 2000 meeting of the Iowa Chapter of The Wildlife Society. Ames, IA. January, 2000. Environmental Impacts of Nutrients in Iowa Surface Water. Invited presentation by T.M. Isenhart to the Iowa Nutrient

Management Task Force. West Des Moines, IA. January, 2000. Gulf of Mexico hypoxia: riparian and wetland systems as nonpoint source nitrogen sinks in the Mississippi Basin. Invited presentation by T.M Isenhart in the Riparian Ecosystem Symposium at the 61st Midwest Fish and Wildlife Conference. Chicago, IL. December, 1999. Hydrology of natural and disturbed riparian areas. Invited presentation by R.C. Schultz in the Riparian Ecosystem Symposium at the 61st Midwest Fish and Wildlife Conference. Chicago, IL. December, 1999. Integrative riparian restoration and management approaches. Invited presentation by R.C. Schultz in the Riparian Ecosystem Symposium at the 61st Midwest Fish and Wildlife Conference. Chicago, IL. December, 1999. Riparian systems: benefit/cost anaylsis. Invited presentation by J.P. Colletti in the Riparian Ecosystem Symposium at the 61st Midwest Fish and Wildlife Conference. Chicago, IL. December, 1999. Economic and social considerations of buffers. Invited presentation by J.P. Colletti in the Symposium on Conservation Buffers at the American Society of Agronomy Annual Meeting. Salt Lake City, UT. October, 1999. Root dynamics in riparian buffers and adjacent croplands. Presentation by A. Tufekcioglu at the American Society of Agronomy Annual Meeting. Salt Lake City, UT. October, 1999. Influence of vegetation type on soil structural stability in a riparian buffer system. Presentation by O. Marquez at the American Society of Agronomy Annual Meeting. Salt Lake City, UT. October, 1999. Assessment and prediction of the fate of nitrate in reestablished riparian buffers. Invited poster presentation by T.M. Isenhart for USDA-NRI grant recipients at the American Society of Agronomy Annual Meeting. Salt Lake City, UT. October, 1999. Integrating woody, prairie, and wetland plants to improve agricultural land stewardship. Invited presentation by J.P Colletti, T.M. Isenhart and R.C. Schultz to the Iowa Society of American Foresters Annual Meeting. Ames, IA. October, 1999. Introduction to the Bear Creek Buffer System. Invited presentation by R.C. Schultz, J.P Colletti, and T.M. Isenhart at the Annual Northeastern Nurserymen conference - Nursery challenges for the new millennium. Ames, IA. July, 1999. Effectiveness of a multi-species riparian buffer in trapping sediment and nutrients during rainfall simulations. Presentation by K.H. Lee at the 6th North American Agroforestry Conference. Hot Springs, AK. June, 1999. Infiltration and surface runoff comparisons of row-crops, pasture, forest, cool-season grass, and switchgrass land-use practices in Central IA.. Presentation by R.P. Maiers at the 6th North American Agroforestry Conference. Hot Springs, AK. June, 1999. Soil respiration differences among a multi-species riparian buffer, grass filters and adjacent crop fields. Presentation by A. Tufekcioglu at the 6th North American Agroforestry Conference. Hot Springs, AK. June, 1999. Microbial Biomass and Nitrate Immobilization in a Multi-Species Riparian Buffer. Presentation by J.E. Pickle at the 6th North American Agroforestry Conference. Hot Springs, AK. June, 1999. Temporal variation of aggregate distribution and organic carbon under different riparian zone vegetation. Presentation by C.O. Marquez at the 6th North American Agroforestry Conference. Hot Springs, AK. June, 1999. Streambank erosion adjacent to different riparian land-use practices. Presentation by G.N. Zaimes at the 6th North American Agroforestry Conference. Hot Springs, AK. June, 1999. Multi-species riparian buffers – an agroforestry practice that provides effective conservation buffers in agricultural landscapes.. Presentation by R.C. Schultz at the 6th North American Agroforestry Conference. Hot Springs, AK. June, 1999. Changes in soil organic carbon following establishment of a riparian buffer on previously cropped soil. Presentation by O. Marquez at the 111th Annual Meeting of the Iowa Academy of Science. Ames, IA. April, 1999. The effect of land-use practices on hydrologic properties of riparian soils in central Iowa. Presentation by R.P. Maiers at the 111th Annual Meeting of the Iowa Academy of Science. Ames, IA. April, 1999. Multispecies riparian buffer system in central Iowa for controlling sediment and nutrient losses during simulated rain. Presentation by Kye-han Lee at the 111th Annual Meeting of the Iowa Academy of Science. Ames, IA. April, 1999. Presentation by K.H. Lee at the 111th Annual Meeting of the Iowa Academy of Science. Ames, IA. April, 1999. Soil respiration, temperature, and moisture differences among a multspecies riparian buffer, grass filters and row-cropped fields. Presentation by A Tufekcioglu at the 111th Annual Meeting of the Iowa Academy of Science. Ames, IA. April, 1999. Presentation by K.H. Lee at the 111th Annual Meeting of the Iowa Academy of Science. Ames, IA. April, 1999. Roles and functions of riparian corridors. Invited presentation by T.M. Isenhart at the EPA Region 7 Annual Nonpoint Source Conference "From the Heartland to the World: the Importance of Clean Water". Ames, IA. March 1999. Carbon research as a component of the Bear Creek Watershed Project. Invited presentation by T.M. Isenhart and R.C. Schultz at the Iowa Carbon Summit. Des Moines, IA. March, 1999.

USGS Internship Program

Student Support

Student Support					
Category	**Section 104 Base Grant**	**Section 104 RCGP Award**	**NIWR-USGS Internship**	**Supplemental Awards**	**Total**
Undergraduate	N/A	N/A	N/A	N/A	N/A
Masters	3	4	N/A	N/A	7
Ph.D.	2	1	N/A	N/A	3
Post-Doc.	1	1	N/A	N/A	2
Total	6	6	N/A	N/A	12

Awards & Achievements

ISU WATER QUALITY PROJECT RECEIVES NATIONAL HONOR AMES -- An Iowa State University project has received a national designation as a model for restoring stream corridors and improving water quality. ISU's Bear Creek Watershed Project was one of 12 projects nationwide selected to be a "National Restoration Demonstration Watershed" under the Clean Water Action Plan, a program by nine federal agencies to revitalize the nation's commitment for clean, safe water. The Action Plan was announced last year as part of the 25th anniversary of the 1972 Clean Water Act. "The designated projects will be demonstration areas that showcase the application of technology to restore stream corridors and to improve environment, water quality and community," said Tom Isenhart, an ISU forestry researcher. This is the project's second national honor in the past year. In 1998 the Bear Creek project was designated a national research and demonstration area by the U.S. Department of Agriculture. The ISU project site, located near Roland, began in 1990 as an effort to study ways to re-establish native vegetation along creeks that run through Iowa farm fields. Working with local landowners, a team of ISU researchers planted a variety of trees, shrubs and native grasses along the streambanks. Researchers also worked to stabilize eroding streambanks and constructed nearby wetlands. Studies have shown the buffers have helped slow runoff, trap sediment, increase water infiltration and reduce nitrate and atrazine levels in the water. The wetlands have helped to slow water movement, improve water quality and enhance wildlife habitat. The site, which now includes five miles of buffers along Bear Creek, has been used extensively by the USDA for promoting water quality and for training others on restoring streamsides. Each year hundreds of people visit the site to learn more about the project. In 1998 ISU, Trees Forever and other agricultural organizations began a five-year project to establish 100 buffer demonstration sites in Iowa. The project recommends using ISU's system of buffers, wetlands and stabilized streambanks as a model. The ISU team continues to study how buffers improve water quality, how wildlife use the areas and whether there are alternative methods to stabilize streambanks. They also are assessing the economics of buffer establishment. The Bear Creek Watershed Project is managed by ISU's Department of Forestry through the Agroecology Issue Team of the Leopold Center for Sustainable Agriculture. Funding has come from the Leopold Center, USDA, Environmental Protection Agency, U.S. Geological Survey, Iowa Department of Natural Resources and Pheasants Forever. http://www.epa.gov/owow/showcase/bearcreek/summary.html STUDENT RECOGNIZED AT SYMPOSIUM Todd Dejournett won the Student Best Paper Award at the 5th International Symposium on In Situ and Onsite Bioremediation, sponsored by Battelle, at San Diego, CA, April 19-22, 1999. TOURS CONDUCTED OF THE BEAR CREEK WATERSHED Jan. 21, 2000 Operations Manager and Regional Forester from the Minnesota

Department of Natural Resources. Sept. 16, 1999 Bear Creek Watershed Project Cooperators Appreciation Day. (100 attendees). Sept. 15, 1999 USDA Farm Services Agency State office employees and State Commissioners. (35 attendees). Sept. 10, 1999 Attendees of the IA Environmental Council Annual Meeting. (26 attendees). Sept. 2, 1999 Team of South African Conservation Professionals (8 attendees). Sept. 1, 1999 Soil and Water District Commissioners from across IA as part of their annual meeting. (45 attendees). Aug. 24, 1999 Julie Elfving (USEPA Region 7) and members of the Federal Coordination Team of the Clean Water Action Plan (7 attendees). Aug. 11, 1999 Members of NCT-179 as part of a meeting being held in Ames organizing an NC project entitled Integrating biophysical functions of riparian systems with management practices and policies. (20 attendees). July 14, 1999 Tour as part of the Annual Northeastern Nurserymen conference - Nursery challenges for the new millennium (65 attendees). July 13, 1999 Story County Master Conservationist class. (25 attendees) July 13, 1999 Chris Hoag, wetland ecologist with USDA-NRCS Interagency Riparian/Wetland Plant Development Team. July 12, 1999 Videographers from the Egyptian Ministry of Water filming a documentary on water quality (8 attendees). June 30, 1999 Natural resource professionals from Kansas (NRCS, K. State, KDNR, etc.) who are working to implement a Kansas buffer initiative (20 attendees). June 29, 1999 Jerry Perkins, Farm and Country Page Editor of the Des Moines Register which resulted in an article in the Sunday Register on July 18, 1999. June 10, 1999 Delegation from IL Farm Bureau and commodity organizations in IL working with Trees Forever to implement an Illinois Buffer Initiative. (12 attendees) June 6, 1999 Attendees of the North Central 1876 College Teaching Symposium (20 attendees). June 4, 1999 Delegation of four senior scientists from the Indian Council of Agricultural Research. (8 attendees) May 28, 1999 Farmer from Wales being hosted by the Leopold Center for Sustainable Agriculture. May 27, 1999 Water quality field day for grade school students from Fellows Elementary School of the Ames School District, organized by Murphy Family Farms (60 attendees). May 17, 1999 Anne Sansom, Rural Land Use Officer, Environment Agency, United Kingdom. May 10, 1999 Visiting scientists from the US Forest Service/USDA National Agroforestry Center, Lincoln NE. (6 attendees) WATER RESOURCE WORKSHOPS HOSTED Iowa Society of American Foresters Annual Conference – Bridges to the 21st Century ISU Field Extension Education Laboratory October 21, 1999 (60 attendees) Riparian Buffers for Water Quality and Wildlife Farm Progress Show Exhibit, Amana, IA September 28-30, 1999 Bear Creek Watershed Project Cooperators Appreciation Day Ron Risdal Farm September 16, 1999 (100 attendees) Alternative Riparian Assessment Procedures Workshop Rathbun Rural Water Association, Centerville IA. Co-hosted with Chariton Valley RC&D May 26-27, 1999 (20 attendees) Workshop designed to train natural resource managers and researchers on current alternative riparian assessment methodologies. Trees, Trees, Trees Iowa State University May 3, 1999 Workshop for nearly 140 (six groups of 24) first to fourth graders from Nevada Elementary School. Riparian Management Systems Workshop Fayetteville, AK April 12, 1999 (40 attendees) Workshop held in conjunction with the USEPA Region 6 Nonpoint Source Watershed Conference: Innovative Strategies for the New Millennium.

Publications from Prior Projects

Articles in Refereed Scientific Journals

Dejournett T. and P.J.J. Alvarez (1999) Combined microbial-Fe(0) system to remove nitrate from contaminated groundwater. Bioremediation Journal (In press) Chung, S. and R. Gu, "Fate and transport of toxic chemicals in a stratified reservoir". Water Research, International Association on Water Quality, Submitted and under review. Chung, S. and R. Gu, "Estimating time-variable kinetic transformation rate of atrazine in a reservoir" Journal of Environmental Engineering, American Society of Civil Engineers, Submitted. Lee, K., T.M. Isenhart, R.C. Schultz, and S.K. Mickelson. 2000 (In press). Multispecies riparian buffers trap sediment and nutrients. J. Environ. Qual. 29: Marquez, C.O., C.A. Cambardella, T.M. Isenhart, and R.C. Schultz. 1999. Assessing soil quality in a riparian buffer strip system by testing organic matter fractions. Agroforestry Systems 44: 133-140. Lee, K., T.M. Isenhart, R.C. Schultz, and S.K. Mickelson. 1999. Sediment and nutrient trapping abilities of

switchgrass and bromegrass buffer strips. Agroforestry Systems 44:121-132. Tufekcioglu, A., J. W. Raich, T.M. Isenhart, and R. C. Schultz. 1999. Root biomass, soil respiration, and root distribution in crop fields and riparian buffer zones. Agroforestry Systems 44:163-174.

Book Chapters

Schultz, R.C., J.P. Colletti, T.M. Isenhart, C.O. Marquez, W.W. Simpkins and C.J. Ball. 2000. Riparian Forest Buffer Practices. Pages 189-281 In: H.E. Garrett, W.J. Rietveld and R.F. Fisher (Eds.) North American Agroforestry: An integrated Science and Practice. American Society of Agonomy, Madison, WI.

Dissertations

Wan Chun Yuan, 2000, Degradation of trichloroethylene using iron, bimetals and trimetals, M.S. Thesis, Dept. of Civil and Construction Engineering, Iowa State University, Ames, IA, 102 pp. Pickle, Joyce E. 1999. Microbial biomass and nitrate immobilization in a multi-species riparian buffer. M.S. Thesis. Department of Forestry. Iowa State University. Andress, Robert J. 1999. Fate and transport of nitrate in groundwater within a riparian buffer in the Bear Creek Watershed. M.S. Thesis. Department of Geological and Atmospheric Sciences. Iowa State University.

Water Resources Research Institute Reports

none

Conference Proceedings

Scherer, M.M., J. Ginner, P.J.J. Alvarez, and K. Johnson (2000). Contaminant remediation by iron metal: shifting kinetic regimes. Proc. Hazardous Waste Research 2000 Conference. Denver, CO. May 23-25, 2000. Dejournett T. and P.J.J. Alvarez* (1999) Combined Microbial-Fe(0) System to Treat Nitrate-Contaminated Groundwater; In: B.C. Alleman and A. L. Leeson (eds.), In Situ and Onsite Bioremediation, Battelle Press, 5(4): 79-84. Ginner G., S. Threkelsen, M. Scherer, and P.J.J. Alvarez (1999). Nitrate reduction by iron metal: the rate limiting step. Proc. 14th HSRC Conference on the Hazardous Waste Remediation, Saint Louis, MO, May 19-21, 1999. Chung, S. and R. Gu, "Two-dimensional modeling of the fate and transport of toxic contaminants in a reservoir" The International Conference on Water, Environment, Ecology. Socio-economics, and Health Engineering, Seoul, Korea, Oct. 18-21, 1999. Yuan, W., T. Fryzek, W. Braida, and S.K. Ong. 2000. Reductive degradation of TCE using bimetallic reductants, 2nd International Conference on Remediation of Chlorinated and Recalcitrant Compounds, May 22 – 25, Monterey, CA. Suroso, I. and S. K. Ong. 2000. Treatment of nitrate-contaminated water with zero-valent iron and bimetals, 2nd International Conference on Remediation of Chlorinated and Recalcitrant Compounds, May 22 – 25, Monterey, CA.

Other Publications

none