Lew, Melvin

WATER RESOURCES RESEARCH GRANT PROGRAM PROJECT DESCRIPTIONS, FISCAL YEAR 1988

U.S. GEOLOGICAL SURVEY
Open-File Report 89—249

OBTAINABLE FROM: National Technical Information Service
Order Department
Springfield, Virginia 22161
U.S.A.

ORDER NUMBER: PB88-161468/AS

COMPLETED PROJECT INFORMATION

GRANT NUMBER: 14-08-0001-G1302

TITLE: Laser Fluorescence/Fiber Optic Monitoring of Ground-Water Contaminant Biodegration

PERFORMING ORGANIZATION: Tufts University

PRINCIPAL INVESTIGATOR: W. A. Chudyk

START: September 1986

FINAL REPORT RECEIVED: December 1987

ABSTRACT:

Land application of hazardous wastes can lead to contamination of ground water and destruction of water resources. The fate and transport of contaminants in ground water are often controlled by natural biodegradation processes that occur under appropriate conditions. These processes can be enhanced, accelerated, or otherwise manipulated to achieve desired results. To predict and control ground-water quality, these processes need to be better understood. It was the aim of this research to find answers to current questions about biodegradation of organic contaminants in aquifers using a newly developed analysis tool.

This report outlines a 1-year research project that determined the utility of the remote, laser-induced fluorescence/fiber optics ground-water contaminant detector (RLIF) technique for monitoring biodegradation processes in ground-water systems. The project involved construction, calibration, and use of model aquifers in the laboratory, as well as use of RLIF to study such models. Results from the small laboratory-model aquifer studies indicate that phenol and trichlorophenol are useful model compounds for the prototype RLIF in monitoring concentration changes resulting from biodegradation.

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ORDER NUMBER: PB88-139761/AS

COMPLETED PROJECT INFORMATION

GRANT NUMBER: 14-08-0001-G1138

TITLE: Influence of Spatial Variability and Scale Effect Parameterization of Hydrologic Responses

PERFORMING ORGANIZATION: Princeton University

PRINCIPAL INVESTIGATOR: E. F. Wood

START: September 1985

FINAL REPORT RECEIVED: January 1988

ABSTRACT:

The overall objective of the proposed research was to investigate the effect of spatial variability on the parameterization of hydrologic models for rainfall-runoff transformation over a range of scales. This work was divided into three tasks: (1) Derivation of the statistics of spatially averaged runoff production (infiltration and runoff) under spatially variable soil, topography, and rainfall. (2) Development of the concept of a representative elementary area (REA) for spatial averaging of hydrologic processes. (3) Investigation of the transition of hydrologic response as the averaging area passes from smaller to larger scales, and of the relations among parameterization of hydrologic processes at different scales.

The following models were developed for runoff prediction: (1) a space-time rainfall generator at the rainband scale, and (2) a runoff production model that includes both infiltration excess using soil hydraulic properties and saturation excess using the topographic index of Beven and Kirkby. Results show that the concept of a REA exists and is the fundamental spatial building block for catchment modeling. For the topography investigated, the REA was about 1 square kilometer. At areas smaller than the REA, the actual pattern of soil and rainfall are needed for accurate modeling; for areas larger than the REA, the derived macro-scale model using the statistics of soil and rainfall patterns gives good results.

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Springfield, Virginia 22161
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ORDER NUMBER: PB88-155411/AS

COMPLETED PROJECT INFORMATION

GRANT NUMBER: 14-08-0001-G1144

TITLE: Sensitivity Constrained Nonlinear Programming: A General Approach for Planning and Design under Parameter Uncertainty and an Application to Treatment Plant Design

PERFORMING ORGANIZATION: University of Illinois

PRINCIPAL INVESTIGATOR: E. Downey Brill, Jr.

START: September 1985

FINAL REPORT RECEIVED: April 1988

ABSTRACT:

An important problem of using mathematical models is that parameter values, and thus the model results, are often uncertain. A general approach, Sensitivity Constrained Nonlinear Programming (SCNLP), was developed for extending nonlinear optimization models to include functions that depend on the system sensitivity to changes in parameter values. Such sensitivity-based functions include first-order measures of variance, reliability, and robustness. Thus SCNLP can be used to generate solutions or designs that useful with respect to modeled objectives, and that also reflect concerns about uncertainty in parameter values. A solution procedure and an implementation based on an existing nonlinear programming code are presented. SCNLP was applied to a complex activated sludge wastewater treatment plant design problem. The alternative designs generated represent the tradeoff between cost and system robustness, where robustness is related inversely to the sensitivity of effluent quality to changes in 55 parameter values. The results show a significant tradeoff between cost and robustness and significant design trends associated with improvements in robustness. These design trends are generally more consistent with recommended design practice than is the minimum cost design. SCNLP should be applicable to many problems where parameter value uncertainty is important, e.g., the design of contaminated ground-water remediation schemes.

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ORDER NUMBER: PB88-199922/AS

COMPLETED PROJECT INFORMATION

GRANT NUMBER: 14-08-0001-G1404

TITLE: An Interactive Environmental Impact and Economic Analysis of the Benefits of Potable Ground Water on Cape Cod

PERFORMING ORGANIZATION: Woods Hole Oceanographic Institution

PRINCIPAL INVESTIGATORS: S. Edwards and A. Solow

START: September 1986

FINAL REPORT RECEIVED: April 1988

ABSTRACT:

The objective of this project was to estimate the economic benefits of protecting potable ground water from nitrate contamination on Cape Cod, Massachusetts. The work consisted of three steps:

1. Estimating the public's total demand for clean water, taking supply uncertainty into account.

2. Estimating the probability of future nitrate contamination using historical data.

3. Combining the results of (1) and (2) to arrive at an estimate of the overall economic benefits of ground-water protection.

Demand estimation was performed by the contingent valuation method. The results of this analysis indicated a strong demand for clean water. The estimation of the probability of future contamination was based on a regression model of the relationship between nitrate level and population. This analysis indicated that the probability of future contamination is extremely small. Therefore, the economic benefits of protecting ground water from nitrate contamination under current conditions are very small.

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ORDER NUMBER: PB88-195896/AS

COMPLETED PROJECT INFORMATION

GRANT NUMBER: 14-08-0001-G1132

TITLE: Behavior of Toxic Metals in Lakes and Streams: Use of Naturally Occurring Radioactive Metals as Tracers of Biochemical Processes

PERFORMING ORGANIZATION: Massachusetts Institute of Technology

PRINCIPAL INVESTIGATOR: Harold F. Hemond

START: September 1985

FINAL REPORT RECEIVED: June 1988

ABSTRACT:

The objective was to investigate the behavior of toxic metals in lakes and streams using the naturally occurring radioactive metals lead-210 and polonium-210 as tracers. The radionuclides were measured as a function of position and time in a Massachusetts lake, its sediments and pore waters, and associated streams. A mass balance for the epilimnion showed that lead-210 direct uptake by bottom sediments was inconsequential. Below the epilimnion, a steep temperature/density gradient limited vertical transport. Anoxic conditions caused remobilization of iron and lead-210, which reprecipitated at the oxycline and returned to the bottom via settling. Below the oxycline, lead-210 and iron distributions resulted from constant release from anoxic sediments and dilution in the water column.

Sediment lead-210 distributions were caused by sedimentation and Fickian transport. The Fickian component was equal to the pore water diffusive flux. In pore waters, lead-210 and polonium-210 were 100 times greater than in overlying water and had steep concentration gradients. Lead-210 partition coefficients decreased with depth, controlled by sorption on iron oxides. Remobilization to the water column comes from a thin layer of iron-rich floc near the sediment/water interface. Deeper in the cores, diffusive transport can redistribute lead-210 to an extent that can affect lead-210 dating.

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Springfield, Virginia 22161
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ORDER NUMBER: PB88-227467/AS

COMPLETED PROJECT INFORMATION

GRANT NUMBER: 14-08-001-G1281

TITLE: Anti-Fouling Surface Modification to Extend Membrane Performance with Constant Fluxes and Selectivities

PERFORMING ORGANIZATION: Georgia Institute of Technology

PRINCIPAL INVESTIGATOR: Lois M. Speaker

START: September 1986

FINAL REPORT RECEIVED: June 1988

ABSTRACT:

The feasibility of mitigating the fouling of ultrafiltration (UF) and reverse osmosis (RO) membranes by modification of the membrane surfaces with monomolecular films of fluorinated surfactants was explored. Monomolecular films were formed by the Langmuir-Blodgett technique on commercially available membranes. Coated membranes were tested at constant pressure while measuring flux using either a stirred 40 psig UF cell or a 250 psig RO cell. It was concluded that the nature of the polar group of the surfactant and its interaction with the substrate are more important than the degree of fluorination of the surfactant in its ability to decrease fouling. A fluorinated surfactant was determined to be effective at reducing the fouling propensity of UF and RO membranes.

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ORDER NUMBER: PB88-235999/AS

COMPLETED PROJECT INFORMATION

GRANT NUMBER: 14-08-0001-G1314

TITLE: Municipal Ground-Water Contamination in Massachusetts: The Case for Wellhead Protection in Humid Regions

PERFORMING ORGANIZATION: University of Massachusetts

PRINCIPAL INVESTIGATOR: E. R. Kaynor

START: September 1986

FINAL REPORT RECEIVED: September 1988

ABSTRACT:

Investigation of municipal ground-water contamination problems in Massachusetts reveals a wide array of approaches to reducing the problem. Generally, strategies of prevention (usually socio-political) are much more cost-effective than cleanup (usually engineering solutions). In humid regions, communities often have supply-source choices and have been able in the past to abandon contaminated sites, a least-cost tactic, but one that is environmentally degrading. Degree of success of preventive strategies is difficult to predict because of individual case differences.

Unresolved tensions between levels of government exist with respect to appropriate roles in reducing problems of ground-water contamination. The most difficult institutional problem is the need for local action to solve local ground-water problems in home-rule states while, at the same time, local agencies often lack both the impersonalism and breadth of expertise to solve such problems. Higher levels of government with adequate expertise are reluctant to participate in traditionally local matters such as control of land use.

Many of the "friends and neighbors" types of local enforcement problems can be overcome by impersonal Federal and State intervention. Massachusetts has achieved substantial success in controlling local ground-water contamination with imaginative State programs administered by generally dedicated environmental agencies.

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ORDER NUMBER: PB89-109771/AS

WATER RESOURCES RESEARCH GRANT PROGRAM
PROJECT DESCRIPTIONS, FISCAL YEAR 1988

Compiled by Melvin Lew and Beverly M. McCoy
Water Resources Division
U.S. Geological Survey

ABSTRACT

This report contains information on the 38 new projects funded by the U.S. Geological Survey's Water Resources Research Grant Program in fiscal year 1988 and on 11 projects completed during the year. For the new projects, the report gives the grant number, project title, performing organization, principal investigator(s), project duration, and a project description that includes: (1) identification of water-related problems and problem-solution approach, (2) contribution to problem solution, (3) objectives, and (4) approach. The 38 projects include 14 in the area of ground-water quality problems, 10 in the science and technology of water-quality management, 4 in climate variability and the hydrologic cycle, 7 in institutional change in water-resources management, and 3 in miscellaneous water-resources management problems.

For the 11 completed projects, the report gives the grant number, project title, performing organization, principal investigator(s), starting date, date of receipt of final report, and an abstract of the final report. Each project description provides the information needed to obtain a copy of the final report.

The report also contains tables showing (1) proposals received according to area of research interest, (2) grant awards and funding according to area of research interest, (3) proposals received according to type of submitting organization, and (4) awards and funding according to type of organization.

INTRODUCTION

In January 1985, the U.S. Geological Survey was assigned responsibility for administering the functions of the Water Resources Research Act of 1984 (Public Law 98-242). Section 105 of the act authorizes funds for research grants, on a fund-matching basis, to qualified individuals and groups as defined in the law. Each year an announcement is issued to solicit proposals for research support from the funds appropriated by the Congress.

In fiscal year (FY) 1985, 24 of 368 proposals that were submitted were selected for funding with the $2.543 million appropriated by Congress. In FY 1986, 43 of 299 proposals were selected for funding with the $4.767 million appropriated and in FY 1987, 34 of 273 proposals were selected for funding with the $4.381 million appropriated. These projects are described in U.S. Geological Survey Open-File Reports 85-687, 86-548, and 88-179 respectively.

In FY 1988, 239 proposals requesting $24.7 million of Federal funding ($26.0 million of non-Federal funding) were submitted in response to U.S. Geological Survey Announcement No. 7336 issued on October 12, 1987. Of this number, 38 were selected for funding with the $4.381 million appropriation (Table 1). As in previous years, proposals from academic institutions dominated the competition for grant funds (Table 2).

Section I of the report presents summaries of 38 proposals selected for funding. Section II presents summaries of the 11 projects completed during FY 1988.

Table 1.--Proposals and awards by research interest area, fiscal year 1988

Proposals

Interest Area	No.	Federal ($) Funds	Non-Federal Funds($)	Total Funds($)
Ground-Water Quality Problems	93	10,101,780	10,611,382	20,713,162
Science and Technology of Water-Quality Management	50	5,233,590	5,778,350	11,011,940
Climate Variability and the Hydrologic Cycle	40	3,820,240	3,876,711	7,696,951
Institutional Change in Water-Resources Management	35	3,200,894	3,345,600	6,546,494
Miscellaneous Water-Resources Management Problems	21	2,352,880	2,427,748	4,780,628
Totals	239	24,709,384	26,039,791	50,749,175

Awards

Interest Area	No.	Federal ($) Funds	Non-Federal Funds($)	Total Funds($)
Ground-Water Quality Problems	14	1,670,302	1,701,829	3,372,131
Science and Technology of Water-Quality Management	10	1,299,387	1,313,289	2,612,676
Climate Variability and the Hydrologic Cycle	4	345,368	374,909	720,277
Institutional Change in Water-Resources Management	7	742,363	801,724	1,544,087
Miscellaneous Water-Resources Management Problems	3	307,221	312,677	619,898
Totals	38	4,364,641	4,504,428	8,869,069

Table 2.--Proposals and awards by organization, fiscal year 1988

Proposals

Organization	No.	Federal($)	Non-Federal Funds($)	Total Funds($)
Academic Institutions	223	23,440,366	24,505,912	47,946,278
Non-Federal Government	5	407,383	629,288	1,036,671
Industry	11	861,635	904,591	1,766,226
Total	239	24,709,384	26,039,791	50,749,175

Awards

Organization	No.	Federal($)	Non-Federal Funds($)	Total Funds($)
Academic Institutions	38	4,364,641	4,504,428	8,869,069
Non-Federal Government	0	0	0	0
Private	0	0	0	0
Total	38	4,364,641	4,504,428	8,869,069

SECTION I

PROJECT SUMMARIES

FISCAL YEAR 1988 GRANTS

GROUND-WATER QUALITY PROBLEMS

PROJECT INFORMATION

GRANT NUMBER:	14-08-0001-G1622
TITLE:	Attenuating Organic Contaminant Mobility Using Organic Clays
PERFORMING ORGANIZATION:	Michigan State University
PRINCIPAL INVESTIGATOR:	Stephen A. Boyd
DURATION:	September 1988 to September 1991

DESCRIPTION

1. Identification of the Water-Related Problems and Problem Solution Approach.

Many toxic organic compounds are found in ground water as contaminants, and represent a serious threat to human health. In nature, the immobilization of nonionic organic contaminants present in water results from nonpolar interactions with natural organic matter. Strong dipole interactions between mineral surfaces and water prohibit nonionic organic compounds (NOCs) from interacting with the mineral components, including natural clays whose surfaces are very hydrophilic. The important practical result is the lack of sorptive capabilities of low organic matter soils and aquifer materials, and of clay containment barriers such as bentonite slurry walls and clay landfill liners, which are virtually devoid of natural organic matter. Modifying soils and clay to enhance sorptive properties may reduce toxic organic compounds in ground water.

2. Contribution to Problem Solution.

Such modified soils and clays may be used: (a) to increase the sorptive capacity of low organic matter soils; (b) to increase the sorptive properties of subsurface materials under existing waste disposal sites through underground injection of the organic cation; and (c) as components of bentonite slurry walls and clay landfill liners to enhance the containment capabilities of waste disposal reservoirs.

3. Objectives.

The objectives of this research are to:

(a) Describe the adsorption and retention of three organic quaternary ammonium cations on clays (smectite, vermiculite and illite) and on actual soil and aquifer materials;

(b) Characterize the sorptive properties of the organic-cation exchanged materials for the retention of common organic ground-water contaminants; and

(c) Use soil columns to validate that the organo-exchanged materials are effective in retarding the mobility of NOCs present in aqueous solutions.

4. Approach.

Test the hypothesis that organic cations of the form $[(CH_3)_3NR]^+$ can be used to displace naturally occurring exchange ions--that is, Ca^{2+} and Na^+ from clays, soils, and aquifer materials, thereby increasing the organic matter contents and greatly enhanced sorptive properties for NOCs. Previous results with hexadecyltrimethylammonium (HDTMA, $R=C_{16}$)-exchanged smectite have shown that the organic phase derived from HDTMA was 10 to 30 times more effective than soil organic matter for removing NOCs from water. The research will determine the effectiveness of organic-cation exchanged clays, soils, and aquifer materials as sorbents for removing toxic organic contaminants from water.

PROJECT INFORMATION

GRANT NUMBER: 14-08-0001-G1632

TITLE: Ground-Water Quality in Pumped Wells Located near Surface-Water Bodies

PERFORMING ORGANIZATION: New Mexico State University

PRINCIPAL INVESTIGATOR: John L. Wilson

DURATION: September 1988 to August 1990

DESCRIPTION

1. Identification of the Water-Related Problems and Problem Solution Approach.

Numerous municipal water-supply wells are located near streams and lakes. These wells receive water from various sources, including the nearby stream (or lake), aquifer underflow beneath the stream, local recharge, or upgradient aquifer underflow. Well-water quality depends on the mix of these sources and the spatial distribution of their capture zones relative to the location of pollutant sources. Typical questions that arise in these cases are: how is a well-head protection zone defined? How much water must be pumped to control well-water quality? Who is responsible for the pollution measured in a well? How should the flow field be manipulated to control a pollutant plume? This research will use mathematical models to study generically the sources of water, capture zones, and travel times for pumped wells near surface-water bodies.

2. Contribution to Problem Solution.

The models' primary value will be to provide an improved understanding of these issues, with secondary applications to the preliminary screening of policy, or site specific design or operation decisions. In no case should these models replace detailed site-specific studies.

3. Objective.

The objective of this research is to estimate how sources of water, capture zones, and travel times are influenced by a variety of factors including well locations, penetration, and pumping rates; aquifer properties, geometry, and ambient flow; and stream penetration, cross-sectional shape, and silt bed lining.

4. Approach.

Analytical and numerical techniques will be used, and the results will be presented by use of computer graphics. Computed velocity fields will be used to determine critical points that allow delineation of source fluxes and capture zones. Travel time will be determined by using particle tracking. Dispersion and nonisothermal effects will be examined by using random walk and hybrid method-of-characteristic methods.

PROJECT INFORMATION

GRANT NUMBER:	14-08-0001-G1635
TITLE:	The Role of Humic Substances in the Partitioning and Transport of Copper (II) in Aquifers
PERFORMING ORGANIZATION:	The University of Arizona
PRINCIPAL INVESTIGATORS:	Martha H. Conklin and Gary L. Amy
DURATION:	September 1988 to August 1990

DESCRIPTION

1. Identification of the Water-Related Problems and Problem Solution Approach.

Metal compounds are found as ground-water contaminants and represent a threat to human health. Research is needed to increase our understanding of how trace metals move in ground-water systems by determining the important interactions in a well-defined system and by improving theoretical and model descriptions of these reactions. The system chosen for investigation is metal/humic substance/solid surface. The metal of interest is Cu^{2+}, which was chosen largely based on health concerns. Ligand humic substances were selected because they occur ubiquitously in natural water systems, and are often found in leachate from landfills.

2. Contribution to Problem Solution.

The research will provide an improved understanding of the transport and fate of contaminants in ground water. The approach of studying highly characterized humic fractions and select model mineral surfaces will permit partitioning and transport modeling, providing a systematic framework for studying transport phenomena at specific sites.

3. Objectives.

The objectives of this research are to:

(a) Improve mechanistic understanding of metal humate interactions in heterogeneous systems;

(b) Quantify the role of background electrolytes on metal/humate interactions; and

(c) Develop mathematical descriptions of partitioning between the aqueous phase and solid surfaces in heterogeneous systems of variable composition.

4. Approach.

Interactions between $Cu(^{2+})$and several model mineral surfaces (e.g., Al_2O_3, SiO_2, and iron-coated SiO_2) and humic substances isolated from aquatic sources will be investigated in both binary systems (metal/humic substance; metal/mineral surface; humic substance/mineral surface) and the ternary system (metal/humic substance/mineral surface). Humic substances are difficult to study because of their heterogeneous character. The approach to be taken in this research will be to isolate and fractionate humic substances into psuedo-components that can be modelled as specific ligands. Other variables to be measured include pH, ionic strength, and the presence of competing metals such as Ca^{2+} and Mg^{2+}. Both batch-mode and continuous-flow column experiments will be conducted to define both partitioning and kinetics. Data will be modeled according to a multi-ligand binding model and a one dimensional transport equation.

PROJECT INFORMATION

GRANT NUMBER:	14-08-0001-G1638
TITLE:	Innovative Approach to Determine Retardation Factors of Organic Contaminants in Ground-Water Systems
PERFORMING ORGANIZATION:	University of Minnesota
PRINCIPAL INVESTIGATOR:	Steven J. Eisenreich
DURATION:	September 1988 to September 1990

DESCRIPTION

1. Identification of the Water-Related Problems and Problem Solution Approach.

Contamination of ground waters with organic chemicals threatens a valuable natural resource. Several areas within Minnesota, because of their hydrogeologic character, are particularly susceptible to ground-water pollution, including the karst formations in the southeastern counties and the sand and gravel aquifers in central Minnesota. Potential sources of organic pollutants to ground waters include the use of agrichemicals, accidental discharge of petroleum products during transport in pipelines or underground storage, and local industrial activities. A central issue in assessing the potential for ground-water contamination is estimating the rate at which organic chemicals migrate through the subsurface environment. Similarly, the feasibility of remediation efforts is often determined by the ease with which contaminants can be pumped from aquifers. The mobilities of many organic chemicals in soils and aquifers are determined by their tendency to adsorb to solids. It is critical, therefore, to identify and quantify the factors that control the extent of sorption of organic pollutants to aquifer solids.

2. Contribution to Problem Solution.

Results of this research work will increase our understanding of contaminant sorption to mineral surfaces and will benefit efforts to model migration of organic chemicals in ground waters.

3. Objectives.

The objectives of this research are to:

(a) Measure distribution coefficients of a suite of organic chemicals that sorb with several well-characterized minerals under environmentally relevant conditions;

(b) Quantify changes in the equilibrium distribution coefficient caused by coating minerals with natural organics present in ground waters; and

(c) Determine factors which influence the rate of contaminant desorption from aquifer solids.

4. Approach.

This research employs a recently-developed analytical technique to extend our studies of contaminant sorption to conditions typical of the subsurface environment. This work will quantify equilibrium and kinetic parameters which describe organic contaminant sorption to aquifer solids. Factors controlling these parameters will be carefully controlled and systematically varied to further our understanding of the sorption process. This study is unique in its use of static headspace gas chromatography to measure sorption of a suite of chemicals to well-characterized solids that have surface chemistries similar to aquifer material (e.g., low organic carbon content). Specific results include equilibrium distribution coefficients of several halogenated organic chemicals on silica, goethite and kaolinte; distribution coefficients to minerals that have been coated with natural organic matter; and rate constants describing desorption kinetics.

PROJECT INFORMATION

GRANT NUMBER: 14-08-0001-G1640

TITLE: Fate and Transport of Chlorinated Solvents

PERFORMING ORGANIZATION: Rutgers, The State University of New Jersey

PRINCIPAL INVESTIGATORS: David S. Kosson and Robert C. Ahlert

DURATION: September 1988 to August 1991

DESCRIPTION

1. Identification of the Water-Related Problems and Problem Solution Approach.

Many toxic organic compounds such as chlorinated solvents are found in soil systems and represent a threat to human health.

Ground-water quality is modified by the physical, chemical, and thermodynamic behavior of contaminants. This research seeks to increase our understanding of physical equilibria, diffusion processes, and chemical interactions that attenuate or facilitate transport of organic solutes in ground water. Thermodynamics and kinetics of individual and coupled processes will be investigated. These soil phenomena will be integrated with results of related studies on microbial processes that occur in the same soil systems.

2. Contribution to Problem Solution.

New data for physical and chemical interactions between soils and chlorinated organic solutes in ground water and soil water will be developed. These data will be assembled and interpreted with an existing numerical model of solute transport and reaction in soil/water systems. Thermodynamic and process rate data will improve the capacity of field sampling programs and geohydrologic models to describe the movements and fates of certain hazardous substances (chlorinated solvents) discharged to ground water.

3. Objectives.

The objectives of this research are to:

(a) Define sorption isotherms in soil/water/solute systems (saturation or aquifer conditions);

(b) Identify and quantify irreversible processes that hinder desorption of organic contaminants from soils;

(c) Define Henry's Law behavior in soil/water/air/solute systems that mimic the unsaturated or vadose zone;

(d) Observe simultaneous multi-phase partitioning, chemical interaction, vaporization and diffusion in unsaturated environments; and

(e) Measure rates of physical and chemical processes cited in (a) through (d).

4. Approach.

Samples of contaminated and uncontaminated soils will be taken from a site that has complex geology and a diversity of ground-water contamination problems. This environment provides an opportunity to make measurements over very broad ranges of soil characteristics, ground-water flow rates, and contaminant concentrations and distributions. Samples will be used for batch adsorption- and desorption-rate determinations, dynamic vaporization and diffusion-rate measurements, and observations of coupled physical processes under saturated and unsaturated conditions. The results of bioreactor experiments carried out within other projects will be integrated with this information to permit quantitative estimation of attenuation and transport rates of solvents and metabolic products in complex subsurface environments.

PROJECT INFORMATION

GRANT NUMBER: 14-08-0001-G1642

TITLE: Influence of Microbial Cell-Transport Processes on In-Situ Biodegradation of Ground-Water Contaminants

PERFORMING ORGANIZATION: Montana State University

PRINCIPAL INVESTIGATORS: W. G. Characklis and A. B. Cunningham

DURATION: September 1988 to August 1990

DESCRIPTION

1. Identification of the Water-Related Problems and Problem Solution Approach.

In-situ biodegradation of organic ground-water contaminants represents an attractive method for aquifer restoration without transfer to another environmental medium. Schemes for aquifer restoration usually involve systems for injection, recovery or infiltration of microbial cells, nutrients and reactants, and require an understanding of the transformation and transport characteristics of the particular subsurface environment. Biotransformation of specific organic contaminants in porous media is the topic of substantial research (including project work presently underway by the principal investigators), however, little is currently being done to advance our knowledge of microbial transport processes in the subsurface. Because in-situ rates are controlled by transport processes rather than by metabolism, a thorough understanding of microbial transport phenomena is of fundamental importance to contaminant remediation activities. The possibility of improving transport and degradation rates with "starved" or "motile" cells likewise should be explored.

2. Contribution to Problem Solution.

The research may provide a theoretical basis for predicting (a) amount and areal distribution of attached biomass (biofilm), and (b) concentration, distribution, and migration rates of suspended cells in contaminated porous media. Knowledge of the subsurface distribution of attached and suspended cells at contaminated ground-water sites will provide a sound basis for design of remediation strategies and facilities.

3. Objectives.

The objectives of this research are to:

(a) Determine interrelations among key microbial transport processes including advection, adsorption, desorption, growth, and filtration in contaminated porous media;

(b) Develop a comprehensive mathematical model of microbial transport and activity;

(c) Evaluate relative transport/transformation characteristics of starved vs. growing and motile vs. non-motile cells; and

(d) Develop guidelines for designing optimal biorestoration schemes for contaminated aquifers.

4. Approach.

The research will be carried out through a program of laboratory experiments. Microbial transport and activity will be investigated in both radial- and uniform-flow porous-media reactors under saturated flow conditions containing pentachlorophenol (PCP). Image analysis will be used to monitor microbial processes including transport rates, adsorption/desorption, growth, and filtration.

PROJECT INFORMATION

GRANT NUMBER: 14-08-0001-G1643

TITLE: Measurement of Soil Structure, Water Movement and Solute Transport Using Computed Tomography

PERFORMING ORGANIZATION: University of Missouri

PRINCIPAL INVESTIGATORS: R. Lee Peyton, Jr. and Stephen H. Anderson

DURATION: September 1988 to September 1990

DESCRIPTION

1. Identification of the Water-Related Problems and Problem Solution Approach.

Structured, heterogeneous porous media present serious problems to engineers, geologists, and soil physicists in understanding and predicting the influence of small-scale structural variations on water and contaminant movement in ground-water environments. Characterization of spatial variability of this movement is essential for effective ground-water management planning and design. This project will use computed tomography-- state-of-the-art technology in medical and materials science-- to produce rapid, nondestructive, three-dimensional, small-scale (1 mm x 1 mm x 2 mm) measurements of natural soil structural features and of water and solute movement through these soils.

2. Contribution to Problem Solution.

This project will develop methods for the application of computed tomography to ground-water quality research. It will produce three-dimensional measurements of water and solute movement through soil that can be used to test and verify the increasingly sophisticated deterministic theories of flow and solute transport through heterogeneous porous media. It will improve estimates of small-scale spatial variability used in stochastic modeling of field-scale transport. The methods developed will allow for future use of computed tomography to study other processes such as dispersion, sorption, and behavior of immiscible organic materials.

3. Objectives.

The objectives of this research are to:

(a) Develop methodology for using computed tomography for nondestructive, three-dimensional characterization of macropores in porous media;

(b) Extend the state-of-the-art of computed tomography to the rapid, non-destructive, three-dimensional measurement of water movement through soil with small-scale heterogeneities; and

(c) Evaluate the potential of three-dimensional measurement of solute movement through soil with small-scale heterogeneities.

4. Approach.

Methodology for the use of X-ray computed tomography to detect macropores will be developed using artifically created pores in carefully packed soil cores. The methodology will be tested using undisturbed field cores. Wetting-front velocities will be measured as a function of space and time in both homogeneous and naturally structured soil cores. The spatial variation of saturated pore-water velocities in soil structures will be measured using a solute tracer.

WATER RESOURCES RESEARCH GRANT PROGRAM PROJECT DESCRIPTIONS, FISCAL YEAR 1988

Compiled by Melvin Lew and Beverly M. McCoy

U.S. GEOLOGICAL SURVEY
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PROJECT INFORMATION

GRANT NUMBER:	14-08-0001-G1645
TITLE:	A Field Study for Model Validation of Multi-Dimensional Flow and Transport in the Unsaturated Zone
PERFORMING ORGANIZATION:	New Mexico State University
PRINCIPAL INVESTIGATOR:	Daniel B. Stephens
DURATION:	September 1988 to August 1990

DESCRIPTION

1. Identification of the Water-Related Problems and Problem Solution Approach.

Ground-water contamination is often a result of transport through the unsaturated zone. Sources of chemical seepage near the land surface may include radioactive waste canisters, landfills, storage tanks, and fluid waste impoundments. In western states where the depth to saturation may be tens of meters, unsaturated -zone processes are important determinants of ground-water contamination. Thus, characterization of the vadose zone is required by California statutes for hazardous waste disposal facilities.

The unsaturated zone is often comprised of relatively dry, stratified geologic materials. Theories and laboratory experiments suggest that this stratification may cause seepage to spread laterally to a great extent under some conditions. That is, flow paths through the vadose zone are likley to be three-dimensional. Numerical models of two- and three- dimensional, variably saturated flow are tools available to hydrologists which are used to predict impacts of seepage on ground water. Unfortunately, the numerical codes have not been validated under field conditions. Field observations of multi-dimensional flow processes have usually been made after an uncontrolled release of seepage; thus, boundary and initial conditions for modeling studies are not known. Controlled field experiments are needed to validate existing numerical codes in heterogeneous media. For thinly stratified systems, current codes may require modification to incorporate moisture-dependent anisotropy that causes lateral spreading of seepage.

2. Contribution to Problem Solution.

The research is expected to demonstrate the accuracy of the numerical model to handle complex field problems and to give modelers and regulators confidence in the predictive capabilities of the numerical codes selected. The site characterization and experimental results will be useful for validating other flow and transport codes. Practical guidelines will be developed to describe how to sample and characterize hydraulic properties in the unsaturated zone.

3. Objectives.

The objectives of this research are to:

(a) Evaluate quantitative hydrogeologic information to describe the physical processes that affect multidimensional, field-scale transport of water and solutes in the unsaturated zone;

(b) Test the capability of multi-dimensional, numerical models to predict flow and transport in the unsaturated zone at the field scale; and

(c) Develop a practical approach for characterizing the geologic and hydraulic properties of the unsaturated zone that are most relevant to predicting flow and transport.

4. Approach.

The research will involve collection of extensive hydrogeologic data at an infiltration test site in a stratified sequence of alluvial deposits near Socorro, New Mexico. Water has been applied by drip irrigation to a 10m x 10m plot at the field site for over 1 year. Significant lateral moisture movement has been detected by use of in-situ tensiometers and a neutron probe. Tracers will be injected to study the dispersive characteristics of the media. Hydraulic properties will be determined from 375 core samples in three vertical boreholes and one horizontal transect. In-situ permeability tests will be conducted in 75 boreholes. Data will be analyzed using geostatistics, including variograms and spectral analysis to evaluate spatial correlation structures. Dispersivity of representative samples will be determined in the laboratory. Significantly different hydrostratigraphic samples will be designated, and effective mean properties will be assigned to these samples. These quantitative data, along with the conceptual hydrogeologic model of the unsaturated zone, will be used to develop a numerical model of flow and transport in a two-dimensional, axisymmetric cross-section; a three-dimensional code will also be considered for development. Model predictions will be compared to observed pressure head, moisture content, and solute concentrations.

PROJECT INFORMATION

GRANT NUMBER:	14-08-0001-G1647
TITLE:	Adsorption of Substituted Phenols and Anilines at the Mineral/Water Interface
PERFORMING ORGANIZATION:	The Johns Hopkins University
PRINCIPAL INVESTIGATOR:	Alan T. Stone
DURATION:	September 1988 to September 1991

DESCRIPTION

1. Identification of the Water-Related Problems and Problem Solution Approach.

Partitioning of purely hydrophobic organic pollutants onto natural particles is well-understood; hydrophobic interactions encourage partitioning into the organic carbon fraction of soils and sediments. With ionic or ionizable organic pollutants, however, chemical and electrostatic interactions with minerals are far more significant and increase the tendency towards sorption. These interactions are poorly understood, but must be known to predict sorption behavior in subsurface environments. Sorption must also be understood in order to predict pollutant fate, because rates of chemical-transformation reactions may be substantially altered by sorption.

2. Contribution to Problem Solution.

By systematically examining how pollutant characteristics and the presence of natural organic matter (NOM) from Lake Drummond or Dismal Swamp influence the extent of pollutant adsorption to mineral surfaces, new approaches to understanding and predicting sorption phenomena in subsurface environments will be developed. Through this research, it should be possible, for example, to account directly for the effects of pollutant acid/base equilibria and log octonol-water partition coefficient on sorption behavior in soils and sediments.

3. Objective.

The objective of this research is to improve our ability to understand and predict the extent of adsorption of ionic and ionizable organic pollutants onto mineral surfaces. The research will focus upon the effects of (a) pollutant acid/base speciation and hydrophobic characteristics and (b) interaction with coadsorbed NOM matter on the extent of adsorption onto mineral surfaces.

4. Approach.

Phenols and anilines, representing two important classes of organic pollutants, will be added to suspensions of aluminum oxide and silica in the presence and absence of NOM. Laboratory experiments will be performed to identify characteristics of organic pollutant molecules, NOM molecules, mineral

surfaces, and the aqueous media that influence the extent of adsorption. Based on these results, a comprehensive model will be developed to explain the adsorption of ionic and ionizable organic pollutants onto mineral surfaces, and to predict extent of adsorption under ground-water conditions.

PROJECT INFORMATION

GRANT NUMBER:	14-08-0001-G1651
TITLE:	Water and Chemical Movement Through the Biologically Active Surface Layer of No-Till Soils
PERFORMING ORGANIZATION:	The Ohio State University Research Foundation
PRINCIPAL INVESTIGATOR:	Warren A. Dick
DURATION:	September 1988 to August 1991

DESCRIPTION

1. Identification of the Water-Related Problems and Problem Solution Approach.

During the past decade, studies have clearly shown that nitrates and some pesticides enter ground water as a result of routine agricultural practices. Effective measures to reduce ground-water contamination cannot be implemented because we do not fully understand the movement and behavior of water and chemicals in soil. Increasing use of conservation tillage and no-tillage in the United States has resulted in soil conditions that differ from those in traditional plow-till systems. Earthworms create a continuous network of channels which, under no-tillage, connect the surface of the soil with the subsoil. These channels remain for years if the soil is not tilled, and permit water to bypass the biologically active surface soil layer where the greatest degradation of nitrates and pesticides occur. Increased understanding of this type of flow is needed to assess accurately the potential for agricultural chemicals to reach our ground-water resource and to design effective strategies to reduce contamination.

2. Contribution to Problem Solution.

This research will define the variables that are most important in affecting preferential water flow in soil. Factors that lead to greatest movement of agricultural chemicals through the soil will be identified. As a result the development of more accurate models to predict water and chemical flow through agricultural soils will be possible. The data will also be useful in formulating management strategies that farmers can use to minimize movement of agricultural chemicals to ground water.

3. Objectives.

The objectives of this research are to:

(a) Assess the contribution of macropores, e.g., earthworm holes, to preferential (or bypass) water flow in soil;

(b) Evaluate the effect of tillage, residue cover, time to rainfall after fertilizer or pesticide addition, antecedent soil moisture, and chemical properties of a fertilizer or pesticide on chemical movement through the soil profile; and

(c) Develop a geostatistically based procedure to quantify preferential flow through aggregated soils containing macropores.

4. Approach.

Undisturbed soil blocks (dimensions 30 x 30 x 30 cm) will be removed from a field and brought to the laboratory. Locations of macropores in the bottom face of the soil block will be recorded and a pesticide or fertilizer applied to the soil surface. The contribution of individual macropores to water and chemical movement through the soil block will be determined by collecting water leached from the soil in 64 containers arranged in a grid pattern covering the bottom surface.

Several soil blocks will be subdivided into 512 cubes (3.75 cm per side) and analyzed for the presence of pesticide or fertilizer. Results will provide a three-dimensional profile of chemical distribution in the undisturbed soil block. A geostatistical procedure will be developed to quantify the water and chemical flow through the macropores. To date, preferential flow has been observed but procedures do not exist to quantify the degree of preferential flow in aggregated soil.

PROJECT INFORMATION

GRANT NUMBER: 14-08-0001-G1652

TITLE: Variable Density Ground-Water Flow near a Closed-Basin Saline Lake: A Case Study at Mono Lake, California

PERFORMING ORGANIZATION: University of California, Santa Cruz

PRINCIPAL INVESTIGATOR: Shirley J. Dreiss

DURATION: September 1988 to September 1990

DESCRIPTION

1. Identification of the Water-Related Problems and Problem Solution Approach.

Arid basins with terminal lakes or playas are common features in the western United States. Understanding and quantitatively describing ground-water circulation in the vicinity of these lakes is essential for assessing potential impacts of climatic and man-made changes in the hydrologic cycle on water availability and biological communities. This research will investigate variable density ground-water circulation in the Mono Lake basin using a combination of field investigations and theoretical modeling.

2. Contribution to Problem Solution.

The field investigations will describe the amount, distribution, and chemical composition of ground-water seepage near Mono Lake. Modeling studies will simulate variable density ground-water flow in the basin and provide a means, with systematic parametric analyses, of defining the extent to which these observations can be generalized to other arid basins. The models will be useful for examining changes in ground-water flow and salinity under hypothetical modifications in geologic and climatic conditions.

3. Objectives.

The overall goal is to develop a better understanding of ground-water circulation in arid basins with saline terminal lakes. Specific study objectives are to measure and simulate quantitatively ground-water flow and salinity variations in the Mono Lake basin and to use these site specific results to draw general conclusions about variable density ground-water flow in this and similar basins.

4. Approach.

The study entails: (a) field measurements of springflow and spring water chemistry as well as measurements of hydraulic properties; (b) a parametric modeling study of closed-basin, variable-density flow using a two-dimensional, radially symmetric ground-water flow model; and (c) use of a three-dimensional model to investigate the effects of man-made and climatic influences on flow rates and directions and ground-water salinities.

PROJECT INFORMATION

GRANT NUMBER:	14-08-0001-G1654
TITLE:	Deterministic and Stochastic Evaluation of Nitrate-Nitrogen Leaching from Soils with Dual Pore Systems in Karst Regions
PERFORMING ORGANIZATION:	The Pennsylvania State University
PRINCIPAL INVESTIGATOR:	Dale E. Baker
DURATION:	September 1988 to August 1990

DESCRIPTION

1. Identification of the Water-Related Problems and Problem Solution Approach.

Nitrate-nitrogen (NO_3-N) concentrations in ground water are difficult to relate to soil-management practices on limestone soils where leaching involves solute transport via saturated flow within macropores or channels and unsaturated flow within micropores. Variability is great; direct measurement of water and NO_3-N across the bottom of the root zone is prerequisite to land-management practices that will reduce ground-water levels of NO_3-N in these soils.

2. Contribution to Problem Solution:

The research from this project will provide models and monitoring methods to evaluate farm nutrient management effects on ground-water quality with the emphasis on NO3-N. These models would be developed into a decision support (expert) systems to predict and measure ground-water pollution from crop nutrient-management practices.

3. Objectives.

The objectives of this research are to:

(a) Select, evaluate, and integrate models and appropriate monitoring approaches into expert systems that can be used on a field scale to predict the effects of manure and fertilizer inputs on the movement of nitrate-nitrogen across the bottom of the root zone on an annual basis in soils with dual pore systems;

(b) Relate parameters under (a), above, to yields of field corn and NO_3-N in ground water; and

(c) Test the hypothesis that, for soils with dual pore systems, the maximum amount of nitrate-nitrogen remaining within the soil to a depth of 1.2 meters at the end of the growing season could be as low as 60 kilograms per hectare and should not exceed 120 kilograms per hectare for soils with dual pore systems.

4. Approach.

The approach will use the probability distribution of the saturated hydraulic conductivity of a field and climatic data to predict water and NO_3-N losses across the bottom of the root zone. Direct measurements and comparisons of NO_3-N movement with water through saturated soils will be accomplished by using pan-type sampling devices.

Porous cup water samplers, and modified Jordan samplers will be compared at 10 sites within the field watershed. A minimum of 2 to 5 soil columns per site for the pan-type sampler and 10 porous cup samplers and 10 modified Jordan samplers will be used at each site. The porous cup samplers are expected to sample water moving with the soil matrix while the pan-type samplers and the modified Jordan samplers are expected to intercept water moving in macropores.

Soil samples to a depth of 1.2 meters (10 per site) will be collected and analyzed for NO_3-N. The amounts of NO_3-N measured will be compared statistically to all quantities projected to occur.

PROJECT INFORMATION

GRANT NUMBER: 14-08-0001-G1657

TITLE: The Effects of Wetting on Transport of Organic Compounds in Ground Water

PERFORMING ORGANIZATION: New Mexico State University

PRINCIPAL INVESTIGATORS: Robert S. Bowman and John L. Wilson

DURATION: September 1988 to August 1991

DESCRIPTION

1. Identification of the Water-Related Problems and Problem Solution Approach.

Contamination of ground water by organic substances dissolved in water is a problem of national scope. While much is known about transport of contaminants in the aqueous phase, much less is known about physical and chemical processes controlling contaminant fate in systems in which a free organic-liquid phase is present. This research will address the changes in surface chemistry that can occur in multiphase systems containing water, free organic liquid, and air, and the resultant effects on the physics and chemistry of contaminant migration.

2. Contribution to Problem Solution.

The research will provide basic knowledge on organic chemical sorption and transport in multiphase systems, such as vadose zones and ground waters contaminated with organic liquids.

3. Objectives.

The objectives of this research are to:

(a) Determine the ability of chemical treatments, and of components present in contaminant solutions, to alter the wettability of solid surfaces;

(b) Determine quantitative and qualitative changes in fluid flow dynamics in porous media having altered wettabilities;

(c) Quantify the sorption of dissolved organic solutes from aqueous and organic liquid solutions onto surfaces having altered wettabilities; and

(d) Determine the relative importance of changes in surface wettability to the general problem of organic contaminant sorption and transport.

4. Approach.

Hydrophobic surfaces will be created on aquifer and soil materials by reaction with wettability-altering chemicals and by sorption of solutes present in

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organic liquid contaminant solutions. Sorption of hazardous organic chemicals from both aqueous and organic solutions onto these modified surfaces and the effects of changes in surface wettability on fluid-flow behavior (water, organic liquid, and air) will be studied in batch and column leaching experiments. Gas and high-performance liquid chromatography will be used for measuring concentrations of organic solutes.

PROJECT INFORMATION

GRANT NUMBER: 14-08-0001-G1658

TITLE: Geochemical Processes in a Modern Coastal Ground-Water Mixing Zone and Their Hydrologic and Petrologic Implications

PERFORMING ORGANIZATION: University of Virginia

PRINCIPAL INVESTIGATORS: Janet S. Herman and Anthony F. Randazzo

DURATION: September 1988 to September 1990

DESCRIPTION

1. Identification of the Water-Related Problems and Problem Solution Approach.

Mixing of seawater and freshwater in a coastal carbonate aquifer system has produced a chemically reactive environment for diagenetic processes. Mineral dissolution, alteration, and precipitation are common processes occurring in the ground-water mixing zone. The dynamic flow characteristics of hydrologic systems are dependent upon the effects of diagenesis on porosity and permeability. Our current understanding of the hydrogeologic and petrologic implications of geochemical processes in this environment is incomplete.

This research tests the general hypothesis that carbonate diagenesis in the ground-water mixing zone of a coast is a dynamic and critical process in the development of porosity and permeability.

2. Contribution to Problem Solution.

The study will result in a detailed understanding of how porosity and permeability evolve in a coastal carbonate-aquifer mixing zone. The results will be used by carbonate petrologists studying the diagenesis of limestone, by hydrogeologists studying the evolution of physical aquifer characteristics, and by ground-water geochemists studying water-rock interactions and their control on the composition of natural waters.

3. Objectives.

The objectives of this research are to:

(a) Establish the geochemistry and petrology of a modern mixing zone;

(b) Quantify the geochemical reactions that yield the current composition of the mixing zone; and

(c) Relate these geochemical processes to the petrologic and hydrogeologic evolution of a coastal limestone aquifer.

4. Approach.

The Floridan aquifer, at a locality along the coast of Pinellas County, Florida, will be the subject of study. Geochemical and petrologic research techniques will be employed to characterize the ground waters above, at, and below the mixing zone and the diagenetic features occurring in the aquifer rocks. This dual approach will define the water-rock interactions occurring in the ground-water mixing zone.

SCIENCE AND TECHNOLOGY OF WATER-QUALITY MANAGEMENT

PROJECT INFORMATION

GRANT NUMBER:	14-08-0001-G1623
TITLE:	A Novel Closed-Loop Air-Stripping Process for VOC Removal from Contaminated Water
PERFORMING ORGANIZATION:	University of Minnesota
PRINCIPAL INVESTIGATOR:	Michael J. Semmens
DURATION:	September 1988 to September 1990

DESCRIPTION

A large number of ground-water supplies in the United States are contaminated by volatile organic compounds (VOC's) and an inexpensive treatment process for such supplies would find wide application. Currently, air stripping is widely employed; however, with the implementation of more stringent regulations on the air discharge of VOC's, many states are requiring removal of VOC's from the stripper air prior to release to the atmosphere. The use of adsorbents such as activated carbon to treat the stripper gas dramatically increases the cost of VOC removal by this method.

This research will investigate a novel process for the treatment of water that is contaminated by low molecular weight volatile organic compounds such as trichloroethylene.

2. Contribution to Problem Solution.

The process could find a wide application in the treatment of contaminated ground waters if it is demonstrated to be less expensive and more effective than conventional treatment methods.

3. Objective.

The objective of this research is to determine the efficiency of the organics-oxidation process as a function of operating conditions such as power input, air/water ratios, TiO_2 concentration, type of organic compounds, residence times, flowrates, etc.

4. Approach.

The proposed research will determine the technical and economic feasibility of this process. The focus of the research will be on the UV-TiO_2 oxidation of organics in the air as the organics transfer across a membrane. This research combines the use of a microporous membrane to separate the VOC's from water followed by photo-oxidation of the organic compounds with ultraviolet light in the presence of a titanium dioxide catalyst. In this process the contaminated water is pumped on one side of a membrane while air containing ultra-fine

TiO_2 dust particles is be blown across the other side of the membrane. The VOC's, because of their volatility, diffuse through the membrane and partition between the TiO_2 and the air.

The VOC-laden air is recirculated through a photo-oxidation chamber containing a UV light in which the TiO_2 catalyzes the oxidation of the organic compounds by UV. The VOC-free air is recirculated to the membrane for the extraction of additional volatile organics. In this way air discharge is avoided.

PROJECT INFORMATION

GRANT NUMBER:	14-08-0001-G1624
TITLE:	In-Situ Treatment of Contaminated Flowing Ground Water Using a Dispersion of Air Microbubbles
PERFORMING ORGANIZATION:	Virginia Polytechnic Institute and State University
PRINCIPAL INVESTIGATOR:	Donald L. Michelsen
DURATION:	September 1988 to August 1990

DESCRIPTION

1. Identification of the Water-Related Problems and Problem Solution Approach.

The in-situ treatment of flowing ground water or leachate contaminated with organic materials is essentially limited to biological techniques that are often restricted by oxygen availability. Water emulsions of fine air microbubbles injected into the saturated zone tend to adhere to and be stablized into soil matrices. In laboratory and pilot studies, microbubbles have been shown to enhance biodegradation. Thus, the possibility exists that these microbubbles with nutrients and microorganisms could form an effective treatment barrier to degrade dissolved organic materials in contaminated ground water.

2. Contribution to Problem Solution.

If successful, the technique would provide a means for ground-water and leachate cleanup for field use such as at Superfund sites.

3. Objective.

The objective of this research is to measure and evaluate the effectiveness of air microbubble treatment formulation to degrade dissolved xylene in ground water as it passes through a treatment barrier.

4. Approach.

The effectiveness of using a combination of 50 to 65 percent dispersion of 20-90 micron stabilized air microbubbles (air emulsion), nutrient, and microorganisms injected directly into the saturated matrix, or into a French drain containing medium to coarse sand that serves as an in-situ active treatment barrier will be determined. Contaminated ground water containing dissolved xylene will flow through a low-permeability matrix and then pass through a treatment area placed perpendicular to the direction of flow in a proven vertical-slice test cell, 2.14 m. by 2.14 m by 12.7 cm. (front to back). Rate of degradation, microorganism counts, dissolved oxygen, permeability, and changes in hydrodynamic dispersion using NaCl will be evaluated to determine treatment and hydrodynamic performance of the bubble injections. The effectiveness of microbubble dispersions as an oxygen source for biodegradation will be compared to sparged dissolved air in water.

PROJECT INFORMATION

GRANT NUMBER: 14-08-0001-G1625

TITLE: The Effects of Humic Substances on the Interactions of Metal Ions with Organisms and Liposomes

PERFORMING ORGANIZATION: University of California, Davis

PRINCIPAL INVESTIGATOR: James H. Swinehart

DURATION: September 1988 to August 1991

DESCRIPTION

1. Identification of the Water-Related Problems and Problem Solution Approach.

The extent of water contamination by metal ions from industrial wastes and natural sources, such as acidic, metal-containing mine waters, is a serious environmental problem. The first interaction of these contaminants with an aquatic organism is at its external membrane. It is important to know the extent of contaminant uptake by this membrane and the effects of a contaminant on membrane processes because any perturbation of the membrane can affect the survival of the organism. Because metal ions occur in natural waters, the effects of the natural constitutents of waters, such as humic substances, on the interactions of metal ions with organisms is of importance. For example, it is possible that the reduction in the negative charge of humic substances by complexation with postively charged metal ions results in enhanced uptake of both the metal and humic substance by a biological membrane.

Such an uptake of humic substance-metal complexes may result in a substantial difference in membrane permeability compared to that resulting from the interaction of the individual metal ion and humic substance. Thus, it is important to know both the level and mechanism by which humic substances affect the interactions between metal ions and biological membranes.

2. Contribution to Problem Solution.

The proposed research will result in a definition of the level and mechanism by which naturally occurring humic substances alter potentially adverse interactions between pollutant metal ions and aquatic organisms. The role of membrane lipids in the interactions between metal ions and organisms will be determined by a study of metal ion-liposome interactions.

3. Objectives.

The objectives of this work are to:

(a) Understand the level and mechanism by which humic substances affect the interactions of metal ions, such as $Hg(2^+)$, $Cu(2^+)$ $Pb(2^+)$, $Cd(2^+)$, and $Zn(2^+)$, with organisms; and

(b) Determine whether lipids play an important role in the processes observed with organisms by studying the effects of humic substances on the interactions of metal ions with liposomes.

4. Approach.

The level and mechanism by which humic substances and model compounds having the same functional groups as humic substances affect the interactions of metals ions, such as $Hg(2^+)$, $Cu(2^+)$, $Pb(2^+)$, $Cd(2^+)$, and $Zn(2^+)$, with the gill of the freshwater mollusk Anodonta californiensis or the eyed-egg stage of the Chinook salmon Oncorhynchus tshawytscha will be studied. The interactions to be studied will be the uptake of the metal ion and the effect of the metal ion on the loss of amino acids from the organism. By knowing both the amount of metal taken up and its effect on a process such as the loss of amino acids from the membrane, a quantitative measure of the effect of the metal will be determined. The role of the humic substances, as opposed to simple complexation, in the uptake of metal ion will be defined by a study of the uptake with both humic substances and their model compounds. It is possible that a neutralization of the surface of the humic substances with metal ions will yield a hydrophobic compound capable of entering the hydrophobic region of the biological membrane, thereby affecting membrane permeability as measured by amino acid losses. These data may define the level at which humic substances affect the interactions of metal ions with the membranes studied. There will be substantial ambiguity as to the mechanism by which humic substances affect the processes because of a lack of knowledge as to which component of the membrane (lipid, protein, or lipid-protein interactions) is being acted upon.

Research to clarify the role of the lipid component of the membrane in the processes observed with organisms will be conducted. Liposomes having the composition of the organisms studied will be prepared. The effects of humic substances and their model compounds on the metal ion-induced leakage of dyes or radioactivity labelled compounds from the liposomes will be measured. These experiments should provide a direct way of defining the importance of lipids in the humic substance-metal ion-organism interactions studied. If a positive correlation exists between liposome and organism data, experiments will be carried out to define better the mechanism of the metal ion-liposome interactions.

PROJECT INFORMATION

GRANT NUMBER: 14-08-0001-G1627

TITLE: Mechanisms of Resistance to Organic Chemical Pollutants by Marine Phytoplankton

PERFORMING ORGANIZATION: State University of New York, Stony Brook

PRINCIPAL INVESTIGATOR: Charles F. Wurster

DURATION: September 1988 to August 1990

DESCRIPTION

1. Identification of the Water-Related Problems and Problem Solution Approach.

Clones of phytoplankton resistant to toxic pollutants have been isolated from polluted areas. Phytoplankton resistance to polychlorinated biphenyls (PCB) was greater in the polluted Hudson River estuary than in the less polluted coastal waters near Sandy Hook, New Jersey, and, in turn, was greater than in unpolluted coastal waters near Montauk Point, New York. Within the Hudson River estuary, several clones were actually enhanced in their growth by PCB. Clone selection in polluted estuaries may not only favor resistant strains of microalgae, but may also favor those that can degrade such pollutants as PCB.

The development of phytoplankton resistance might initially appear to be desirable, allowing organisms to survive in hostile, polluted environments, and possibly even to detoxify the pollutants. But resistant, contaminated microalgae may increase risk of contamination to organisms at higher levels in the food chain. These possibilities will be investigated by evaluating the physiological mechanisms associated with the development of resistance to PCB, as well as any enhanced cellular accumulation, the fate of the pollutant, and any metabolic transformations which could enhance algal growth.

2. Contribution to Problem Solution.

Information gained from this research will increase knowledge about the effects of toxic wastes on coastal environments and the human health consequences, especially the interactions of toxic organic chemicals with organisms and the resilience of communities to these impacts.

3. Objectives.

The objectives of this research are to:

(a) Investigate resistance and cross-resistance of marine phytoplankton to toxic organic chemicals;

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(b) Determine whether the physiological mechanisms associated with resistance to organic pollutants enhance bioconcentration of pollutants in phytoplankton; and

(c) Elucidate the physiological mechanisms associated with resistance by phytoplankton to organic pollutants to determine whether PCB-resistant phytoplankton strains metabolize or break down PCB, leading to enhanced algal growth.

4. Approach.

The research will test for the concomitant development of cross-resistance within several classes of pollutants --the chlorinated, aromatic, and petroleum hydrocarbons. Building from work with diatom strain Ditylum brightwellii, which showed cross-resistance to DDT coincident with the development of resistance to PCB, test for cross-resistance to other chlorinated hydrocarbon pollutants, including chlordane and dieldrin. Then it will be determined if the cross-resistance also extends to the aromatic and petroleum hydrocarbons, including naphthalene, anthracene, and phenanthrene.

PROJECT INFORMATION

GRANT NUMBER:	14-08-0001-G1631
TITLE:	Risk Management for Nitrate-Contaminated Ground-Water Supplies
PERFORMING ORGANIZATION:	University of Nebraska-Lincoln
PRINCIPAL INVESTIGATORS:	Mohamed Dahab and Istvan Bogardi
DURATION:	September 1988 to August 1990

DESCRIPTION

1. Identification of the Water-Related Problems and Problems Solution Approach.

Nitrate concentrations in ground-water supplies in many areas in the United States, particularly in the Midwest, have steadily increased to levels that exceed Maximum Contaminant Limit mandated by the Safe Drinking Water Act. The concern over nitrate contamination stems from the fact that consumption of these salts is linked to infant methemoglobinemia. Nitrates also have been linked to the formation of nitrosoamines and nitrosoamides, which are etiologic agents for human gastric cancer.

To achieve new risk management techniques for nitrate-contaminated ground-water supplies, classical risk analysis will be extended according to two principles: (a) the use of probabilities whenever a frequency based estimation can be made, or alternatively, when subjective probabilities can be assessed; and (b) the use of fuzzy sets to account for imprecision in non-probabilistic cases.

2. Contribution to Problem Solution.

The results of this research will enable state and local agencies to select cost-effective nitrate-control strategies, including the most feasible nitrate removal systems. In addition, the risk-analysis approach to ground-water pollution focusing on either the engineering aspects or health consequence aspects will be improved by giving similar importance to both elements.

3. Objectives.

The objectives of this research are to:

(a) Develop a risk management methodology to select cost-effective methods of nitrate contamination control;

(b) Encode uncertainties in the elements of risk management with a combined probabilistic fuzzy-set approach;

(c) Investigate the cost and nitrate removal efficiency for available nitrate treatment methods and other emerging types of control strategies; and

(d) Verify the methodology in the analysis of an actual case-study area in Nebraska where nitrate contamination poses potential health and economic problems.

4. Approach.

The research is directed at developing new risk-management techniques for nitrate-contaminated ground-water supplies. The methodology will address specific, yet common, cases of ground-water contamination in Nebraska. The risk management methodology will consider both health risk and the cost of control with special attention to nitrate treatment. A combined probabilistic/fuzzy-set approach will be used to address uncertainties common to risk management. Different nitrate inputs (point as well as non-point sources) as well as different control strategies, including source control, will be considered.

PROJECT INFORMATION

GRANT NUMBER:	14-08-0001-G1633
TITLE:	Evaluation of Saprolite for On-Site Wastewater Disposal
PERFORMING ORGANIZATION:	North Carolina State University
PRINCIPAL INVESTIGATORS:	Aziz Amoozegar and Michael T. Hoover
DURATION:	September 1988 to August 1991

DESCRIPTION

1. Identification of the Water-Related Problems and Problem Solution Approach.

Over 50 percent of North Carolinians rely on septic tank systems for managing their household wastewater. The soils in the North Carolina Piedmont and Mountain Regions (occupying 55 percent of the State) are characterized by the presence of saprolite at or near the surface. Present North Carolina (NC) rules governing septic tank systems consider saprolite unsuitable for wastewater disposal, however, changes are underway to reclassify some saprolite for direct wastewater application. Because of cracks, foliations, natural dikes and various pores in saprolite, it is suspected that direct application of wastewater to saprolite will result in the rapid movement of pollutants into the ground water. In light of the lack of information, it is difficult to determine if any saprolite is suitable for wastewater disposal. Also, the procedures by which suitable material could be recognized are not clearly established. The research proposed here is aimed at identifying properties of various saprolites associated with the major soils and rock types in the two regions, and developing procedures to identify suitable saprolites for septic tank systems.

2. Contribution to Problem Solution.

The information obtained in this study will help regulatory agencies to develop regulations regarding use of saprolite for wastewater disposal in Piedmont and Mountain Regions. Also, by studying soil and saprolite sequences associated with the major soils, we will be able to extrapolate findings to other soil an saprolite materials. This information will also be important for assessing ground-water recharge and movement of other inorganic chemicals in waste materials such as sludge or landfill leachate throughout the soils of the two regions.

3. Objectives.

The objectives of this research are to:

(a) Determine the important properties of the soil and saprolite sequences, and relate them to the saprolite's associated reference soil;

(b) Evaluate the effectiveness of saprolite in removing the constituents of wastewater from septic tank systems; and

(c) Develop guidelines for field evaluation of saprolite for its suitability as a receptacle of septic tank effluent.

4. Approach.

For objective (a), eight sites in the Piedmont and four sites in the mountain regions of NC will be selected. Disturbed and undisturbed samples from the B, transitional and saprolite horizons at each site will be collected by a conventional hand auger and analyzed in the laboratory for saturated hydraulic conductivity, moisture characteristics, bulk and particle densities, texture, CEC, EC, pH, free Fe_2O_3, and for a number of water soluble and total ions commonly found in septic tank effluent (e.g, Ca, K, $N\text{-}NH_4$, $N\text{-}NO_3$, and Cl). The attenuation capacity of the material from each horizon for the above ions will also be determined by a batch experiment.

For objective (b), soil water content and potential in and around at least six septic tank systems located in shallow soils underlain by different saprolites for at least six of the sites will be monitored for over one year. Soil samples will be collected on three transects parallel to the drainlines and three transects perpendicular to the drainlines of each of the systems. The samples will be analyzed for a number of solutes commonly found in household wastewater.

For objective (c), field estimates of soil properties of the three horizon samples collected by the hand auger at at least five of the twelve sites selected for objective (a) will be compared to results of laboratory analyses of these properties in composite samples collected from pits dug there to determine removal of constituents of wastewater from the septic tank systems. Soil profile decriptions will be prepared for each of the twelve sites and compared against the six septic tank systems to develop a field evaluation protocol for saprolite.

PROJECT INFORMATION

GRANT NUMBER: 14-08-0001-G1636

TITLE: Microbial Transformations in Alkali Lake, Oregon

PERFORMING ORGANIZATION: Oregon Graduate Center

PRINCIPAL INVESTIGATOR: David R. Boone

DURATION: August 1988 to July 1991

DESCRIPTION

1. Identification of the Water-Related Problems and Problem Solution Approach.

The current level of understanding of microbial processes occurring in groundwater brines and hypersaline lakes is poor, and this lack of knowledge limits our ability to protect such environments or safely utilize them for waste disposal. Further, the irrigation of arid area soils may increase salinity of ground waters and lakes and may result in increased concentrations of toxic elements such as selenium. The research examines the microflora and their activities in an alkaline, saline environment (Alkali Lake, Oregon).

2. Contribution to Problem Solution.

The findings will permit rational decisions for the utilization of some saline environments as sites for waste disposal, improve the predictions of effects of irrigation or other man-made changes in water flow patterns, and allow management techniques to maximize detoxification of selenium. The data may also be extrapolated to microbiology of brine aquifers.

3. Objectives.

The objectives of this research are to:

(a) Enumerate methanogenic and sulfate-reducing bacteria from various depths in Alkali Lake sediment;

(b) Isolate and characterize the most numerous methanogenic and sulfate-reducing bacteria;

(c) Determine ability of predominant methanogenic microflora to catabolize methyl selenides;

(d) Enumerate peptone- and fatty acid-degrading bacteria from various depths in Alkali Lake sediments; and

(e) Isolate and characterize the most numerous peptone and fatty acid-degrading bacteria.

4. Approach.

During the first year of this project, we will enumerate and characterize the bacteria that produce the end-products of degradation (i.e., methane and sulfide) in Alkali Lake. Besides their pivotal role in carbon flow, these physiological groups are the major agents of methylation and demethylation of metalloids in anaerobic environments. The quantitatively important methanogens and sulfate reducers will be examined to determine how environmental conditions such as pH, salinity, and temperature affect their growth and metabolism. In other ecosystems, such as anaerobic digestors, such characteristics of predominant organisms have been used to predict the effects of environmental conditions on the overall carbon flow. Because microbial transformations dominate chemical reactions in these saline environments, the effect of changing chemical and physical parameters on the dominant microflora is a fine predictor of the change in these environments. In the next 2 years of the study, detailed characterization of the most important methanogens and sulfate-reducers will be pursued, especially with respect to their abilities to methylate and demethylate selenides. We will also characterize bacteria occupying positions higher in the microbial food-chain, including fatty-acid-degrading bacteria and protein-degrading bacteria, in order to evaluate their role in metal transformations.

PROJECT INFORMATION

GRANT NUMBER: 14-08-0001-G1648

TITLE: Development of Biologically Relevant Methods for the Determination of Bioavailable Aluminum in Surface Waters

PERFORMING ORGANIZATION: University of Wyoming

PRINCIPAL INVESTIGATORS: Harold L. Bergman and James I. Drever

DURATION: September 1988 to September 1990

DESCRIPTION

1. Identification of the Water-Related Problems and Problem Solution Approach.

As a result of surface-water acidification, aluminum has been identified at potentially toxic concentrations in surface waters. Concentrations of total aluminum present in these waters, however, often do not adequately indicate the toxicity observed. Research has shown that waters containing high concentrations of organic acids show lower toxicity than those without these organics at given equivalent aluminum concentrations. For this reason, the inorganic monomeric fraction aluminum has been proposed as the "toxic" fraction of aluminum. Currently, measurement of inorganic monomeric aluminum is procedurally-based, and is accomplished by a variety of chemical methodologies. Recent evidence suggests, however, that discrepancies exist between these chemically-defined fractions and their toxicity to aquatic organisms. We propose that fractionating aluminum on the basis of toxicity to organisms is a more relevant approach, because toxicity is the parameter of interest.

2. Contribution to Problem Solution.

The research will eliminate the current ambiguity regarding the measurement of "toxic" aluminum in acidic surface waters, providing concise methodology for this measurement. This will allow more accurate assessment of potential damage to fisheries caused by environmental acidification, because increased aluminum concentrations are considered to be the cause of damage in many aquatic systems.

3. Objectives.

The objectives of this research are to:

(a) Evaluate the suitability of different cation-exchange resins for separation of free and organically-bound aluminum;

(b) Determine the amount of biologically active aluminum in acidic waters in the presence and absence of various organic acids, using measurements of plasma sodium and mortality of fingerling brodo trout as indices of stress;

(c) Determine the adequacy of the newly developed analytical technique in acid waters; and

(d) Recommend appropriate techniques for the analysis of fractionation of aluminum in acidic surface waters.

4. Approach.

The toxicity of various aluminum/organic acid solutions to fingerling brook trout will be evaluated through laboratory bioassays. By testing organic acids of varying aluminum-binding affinity, we will estimate the apparent aluminum-binding affinity of brook trout. By manipulating various column characteristics (e.g., resin, column dimensions, flow rate, regenerating cations), we will adjust the aluminum-binding affinity of the column to approximate that of the fish. The resulting procedure will be verified using *in situ* bioassays in acidic surface waters. In addition, the results obtained via the newly developed method will be compared to those obtained with previously used methods for aluminum fractionation, both to quantify the increase in accuracy and assess the potential errors caused by previous methods of aluminum fractionation.

PROJECT INFORMATION

GRANT NUMBER:	14-08-0001-G1650
TITLE:	Recombinant Organisms in the Drinking Water System: Survival, Plasmid Transfer, and the Role of Material Surfaces
PERFORMING ORGANIZATION:	University of Delaware
PRINCIPAL INVESTIGATOR:	Diane S. Herson
DURATION:	September 1988 to September 1990

DESCRIPTION

1. Identification of the Water-Related Problems and Problem Solution Approach.

Genetically engineered microorganisms (GEMS) are widely used in laboratory studies. As these organisms are not meant to be released into the environment, they have been constructed not to survive well outside of the laboratory. The plasmids of these organisms are classified as non-conjugative; --that is, they cannot be directly transferred by conjugation into other organisms.

Studies of GEMS have demonstrated that survival does occur outside the laboratory. In addition, although these organisms cannot directly transfer their plasmids to recipient organisms, they can be mobilized to do so by other bacteria in the environment. Bacteria that have been able to act as mobilizers and recipients have been isolated from wastewater.

This research will use a recirculating system to monitor the survival of GEMS and their ability to transfer plasmids in drinking water.

2. Contributions to Problem Solution.

The research will contribute to the body of information on survival of GEMS in the environment. Specifically, the study will determine the potential for recombinant organisms to survive and transfer their plasmids in the drinking water environment. If survival and transfer occur, the conditions necessary for these processes to occur and the role of surfaces in fostering them will be recorded.

3. Objectives.

The objectives of this research are to:

(a) Assess the ability of recombinant organisms to survive in the drinking water distribution system;

(b) Determine if plasmid transfer occurs in the drinking-water environment; and

(c) Determine the role of material surfaces in fostering plasmid transfer.

4. Approach.

Survival of recombinant organisms will be studied using flask cultures. We will use the results of these studies to modify the physical, chemical, and biological parameters of waters used in recirculating water experiments. To determine if plasmid transfer can occur in these waters, we will add all combinations of donors, mobilizers, and recipients. We will detect transfer by finding recipients that exhibit the appropriate antibiotic resistance profile and the Herpes simplex thymidine kinase gene. We will determine the role of surfaces in survival and transfer by adding organisms of flask cultures or the recirculating system attached to artificial substrates and then assaying these populations for survivors and recombinants.

PROJECT INFORMATION

GRANT NUMBER:	14-08-0001-G1659
TITLE:	Organic Phosphorus Compounds in the Hydrosphere: Characteristics, Identity, and Dynamics
PERFORMING ORGANIZATION:	University of Illinois
PRINCIPAL INVESTIGATOR:	Roger A. Minear
DURATION:	September 1988 to September 1991

DESCRIPTION

1. Identification of the Water-Related Problems and Problem Solution Approach.

Organic phosphorus (P) generally represents the major source of available P in most aquatic and terrestrial ecosystems. Although P availability is frequently the principal limitation to inorganic carbon fixation and organic carbon mineralization, and P is tightly conserved or retained within these ecosystems, the dynamics of organic P mineralization and fixation in aquatic and terrestrial ecosystems are poorly understood. This is due to a lack of information on the chemical identity of organic P compounds in soils, sediments, and ground and surface waters.

2. Contribution to Problem Solution.

This information will assist in better defining the biologically available fractions of organic P in sediments, soils, and ground and surface waters; determining the turnover rates of these functions; and understanding the biological and geochemical mechanisms that control the mineralization and fixation of organic P in aquatic and terrestrial environments.

3. Objectives.

The objectives of this proposal are to:

(a) Characterize organic phosphorus compounds in sediments, soils, and ground and surface waters;

(b) Determine the relative distribution of organic P compound types in selected aquatic and terrestrial ecosystems;

(c) Determine the role of individual compounds in P transfers through selected aquatic and terrestrial ecosystems; and

(d) Investigate the mineralization rates of selected organic P compounds in soils, sediments, and ground and surface waters.

4. Approach.

To achieve our overall objective, we will use recent analytical developments in applications of Fourier Transform ^{31}P Nuclear Magnetic Resonance spectroscopy and high performance liquid chromatography to provide more detailed investigations of the organic phase of the P cycle. This will require collection of large volumes of sample waters from the various hydrosphere compartments in one or more watersheds and employing extreme concentration procedures to yield concentration factors of 1,000 or more. Preliminary results indicate that ultrafiltration can achieve the necessary concentration factors. Specific compound identification and/or compound class information will be used to assess the extent of P form change through the hydrosystem compartments. Time-series analysis will be applied to assess individual compartment dynamics. Specific compound identification will be attempted with both primary analytical techniques with mass spectrometry assistance. If successful, specific compound identity will be used to determine the role of these compounds in individual ecosystems by study of their formation and transformation kinetics.

CLIMATE VARIABILITY AND THE HYDROLOGIC CYCLE

PROJECT INFORMATION

GRANT NUMBER:	14-08-0001-G1630
TITLE:	The Role of Climate and Topography on Ground-Water Circulation in Hydrologically Closed, Mountain and Basin Terrain
PERFORMING ORGANIZATION:	Utah State University
PRINCIPAL INVESTIGATOR:	Christopher Duffy
DURATION:	September 1988 to August 1991

DESCRIPTION

1. Identification of the Water-Related Problems and Problem Solution Approach.

From a hydrologic standpoint lack of external surface drainage is the essential physical characteristic of the mountain and desert valleys in the Great Basin. As a result of the arid to semi-arid climate of the region, potential evaporation exceeds basin precipitation and all the waters circulating within these basins drain internally and are returned to the atmosphere through direct evaporation or transpiration of plants. It is precisely this feature that makes closed basins such hydrologically sensitive and complex environments. Historically this region has received limited development pressure, principally as a result of the extreme aridity of the region and the general lack of adequate ground-water supplies of suitable quality for development. Major land uses have been related to the mineral extraction industry, ranching, and military training and testing operations. In recent years, however, new commercial and Government development demands on this sensitive arid region are beginning to emerge that will compete with the traditional land uses. It is not certain that our understanding of the hydrology of this region matches the pace of current development. The research is an effort towards a better understanding of hydrology in this remote desert environment.

2. Contribution to Problem Solution.

On the basis of results of our 'single basin' study, it is expected that considerable insight into the complex nature of hydrogeochemical clycling may be gained from carefully designed numerical and field experiments.

3. Objectives.

The objectives of this research are to:

(a) Develop a physical model of subsurface flow in a topographically closed, mountain, and basin system; and

(b) Begin an experimental study of the near-surface hydrology of a saline playa for the purpose of determining the role of evaporating brine on the hydrodynamics of ground-water flow.

4. Approach.

In the western United States the desert landforms of the Great Basin portion of the Basin and Range physiographic province provide a unique geometry for the study of terrestrial circulation and storage of water. In this hydrologically closed region, topographic relief is consistently correlated with climatic change, as seen by the deep snows of high-elevation ranges, and the aridity of lower elevation terrain. The alluvial basins as well as the fractured bedrock of mountain ranges accommodate ground-water aquifers, which vary in size and shape according to the physical constraints of the landform and the prevailing climate conditions. In a previous study, an attempt was made to explore the role of mountain recharge and playa-lake evaporation on ground-water flow in this system. The study demonstrated that characteristic topography of steep mountains adjacent to flat playas may have important implications for ground-water flow, through the orographic effect of mountain precipitation. By contrast, the effect of high evaporation rates on the playa is to produce concentrated brine solutions, leading to large horizontal and vertical density gradients in underlying ground water. Numerical experiments demonstrated the existence of a free convection cell whose motion was shown to be balanced by recharge from the adjacent mountain range. A Rayleigh number for solutes was defined and related to hydroclimatic conditions. This study will extend this research to include the role of complex variations in topography, geology, and associated climate conditions in controlling the regional transfer to water and salt.

PROJECT INFORMATION

GRANT NUMBER: 14-08-0001-G1653

TITLE: Determination of Regional Evapotranspiration from Measurements of the Atmospheric Boundary Layer

PERFORMING ORGANIZATION: Utah State University

PRINCIPAL INVESTIGATOR: Lawrence Hipps

DURATION: September 1988 to September 1991

DESCRIPTION

1. Identification of the Water-Related Problems and Problem Solution Approach.

Evapotranspiration (ET) is a critical component of the hydrologic cycle, and mediates the exchanges of mass and energy between the earth's surface and the atmosphere. Although ET has been studied a great deal for local scales, studies of short-term regional scale ET are necessary to understand large-scale hydrologic problems and manage water resources effectively.

A large portion of the land surface is comprised of semiarid ecosystems. These include rangelands. Improvements in understanding the large scale ET of these lands are needed in order to achieve a general understanding of the hydrologic problems in these areas.

2. Contribution to Problem Solution.

This research would examine the feasibility of calculating regional ET from measurements of a deep layer of atmosphere that could be made routinely. The methods have been published, but never rigorously evaluated. Results will improve understanding of the hydrology of these regions, and should reveal the interactions between local and regional scales of hydrologic processes.

3. Objectives.

The objectives of this research are to:

(a) Calculate regional ET for a shrub-steppe ecosystem from atmospheric profiles of wind, temperature, and humidity using several theoretical approaches;

(b) Evaluate the accuracy of such methods by comparing the results to an array of ground-based measurements; and

(c) Examine the hydrological implications of the results.

4. Approach.

A large flat site north of Randolph, Utah, has been selected for the study. The plant community at the site is dominated by Artemisia tridentata (sagebrush), a dominant species of the arid to semiarid regions of the western United States, thus making the site appropriate for studies of a shrub-steppe region. Sets of radiosonde measurements to calculate vertical profiles of wind, humidity, and temperature will be collected and used to estimate regional ET. A set of ground-based measurements of ET will be made at each site.

Agreement between calculated ET values from the sondes and ground measurements will be evaluated for various times of day. The following questions will be addressed: How many sondes are necessary to yield a reliable estimate for daily ET? When should the sonde measurements be taken? Under what conditions is the agreement with ground measurements best? This will require a rigorous analysis of the results.

The regional ET values will be studied to examine their magnitudes, as well as their variation in time. The magnitude of ET in this ecosystem will be elucidated. In addition, seasonal variations in ET will be studied. The implications of the findings towards the hydrology of these lands will be considered.

PROJECT INFORMATION

GRANT NUMBER: 14-08-0001-G1655

TITLE: The Paleoclimatic History of Devils Lake, North Dakota

PERFORMING ORGANIZATION: University of New Hampshire

PRINCIPAL INVESTIGATOR: William Berry Lyons

DURATION: September 1988 to August 1990

DESCRIPTION

1. Identification of the Water-Related Problems and Problem Solution Approach.

The level and volume of Devils Lake, a closed-basin lake in northeastern North Dakota, have fluctuated significantly in recorded history. Marked changes in salinity have occurred along with these variations in volume. For the period of record, the maximum lake level was 438 meters above sea level (MASL) in 1867, and the minimum was 424 MASL in 1940. During this period lake-surface area decreased from 363 square kilometers to 26.4 square kilometers. Present lake level is approximately 1,428 MASL. During 1900-1987 mean salinity for the lake varied from approximately 2,000 parts per million (ppm) to 25,000 ppm TDS. These fluctuations have led to problems of substantially increased salinity during periods of low lake level, and loss of arable land during periods of high lake level.

To understand better the effect of climatic change on lake level, and to assist in forecasting future lake level fluctuations, the U.S. Geological Survey (USGS) and the North Dakota Water Commission are investigating the hydrology of the Devils Lake basin. Together the two organizations are monitoring the meteorology and hydrology of the basin. In addition the USGS is analyzing 100 years of climatic and hydrologic data to develop models of the effect of climate on lake level.

2. Contribution to Problem Solution.

The study will develop a long term (1000 year) record of lake-level change based upon geochemical analysis of sediment cores from Devils Lake. A 1000 year record of lake level variation unavailable in historical records will enhance our ability to predict the future change and should provide valuable insight concerning the combined use of the stable carbon and nitrogen isotopic composition of sedimentary organic material as an indicator of past lake level variation. If successful, this technique should provide the most continuous sedimentary record possible and prove to be a valuable component of many paleolimnologic studies.

3. Objective.

The objective of this research is the development of a paleoclimatic model based upon geochemical criteria that can be used to develop a climatic history for the Devils Lake region.

4. Approach.

The research will involve collecting three cores from Devils Lake and taking samples of the cores at (1 cm intervals). Because the changes in the volume and salinity of Devils Lake should have a profound affect on the sediment deposited on the lake floor, the mineralogy, grain size, major and trace metal content of the sediment, and the amount and type of organic material should be distinctly different during periods of high and low lake levels. After radiochemical age dating to ascertain the sedimentation rate, the isotopic and geochemical profiles can be compared directly to the available precipitation, lake-level, and salinity data to aid in the understanding of the effect of climate on the chemical properties of the sediment. Detailed changes in the isotopic and geochemical content of sediment cores should be useable to discern a history of lake-level fluctuation. These relationships can then be used to develop longer climatic records for Devils Lake.

PROJECT INFORMATION

GRANT NUMBER:	14-08-0001-G1656
TITLE:	Precipitation Regime Changes Resulting from Climatic Changes
PERFORMING ORGANIZATION:	North Carolina State University
PRINCIPAL INVESTIGATORS:	Peter John Robinson and Stephen J. Walsh
DURATION:	September 1988 to August 1990

DESCRIPTION

1. Identification of the Water-Related Problems and Problem Solution Approach.

Climatic changes have the potential to create dramatic changes in the precipation regime and the water resources of a region. Climate scenarios based on general circulation models indicate the potential changes, but do not provide adequate detail for impact assessments. Analogue scenarios, using historical records, provide much greater detail but cannot incorporate the effects of the processes creating future climates. The research will combine the strengths of the two approaches and develop climate scenarios for the southeastern United States directly applicable to assessments of the impact of climatic change on water resources.

2. Contribution to Problem Solution.

The research results, given in terms of precipitation-event/frequency distributions, can be used both as input to the latest generation of stochastic hydrologic models and as estimates of seasonal precipitation for use by water managers.

3. Objectives.

The objectives of this research are to:

(a) Determine frequency distributions of the intensity and duration of precipitation events, and the intervals between events, as required by stochastic hydrologic models;

(b) Determine the contribution of cyclonic and convective precipitation events to the total precipitation as a function of atmospheric flow characteristics;

(c) Identify the likely flow characteristics of future climates as suggested by general circulation model results; and

(d) Estimate the changes in precipitation regimes resulting from circulation changes.

4. Approach.

It is hypothesized that the frequency and characteristics of precipitation events will vary as a result of alterations in atmospheric-flow patterns arising from a changed climate. Flow patterns, characterized by the pressure gradient across the Southeast and the frequency and path of depression movements, will determine the relative importance of convective and cyclonic precipitation. These two precipitation types have different intensities, durations, and spatial characteristics. Frequency distributions of the intensity and duration of individual events, and of the lengths of intervals between events, will be determined for each type from the historical record. The parameters of the distributions will be established on a seasonal basis as a function of flow patterns. These will be used with the suite of likely future flow patterns established from general-circulation model outputs to estimate probable precipitation regimes under a changed climate.

INSTITUTIONAL CHANGE IN WATER-RESOURCES MANAGEMENT

PROJECT INFORMATION

GRANT NUMBER:	14-08-0001-G1629
TITLE:	Water-Quality Enhancement via Integrative Management of Non-Point Source Water Pollution and Flood Damage Reduction Control Strategies
PERFORMING ORGANIZATION:	Georgia Institute of Technology
PRINCIPAL INVESTIGATOR:	Augustine O. Esogbue
DURATION:	September 1988 to September 1990

DESCRIPTION

1. Identification of the Water-Related Problems and Problem Solution Approach.

When urbanization occurs within a watershed, the rate and volume of runoff generally increase. The higher flow rates also result in increased flooding of areas downstream of the developed area. Additionally, the increased rates of runoff, together with the destruction of natural vegetation, lead to increased erosion. The resultant erosion, besides causing problems such as stream-bank caving and gullying, can also result in the deposition of large quantities of sediment in downstream areas. Together, non-point source pollution and flooding pose serious challenges to effective water-resources management.

2. Contribution to Problem Solution.

Difficulties inherent in planning and management of complex socio-technical systems involving imprecise and usually vague data will be minimized via the methodologies to be developed. The research should provide decision techniques that can assist water-resources planners in evaluating quantitatively and choosing an "optimum" from among a myriad of feasible combinations.

3. Objectives.

The objectives of this research are to:

(a) Develop new planning methodologies that will enable water-resources planners to select a combination of structural and non-structural measures to address the twin problems of non-point source water pollution and flood control measures over time and space;

(b) Implement the methodologies on a digital computer; and

(c) Test and assess the feasibility and utility of the methodologies in a real-world setting.

4. Approach.

The research approaches include multi-attribute decision theory, fuzzy and approximate reasoning, and mathematical programming, specifically Benders' decomposition, dynamic programming, and possibly some heuristics. An important departure from previous approaches is the explicit injection of new but potent methodologies for generating and incorporating vague and imprecise water-quality data - both benefits and costs such as damages in the optimization models.

PROJECT INFORMATION

GRANT NUMBER:	14-08-0001-G1634
TITLE:	Development of Stochastic Demand Models for Water-Resources Planning
PERFORMING ORGANIZATION:	The University of Arizona
PRINCIPAL INVESTIGATORS:	Soroosh Sorooshian and R. B. Billings
DURATION:	September 1988 to September 1990

DESCRIPTION

1. Identification of the Water-Related Problems and Problem Solution Approach.

Many researchers recognize that the identification of a proper water demand model, when all the variables are noisy, is a major problem in the planning process. Although econometric-type regression models or time-series models are in general use, they have many deficiencies such as nonidentifiability, nonuniqueness of the solution set, and unboundedness in the solution set. This research is aimed at identifying the suitable water demand model from a set of noisy data using realization theory.

2. Contribution to Problem Solution.

With this approach a complete set of demand scenarios for the future will be obtained that could be used to generate different policy options. The results are expected to be of significant value in the planning and decision-making process regarding the range of future water demands.

3. Objectives.

The objectives of this research are to:

(a) Develop an extension of the noisy realization theory to obtain a bounded solution set;

(b) Develop a dynamic model when the time dependency of the demand needs to be taken into consideration;

(c) Develop an efficient mathematical programming algorithm for obtaining minimum and maximum bounds on a parameter set; and

(d) Develop static and dynamic recursive identification procedures to estimate the model parameters.

4. Approach.

This research will focus on two aspects of modeling and parameter estimation in the context of noise in all variables. First, extensions of the theoretical issues that facilitate the explicit consideration of noise in all variables will be analyzed. Second, the proposed methodologies will be implemented using real and simulated data to assess their effectiveness compared with traditional modeling techniques.

PROJECT INFORMATION

GRANT NUMBER:	14-08-0001-G1637
TITLE:	Model for Regional Solute Transport Suited for Calibration and Management
PERFORMING ORGANIZATION:	Colorado State University
PRINCIPAL INVESTIGATOR:	H. J. Morel-Seytoux
DURATION:	September 1988 to August 1991

DESCRIPTION

1. Identification of the Water-Related Problems and Problem Solution Approach.

The problem addressed is the general one of conjunctive management of ground- and surface-waters for modeling both quantity and quality. As an example, changes in operations in a stream-aquifer system such as the South Platte River system are constrained by the fear of the senior water-rights holders that they may lose in the change without receiving fair compensation. Whereas it is relatively easy to measure and assess the effect of a surface diversion on downstream flows, it is not possible to measure aquifer return flows and it is not possible to measure the reduction in base flow in space and time due to a particular pumping well.

A model is needed because one cannot see ground-water flow and how its motion is affected by various variables (pumping, recharge, evapotranspiration, etc.). Yet, model results are often received with skepticism precisely because flow cannot be seen. Thus, the model must be realistic. It must predict the system's behavior at a fine level both in time and space, and over long horizons. Such detailed capability of the model increases its cost. Thus, the model, besides being accurate, realistic, and detailed, must also be cost effective.

One such model has been developed in the past but for quantity only. The proposed solution approach is to add the capability of prediction of quality (solute concentration) to the quantity model without jeopardizing its inexpensive features.

2. Contribution to Problem Solution.

Previous studies indicated that the augmentation plan of the ground-water appropriators of the South Platte River valley was adequate. The studies did not provide any clue, however, as to the impact of such a plan on the salt content of the water. The new model will provide useful solutions to these problems.

3. Objectives.

The objectives of this research are to:

(a) Complement a current methodology to predict a stream-aquifer system response to various management strategies with predictive capabilities in terms of quality and management; and

(b) Develop an efficient calibration procedure of the aquifer parameters for mass and solute transport.

4. Approach.

Current methodology relies on the analytical-numerical description of the velocity field in a heterogeneous horizontal rectangular aquifer block, on the solution of the concentration equations by the method of characteristics, and on a method akin to kriging to obtain interpolated values of concentration at a set of fixed points. Each of these steps needs to be thoroughly tested . For example, the analytical-numerical procedure uses a two-dimensional Fourier analysis. Naturally, only a finite number of terms can be retained. Criteria are needed to guide in the selection of that number in terms of various parameters such as the extent, nature and shape of the transmissivity variations within a block.

The matching of the within-block flow field and solute transport with the general inter-block flow field in the large-scale system must be developed and tested. The merit of the approach with regard to accuracy and efficiency must be assessed by comparision with standard approaches. Under what circumstances is the new approach superior or inferior to other approaches? A number of tests have demonstrated the cost effectiveness of the discrete-kernel approach for modeling of ground water. Tests will be conducted to evaluate the effectiveness of this approach with solute transport.

PROJECT INFORMATION

GRANT NUMBER:	14-08-0001-G1639
TITLE:	Institutional Response to a Changing Water-Policy Environment
PERFORMING ORGANIZATION:	The University of Arizona
PRINCIPAL INVESTIGATORS:	F. Gregg, W. B. Lord, and M. Waterstone
DURATION:	September 1988 to September 1990

DESCRIPTION

1. Identification of the Water-Related Problems and Problem Solution Approach.

The decline of the Federal Government's commitment to, and investment in, the management of the nation's water resources has stimulated the States and other political jurisdictions to become more innovative in use of institutional (legal, political, and administrative) structures and processes involved in water-resources decisionmaking. As the pace of such innovation accelerates, it becomes increasingly possible and important that experience to date be reviewed and analyzed. Thus, the lessons of that experience can be extracted and made available to guide future institutional change. At issue are the most productive roles, types, and levels of commitment for general and special purpose units of government at all levels (including those institutions that support market-based decisionmaking), and the most productive patterns of institutional interactions.

Directing and supporting institutional innovation requires understanding of the institutional options available and of the probable consequences of adopting and implementing them. Therefore, the approach to institutional change is that of systematically classifying institutional alternatives and projecting their likely consequences.

2. Contribution to Problem Solution.

The research work will clarify what participants want water-management institutions to accomplish, will identify the kinds of institutions most likely to accomplish those ends, and will describe the resources or inputs needed for effective operation of those institutions.

3. Objective.

The objective of this research is to develop and test a model that can illustrate the institutional capactiy to meet water policy demands under different sets of conditions.

4. Approach.

The research will involve literature review of water-management institutional arrangements and processes; development of comprehensive typologies of water-management institutions, policy inputs, and outputs; testing of hypotheses on relationships between policy inputs, implementation processes and outputs; and analysis of characteristics and policy outputs for a representative set of institutional arrangements.

PROJECT INFORMATION

GRANT NUMBER:	14-08-0001-G1644
TITLE:	Economic Impacts of Alternative Water-Allocation Institutions in the Colorado River Basin
PERFORMING ORGANIZATION:	Colorado State University
PRINCIPAL INVESTIGATOR:	Robert A. Young
DURATION:	September 1988 to December 1989

DESCRIPTION

1. Identification of the Water-Related Problems and Problem Solution Approach.

The water economy of the Colorado River basin is moving from the "expansionary phase" (when new supplies are readily available at reasonable cost) to the "mature phase" (when costs of new supplies are rapidly escalating and water users are increasingly interdependent). Even though the river is now nearly fully utilized under normal flow conditions, potential urban growth in the lower basin and potential energy development in the upper basin bring the prospect of further increase in water demand. Many observers believe that the existing institutional arrangements for allocation of water in the basin are inadequate to achieve maximum economic productivity from the Colorado River water resource. Water markets, based on firm entitlements that are exchangeable across and within State boundaries, are hypothesized to be an improved institutional mechanism.

2. Contribution to Problem Solution.

The results of the analysis will identify barriers to achieving maximum productivity of the water of the Colorado River basin. The measured gains from trade will indicate the potential gains from institutional change.

3. Objectives.

The objective of the research is to measure the potential magnitude and distribution of economic value gains from establishing water markets in the Colorado River basin.

4. Approach.

An interregional mathematical programming model representing the allocation of Colorado River water will be developed. Agricultural, industrial, and household-demand sectors will be included for western Colorado and southern California, representing sources and demands in the upper and lower basins, respectively. Each sector will be modeled as a distinct region, such that any sector can purchase water from any other provided it can pay the going

price plus the transfer (transport plus transactions) costs. Instream flow values will be credited or debited against transfer costs as appropriate. The analysis will be conducted for demand scenarios representing 1990, 2010, and 2030 under normal water supply and drought conditions. The 1990 scenarios with no transfer possibilities will provide a baseline from which to assess potential gains from trade.

PROJECT INFORMATION

GRANT NUMBER:	14-08-0001-G1646
TITLE:	Institution Needs and Distribution of Benefits in Use of Hydrologic Criteria to Expedite Changes in Water Use
PERFORMING ORGANIZATION:	New Mexico State University
PRINCIPAL INVESTIGATORS:	John W. Hernandez, Jr. and Susan C. Nunn
DURATION:	September 1988 to February 1990

DESCRIPTION

1. Identification of the Water-Related Problems and Problem Solution Approach.

Water management in the West has shifted focus from a resource allocation approach to one of reallocation among competing users. Market transfers are the means of reallocating privately held rights to use water that are most consistent with the doctrine of prior appropriations, under which most water rights in the West are held. For many reasons, existing laws, regulations, and court decisions on transfers of water rights make such transactions time-consuming, costly, and uncertain. Using New Mexico as a test case, we will identify the problems that are most likely to result in high transaction costs, study the nature of the existing institutional barriers that lead to these problems and the remedies currently being considered or which should be considered by policymakers, and evaluate the benefits and costs of selected remedies from the perspectives of the public interest, efficiency of water use, and impacts on the community. We also plan to develop hydrologic criteria that can be used to accelerate decisionmaking while protecting third parties from damage and to explore the distribution of economic and social effects.

2. Contribution to Problem Solution.

The identification of standard criteria and procedures that expedite transfers of rights to use water would benefit the citizens of all western States by contributing to rational resource allocation.

Results of the research will be of primary benefit to: (a) the Office of the State Engineer of New Mexico in processing requests for change in place or purpose of water use; (b) water users who wish to acquire or to sell water rights and; (c) courts and/or administrative agencies involved in assessment of damage claims arising from a change in place or purpose of water use.

3. Objectives.

The objectives of this research are to:

(a) Identify the most important sources of delay and transaction cost in applications for change in place or purpose of water use;

(b) Develop relatively inexpensive hydrologic criteria that can be used to evaluate the effects of proposed changes in water use; and

(c) Evaluate the magnitude and distribution of the economic and social benefits and costs of implementation of these criteria, including effects on the local economy, institutions, and environment.

4. Approach.

Data on expenditures and opportunity costs for applicants, protestors, and the State in deciding on applications for change in water use will be collected from the files of the State Engineer. Statistical analysis will be employed to identify the conditions that cause highest transaction costs and time delays. Third party effects will be identified in interviews with protestors of applications and through interviews of water attorneys and brokers as well as researchers inside and outside of New Mexico who have studied similar problems.

Relatively low-cost hydrologic, economic, and social criteria will be identified that evaluate the impairments to existing rights or protected interests. An administrative model of an application for change in water use will be developed; cost/benefit analysis will be employed to evaluate the probable magnitude and distribution of the social costs and benefits of application of these criteria.

PROJECT INFORMATION

GRANT NUMBER: 14-08-0001-G1649

TITLE: Benefit Estimation in Ground-Water Protection by Local Decisionmakers

PERFORMING ORGANIZATION: Cornell University

PRINCIPAL INVESTIGATOR: David J. Allee

DURATION: September 1988 to September 1990

DESCRIPTION

1. Identification of the Water-Related Problems and Problem Solution Approach.

Prevention of ground-water contamination is often considered the cost effective strategy compared to cleanup. Yet, institutions for prevention are not developing rapidly. The billions of dollars being spent for cleanup suggest that the nation should speed up this process of institutional evolution. Public officials and community leaders would be more successful in creating risk-management institutions if there were defensible estimates of the benefits of prevention. Information on the costs of not protecting ground water is an important factor in the policy development process. Thus, state-of-the-art valuation techniques will be adapted to the problem of ground-water protection and their use by those involved in the development of preventative-type programs will be evaluated.

2. Contribution to Problem Solution.

The intensity of support for ground-water protection can be captured in contingent valuation methodology, which provides measures of willingness-to-pay (WTP) for non-market values, providing both use and intrinsic values, and allows some adjustment for income differences. This research will assist public officials to attain local institutional development programs for ground-water protection.

3. Objectives

The objectives of this research are to design and test economic valuations that capture not only the out-of-pocket expenditures that result from ground-water contamination but also, and surely more importantly, the intensity of citizen willingness to support protective measures, in order to evaluate the usefulness of WTP estimates in ground-water protection policy.

4. Approach.

The general plan of work consists of literature review, sample design, and instrument development including model testing. Two types of surveys will be conducted in watersheds where aquifers with a variety of contamination

histories and ground-water protection levels exist. The first type will consist of a mail questionnaire to a sample of the general public residing in the community to elicit WTP measures for ground-water protection measures to ensure a safe drinking-water supply. The second type will consist of interviews of the three or four persons most likely to be involved in making decisions on ground-water issues in each community to develop information about contamination histories, forms of protection, and out-of-pocket costs by public entities. Results of the mail survey will be distributed to the interviewees and a second round of interviews will be conducted. Concept mapping and content analyses of these interviews will be used to judge the impact of WTP information on these persons.

MISCELLANEOUS WATER-RESOURCES MANAGEMENT PROBLEMS

PROJECT INFORMATION

GRANT NUMBER: 14-08-0001-G1626

TITLE: A Study of Growth, Resource Allocation, and Nutrient Requirements of Myriophyllum aquaticum

PERFORMING ORGANIZATION: University of California, Davis

PRINCIPAL INVESTIGATOR: Marcel Rejmanek

DURATION: September 1988 to August 1990

DESCRIPTION

1. Identification of the Water-Related Problems and Problem Solution Approach.

Myriophyllum aquaticum, parrot-feather, is an emergent, aquatic plant native to South America. Introduced into North America in the early 1900's, M. aquaticum now occurs on the east coast from New York through Florida, across the South and along the entire west coast. Growth of M. aquaticum impedes flow in irrigation, flood control, and drainage ditches, enhances evapotranspiration, interferes with recreation, modifies fish habitat and water quality, and provides mosquito breeding areas. In 1985, M. aquaticum infested about 960 km of waterways and over 200 hectares in California. Irrigation, flood control, mosquito abatement, and reclamation agencies in California have attempted control of M. aquaticum, primarily with herbicides. Approximately $215,500 were spent in California to control M. aquaticum in 1984 and 1985. Despite the control efforts, the infestation has continued to spread.

This research will compare growth of M. aquaticum populations in flowing and static-water systems and, in laboratory studies, the nitrogen and phosphorus requirements for plant growth and the relative importance of sediments and the water column in the supply of nitrogen and phosphorus for growth.

2. Contribution to Problem Solution.

Information on growth limiting factors and nutrient requirements of M. aquaticum is necessary for development of effective, economical, and environmentally sound management strategies that integrate consideration of the benefical aspects of aquatic plants in freshwater ecosystems, plant biology, the environmental impact of the control technique, and present and future use of the water resource.

3. Objectives.

The objectives of this research are to:

(a) Compare the allocation of biomass, nutrients (N, P, K, Fe, Ca), and carbohydrates to sediment roots, submersed shoots, water-column (adventitious) roots, and emergent shoots in plants growing in lentic and shallow, lotic environments;

(b) Determine the importance of nitrogen and phosphorus in limitation of growth in lentic and shallow, lotic environments;

(c) Determine nitrogen and phosphorus requirements of submersed and emergent growth forms of M. aquaticum; and

(d) Determine the contribution of the sediment and water column to the nitrogen and phosphorus nutrition of M. aquaticum, and the interactions of shoots and roots in nitrogen and phosphorus uptake using ecologically relevant nutrient species and conditions.

4. Approach

Field observations suggest that M. aquaticum growth and biomass allocation patterns vary with water depth. Nuisance growth of M. aquaticum is often associated with nutrient enrichment, suggesting that distribution and abundance of M. aquaticum is determined by nutrient availability.

The approach is to compare biomass, nutrient and carbohydrate allocation, and nutrient limitation in natural populations growing in lentic and shallow, lotic environments and, in the laboratory, to establish nitrogen and phosphorus requirements and the interaction of root and shoot uptake.

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PROJECT INFORMATION

GRANT NUMBER: 14-08-0001-G1628

TITLE: Turbulent Mixing at Freshwater/Saltwater Interfaces

PERFORMING ORGANIZATION: California Institute of Technology

PRINCIPAL INVESTIGATOR: E. John List

DURATION: August 1988 to July 1990

DESCRIPTION

1. Identification of the Water-Related Problems and Problem Solution Approach.

A major problem in the assessment of river water-resource projects is the impact such projects may have on the intrusion of saline ocean waters into downstream estuaries and bays. Current methods of predicting the impact of upstream consumptive use depend upon modeling the transport of water and salinity using digital computer, or analogue (hydraulic) simulations of the hydrodynamic transport processes.

Hydraulic models are site specific and need extensive calibration period before they can be used reliably. They are expensive to build, operate, and maintain. These limitations have motivated the development of general numerical modeling techniques that utilize recent developments in computational machinery and software. Computer models of estuarine flows may be one, two, or three dimensional, or hybrid combinations thereof. Regardless of the type of model, a key modeling issue is the description of the mixing and balance between inflowing ocean water and outflowing river water.

2. Contribution to Problem Solution.

The research will find widespread application in computer modeling of estuarine salinity transport, as well as many other flow situations that involve mixing in sheared density-stratified fluids.

3. Objective.

The objective of the research is to utilize modern laboratory techniques, including laser-Doppler velocimetry and laser-induced fluorescence, to develop a usable and verified theory of mixing within density-stratified flows that is suitable for inclusion in computer models used to describe Bay/Delta salinity transport.

4. Approach.

Recently published work by the investigator's research group has shown that such high resolution non-intrusive laboratory instrumentation, when properly applied to density-stratified fluids with a homogeneous refractive index, can

provide revolutionary insight into turbulent mixing processes. The work will apply the techniques of recently completed research on mixing in density-stratified fluids (with no mean shearing motion), to estuarine mixing processes that do include mean shearing motions. This effort is to categorize all of the possible mechanisms by which mixing occurs in estuaries and to quantify them in a way that is suitable for inclusion in computational models.

PROJECT INFORMATION

GRANT NUMBER:	14-08-0001-G1641
TITLE:	Increased Water Use Efficiency in Alfalfa by Selection for Two Key Heritable Physiological Traits
PERFORMING ORGANIZATION:	New Mexico State University
PRINCIPAL INVESTIGATOR:	Vincent P. Gutschick
DURATION:	September 1988 to August 1991

DESCRIPTION

1. Identification of the Water-Related Problems and Problem Solution Approach.

Crop growth accounts for 80 to 95 percent of water consumption in the southwestern States. The efficiency of water use, measured as crop yield of dry matter per quantity of water used, is particularly low in alfalfa, the major forage crop. Water-use efficiency (WUE) in crop plants is under the plant's physiological control to a significant degree, and thus is under genetic control. Selection of existing genetic variability in alfalfa is one potentially effective way to improve its WUE. Specifically, selection for lower values of the CO_2 concentration maintained in the leaf (C_i) and higher values of the specific leaf mass (SLM) should give higher WUE with little or no effect on yield. An estimated 9 percent relative decrease in C_i and a 20 percent increase in SLM could raise WUE 28 percent while decreasing yield only 5 percent. Alternatively, a 17 percent increase in SLM with no change in C_i could raise WUE 8 percent with no change in yield.

2. Contribution to Problem Solution.

The research extends recent success in selecting WUE by C_i selection in the peanut. The method of indirect selection for WUE by selecting for C_1 and SLM could be faster and could have fewer adverse effects on other desirable traits than would direct selection for WUE. Furthermore, the actions of C_i and SLM on WUE and yield may be generally shared in plants, and thus WUE might be improved in other crop species by selecting C_i and SLM.

3. Objectives.

The objectives of this research are to:

(a) Examine the selection principle more extensively, in a controlled growth environment;

(b) Determine if selection of genotypes for C_i and SLM gives similar results in other controlled environments;

(c) Determine if C_i and SLM are sufficiently heritable for breeding purposes;

(d) Determine if the use of $^{13}C/^{12}C$ isotope discrimination in plant tissue is a reliable and cost-effective technique to estimate C_i in mass screening; and

(e) Determine if the selection principle works under field conditions.

4. Approach.

Eighty alfalfa plants (distinct genotypes) will be grown individually in soil columns. Individual plant's C_i will be measured by gas-exchange, their SLM by dry mass and leaf area determinations, their yield by harvest, and their WUE and yield with C_i and SLM to test for statistical significance with magnitudes comparable to model predictions. For objective c, 80 original plants will be crossed in groups selected as high and low in C_i and in SLM, the C_i and SLM will be measured in the progeny and the results compared statistically to parental values.

For objective d, isotope discrimination will be measured in each of the 80 plants and its accuracy tested in predicting C_i measured directly by gas exchange. For objective e, 80 plants will be transplanted from the controlled environments to the field. C_i will be measured by isotope discrimination, and SLM, WUE, and yield as in the controlled environments. Larger populations will be grown out and their ^{13}C discrimination ratio, SLM, and yield measured as before, while measuring their WUE indirectly, from the yield response to irrigation amount.

SECTION II

SUMMARIES OF PROJECTS COMPLETED

IN FISCAL YEAR 1988

COMPLETED PROJECT INFORMATION

GRANT NUMBER: 14-08-0001-G1134

TITLE: Financing Water and Sewer Extensions in Urban Growth Areas: Current Practices and Policy Alternatives

PERFORMING ORGANIZATION: North Carolina State University

PRINCIPAL INVESTIGATOR: R. J. Burby

START: September 1985

FINAL REPORT RECEIVED: October 1987

ABSTRACT:

Increasing population and rapid economic development in the Southeast are straining the financial resources of local governments charged with providing water and sewer services to accommodate growth. This study of utility extension policies and financing practices in nine States (Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, Tennessee, and Virginia) indicates that in many cases utilitites are turning to the private sector to pay capital costs of extending water and sewer lines. The arrangement is in keeping with a fundamental principle of public finance (beneficiaries of services should pay the costs associated with those services), but we show that it may be inequitable in some circumstances.

Analysis of facility expansion decisionmaking by public utilities indicates that if demand management techniques are used widely, utilities will be able to defer the need for costly capital investment in facility expansion. Also, by increasing the sophistication of capital facility planning and more frequently coordinating water and sewer extensions with local governments' land use and growth-management plans, utilities will improve the efficiency of their operations and at the same time provide a defensible basis for imposing capital facility charges on the private sector.

State governments can foster improvements in utility service extension and financing practices by initiating capacity-building programs designed to inform utility directors and their staffs of new planning and budgeting techniques. Finally, it is desirable that State governments take steps to discourage the use of special districts to provide water and sewer services, since such districts tend to lag behind city and county agencies in adopting sophisticated planning and budgeting techniques and are less likely to coordinate their policies with community land-use plans and growth-management efforts.

OBTAINABLE FROM: National Technical Information Service
Order Department
Springfield, Virginia 22161
U.S.A.

ORDER NUMBER: PB88-128145/AS

COMPLETED PROJECT INFORMATION

GRANT NUMBER: 14-08-0001-G1307

TITLE: Wastewater Purification by Solvent-Induced Precipitation Using Freeze Technology to Recover Solvent

PERFORMING ORGANIZATION: CBI Industries

PRINCIPAL INVESTIGATOR: Y. A. Selcukoglu

START: September 1986

FINAL REPORT RECEIVED: October 1987

ABSTRACT:

A method of treating hazardous wastewaters by combining solvent-induced precipitation and freeze technology has been experimentally evaluated. The process involves the addition of a miscible organic solvent to an aqueous stream to lower the solubility of salts present in that stream. Precipitates are then separated from the solution, and the remaining brine is subjected to an indirect freeze system. The freeze process removes clean water as ice and concentrates the solvent-laden brine for recycling to the system.

Laboratory tests were performed on a mixture of synthetic wastewater and common solvents to determine freezing point depressions, solubilities, and effectiveness in inducing precipitation of salts. Precipitates formed were sulfates of sodium and calcium. Nitrate, chloride, and magnesium ions were not precipitatable. From these tests, ethanol was selected for use in a full pilot-plant simulation.

A pilot plant utilizing an indirect freeze separation process, crystallizer, and vacuum filter was assembled and operated using the same synthetic wastewater. The test results indicated an acceptable solvent loss of 1.24 percent of the feed rate. During stable operation, 68 percent of the salts in the incoming feed stream was precipitatable, but with improved separation techniques it is estimated that 80 percent of the salts would precipitate.

OBTAINABLE FROM: National Technical Information Service
Order Department
Springfield, Virginia 22161
U.S.A.

ORDER NUMBER: PB88-116744/AS

COMPLETED PROJECT INFORMATION

GRANT NUMBER: 14-08-0001-G1129

TITLE: Optimal Design Methods for Maximizing Water Use Efficiency Utilizing Surge Flow Irrigation

PERFORMING ORGANIZATION: University of Texas

PRINCIPAL INVESTIGATORS: E. Smerdon and A. Blair

START: September 1985

FINAL REPORT RECEIVED: December 1987

ABSTRACT:

Theoretical work primarily consisted of developing and verifying both analytical and numerical models of surface-irrigation hydraulics and infiltration. These models were incorporated into a surface-irrigation design and evaluation software system. Models were developed in which accuracy was commensurate with computational efficiency and minimization of field-measured inputs. Field and laboratory experiments vital to the verification of the theoretical developments were carried out. Efforts were concentrated on field and laboratory measurements of infiltration and physical modeling of surface-irrigation hydraulics.

The research analyzed six alternative irrigation methods and prepared a PC-based spreadsheet template that can be used by agricultural producers to analyze the cost effectiveness of improving irrigation efficiency. An interactive software system was developed that can be used to determine the duration, cycle times, and number of surges that maximize irrigation efficiency for a specific field. This comprehensive software system provides methods for determining all important field parameters with emphasis on minimizing the amount of field data required while providing options as to which methods are used to determine the required parameters. This system also allows the use of more extensive data sets.

OBTAINABLE FROM: National Technical Information Service
Order Department
Springfield, Virginia 22161
U.S.A.

ORDER NUMBER: PB88-142757/AS

COMPLETED PROJECT INFORMATION

GRANT NUMBER: 14-08-0001-G1145

TITLE: Multiobjective Reservoir Operations Using Forecasts of Water Supply and Water Use

PERFORMING ORGANIZATION: Interstate Commission on the Potomac River Basin

PRINCIPAL INVESTIGATOR: J. A. Smith

START: September 1985

FINAL REPORT RECEIVED: December 1987

ABSTRACT:

In Chapter 1 techniques are developed for selecting a model of daily municipal water use. Techniques are applied to daily water-use observations for the Washington D.C. Metropolitan Area. Of principal importance are "nonstationary" features of water use. A forecast system for daily municipal water use is developed in Chapter 2. The forecast system is based on a simple model of daily water use; the model can be interpreted as an autoregressive process with randomly varying mean. Model structure dictates that the key step in producing a water-use forecast is an updating step in which a revised estimate of current mean water use is computed. Nonparametric techniques for long-term water supply forecasting are developed in Chapter 3. The forecast model uses only daily streamflow data. The model is applied to forecasting minimum daily flow of the Potomac River at Washington, D.C. In Chapter 3, 4, and 5 parametric operating rules for water quality, water supply, and flood-control operation are developed. Heuristically, a parametric operating rule specifies reservoir release at time t as a function of data available at time t and a finite number of real-valued parameters. In Chapter 3 conditional yield operating rules are developed for water-quality operation. Conditional yield operating rules extend safe yield operating rules in a straightforward fashion. The principal difference is that for conditional yield rules reliability remains constant over the course of the year, not release. In Chapter 4 parametric operating rules are developed for operating a system of water-supply reservoirs in the Potomac River basin. A unique contribution of this section is the statistical framework in which water-supply yield analysis is carried out. Parametric operating rules for flood-control operation developed in Chapter 6 characterize the regulation of a flood hydrograph by the delay and attenuation of the flood peak. In Chapter 7, real-time flood-control operation is viewed as a stochastic sequential decision problem in which the finite volume of reservoir storage is sequentially allocated over time to maximize flood-protection benefits. The stochastic sequential nature of real-time operation is represented as a two-stage recourse problem. The combination of stochastic optimization and multiobjective programming is a unique feature of this section.