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Leland L. Mink, Director

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Abstract

This report addresses the research and information dissemination activities of the Idaho Water Resources Research Institute during the 1989 fiscal year. Synopses are presented for the following research projects:

- Assessment of the Severity and Spatial Variability of the 1980's Idaho Drought
- Evaluation of Recharge from Paradise Creek to the Basalt Aquifers at the UI Groundwater Site
- Modification of Phosphorus Transport through Soil Materials
- Municipal Groundwater Supply for the Boise, Idaho Area: Phase II, Testing to Determine Aquifer Parameters
- Role of Mobile Soil Colloids in the Transport of Synthetic Organic Pesticides
- A Transfer Function Model for Prediction of Solute Transport in Surface Irrigated Fields

Information dissemination and workshop activities are also reported.

Water Problems and Issues for the State of Idaho

Non-point source pollution of our state's waters is a primary focus area in research. The impacts are widespread and the sources diverse. The consequences of non-point source pollution, the degradation of our surface and ground waters, and the associated high cost of restoring water quality affects over half of our waters. Researchers in agriculture, forestry, economics and hydrogeology are investigating land use efficiency, agricultural run-off, economic impacts, and waste disposal, to name a few.

Idaho has suffered from drought conditions for the past five years. Agriculture is being seriously impacted, as are other industries such as recreation. Studies are focusing on the severity of this drought and evaluating the effects on industry. In addition, concerns regarding the impacts of agriculture and other land uses on ground water quality is attention is being focused on monitoring and evaluation of aquifer systems.

Clean-up of hazardous waste sites remains a serious issue in Idaho. Investigations concerning the realized and/or potential damage to our surface and ground waters will remain a high priority.

Protecting and managing our water is critical to the continued prosperity and well-being of the state. Idaho's main industries are agriculture and recreation, both of which are significantly dependent on water. The quantity and quality of water is primary to the increased development and success of these industries. On the "flip side" both of these industries, as well as others, have the greatest impact on the state's water quality, and are most effected by water management decisions made by the state. Ultimately, the citizens are impacted. Idaho's community discerned early on the importance of water and endeavors to gain greater knowledge and understanding for the protection of its greatest natural resource.

Program Goals and Priorities

The basic goals and priorities of the Institute's program are as follows:

1. To promote research that is relevant to state and regional needs for conservation of water and related land resources with emphasis on economic resource development, preservation and enhancement of environmental quality and social well being of people.

2. To stimulate, coordinate and provide leadership for water resources research in the established units of the universities of the state of Idaho and to cooperate with sister institutions in adjoining states. Such research should utilize an interdisciplinary approach and provide opportunities for training of students.

3. To cooperate with and help local entities, state and federal government agencies to carry out their responsibilities concerned with water and related land resources and to provide public involvement in identifying research needs.

4. To provide for dissemination of research findings in an expeditious and comprehendible manner to interested persons.

5. To develop funding for needed research and to encourage cooperation with regional research organizations in conducting an efficient and productive research effort.

Solving any of these water resource problems in the state involves five steps:

1. The problem must be identified by consultation with people affected by the problem.

2. An individual or several individuals must be identified who have expertise that may solve the problem.

3. A funding source must be identified which may even be private individuals concerned with the problem.

4. The prospective researcher must develop a proposal and present it to the funding agency or individuals.

5. The research is accomplished and the information disseminated to any persons who may be involved in this or similar problems.

The majority of research expenditures are for operating expenses and graduate student support with very little for capital outlay or faculty salary. The money for information dissemination supports a secretarial position and operating expenses for publications. The secretary answers all publication requests and maintains the publication list and reference library and types all the technical completion reports.

Most of the money for administration is partial salary for the associate director who maintains contact with state, federal and private agencies in southern Idaho.

SYNOPSIS

Project No. 02

Start: 06/91
End: 05/92

Title: Assessment of the Severity and Spatial Variability of the 1980's Idaho Drought

Investigator(s): Horn, Dennis

COWRR: 03D Congressional District: First

Descriptors: Drought; Water Supply; Modeling

Problem and Research Objectives:

This research project addressed the need to quantitatively describe the nature, extent, and severity of the continuing 1980's drought in Idaho, one of the more significant drought events for this region. In its sixth year at many locations, it has had an impact on nearly every section of the state and every category of water use, with economic hardship to water users throughout the state.

To plan appropriate drought management measures dealing with this drought or future occurrences of similar events, it is critical that an assessment be made of its severity, so that it can be viewed in the proper perspective and context. Decisions regarding both future water projects and management of existing projects can then be made within an adequate drought risk assessment framework.

Accordingly, the following specific objectives were met by this research:

1. The characteristics of the 1980's Idaho drought, as determined from streamflow records, from long-term gages, were examined. This included the assignment of return periods to the streamflow deficit for various truncation levels, using the theory of runs.

2. To compare this drought event with other significant droughts recorded within the same region, return periods were also assigned to these prior single- and multi-year droughts.

3. The spatial variabilities of the current and prior droughts were examined and compared, to determine whether any specific regions of the state are more prone than others to prolonged severe droughts.

Methodology:

To provide the data base for this research, the streamflow records at all current and former U.S. Geological Survey gages within Idaho and neighboring portions of adjacent states were compiled. Criteria were established to exclude those records with less than 20 years of data, and those with significant upstream storage impoundments or diversions. This resulted in a final data set consisting of flow records at 210 gages, with 140 in Idaho and 70 in adjacent states.

Since, at a number of these gages, there were short gaps in an otherwise long period of record, a stochastic multivariate data augmentation model was used to fill in these gaps with synthetic data.

This provided a continuous record at all gages for purposes of determining annual flow statistics, including the mean, variance, skew coefficient, and serial correlation coefficient.
Using the flow records and gage statistics, a negative run-sum analysis was performed at each gage to calculate the cumulative streamflow deficits for all periods where the flows were below a specified truncation level. These multi-year, negative run-sums were then assigned return periods, based on stochastic methods developed in prior research studies. In addition to the multi-year analyses, the most significant single-year drought events were also assigned return periods, using standard statistical methods.

Following the statistical analyses, the results were reviewed to determine which time periods appeared to represent the largest drought events throughout the region, both from a single- and multi-year perspective. The return periods of these selected events were compared, and an assessment was made of the spatial variability of the events.

Principal Findings and Significance:

The study disclosed at least six significant Idaho multi-year drought events, covering the periods 1929-1937, 1939-1941, 1944-1945, 1959-1961, 1966-1968, and 1985-1990. Additionally, there were two major single-year drought events (1973 and 1977) that impacted the entire state.

When the 1980's drought is compared to prior events, such as the 1930's drought, the return periods appear to be much less significant than had been expected. In fact, at many gages the 1980's streamflow deficit does not rank in the top three or four drought events. There are two explanations for this finding. First of all, the compiled records available for the study ran only through the 1990 water year (ending in September 1991). At most locations in the state, the drought has continued through the subsequent months, adding to its severity and significance. Secondly, the use of run-theory to assess streamflow deficits requires that each negative run-sum be from a continuous time period, where all flows are less than the specified truncation level. For the 1980's drought, most gages indicated a recovery in 1986, with flows slightly above the truncation levels. Therefore, even for gages with drought conditions from 1983 to 1990 (with the exception of 1986), the return periods assigned separately to the 1983-1985 and 1987-1990 events are not necessarily significant. It is suggested that other procedures might be used to perform multi-year drought risk assessments, to overcome this inherent problem in run-theory application.

Publications and Professional Presentations: None.

MS Theses: Milligan, Sean, University of Idaho, Moscow, Idaho. In progress.

PhD Dissertations: None.

SYNOPSIS

Project No. 04

Start: 06/91
End: 05/92

Title: Evaluation of Recharge from Paradise Creek to the Basalt Aquifers at the UI Groundwater Site

Investigator(s): Ralston, Dale

COWRR: 02F Congressional District: First

Descriptors: Groundwater; Aquifers; Recharge

Problem and Research Objectives:

Knowledge of locations and controls for recharge to basalt aquifers in the Pacific Northwest is critical to the development of ground water management plans. This research is directed toward gaining a better understanding of recharge to basalt aquifers from streams in the Pullman-Moscow basin of Washington and Idaho. The results of this research will be applicable to other sites with similar hydrogeologic conditions within the Columbia Plateau.

The specific objectives of the project are to:

1. Review the hydrogeology of the UI Ground Water Research Site (GRS) and the data base of water levels from wells at the GRS.

2. Establish a regular program of water level measurements from all wells at the GRS. Place special emphasis on recording ground water level responses to extreme high flow events in nearby Paradise Creek.

3. Correlate ground water level data to information on stream stage and discharge obtained from the USGS gaging station on Paradise Creek located adjacent to the GRS. Use analytical and numerical models as needed to analyze the response of particular fracture systems to extreme flow events.

4. Relate the results of the study to ground water recharge and basalt hydrogeology.

Methodology:

Ground water levels have been monitored in a number of wells completed in individual basalt aquifers at the UI Ground Water Research Site. Wells are completed in two intraflow fracture systems within the Lolo flow of the Wanapum basalt or the flow contact at the base of the Lolo flow. The hydraulic characteristics of the intraflow fracture systems have been described by Li (1991) in a previous UI research effort at the GRS.

Measurements of ground water levels in completed wells has been ongoing since the development of the GRS in 1989. Analysis of these data are part of the research effort. An additional well was drilled early in 1992 that penetrates the aquifer at the base of the Lolo flow. Water level data are

available for this well only for 1992.
A masters student in Hydrology at the University of Idaho, Begona Garcia-Pardo, has been conducting the field data collection starting in 1991. The water level data were collected by other students prior to 1991. An extreme high flow event did not occur during the winter and spring of 1991-92 when all wells were completed. Thus, the data collection program was extended through the winter and spring of 1992-93 in an effort to record the ground water response to an extreme high flow event.

Principal Findings and Significance:

Analysis completed to date shows that each of the identified fracture systems respond differently to small runoff events within Paradise Creek. The E-fracture system responds to changes in stream stage with a relatively short time lag. These wells have water levels about 15 feet below the base of the stream. The fracture is located about 40 feet below the stream. The W-fracture system has a smaller total fluctuation with greater time lag from the runoff event. This fracture system appears to be more isolated from the surface water system. Water level data are not available for the well completed in the base of the Lolo flow for any large runoff event.

The preliminary results of this research indicate that recharge from Paradise Creek to the basalt aquifers does occur. However, the quantity of water recharge is limited because of the low hydraulic conductivity characteristics of the center of the Lolo flow of the Wanapum Basalts. Analysis of the water level characteristics of the well completed in the base of the Lolo flow and the water level responses in all wells to an extreme flow event will allow a more complete analysis of recharge characteristics.

Knowledge of recharge characteristics from streams flowing over basalts of the Columbia River Group is critical to the development and testing of computer models of the ground water system used for resource management. The results of this study will be coupled with an analysis of stream gain and loss over reaches of Paradise Creek and other streams where contacts between individual basalt flows are cut by the streams. The combined research product will aid the modification of the Pullman-Moscow ground water model used for basin management.

Publications and Professional Presentations: None.

M S Theses: Garcia-Pardo, University of Idaho, May 1993. In progress.

PhD Dissertations: None.

SYNOPSIS

Project No. 04

Start: 06/90
End: 05/92

Title: Modification of Phosphorus Transport through Soil Materials

Investigator(s): Naylor, Denny and McGeehan, Steve

COWRR: 05A Congressional District: First

Descriptors: Transport; Phosphorus; Pollutants; Soils

Problem and Research Objectives:

The numerous pristine lakes and streams in Idaho are an important natural resource. Low population density makes many parts of Idaho well suited to land application of wastes. A major concern associated with this method of waste disposal is the control of phosphorus (P) leaching. Shoreline and regional development places the water resource at risk due to the generation and disposal of associated waste materials. Septic tank drainfields and land application of liquid and solid wastes from municipal and industrial sources have, at times, diminished water quality. Seasonal soil saturation, organic amendments, and waste application rate and frequency have been shown to have dramatic effects of soil P mobility. A better understanding of soil and waste properties that enhance P sorption and minimize P transport will facilitate improved site selection and management of land applied waste.

Specific objectives of the proposed research are:

1. to determine the soil properties that can be used to predict P sorption from waste leachates and to recommend specific soil analyses that can evaluate these soil properties;

2. to evaluate the reliability of P sorption data for predicting P transport through soil materials; and,

3. to determine the management and environmental factors which modify or enhance the transport of P through soil materials.

Methodology:

A diverse group of soils, representing the broad spectrum of soil properties found in Idaho, is being investigated. Emphasis was placed on soils adjacent to streams, rivers and lakes or having shallow water tables where P transport to receiving bodies of water might be important. Samples of major horizons have been collected, air dried and ground to pass a 2 mm sieve.

Objective 1: Phosphorus sorption isotherms and extractable P have been determined for each horizon sampled. Soil properties relevant to P sorption have been measured and a data base prepared. The sorption of P by the soils is being correlated to the measured soil properties using various statistical techniques including regression and cluster analyses.

Objective 2: A leaching column study is being used to evaluate P transport. Soils representing a range in properties and P adsorption capacity were selected for the column study. The columns are packed with soil to a fixed bulk density and a 10 mg L^{-1} P solution, representing a median P concentration for municipal waste water, is added to the columns. The columns are leached with the P solution under saturated flow using a constant head device and a small negative pressure. All drainage solutions are collected, measured for volume, and analyzed for phosphorus. The columns are leached until breakthrough of the added P occurs. The measured breakthrough volume is compared to that predicted from measured soil properties and P adsorption data.

Objective 3: A leaching column study will be used to determine management and environmental factors which can modify or enhance P transport. Variables will be waste material, frequency and duration of a high water table, and P sorption capacity. Columns used for Objective 2 are modified by installation of a sampling chamber midway down the soil column to monitor aeration status and the composition of the soil solution. All drainage solution will be collected, measured for volume, and analyzed for P. The soil solution midway down the column will be sampled and analyzed for oxidation state, P, and Fe and Mn status. The transport of the P down the column will be compared to that obtained in Objective 2 to determine the influence of the waste materials and water table on P sorption and subsequent movement in the soil materials.

Principal Findings and Significance:

Sites were selected for sampling and study. A total of 42 surface and subsurface soil samples were collected at 18 sites covering the area from Lake Pend Oreille and Lake Coeur d'Alene in northern Idaho to Cascade Reservoir and the Caldwell area in southern Idaho. Approximately 0.5 kg of soil was collected, air dried and lightly ground to pass a 2 mm sieve. Chemical analyses were conducted to characterize the soil samples and a P sorption isotherm was run on each sample. A data base has been developed from the soil characterization analyses. The soils exhibited a wide range in both extractable P and P adsorption capacity indicating that soils in Idaho in the vicinity of water sources have a wide range or properties. Some of the soils had very high extractable P values indicating a very high level of bioavailable P to the growing plant community. Likewise some of the soil only weakly adsorbed P while others had a much higher ability at removing P from water moving through the soil. There was a general decrease in P adsorption capacity with depth which has important implication in waste management. High P sorbing soils are desirable to limit movement of P to water resources. Some of the soils would be quite effective at removing P from water while others would tend to keep soluble P in the water at elevated levels. The data base is being analyzed by various statistical techniques to develop a model for predicting the ability of soils to adsorb P. Simple linear regression did not result in adequate prediction. Multiple regression and cluster analyses techniques are being applied to the data base.

The P adsorption isotherms were evaluated using two common models, the Tempkin and Freundlich, to evaluate P sorption over a wide range of P concentration. The average r^2 over all the soils using the Tempkin model was 0.85 and the average r^2 for the Freundlich model was 0.84 indicating the data fit both models reasonably well considering the wide range of soils. However, negative adsorption (desorption) of P was observed from many of the soils at low levels of added P. Negative adsorption values cannot be used with the Freundlich model due to the log transformation employed for linear evaluation of the model. Therefore, the Tempkin model proved more useful in evaluating P sorption characteristics of the soils, particularly at the low P levels that are important to maintaining good water quality. The observed negative adsorption or desorption of P could have a negative impact on

quality of the initial percolation water moving through the soils as they are leached but should be a short term influence.

The data base was used to identify sites meriting more intensive study. Large (10 kg) samples of selected soils were collected from fifteen soil horizons at eight sites for column leaching experiments. The amount of P adsorption at an equilibrium solution P level of 10 mg L^{-1} as predicted by the Tempkin model was used to calculate the breakthrough volume of the leaching solutions for the soil columns. Breakthrough of the P was obtained for all the soils and the predicted breakthrough volume was compared to the measured volume. The measured P breakthrough volume was generally larger than predicted. This might be expected due to the increased contact time in the soil columns as compared to the procedure used for measuring P adsorption. However, the relative breakthrough volumes were consistent with the measured P sorption capacity of the soils.

When soil materials are flooded, especially in the presence of organic materials, the microorganisms in the soil will consume oxygen (O_2) that cannot be replenished from the atmosphere due to the excess water. This results in low oxidation (anaerobic) status or reducing conditions. Fe and Mn will subsequently be reduced which increases their solubility and can influence the adsorption of P. Therefore, the columns were redesigned and modified by adding a sample port so that the oxidation status of the soil column could be monitored and a sample of the soil solution obtained for chemical analysis. The sample port consisted of a piece of lucite tubing (drilled with numerous small holes) sealed horizontally about midway down one side of the column. The tube was filled with fiberglass and the exposed end covered with a rubber septum. Soil solution is obtained with a syringe through the septum, the plunger of the syringe removed, and the oxidation status of the solution measured with a platinum electrode. The solution is then analyzed for P, Fe and Mn to evaluate P movement and to compare solubilization of the Fe and Mn with the oxidation measurement. Testing of the redesigned columns showed that when organic matter is added to soils and flooded it was possible to measure the lowered oxidation status and the resulting increased levels of Fe and Mn.

Publications and Professional Presentations: None.

MS Theses: Mohammad Zamir Hussain. Phosphorus Sorption Characteristics by Volcanic Ash Influenced Soils in Flooded Conditions. 1992. University of Idaho.

PhD Theses: None.

SYNOPSIS

Project No. 05

Start: 06/90
End: 05/92

Title: Municipal Groundwater Supply for the Boise, Idaho Area: Phase II, Testing to Determine Aquifer Parameters

Investigator(s): Wood, Spencer, Osiensky, Jim, and Waag, Charles

COWRR: 02F Congressional District: First

Descriptors: Water Supply; Groundwater Basins; Aquifer Characteristics; Geohydrology; Borehole Geophysics; Test Wells

Problem and Research Objectives:

The groundwater system beneath the Boise Valley furnishes virtually all the municipal water supplies for the city of Boise, Idaho. Boise Water Corporation, South County Water Company, Mesa Water Corporation, and Capital Water Corporation are the first water utility corporation with groundwater wells and distribution systems. Current annual production (1990) for these four municipal suppliers is about 15 billion gallons (46,000 acre-ft.). These corporations are experiencing shortages in some parts of their distribution systems during drought years. With the present distribution and local of wells, the cones-of-depression of most large production wells overlap one another. It is important to the further development of this groundwater basin that a predictive tools be developed to anticipate the effects of new wells and altered production schedules. In certain areas of the basin, additional wells could cause large interference effects such that water-level declines would interfere with existing water rights of well owners.

Phase I of this study (Geologic Framework) has shown the system of unconfined-to-confined aquifer units beneath Boise to be limited in areal extent and depth. The sedimentary basin is bounded on the north by the crystalline rocks of the Idaho batholith where sedimentary strata lap onto or are faulted against these relatively impermeable granitic rocks. The drinking-water-quality water-bearing section is further truncated along the basin-bounding fault zone and other down-to-basin normal faults. A thick section of relatively impermeable volcanic rocks forms a "basement" to the potable cold water-bearing section. Occurrence of warm water at relatively shallow depth in some parts of the basin also placed a legal limit on the depth from which water can be produced, owing to restrictions imposed by the Idaho Geothermal Resources Act of 1982.

The possibility of a municipal water shortage within the next 20 years exists because: (1) the rapid population growth which Boise is presently experiencing is expected to continue into the next century, (2) the groundwater reservoir for the Boise supply exists only beneath the city and so is more susceptible to contamination by urban activity than if the basin were located at some distance up-gradient on undeveloped land, and (3) urbanization of flood irrigation agricultural land is diminishing the amount of recharge available to the deep aquifer system.

Methodology:

With very few exceptions, the hydrogeologic testing carried out to date, within the Boise basin, consists of well-completion tests and/or pump-capacity tests of short duration (seldom in excess of 8 hours). Such tests have proven of marginal use of determination of aquifer coefficients and the local of hydraulic barriers which exist within this faulted stack of fluvio-lacustrine sediments. This phase of the study has been to partly remedy this void.

This project has utilized existing wells of Boise Water Corporation (BWC) to conduct testing. Close coordination with BWC's engineering and production staff has allowed us to carry out long-term highly controlled testing which has been designed around information obtained during Phase I of this study. A working knowledge of the BWC distribution system, obtained during Phase-I of the project has allowed us to manipulate the city water-supply and control production rates for large areas of Boise. By creatively "redistributing" water for domestic use and fire-protection, pumping wells within extensive areas were turned off or the pumping rates controlled in order to minimize interference effects to our aquifer-testing efforts. Objective here was to use selected existing wells of known completion as both pumping and observation wells for quantitative aquifer-testing with minimal interference effects from surrounding wells.

A network of observation wells were monitored for the duration of the study to obtain information on yearly fluctuation of pressure-levels in aquifers and in an attempt to gain insight into recharge dynamics of the aquifer system.

Second year results were objectively analyzed, in light of the first-year hydrogeologic framework theories, and whenever possible used to substantiate or refute first year findings.

Principal Findings and Significance:

Following is a profile of the findings of this study: (1) Aquifer tests support hydrogeologic framework theories of Phase I study, (2) the Boise aquifer system behaves as a very leaky artesian system (hydraulic connection across system, (3) pressure levels in aquifers (hydraulic heads) are declining in some areas, (4) water levels in observation wells of the boise area fluctuate 20-to-30 feet annually in response to pumping and recharge, (5) draft areas of groundwater recharge/discharge - significance lies with recharge dynamics of the Boise groundwater system and land use practices, (6) compilation of water-table elevation maps for portions of Boise area - important to determination of direction of groundwater flow under presently induced hydrogeologic conditions, and (7) quantitative testing has been carried out in a developed basin using existing wells.

Publications and Professional Presentations: None.

MS Theses: In progress.

PhD Theses: None.

SYNOPSIS

Project No. 06 Start: 06/91
End: 06/92

Title: Role of Mobile Soil Colloids in the Transport of Synthetic Organic Pesticides

Investigator(s): Morra, Matt, von Wandruszka, Ray and Hammel, John

COWRR: 05B Congressional District: First

Descriptors: Transport; Contaminants; Pesticides; Water Movement

Problem and Research Objectives:

Groundwater represents the source of 90% of Idaho's public water supply. Preservation of groundwater quality is therefore a high priority within the region, particularly in those areas lacking an alternate source such as the Rathdrum Prairie area of northern Idaho and eastern Washington. Groundwater is susceptible to contamination from agricultural amendments including inorganic fertilizers and organic pesticides (i.e. herbicides, insecticides, nematicide, and fungicides). Groundwater supplies in Ontario, Oregon, near the Idaho border, are contaminated by DCPA. In Idaho, DCPA was detected at levels up to 10 ppb in 80% of the wells in Fruitland and Aldicarb at 2 ppb was detected in 1 well in Eastern Snake Plain of the Boise area. Dinoseb, picloram, and dicamba have also been detected in groundwater of the Boise area. Little else is known about present or potential contamination of groundwater in Idaho. The problem is compounded by the variability in soils, tillage practices, type and volume of pesticide applied, and water regime to which the system is subjected. Regular monitoring of pesticide concentrations present in groundwater is not feasible because of the large number of different pesticides used and the lack of a sufficient quantity and distribution of monitoring wells. In addition, groundwater reclamation is costly, thus necessitating the recognition of a potential contamination problem.

Models have been developed for other regions of the country in order to overcome the site-specific problems associated with assessing pesticide movement in soils. Unfortunately such models have not yet proven accurate enough to serve as a predictive tool for making management decisions. The lack exists not in the model itself, but from an incomplete understanding of the fundamental principles governing pesticide interactions with soil constituents. As a result, the Idaho Water Quality Bureau cannot accurately predict pesticide movement in soils. Soil, crop, and weed scientists as well, are unable to provide pesticide application recommendations which integrate potential groundwater contamination as an important variable in the decision making process. Studies are necessary to define the missing parameters governing pesticide mobility in soils so that a useful model can be developed. Accurate pesticide application recommendations are critical since aquifers underlie substantial expanses of agricultural lands throughout the state and current levels of agricultural production rely upon the continued use of pesticides.

The greatest current limitation on predicting organic contaminant behavior in the environment lies not in the development of additional models. Instead, accurate descriptions of contaminant interactions with system components and a clear understanding of the variables controlling the transport process are needed. Interaction of synthetic organics with colloidal materials such as clays and natural

organics radically alters the chemical and physical characteristics of the contaminant. These interactions, in combination with preferential flow, may increase contaminant mobility far beyond that currently predicted. We propose to make direct measurements of organic contaminant interactions with colloidal materials isolated from soils using fluorescence polarization and fluorescence quenching techniques. Once the extent and type of interaction is well understood, altered contaminant mobility will be determined using soil columns. Key variables governing a comprehensive understanding of the process and provide the necessary data for modification of an existing model.

Methodology:

A Perkin-Elmer MPF-66 Fluorescence Spectrophotometer equipped with a thermostated cell compartment was used for the fluorescence measurements. The instrument uses a built-in Rhodamine 101 quantum counter to give corrected excitation and emission spectra. Fluorescence polarization measurements were taken by inserting a pair of matched Glan-Taylor polarizing prisms in the excitation and emission beams in either the parallel or perpendicular orientation. All fluorescence intensity values were reported as the average of triplicate measurements.

The samples were prepared by placing a 3-ml aliquot of clean hectorite, 0.3 ml 1.0 M $NaClO_4$ and the correct amount of the various fluorophores to give the desired concentration in a 10 ml volumetric flask that was diluted to mark. The water used in all solutions was deionized and treated with a 0.22 μm Millipore filter system to give 10 MΩ.cm resistivity. The samples were shaken for 5 min and allowed to stand for 1 h to allow equilibration. The fluorescence polarization measurements were taken in quartz cells at ambient temperature. A hectorite blank (without a fluorophore) was used to determine background scatter.

The samples from the fluorescence polarization measurements were put into Teflon test tubes and centrifuged at 23,200 g for 30 min (ICE-B20A centrifuge, Damon/IEC Division), the supernatant decanted and the fluorescence measurements taken.

The fluorescence intensity measurements in column leaching studies were made using an Aminco-Bowman spectrophotofluorometer (SPF) equipped with a flow cell. The excitation wavelength was set at 256 nm and the emission wavelength at 368 nm. The excitation slit was 2 mm with the emission slit 5 mm. The Aminco-Bowman is not a modern computer controlled instrument, and an interface based on a Motorola 6821 peripheral interface adapter was built to modernize the instrument and to meet the application needs. The interface also comprises an ICL 7109 analog-to-digital converter (ADC). This is a 12-bit dual-slope integrating ADC, which is slow (maximum 20 Hz) but is not noise sensitive. Data acquisition was accomplished using an Apple IIe computer enhanced with an 8 MHz Zip chip. The software was written in compiled BASIC. A vacuum pump was used to increase the flow rate in circumstances where gravity flow was impractically slow (e.g. with a sand filled column).

Latahco silt loam soil (Argiaquic Xeric Argialbolls) was used in the column studies. The top 25 cm of soil was field-collected, air- dried, and crushed to pass a 2.0-mm sieve. The collected soil contained 17 g total C, 1.5 g total N, 185 g clay, 745 g silt/kg soil, and had a pH of 6.0. Total C and N were determined by Dumas combustion, particle-size distribution by the hydrometer method. and pH by glass electrode 1:1 soil to water.

A Kontes Chromaflex 1 cm X 30 cm column was filled to a depth of 22.3 cm with Latahco Silt Loam

Soil particle size 0.5 to 1.0 mm, with minimal tapping to induce settling for maximum density with minimal particle size degradation. A Pharmacia Q.V.F. column 1.4 cm X 30 cm was used for the sand columns. The commercially available sand had a particle distribution of < 1% medium (0.5-0.25 mm), 14.8% fine (0.25-0.1 mm), 78% very fine (0.1-0.5 mm) and 6% < 0.05 mm. The columns were conditioned (i.e., cation exchange sites saturated) by adding 1.0×10^{-2} M $CaCl_2$ solution in the upflow mode to minimize the amount of air entrapped in the soil matrix. The soil columns were allowed to equilibrate for 12 h by allowing 1.0×10^{-2} M $CaCl_2$ solution to flow in the downward direction via a constant head method of addition.

Principal Findings and Significance:

Fluorescence anisotropy (FA) has been shown to be a viable method for studying adsorptive/desorptive interactions between a number of fluorophores and colloidal hectorite. The advantage of FA over the batch adsorption isotherm technique is that the former is a direct measurement method, in which the adsorptive/desorptive equilibrium need not be disrupted by separation prior to measurement. FA is also much quicker than measuring batch isotherms.

The FA study showed that hectorite binds difenzoquat, 1-naphthol, anthracene, phenanthrene, and pyrene. The percent of hectorite surface covered is small (0.06% to 5.4%), but because of the large surface area of the colloidal clay (554.7 m^2/g), the "carrying capacity" of the hectorite is significant (0.12 to 9.6 g/kg colloidal hectorite).

The column experiments verify that colloidal hectorite is capable of enhancing the transport of difenzoquat through both sand and soil matrices. Hectorite increased the rate of transport of difenzoquat through sand by an average factor of 1.3. This fact, in addition to the binding interaction and the carrying capacity of the colloidal hectorite, establishes colloidal hectorite as an effective carrier for the facilitated transport of certain contaminants in the environment.

Publication and Professional Presentations: None.

MS Theses: Garcia, Roberto, Jr. 1992. Interaction of Fluorescent Contaminants with Soil Components. M.S. Thesis, Department of Chemistry, University of Idaho.

PhD Dissertations: None.

SYNOPSIS

Project No. 07

Start: 06/91
End: 06/92

Title: A Transfer Function Model for Prediction of Solute Transport in Surface Irrigated Fields

Investigator(s): Izadi, Behzad, King, Bradley, and McCann, Ian

COWRR: 05B Congressional District: First

Descriptors: Transport; Contaminants; Pesticides; Water Movement; Modeling; Irrigation

Problem and Research Objectives:

Non-point source contamination of groundwater resources caused by agricultural practices is gaining public concern. In particular, pollution of groundwater resources by nitrate fertilizer is a major environmental concern. In heavily irrigated states such as Idaho, proper irrigation and nitrate management is essential for preserving groundwater quality. Effective nitrate management practices can only be implemented if field-scale nitrate movement through the soil can be accurately predicted.

Variable field conditions (i.e. macroporosity and variations in permeability) and the difficulties in describing chemical processes led the soil scientists at the University of California, Riverside, and Oxford University, England, to question the conceptual validity of existing models and introduce the Transfer Function Model (TFM). The TFM is a promising stochastic, non-mechanistic modeling approach to field-scale solute movement under variable soil conditions and nonuniform water applications. The TFM is a linear model that treats the soil (system) as a "black box". The input to this system is the amount of solute added to the soil surface while the output is solute concentration at various depths. The TFM requires a calibration function which can be estimated by determining the average breakthrough curve of the solute at a given depth in the field.

The purpose of this study was to validate a simple form of the TFM for prediction of field-scale nitrate transport. Bromide (BR) in addition to nitrate was used as the tracer, since BR is a good tracer of nitrate and has low background concentration in soils. The overall objective of this study was to validate the simple TFM under highly variable conditions observed in a furrow irrigated fallow field.

The specific objectives were:

1. to conduct a comprehensive field experiment to monitor movement of nitrate and bromide in a furrow irrigated fallow field;
2. to develop the field-average calibration functions; and
3. to validate the simple TFM using both solution sampler and soil sample calibration functions.

Methodology:

Field research was conducted at the Kimberly Research and Extension Center, during the summer of 1991 to validate the simple Transfer Function Model (TFM) under variable conditions observed in a

0.9 ha furrow irrigated fallow field. Twenty one spatially distributed sampling stations were established to monitor movement of bromide (BR). Each station consisted of soil solution samplers at 0.3 m and 0.9 m depth, and a neutron probe access tube to a depth of 2.1 m. A narrow pulse of nitrate and BR tracer was applied by injection through a sprinkle irrigation system. The tracer was subsequently transported downwards by two 8-hour and one 36-hour furrow irrigation events, approximately 3 weeks apart. Soil samples were taken to a depth of 2.4 m prior to each irrigation and at the end of 63 day study period.

The simple TFM was not validated for nitrate due to relatively high background soil nitrate which interfered with the narrow nitrate pulse. The BR concentration data were normalized at each station, and the field-average BR profiles were determined for each soil sampling date. The simple TFM calibration functions were successfully developed based on both soil sample and solution sampler data.

Principal Findings and Significance:

Methods based on Darcy velocity and piston flow under-predicted the final BR position. This under-prediction was attributed to the possibility of macropore flow during the third irrigation. The simple TFM calibrated based on soil samples predicted the BR position and general BR profile with reasonable accuracy. The simple TFM predicted a slower movement of the solute front when the calibration function based on 0.3 m solution sampler data was used. The delayed response was attributed to lack of direct contact to soil macropores. Considering the variability and sources of error in a study such as this, use of the simple TFM based on soil sampling is a promising approach for field-scale prediction of solute movement.

Publications and Professional Presentations:

Izadi, B., B. King, D. Westermann and I. McCann. 1992. Predicting field-scale solute transport using the Transfer Function Model. Paper no. 9209-104 presented at the International Conference on Agricultural Engineering (AGENG 92) at Uppsala Sweden.

Izadi, B., B. King, D. Westermann and I. McCann. 1992. Validating simple Transfer Function Model under variable conditions observed in a furrow irrigated field. Journal of Soil Science. In review.

MS Theses: None.

PhD Dissertation: None.

Information Transfer Activities

The principal information transfer activities were:

Conference: Wetlands Protection in Idaho: Living with No Net Loss, Boise, Idaho, February 20-21, 1991. Participation: 424. Focus: Statewide. Leader.

Conference: Nonpoint Source Pollution: The Unfinished Agenda, Tacoma, Washington, March 20-21, 1991. Participant: 400. Focus: Regional. Cooperator.

Conference: Idaho Lakes: A Clear Challenge, Coeur d'Alene, Idaho, May 10-11, 1991. Participation: 125. Focus: Statewide. Leader.

Program: Project WET (Water Education for Teachers), Idaho. Implemented an interdisciplinary, supplementary water education program for Idaho educators. Focus: Idaho Educators. Leader.

Program: Idaho Streamwalk. Implemented a citizens monitoring program which focuses on physical characterization of streams. The data is housed in a database and provides trend information to state and federal agencies.

Newsletter: Idaho Water Project Update, Published Spring, 1991. Provides a synopsis of all of the water and water-related research currently going on in the state of Idaho. Contributors include state and federal agencies, local governments, and public institutions. Focus: Statewide.

Center: The Idaho Water Institute and the Institute for Agricultural and Genetic Engineering collaborated to established the Center for Hazardous Waste Remediation Research. This is an interdisciplinary center which focuses on research in waste characterization, and bioremediation and chemical remediation technologies. Focus: Statewide and Regional. Co-Leader.

Federal Agencies/Entities
Army Corp of Engineers
Bureau of Land Management
Bureau of Reclamation
Environmental Protection Agency
Idaho Association of Soil Conservation Districts
Indian Tribes
Soil Conservation Commission
Soil Conservation Service
U.S. Fish and Wildlife Service
U.S. Forest Service
U.S. Geological Survey
Idaho State Agencies/Offices
Attorney General's Office
Governor's Office
Division of Environmental Quality
Idaho Department of Agriculture
Idaho Department of Commerce
Idaho Department of Lands
Idaho Department of Parks and Recreation
Idaho Department of Transportation
Idaho Department of Water Resources
University of Idaho Cooperative Extension Service
Statewide Organizations
Ducks Unlimited
Idaho Association of Commerce and Industry
Idaho Cattle Association
Idaho Conservation League
Idaho Farm Bureau
Idaho Food Producers Association
Idaho Mining Association
Idaho Petroleum Council
Idaho Water Users Association
Nature Conservancy
Wildlife Council
Wool Growers
American Fisheries Society, Idaho Chapter
Businesses
Coeur d'Alene Mines
Davis Wright Tremaine
Nelson, Rosholt, et al.
Wilsey and Ham Pacific

Publications, Special Recognition Awards, Notable Achievements

No Information Available to Report.

Training Accomplishments

Field of Study	Undergraduate	MS	PhD	Post PhD	Total
Chemistry		1			1
Soils		1			1

Post Graduate Employment

No Information Available to Report.