Illinois Water Resources Center
Annual Technical Report
FY 2006

Introduction

The Illinois Water Resources Center (IWRC supports outreach, education and research to promote better understanding and use of Illinois water resources. In 2006, IWRC supported two continuing research projects with state funding and conducted a solicitation for two additional projects to start in 2007. We monitored five projects funded with 104G money. We held the 2006 Illinois Water conference, a conference that showcases research and outreach activities in the state and we co-sponsored the Governor's Conference on the Illinois River.

IWRC continues to receive EPA funding for a regional center that provides research and other forms of technical assistance to drinking water systems in small communities. The Midwest Technology Assistance Center (MTAC) started in November 1998 and is a collaborative effort of the IWRC and nine other water resources research institutes in the Midwest and the Illinois State Water Survey.

IWRC staff members also assist in administering the research component of the Illinois-Indiana Sea Grant College Program in partnership with the University of Illinois, Purdue University and the National Oceanic and Atmospheric Administration (NOAA). IWRC's involvement in this program has increased the Centers opportunities for coordinating research activities with other water-related programs in the Midwest. Research topics include: water quality tracking, aquatic nuisance species mitigation, and aquaculture. Outreach topics include: aquatic nuisance species education and prevention.

Research Program

Research priorities for IWRC include: Watershed and stream protection; integrated water management for multiple users; wetland processes; and emerging issues, including other innovative research topics that are not included in the priorities above. The Center takes a special interest in helping young scientists establish a record of accomplishment in water resources research. Virtually all projects supported by the IWRC contribute significantly to the education of students, both graduate and undergraduate, who participate in the research projects.

IWRC also strongly encourages researchers in Illinois to compete for 104G funding. We have been very successful in advancing water research in Illinois through this additional funding source. In 2006, we monitored five projects funded through this source.

Development and Validation of a 3D Coupled Hydrologic-Biogeochemical Model for Evaluation of the Impact of Water-Table Management on Nitrate Loads from Tile-Drained Agricultural Fields

Basic Information

Title:	Development and Validation of a 3D Coupled Hydrologic-Biogeochemical Model for Evaluation of the Impact of Water-Table Management on Nitrate Loads from Tile-Drained Agricultural Fields
Project Number:	2002IL7G
Start Date:	9/1/2001
End Date:	5/31/2006
Funding Source:	104G
Congressional District:	15th
Research Category:	Water Quality
Focus Category:	Nitrate Contamination, Non Point Pollution, Solute Transport
Descriptors:	
Principal Investigators:	Robert J. Hudson, Albert Joseph Valocchi

Publication

1. Feng Yue, A.J. Valocchi, R.J. Hudson, 2004, Physically-based 3D hydrologic conjunctive modeling of water flow in tile-drained agricultural fields in Groundwater Quality 2004 Proceedings, 4th International Conference, University of Waterloo, Ontario, Canada.

Problem and Research Objectives

One of the most promising approaches to minimizing nitrate export to rivers draining agricultural watersheds is water table management, or controlled drainage. The Illinois District of the USGS has conducted a field pilot study of the benefits of controlled drainage at an active farm in east-central Illinois. Two adjacent 40-acre plots, one with tile management and the other without, have been instrumented for collecting a variety of data. Modeling is required to fully interpret the field data and to extend the results to conditions on other farms.

The project involves developing and applying sophisticated simulation models to properly quantify the hydrologic and nitrogen cycle fluxes on such sites. Fully 3-D models of subsurface flow and nitrogen processes will be necessary in order to simulate both surface runoff/runon and subsurface flow between the adjacent managed/conventional plots. This will allow us to properly analyze the field data and assess the environmental benefits of water table management.

Methodology

We have been combining two different modeling approaches in order to interpret data previously collected by USGS researchers from the paired set of agricultural fields with and without controlled subsurface drainage.

For hydrologic analysis, we have employed a 3-dimensional model with accurate topography to simulate both surface runoff/runon between the fields and subsurface flow between the two halves of the study sites. These results are being combined with water budgets over both short and long time periods in order to characterize the water fluxes at the site.

For nitrogen cycle modeling, our initial plan was to employ the DRAINMOD model and develop a new model for in studying the field sites, but we have chosen instead to focus on an established model (DSSAT) with excellent and soil and plant process representations. Automatic calibration using the University of Arizona Shuffled-Complex Evolution algorithm has been employed to obtain optimal parameters for Illinois conditions and develop means of predicting N mineralization for sites based on simple soil N test results.

Principal Findings and Significance

3-D Physical Model Development and Testing: Following our previous work updating the hydrologic code in the CHM3D model, further tests of its suitability for application in this study were conducted. The relatively fast Alternating-Direction-Implicit method (ADI) was employed to solve the system of coupled differential equations. We found that the accuracy of ADI is limited to extremely small time steps (~10^{-3} s) when solving variably-saturated subsurface flows. Although the ADI method is known to be reasonably accurate in solving parabolic differential equations, those equations usually contain small diffusion coefficients. The subsurface flow equation is not such a case because the presence of specific storage coefficients on the order of 10^{-6} can results in large "diffusion" coefficients. If large time steps are employed, the numerical results with ADI showed strong artificial orientation errors when compared with the analytical solutions of some example problems. We believe this type of error is common the whole family of directional splitting methods. Therefore, in the future we would consider applying another robust numerical solver in the CHM3D model that aims at long term flow simulations.

Hydrologic Modeling of the Ford County Field Site: Hydrologic modeling efforts for the Ford County drainage site include: i) inspection of the field data, ii) analysis of water budgets, and iii) numerical simulations carried out with the integrated hydrology model HydroGeoSphere. i)

Inspection of the Data: The hydrologic data provided by the USGS were compiled and inspected for problems. The main problem that we are aware of is that during some periods, some drainage tiles became full, rendering the flow meter readings invalid. Alternate means of estimating flows are being examined.

ii) *Water budgets*: As an example water budget, we present here results over one time period that we carefully analyzed − Oct. 11-Nov. 14, 2001. The main terms in the budget include precipitation (15.4 cm), evapotranspiration (7.6 cm), drainage discharge (7.7 cm) and soil water storage change (<~2.5 cm), which are balanced to within the margin of error. The cumulative depth of water discharged from the managed side of the field was twice that of the unmanaged side. We are currently pursuing explanations of this counterintuitive result.
iii) *Modeling*: To generate the finite element mesh for the field site, actual topography data were used and all 16 tiles were given a uniform slope and diameter. Simulations were generated for a part of the period of the water balance above. The initial groundwater table was set right below the tile lines and the subsurface boundary fluxes were assumed to be zero everywhere except at tile drain outflow nodes. The critical depth boundary condition was used over the entire surface domain. To make calibration tractable, a uniform set of soil physical properties was employed. The simulated tile discharges from the conventional and controlled fields match the timing of the observed data reasonably well, but tends to underestimate the flow peaks in both fields.

Nitrogen Cycle Modeling of the Ford County Field Site: Nitrogen cycle modeling efforts at the Ford

County drainage site include: i) inspection of the field data and ii) preliminary field N balances.
i) *Inspection of Data:* The chemistry and flow data received from the USGS include nitrate, nitrite and dissolved phosphorous concentrations. Due to gaps in flow and N data records, it is difficult to accurately quantify fluxes from the site. Unfortunately, the data on fertilizer inputs and crop yields were not available due to difficulties in communicating with the owners of the field site. To enable us to estimate the input of inorganic nitrogen to the field via mineralization of organic matter, we measured labile organic N for 120 samples collected from the field. The labile organic N was measured using the new Illinois Soil Nitrogen Test.

ii) Preliminary N Balance: While N export via tile discharge is considerably lower in the managed field, it is likely that subsurface export from the managed field added to the conventional field fluxes of water and nitrate. Our final N balance is pending.

Plant-Soil Model Calibration: A critical part of modeling the effects of water table management on nitrogen fluxes is determining how it affects crop growth and soil N mineralization. Thus, we began working with a well-established plant-soil model (DSSAT). First, the model code was adapted for use in tile-drained fields by incorporating Hooghoudt's equation into the hydrology subroutines. Next, we employed automatic calibration by a genetic algorithm (SCE-UA) to determine optimal parameter values for simulating N mineralization and organic matter decay. We found a significant correlation between the quantity of N in the model's "slow SOM" pool (R^2=0.70, P<0.001) and ISNT measurements in fields where fertilizer rate studies had been

conducted. This relationship can be used to develop strong constraints for model calibration at sites where N-rate trials have not been conducted, perhaps even permitting direct estimation of the initial magnitudes of the model N pools from ISNT and total soil C and N measurements. In other words, we expect to be able to accurately predict net mineralization of soil organic N for the Ford County field site by combining the model and ISNT measurements that we have obtained.

Significance: We expect that our final results will show that accounting for losses of N via subsurface flow from fields with water table management will be important for assessing their net environmental impact. In addition, we have developed methods of estimating net mineralization of N in fields by combining measurements of a labile soil N fraction (ISNT) with automatic calibration of a dynamic simulation model (DSSAT). Such results will be highly useful for managing fertilizer application rates in a way that reduces N losses to the environment impacts.

Estimating shallow recharge and discharge in northeastern Illinois using GIS and pattern recognition procedure

Basic Information

Title:	Estimating shallow recharge and discharge in northeastern Illinois using GIS and pattern recognition procedure
Project Number:	2004IL49G
Start Date:	9/1/2004
End Date:	8/31/2006
Funding Source:	104G
Congressional District:	15
Research Category:	Ground-water Flow and Transport
Focus Category:	Groundwater, Methods, Models
Descriptors:	None
Principal Investigators:	Yu-Feng Lin, Albert Joseph Valocchi, Randall Hunt

Publication

Problem and Research Objectives

Evaluations of water availability and the management of water resources requires quantifying the interaction between components of the hydrologic cycle, including the rates and variability of the recharge and discharge (R/D) to aquifers. These R/D rates define the relationships among groundwater, precipitation, and surface water, and thus can restrict management options for water supply. The management of water resources in northeastern Illinois is complicated by interstate agreements, hydraulically coupled aquifer systems, natural and anthropogenic contamination, groundwater / surface water interaction, and conjunctive use of multiple resources. This research is developing an automated computer software system implementing several methods of estimating and mapping R/D, and will apply the resulting software to improve the understanding of spatial variability of shallow R/D in northeastern Illinois, thereby addressing a research priority of national importance and of broad interest.

Methodology

The first task to be addressed is the development of a Pattern Recognition Utility (PRU) to identify recharge zones within noisy spatial data and estimate R/D rates for each zone. The PRU will be a graphical user interface (GUI) tool and compatible with ArcGIS 9 that implements several advanced image processing methods and couples these to the R/D estimation codes of Stoertz and Bradbury (1989), Bradbury et al. (2000), and Lin (2002). The software will be tested on a USGS internal project (Krohelski et al., 2003) in Wisconsin to determine trends (spatial and temporal) in recharge rates and investigate dominant recharge processes occurring in selected undeveloped, agricultural, and urban watersheds.

This approach will be used to assist in the estimation and mapping of R/D for the groundwater models that are part of a water resources assessment for northeastern Illinois (Meyer et al., 2002). Previous studies for regional R/D in this region are limited and the software will be applied to estimate the R/D to the shallow aquifers within a much shorter preparation time than current methods.

Principal Findings and Significance

The software has been upgraded in Visual Basic in order to be compatible with the latest version of ArcGIS 9.2. In addition to the integration of ArcGIS building functions (e.g., moving average, color ramp, rate options) and our adapted algorithm from recently developed image-processing, ($TV+L^1$), we have also added an algorithm based on normalization to enhance the efficiency of recognition for the R/D rates in various scales such as dry and wet seasons.

We have also developed an additional GIS tool to estimate grid R/D rates based on the water balance method (Stoertz and Bradbury, 1989). This additional utility will serve as a default R/D estimator to provide a convenient option prior to the R/D pattern recognition process.

We are currently in the final refinement stage of the software development in order to make the PRU robust. We have been testing and refining the PRU using the example sites in Wisconsin. In addition, Dr. Hunt is also testing the PRU with an alternative recharge estimation method (Dripps, 2003). At the same time, we have also been estimating the R/D patterns and rates in

Illinois using this software.

Budget

This project is progressing as scheduled in our latest progress report. Our work has been presented at several conferences and, as a result, many scientists have shown an interest in our research and have volunteered to be software testers. We now have volunteer testers from a variety of universities, national laboratories, and federal and state agencies ranging across the US and extending to Asia.

Therefore, the PI recently requested a further no-cost extension to December 31, 2007 in order to demonstrate our final results at two major conferences and publications. The two conferences are the Geological Society of America Annual Meeting in Denver, Colorado and the American Geophysical Union Fall Meeting in San Francisco, California. These promise to be excellent opportunities to promote and share our work with the domestic and international science community. However, some budget re-allocations (the net total budget change is $0) were necessary and requested on May 9, 2007 as the following:

Budget Item	Current Budget	Re-allocation	Proposing Budget
Equipment	6,695	- 400	6,295
Travel	5,941	+ 2,155	8,096
Contractual	6,730	- 900	5,830
Telecommunications	855	- 855	0

The preparation of final report is already in progress. The report is scheduled to be completed at the end of this year so we can include the comments from the conference presentations mentioned above.

Related and Seed Projects

A new research project, “The development of point-to-zone pattern learning (P2Z) for groundwater recharge,” based on the development of the PRU has been funded by National Center for Supercomputing Applications (NCSA) and started in September 2006. The NCSA project has been collaborating with this NIWR/USGS project successfully by developing innovative R/D pattern learning algorithms with not only image processing methods, but also machine learning approach to help users classify their conceptual recharge maps. A new proposal based on the achievements of both projects was recently submitted to the National Science Foundation. This new proposed research will develop algorithms and procedures that will enable scientists to improve conceptual models and understand the impact of conceptual model uncertainties arising from field measurements and ancillary data. This sequential research development has demonstrated the scientific merit and superior quality of this NIWR/USGS project.

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Carbonaceous Material Fractions in Sediments and Their Effect on the Sorption and Persistence of Organic Pollutants in Small Urban Watersheds

Basic Information

Title:	Carbonaceous Material Fractions in Sediments and Their Effect on the Sorption and Persistence of Organic Pollutants in Small Urban Watersheds
Project Number:	2004IL52G
Start Date:	9/1/2004
End Date:	8/31/2007
Funding Source:	104G
Congressional District:	15th Illinois
Research Category:	Water Quality
Focus Category:	Non Point Pollution, Sediments, Water Quality
Descriptors:	
Principal Investigators:	Charles J. Werth, Barbara June Mahler, Peter Chapman Van Metre

Publication

1. Yang, Y., C. J. Werth, 2006, Carbonaceous material fractions in sediments and their effect on the sorption and persistence of organic pollutants in small urban watersheds in the 12th Annual Environmental Engineering and Science Spring Symposium, the University of Illinois, Urbana, IL, 49.
2. Yang, Y., C. J. Werth, 2005, Carbonaceous material fractions in sediments and their effect on the sorption and persistence of organic pollutants in small urban watersheds in the11th Annual Environmental Engineering and Science Spring Symposium, the University of Illinois, Urbana, IL, 23.

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Title: Carbonaceous Material Fractions in Sediments and Their Effect on the Sorption and Persistence of Organic Pollutants in Small Urban Watersheds

Principal Investigators: Charles J. Werth, Peter C. Van Metre, and Barbara J. Mahler

Research Categories: Water Quality

Problem and Research Objectives:

Particle-associated contaminants (PACs), including chlorinated organic compounds, trace elements, and polycyclic aromatic hydrocarbons (PAHs), are an important contributor to urban non-point source pollution across the Nation. Occurrence of PACs has resulted in the impairment of thousands of streams, lakes, and reservoirs. In the past decade, researchers at the U.S. Geological Survey (USGS) investigated the extent to which the contaminant concentrations and trends recorded in sediment cores were associated with suspended sediment in influent streams (Van Metre et al., 1997). Van Metre and Mahler (2004) indicated that in small urban watersheds, concentrations of some PACs on suspended sediment in influent streams can greatly exceed those in bed sediment in the downstream reservoir, and that trends may not be preserved in cores for some PACs. Their observations present a problem for effective sediment monitoring and best management practices for mitigating PAC occurrence. Although the significant loss of contaminants during transport and soon after deposition has been attributed to the solubilization of some contaminants, and the solubilization and mineralization of some solid-phase carbonaceous materials (CMs), relatively little is known about the role played by CMs in the transport and fate of PACs in small urban watersheds.

In this research, we focus on one class of PACs, polycyclic aromatic hydrocarbons (PAHs). PAHs have been a major concern regarding public health and environmental impact because of their widespread occurrence in the environment, as well as their carcinogenic and mutagenic properties. Concentrations of PAHs have increased in recent decades in many urban lakes and streams, particularly in areas with rapid urbanization (Van metre and Mahler, 2005). PAHs are strongly sorbed to solid particles and enter receiving water bodies with storm runoff from impervious surfaces or storm sewers in urban watersheds, as well as by atmospheric deposition. We hypothesized that CM particles are the primary carriers of PAHs in urban watersheds and control the persistence of PAHs as they undergo transport from the land surface into receiving water bodies, and deposition and burial as sediments.

The overall objective of this study is to determine how CM fractions affect the persistence of PACs, with a focus on PAHs in small urban watersheds. The specific objectives are 1) to determine the types and amounts of CMs in urban soil and dust particles with storm runoff, in suspended particles during transport, and in lake sediments after settling, accumulation and burial, 2) to identify the sources of CM particles that may concentrate, transport, and redistribute PAHs in urban watersheds, and elucidate the relationships between CM properties and PAH loadings, and 3) to simulate the particle-associated PAH loading in urban waterhsheds.

Methodology: This research project consists of three phases.

Phase I: Sampling and bulk sediment PAC analysis.

Lake Como and Lake Fosdic watersheds in Fort Worth, Texas were chosen to be urban "laboratories". Samples of lake sediments, suspended sediments and bed sediments in influent streams, soils, street dust, and parking lot dust were collected from each watershed. One split of the samples was used for PACs analysis, PAH desorption, and the determination of sediment deposition time at the USGS National Water Quality Lab (NWQL), and the other split is being used for CM fractionation, characterization, and sorption in our laboratory. All Phase I work has been completed.

Phase II: Enrichment and characterization of CM fractions.

All Lake Como and Lake Fosdic samples, except suspended sediments (due to sample mass limitations), were density separated with a sodium polytungstate solution to obtain loose particulate carbonaceous material (LPCM), occluded particulate carbonaceous material (OPCM), and the remaining humified and mineral associated fraction (HFr). The former two fractions for each lake were combined to create light fractions (LFr), and the HFr fractions from Lake Como were subjected to a series of chemical and thermal treatment steps to obtain sub-samples enriched in different CM fractions (Jeong and Werth, 2005). Chemical treatment steps are exposure to HCl and HF to remove inorganic minerals and acid soluble organic materials, exposure to trifluoroacetic acid (TFA) to remove easily hydrolysable organic materials, exposure to NaOH to remove humic and fulvic acids, and exposure to $K_2Cr_2O_7/H_2SO_4$ to remove the more recalcitrant kerogen and humin. Thermal treatment refers to sample oxidation in excess air at 375^{o}C (CTO 375) (Gustafusson et al., 1997), which was used to quantify the soot carbon contents of bulk samples. All Lake Como samples were also evaluated using organic petrography to quantify CM types and amounts. Remaining enrichment and CM characterization work in Phase II involves treating all Lake Como samples with $K_2Cr_2O_7/H_2SO_4$ in order to quantify kerogen and humin, measurement of organic carbon in all samples via elemental analysis, and surface functional group characterization using Fourier-transform infrared spectroscopy.

Native PAH loadings on all light and heavy (LFr and HFr) fractions of Lake Fosdic samples are in the process of being determined using a Dionex accelerated solvent extraction (ASE) system and a Varian gas chromatography/mass spectrometer (GC/MS) following EPA method 3545 and 8270c. As part of Phase II, we also plan to select different types of CM particles from these samples using a microscope, and measure the PAH loadings on these isolated CM particles. This will allow us to determine on what CMs the native PAHs concentrate, and whether this corresponds to the CMs that have the highest sorption capacity. If the two do not correspond, then redistribution of PAHs during transport and burial is likely.

Phase III: Measurement and prediction of sorption for PAHs and modeling of contaminant loading in urban watersheds

Sorption isotherms were measured at 25°C for all Lake Como bulk and acid treated sub-samples except suspended sediments using established batch equilibrium methods (Xia and Ball, 1999). Radio-labeled phenanthrene was used as the sorbate to distinguish spiked sorbate from background contaminants.

Remaining Phase III work involves measuring the sorption isotherms for the Lake Fosdic samples. The sorption isotherms and the surface properties characterized in Phase II will be used to predict PAHs sorption capacities of CM particles and to identify mechanisms that control the persistence of PAHs in urban reservoirs. Although not part of our original proposal, we also plan to use the EPA Storm Water Management Model (SWMM) to estimate the production of pollutant loads associated with the runoff during strom events, and to evaluate the effectiveness of BMPs for reducing pollutant loadings in the Lake Como urban watershed.

Principal Findings and Significance

Total PAH concentrations on Lake Como bulk samples are shown in Figure 1. Results indicate that total PAHs in sealed parking lot dust are 30 times greater than in unsealed parking lot dust, and 80-110 times greater than in lake sediments. The higher PAH concentrations in sealed parking lot dust indicate that coal tar pitch from sealed parking lots may dominate PAH loading in watersheds with commercial and residential land use (Mahler et al., 2005). The asphalt street dust and soil in the residential area have the lowest concentrations of PAHs. Total PAHs in the suspended stream sediment greatly exceed the probable effect concentrations (PEC, 22800 μg/kg) and threshold effect concentrations (TEC, 1610 μg/kg) in consensus-based sediment-quality guidelines (MacDonald et al., 2000), and are 4-6 times greater than in the stream bed sediments and lake sediments where the total PAHs are lower than the PEC. This observation is consistent with the previous published work (Van Metre and Mahler, 2004), indicating that particles with relatively high PAH concentrations are transported to the lake, but that these concentrations decrease during particle transport and burial in the sediments.

Organic carbon contents of all Lake Como samples are shown in Figure 2. Organic carbon contents generally increase with the sediment depth. This corresponds to the trend in PAH concentrations (Figure 1). Total PAH concentrations were normalized to organic carbon contents and results are shown in Figure 3. The normalized PAH concentration in the sealed parking lot material is almost 20 times more than in the sealed parking lot dust, and almost 80 times more than in the remaining samples.

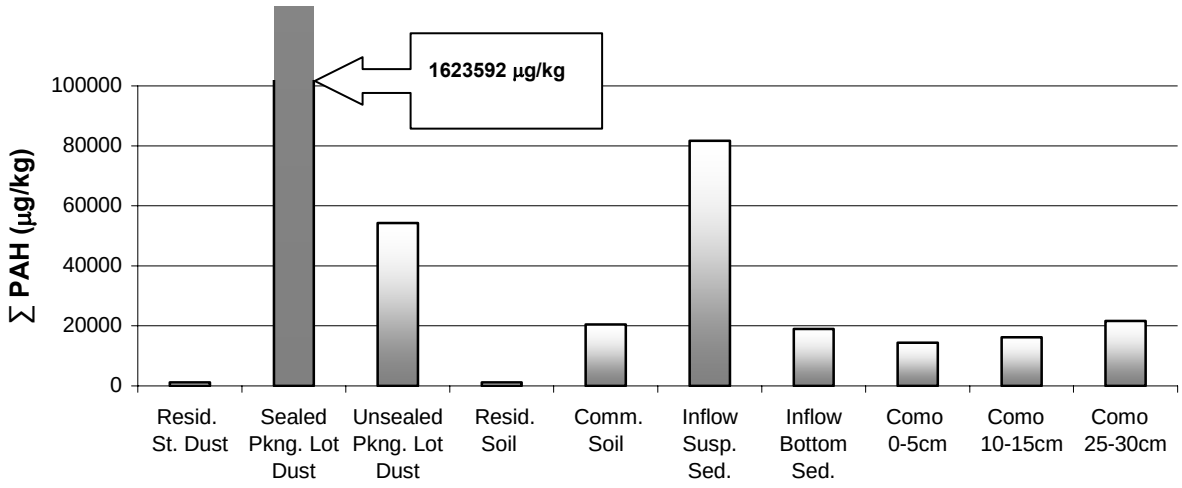


Figure 1. Total PAH concentrations in bulk samples from Lake Como watershed.

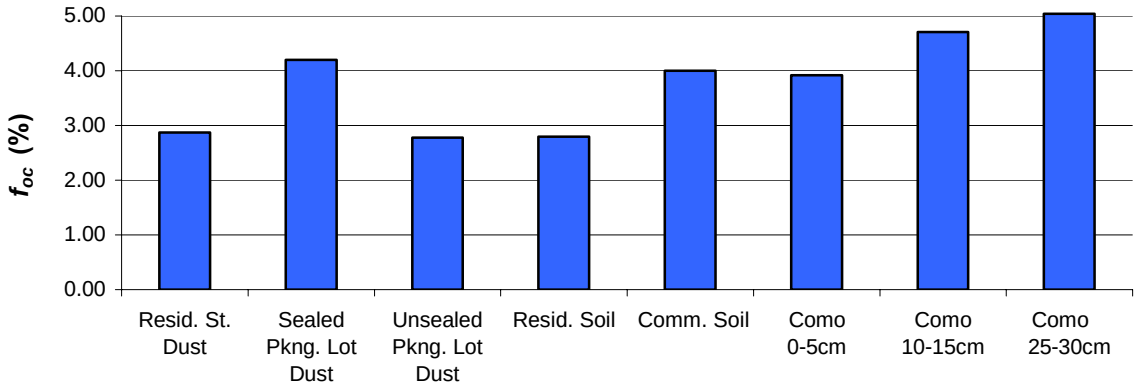


Figure 2. Organic carbon contents (f_{oc}) in bulk samples from Lake Como watershed.

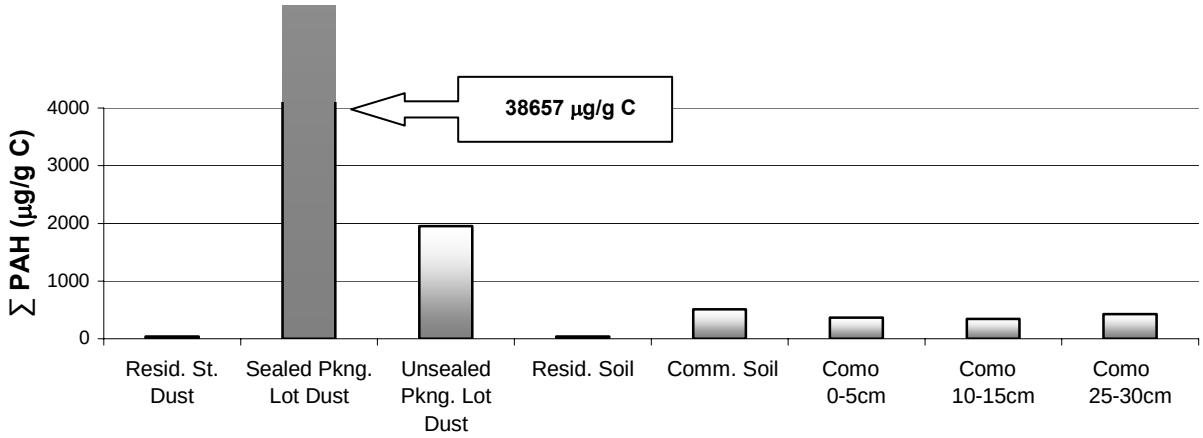


Figure 3. Total PAH concentrations normalized to the organic carbon contents in bulk samples from Lake Como watershed.

Photomicrographs from petrography analysis are shown in Figure 4. Amounts of different CMs determined from the corresponding quantitative analysis are shown in Figure 5. Results indicate that recent organic matter (OM) and OM in ancient sediments dominate CMs in soils and sediments. Asphalt-like and bitumen-like substances are greater in inflow bed sediment than in lake sediments, and greater in top sediment than in deeper sediments. Soot is relatively abundant in lake sediments. Coal tar pitch dominates sealed parking lot dust, while asphalt-like and bitumen-like substances dominate unsealed parking lot dust and street dust. However, relatively little to no coal tar pitch particles was observed in inflow bed sediments and lake sediments by organic petrographic analysis (with a sensitivity of 0.2% for particles greater than 1 to 2 microns). Since PAH levels in coal tar pitch are very high (3.4 to 20 wt %) (Mahler et al., 2005), it takes only a few coal tar pitch particles to elevate the PAH concentrations in sediments. The gradually eroded coal tar particles may be broken down during transport with runoff and diluted by larger CM particles when they get into the streams and lakes, so their concentrations in sediments may be lower than the detection limit of organic petrography. However, due to their great PAH loadings (Figure 1), coal tar particles from sealed parking lot dust may contribute to

PAH contamination in Como sediments. Mass spectroscopy fingerprints of PAHs for coal tar particles, asphalt-like and bitumen-like substances, soot, recent OM and OM in ancient sediments and lake sediments will be compared to assess this assertion.

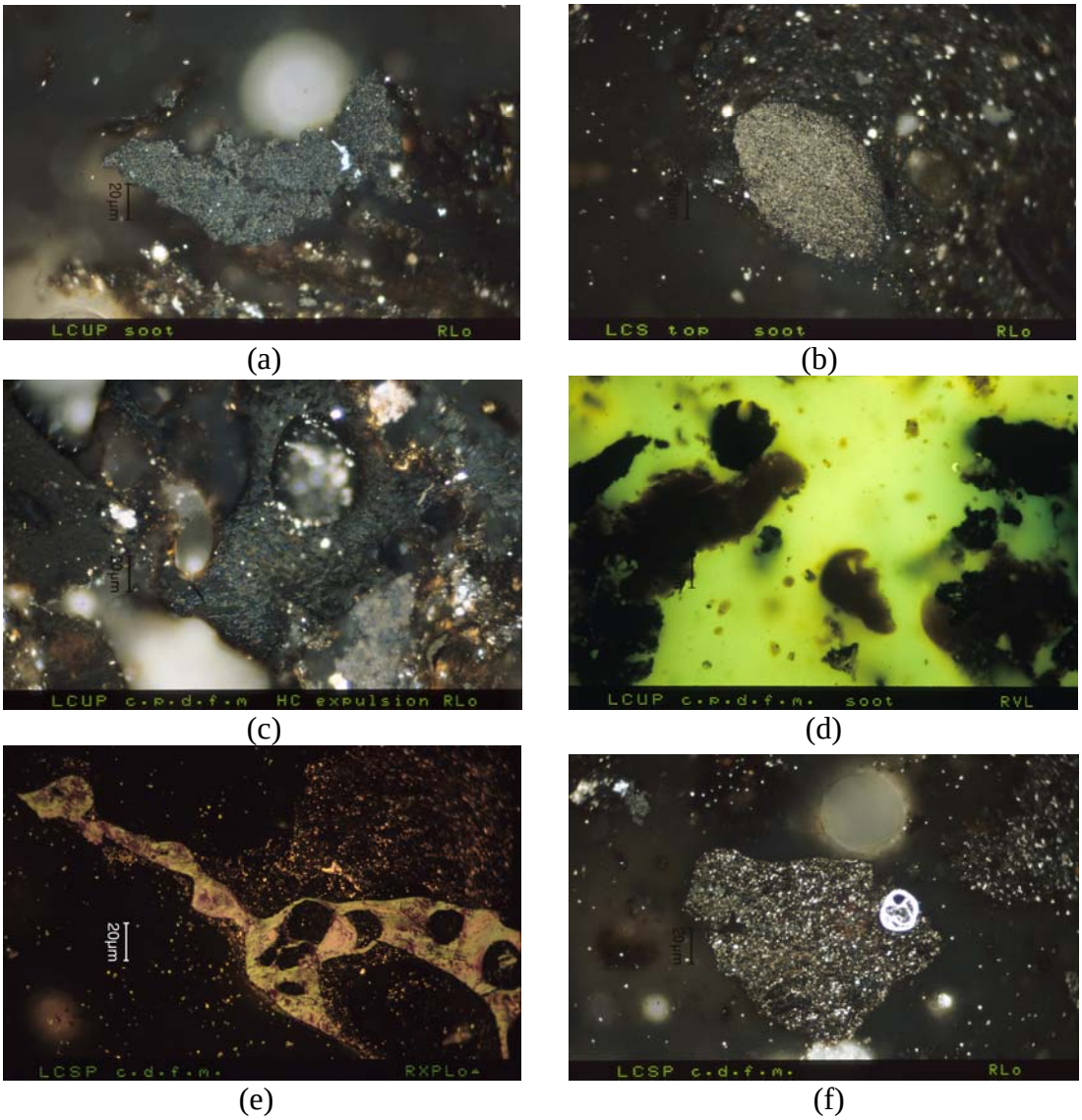
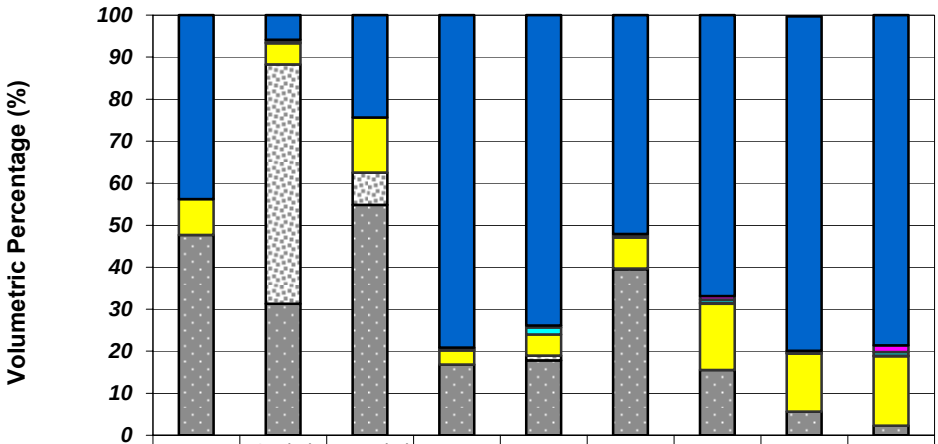


Figure 4. Photomicrographs illustrating the different organic matter present in selected samples: (a) blue grey soot from Lake Como unsealed parking lot dust; (b) rounded soot particle from Lake Como top sediment (0-5 cm); (c) porous asphalt producing a film of oil from Lake Como unsealed parking lot dust; (d) brown fluorescing bitumen & drops related from Lake Como unsealed parking lot dust; e) coal tar pitch with coke particles from Lake Como sealed parking lot dust; f)coal tar pitch with cenosphere from Lake Como sealed parking lot dust. All pictures were taken with a Leitz DMRX-MPVSP microscope photometer in both reflected white-light and UV+violet-light illumination (fluorescence mode), equipped with a WILD MPS48 photoautomat.

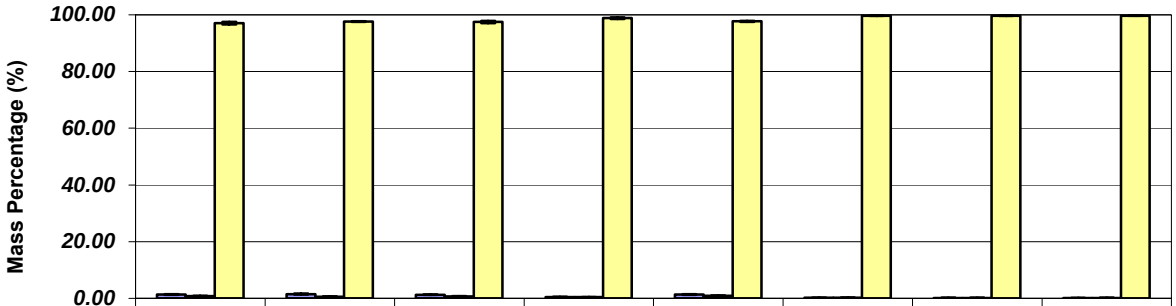


	Resid. St. Dust	Sealed Pkng. Lot Dust	Unsealed Pkng. Lot Dust	Resid. Soil	Comm. Soil	Inflow Bed Sed.	Como 0-5 cm	Como 10-15 cm	Como 25-30 cm
Recent OM and OM in Ancient Sediments	43.8	5.9	24.4	79.1	73.9	52.1	66.9	79.6	78.6
Hard Coal	0	0.6	0	0.2	0.4	0.4	0.8	0.3	1.6
Charcoal	0	0	0	0.3	1.7	0.2	0.8	0.2	0.8
Coke Carbon Forms	0	0.2	0	0.2	0	0.2	0.2	0	0.2
Char	0	0	0	0	0	0	0	0.2	0
Soot	8.5	5	13.1	3.4	5	7.4	15.8	13.8	16.5
Coat Tar Pitch	0	57	7.7	0	1.2	0.2	0	0	0
Asphalt-like and Bitumen-like Substances	47.7	31.3	54.8	16.8	17.8	39.5	15.5	5.6	2.3

Figure 5. Volumetric percentages of various CMs in bulk samples from Lake Como watershed determined by organic petrography.

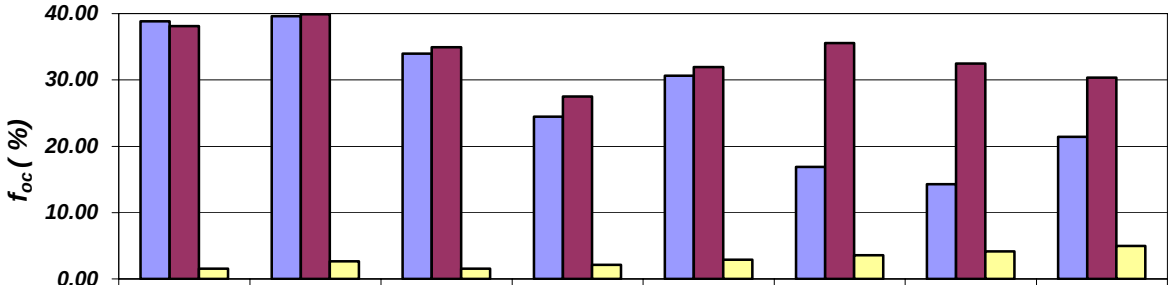
The mass percentages of density-separated fractions are presented in Figure 6, and the organic carbon contents of these fractions are shown in Figure 7. The HFr fractions dominate the mass contents of all bulk samples, ranging from 97.8% to 99.7%. Although the organic carbon contents of the LPCM and OPCM fractions are much greater than that those of the HFr fractions (Figure 7), the majority of CMs are associated with the HFr fractions (>52%) due to the dominant mass contents.

The remaining mass percentages of the different HFr fractions after sequential chemical treatment are presented in Figure 8, and the remaining carbon contents of these fractions after sequential chemical treatment are shown in Figure 9. The significant mass loss of the HFr fractions after the HCl/HF acidification (89.5-95.7%) indicates that minerals (carbonates and silicates) are the major contents of particles in urban runoff (Figure 8). The most recalcitrant CMs are in sealed parking lot dust, which only lost about 32% of the total carbon after sequential chemical treatment (Figure 9). The fact that the resistance of CMs to the chemical treatment slightly increases with the sediment depth suggests the maturity of sediment CMs, which are subjected to years of chemical and biological reactions after deposition and burial.



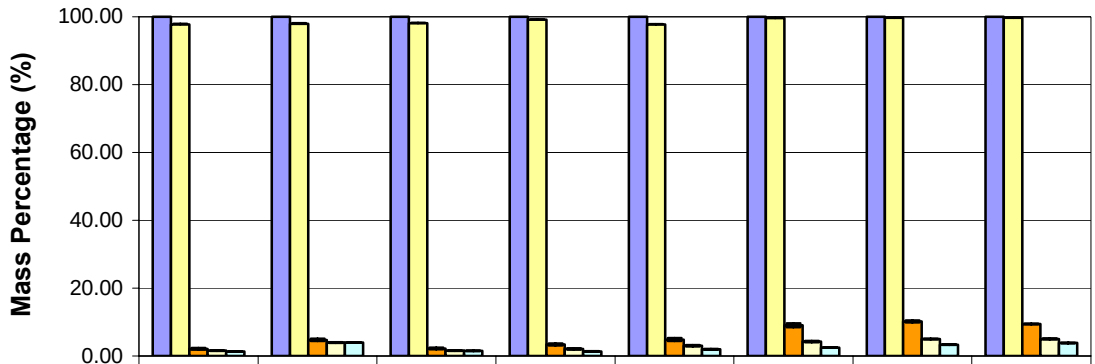
	Resid. St. Dust	Sealed Pkng. Lot	Unsealed Pkng. Lot	Resid. Soil	Comm. Soil	Como 0-5 cm	Como 10-15 cm	Como 25-30 cm
LPCM	1.40	1.52	1.26	0.48	1.38	0.18	0.15	0.13
OPCM	0.83	0.58	0.65	0.40	0.87	0.18	0.17	0.17
HFr	97.07	97.68	97.47	98.82	97.71	99.64	99.68	99.71

Figure 6. Mass percentages of density-separated fractions of Lake Como samples.



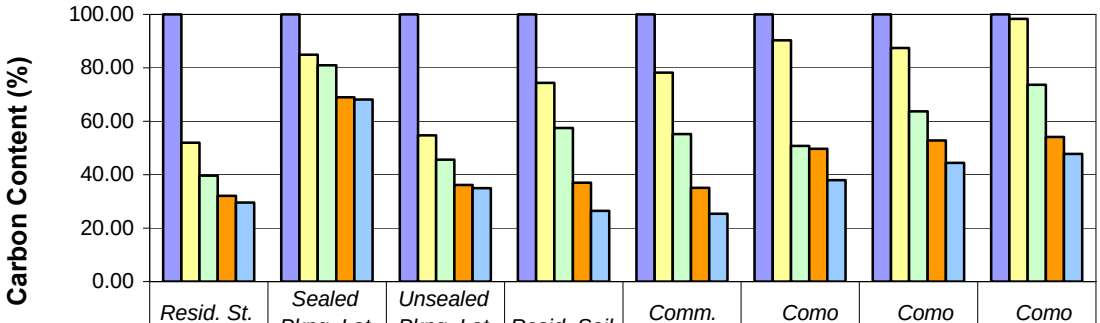
	Resid. St. Dust	Sealed Pkng. Lot	Unsealed Pkng. Lot	Resid. Soil	Comm. Soil	Como 0-5 cm	Como 10-15 cm	Como 25-30 cm
LPCM	38.83	39.63	33.97	24.46	30.66	16.86	14.30	21.42
OPCM	38.14	39.92	34.95	27.52	31.92	35.56	32.49	30.36
HFr	1.53	2.64	1.55	2.10	2.90	3.55	4.13	4.99

Figure 7. Organic carbon contents (f_{oc}) of bulk samples and density-separated samples from Lake Como watershed.



	Resid. St. Dust	Sealed Pkng. Lot Dust	Unsealed Pkng. Lot Dust	Resid. Soil	Comm. Soil	Como 0-5 cm	Como 10-15 cm	Como 25-30 cm
Bulk	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
HFr	97.78	97.91	98.09	99.12	97.75	99.64	99.68	99.71
HCl/HF-treated HFr	2.12	4.76	2.18	3.40	4.85	9.05	10.19	9.43
TFA-treated HFr	1.58	3.99	1.58	2.07	2.98	4.24	5.00	5.02
NaOH-extracted HFr	1.34	3.95	1.48	1.36	1.98	2.49	3.33	3.83

Figure 8. Remaining mass percentages of density-separated HFr fractions after the sequential chemical treatment.



	Resid. St. Dust	Sealed Pkng. Lot Dust	Unsealed Pkng. Lot Dust	Resid. Soil	Comm. Soil	Como 0-5 cm	Como 10-15 cm	Como 25-30 cm
Bulk	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
HFr	52.01	84.85	54.71	74.43	78.20	90.28	87.44	98.32
HCl/HF-treated HFr	39.62	80.96	45.67	57.49	55.22	50.84	63.71	73.64
TFA-treated HFr	32.12	69.04	36.14	36.97	35.15	49.66	52.84	54.15
NaOH-extracted HFr	29.57	68.16	34.93	26.43	25.38	37.96	44.47	47.80

Figure 9. Remaining carbon contents in density-separated HFr fractions after the sequential chemical treatment.

All sorption isotherms are nearly linear, with Freundlich exponents, n, greater than 0.90 (Table 1). Freundlich constants (K_f) of LFr fractions are greater than those of HFr and bulk samples due to the high organic carbon content in LFr.

Table 1. Parameters of sorption isotherms and organic carbon contents (f_{oc}) in Lake Como samples.

		K_f $(ug/L)/(ug/g)^n$	n	f_{oc} (%)	log Koc (L/kgC)
	Bulk	2.01	0.91	3.92	4.43
Como 0-5cm Sediment	HFr	1.74	0.93	3.55	4.48
	LFr	18.08	0.91	26.20	4.66
	Bulk	2.38	0.97	4.71	4.63
Como 10-15cm Sediment	HFr	2.18	0.95	4.13	4.55
	LFr	19.20	0.91	23.90	4.74
Como 25-30cm Sediment	Bulk	2.68	0.96	4.93	4.65
	HFr	2.29	0.98	4.99	4.62
	LFr	17.01	0.92	27.00	4.56
	Bulk	1.35	0.93	2.87	4.54
Resid. St. Dust	HFr	1.28	0.93	1.53	4.76
	LFr	7.84	0.99	38.58	4.45
	Bulk	3.76	0.94	3.53	4.86
Sealed Pkng. Lot Dust	HFr	2.97	0.94	2.64	4.97
	LFr	15.77	0.94	39.71	4.50
	Bulk	0.92	1.00	2.78	4.51
Unsealed Pkng. Lot Dust	HFr	1.11	0.97	1.55	4.81
	LFr	11.49	0.95	34.30	4.53
	Bulk	0.62	0.95	2.80	4.25
Resid. Soil	HFr	0.81	0.90	2.10	4.43
	LFr	7.21	0.93	26.14	4.23
	Bulk	0.92	0.94	2.92	4.44
Comm. Soil	HFr	1.00	0.93	2.90	4.56
	LFr	6.69	0.96	31.14	4.42

Organic carbon normalized sorption coefficients are presented in Figure 10. Previous research has revealed that in addition to the organic carbon content, the nature or quality of the CMs has a significant impact on sorption capacity (Rutherford et al., 1992). For soil and dust samples, K_{oc} values are higher in HFr fractions than in LFr fractions, indicating more geologically mature CMs may be associated with HFr fractions (Kleineidam et al, 1999). The greater K_{oc} values for the bulk and HFr fraction of the sealed parking lot dust could also account for the higher PAH concentrations in this sample, in addition to the original contributions from the coal tar pitch sealcoat (Figure 3).

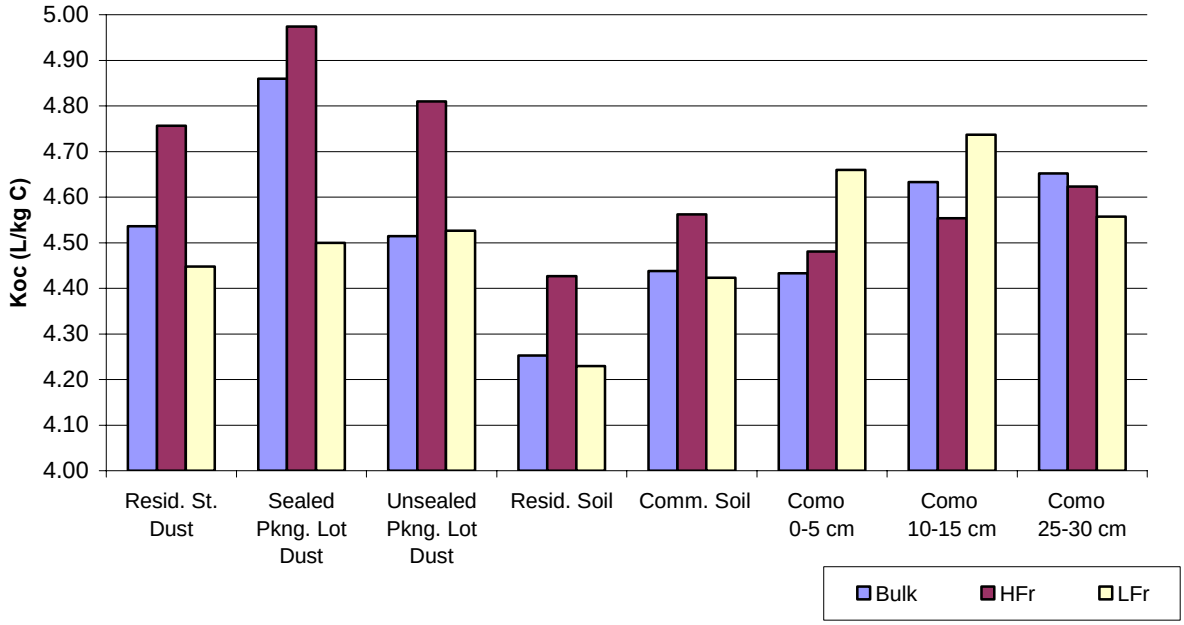


Figure 10. Calculated organic carbon normalized partition coefficient (K_{oc}) in all samples.

Assuming that, at a fixed aqueous concentration, the mass sorbed to the density separated fraction *i* is the same when this fraction is alone, or is part of the bulk sample, relative sorption contribution of fraction *i* at a given concentration *C* can be defined as:

$$Relative\ \ Sorption\ \ Contribution\ \ of\ \ Fraction\ \ i = \frac{q_i}{\Sigma q_i} \times 100\%$$

where $q_i = K_F C^n \times m_i$

and m_i is the mass percentage of fraction i in bulk samples.

The relative sorption contribution of LFr and HFr fractions of all samples at the equilibrium concentration of 0.1 ppm are shown in Figure 11. The HFr fractions dominate the sorption of phenanthrene relative to the LFr fractions, due to their considerable mass contents. PAHs loadings on these two density-separated fractions will be analyzed to verify that the CMs associated with HFr fractions are the primary carriers of PAHs in urban watershed.

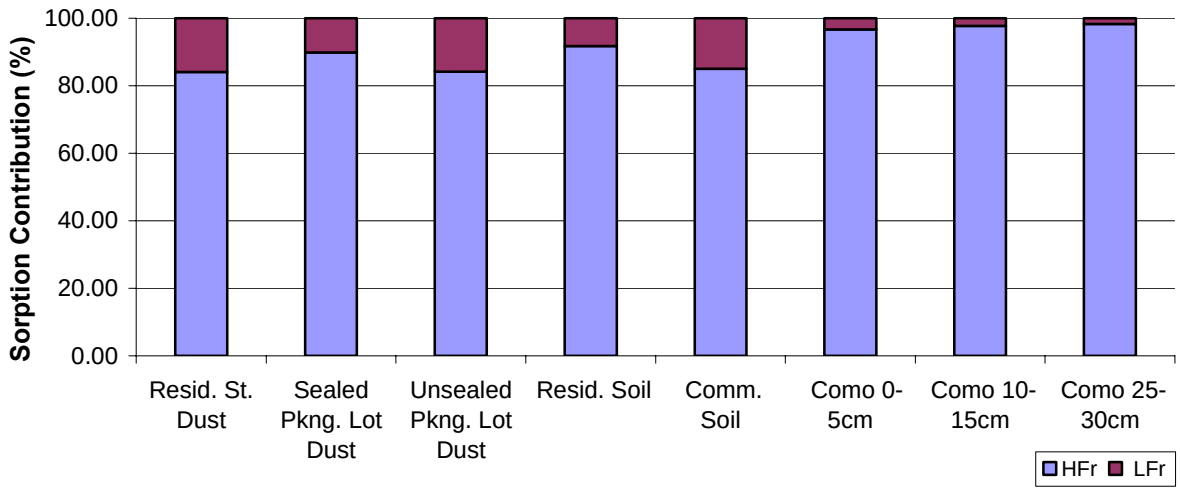


Figure 11. Relative sorption contribution of Lake Como samples at the equilibrium concentration of 0.1 ppm.

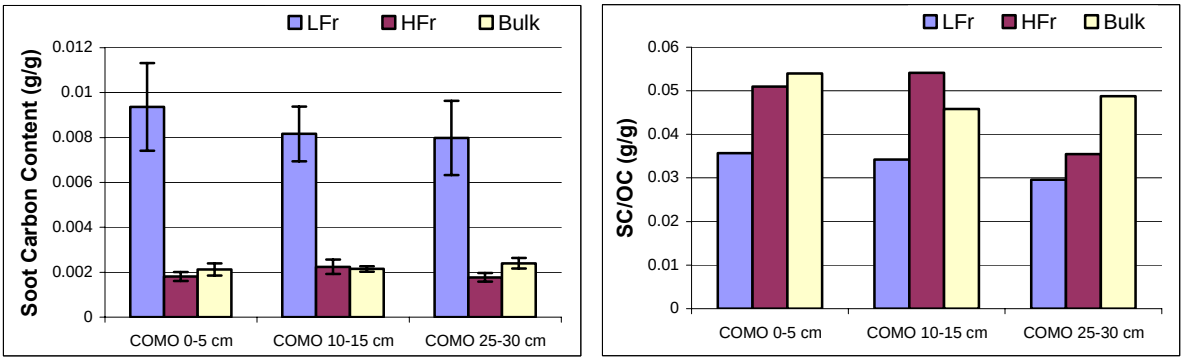


Figure 12. Soot carbon (SC) contents in density-separated fractions of Lake Como sediments quantified by CTO 375 method: (a) SC contents; (b) ratio of SC to organic carbon (OC).

Soot carbon (SC) contents of Lake Como sediments are listed in Figure 12 (a). The LFr fractions contain up to 4 times more SC than the HFr fractions; however, the ratio of SC/OC is lower in the LFr fractions than in the HFr fractions due to the greater amounts of total organic carbon in the LFr fractions (Figure 12 (b)). This ratio reflects the dominance of SC in the organic carbon pool. The small values of SC/OC (<0.055) suggest the dominant amounts of other types of OM in sediments, which can be the recent OM and OM in ancient sediments revealed by organic petrography (Figure 5).

Graduate Students Supported with Funding
Yaning Yang, a PhD student, has been supported on this project for the past three years.

Yaning Yang
Department of Civil and Environmental Engineering
College of Engineering
University of Illinois at Urbana-Champaign
Ph.D. student (degree expected in 2008)

Multiple undergraduates have also worked on the project. These are Bushra Dinkha in year 2, Bushra Dinkha and Karina Lairet in year 3, and Ben Dukes in the summer of 2007.

We presently have funds remaining on the project and request a one-year no-cost extension to complete the project work and write the associated manuscripts for publication in peer-reviewed journals. The no-cost extension will also allow Yaning Yang to complete her PhD thesis and graduate.

Publications and Presentations
Yang, Y., C. J. Werth, P.C. Van Metre, B.J. Mahler, J.T. Wilson, B. Ligouis, M. Razzaque, 2007, The role of carbonaceous materials in the fate of PAHs in an urban watershed in European Geosciences Union General Assembly 2007, Vienna, Austria.

Werth, C.J., Y. Yang, P.C. Van Metre, B.J. Mahler, M. Razzaque, 2007, Watershed-scale processes that affect pollutant partitioning, transport and fate, Biogeochemistry workshop, Tuebingen, Germany.

Yang, Y., C. J. Werth, 2006, Carbonaceous material fractions in sediments and their effect on the sorption and persistence of organic pollutants in small urban watersheds in the 12th Annual Environmental Engineering and Science Spring Symposium, the University of Illinois, Urbana, IL, 49.

Yang, Y., C. J. Werth, 2005, Carbonaceous material fractions in sediments and their effect on the sorption and persistence of organic pollutants in small urban watersheds in the11th Annual Environmental Engineering and Science Spring Symposium, the University of Illinois, Urbana, IL, 23.

Notable Achievements
Coal tar particles from sealed parking lot dust may be the major source of PAH contamination in lake sediments due to their great PAH loadings.

Related and Seed Projects
N/A

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Jeong, S., C.J.Werth, 2005, Evaluation of Methods To Obtain Geosorbent Fractions Enriched in Carbonaceous Materials That Affect Hydrophobic Organic Chemical Sorption, *Environ. Sci. Technol.*, 39(9), 3279-3288.

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Development of Water Use Benchmarks for Thermoelectric Power Generation in the United States

Basic Information

Title:	Development of Water Use Benchmarks for Thermoelectric Power Generation in the United States
Project Number:	2004IL56G
Start Date:	7/1/2004
End Date:	8/15/2006
Funding Source:	104G
Congressional District:	Illinois 12th
Research Category:	Social Sciences
Focus Category:	Water Use, Methods, Models
Descriptors:	
Principal Investigators:	Ben A. Dziegielewski, Tom Bik

Publication

1. Dziegielewski, Ben, 2005, "Altering Water Demands of Thermoelectric Power Generation in Proceedings of the XIIth World Congress on Water Resources, November 22-25, 2005, New Delhi, India. (Published in both hard copy book and CD-ROM proceedings).
2. Xiaoying Yang and Benedykt Dziegielewski. 2005. Water Withdrawals by Thermoelectric Power Plants in the U.S. Journal of the American Water Resources Association (Approved for publication, In press for 2006).

EXECUTIVE SUMMARY

Water Use Benchmarks for Thermoelectric Power Generation

by
Ben Dziegielewski, Thomas Bik, Usama Alqalawi, Stanley Mubako, Nathan Eidem, and Shauna Bloom, Southern Illinois University Carbondale

Study Purpose

The purpose of this study was to examine water use at electric power plants in the United States and determine both the average rates of water withdrawals and consumptive use as well as the levels of water-conserving usage in the most water-efficient plants and cooling systems. The generalized water-use parameters represent benchmark measures of the quantities of water used by the different types of cooling systems and power plants. This was accomplished by exploring publicly-accessible thermoelectric water use data from the U.S. Department of Energy, Energy Information Administration (EIA), as well as by conducting on-site visits at power plants and completing a questionnaire survey of plant water managers.

Significance of Thermoelectric Water Use

Generation of electricity requires large quantities of water either for turning water turbines to generate hydroelectric power or for cooling and condensing steam in thermoelectric generation. Nearly 90 percent of generation capacity in the U.S. is in thermoelectric plants.

Precise estimates of the actual volume of water that is used to generate electricity at the national level are difficult to obtain. The U.S. Geological Survey's National Water Use Information Program (NWUIP) prepares nationwide compilations of all reported water uses, which are published every five years (Hudson et al., 2004).

The most recent USGS compilation reported that the combined country-wide water withdrawals by all sectors had increased since 1995 and in the year 2000 had reached an average daily volume of 408 billion gallons per day or 1,432 gallons per capita per day. Nearly 48 percent of all withdrawals, or 195.5 billion gallons per day, were for thermoelectric power generation, primarily to satisfy cooling requirements of power plants. Total utility-based generation of electricity in the year 2000 (not counting hydroelectric power) reached 2,762,200 million kWh, and required approximately 26 gallons per each kWh of generation. In per capita terms, total withdrawals for thermoelectric generation in the year 2000 amounted to 686 gallons per capita per day – more than four and a half times the per capita amount of all publicly supplied water for domestic, commercial and industrial uses.

Nearly 85 percent of all water withdrawals and nearly 70 percent of all thermoelectric withdrawals are obtained from the country's limited supplies of fresh water. In 2000, thermoelectric use accounted for nearly 40 percent of all freshwater withdrawals in the country, with the total freshwater withdrawals for the thermoelectric sector approximately

equal to those of the irrigation sector. Despite these high annual withdrawals for thermoelectric power generation, only a few studies of thermoelectric water demands have been conducted. The reason may be that unlike irrigated agriculture where most of the water is evaporated or lost, approximately 98 percent of water withdrawn by thermoelectric sector is returned back to the source.

However, even the "non-consumptive" withdrawals of water for thermoelectric power plants can have significant impacts on water resources. Power plants are the largest dischargers of thermal pollution that affects both aquatic ecosystems and evaporation rates. Also, the large quantities of water required for power generation must be continuously available for power utilities to provide reliable service to their customers. This quantity of water is therefore "reserved" for power generation and is not available to other user such as irrigators or public water suppliers

Average Rates of Water Use

The database used in the statistical analysis was developed primarily from the information in the Department of Energy's Form EIA-767, and contained 7,365 observations of estimated thermoelectric water withdrawals and consumptive use, for cooling systems in fossil-fuel plants, during the nine-year period from 1996 to 2004. A smaller number of observations was available for nuclear-powered plants because the annual EIA data reporting for this type of plants was discontinued after 2000, and the data were only available from 1996 to 2000.

In addition to the data on water withdrawals and consumptive use, five categories of likely determinants of cooling water withdrawals were included in the analysis: (1) cooling systems type; (2) fuel type; (3) operational conditions; (4) water sources; and (5) other relevant variables. Additional information about thermoelectric water use was obtained from site visits and interviews at five power generation facilities and questionnaire survey responses from 40 power plants.

Water withdrawals per unit of net generation of electricity were estimated from the EIA-767 data, and the average unit-use was calculated for ten different types or combinations of cooling systems. A review of the distribution of unit-use estimates determined that these calculated averages were significantly influenced by outlier values. The outliers were removed from the analysis and the mean values of water withdrawals for each cooling system type were recalculated (see Figure ES-1).

Unit withdrawals for once-through systems were estimated to range from approximately 50 to 65 gal./kWh; for closed-loop systems with cooling towers from 1.0 to 2.0 gal/kWh; and for recirculating systems with cooling ponds or canals and other mixed recirculating systems from 14 to 24 gal/kWh. Net generation weighted averages were also calculated for three general aggregations of the ten cooling system types for both fossil-fuel and nuclear plants. The resultant weighted average water use rates represent water use benchmark measures for these categories of cooling systems (see Table ES-1). Because of

the weighing by total (net) generation the resultant estimates tend to reflect water usage rates in larger plants.

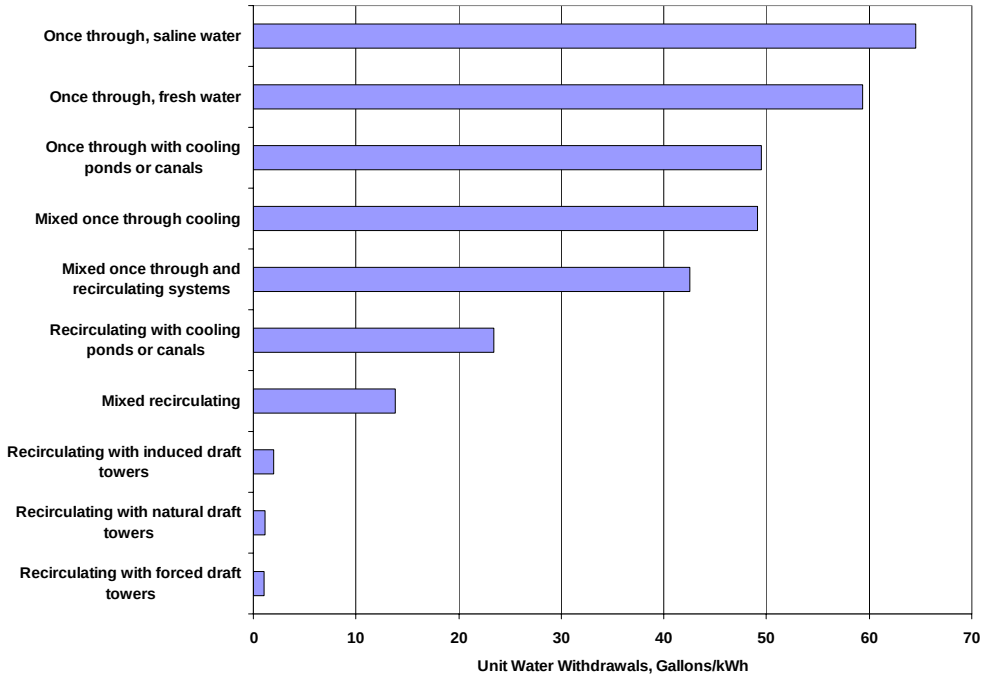

Figure ES-1. Average Rates of Unit Water Withdrawals in Different Types of Cooling Systems in Fossil-Fuel Plants

Table ES-1. Benchmarks of Weighted-average Use Rates of Cooling Water

Description	Withdrawals per unit (gallons/kWh)	Consumptive use (gallons/kWh)	Percent consumptive use (%)
Fossil fuel plants:			
Once-through systems	44.0	0.2	0.5
Recirculating systems with ponds	24.0	0.7	3.0
Closed-loop w/ cooling towers	1.0	0.7	70.0
Nuclear plants:			
Once-through systems	48.0	0.4	0.7
Recirculating systems with ponds	13.0	0.5	4.0
Closed-loop w/ cooling towers	2.6	0.8	30.0

Regressions of Water Use on Explanatory Variables

Ordinary least-squares regression procedures were used to identify the relationship between water withdrawals and various plant and cooling system characteristics. The resulting regression models demonstrated that unit water withdrawals are primarily a function of the operational efficiency (i.e., percent of capacity utilization), maximum temperature rise at the condenser, and, to a lesser extent, the age of the cooling system and thermal efficiency of the generators. The observed rates of water withdrawals were also found to depend on the type of water source and the type of fuel.

The estimated regression equations were used to calculate low, average, and high water rates for different types of cooling systems. The average water withdrawals and consumptive use were calculated by substituting the mean values of the continuous explanatory variables into the estimated regression equation (Table ES-2). The lowest value was calculated by combining the 90 percentile values for variables with negative coefficients and 10 percentile values for variables with positive coefficients. The reversed 10 and 90 percentile values were used to calculate the maximum value. Also, because some regression equations included binary indicator variables, the values in Table ES-2 apply to systems with only some water sources and fuel types as indicated in the footnotes under the table.

Table ES-2. Regression-based Benchmarks of Average Water Withdrawal Rates

Description	Minimum (gallons/kWh)	Average (gallons/kWh)	Maximum (gallons/kWh)
WATER WITHDRAWALS			
Fossil fuel plants:			
Once-through systems[a]	--	78	181
Recirculating systems with ponds[b]	19	53	91
Closed-loop w/ cooling towers[c]	0.4	1.2	2.4
Nuclear plants:			
Once-through systems	30	49	56
Recirculating systems with ponds[d]	--	0.8	2.2
Closed-loop w/ cooling towers[e]	0.9	1.5	2.3
CONSUMPTIVE USE			
Fossil fuel plants			
Once-through systems[f]	1.7	3.1	4.1
Closed-loop w/ cooling towers[g]	0.5	0.9	1.5

[a] Other than public water delivery or mixed water sources; [b] Other than recirculating systems w/ponds; [c] Other than mixed fuels with coal, petroleum as fuel, fresh groundwater source, or saline surface water source; [d] Other than surface freshwater source; [e] Other than saline surface water supply or induced air-flow tower; [f] Other than once-through freshwater systems or petroleum as fuel; [g] Other than mixed fuel w/ coal, or fresh groundwater source

The regression-based benchmarks for average water use in Table ES-2 differ from the weighted estimates in Table ES-1 (and are generally higher) because no weights were applied during the regression procedure, and because of the added regression effects of the fuel types

and water supply source. However, the estimates are generally consistent across the different types of cooling systems.

Technical Efficiency Estimates

The stochastic production frontier analysis of the data demonstrated that the estimated technical efficiencies of cooling system water use vary significantly, and are lower (on average) in fossil fuel plants than in nuclear power plants (Table ES-3).

Table ES-3. Technical Efficiency Estimates for Cooling Systems Based on Stochastic Production Frontier

Description	Minimum (%)	Average (%)	Maximum (%)
Fossil fuel plants:			
Once-through systems	22.5	52.9	91.6
Closed-loop w/ cooling towers	40.0	67.2	93.0
Nuclear plants:			
Once-through systems	44.0	69.6	100.0
Closed-loop w/ cooling towers	55.8	80.8	100.0

The mean technical efficiency in once-through systems is 52.9 percent for fossil-fuel plants and 69.6 percent for nuclear plants. Closed-loop systems with cooling towers were estimated to have mean efficiencies of 67.2 and 80.8 percent, respectively. This result suggests that nuclear plants tend to use cooling water more efficiently than fossil-fuel plants. Nevertheless, there is still a 20 to 30 percent theoretical potential for reducing water withdrawals at nuclear plants, and a 30 to 50 percent potential for reductions at fossil-fuel plants.

Recommendations

The results of this study indicate that the reported average rates of water withdrawals and consumptive use in thermoelectric power plants exhibit very high variability within the same cooling system type at different power generation facilities. While a part of this variability can be explained in terms of the system design parameters and operational conditions, a significant portion of the variability cannot be explained and can be attributed to inefficiency of using cooling water. The results of the stochastic frontier analysis conducted in this study indicate that water intake by thermoelectric power plants could be reduced on average between 20 and 50 percent depending on the type of plant and cooling system.

Further development and refinement of water-use benchmarks should be undertaken to facilitate the improvement of water-use efficiency in thermoelectric generation. Further studies should include the collection of data from a sample of “best performing” plants, which could be identified using the analysis presented in this study. The benchmark practices

at these facilities could serve as standards in the design and operation of wet cooling systems, and guide the process of gradual elimination of inefficient use of water in thermoelectric power generation.

The Flow Dimension of Groundwater Resources in Northeastern Illinois

Basic Information

Title:	The Flow Dimension of Groundwater Resources in Northeastern Illinois
Project Number:	2005IL62B
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End Date:	8/31/2007
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Congressional District:	15
Research Category:	Ground-water Flow and Transport
Focus Category:	Groundwater, Water Supply, Methods
Descriptors:	
Principal Investigators:	Douglas D. Walker, Albert Joseph Valocchi

Publication

1. Walker, D. D., and R. M. Roberts, 2007. Reply to Comment by Chia-Shyun Chen and I. Y. Liu on Flow dimensions corresponding to hydrogeologic conditions, Water Resources Research, vol. 43, no. 2, W02602, doi:10.1029/2006WR005781.
2. Walker, D. D., P. A. Cello, A. J. Valocchi, and B. Loftis, 2006. Flow dimensions corresponding to stochastic models of heterogeneous aquifers, Geophys. Research Letters. vol. 33(4), L07407, doi: 10.1029/2006GL025695.
3. Walker, D. D., P. A. Cello, A. J. Valocchi, and B. Loftis, 2006. High-Throughput Computing for the Analysis of Tracer Tests in Fractured Aquifers, Illinois State Water Survey Contract Report 2006-4, Champaign, IL.
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6. Cello, P. A., D. D. Walker, A. J. Valocchi, and B. Loftis, 2005. The behavior of tracer tests in aquifers with noninteger flow dimensions, AGU Fall Meeting, San Francisco, Dec, 2005.

Illinois Water Resources Center
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Project Title/PIs:
The flow dimension of groundwater resources in northeastern Illinois / Douglas D. Walker, Albert J. Valocchi

Research Category:
Aquifer characterization and modeling

Problem and Research Objectives:
Characterizing groundwater flow and contaminant transport in fractured rock aquifers is complicated by their highly heterogeneous nature, translating into uncertainties in managing groundwater resources. An alternative approach to interpreting aquifer tests is the Generalized Radial Flow (GRF) approach, which infers the geometry of groundwater flow via an additional parameter, the flow dimension, which describes the effective flow area and how it changes with the radius of investigation. This research will elucidate the relationship between aquifer heterogeneity and the flow dimension, with the specific focus on the characteristics of fractured dolomite aquifers that are part of the groundwater resources in northeastern Illinois.

Methodology:
The principle tasks of this research are:
1. Reinterpret existing aquifer test data from ISWS archives to infer the range of flow dimensions observed for fractured dolomite aquifers in northeastern Illinois. This task will use nSIGHTS, an advanced software package created by Sandia National Laboratories for the analysis of hydraulic tests.
2. Enhance the Monte Carlo simulation to include additional statistical analyses and thus help define the relationships between the flow dimension and aquifer parameters. Determining the flow dimensions for complex models of aquifer heterogeneity requires a Monte Carlo analysis of numerical models. In collaboration with and funded in part by NCSA, the ISWS has adapted public domain programs for geostatistical simulation (GSLIB) and transient groundwater flow (MODFLOW2000) to estimate the expected value and variability of the flow dimension for an aquifer test in candidate models of heterogeneity. The computational burden of this analysis is managed through the use of the NCSA TeraGrid set of distributed computing resources.
3. Manually calibrate the parameters of candidate models until the results of the Monte Carlo simulation reproduce the observed flow dimensions.

Note: A six-month, no-cost extension of this project was approved on February 15, 2007. This changes the completion date to August 31, 2007.

Principle Findings and Significance:
During the second year of this two-year project, we have used nSIGHTS to determine the flow dimensions for 10 aquifer tests from the ISWS archives (Task 1). We have

continued using the Monte Carlo simulator to determine the flow dimensions of candidate models of aquifer heterogeneity (Task 2). The results this year indicate the following:

1. Aquifer tests in fractured dolomites have apparent flow dimensions ranging from 1.44 to 2.05 with an average of 1.7.
2. Several commonly used models of aquifer heterogeneity do not produce the flow dimensions observed in aquifer tests of fractured dolomite aquifers, even over a wide range of parameters for those models.
3. Site percolation networks can produce the flow dimensions of fractured dolomites, at least temporarily.
4. Fracture networks (Boolean models) also appear to be able to produce the flow dimensions of fractured dolomites. Ongoing work is helping to establish how the parameters of this model are related to the flow dimension.

The finding that the flow dimension appears to be associated with network models is significant because these networks have fractal characteristics, and as such, would have dramatically different contaminant transport than is found in the more traditional models of aquifer heterogeneity.

Related and seed projects:

Dr. Walker's participation in this project is funded by the Illinois State Water Survey. The computations for this research were performed on the TeraGrid resources hosted by the National Center for Supercomputing Applications, the San Diego Supercomputing Center, Argonne National Laboratories, and Purdue University. Sandia National Laboratories has provided access to nSIGHTS, a proprietary software package for the interpretation of hydraulic tests.

Related research efforts include:

NCSA Faculty Fellowship, 2003-2004 ($16,000)
Sandia National Laboratories research contract PO 24699 ($18,504).
NSF/NCSA Medium Resource Allocations Grant EAR050016, approved 9/22/05.
NSF/NCSA Medium Resource Allocations Grant (submitted).

Occurrence and Ecological Effects of Pharmaceutical Chemicals in Chicago Metropolitan Area Streams

Basic Information

Title:	Occurrence and Ecological Effects of Pharmaceutical Chemicals in Chicago Metropolitan Area Streams
Project Number:	2005IL63B
Start Date:	3/1/2005
End Date:	2/28/2007
Funding Source:	104B
Congressional District:	9
Research Category:	Water Quality
Focus Category:	Water Quality, Toxic Substances, Ecology
Descriptors:	
Principal Investigators:	Emma J. Rosi-Marshall, Emma J. Rosi-Marshall

Publication

Occurrence and effects of pharmaceutical chemicals in Chicago metropolitan area streams

Primary Investigator: Dr. Emma Rosi-Marshall

Problem and Research Objectives

Since the 1970's, aquatic ecologists and toxicologists have become increasingly concerned with the presence of human associated contaminants in the environment. In recent years, the occurrence and effects of pharmaceuticals and personal care products (PPCP's) in our rivers and lakes have received increased attention (Kolpin et al. 2002). Significant amounts of PPCP's such as hormones, antibiotics, caffeine and antacids persist after their intended use and enter wastewater treatment facilities. Treatment facilities are not designed to remove these chemicals so they are discharged into our nation's rivers. Currently the presence of PPCP's has been detected (Kolpin et al. 2002); however, the ecological effects of these novel contaminants in surface waters have not been measured.

Metropolitan areas affect the aquatic ecosystems draining them in numerous ways, including altered hydrology, increased nutrient loading and increased exposure to contaminants such as pesticides, trace metals and organic contaminants (Paul and Meyer 2002). Recently pharmaceutical chemicals have been detected in surface waters receiving wastewater treatment (WWT) effluent in highly urbanized watersheds (Kolpin et al. 2002, Gross et al. 2004, and others). The US Geological Survey conducted a nationwide survey of surface waters and detected numerous PPCP's in Illinois streams (including hormones, caffeine, and painkillers) (Barnes et al. 2002). Given the large amounts of permitted wastewater discharged into streams draining the Chicago area, the prevalence and ecological significance of PPCP's in these streams may be high.

The goals of this project were to measure the concentration of pharmaceutical compounds in the Chicago area and measure the effects of PPCP's on four major components of stream ecosystems (algae, detritus, grazers and shredders). Per advice from reviewers, we focused our attention on measuring the effects of PCPPs in a laboratory setting, rather than measuring concentrations extensively in the field.

Our first major task was to narrow down the list PCPPs present in surface waters to a few that might affect aquatic taxa. A group of commonly used PPCP's are H_2 histamine receptor antagonists. Histamine is a neuroactive amine found in the nervous systems of animals from diverse phyla (Hashemzadeh-Gargari and Freschi 1992). In humans, H_2 histamine antagonists are commonly used for the treatment of acid related gastrointestinal conditions. The H_2 antagonist reduces acid stimulation by competitively binding to parietal cells in the stomach. Since the introduction of the first H_2 antagonist in 1967 the effects of H_2 antagonists on mammals has been well documented. Cimetidine HCl (Tagamet®) continues to be one of the most commonly used H_2 antagonists today. Consequently, an estimated maximum concentration of cimetidine found in 84 samples from U.S. streams was 0.58µg/L (Kolpin et al. 2002). Although invertebrate histamine receptors have not been widely studied, research has shown histamine to be a regulator of invertebrate functions. Histamine stimulates pyloric rhythm and gastric mill rhythm in the stomatogastric nervous system of the crab (*Cancer borealis*) and these actions were blocked by doses of cimetidine (Christie et al. 2004). This research has provided valuable knowledge into the neurological effects of cimetidine on invertebrates. Research on the ecotoxicological effects of Cimetidine was one of the major accomplishments of this grant.

In addition to Cimetidine, we have also been examining the effects of the generalized anti-microbial agent, triclosan, a popular antimicrobial and antifungal agent found in consumer products ranging from dish soap to toothpaste to makeup. Triclosan is classified as a specific biocide; it functions by a physical-chemical mechanism that targets a specific biochemical pathway in bacterial and fungal cells. Triclosan was found to have a concentration of 0.14 ug L^{-1} in a recent US Geological Survey (Kolpin et al 1999). Triclosan targets the fabI protein Enoyl-acyl protein reductase, blocking the synthesis of lipids in cells (McMurry 1999). As lipid synthesis is critical for the integrity of the cell membrane and for cell replication, Triclosan ultimately causes lysis of cells (McMurry 1999). We have examined the effects of triclosan on microbial function and have established that sediments below waste water treatment plants contain triclosan resistant bacteria. We are continuing to investigate this in our laboratory using internal funds.

The third compound we have been exploring are the effects of caffeine. Caffeine is a very common PPCP and was found in 70% of water samples (0.1µg/l median concentration) collected in a nationwide survey (Kolpin et al. 2002, Audenkampfe 2006) and has been used as a tracer of human activity and indicator of water quality (Ferreira 2005, Buerge 200). Caffeine occurs in plants where they presumably are natural pesticide and reduce herbivory. Caffeine is a purine alkaloid and as a result affects adenosine receptors on the cell surface and phosphodiesterase inside cells. Caffeine usually acts as an adenosine antagonist, accounting for its stimulating effects. As adenosine is a very common transmitter and secondary messenger, caffeine may affect ecosystem constituents. As caffeine is very common in surface waters, chronic exposure to ecologically relevant doses of caffeine may have integrated consequences on ecosystem functions. An graduate student, Antoine Aubeneau has received internal funding from Loyola University Chicago to conduct this research using methods we developed for our examination of cimetidine, worked funded by this grant.

Methodology

In order to adequately assess exposure concentrations to contaminants in a laboratory experiment, effective analytical chemistry to measure compounds is essential. Using grant funds, we successifully develop high-performance liquid chromatography (HPLC) methods to extract and detect low concentrations of specific pharmaceutical compounds in water samples (cimetidine and caffeine methods are complete and successful). The input of PPCP's is continual via WWT effluent, but it is not known how long these compounds persist in aquatic ecosystems. We are currently employing these analytical techniques to measure the concentrations of compounds in the artificial streams and are analyze Chicago area surface waters for cimetidine to put our laboratory findings in context.

Instantaneous growth and mortality experiments have been performed using the pharmaceutically active compound cimetidine. Chironomids were collected and then exposed to 0.07 µg/L, [x10], [x100], [x1000] and [0]. Organisms were placed in an incubator for 1 week under controlled conditions, and then growth and mortality were analyzed. Microbial communities have been used to measure the effects of Triclosan, another PPCP found in Illinois Rivers. To determine the ecological impact of Triclosan, we incubated leaves (source of microbes) with concentrations of 0.14 µg/L, [x10], [x100], [x1000] and [0]. Microbes were incubated in LB agar with the same concentrations.

The artificial stream facility (48 recirculating streams of 4 meter length) has been an invaluable match from Loyola University Chicago in this research. Each stream contained unglazed clay tiles to measure algal growth, leaf packs to measure decomposition, and three species of aquatic invertebrates. The streams were used to look at the effects of cimetidine on

stream ecosystems. The results of this experiment will be published in peer a reviewed journals and will be the work of Paul Hoppe who has been conducting this research for his MS thesis. Currently, a similar experiment will be started looking at the effects of caffeine in stream ecosystems using internal funds. The combination of these two experiments will be invaluable for obtaining additional external funds.

We are also conducting fieldwork in the Chicago area, mainly to collect specimens for our laboratory experiments. In addition, we are striving to put our laboratory experiments in context, i.e., to determine if the endpoints we observe in the artificial streams are occurring in the field. The sampling sites focus on proximity to three major waste water treatment facilities in the Chicago area including Stickney, North Side and the Kirie Water Reclamation Plants. 10 established sampling sites have varying degrees of urbanization and inputs of waste water treatment effluent. At these sites, a number of Loyola University Chicago supported undergraduate research projects are being conducted in conjunction with this research.

Principal Findings and Significance

The results of our experimental stream experiment demonstrated that cimetidine did not affect basal resources, such as algae and leaves, but increasing concentrations of cimetidine (at concentrations measured in US surface waters) did have a significant affect on invertebrate growth, mortality and population dynamics. The results of this experiment will be submitted for publication in a peer-reviewed journal by Dec. 2007. These results suggest that continual input of cimetidine and other PPCP's could affect mortality of and growth rates aquatic invertebrates in surface waters.

The triclosan study showed that increasing triclosan concentrations lead to increased variation in microbial respiration. The concentrations of triclosan measured in US surface waters did not affect microbial respiration or microbial growth rates; however, this research is ongoing. As mentioned above we did find significant microbial resistance to triclosan. We are continuing this line of research in collaboration with Dr. John Kelly (a microbial ecologist, Loyola University Chicago) and plan to examine if there is an effect of triclosan on microbial community composition.

In laboratory incubations, we found that caffeine affected *Helicopsyche* growth rates but not *Gammarus* growth. This research is ongoing with additional support provided by Loyola University Chicago.

Related and Seed Projects

A graduate student received funding ($24000 tuition and $32000 stipend) from Loyola University Chicago Biology Department to continue working on this project. Undergraduates received funding ($10,500) from the Mulchahy Scholarship program and ($6000) from Loyola University Chicago Center for Urban Environmental Research and Policy (CUERP). An undergraduate received funding ($4000) from CUERP, work-study from Loyola University Chicago ($4000) and a Mulchahey Scholarship ($2000) to conduct research that contributes to this project. Although funds from this grant are exhausted, we continue to conduct research in this area. We have 2 undergraduates, one graduate, student and a high school student continuing to work on the effects of pharmaceuticals in streams, using internal funds.

Evaluating Alternatives for Watershed-Scale Design of BMPs

Basic Information

Title:	Evaluating Alternatives for Watershed-Scale Design of BMPs
Project Number:	2006IL134G
Start Date:	8/16/2006
End Date:	8/15/2008
Funding Source:	104G
Congressional District:	12th District, IL
Research Category:	Engineering
Focus Category:	Management and Planning, Hydrology, Models
Descriptors:	
Principal Investigators:	John William Nicklow

Publication

1. Kaini, P., K. Artita, J. Nicklow, 2007, Evaluating optimal detention pond locations at a watershed scale, in Proceedings of the 2007 World Environmental and Water Resources Congress, American Society of Civil Engineers, Reston, VA, CD-ROM.

National Institutes of Water Resources/
Illinois Water Resources Center
Annual Report

1. **Project Number:** 2006IL134G

2. **Project Title and PIs:** Evaluating Alternatives for Watershed-Scale Design of BMPs; Dr. John W. Nicklow, P.E., P.H., D.WRE, Professor, Department of Civil and Environmental Engineering, Southern Illinois University at Carbondale (SIUC)

3. **Research Category:** Best Management Practices, Decision Support Modeling

4. **Problem and Research Objectives:** In recent years, stormwater runoff has received significant attention in the U.S. due to an improved understanding and increased public awareness of it potential impacts. One of the most significant outcomes of this attention has been an increased emphasis on the application of Best Management Practices (BMPs) as runoff controls. Too often, however, the overall layout of BMPs throughout a watershed is a patchwork of individually-designed structures and devices. Recent literature suggests that such fragmented layouts may actually worsen storm water impacts in a watershed, thus negating the intended purpose of runoff controls. Detention-based systems and other structural BMPs are instead most cost-effective when designed and implemented in regionally-strategic combinations to meet related stormwater treatment goals. This concept is consistent with recent emphasis on comprehensive, holistic watershed-scale management, an idea strongly promoted by the U.S. EPA since the early 1990s. Unfortunately, there exists neither a methodology, nor a generalizable model, for selecting, placing, and sizing BMP combinations that cost-effectively achieve treatment goals at the larger spatial scale of an entire watershed.

   The objectives of this research include development of a new, publicly-available decision-support framework and corresponding software model that bridges the gap between individual BMP design and the implementation of watershed-scale runoff controls. This decision-making framework and corresponding computational model will assist in determination of the most cost-effective combination, including types, sizes, and locations, of BMPs and a set of near-optimal alternatives for the control of storm water impacts. The benefit of such an approach is straightforward: implementation of the optimal design or near-optimal alternatives will likely result in a more effective reduction of stormwater impacts at lower stakeholder cost. Although the decision-support model is designed to be transferable to other basins, it is being developed and tested using a portion of the Lower Kaskaskia watershed in southwestern Illinois. Eastward expansion of the city of St. Louis and the Metro East region will require construction of structural BMPs, especially detention and retention ponds, to limit adverse affects of this future growth. To promote the realization of benefits of watershed-scale design in professional practice, the methodology and application results will be disseminated to federal and state agency personnel, concerned local stakeholders, and the wider water resources community through

regional meetings and workshops, an outreach bulletin, nationally-organized conferences, and peer-reviewed journals.

5. **Methodology:** A decision support model has been created by linking an evolutionary optimization algorithm (genetic algorithm) with the U.S. Department of Agriculture's Soil and Water Assessment Tool (SWAT) for comprehensive hydrologic simulation. The initial model is currently undergoing testing, evaluation, and refinement to improve predictive capacity and computational performance. The resulting modeling framework is capable of determining watershed-scale detention pond design parameters that:

   Minimize → total cost of detention facilities
   Subject to → (i) governing physical laws of watershed hydrology and water quality, (ii) maximum allowable peak flow rates, maximum detention pond sizes)

   Constraints on water quality/quantity (e.g., maximum nutrient concentrations) will be added in the coming months. Furthermore, additional BMPs (e.g., swales, filter strips, and wetlands) will be added to the decision support framework.

   Within the new model, SWAT is used to solve constraints that govern watershed hydrology such that the complex interactions between water quantity and quality are fully captured. In addition, SWAT is capable of simulating several standard structural BMPs, including detention ponds, constructed wetlands, filter strips, and swales. Meanwhile, the evolutionary algorithm identifies optimal BMP designs. Two types of evolutionary algorithms, a genetic algorithm (GA) and a species conserving genetic algorithm (SCGA), are being investigated for solution to this problem. The GA solves the problem by finding a single near-optimal solution while the SCGA produces multiple alternative designs that vary minimally in cost from that of the optimum, but are different with respect to design parameters (i.e., BMP type, size, and/or location) and unmodeled objectives (e.g., stakeholder preferences). Originally, another evolutionary algorithm known as the artificial life algorithm was to be used for alternatives generation; however, the SCGA was found to be less computationally demanding and better suited for the distributed nature of the problem.

   To meet outreach objectives, an educational brochure aimed at local stakeholders was assembled to introduce and explain important concepts in watershed-scale BMP design such as "What is a watershed?", "What is a BMP?", and "Why is watershed-scale design important?" Currently, these brochures are in final printing and awaiting distribution. Additional outreach will involve demonstration and visualization of the decision-support model on the entire Lower Kaskaskia basin and a roundtable discussion on future model improvements with local stakeholders that include the Southwest Illinois Resource Conservation and Development Council (SWILRC&D), National Resource Conservation Service, Illinois Dept. of Agriculture,

Illinois Dept. of Natural Resources, U.S. Fish and Wildlife Service, Farm Bureau, Soil and Water Conservation Districts, county board members, and others.

6. Principal Findings to Date and Significance:

- Collection and review of pertinent scientific literature demonstrates increasing emphasis on watershed-scale design of BMPs;
- A digital elevation model and related thematic GIS data for the Lower Kaskaskia basin have been collected and evaluated;
- Development and testing of a GA, artificial life algorithm, and SCGA software modules for various benchmark test problems demonstrated the strength and flexibility of these algorithms and have revealed that the GA and SCGA are appropriate for integration into the decision support model;
- The SWAT source code was modified to facilitate a seemless link to the optimization algorithms and the SWAT-GA interface was created;
- Initial testing and application of the SWAT-GA model on Silver Creek basin demonstrates a capability to identify least-cost detention pond design;
- The educational outreach brochure has been created for stakeholders and decision-makers in the Lower Kaskaskia basin;
- Positive feedback received at a recent peer-reviewed national conference (see Section 8) has reaffirmed the importance of the current problem and the approach being applied.

Information Transfer Program

A key function of the Illinois Water Resources Center is to oversee a research program and convey the results of research and development within the water resources field to water professionals and the interested public. Information transfer is accomplished through workshops, conferences, published proceedings, a website, and maintenance of a library of Illinois Water Resources Center reports and videotapes. In addition, the IWRC staff sit on many advisory committees and planning groups and provide council to local, state and national officials.

2007 Governor’s Conference on the Illinois River

Basic Information

Title:	2007 Governor’s Conference on the Illinois River
Project Number:	2005IL154B
Start Date:	10/1/2005
End Date:	12/1/2007
Funding Source:	104B
Congressional District:	15th
Research Category:	Not Applicable
Focus Category:	Education, None, None
Descriptors:	conferences, outreach, Illinois River
Principal Investigators:	Lisa Merrifield, Jennifer Fackler

Publication

1. Fackler, Jennifer, 2005, Governor's Conference on the Management of the Illinois River System, Illinois Water Resources Center, Urbana, Illnois.

In 2006, IWRC served as a co-sponsored and planning committee member for the the Governor's Conference on the Illinois River. Staff members will prepare the abstract book in advance of the conference and the proceedings at the conclusion of the conference.

This conference began in 1985 when a group of concerned scientists, citizens and river activists began to focus new attention on the growing problems of sedimentation and erosion along the Illinois River and its tributaries. Over the past twenty years, conference attendance has grown from 150 to over 350 participants who represent a diversity of backgrounds, agencies, organizations, and communities. The Governor's Conferences on the Management of the Illinois River System have served as an important forum to bring together local, state, and federal leaders to create awareness of the problems of soil erosion and sedimentation, identify important river research initiatives, develop working coalitions, apply conservation practices to the watershed, prepare new river and watershed legislation, and provide for state and federal funding to address the problems of the Illinois River system. The foundations for the following programs can be directly attributed to successful interagency and multi-disciplinary cooperation, fostered at the Governor's Conference on the Illinois River System and subsequently implemented at the local, state and federal level.

The 2005 conference was attended and opened by the Illinois Lieutenant Governor and include a meeting of the state run Illinois River Coordinating Council. Sessions include updates from federal and state leaders, volunteer stewardship, wetland restoration, watershed planning, tourism, monitoring, sediment removal, technology, economic development, and more. A pre-workshop conservation tour took participants along the Illinois River from Peoria to Hannepin, Illinois. Tour participants explored the features of the Illinois River Valley, including recreational resources, historical cultural resources, backwater wetland restoration and aspects of a working waterway. The 2007 conference, to be held in October, will be similarly formatted.

Illinois Water 2006 Conference

Basic Information

Title:	Illinois Water 2006 Conference
Project Number:	2005IL155B
Start Date:	10/1/2005
End Date:	11/1/2006
Funding Source:	104B
Congressional District:	15th
Research Category:	Not Applicable
Focus Category:	Education, None, None
Descriptors:	conference, education, outreach, Illinois water
Principal Investigators:	Lisa Merrifield, Jennifer Fackler, Stephanie Lage, Phil Mankin, Richard Warner

Publication

1. Fackler, Jennifer, 2006, Illinois Water Conference 2006 Proceedings, Illinois Water Resources Center, Urbana, Illiois.

Beginning in 1998, the Illinois Water Resources Center has hosted the biennial Illinois Water conference. Drawing approximately 200 people, the conference focuses on Illinois water resource issues, scientific discoveries, social and cultural realities and outreach and education. The conference targets researchers, government officials, concerned citizens and students over two days of panel discussions, technical sessions and poster presentations.

This year's conference was held in October. "Preparing for the Future" was the conference theme and all sessions would look towards how we should apply the state of the science and practice to meet future demands. The keynote speaker was given by Charles Howe. Howe, Ph.D., Stanford University, is a retired professor of economics at the University of Colorado - Bolder. He was the Chair for the National Research Council Committee on Privatization of Urban Water Services for three years and President for the Association of Environmental and Resource Economists for two years. He received the Warren A. Hall Medal of the Universities' Council on Water Resources for Distinguished Contributions to the Field of Water Resources in 2003 and Friends of UCOWR Award in 2000 along with many other awards. He spoke on the state of global water resources.

Themed sessions included:
- Water supply and planning
- Emerging issues in human health and aquatic ecosystems
- Challenges facing Lake Michigan water management
- Data needs for water planning

Papers were invited for technical and poster sessions. A student career panel also gave students a glimpse of what water professionals really do. Student paper and poster presenters will compete for awards as well.

IWRC Web Site

Basic Information

Title:	IWRC Web Site
Project Number:	2005IL156B
Start Date:	1/1/2005
End Date:	1/1/2011
Funding Source:	104B
Congressional District:	15th
Research Category:	Not Applicable
Focus Category:	Education, None, None
Descriptors:	web site, outreach, education
Principal Investigators:	Jennifer Fackler, Lisa Merrifield

Publication

1. Fackler, Jennifer, ed., 2006, Illinois Water Resources Center Web Site, www.environ.uiuc.edu/iwrc.

IWRC maintains a web site with news, publications, requests for proposals and other information of interest to the water resources community in Illinois

Menu items on the site include:
Center information – this section describes our operational and funding structure, staff, and other details about IWRC.

News and Announcements – in this section we list upcoming events, news headlines of interested to water professionals, and other time sensitive information.

Call for Proposals – we provide information about state and national funding on this page.

Publication – IWRC has over 200 research publications and almost 40 special publications available. We are currently working to make our publications available electronically to make access even easier.

Research – current, past and future research projects are briefly described here.

Conferences -- this page contains details about our biennial Illinois Water conference.

Kids – we provide links to various water-related resources for kids in Illinois.

Contact Us -- quick contact information, including our physical address, phone numbers and email addresses.
Links – these are links to water-related sites that might be useful to water resource professionals in Illinois.

IWRC Newsletter

Basic Information

Title:	IWRC Newsletter
Project Number:	2005IL157B
Start Date:	1/1/2005
End Date:	1/1/2011
Funding Source:	104B
Congressional District:	15th
Research Category:	Not Applicable
Focus Category:	Education, None, None
Descriptors:	newsletter, education, outreach
Principal Investigators:	Lisa Merrifield, Jennifer Fackler, Phil Mankin, Irene Miles

Publication

1. Miles, Irene, Jennifer Fackler, Lisa Merrifield, eds., Fall 2005, Illinois Water Resources Center Newsletter.
2. Illinois Water Resources Center, 2006, Illinois Water Resources Center Newsletter, Illinois Water Resources Center, Urbana, Illinois, 4 pages.

Each fall, IWRC produces a newsletter detailing our activities over the past year. We focus on research findings and funding, upcoming events, and other items of interest to water professionals in Illinois. Articles in the 2006 issue included:

- IWRC's 40th birthday
- Call for research proposals
- The Illinois Water Conference
- The web site redesign

The newsletter is sent to approximately 700 people around the state. Recipients include state and local government officials, concerned citizens, business and industry representatives, academics, students, and non-governmental organizations. State and national legislators also receive a copy of the news letter.

Midwest Technology Assistance Center

Basic Information

Title:	Midwest Technology Assistance Center
Project Number:	2005IL158B
Start Date:	1/1/2005
End Date:	1/1/2011
Funding Source:	104B
Congressional District:	15th
Research Category:	Water Quality
Focus Category:	Water Supply, Water Quantity, Water Quality
Descriptors:	small water systems, Midwest
Principal Investigators:	Richard Warner, Jennifer Fackler, Phil Mankin, Lisa Merrifield

Publication

1. Lau, Boris L. T., Gregory W. Harrington, Marc. A. Anderson, 2006, Arsenic and Bacteriophage MS2 Removal from Groundwater by Nanoparticulate Aluminum Oxide Coated Granular Filter Media: A Pilot-Scale Evaluation on the Effect of pH and Coating Density, Illinois State Water Survey, (FS06-01).
2. Moore, Michelle, 2006, Chlorine's Effect on Corrosion in Drinking Water Systems, Illinois State Water Survey, NDWC, Tech Brief #3, Item # DWBRPE52.
3. Winstanley, Derek, James R. Angel, Timothy P. Bryant, H. Vernon Knapp, Michael A. Palecki, Amy M. Russell, H. Allen Wehrmann, 2006, Drought Planning for Small Community Water Systems, Illinois State Water Survey,(FS06-02).

IWRC helps support the Midwest Technology Assistance Center for Small Public Water Systems (MTAC). MTAC cooperates closely with other regional technology assistance centers established by the USEPA, and with other partner agencies and organizations in order to ensure efficient response to the highest priority needs of small public water systems and Indian Tribal systems in the Midwest.

Recently, MTAC conducted a number of trainings and workshops. Among them was a workshop on using sensor technology to monitor small water systems quality and quantity. Approximately 20 people from the senor technology and Technical Assistance
Center communities attended the two day event and contributed to an interactive web site.
Over the last year, MTAC staff members have written fact sheets based on the findings of funded research. Fact sheets include:

- Arsenic and Bacteriophage MS2 Removal from Groundwater by Nanoparticulate Aluminum Oxide Coated Granular Filter Media: A Pilot-Scale Evaluation on the Effect of pH and Coating Density (FS06-01)
- Chlorine's Effect on Corrosion in Drinking Water Systems Drought Planning for Small Community Water Systems (FS06-02)

Outreach Projects conducted by MTAC include:

- Testing of Vulnerability Assessments & Emergency Response Plans, ERTC SIU Edwardsville
- Cross-Connection Control for Small System Administrators, ERTC SIU Edwardsville
- Groundwater Resource Assessment for Small Communities, ISWS
- Non-Community Water System Compliance to the New Arsenic Rule, ISWS

Competitive Grants and Applied Research conducted in 2005 included:

- Watershed Modeling to Evaluate Water Quality at Intakes of Small Drinking Water Systems, ISWS/U of I
- Technical, Managerial, and Financial Capacity Measures in an Assistance-Oriented Approach to Comparative Performance of Small
- Drinking Water Utilities, Ohio State University National Regulatory Research Institute
- Development of Low-Cost Treatment Options for Arsenic Removal in Water Treatment Facilities, ISWS/U of I
- Chemical Addition for Arsenic Removal, ISWS/U of I
- Microcosm Experiments for Arsenic Solubility Determination, ISWS/U of I
- Time Series Sampling and Resampling Facilities with High Particulate
- Arsenic to Evaluate the Variability of Arsenic Concentration Small Community Water Supplies, ISWS/U of I
- Assessment of the Needs, Requirements, and Available Tools for Drought Planning for Small Public Water Systems in Midwest, ISWS/U of I
- Continuing Education to Support Smaller Water Systems Assessment, U of I
- Improved Monitoring for Safe and Secure Water Supplies: An Integrated
- Approach to Emerging Monitoring Technologies, U of I

- Building Technical, Financial, and Managerial Capacity for Small Water Systems: Consolidation, Partnership, and other Organizational Innovations, U of I

Student Support

Student Support					
Category	**Section 104 Base Grant**	**Section 104 NCGP Award**	**NIWR-USGS Internship**	**Supplemental Awards**	**Total**
Undergraduate	2	4	0	0	6
Masters	2	0	0	0	2
Ph.D.	1	8	0	0	9
Post-Doc.	0	0	0	0	0
Total	5	12	0	0	17

Notable Awards and Achievements

From a research perspective, two projects completed this year achieved notable successes. Emma Rosi-Marshall, Loyola University, worked identifying pharmaceuticals in waterways. From her IWRC research, she and her colleagues are developing new and improved methods for using artificial streams to measure the effects of novel contaminants on stream ecosystems. These methods allow experimental manipulation of contaminant concentrations while using replication to analyze ecosystem effects. The researchers are bridging a gap between toxicology and ecology by responses in ecosystem function to novel contaminants. Emma Rosi-Marshall, in collaboration with 3 additional PIs (at Loyola University Chicago, Southern Illinois University, and Indiana University) will submit a grant proposal to National Science Foundation in Jan 2008. The data collected during their IWRC funding will be invaluable to this proposal. In addition to undergraduates working on this project, Emma Rosi-Marshall mentored a High School student, Amatul Salma (funded by the Army, $1600) to participate in this research. Amatul conducted research on the effects of cimetidine on algae and individual Gammarus growth rates and submitted her work for the area science fair. Amatul advanced to the International Science Fair and won 4th place in the Environmental Science Division.

Ben Dziegielewski, Southern Illinois University, completed a study using benchmarks to evaluate thermoelectric power generation. His findings indicate that improved water use efficiencies at power generation facilities are likely to require significant managerial and financial investments. The findings from this study suggest that reductions in power plant water use are always beneficial to the extent that reductions in the power generated to provide water pumping then become available to sell to customers. However, while this benefit is often considered to be marginal, there clearly appear to be other situations where reduced water usage can provide significant benefits. For example, generating facilities located on shared reservoirs or aquifers may be able to free-up water resources for economically important domestic or irrigation uses, or facilities using surface water sources may be able to significantly reduce the impacts of thermal pollution on aquatic resources. Research that can identify those situations that result in the most beneficial reductions of power plant water uses can focus water use efficiency studies on the categories of generating facilities that are most like to welcome improvements in water use efficiency.

From the technology transfer perspective, IWRC's Illinois Water 2006 conference was our most notable event. Approximately 200 people from academia, government, industry and NGOs attended the two day event.

Publications from Prior Projects