Kentucky Water Resources Annual Symposium

March 26, 2007

Marriott's Griffin Gate Resort
Lexington, Kentucky

UK
UNIVERSITY OF KENTUCKY
Kentucky Water Resources Research Institute

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Kentucky Water Resources Research Institute
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DETECTING MULTIPLE SOURCE ORIGINS FROM FECAL BACTERIA ANTIBIOTIC RESISTANCE PATTERNS

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Fecal bacteria in surface waters are one of the most commonly cited impairments to water quality. These impairments are generally attributed to malfunctioning septic systems, wildlife defecation in water, and land-applied wastes. Given the nature of contaminants, this study was initiated to evaluate microbial source tracking (MST) as a management tool to differentiate nonpoint source pollution into source groups.

Microbial source tracking (MST) techniques offer unique methods for differentiating nonpoint source pollution. By tracking a pollution source to its origin, resources and management tools may be better allocated to improve water quality. Many of these techniques require a database or 'library' for identifying the host origin; however, appropriate database size, portability, and temporal characteristics to yield adequate power of prediction given the diversity of patterns in a watershed are as yet undetermined. Use of phenotype-based MST methods, such as antibiotic resistance analysis (ARA), has shown great potential for characterizing nonpoint source pollution. Simpson et al. (2002) reported on the practicality of using the ARA technique for small watersheds due to its relative simplicity and expense; however, there is no consensus on the optimum database size for representativeness of a given area, nor is there a consensus on whether using either *Escherichia coli* or *fecal streptococci* as indicator bacteria is preferred. Merely increasing database size does not necessarily correspond to an increase in rates of correct classification (RCC). There are more complex factors involved such as genetic diversity of the bacteria (i.e., clonal nature), geographical area, antibiotic array, source character, and temporal characteristics.

Given the labor-intensive and time-consuming nature of database building, the characteristics of a useful database are critical in the future applicability of MST methodologies. An existing database originally containing poultry, human, and wildlife sources of *E. coli* (EC) and fecal streptococci (FS) was enlarged by three additional host groups - horse, dairy cattle, and beef cattle - to better represent the central Kentucky area. Sample material was collected from manure, soil, sod, water, and sediment. The samples were enumerated for FC and FS and representative EC and FS isolates were selected. Antibiotic resistance analysis (ARA) was conducted on these isolates using a profile of seven antibiotics: ampicillin (10 µg), cephalothin (30 µg), erythromycin (15 µg), rifampin (5 µg), streptomycin (10 µg), tetracycline (30 µg), and trimethoprim (5 µg).

The rates and average rate of correct classification (RCC and ARCC, respectively) of the database were all below a 60% threshold criterion when analyzed at the species-level (Fig. 1). The domestic animal source RCC was 63% for EC and 69% for FS and the ARCC was 57% for EC and 65% for FS with the human and wildlife groups below the threshold when analyzed at the management-level (Fig. 2). All groups were above the threshold level when analyzed at the human/nonhuman-level of classification (Fig. 3). The RCC for human source groups was 66% for EC and 75% for FS. The RCC for nonhuman source groups was 67% for EC and 70% for FS. The ARCC of the database was 67% for EC and 74% for FS.

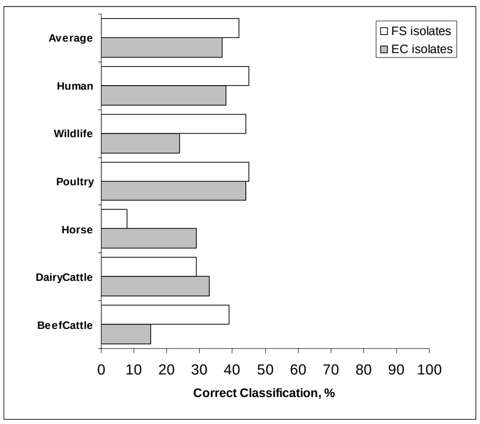

Figure 1. Species-level classification (six-way split) of *Escherichia coli* (EC) and fecal streptococci (FS) known source databases based on rates of correct classification using resubstitution.

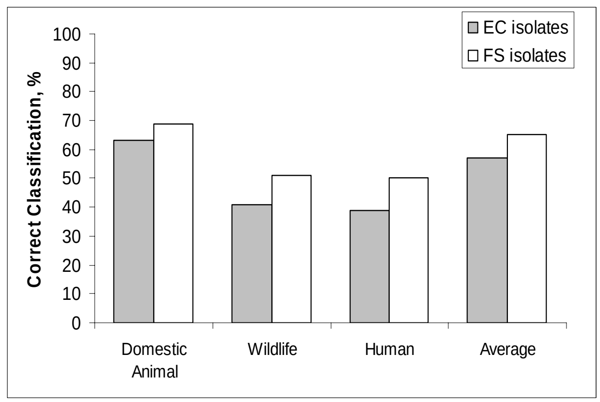

Figure 2. Management-level classification (three-way split) of *Escherichia coli* (EC) and fecal streptococci (FS) known source databases based on rates of correct classification.

The database used in this study was sufficiently useful, despite its small size, to be a resource management tool to delineate human verses nonhuman sources of nonpoint pollution regardless of indicator bacteria used, i.e. EC or FS. The application of MST techniques as resource management tools may be optimally applied when used for confined geographical regions. This could particularly hold true when the various inputs of fecal contamination are expected to be relatively continuous.

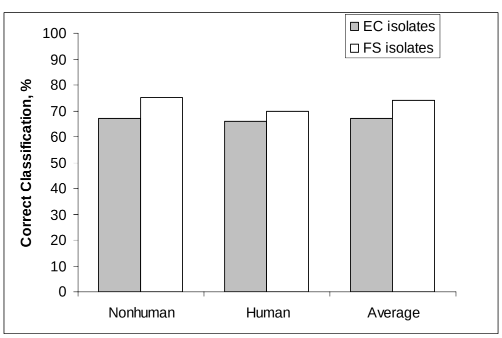

Figure 3. Human/nonhuman-level classification (two-way split) of *Escherichia coli* (EC) and fecal streptococci (FS) known source databases based on rates of correct classification using resubstitution.

References

Simpson, J.M., J.W. Santo Domingo, and D.J. Reasoner. 2002. Microbial source tracking: State of the science. Environ. Sci. Technology 36:5279-5288.

MICROBIAL SOURCE TRACKING: LIMITS AND APPLICATION

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Waterborne disease has long been a public health issue. According to one recent report, more than five million people die each year from water-related disease and the leading cause of child death worldwide is diarrhea. The United States Environmental Protection Agency lists pathogen (or microbial) pollution as the second most common cause of impairment in watersheds throughout the US. In Kentucky, the US EPA's 1998 303(d) list indicates that 20,964 acres of wetland and lake as well as 1,289 miles of stream and river exceed pathogen standards. Thus, controlling microbial (or fecal) pollution is a local issue as well as a national and international one.

To date, methods for remediating microbial pollution have been generally unreliable. Traditionally, the answer has been to monitor concentrations of fecal indicator organisms, like total coliform and E. coli. *However, simply monitoring the organisms doesn't identify the source and the potential for disease outbreak and environmental impact.*

More recently, researches have begun to focus on methods to identify the source of the contamination. Microbial source tracking (MST) techniques enable researchers to identify the dominant source of microbial pollution, especially on smaller scale watersheds. Currently, there are several methods available offering differing degrees of source discrimination and reliability. All source tracking tools operate on the assumptions that the bacteria or viruses of interest are geographical and temporally stable, host specific, and found representatively in water or soil sampling.

Comparative studies reveal that all MST methodologies have not developed to the same degree, nor do they meet identical objectives. These studies tested the successfulness of differing methodologies to correctly classify blind samples containing human, dog, cattle, cow, gull, or sewage sources of microbial contamination. Results indicate that no methodology can correctly classify all blind samples correctly, but depending upon the objective of the project, can be applied successfully. For example, library-based methods, to differing degrees, can correctly identify the dominant source, but have high rates of false positives and require the development of large isolate libraries. Library-independent methods are the most accurate and cost efficient, achieving up to 92% correct identification of human and cattle, but have not yet been developed to identify all host-specific sources.

MST methods should be applied in a toolbox fashion selecting the appropriate tools based upon the individual watershed and project objectives. Before MST analysis is conducted, watershed size, number of potential sources, resolution required between those sources, time and financial constraints, and other relevant factors must be taken into consideration. Based upon the evolving state of the science, understanding the wide array of methodologies (*with variable assumptions and performance*) is essential to targeting successful remediation strategies.

TRIPLETT CREEK FOCUS STUDY

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Triplett Creek is a fourth-order Licking River tributary that flows through the city of Morehead, Kentucky in Rowan County. Like many eastern Kentucky rivers and streams, it is impacted by point and non-point pollution, especially contamination from sediment and potentially pathogenic microorganisms. This pollution could have it origins in agricultural, urban, and suburban non-point runoff. Many regional residences and businesses lack adequate waste-water treatment; however, compared to other eastern Kentucky regions, Morehead has a greater percentage of residents and businesses that utilize city sewer. We analyzed water quality in Triplett Creek and its major tributaries from June through September 2006 to identify which tributaries and regional landscape uses had the greatest impact on water quality in Triplett Creek. We measured stream biological components (fecal coliform, fecal streptococcus, and E. coli bacteria) and physiochemistry (flow and discharge, dissolved oxygen, pH, temperature, nitrate, nitrite, ammonium, total suspended solids, conductivity, alkalinity, sulfate, and iron). All measured streams showed some degradation; however, some tributaries were of particular interest because they exceed limits for use by humans or aquatic life.

NOTES

EXPERIMENTAL STUDY OF THE IMPACT OF UPLAND SEDIMENT SUPPLY UPON COHESIVE STREAMBANK EROSION
PART 1: FLUID TURBULENCE

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This research project is experimental in nature and studies the in-stream interaction of fluid turbulence, upland sediment supply, and cohesive streambank erosion. Experiments were designed for testing these complex interactions within the controlled setting of the 12 m recirculating flume in the Hydrosystems Laboratory located at the University of Kentucky. Currently, the presenters are describing results of experiments performed to qualitatively and quantitatively determine the fluid turbulence in smooth and rough channels, including the importance of coherent structures, to educe the dominant eddy processes which act to dislodge sediments from the bed and banks of an erodible channel. Particle Image Velocimetry (PIV) and Acoustic Doppler Velocimetry (ADV) were used to measure turbulent properties in the test channel, and the analysis, including cross-covariance functions, integral length scales and power spectral densities, indicated that the eddies vary in time and space. Mathematical decomposition methods were used to create filters for the spatial and temporal velocity data to help visualize the shape of the dominant eddies in instantaneous turbulent fields. A homogenous large-eddy simulation (LES) decomposition was used to visualize the scale of the energy-containing eddies and an inhomogeneous LES decomposition with proper orthogonal decomposition (POD) was used to visualize even larger scale coherent structures originating from the bed. A moving average was used on the time-series data collected with ADV to identify very large-scale groupings of coherent eddies into streamwise patterns on the order of 12-times the flow depth. The presenters also discuss the latter phase of the project which involves further experiments including sediment supply and cohesive bank materials.

NOTES

TOWARD USING A THREE-DIMENSIONAL NUMERICAL MODEL FOR SIMULATING HYDRODYNAMICS NEAR A DAM FOR CONSTRUCTING THE RATING CURVE

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A dam is an important hydraulic structure for control of flooding problems, navigation and recreations purpose. Most dams in United State were constructed more than 100 years ago and certain elements are now in serious need of upgrading, repair and/or replacement. Kentucky Water Division requires that elevation discharge relationship must be submitted as part of the plan for each new structure or modifications on old dams. To get approved by the water regulation agency, it is important for the new structure has the same hydraulic features as the old one, i.e, discharge ~ stage relationship. A rating curve has to been studied first to make sure any new constructions will not change the flow pattern on the existing river system.

Traditional approaches for studying the hydrodynamics near a hydraulic structures involve field measurements and setting up laborer physical model. There are limits with the laboratory model studies. Laboratory models hardly satisfy the hydraulic similarity with the original physical model because of the existence of some dominant non-dimensional parameter that can not be represented in labor model. Another shortcoming of lab models is the lack of flexibility in configurations.

Numerical simulations provide a flexible way to study the hydrodynamics near hydraulic structures. Numerical models are flexible to simulate several possible scenarios without much extra efforts. A few numerical models have been set up to study flows and sediment transport process in natural streams with complex geometry since 1980's. Early numerical models for natural rivers solved the depth averaged Shallow Water equation which is an approximate of Navier-Stokes equation. Shallow Water equation has great limitations in engineering applications since it is a hydrostatic model. But the dynamics near and over a dam are very dynamic. With the development of advanced algorithms for Navier-Stokes equation and the improvement of computation capabilities in super computers, more sophisticate numerical models are being used for natural streams.

Application of computational fluid dynamics (CFD) models to natural rivers provides the potential to develop solutions to a wide range of geomorphologic and river management problems. FLUENT has been successfully used to simulate small scale fluid dynamics problems in mechanic engineering such as ink jet, combustion chamber and flows in pipes. Occasionally, it has been applied in large scale problems such as open channel flow simulations in civil engineering. Also most of the open channel problems that have been studied using FLUENT are 2 dimensional instead of 3 dimensional. In this study, the possibility of using FLUENT in large scale water resources projects such as a dam. In this study, a three – dimensional FLUENT model was used with the developed grid. The geometry of the new Lock&Dam 9 was translated into a computational grid using a commercial grid generation package – Gambit. The 3D mesh, which contains both tetrahedral and hexahedra grids was generated 500m upstream and downstream of dam. Figure 1 show the geometry of Lock&Dam 9 used to generate the computational grid. To simulate the complex and changing free-surface, the FLUENT model used a VOF method. The preliminary results include dynamic pressure, velocity vectors and the free surface.

The realities of using the advanced computational software for such applications are the need for vast computational resources. There is also a significant amount time need to learn the intricacies of the model and to generate the grid. While the resource commitment would be similar to that of developing a physical model, there is little acceptance of numerical models as viable substitutes for physical models, even though the benefits and flexibility are great. Computational details and estimated cost will be presented, with a candid discussion on the limitations and challenges.

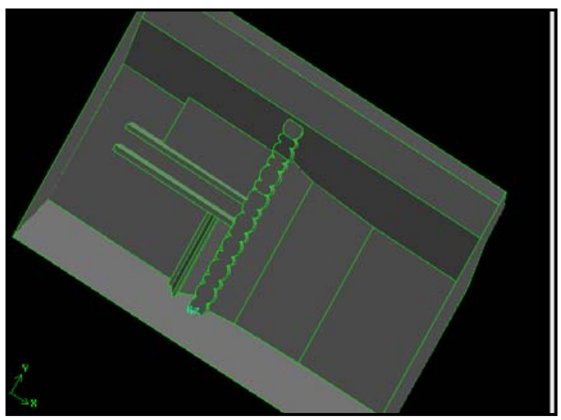

Figure 1 Geometry of Dam Site in Gambit

PROPERTY TAXATION AND FOREST FRAGMENTATION IN KENTUCKY WATERSHEDS

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This study examines the current practices utilized in assessing forest land for property tax purposes in thirty-seven counties in the Green River and the Lower Cumberland River Watersheds in Kentucky. These watersheds are among the top fifteen watersheds in the United States expected to experience increased development and fragmentation according to the U. S. Forest Service. As urban sprawl and development pressures influence land uses and property values, the likelihood of forests being converted to other land uses is a concern to natural resource managers and a threat to water quality. Land uses other than forests threaten water resources through the loss of the natural filtration services that forested areas provide. These areas serve as buffers to reduce the amount of foreign materials deposited by water runoff. The goal is to build a foundation for future studies related to forest land taxation and for changes in tax policy to promote sustainable forest management. By promoting forest management through tax policy the rate of fragmentation and conversion of forest lands to other uses may be reduced. A survey was conducted with the property valuation administrators for the counties in the Green River and Lower Cumberland River Watersheds. The survey provides data on how properties are valued for taxation in each county. After the valuation methods were identified and grouped, they were used to compare the net present value of a single forest rotation under different assessment methods. A sensitivity analysis was performed to determine the impact of each of the assumptions used in calculating net present values. The results demonstrate the disincentives that property tax assessing methods can have on the decision to manage forests.

NOTES

SOLUTE AND PARTICLE TRACER MOVEMENT UNDER VARIOUS FLOW CONDITIONS IN A KARST GROUNDWATER BASIN, INNER BLUEGRASS REGION, KENTUCKY

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Quantitative tracer tests are commonly performed to determine solute travel times and transport parameters in karst aquifers. However, particle tracer tests are less common, even though movement of pathogens and suspended contaminants from surface sinks to springs is of concern. Blue Hole Spring drains the city of Versailles and outlying farm land and is the headwaters of Glenns Creek in Woodford County, Kentucky. We have monitored discharge and water quality at the spring since 2002. Recently, we examined the movement of solute and particle tracers along a ~500-m flow path from a swallet in Big Spring Park to Blue Hole Spring. We injected tracers as slugs through a piezometer into the swallet. On June 2, 2006, a solute trace was conducted at low flow using rhodamine WT fluorescent dye and the conservative ion bromide (Br^-). On July 11, 2006, we used the same solutes in combination with 1-μm-diameter fluorescent latex microspheres under storm-flow conditions.

Discharge for the low-flow trace averaged 0.079 m^3/s. Solute breakthrough at the spring was almost simultaneous, with rhodamine WT arriving ~ 6.16 hours and Br^- ~ 6.5 hours post-injection. Likewise, concentration peaks nearly coincided (at 7.8 hours for the dye and 7.75 hours for the salt). However, rhodamine WT was detectable longer: concentrations fell below the detection limit (DL) after 21.16 hours, whereas Br^- was no longer detectable 12.66 hours after injection. The DL was 0.1 μg/L for rhodamine WT (by fluorescence spectrophotometer) and 0.1 mg/L for Br^- (by ion chromatograph). Calculated mass recoveries were slightly less for rhodamine WT (79.15 %) than for Br^- (84.19 %).

Immediately prior to the storm-flow trace, 2.4 cm of rainfall was recorded at the University of Kentucky Animal Research Center (4 km northwest) over a 5-hour period Another 11.6 cm of rain fell during the 2-week monitoring period. Spring discharge during the storm-flow trace peaked at 0.262 m^3/s and averaged 0.165 m^3/s. Breakthrough was nearly simultaneous for the solutes (~ 2.33 hours post-injection) and the microspheres (~ 2.5 hours post-injection). Tracer concentrations at the spring peaked quickly thereafter (~ 2.67 hours post-injection). Concentrations fell back below the DL 14 hours after injection for rhodamine WT and 5.5 hours after injection for Br^-. Calculated mass recoveries were less than at low flow (56.67 % for rhodamine WT and 52.61 % for Br^-). Using a fluorescent microscope, we detected microspheres in spring water until 164 hours after injection. Microsphere breakthrough was noticeably erratic relative to the solute breakthrough curves.

Preliminary results indicate that solutes and colloid-sized particles in storm runoff can arrive simultaneously at Blue Hole Spring, but particle arrival may persist days after introduced solutes are no longer detectable. However, latex microspheres are only gross analogs of actual microorganisms. Therefore, we plan to conduct another high-flow trace in January or February 2007 to compare the behavior of microspheres with isotopically-labeled native bacteria and to compare microsphere breakthrough under summer and winter conditions.

COLLOIDAL ARSENIC IN POULTRY-LITTER AMENDED SOILS

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Large amounts of organo-arsenicals such as roxarsone (3-nitro-4-hydroxyphenylarsonic acid) are used in the poultry industry to control coccidial intestinal parasites, improve feed efficiency, and accelerate growth. In 2000, 70% of the chickens in the United States (5.8 billion animals) consumed 45.4 g of roxarsone per ton of feed. Over the lifetime of a single chicken, this results in the excretion of 150 mg of arsenic. At present, approximately 400 chicken houses operate in McLean County, each producing 150 tons of poultry litter annually. The poultry litter, comprised principally of wood chips and excrement, is applied to nearby agricultural fields as fertilizer. A preliminary analysis of several Karnak soils from this region revealed the presence of 38 – 90 ppb As. A litter sample that had aged for several weeks open to the air contained 34 ppb As.

In laboratory soil column elution studies it was found that clear, filtered (0.2 μm) water contained no detectable As by GFAAS. Appreciable As, 8-30 ppb, was only found in cloudy samples that were coarsely filtered (0.45 μm). Thus, the As eluting from the soil columns was always associated with suspended or colloidal soil particles in the water. The metals, Cd, Pb, Hg and Ni were present in low ppm levels (~0.2 ppm), if at all. The Mg and Ca levels were ~ 20 ppm. Clear water samples from field runoff were obtained and found to contain less than 5 ppb As.

This project will integrate the analysis of poultry-amended soil for arsenic from McClean County, KY, with the potential implementation of a continuous monitoring system for arsenic and the development of a system for removing arsenic if the effluent water proves to be contaminated. This presentation will provide details of the preliminary study on McClean soils, a description of the real-time monitoring technology, and potential remediation strategies that might be employed.

NOTES

ENVIRONMENTAL MONITORING AND ASSESSMENT OF ARSENIC METAL IN GROUNDWATER SAMPLES FROM BALLARD, CARLISLE, AND GRAVES COUNTIES, KENTUCKY

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The infiltration of contaminants into groundwater wells is a concern, especially to individuals who rely on wells as a source of potable water; therefore it is important to monitor groundwater in order to determine the concentrations of chemicals present and to protect the population from being exposed to harmful contaminants. Arsenic is a particularly harmful element that is added to poultry feed, in the form of roxarsone, to control coccidial parasites. Groundwater was sampled in Graves, Ballard, and Carlisle counties in western Kentucky, where poultry houses are abundant. The poultry litter is used as fertilizer in each of the three counties. Approximately 110 samples were analyzed for arsenic using graphite furnace atomic absorption spectroscopy (GFAAS) at the University of Kentucky's Environmental Research and Training Laboratory (ERTL). All samples analyzed were below the MCL of 10 ppb As, which indicates that arsenic from poultry litter has not yet infiltrated the groundwater.

In addition to the arsenic analysis, the concentrations of twenty-four other metals were determined by inductively coupled plasma atomic emission spectroscopy (ICP-AES) at ERTL and MSU. Analytes in this study were Al, Ba, Be, Ca, Cd, Co, Cr, Cu, Fe, K, Mg, Mn, Mo, Na, Ni, Sb, Si, Sr, Ti, Tl, V, and Zn. Lead and selenium were analyzed using GFAAS. Sites chosen for analysis are representative of the geological formations that are present in the three counties. The concentrations of the metals were compared with their respective maximum concentration limits (MCLs). Additionally, the statistical correlations between metal concentrations and sample site variables, such as well depth and geological formation, were examined.

NOTES

ENVIRONMENTAL MONITORING AND ASSESSMENT OF THE GROUNDWATER QUALITY IN CALLOWAY COUNTY, KENTUCKY

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Two EPSCoR (Experimental Program to Stimulate Competitive Research) projects were conducted in 2006 to assess the general groundwater quality of Calloway County, Jackson Purchase Region, Kentucky. Working with researchers from the Kentucky Geological Survey (KGS), 56 domestic water wells were identified for sampling. Sandra Thompson (undergraduate student) and Dr. Harry Fannin (Murray State University) sampled the 56 wells for metals. In conjunction with Thompson and Fannin's sampling, Daniel Kotter (undergraduate student) and Dr. Paul Doss (Southern Indiana University) sampled the same wells for anions.

In Calloway County groundwater is derived from 4 distinct aquifers, a Mississippian limestone (Fort Payne and Warsaw Formations), Cretaceous sand (McNairy Formation), Tertiary sand (Claiborne Formation), and Quaternary gravel (continental gravel deposits). Fifty-six water wells (bored and drilled) were randomly selected throughout the county and sampled from outside faucets. Samples were analyzed by Thompson and Kotter for major anions and metals using ion chromatography, inductively coupled plasma atomic emission spectroscopy, and graphite furnace atomic absorption spectroscopy at the University of Kentucky's Environmental Research and Training Laboratory (ERTL). Alkalinity titrations were performed at the KGS Environmental Laboratory. Statistical analyses were performed to identify trends and relationships between groundwater quality data, hydrogeology, land use, well type (bored and drilled) and well depth.

All of the anion and metal concentrations were below U.S. EPA Maximum Contaminant Levels (MCL), except for nitrate-nitrogen (nitrate-N). Nitrate-N concentrations were above the MCL of 10 mg/L in 4 of the 56 wells sampled. Twenty-nine of the 56 wells contained groundwater with nitrate-N concentrations above background (2 mg/L). Nitrogen isotope data collected by KGS researchers indicate that elevated nitrate-N concentrations stem from 4 major sources; septic tank effluent, livestock manure, synthetic fertilizers and soil organic nitrogen.

Major ionic species were plotted on a Piper diagram to determine general groundwater chemistry. Groundwater type ranges from calcium and bicarbonate rich to alkali and chloride rich. The wide range in groundwater chemistry is likely due to differences in aquifer composition, depth of water table, and local land use practices.

NOTES

LAND-USE EFFECTS ON WATER QUALITY WITHIN LOWER HOWARD CREEK WATERHSED, SOUTHWESTERN CLARK COUNTY, KENTUCKY

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Lower Howard Creek has been on the Kentucky 303(d) list of impaired watersheds since 1998 due to nutrient enrichment and low dissolved oxygen. The causes named for this impairment were agricultural grazing and 'hydromodification.' In an attempt to show the extent of agricultural impact on the watershed, land use was estimated for segments of the stream representing contrasting land-usage, and comparisons were made to the quality of samples taken at these sites. This study investigated general water-quality parameters and microbial concentrations in LHC watershed.

Samples were collected from six sites for two sampling sets, and tested for Escherichia coli concentration with additional analysis done by ratio of atypical to total coliform bacteria (AC/TC) in an attempt to determine age and primary input of fecal contamination. *E. coli* were sufficiently below the maximum concentration level of 1000 CFU/100 mL for secondary-contact recreational waters required by the U.S. Environmental Protection Agency. The highest concentration obtained from the two sampling sets was 44.8 CFU/100 mL, which was collected below the Winchester water-supply reservoir. Standard measured parameters of electrical conductivity, turbidity, total suspended solids, alkalinity, and pH were also within limits satisfactory to U.S. EPA for secondary contact recreational waters.

The AC/TC ratio indicated the presence of freshly input fecal contamination throughout the stream but the source of this contamination was not identified. Comparing the two sampling runs, conflicting results were found relating AC/TC ratio and source type, namely agricultural activity versus urban sources. The upper reaches of Lower Howard Creek are dominated by urban runoff, which collects in the water supply reservoir. West Fork and Deep Creek tributaries to Lower Howard Creek are dominated by agricultural land use, principally pasture land. Possible reasons for variability in results from the two sampling runs include unobserved land use activity, recharge events, and variation in stream flow.

Unobserved land use activity could include agricultural activity and/or illegal dumping of sewage, both of which would add nutrients and bacteria to the stream. Without daily observation of the watershed, such activities would be difficult to evaluate. No precipitation occurred during either of the sampling runs, therefore, recharge is not assumed to have contributed to the fluctuation of the AC/TC ratio. However, there was a decrease in stream flow between sample run 1 and sample run 2. This was most likely due to a period of freezing temperatures, which froze first-order tributary input to Lower Howard Creek. Therefore, we conclude that the most probable explanation for variation in AC/TC ratio is related to stream flow conditions.

It is important to note that although all samples analyzed were within limits required by the U.S. EPA, this study cannot be considered a comprehensive analysis of the health of the Lower Howard Creek watershed. Our results indicate that a complex stream system entailing diverse land uses, such as Lower Howard Creek, would require detailed observation concerning immediate land use that effect water quality.

LONG-TERM ASSESSMENTS AND SEASONAL VARIATIONS OF POLYCHLORINATED BIPHENYLS (PCBS) IN WATER, SEDIMENTS, FLOODPLAIN SOILS, AND SENTINEL FISH SPECIES FROM BIG AND LITTLE BAYOU CREEKS, MCCRACKEN COUNTY, KENTUCKY

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PCB assessments at two moderately impacted streams, Big and Little Bayou Creeks, were conducted in 1988-2005. Samples collected during spring and summer corresponded with periods of high- and low-flow. The two streams were impacted by effluents from the Paducah Gaseous Diffusion Plant. Water, stream sediments, floodplain soils, and fish were analyzed for Aroclor 1248, 1254, and 1260. Five sport fish were selected for the study: green sunfish (*Lepomis cyanellus*), longear sunfish (*L. megalotis*), bluegill (*L. macrochirus*), largemouth bass (*Micropterus salmoides*), and the yellow bullhead catfish (*Ameiurus natalis*). The stoneroller minnow (*Campostoma anomalum*), a benthic feeder, was included since they are in direct contact with and ingest contaminated sediments. Only 8 of 263 water samples analyzed showed detectable PCBs, indicating the transitory nature of PCBs in the water column. Detection of Aroclor 1248 in sediments was sporadic, while Aroclor 1254 and 1260 were prevalent, indicating greater binding capacity to sediment/soil particles. Aroclor 1248 sediment concentrations were lower during the summer compared to spring values, whereas 1254 and 1260 were influenced less by seasonal variations. Floodplain Aroclor 1254 and 1260 were detected mainly in the spring, but all three Aroclor were detected in the summer, indicating that floodplain areas were receiving recently contaminated sediment particles following high-flow events and acting as PCB sinks. Overall PCB concentrations in fish fillets decreased in all sunfish species after 1991, but not all PCBs were eliminated from the sunfish and a “baseline” concentration was observed. Although Aroclor 1248 and 1254 in stoneroller minnows decreased over time, Aroclor 1260 levels remained somewhat constant. As with the sunfish, a “baseline” PCB concentration was observed in stoneroller minnows. Species specific trends were observed when comparing PCB concentrations and stream flow. In green sunfish, Aroclor 1248 and 1254 levels were not strongly influenced by flow, but Aroclor 1260 levels increased with increasing flow. The green sunfish has a unique metabolism that allows it to eliminate PCBs more rapidly than other sunfish and may partially explain these results. PCB concentrations in longear sunfish increased with increasing flow. However, opposite results were observed for stoneroller minnows, where PCB concentrations decreased with increasing flow. These results correspond to seasonal variations seen for the stoneroller minnow, with higher summer Aroclor 1248 levels. Seasonal trend were less distinct for Aroclor 1254 and 1260. Based on our findings, we propose that PCBs are being remobilized during high-flow events, then redistributed into fish after a lag-time, thus increasing summer body burdens. Results from this field study demonstrate that seasonal variability and flow conditions can alter PCB bioavailability.
Key words: PCB, sentinel fish, stoneroller minnow, seasonal variability, stream flow

NOTES

CHARACTERIZATION OF TOTAL DISSOLVED SOLIDS (TDS) TOXICITY TO *Ceriodaphnia dubia* ASSOCIATED WITH EFFLUENT DISCHARGES FROM A MEAT PACKAGING INDUSTRY

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Total dissolved solids (TDS) are common components in meat packaging industries due to the abundant use of salts (*i.e.*, NaCl) during processing. Toxicity related to TDS is mainly due to specific combinations and concentrations of contributing ions such as sodium, potassium, magnesium, chloride, sulfate, nitrate, and bicarbonate. The correlation between increasing TDS concentration and toxicity may vary with different ionic combinations. Therefore, TDS concentration is not a good predictor for toxicity. However, some regulatory authorities have set TDS limits for many effluents around 1,000 mg/l. To determine the contribution of TDS to toxicity, characterization of effluent discharges from a meat packaging company were conducted in 2004-2006. Several artificial waters with various TDS concentration were also tested to determine the correlation between TDS and toxicity. The tests were performed using standard method 1002.0 and 2002.0 for *Ceriodaphnia dubia* chronic and acute toxicity tests, respectively. Results of acute toxicity tests showed that *C. dubia* was able to tolerate the highest TDS concentration tested (2943.55 mg/l). Whereas results of chronic toxicity showed that *C. dubia* was able to tolerate TDS as high as 1314.76 mg/l. Correlation between TDS and chronic toxicity was relatively strong (r^2=0.52). Further investigation revealed that the toxicity was mainly due to the ionic combination with chloride as the primary toxic element (r^2=0.66), while sulfate and sodium showed to be weak contributors (r^2=0.23 and 0.10, respectively). However, sulfate and sodium ions also contributed to TDS toxicity at much higher concentrations. These findings indicate that TDS is not a good regulatory predictor for toxicity. Determination of ionic combinations in effluents with high TDS concentrations would be more useful in regulatory strategies.

NOTES

WILSON CREEK RESTORATION AND THE RESPONSE IN FOOD WEB FUNCTION AND FISH COMMUNITY STRUCTURE.

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Stream restoration projects are often justified based on expected improvements in habitat and biodiversity, but few have been systematically studied to assess their “success.” A channelized section of Wilson Creek (Bernheim Arboretum and Research Forest, Kentucky) was relocated to a new, meandering channel using a natural channel design approach. Fish communities were sampled before and after the restoration and compared to an upstream site in Wilson and two control streams that were not restored. We analyzed the stable isotope signatures of a sub-set of the sampled fishes along with macroinvertebrates, periphyton, and detrital leaf material to reconstruct the stream food webs. Museum fish specimens from Wilson and a control stream where used to recreate historical food webs. Kentucky Fish Index of Biotic Integrity (IBI) scores in Wilson were Excellent for the pre-restoration fish community and most of the reaches sampled after the restoration retained that classification. The reference streams’ IBIs were classified as Good and remained unchanged throughout the study period. Pre and post restoration Wilson isotope signatures showed very little change in food web base resources and the general trophic structure. More pre- and post restoration studies are needed to help develop success criteria and incorporate “lessons learned” in stream restorations.

NOTES

DEVELOPMENT AND APPLICATION OF A NEW FINGERPRINTING METHODOLOGY FOR THE COMMONWEALTH OF KENTUCKY

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Sedimentation is one of the primary sources of non-point source pollution for surface waters. This problem can lead to a number of environmental problems, including decreases in water quality, ecological development, and aesthetic properties of rivers and streams. Sediment fingerprinting is one tool developed by researchers to address sedimentation issues. This process can aid watershed managers in developing efficient remediation strategies for sedimentation issues within their respective watersheds. Sediment fingerprinting can be defined as a method to identify sediment sources in a watershed and attribute the amount of sediment contributed by each source. Sediment fingerprinting utilizes tracer technology with a combination of field, lab, and numerical modeling techniques to discern sediment source. A tracer can be defined as a distinct physical, chemical, or biological characteristic of the soil or sediment.

Researchers have applied sediment fingerprinting strategies to various types of watersheds both nationally and internationally. The methods utilized previously to perform these studies have been developed based upon site-specific conditions. Our research works towards the development of a flexible sediment fingerprinting methodology for studies conducted within the Commonwealth of Kentucky. Tracer properties can vary among watersheds due to a number of site characteristics, such as climate, vegetation, site topography, geology of the soil parent material, effects of time on the soil, land use and management practices, and other human disturbances. A methodology that selects tracers and sample locations based on watershed variability is needed.

The focus of this presentation is to explain the methodological steps of sediment fingerprinting. The authors have developed a step-by-step sediment fingerprinting methodology that is applicable across watershed scales. This method development included research by the authors to incorporate a broad range of potential sediment tracers in a variety of geographic regions.

Further methodology development through data collection and analysis is required to refine the steps presented and to specify controlling parameters for application specifically in Kentucky's watersheds. This future research will be outlined in detail.

ACCOUNTING FOR CONSTRUCTION STORMWATER IN TMDL DEVELOPMENT FOR SEDIMENT IMPAIRED STREAMS IN RAPIDLY GROWING RESIDENTIAL AREAS

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In recent years, the Washington, DC metropolitan area has expanded to include the eastern panhandle of West Virginia. Agricultural land and open space is being converted to roads and subdivisions. Housing construction activities leave soils vulnerable to erosion that can cause sediment impairment in receiving streams. Because of the potential for sediment pollution, construction sites in West Virginia require a state-issued NPDES permit to discharge stormwater.

Sediment TMDLs were developed for tributaries of the Potomac River in Berkeley and Jefferson Counties, WV. Sediment models included contributions from permitted construction stormwater sites. Although literature values were available for yearly sediment erosion loads from West Virginia agricultural landuses, upland sediment loads from construction sites were much more difficult to estimate because of the relatively short duration of the disturbance and the variability of effectiveness of sediment control Best Management Practices (BMPs). The modeled unit area load for permitted construction sites (0.8 tons/acre/yr) was assumed to be approximately 40% of the annual load from cropland without BMPs (2.25 tons/acre/yr), reflecting a best-case scenario for BMP effectiveness in reducing sediment runoff. To establish equity among other sediment contributing nonpoint sources, TMDL load allocations were assigned to reflect the best-case scenario for BMP effectiveness.

Modeling was used to calculate the sediment contribution from construction stormwater sources in TMDL watersheds. Model results were also used to estimate the total number of acres of construction that could be permitted at any given time without causing sediment impairment in receiving streams. Because construction stormwater discharges are precipitation-driven, acreage associated with each point-source permit was incorporated into a watershed model (Mining Data Analysis System) that would return the flow and concentration of sediment from each source. Modeled daily sediment loads

over a 20-year period were used to calculate average annual loads. These watershed loads were area-weighted to distribute yearly loads back to individual NPDES permits and outlets. Sediment modeling is expected to refine TMDL implementation efforts, as well as help state permit writers and local decision makers balance environmental protection with economic development.

KEY WORDS

construction stormwater, sediment, watershed, TMDL

RESPONSES OF RIPARIAN PLANT DIVERSITY TO GRADIENTS IN FLOOD FREQUENCY AND SEVERITY

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Species richness of riparian vegetation is attributable to the environmental heterogeneity that typifies fluvial systems. Interaction of floods with a topographically complex landscape produces primary gradients in the frequency, duration, and severity of flooding and spatially correlated secondary gradients in environmental conditions. In order to explain spatial variation in riparian plant diversity, the response(s) of diversity to gradients in flood disturbance characteristics and associated environmental conditions must be determined. Previous studies typically have focused on the response of diversity to a single component of the flood disturbance regime. Consequently, significant sources of spatial variation in diversity may have been undetected. In this study, we investigated 1) the general responses of fine-scale riparian plant diversity to a gradient in flood frequency and to a gradient in flood severity, and 2) the relative capabilities of flood frequency and flood severity to explain variability in diversity in cobble bar grasslands in the Big South Fork of the Cumberland River (Tennessee and Kentucky). In our study system, species richness and Shannon-Wiener diversity were negatively correlated with both flood frequency and flood severity. These patterns are attributed to the low total plant cover and large species pool size at the low end of the flood frequency gradient and the strong correlation between flood frequency and flood severity within bars. These data are consistent with Huston's Dynamic Equilibrium Model, which predicts maximal diversity in locations where fertility is high and disturbances frequent or where fertility is low and disturbances infrequent. Flood frequency explained a much higher percentage of the variation in these two diversity indices than did flood severity. The persistence of herbaceous cobble bar vegetation is dependent upon floods of an adequate severity to prevent fine sediment accumulation and thus hinder significant encroachment by large tree species. Frequent flood events will be required to maintain current patterns in the diversity and composition of cobble bar grasslands, which largely are determined by soil moisture availability.

NOTES

KENTUCKY GROUNDWATER-QUALITY MAPPING SERVICE

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The Kentucky Geological Survey maintains the Groundwater Data Repository, which includes an archive of water-well records, spring information, and water-quality data. The groundwater-quality archive includes results for samples collected from 1940 to the present by more than 70 State, Federal, and research agencies, and analyzed at more than 100 different laboratories. The resulting variety of measurement and reporting methods has made it difficult to compare data from different sampling programs or to resolve regional geologic effects on groundwater quality.

KGS staff have recently standardized the reporting nomenclature for 38 of the most significant water properties, inorganic solutes, metals, nutrients, pesticides, and volatile organic compounds, and are developing an interactive map service that will display groundwater quality on base maps of Kentucky geology, physiography, or major watersheds. This new service will allow individuals, agencies, and organizations to investigate regional patterns in groundwater quality and to see spatial relationships between sampled wells and springs. Users will also be able to view statistical summaries of water quality, such as data distributions, comparison of water from wells versus springs, and plots of concentrations versus well depth. The service also provides information about each water-quality parameter, natural and nonpoint sources of the chemical, potential health effects in drinking water, and health-related water-quality standards, if any exist.

This presentation will demonstrate the new mapping service. A related presentation in this session will present the new tabular data search capability that allows users to obtain groundwater quality statewide or in counties, quadrangles, or in the vicinity of specific sites. Together, these new services make groundwater-quality data more accessible to the public than ever before.

For more information on Kentucky groundwater-quality data, contact KGS at 859-257-5500 x 162 or x 158. The interactive water-quality map server can be accessed through the KGS Web site: kgsweb.uky.edu/main.asp.

NOTES

KENTUCKY GROUNDWATER-QUALITY DATA SEARCH ENGINE

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In 2003, the Kentucky Geological Survey began providing online access to groundwater-quality data for the state. Until recently, these data were only available in an "all-or-nothing" format – after performing a water-well or spring search, customers could then download all associated water-quality analyses for that site. Through an EPA 319 grant awarded by the Kentucky Division of Water, personnel from the Water Resources and Geospatial Analysis Sections have enhanced and streamlined searching for Kentucky water-quality data. Users can now select individual or multiple parameters of interest, view search results, and download the data to delimited text files for use in spreadsheets or various GIS software packages.

The source of these data is the Kentucky Groundwater Data Repository, maintained by KGS. To date, 38 parameters in five major categories (water properties, volatile organic compounds, nutrients, pesticides, and inorganic solutes) can be searched either as an entire group or by individual analyte. Each analyte also has associated text files with descriptive information about the substance, possible health hazards, and EPA drinking-water standards. There are several search methods, including the entire state, by county or multiple counties, by USGS 7.5-minute quadrangle, or by a radius-search from a user-specified location (the user also specifies the radius).

This presentation will review the process of searching for these analytes, and the procedure for downloading data. A related presentation in this theme session will review a new online interactive mapping program that allows the user to view search results on a map along with statistical summaries of the data.

The groundwater data in the repository were collected from the 1940's to the present, from both springs and wells. Data searches can be formatted to include all sample data for every location for which records are available, or as a summary report that provides the median, maximum, and most recent result values. The number of samples below detection is also included in the summary report. Search results can be sorted by sampling date or by a range of dates.

Web sites are listed for the user to obtain information about maximum contaminant levels set by the Environmental Protection Agency, as well as sites by other Kentucky agencies, including the Kentucky Division of Water and the U.S. Geological Survey. For more information on water-quality or water-well data, contact the Survey at 859-257-5500 x162.

The newly released water-quality search engine can be accessed online at kgsweb.uky.edu/DataSearching/Water/WaterQualSearch.asp (Figure 1).

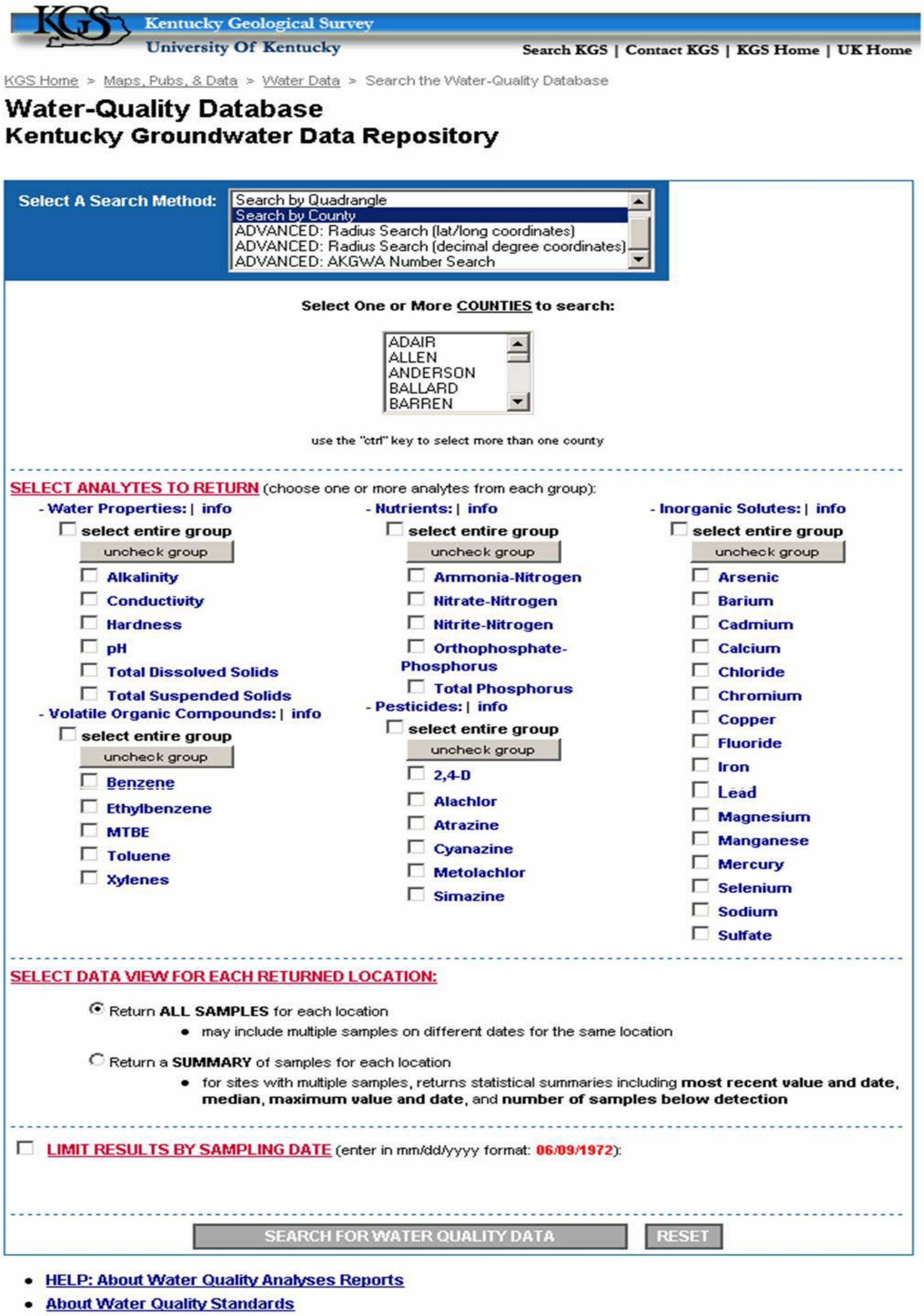

Figure 1. Layout of new water-quality data Web search page.

WATER QUALITY IN THE KARST TERRANE OF THE SINKING CREEK BASIN, KENTUCKY, 2004-06

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The effects on water quality from human activities (construction, logging, and certain agricultural practices) are important considerations for resource management in the ground-water recharge area of Sinking Creek. Understanding the role of best-management practices in protecting shallow ground water from human activities is fundamental in developing and implementing sound land-use polices. Thus, water samples were collected in Sinking Creek and surrounding springs and karst windows in the karst terrane of the Sinking Creek Basin in 2004, 2005, and 2006 as part of study conducted by the U.S. Geological Survey in cooperation with the Kentucky Department of Agriculture. About 130 water-quality samples were collected at 7 sites (2 main stem sites, 4 springs, and 1 karst window) from April through November 2004; March through December 2005; and April through June 2006. The karst terrane of the Sinking Creek Basin (also known as Boiling Spring Basin) encompasses about 125 square miles in Breckinridge County and portions of Meade and Hardin Counties in Kentucky.

Sixteen pesticides were detected of the 52 pesticides analyzed in the stream and spring samples. Of the 16 detected pesticides, 13 were herbicides and 3 were insecticides. The most commonly detected pesticides—atrazine, simazine, metolachlor, and acetochlor—were those most heavily used on crops during the sampling period. Atrazine was detected in 95 percent of all samples; simazine, metolachlor, and acetochlor were detected in more than 30 percent of all samples. The pesticide-transformation compound, deethylatrazine, was detected in 93 percent of the samples. Only one nonagricultural herbicide, prometon, was detected in about 16 percent of the samples. Carbaryl, the most commonly detected insecticide, was found in 14 percent of the samples, which was followed by Malathion (2 percent). Concentrations of most of the pesticides analyzed were less than their detection limits. However, atrazine was found in water samples exceeding the U.S. Environmental Protection Agency's (USEPA) standards for drinking water (greater than 3 micrograms per liter). Atrazine exceeded the USEPA's maximum contaminant level 10 times in 123 detections. In general, the highest concentrations of atrazine, simazine, metolachlor, and acetochlor occurred during runoff events in April, May, and June each sampling year.

Concentrations of nitrate greater than 10 milligrams per liter (mg/L) were not found in water samples from any of the sites. The criterion of 10 mg/L for nitrate was established by the U.S. Environmental Protection Agency for the protection of domestic water supplies. Concentrations of nitrite plus nitrate ranged from 0.21 to 4.9 mg/L at the seven sites. The median concentration of nitrite plus nitrate for all sites sampled was 1.6 mg/L. Concentrations of nitrite plus nitrate generally were higher in the springs than in the main stem of Sinking Creek.

Phosphorus and suspended sediment concentrations generally were higher in runoff-event samples than in base-flow samples. Higher concentrations of phosphorus and suspended sediment in runoff-event samples potentially are associated with erosion and runoff from land surfaces and from resuspension of sediment from stream beds and banks. During lower flows, concentrations of phosphorus and suspended sediment typically are lower because ground water, having flowed through watershed soils, is the principal source of streamflow. Forty-five percent of the concentrations of total phosphorus at the seven sites were greater than the U.S Environmental Protection Agency's desired goal of 0.1 mg/L for preventing excessive growth of aquatic plants and algae. The median concentration of total phosphorus for all sites sampled was 0.09 mg/L. The highest median concentrations of total phosphorus were found in the springs. Median concentrations of orthophosphate followed the same pattern as concentrations of total phosphorus in the springs. Concentrations of orthophosphate ranged from <0.006 to 0.459 mg/L. The median concentration of suspended sediment for all sites sampled was 70 mg/L. The highest concentration of suspended sediment (1,490 mg/L) was measured following a storm event at the Sinking Creek near Lodiburg site (03303205).

SALT MOVEMENT THROUGH THE VADOSE ZONE OF A KARST SOIL
FIRST EXPERIENCES WITH A TRANSFER FUNCTION APPROACH

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Water and solute movement through the vadose zone of soils developed on karstic bedrock and under agricultural use, deserve special attention with respect to observing flow phenomena and quantifying transport properties. So far, most studies on karst topographies have been focused on groundwater quality and the arrival of water and solutes to ground and surface waters. This study is a first attempt in this region to evaluate and quantify vadose zone transport phenomena and transport coefficients for salt and water movement. The objectives were to test the applicability of TDR-methodology, and to derive transport coefficients for salt movement, i.e., the pore water velocity and the dispersion coefficient. These were derived from input-output response, with four cycles of salt pulses applied to the land surface as input, and the electrical conductivity (EC) monitored as output. One reason for choosing the TDR methodology was the relatively undisturbed measurement of salt concentration, and the automatic monitoring capability. Moreover, EC time series could be obtained with high spatial and temporal resolution, which is necessary for the analytical procedure. In Figure 1, the temporal design of salt pulses and the EC responses at the 10, 30, and 50 cm depths are shown.

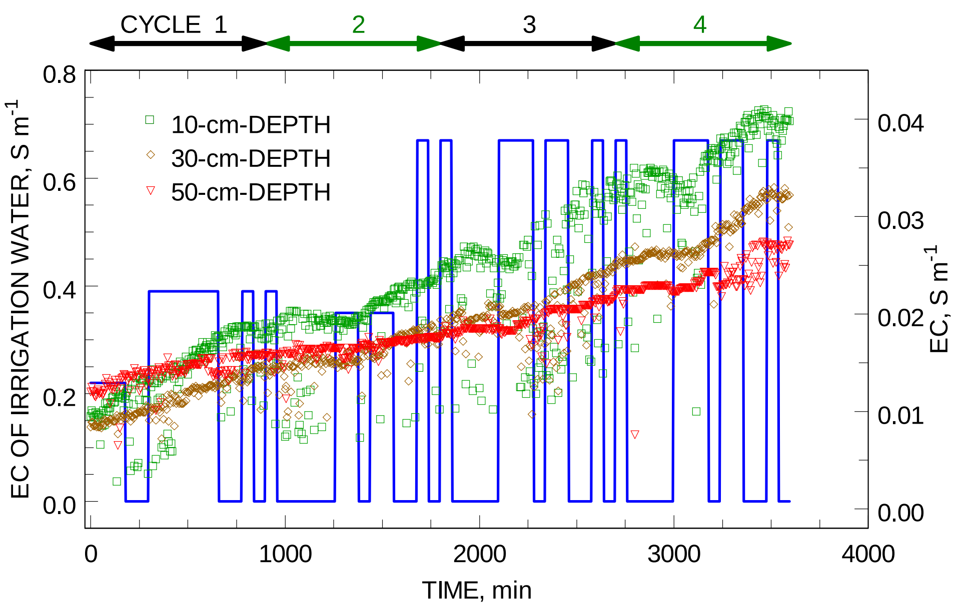

Figure 1. Input of four solute cycles and response of electrical conductivity (EC) at 3 different soil depths (10, 30, and 50 cm).

The analysis of time series was based on auto- and crosscorrelation functions of the various input and output time series, as well as their integration in the frequency domain. Figure 2 shows power spectra and cospectra of input and output time series of EC. The transport experiment was carried out in a sinkhole profile on the Woodford County Experiment Farm of the University of Kentucky. Water and solutes were applied, at a precipitation rate of approximately 10 cm day^{-1}, continuously for approximately three days, corresponding to four application cycles. First results show the applicability of the measurement technology and analytical procedure using the transfer function concept according to Jury and Roth (1992, Transfer functions and solute movement through soil). The following transport coefficients were derived from this experiment: The pore water velocity was estimated to be on the order of 0.013 m hr^{-1}, and the dispersion coefficient yielded a magnitude of approximately $4 \cdot 10^{-5}$ m^2 hr^{-1}. These results were based on the assumption of spatial homogeneity in soil structure and are comparable with results reported in the literature for loamy soils. Future analyses will include site-specific estimates and an evaluation of the hierarchical pore systems with different levels of water and solute mobility.

This experiment was carried out, and the transport coefficients were obtained, for conditions close to field soil water saturation. Future experiments will be conducted with lower water application rates in order to derive transport properties for a range of field soil moisture conditions.

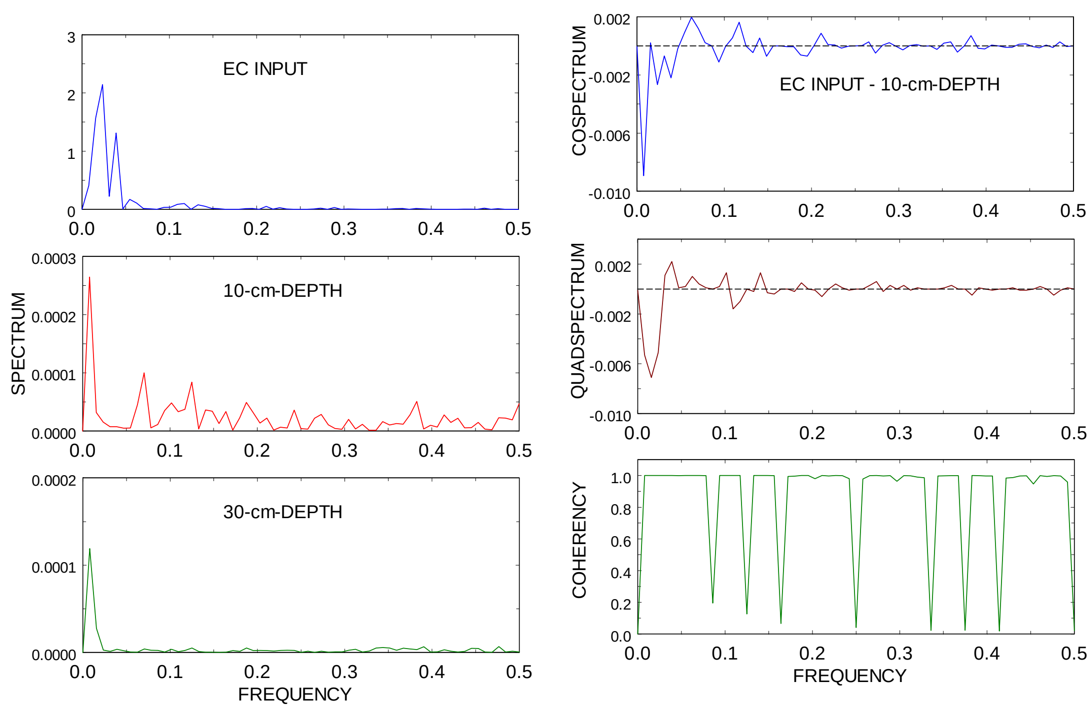

Figure 2. Power spectral densities for input and output EC at 10 and 30 cm depth (left column) and cospectral densities and coherency between EC input and response at 10 cm soil depth (right column).

5 STARS, 15 STUDENTS, 5000 TREES

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The Red River Mouth watershed covers north-central Powell County, Kentucky. The surface waters of the watershed supply the drinking water for municipal systems in Clay City and Stanton, KY, and for the Beech Fork Water Commission. The Kentucky Division of Water has ranked this subwatershed of the Kentucky River as a high priority for watershed protection. Powell County middle school students, along with resource professionals, assessed the status of the Red River Mouth watershed and implemented a plan to restore a section of riparian area with native floodplain species. Students toured their watershed, taking digital photos and field notes. With this information, students reviewed existing water quality data, collected and analyzed additional water samples, and reviewed aerial photos and maps to formulate a watershed assessment. Students identified potential areas for restoration in the watershed and created a plan for restoring one of these areas. Students worked with resource professionals and a local landowner to implement their restoration plan. Student knowledge was assessed using a K-W-L chart. Students communicated their new knowledge to classmates, teachers, community leaders, and other organizations through news articles and presentations, and participated in a local field day to share their project with the community. A National Fish and Wildlife Foundation Five-Star Restoration Grant funded the project.

NOTES

THE WATER PIONEERS WATER QUALITY INITIATIVE

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In 1991, the University of Kentucky Board of Trustees approved a plan that set aside coal royalties from a 5,000-acre section of the Robinson Forest to support economic development efforts. In 1996, the Board allocated a significant portion of those funds to provide scholarships to students in 29 eastern Kentucky counties with historically low rates of college attendance. The Robinson Scholars Program serves first generation college-bound and college students who have demonstrated the potential to succeed but who might encounter economic, cultural, or institutional impediments to their completion of four-year college degrees. Not only does the Scholars Program aim to provide opportunities for these students, but through a collateral effect, the Program also seeks to increase the college-going rates in their communities.

Upon successful completion of high school, Scholars who have fully participated in program activities receive annual scholarships. At the college level, Scholars must maintain an acceptable academic record and fully participate in programming. If Scholars meet program requirements, their awards are renewable for up to four years of undergraduate study at the University of Kentucky or up to two years at a KCTCS institution with the remainder at UK.

The Water Pioneers Water Quality Initiative is a program for rising high school sophomores in the Robinson Scholars Program at the University of Kentucky. First, students participate in an in-depth study of an Appalachian watershed during a week-long summer program. Students then take this knowledge and partner with educators, volunteers, and other interested local groups to increase awareness of Best Management Practices for water quality in their respective counties through a community service/outreach project of their own design.

During the summer program, students were introduced to watershed concepts and discovered how people impact a watershed. Robinson Scholars developed ideas, communicated their knowledge, and compared and contrasted watersheds in the area. The students' hands-on activities included stream sampling, tree and insect identification, cave exploration, watershed management, sustainability analysis, team building, leadership study, and reflective writing.

The conclusion of the program required that Scholars partner with local groups, educators, and volunteers to create a community project to addresses water quality problems in their community. As future University of Kentucky students, the Scholars will ensure high visibility for their projects within their communities. The Scholars must present the projects and findings at a culminating event or local summit with parents, local officials, decision makers, school administrators, teachers, Division of Water employees, and others.

LOCAL AND STATE PARTNERSHIP FOR MS4 SUCCESS IN KENTUCKY COORDINATED COMMUNICATION, EDUCATION AND OUTREACH

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In 2003 the Kentucky Transportation Cabinet (KyTC) was required to participate in the National Pollutant Discharge Elimination System (NPDES) small Municipal Separate Storm Sewer System (sMS4) also known as the Phase II stormwater quality permit program administered by the Kentucky Division of Water (KDOW). Around the country, Departments of Transportation (DOT) and state regulators have taken a variety of approaches for how the DOTs would participate in the program. For Kentucky, the KDOW instructed KyTC to participate in the program as a subordinate co-permitee with the 44 designated sMS4 communities in the Commonwealth (also referred to as the local sMS4 partners). The intent was to force/facilitate a more direct relationship at the local level through the 12 KyTC District Offices, while providing statewide tools, guidance and support from KyTC's central office.. Through a benchmarking exercise it was found that this arrangement is rare in the country.

In 2006 the KyTC intensified its preparations for the second sMS4 permit cycle (2008 – 2012). It is evaluating and determining how it may better support the local sMS4s.. Coordinated public communication, education and outreach has been one of the more significant needs discussed. A robust approach to this challenge is being formulated in anticipation of a resolution by September 2007. While significant progress has been made to preposition the qualified resources, the KyTC anticipates discussions with the local sMS4 partners and KDOW will shape the program significantly.

This presentation will discusses the challenges and opportunities of the co-permitee framework. It outlines the activities recently performed, conclusions drawn and implications for the next permit cycle (2008-2012) program. This presentation will be helpful to communities, DOTs and environmental stakeholders that participate or are recipients of the MS4 stormwater quality permit program.

NOTES

ILLICIT DISCHARGE DETECTION AND ELIMINATION: A CHALLENGE FOR KENTUCKY'S STORMWATER PROGRAM CITIES

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The federal stormwater program for managing polluted runoff from urbanized areas includes a number of new requirements for Kentucky cities unaccustomed to operating under a National Pollutant Discharge Elimination System permit for discharges to regulated waters through municipal separate storm sewer systems (MS4s). The two-phased implementation program for complying with stormwater Clean Water Act Section 402 requirements includes, among other things, a program to identify and eliminate non-stormwater pollutant discharges to the MS4. This so-called "illicit discharge detection and elimination" component involves desktop surveys to screen for likely illicit discharges, field investigations to verify MS4 maps and detect such discharges, and an active program to end the discharges through enforcement actions backed by local ordinances.

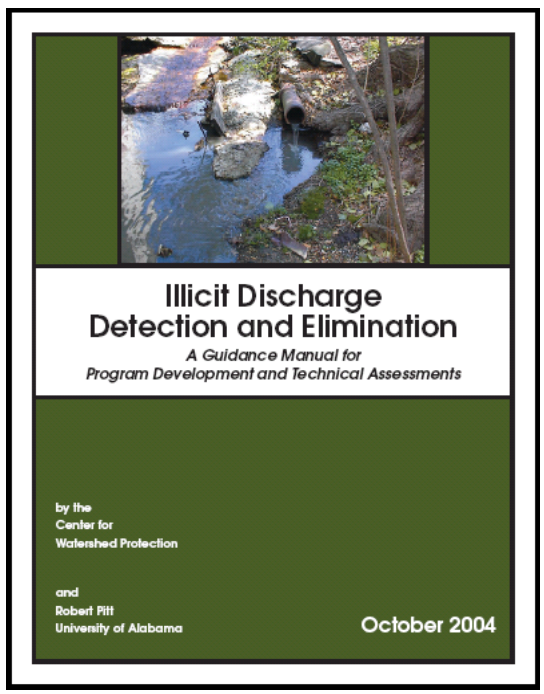
Congress amended the Clean Water Act 20 years ago to require US EPA to establish phased NPDES permit requirements for stormwater discharges, which significantly degrade surface waters through bank-scouring flows, discharge of runoff pollutants, and lowering of baseflows linked to a general reduction in infiltration. Stormwater collection systems have also served as rapid conveyances for pollutant discharges from septic systems, floor drains, sinks, sewers, dumping incidents, spills, and other activities or sources. US EPA implemented the Phase I Stormwater Permit Program for medium-sized and large MS4 cities (i.e., with a population of 100,000 or more) in 1990, and brought small MS4s (population = 10,000) into the Phase II program in 2003.

Phase I cities must characterize their stormwater discharges, survey outfalls in the field, screen for dumping and illicit discharges, and demonstrate that they have legal authority to conduct inspections, prohibit illicit discharges, require compliance, and conduct monitoring. US EPA also requires that Phase I cities create and implement integrated stormwater management programs that incorporate IDDE and other activities that seek to improve stormwater and receiving water quality. Cities that have not fully met the stormwater permit program requirements have faced US EPA legal action in Kentucky and other states.

In addition, by 2008 the smaller Phase II cities must implement the NPDES stormwater permit programs they have been developing over the past four years. This consists primarily of addressing six minimum control measures dealing with stormwater: public outreach, public involvement, construction phase stormwater management, post-construction stormwater control, pollution prevention and good housekeeping for municipal operations, and illicit discharge detection and elimination.

US EPA has provided training and technical assistance to Phase I and Phase II programs faced with implementing the IDDE components. In September, 2006, the US EPA Office of Wastewater Management sponsored a two-day workshop in Lexington KY on stormwater permit program compliance, which included nearly a day devoted to detecting and eliminating illicit discharges. US EPA also supported the development of a guidance manual for IDDE program development and technical (desktop and field) assessments, which was published by the Center for Watershed Protection in October 2004. The manual – based on the work of Dr. Robert Pitt of the University of Alabama and other researchers – covers the full range of IDDE topics, from regulatory background and terminology to developing and implementing the permit-required IDDE program. Much of the manual addresses establishment of legal authority, conducting the desktop screening analyses, identifying problems in the field, and preventing or fixing the discharges. A low-tech outfall reconnaissance inventory procedure is described, complete with field data collection forms, important discharge indicator parameters, and source tracking techniques.

Kentucky cities have only recently realized the breadth and depth of the stormwater program requirements, especially the IDDE component. Developing the program and conducting the desktop and field surveys will require a considerable level of effort for Kentucky municipalities, which can be supported by a range of innovative approaches. For example, involving science and engineering graduate students in desktop screening, mapping, and field investigations could help small and medium-sized cities meet their permit requirements while providing an excellent educational opportunity for program participants. Volunteer water quality monitoring organizations might also wish to participate in such a program – the city of Lexington pioneered this approach during a 2006 project on Wolf Run, a tributary of Town Branch that drains much of the southwestern portion of the city.



This session will feature a broad overview of the IDDE program requirements for Kentucky cities, a summary of program development and system survey activities, and snapshot of what's involved in desktop screening and field investigation of pipe, ditch, and other outfalls. A list of web-based resources and ready-to-use educational slides will be provided to attendees with flash drives or laptops at the session.

CHALLENGES AND OPPORTUNITIES IN WORKING DIRECTLY WITH AFFECTED SUPERFUND COMMUNITIES IN KENTUCKY

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Since 2000, the University of Kentucky's (UK's) Superfund Basic Research Program (SBRP) Community Outreach Core has provided support and guidance through Superfund Community Action through Nutrition (SCAN) programs, which meet the needs of individuals and communities affected by environmental contaminants. UK's SBRP's researchers have shown that nutrition can modulate the toxicity of persistent organic pollutants, particularly polychlorinated biphenyls (PCBs) and trichlorethylene (TCE), and it is now known that these compounds may contribute to an increased risk for chronic diseases especially in combination with poor diet. SCAN programs integrate nutrition education programs to encourage healthy eating habits, research communication techniques from UK's SBRP Research Translation Core, and nutrition science research from UK's SBRP to increase understanding of risks associated with residing near Superfund sites. SCAN has established close ties to community groups in western and eastern KY. SCAN programs involve three key steps: identifying the groups and individuals who have been affected by the contaminants, recruiting and establishing the trust of those affected, and providing meaningful programs that can be shown to be helpful to the affected groups and individuals. Community contacts from a number of different sources are used to identify affected community members. SCAN personnel work to establish trust by attending group meetings and listening to health concerns. Documenting outcomes from SCAN programs and legal issues present some complications. At both sites, community members are concerned about strangers conducting research studies and SCAN activities that might affect their litigation. As to such concerns, SCAN personnel can assure continued interaction with community members, and programs that pursue a more qualitative approach. SCAN, in full partnership with affected communities, will maintain its role in translating safe, effective nutrition information to support the needs of Superfund communities.

Supported by NIEHS/NIH (P42ES07380)

NOTES

SELECTED CHLORO-ORGANIC DETOXIFICATIONS BY POLY-CHELATE (POLY-ACRYLIC ACID) AND CITRATE-BASED FENTON REACTION AT NEUTRAL pH

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Poly-acrylic acid (PAA) is widely used for solid surface modification. It also can act as a poly-chelating agent to combine iron ion (Fe^{2+}/Fe^{3+}), and prevent $Fe(OH)_3$ (s) precipitation even at neutral pH. In this study, polyacrylic acid was proven to act as a poly-chelate in the modified Fenton reaction for oxidation of chlorinated organic compounds (such as 2,2'-dichlorobiphenyl and biphenyl) at neutral pH. Numerical simulation based on the kinetic model developed from the well known Fenton reaction and iron-chelate chemistry fits experimental data well for both standard and chelate modified Fenton reactions without pollutant. This is the first reported confirmation of dechlorination of carbon tetrachloride (CCl_4) from aqueous phase by superoxide radical anion using both monomeric (citrate) and polymeric (PAA) chelate based modified Fenton reactions. The main purpose of this research is to understand and model chelate based modified Fenton reaction in homogeneous phase. The oxidation reactions involving immobilized iron by PAA functionalized solid support (silica particles and PVDF membrane) were also explored. This research is supported by the NIEHS-SBRP and by KRCEE-DOE programs.

NOTES

REDUCTIVE DEGRADATION OF CHLORINATED ORGANICS BY MEMBRANE-SUPPORTED NANOPARTICLES

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Chemical degradation of chlorinated organics using bimetallic nanoparticles (Fe/Ni or Fe/Pd) has been extensively studied. In the presence of the secondary metal, contaminants were dehalogenated by catalytic hydrodechlorination, which can greatly enhance the reaction rate as well as inhibit toxic intermediates formation. In this study, nanosized Fe/Pd particles were synthesized in polyacrylic acid (PAA) functionalized polyvinylidene fluoride (PVDF) MF membranes. The membranes and Fe/Pd nanoparticles were characterized by several electron microscopy techniques: SEM, TEM, and X-ray Mapping. Special emphasis has been given to examine the distribution of PAA inside the PVDF support membranes and the chelation of ferrous ions and carboxylic acid by high resolution X-ray mapping. 2,3,2',5'-Tetrachlorobiphenyl (TeCB) was used as a model compound to examine the reactivity of Fe/Pd nanoparticles and study the catalytic hydrodechlorination reaction pathway. The results show that nonortho chlorines (para or meta) are preferentially removed over chlorines in the orthoposition. This is due to the higher static hindrance from coplanar aromatic rings for nonortho chlorines. For Fe/Pd nanoparticles with various Pd coating, although the observed reaction rate constant was different, the normalized reaction rate constant in terms of reactive surface sites (Pd atom) was the same. Batch reactions were also performed at various temperatures to find the reaction activation energy and to understand the catalytic property of palladium. A Langmuir-Hinshelwood kinetic model including mass transfer, diffusion, and membrane partition is formulated to obtain intrinsic reaction rate. This research is supported by the NIEHS-SBRP and by KRCEE-DOE programs.

NOTES

IDENTIFICATION OF POTENTIAL BACTERIAL SOURCES AND LEVELS, RED DUCK CREEK, MAYFIELD, KENTUCKY

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Our grant work was directed towards finding possible point sources for fecal contamination of Red Duck Creek in Mayfield, Kentucky. We chose this topic because Watershed Watch sampling results showed extremely high e-coli colonies at various locations along the creek. From the Watershed Watch data, we believed a single pollutant source could be isolated.

For the data collection, we chose 12 spots scattered throughout the residential and commercial area of Mayfield. The locations were chosen based on possible contamination sources. We defined possible contamination sources as being sewage pipes, run off from agriculture areas, run off from industry, and possibly, unidentified septic systems. At each location we measured dissolved oxygen, turbidity, conductivity, temperature, pH, total coliforms, and e-coli colonies. Flows were generally too low to measure. Red Duck Creek rapidly recedes following precipitation and is typically ponded rather than flowing during low flow conditions.

The results from our data turned out to be inconclusive. Although some sampling events showed high levels of coliforms, we had no clear trend at the various locations. The overall results were uniform throughout the stream. Results from up stream and down stream of Mayfield could not be statistically differentiated. With no clear statistical evidence to point to any specific location, specific sources could not be determined.

Since specific sources could not be identified, widely distributed non-point runoff may have been the largest contributor for contamination of Red Duck Creek. Contamination sources could have included animal feces since domestic pets are numerous around Red Duck Creek, feces from birds that fly over and rest in nearby trees and in the water, and domestic livestock upstream of Mayfield.

Due to a funding delay, we were only able to sample in the Fall rather than Spring and Fall as intended. Hence, high flow data could not be obtained. Also, some local industries are seasonal and operate at a reduced level in the Fall. Furthermore, inputs from sewer lines and septic systems may have been reduced due to less infiltration and inflow. Additional research might include sampling in wetter seasons and running DNA tests on the bacteria to better differentiate possible sources.

NOTES

WATER-QUALITY TREND ANALYSIS FOR STREAMS IN KENTUCKY

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Increasingly complex water-management decisions require water-quality monitoring programs that provide data for multiple purposes, including trend analyses to detect if water quality has improved, deteriorated, or remained stable with time. Identifying reasons for changes in water quality (natural or anthropogenic causes) is an additional component of trend analyses.

Trends in surface-water quality for 16 properties and water-quality constituents were analyzed at 37 sites with drainage basins ranging in size from 62 mi^2 to 6,431 mi^2. Analyses of nutrients, major ions (chloride, sulfate), suspended solids, select metals (iron, manganese), fecal coliform, and select physical properties (pH, temperature, dissolved oxygen, specific conductance, and hardness) were compiled from the State's ambient water-quality monitoring network. Trends analyses were completed using the S-Plus statistical software program S-Estimate Trend (S-ESTREND) that detects trends in water-quality data. The trend detection techniques supplied by this software include the Seasonal Kendall nonparametric methods for use with uncensored data or data censored with only one reporting limit (Hirsch and others, 1982), and the Tobit parametric method for use with data censored with multiple reporting limits (Cohn, 1988). One of these tests was selected for each property and water-quality constituent and applied to all site records so results of the trend procedure could be compared among sites.

Statewide results indicate scattered statistically significant (p-value <0.05) upward or downward trends for most water-quality constituents or properties. A summary of selected results for nutrients, total suspended solids, chloride and sulfate is shown for 31 of the 37 sites in table 1. The 6 remaining sites had not been analyzed at the time of the abstract preparation.

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Table 1. Summary of selected trend results for nutrients, total suspended solids, chloride, and sulfate at selected Kentucky Division of Water ambient water-quality network sites.

[WV, West Virginia, TN, total nitrogen, NO_3, nitrate; TKN, total Kjeldahl nitrogen; TP, total phosphorus; TSS, total suspended solids; Cl, chloride; SO_4, sulfate; +, increased trend; --, decreased trend; blank space, no significant trend]

Site name	Site number	Trends						
		TN	NO_3	TKN	TP	TSS	Cl	SO_4
Tug Fork at Kermit, WV	PRI002			--	--			+
Levisa Fork near Pikeville	PRI006				--	--	+	
Cumberland River near Burkesville	PRI007	--	--	--	--	--		
South Fork Cumberland River at Blue Heron	PRI008	--	--		--	--	--	--
Rockcastle River at Billows	PRI010	--			--	--		--
Pond River near Sacramento	PRI012							
Rough River near Dundee	PRI014	--	--	--	--			--
Green River at Munfordville	PRI018			--	--			
Nolin River at White Mills	PRI021		+	--		--	+	
Eagle Creek at Glencoe	PRI022	--		--		--	+	
Kentucky River at Lock 4	PRI024	--		--			--	
Salt River at Shephardsville	PRI029	--	--	--	--			
North Fork Kentucky River at Jackson	PRI031			--	--		+	
Middle Fork Kentucky River at Tallega	PRI032				+			+
South Fork Kentucky River at Booneville	PRI033	--						
Beech Fork near Maud	PRI041			--	--	--	+	
Little River near Cadiz	PRI043	+		--	--		+	
Dix River near Danville	PRI045			--	--		+	
Red River at Clay City	PRI046			--	+			
Little Sandy at Argillite	PRI049	+	+	--		--		+
Horse Lick Creek near Lamero	PRI051		--			--		--
Salt River at Glensboro	PRI052				--		+	
Green River at Livermore	PRI055							
Mud River near Gus	PRI056				--			--
Rolling Fork near Lebanon Junction	PRI057						+	
Kentucky River near Trapp	PRI058							+
North Fork Licking River near Milford	PRI060				--		+	
Licking River at Claysville	PRI061						+	
Levisa Fork near Louisa	PRI064						+	+
Kentucky River at Lockport	PRI066		+	--	+			+
Kentucky River at High Bridge	PRI067					+		

PRELIMINARY RESULTS OF A FECAL MICROBE SURVEY IN AN EUTROPHIC LAKE, WILGREEN LAKE, MADISON COUNTY, KENTUCKY

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Wilgreen Lake is a small (~14 mi^2), eutrophic lake formed by damming several tributary streams to Silver Creek, Madison County, Kentucky. The lake receives runoff from industrial and urban areas (Richmond) that comprise ~10% of the total watershed area; most runoff is from cattle pasture or human developments encircling the lake. Present and past developments are on septic systems, and effluent from these systems is known qualitatively to seep into lake waters.

Our research group is currently conducting a study of the lake in order to identify major nutrient sources, and one possible tracer method is to quantitatively assay species-specific microbes in lake waters. In preparation for this effort in the 2007 field season, we sampled lake waters in July and August 2006 to characterize the spatial distribution and abundance of fecal microbes. Sampling stations (15 in number) encompass the lake's breadth and include samples from not only the trunk of the lake system (where deeper water occurs) but also from 3 tributaries – two of which have possible inputs from septic systems. We use the *Colisure* method from IDEXX Laboratories to determine the most probable number (MPN) of total coliform and *Escherichia coli* bacteria.

Higher numbers of fecal microbes occur in the two most densely populated tributaries, and we note 14 cases (at 8 sites) where assays exceed maximum standards of the EPA for bathing exposure (200 cfu per 100 mL for total coliform, TC; 235 cfu per 100 mL for *E. coli, EC*). The trunk locations show low numbers of fecal microbes (TC generally <150 cfu per 100 mL; *EC* generally <20 cfu per 50 mL) whereas the upper reaches of both Taylor's Fork and Old Town Branch show higher microbial abundance (TC generally >300 cfu per 100 mL; *EC* cfu generally >100 per 100 mL). Another tributary stream with no apparent human effluent at present shows much lower fecal microbe abundance. From the data, we infer there is significant input from septic systems into these specific regions of the lake. There are several other sources that must be eliminated as possibilities, but it is likely that the source of these fecal microbes is from septic systems encircling the lake. Substantial residential development is underway around Wilgreen Lake at present, and we intend that 2007 field results inform development practices.

Kentucky Water Resources Research Institute Symposium, March 2007.

NOTES

PRELIMINARY PHYSICAL AND CHEMICAL CHARACTERISTICS OF AN EUTROPHIC LAKE, WILGREEN LAKE, MADISON COUNTY, KENTUCKY

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Wilgreen Lake (Madison County, Kentucky) has been listed as “nutrient impaired” by the State, thus identifying the sources of nutrient (nitrogen and phosphorus) input into the system is critical in establishing best-practices management of this watershed. The lake’s drainage basin is diverse, receiving water from urban and industrial areas, residential property, and pasture land. Prior to tracer studies that will commence in the 2007 field season, we gathered framework data necessary to understanding the physical, chemical, and biological characteristics of Wilgreen Lake.

We established 9 water sampling stations and 16 data stations over the expanse of the lake, including its tributary and trunk drainages. Maximum water depth is about 16 meters near the dam. At all these stations we use an YSI probe to take temperature, conductivity, pH, and oxygen concentration measurements at depth intervals of 1 meter. We also collect water samples at depth intervals of 1 meter at appropriate stations. The chemical data we report here include ammonium (NH_4^+) nitrogen concentration measured by the colorimetric method of Solorzano (1969). We gathered data monthly from June through September, taking probe data an additional time during September.

Preliminary data show that Wilgreen Lake is a typical eutrophic system. The lake was already stratified with our first sampling (31 May), showing a strong thermocline between 2 and 7 meters. Thus, the lake is segregated through the summer into a top and bottom layer, each with stark differences in their physical and chemical properties. Conductivity values in the upper layer are 0.4 ± 0.05 μS/cm^2 and increase in along the thermocline reaching maximum values ($\geq$0.55 μS/cm^2) near the bottom. The top layer is alkaline (pH 8 - 9), whereas bottom waters are more acidic (pH 7 - 7.5). Dissolved oxygen concentration is highest in the top layer (8 -13 mL/L) with disoxic (0 - 2 mL/L) and anoxic (0 mL/L) waters in the bottom layer. Ammonium concentration is near zero in the upper layer and increases with depth in the lower layer to 5 ppm. Over the summer, the disoxic-oxic boundary remains at a depth of 3 to 4 meters, but anoxia moves upward in the water column, sharpening the oxygen gradient. The lake is surprisingly homogeneous, both physically and chemically, at the deeper-water sites. Shallow sites at the inlets are more variable. In some cases, surface waters there contain markedly less dissolved oxygen, perhaps due to higher oxygen demand and/or decreased photosynthesis.

Kentucky Water Resources Research Institute Symposium, March 2007.

NOTES

LETHAL AND SUBLETHAL EFFECTS OF NUTRIENT POLLUTION ON AMPHIBIANS

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Fertilizer application is a widespread practice that greatly affects aquatic ecosystems in a variety of ways. One important affect is the toxicity of nutrients to various species of amphibians. Previous studies show that nitrate toxicity could be a major problem for amphibians at elevated levels, though few studies examine sublethal effects. On the other hand, phosphate has not been evaluated at all for toxic effects. To examine nutrient toxicity, laboratory experiments were conducted to measure the response of American Toad and Cope's Gray Treefrog tadpoles to various concentrations of nitrate and phosphate. The phosphate experiments exposed Cope's Gray Treefrogs to five treatments with concentrations ranging from 0 to 200 mg/L P-PO_4 and lasted for 15 days. Nitrate was examined in both the American Toad and Cope's Gray Treefrog using seven treatments: four with constant concentrations, ranging from 0 to 5 mg/L N-NO_3, and three pulses that simulated the quick increase in concentration to 5 mg/L and slow decline that would be associated with runoff from a rain event. Pulses were timed at different points during development to determine critical developmental stages when tadpoles are most vulnerable. The amphibian responses that were measured included mortality, body condition, size at metamorphosis, time to metamorphosis, fluctuating asymmetry, directional asymmetry, and deformities. Phosphate was found to have no effect on any of the lethal or sublethal responses in Cope's Gray Treefrogs, indicating that phosphate may not be toxic to this species. Nitrate had no effect on American Toads but did affect the Cope's Gray Treefrog. Individuals from the treatment with the pulse late in development had more extreme directional asymmetry than other treatments in calcaneum length. The late pulse occurred during hind limb development; directional asymmetry in a hind limb trait suggests the disruption of the developmental process during the sudden increase in the concentration of nitrate. Individuals from the early and middle pulses may have had similar disruptions in development but were able to compensate prior to metamorphosis.

NOTES

DIATOM COLONIZATION PATTERNS IN SPRINGS AT LAND-BETWEEN-THE- LAKES NATIONAL RECREATION AREA, WESTERN KENTUCKY AND TENNESSEE

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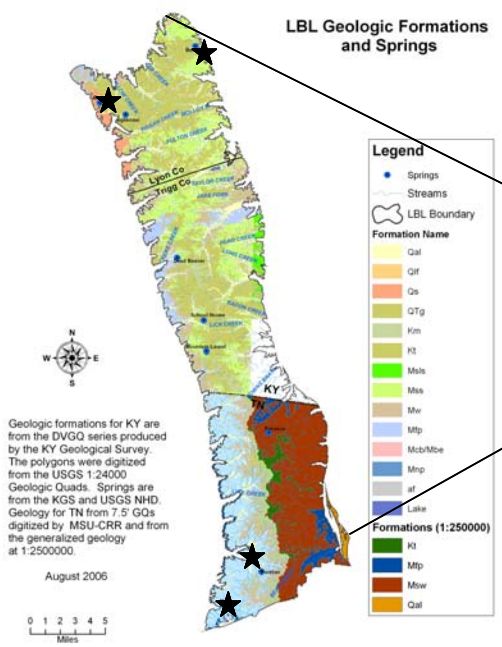
Diatoms (Bacillariophyta) are algae known for their sensitivity to chemical conditions in water. Therefore, they are a useful supplement to chemical analyses in assessments of water quality. Parent geology determines conductivity, alkalinity, pH and nutrient concentrations in spring ground waters that ultimately seep into streams. Spring water chemical factors may influence species composition of periphyton colonizing stream substrates.

In October 2006, an exploratory study of diatom colonization patterns was carried out in several springs emerging from different geological materials in Land-Between-the Lakes National Recreation Area located in western Kentucky and Tennessee (Figure 1). Two springs emerge from limestone geology (Panther and Mint in the south) and two springs emerge from siliceous/argillaceous geology (Barnett and Brown in the north). Unglazed quarry tiles were deployed in each stream a few meters downstream from each spring and were allowed to colonize for four weeks. The tiles were retrieved, diatoms were identified to genus, and biomass was determined from chlorophyll *a* analysis. Physiochemical characteristics and nutrient concentrations also were measured in each spring.



There were significant differences between at least two of the springs in dissolved oxygen, alkalinity, pH, DO, turbidity, SiO_2, SO_4, Cl, and SRP concentrations. Discharge, chl a, NO_3+NO_2 and NH_4 were not significantly different among any of the springs. Only conductivity was significantly different among all four springs. *Achnanthes, Cocconeis* and *Gomphonema* were dominant in the carbonate streams with limestone geology (Panther and Mint springs); these taxa are calciphilous and high conductivity (107–481 uS cm^{-1}) provide optimal conditions for growth. *Diatoma*, *Eunotia,* and *Pinnularia* were more abundant in the streams with siliceous and argillaceous geology (Brown and Barrett springs); these taxa are considered acidophilous and low conductivities (48–163 uS cm^{-1}) are optimal for growth.

This study will be expanded over the next 8 months to test the hypothesis that springs with contrasting geologies (and therefore different water chemistries) will develop different diatom community compositions. Developmental sequence analysis of stream periphyton also will be used to test the hypothesis that different spring water origins as defined by stable isotope (^{13}C) signatures will be reflected in the biomass of periphyton colonizing the substrata over time.

DENITRIFIER ECOLOGY IN FRAGIPAN SOILS OF KENTUCKY

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Fragipans provide conditions conducive to denitrification because of seasonally perched water. Previous work on denitrifiers in fragipan soils indicated that surface manure addition could increase denitrifiers at all soil depths and cause stratification above fragipans (Fig. 1)(Fairchild et al., 1999). However, evaluating denitrifier populations by culture alone is not comprehensive because of the limitations of culture-based techniques. Functional genes involved in denitrification have been extensively and effectively used to study the highly diverse denitrifying bacteria in various soil and marine environments (Braker et al., 1998). In particular, the structural genes for Cu- (NirK) and heme- (NirS) nitrite reductases and nitrous oxide reductase (NosZ) have been used to characterize denitrifier communities. However, this has not extended to the fragipan/soil interface.

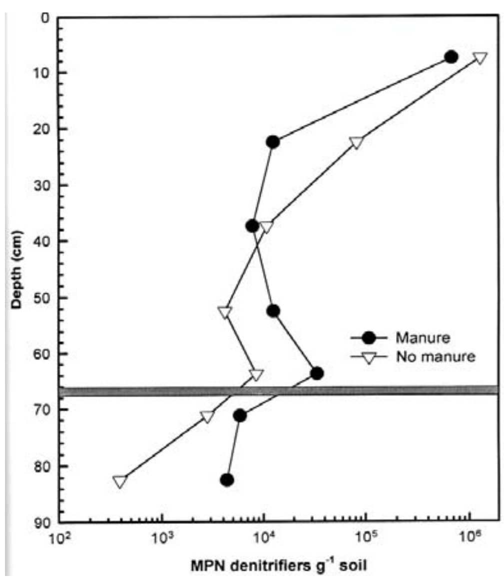

Figure 1. Manure effects on stratification of denitrifiers (Fairchild et al., 1999).

In our study we compared the denitrifier composition between surface and subsurface boundary layer soils from Princeton, KY in a cultivated site previously amended with poultry litter, and an unamended pasture site - both with identified fragipans. Most probable number (MPN) and denitrification enzyme assay (DEA) were used to determine the denitrifier population and activities, respectively. DNA based molecular analysis was used to compare denitrifier populations from soil of different depths.

The MPN results showed that denitrifier populations decreased exponentially from the soil surface to the depth of fragipan, and were stratified above the fragipan in some samples at both sites (Fig. 2). Nutrient analysis of soils from the cultivated site showed no significant difference in total C and N at the similar depths between the plots with and without previous poultry litter amendment. Correspondingly, neither was there significant difference in denitrifier population size.

The DEA results showed higher denitrifier activity in the surface soil than in the boundary layer soils, which corresponded with our MPN data. However, due to the low denitrifier populations at the fragipan layers, denitrifier activity in soil immediately above or below the fragipans was minimal at both sites.

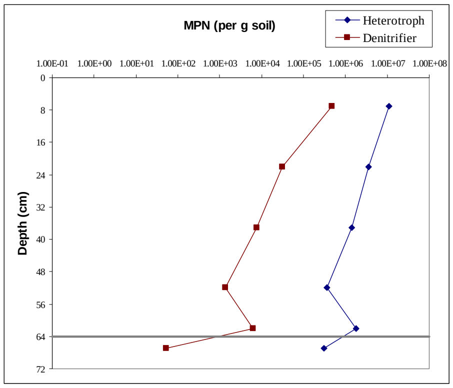

Figure 2. Denitrifier populations vs. depth in a pasture soil with fragipan appearing at 62cm.

The band densities of extracted DNA from soils at each site and depth indicated a dramatic decrease in the microbial population with the increasing depth. DNA recovery could be improved by adding skim milk to the commercial DNA extraction kits. Primers for *nirS* and *nirK*, encoding nitrite reductase, which catalyzes the rate-limiting step in denitrification, were used for the PCR amplification of DNA extracted from the various soils by depth. The Cu-type nitrite reductase NirK was found in both surface and subsurface soils while heme-type NirS enzyme was only found in the surface samples. These results suggest that either different denitrifier community structures occurred at different depth of soils, or the published primer sequences for *nirS* were less effective at reflecting the denitrifier populations existing in the fragipan soil environment.

The preliminary data from MPN and DEA analysis suggest that perched water alone is insufficient to drive significant denitrifier population changes at the fragipan boundary layer. While results of the nitrite reductase gene analysis suggest that the community structure of denitrifiers differs by depth in these soil environments, and potentially could contain unique types of denitrifiers. Our future study will focus on attempting to quantify changes in the denitrifier community structure and to manipulate denitrifiers at the fragipan boundary layers by surface amendments such as additional C and N.

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LEVERAGING PARTNERSHIPS FOR IMPROVED RESEARCH TRANSLATION: THE UNIVERSITY OF KENTUCKY SUPERFUND BASIC RESEARCH PROGRAM RESEARCH TRANSLATION AND COMMUNITY OUTREACH CORES

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The University of Kentucky Superfund Basic Research Program Research Translation (RT) and Community Outreach Cores (COC) have forged a close relationship to promote improved communication with a number of audiences, including government agencies, impacted populations, and industry and healthcare professionals. Working together, the RT and COC have created an operational model that allows for optimal division of communication labor while promoting audience feedback for quantifiable measures of success. Among the University of Kentucky's ongoing RT and COC efforts are Superfund Community Action through Nutrition programs in impacted communities, the creation and maintenance of an RT database, the hosting of both academic workshops and public forums, and the development of an innovative tailored website. In addition, the UK-SBRP RT and COC leverage partnerships with a number of stakeholders to ensure successful, widespread communication of research findings and their implications for specific constituencies.

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NOTES

EFFECT OF WASTEWATER TREATMENT PLANT EFFLUENT ON AQUATIC MIRCOBIAL COMMUNITIES

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Little is known about the effect of wastewater on stream microbial communities. Water samples were taken upstream and downstream from the wastewater treatment plant on Tates Creek which runs from Richmond, Kentucky to the Kentucky River. At the time of sampling, Hach water testing kits were used to measure chloride, dissolved oxygen, ammonium, nitrate, and phosphate. Nutrient increases were associated with wastewater effluent addition to the creek. Total heterotrophic counts were performed using R2A agar. Bacterial numbers peaked one mile down stream from the wastewater treatment plant but the number then decreased to pre-treatment levels further down stream. Microbial community structure was assessed using Biolog© microplates. The microbial communities immediately downstream from the plant differed from those before the plant and further downstream. The results suggest that effluent from wastewater treatment plants temporarily alters microbial communities but this effect does not persist further downstream.

NOTES

EFFECTS OF PERVIOUS CONCRETE ON POTENTIAL ENVIRONMENTAL IMPACTS FROM ANIMAL PRODUCTION FACILITIES

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Studies have shown that pervious concrete has the potential to increase water quality in urban areas as stormwater or wastewater passes through the concrete matrix. Pervious concrete could provide positive results for pollution reduction when used for animal feeding pads, manure storage pads, or floor systems in animal buildings. Runoff from agricultural activities can have negative impacts on the environment; however, little research has been conducted to determine the performance of pervious concrete for uses in these areas. The objective of this study was to provide more information concerning the use of pervious concrete in agricultural settings.

Laboratory tests were conducted on replicated samples of pervious concrete made from two aggregate sources (river gravel and limestone) with two size fractions of each aggregate. Compost composed of beef cattle manure and bedding was placed on top of the pervious concrete specimens and one liter of water was filtered through the compost and pervious concrete for two separate daily leaching events. T- tests indicated that the mass of compost retained on the surface of the pervious concrete specimens was significantly greater when smaller aggregate sizes (#8 river gravel) were used ($p = 0.012$). Nutrient analyses were conducted on the effluent from the compost and pervious concrete and compared to values from an identical test performed by filtering water through compost on a No. 80 wire mesh screen. These tests indicated that filtering the compost effluent through pervious concrete resulted in significant reductions in total nitrogen, soluble phosphorus, and total phosphorus compared to the wire screen. There were no consistent significant differences between the effects of filtering with pervious concrete or wire mesh screen with respect to other analytes (e.g. dissolved organic carbon, ammonium, nitrate, and nitrite). Effluent BOD levels from the compost and pervious concrete for both daily leaching events (38.7 and 42.5 mg/l, respectively) averaged above typical allowable wastewater concentrations of 30 mg/l. Use of the pervious concrete for filtering resulted in significantly higher pH (9.3) (p value <0.0001) compared to the effluent pH from the wire mesh screen (7.7).

Weekly rainfall simulations were conducted after manure was applied to the surface of pervious concrete specimens. The effluent from the manure and pervious concrete was tested for five-day BOD, dissolved organic carbon, ammonium, nitrate, nitrite, total nitrogen, soluble phosphorus, and total phosphorus. Statistical analysis indicated that significant increases and decreases can occur in these analyte concentrations after rainfall events. The highest concentrations of some analytes (five-day BOD, nitrate, total nitrogen and total phosphorus) in the effluent occurred after the first rainfall simulation. Maximum concentrations for other analytes (DOC, ammonium, nitrate, and soluble phosphorus) occurred after subsequent rainfall events. Further analysis of the effluent indicated a significant decrease in fecal coliform concentration one week after the initial rainfall simulation. Ammonia and carbon dioxide emissions from the manure and pervious concrete specimens were also monitored for a five day period following three weekly rainfall events. Results indicated that the pervious concrete was capable of providing an environment where ammonia and carbon dioxide could be volatilized. The carbon dioxide emissions indicate microbial activity where immobilization of nutrients and decomposition of the manure could occur. Therefore, additional nutrients could be retained by microorganisms in animal waste deposited on the pervious concrete surface.

ASSESSMENT OF COAL WASTE IMPACTS ON THE MUNICIPAL WATER SUPPLY IN MARTIN COUNTY, KENTUCKY USING HOT WATER TANKS

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In 2000, a breach in a coal waste impoundment in Martin County, KY released over 300 million gallons of coal sludge and black water into area waterways. Government and corporate sponsored agencies conducted impact assessments. Local residents were dissatisfied by the conclusions reached by the environmental firms under subcontract by the coal company. In 2005, the Kentucky General Assembly authorized money to independently assess the spill's impact on the human and natural environment, especially the local water supply. These studies were conducted with local citizen participation and oversight to ensure the transparency and reliability of data thus generated. Water taken from the drain valve of hot water tanks was used to test for possible accumulation of heavy metals from the municipal water supply. Since sediment and precipitates may accumulate in the tanks from the moment the tank is installed, they may reflect historical accumulation either through long term low level buildup up or though high level spikes that may periodically occur. Fifty-six water heaters were analyzed in Martin county with an additional 30 and 33 samples taken from Pulaski and Madison Counties, respectively, for comparison. Metals analyzed included mercury (Hg), arsenic (As), barium (Ba), cadmium (Cd), chromium (Cr), cobalt (Co), copper (Cu), iron (Fe), lead (Pb), manganese (Mn), and selenium (Se). The type of water heater, type of usage, and usage volume were recorded. Arsenic, Cu, Fe, and Pb exceeded safe drinking water levels in some cases.Further research is underway to assess relationships between this sort of sample and hot water delivered to the tap and thus available to residents. The concentrations of some metals, including As, Ba, Cd, Cr, Co, and Fe were found to correlate with each other consistently. This may allow one of more of these metals to act as an indicator for a broader variety of metals. No clear relationships were detected between age of tank and metal accumulation. A higher percentage of samples from Pulaski County had safe drinking water exceedences than either Martin or Madison counties. Several metals, including As, Cu, Fe, Hg, Mn, and Pb were significantly higher on average (ANOVA-Scheffe's test) than Martin and/or Madison counties. This method may allow the assessment of water quality provided by different municipal water supplies.

NOTES

STUDY OF SOIL EROSION MODELS AT THE WATERSHED SCALE AND DATABASE DEVELOPMENT

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Soil erosion in watersheds is the process by which particles of minerals, nutrient, and organics are removed from the earth's surface. The particles are transported by water and either settled in-stream temporarily or flushed out of the watershed. Watershed erosion models are used to predict soil transported in a watershed based on size and mass flow of water. The models are developed to understand erosion across different size watersheds, physical features, land-use, and GIS ability, all using the type of model and time of the event. This research focuses upon a comprehensive review of over 50 watershed erosion models and construction of an accompanying database for model selection based on modeling characteristics. The review studies models from small and large scale watersheds. Also, I am looking to link GIS programs to models to assist and understand the topography with erosion. We also would like to learn the erosion of soil when land is being used, such as for mining and agriculture sources. These models are categorized as either continuous or event-based. They are also separated as empirical, semi-empirical, and physically-based models. The significance of this research is that with our database, models may be easily chosen for study sites based on different scales, GIS, land-use, and vegetation. It is anticipated that in the future our database will be used for watershed erosion model selection for solving watershed sedimentation problems.

NOTES

EXPERIMENTAL STUDY OF A CORRELATION BETWEEN VARIOUS SOIL PARAMETERS AND RESULTANT EROSIONAL COHESIVE STRENGTH

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Erosion of cohesive sediment (silt, clay, and fine organics) heavily influences surface water quality. Many harmful particles such as organic contaminants and metals are entrained in the sediment/pore-water strata of a given sediment bed. The contaminants adsorb to cohesives due to cohesives' distinct attractive nature. Upon sediment resuspension via erosion, the harmful particles are released into surface water flow and pose a potentially dangerous threat. This danger is especially applicable to Kentucky, as siltation due in large part to cohesive sediment erosion is the leading surface water impairment in the state.

Erosional cohesive strength refers to the magnitude of microscopic, electrochemical bonding present in cohesive sediment. In practical application, it describes sediment bed particles' resistance to resuspension in the water column. Because of the microscopic nature of erosional cohesive strength, it has historically been much harder to test and observe experimentally than its macroscopic counterpart we are more familiar with – mechanical cohesive strength.

The relationship between specific soil properties and resultant mechanical cohesive strength is well defined. Less is known about a similar relationship for fluvial erosional strength which, if developed, could aid in current efforts to mitigate Kentucky's surface water quality concerns. The objectives of this study are to examine this relationship and its controlling properties through a literature review, to develop an equation relating the erosional cohesive strength of a soil to those properties, specifically for sediments typical of Kentucky, and to test the equation in the lab by engineering soils with desired properties and observing their resultant erosional cohesive strength in an experimental flume. This poster presentation describes our ongoing methods and preliminary results to complete the described tasks.

STUDY OF SEDIMENT AGGREGATES IN THE KENTUCKY RIVER BASIN

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Fine sediment in streams impacts several aspects of water quality including (1) transport of pollutants such as heavy metals, (2) directly and indirectly causing fish kills, and (3) disrupting intake systems of water treatment plants. It is well known that sediment largely travels as composite particles called aggregates or flocs. Despite their significance, a conclusive theory of the factors and processes impacting sediment aggregates in streams has not been substantiated. Further, modeling tools that predict the size of sediment aggregates within the watershed setting do not exist. The objective of this project was to sample sediment aggregates from streams in the Kentucky River Basin and study their size and organic matter characteristics in order to better understand the factors and processes impacting the aggregates. Size is an important characteristic of aggregates because it is directly related to whether the particle will settle or remain suspended for subsequent transport downstream. Organic matter, such as algae, is an important characteristic because it directly impacts aggregate size. Microbial organisms excrete exopolymeric substances (EPS) which have been described as the most important characteristic affecting aggregate size. In addition, organic matter was studied because it is related to a number of environmental issues (e.g., fish habitat, carbon cycling). GIS methods were also employed to determine watershed characteristics such as slope, land use, climate, and soil properties that could potentially affect the aggregates. Three regions within the Kentucky River Basin were chosen to represent different types of land use, because it is hypothesized that land use will impact the processes controlling aggregate size. The South Elkhorn watershed in Lexington, Kentucky was chosen because of its urban and agricultural regions and was broken up into agricultural, urban, and mixed sub-watersheds. The Red River watershed was chosen because of its forested and agricultural land uses. In addition, the Letcher County region was chosen because of the mining and forested land uses and the watershed was broken up into sub-watersheds with land uses including active mining, recently reclaimed, reclaimed more than 10 years ago, and old growth forest. To study the aggregates, samples are collected in sediment traps and brought back to the lab where a sub-sample is taken for aggregate analysis with an inverted microscope. Algal counts are made, and image analysis software is then used to analyze the size distribution of the aggregates in each sample. Results from the GIS analysis reveal that land use is the most varied characteristic in the sub-watersheds, with other characteristics remaining fairly constant between sites. Algal counts will show trends which may correlate with the trends observed through the aggregate size analysis. Spatial and temporal trends can also be identified with the algal counts and aggregate size analysis. These results will provide an important step towards developing a model to predict sediment aggregate size at the watershed scale.

2001 vs. 1992 LAND COVER CHANGE PATTERNS OVER A FIXED SPATIAL INTERVAL USING THE USGS KENTUCKY CLIMATE DATA GENERATOR OF THE KENTUCKY WATERSHED MODELING INFORMATION PORTAL (KWMIP)

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In September, 2004, The Kentucky Commonwealth Office of Technology (COT) was awarded $750,000 from the US Environmental Protection Agency (USEPA)'s Environmental Information Exchange Network (EIEN) to develop the Kentucky Watershed Modeling Information Portal (KWMIP). This 2-year project will develop a web-based portal to quickly and accurately deliver current, and appropriately formatted, watershed model input data for selected models.

The US Geological Service (USGS) has been continuing work on development of the KY Climate Model (KCM) for temperature and precipitation. The model applies and enhances a spatial regression approach that has been applied in New Jersey and Colorado. The spatial regression model equations have been established and work on the user interfaces is ongoing. The KCM will be accessed through KWMIP to provide daily temperature and precipitation model results in model-ready format. Climactic data are interpolated for nodes along a 1-km grid.

The 2001 vs. 1992 Anderson Level I land cover change mask was produced by USGS (Coan et al., 2006) and processed to eliminate image clutter. The KCM 1-km grid was used to characterize spatial variability of change at pre-determined intervals across several watersheds of interest (Figure 1).

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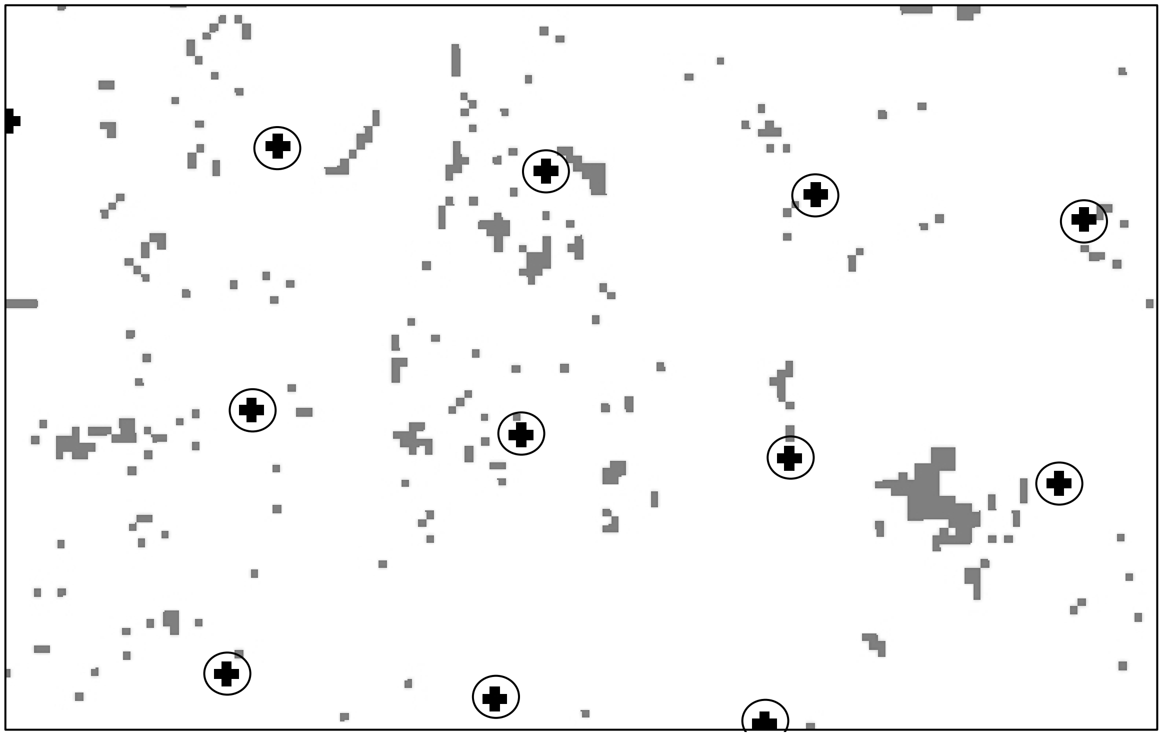

Figure 1. The Kentucky Climate Model 1-km grid (indicated by encircled crosses) overlaying areas of land cover change between 1992 and 2001. Approximate scale: 1:30,000; North direction is up.

MONITORING SOIL MOSITURE FOR EFFICIENT USE OF IRRIGATED WATER ON SELECTED GRASS LAWNS

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Soil moisture content is one of the factors that controls the infiltration capacity of soils. Precipitation and irrigation increase soil moisture which in turn reduces infiltration capacity. This results in increased runoff during subsequent storm events. Increased stormwater runoff may cause adverse environmental problems such as increased soil erosion, increased bed and suspended loads in streams, and increased non-point source pollution. Monitoring soil moisture on irrigated plots can be used as a guide for efficient use of irrigated water. Thus, irrigation systems only will be turned on when soil moisture falls below a threshold value for the respective soil type. However, landscapers at Northern Kentucky University (NKU) schedule the irrigation of grass lawns without taking into consideration the level of soil moisture. This has resulted in irrigation of the lawns during or immediately after a heavy storm event.

Effective monitoring of the soil moisture of irrigated fields has been shown to help in controlling cost of irrigation and conserving valuable resources. This can be achieved by using instruments such as tensiometers and neutron probes to monitor soil moisture (Manning, 1992). On an irrigated field such as a grass lawn, the ideal condition will be to maintain soil moisture between field capacity and wilting point. The objective of this study is to investigate the effect of soil texture and slope on the amount of irrigated water used on selected grass lawns on NKU campus at Highland Heights, Kentucky. The grass lawns were selected based on low slope (0 to 10^0), medium slope (10^0 to 15^0), and high slope (more than 15^0). Two plots were selected for each slope category. The soil texture of each grass lawn was determined by performing standard particle size distribution analysis of samples taken during the installation of the tensiometers. A survey instrument and GIS software were used to analyze the slopes. The tensiometers were monitored daily and NKU Grounds Department was advised to irrigate those plots only when the soil moisture fell below a specified threshold level. The threshold value was between 70 and 80 centibars for the range of soil textures at the site. Temperature and precipitation data were gathered from NKU’s Department of Physics and Geology weather center and the Northern Kentucky Airport Weather Station.

The second low slope plot (LSII) has the highest percent sand of 40% whilst the second medium slope (MSII) has the lowest sand of 30%. Although the textures of the low slope plots are significantly different, there was not much difference between the moisture readings. However, a slight difference in the texture of the high slope plots tends to affect water infiltration and moisture retention capacities. It takes longer for water to infiltrate the finer grained, high slope plot but it retains the moisture longer once it is saturated. Air temperatures of 85^0 F and above were the controlling factor as all plots dried faster after irrigation or precipitation. Overall, the soil moisture monitoring resulted in less irrigated water use; less than half the normal amount.

NOTES

NITRITE REDUCTION BY FE(II) ASSOCIATED WITH KAOLINITE

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The microbial reduction of solid Fe(III) hydr(oxide) minerals by iron reducing bacteria is an important process in biogeochemical cycling of nutrients and trace metal contaminants. The presence of NO_3^- can inhibit the net Fe(III) reduction to Fe(II) under anoxic conditions. There are several mechanisms proposed to explain such phenomena (Matocha and Coyne, 2007). One proposed mechanism involves simultaneous NO_3^- and Fe(III) reduction coupled to chemical reoxidation of Fe(II) to Fe(III) by NO_2^-, the intermediate of NO_3^- reduction (Komatsu et al., 1978; Obuekwe et al., 1981).

A majority of the Fe(II) produced during microbial Fe(III) reduction exists in precipitated or sorbed forms. For example, Kukkadapu et al. (2001) reported that in Fe(III) oxide-rich subsoils with mixed mineralogy, dissolved biogenic Fe(II) adsorbed strongly to kaolinite. Accordingly, the objective of this study was to investigate the role of Fe(II) associated with kaolinite in the reduction of NO_2^-.

Nitrite was added to stirred kaolinite suspensions under anoxic conditions to simulate field conditions where Fe(III)-reducing conditions occur. It was found that nitrite was reduced rapidly by Fe(II) associated with kaolinite when compared with solutions devoid of kaolinite. One of the major products of nitrite reduction was nitrous oxide (N_2O), an important greenhouse gas. In the process, Fe(II) was reoxidized to Fe(III). This supports the chemical reoxidation pathway of Fe(II) by NO_2^- in contributing to the inhibition of Fe(III) reduction. This research is a timely pursuit given the high costs of N fertilizer and the desire to protect water resources from elevated NO_3^- levels.

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NOTES

EUTROPHIC CONDITIONS IN THREE NORTHERN KENTUCKY STREAMS

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Census Bureau data indicates that the Northern Kentucky region, with a population growth of more than 13.5% since 2000, is rapidly transforming from an agricultural to an urban landscape. With urbanization comes pollution and water quality degradation. Eutrophication, a highly productive condition caused by excess nutrient loading from agricultural runoff and/or treated sewage effluent from urbanized areas, causes noxious algal blooms promoting diurnal dissolved oxygen and pH swings that degrade water quality and aquatic habitat integrity. Water quality declines when impervious surfaces reach 10% of watershed area and at 25% channels incise, banks erode and sediment load is transported downstream where it settles out and destroys physical habitat (Pelley, 2004). Ultimately, though agriculture does contribute to nutrient enrichment, urbanization is currently the biggest threat to local and regional water resources. Urbanization leads to impaired chemical and physical conditions that negatively impact the biological component of surface waters. Though degraded water quality associated with both agricultural and urban land use is well documented, no data exist that describe the trophic state of area streams or land use impacts.

The United States Environmental Protection Agency (USEPA) developed nutrient and eutrophic response variable criteria to prevent nuisance algal growth (USEPA 2000a, 2000b). These criteria are specific to streams with similar geology, topography, land use, and nutrient concentrations (*i.e.* subecoregion), and serve as a starting point for states to delineate their own criteria. For each subecoregion, recommended limits were published for N, P, sestonic and benthic algal biomass (*i.e.* primary eutrophic response variables), DO, and phosphorus storage in benthic algae (*i.e.* secondary response variables) (USEPA, 2000a; 2000b).

Given the current population growth and expansion of urbanized areas in northern Kentucky, it is imperative that we understand as much as possible about the impact of urbanization on local streams. To that end, we are assessing nutrient concentrations and eutrophic response variables in three Northern Kentucky streams. The year-long study, still in-progress, began in April 2006 and will continue through March 2007. There are three main objectives: 1) to document the trophic status of 12 Mile, Doe Run and Banklick Creeks by sampling bi-weekly and comparing data to U.S. EPA criteria for water quality protection; 2) to assess the relationship between trophic indicators: pH, dissolved oxygen, conductivity, nitrogen and phosphorus concentrations, sestonic and benthic algal biomass, and phosphorus concentration in benthic algae in the sampled streams; and 3) to examine the potential for developing a model of water quality parameters that quantifies land use impacts on northern Kentucky streams.

Results presented here indicate that nutrient concentrations, nitrogen and phosphorus, exceed U.S. EPA standards > 70% of the time (one tailed t-test comparison of data to U.S. EPA recommended values, p = 0.05). As would be expected with eutrophic waters (*i.e.* nutrient enriched), sestonic and benthic algal biomass, a primary eutrophic response, exceeded U.S. EPA criteria of 5.37 ug/L chlorophyll a and 150 mg chlorophyll a per m^2, respectively. Periphyton phosphorus storage, a secondary response to eutrophication, also exceeded U.S. EPA criteria of 20 mg/m^2 nearly 85% of the time (p = 0.05). We conclude that all three Northern Kentucky streams are eutrophic and that the biological responses to eutrophication detected thus far are a signature of land use impacts on water quality.

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THE BIG DIP: GEOGRAPHIC DISTRIBUTION OF HIGH METALS OBSERVED IN EASTERN KENTUCKY HEADWATER STREAMS

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The "Big Dip" was a diagnostic sampling of 917 headwaters streams in southeastern Kentucky conducted in the summer of 2006 by 30 volunteers and 6 paid staff in a collaborative project between the Eastern Kentucky Environmental Research Institute, and Head of Three Rivers Project, which staffs an AmeriCorps*VISTA member in Letcher County as part of the U.S. Office of Surface Mining's Appalachian Coal Country Watershed Team.

The interdisciplinary community-based research project integrated geography and chemistry to establish baseline data on a suite of analytes that could be tested at relatively low cost and using simple field collection methods (e.g., multi-parameter probes and test strips) over a wide geographical area. The field team endeavored to take a water sample at every reasonably accessible first-order stream in a six-county area of eastern Kentucky (Breathitt, Harlan, Knott, Leslie, Letcher, and Perry counties). The samples are concentrated primarily in the Kentucky River headwaters, and Letcher County portions of the Cumberland River (Poor Fork) and the Big Sandy River (Levisa Fork.)

Between June and September, 917 sites were sampled for pH, conductivity, temperature, alkalinity, hardness, nitrite, nitrate, and iron and mapped using GPS units. Among the nine parameters examined, three stood out as potentially good indicators of threats to stream health—conductivity, iron, and pH. While about a third of the samples were in the good or normal range of these parameters, two out of every three sites registered an extreme value of at least one—and often more than one—of these three basic water quality indicators (conductivity > 500µhos; iron > 1 ppm; pH > 8.2 or <5.0).

In addition, a full metals analysis of 36 metals and metalloids was conducted for 21 samples using the ICP at the Environmental Research Training Laboratory (ERTL) at the University of Kentucky. High levels of aluminum, manganese, and iron were identified in many of these samples. These high metals are consistent with acid mine drainage that originates from abandoned mine lands—or what EPA considers "preexisting discharges."

While several simultaneous analyses of these data are ongoing, this presentation will focus on the geographic distribution of these samples were high metals were observed. Using a GIS-based cluster analysis approach, the geographic distribution of these high metals observations is examined to determine whether or not they are associated with abandoned mines. Furthermore, the “analytic signatures” of the basic parameters that were collected at all 917 sites is compared with these 21 metals analysis sites to determine whether a pattern can be discerned that might be used to identify additional sites that should be tested for heavy metals.

ASSESSMENT OF AGRICULTURAL BEST MANAGEMENT PRACTICES IN THE BRUSHY CREEK WATERSHED

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The Brushy Creek watershed is located in the south central Kentucky counties of Lincoln, Pulaski, and Rockcastle. This watershed encompasses approximately 29,000 acres located in the Mississippian Plateau physiographic region of Kentucky. This boundary includes the four 14-digit subwatersheds of Upper Brushy Creek, Lower Brushy Creek, Bee Lick Creek, and Clifty Creek. Brushy Creek is a major tributary of Buck Creek. Buck Creek and its tributaries have been a primary focus for the Kentucky Chapter of the Nature Conservancy as they are home to more than 30 species of freshwater mussels (nine of which are endangered or of state concern), 77 species of fish, and one endangered bat species . The threats to this outstanding resource water are incompatible forestry practices, livestock production practices, crop production practices, invasive species, recreational vehicles, and unimproved creek crossings (The Nature Conservancy, 2006).

Buck Creek and its tributaries have been an area of interest for federal and government programs that provide funding for agricultural best management practices (BMP). Buck Creek was a designated United States Department of Agriculture (USDA) Environmental Quality Incentives Program (EQIP) priority area in 2001 and 2002. There has also been funding from the US Fish and Wildlife Service Partnership for Wildlife Program, Kentucky Division of Conservation's State Cost Share Program, and federal Farm Bill programs such as the Continuous Conservation Reserve Program (CRP).

Agricultural best management practices (BMPs) can be defined as methods or a system of methods that are implemented for the reduction of non point source pollution in agricultural watersheds. There is much documentation to attest that these methods are of great value at the small watershed (field) scale, but there is little existing research of effectiveness at the medium or large watershed scale. Spatial scale has a great influence on the modeling of non point source pollution and BMPs. The small (field) scale approach has been successful in modeling the upstream-downstream effects of BMPs on small plots of land such as large farms or groups of small farms. The effects of BMPs at the medium watershed scale, such as that of a small tributary stream or at the large watershed scale, such as a 14-digit HUC watershed is still largely unknown. This research project used water quality and statistical analysis along with geotechniques to assess the effects of BMPs in the large-scale (29,000-acre) Brushy Creek watershed.

Water samples have been collected in the Brushy Creek watershed since May of 2006. These samples have been collected from 25 surface water and 5 groundwater sites. The samples have been analyzed for nutrients (nitrogen, nitrogen ammonia, total phosphorus, and orthophosphate), total coliforms, and escherichia coli. Dissolved oxygen, water temp, pH, and specific conductance measurements were collected in the field using a YSI 556 multi-probe instrument.

Results of the preliminary statistical and geostatistical analysis relating water quality to BMP implementation at the watershed scale will be discussed. While data collection is still in process, preliminary analysis indicates that, at the watershed scale, BMPs may not have a significant influence on water quality. Furthermore, the karstic nature of the watershed and the resulting ground-surface water interactions may reduce the effectiveness of some BMPs—particularly those that aim to restrict cattle from creek bank access by providing alternate watering supplies if the practice leads to cattle congregating in very karstic areas where pollutants are likely to be transported quickly to the stream network via groundwater.

GROUND-TRUTHING REMOTELY SENSED DATA IN A SMALL WATERSHED ON THE URBAN/RURAL FRINGE

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Accurate land use data is essential to the study of how land use practices affect the quality of receiving waterways, but obtaining very high accuracy at the large scale—the scale necessary to link land use with water quality in a small watershed—can be prohibitively expensive. The purpose of this study was to test a method of generating a land coverage at reasonable cost by combining the NLCD dataset, the National Agriculture Imagery Program (NAIP) digital orthophotography, and a limited number of field observations to produce a revised polygonal land use layer. The study site is the drainage area for Wilgreen Lake—a small manmade lake on the outskirts of Richmond, Kentucky.

At present, a common and inexpensive land cover layer is the National Land Cover Dataset (NLCD), a raster-based coverage derived from 1992 Landsat thematic mapper imagery at a 30-meter resolution. While it is good for the state scale, the 30-meter resolution and rasterized pixellation is much less accurate at the small watershed scale where many land management decisions take place.

During fall 2006, a geographic information system (GIS) was used to overlay the NLCD layer with the NAIP imagery, highlighting conflicts in landscape type primarily by shape. Using the maps generated, a series of field sampling sites were identified, and observations of landscape type were made at these locations and hand-drawn over the printed map. A revised land coverage was then generated in polygonal form using the same 21 land cover categories from the NLCD.

While the methodology was generally successful at producing a high-resolution land coverage at relatively low cost, several problems were encountered in the process that should be noted. First, pixels were not always aligned with the NAIP land cover images. Second, when the newly generated coverage was compared to the NLCD, some forested areas appeared misplaced due to pixilation imprecision. Visual inspections of the watershed also identified several misclassifications in the NLCD imagery—notably that "pasture" was incorrectly classificed as "developed open space"—a classification error that could have major impacts on a watershed study. Finally, changes in land coverage have occurred since the imagery was taken in 2001. These last two issues highlight the importance of supplementing the GIS overlay process with adequate in-field ground-truthing to derive a sufficiently accurate land coverage for use at the watershed scale.

NOTES