Mar 21st, 2:30 PM

Session 2C

Kentucky Water Resources Research Institute, University of Kentucky

---

Kentucky Water Resources Research Institute, University of Kentucky, "Session 2C" (2011). *Kentucky Water Resources Annual Symposium*. 8.
https://uknowledge.uky.edu/kwrri_proceedings/2011/session/8

COMPARING THE KENTUCKY PHOPHORUS INDEX WITH THE P LOSS CALCUALTED WITH A PROCESS-BASED MODEL

Carl H. Bolster
Animal Waste Management Research Unit, USDA-ARS, Bowling Green, KY 42104
Phone: 270-781-2632; E-mail: carl.bolster@ars.usda.gov

Introduction: Eutrophication from excess phosphorus (P) loading is widespread among U.S. water bodies with a substantial portion of the P originating from agricultural fields. To reduce the impact agriculture has on water quality, USDA-NRCS includes P-based planning strategies in their 590 Standard to restrict P application to fields where the risk of P loss is high. In the 590 Standard, the most common strategy employed to rate a field's vulnerability to P loss is the P index. The P index is an assessment tool developed to identify fields which are most vulnerable to P loss by accounting for the major source and transport factors controlling P movement in the environment. USDA-NRCS is currently revising the 590 Standard and may require states to test the accuracy of their P index. When measured edge-of-field P loss data are scarce, as is the case in Kentucky, a P index can be tested against P-loss data generated from a validated process-based P transport model. With this in mind, the objective of this study was to compare KY P index values with simulated P loss data obtained from a validated P-loss model to identify areas where the index may need revising.

Methods: The Kentucky P index includes 10 field characteristics, each weighted by a factor of 1, 2, or 3 to reflect that factor's perceived importance on P loss. Each site characteristic is assigned a value rating of 1, 2, 4, or 8 points representing low, medium, high, and very high risk of P loss, respectively. The weighted value ratings for each characteristic are then summed to obtain a final P index value.

Risk values generated by the KY P index were compared with simulated P loss generated from the model of Vadas et al. (2009) to determine if values from the index were directionally and proportionately consistent with the P loss model. The index was first compared with simulated P loss data for field conditions where runoff P loss from soil is the dominant P loss pathway. Annual runoff required for the P loss model was calculated with the SCS curve number method using 30-yr daily precipitation data collected in Leitchfield, KY. Curve numbers (*CN*) for moisture condition II were obtained from SCS published tables for all four hydrologic soil groups for a cultivated field with conventional tillage. Curve numbers were modified to account for slope.

Output from the KY P index was also compared with simulated P loss data under conditions where the predominant pathway of P loss is through soil erosion. Soil loss was calculated for a representative field in Kentucky using the Revised Universal Soil Loss Equation (RUSLE). Because land cover is used as a surrogate for erosion in the KY P index, erosion rates were calculated for land cover values of 7, 22, 45, and 75 % representing low, medium, high, and very high risk values in the KY P index by modifying the cover management parameter (C) in RUSLE accordingly. Erosion rates were also calculated by modifying the RUSLE slope length and steepness factor (LS) for field slopes of 1.5, 3.5, 9, and 13 % representing low, medium, high, and very high risk values in the KY P index, respectively.

Results: Results show that the KY P index is directionally consistent with the Vadas P loss model when assessing the risk of dissolved P loss from soil. The increase in the P index with soil test P (STP), however, is nonlinear whereas the Vadas model predicts a linear increase in simulated P loss with runoff. A linear relationship between dissolved P and STP is often observed in P loss studies.

The KY P index uses both soil hydrologic group and field slope to calculate risk of P loss from runoff. Results show that the KY P index is directionally consistent with the simulated P loss data with increasing risk with increasing runoff potential. The increase in the P index with hydrologic soil group, however, is nonlinear whereas the increase in P loss with runoff is linear for the simulated P data with slope depending on STP. Differences in simulated P loss for soils with different STP values increases with increasing runoff, whereas for the KY index these differences are the same regardless of runoff.

Field slope is also included in the KY P index to account for risk of P loss through runoff. The effect of field slope on runoff depth is relatively minor when using the *CN* slope modification equation. As a result, predicted P loss increases only slightly with increasing slope as compared to increases in P loss with increasing runoff. The KY P index, on the other hand, is formulated in such a way that increasing slope has the same effect on calculated P loss risk as increasing field runoff potential. This discrepancy between the simulated data and the KY P index suggests a limitation in how field slope is weighted in the KY P index.

Comparison of P index values with simulated P loss data shows that output from both models increases nonlinearly with decreasing land cover (and thus increasing soil erosion). While the KY P index is directionally consistent with the output from the process-based model, it is not proportionately consistent with the model. This suggests that as formulated and weighted, the KY P index underestimates the impact that decreasing land cover has on the risk of P loss by eroding soil. An additional limitation to the KY P index is that it only uses land cover as a surrogate for erosion even though erosion is a function of many different factors.

Summary: Comparing the KY P index with output from a process-based P loss model suggests that in some areas the index does a good job in assigning P risk. However, this analysis also showed some important deficiencies in the index, including the neglect of important factors known to affect P loss and in how the different factors in the index are weighted. To reduce the amount of P that is exported from agricultural fields to waterways within Kentucky, effort and resources should be devoted to updating the KY P index as well as developing long-term monitoring sites where the index and process-based models can be evaluated against measured P loss data.

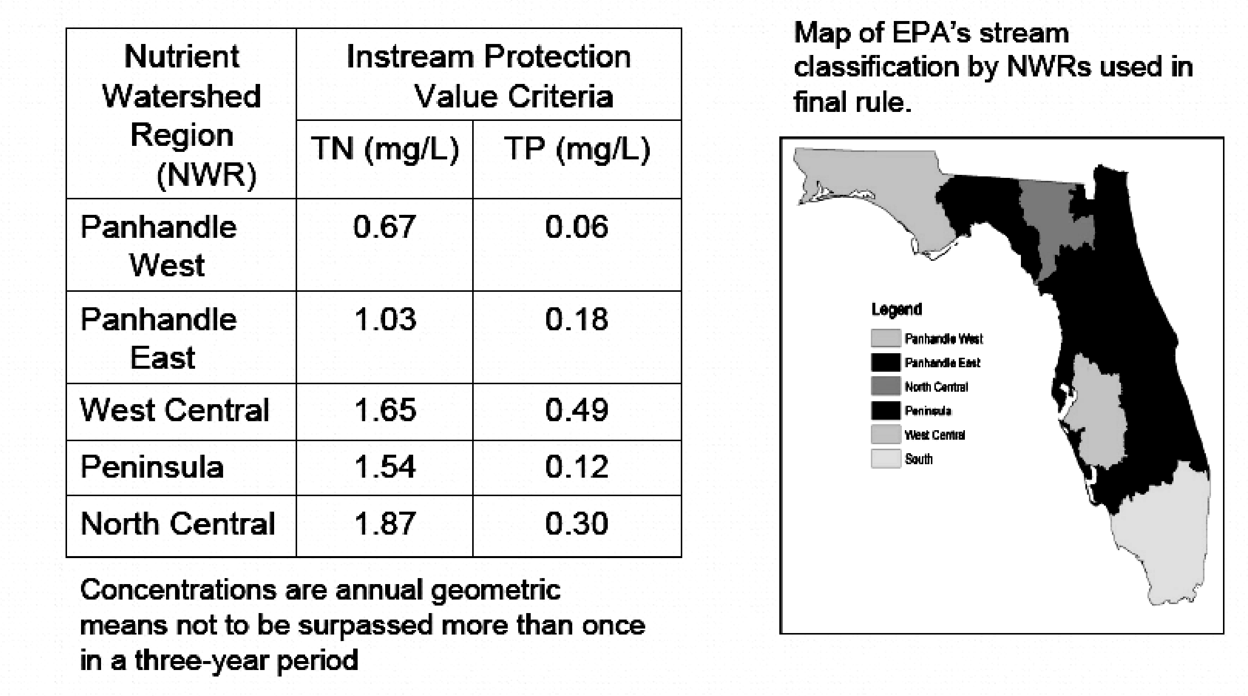
Reference: Vadas, P.A., L.W. Good, P.A. Moore Jr., and N. Widman. 2009. Estimating phosphorus loss in runoff from manure and fertilizer for a phosphorus loss quantification tool. Journal of Environmental Quality 38:1645-1653.

KENTUCKY NUTRIENT CRITERIA
DEVELOPMENT AND REDUCITON STRATEGY

Clark Dorman, Manager
Water Quality Branch
KY Division of Water
200 Fair Oaks, 4th Floor
Frankfort, KY 40601
Ph. 502-564-3410
Clark.Dorman@ky.gov

The presentation will: 1) summarize the nutrient problem nation-wide and in Kentucky including the number of impaired lakes and stream miles; 2) address how designated uses are affected; 3) outline economic and social costs of nutrient problems (water treatment costs, lost tourism dollars, reduced recreation opportunities, loss of stream ecosystem services), and 4) discuss EPA's push for numeric standards – rationale (assessment, TMDL targets, permit limits)

Florida standards for wadeable streams: utilizing a reference site approach



Nutrient Watershed Region (NWR)	Instream Protection Value Criteria	
	TN (mg/L)	TP (mg/L)
Panhandle West	0.67	0.06
Panhandle East	1.03	0.18
West Central	1.65	0.49
Peninsula	1.54	0.12
North Central	1.87	0.30

Concentrations are annual geometric means not to be surpassed more than once in a three-year period

Map of EPA's stream classification by NWRs used in final rule.

Kentucky's development of wadeable streams bioregional nutrient guidelines: Multiple lines of evidence.

- Stressor-response relationships (macroinvertebrates and algae)
- Reference stream nutrient ranges
- Nutrient ranges for sites with "passing" Macroinvertebrate Bioassessment Index
- Regionally relevant literature values for adverse effects or trophic status

Draft wadeable streams **bioregional nutrient guidelines** for Kentucky:

Bioregion	**TN (mg/L)**	**TP (mg/L)**
Mountains	0.65	0.03
Miss Valley - Interior River Lowland	1.40	0.07
Pennyroyal	1.40	0.05
Bluegrass	1.20	0.10*

Numbers are similar in magnitude in many cases to Florida regional criteria. While our approach has added benefit of weighing more lines of evidence, our datasets are much weaker (less confidence that the nutrient ranges are fully described by the data available – most data from summer baseflow conditions). Still, if EPA were to promulgate criteria for Kentucky, the numbers would very likely be similar to these.

Challenges in translating general guidelines to numeric standards

- Local factors important in predicting actual effects on uses
- Local factors important in determining expected natural inputs

Better nutrient standards are an important tool in reducing nutrient-related problems in surface waters. The current narrative standards have not prevented impairment of the uses and have not provided clear targets for restoration of uses. Establishing numeric criteria for instream concentrations is the prevailing approach to improving standards, but this is just a step in the process.

Nutrient Reduction Strategy
Kentucky-wide strategy to reduce nutrients through multi-dimensional approach.

Gaps: Research Areas and Data Needs

GENOTYPIC DIVERSITY OF *ESCHERICHIA COLI* ISOLATES FROM ENVIRONMENTAL SOURCES AND THE INFLUENCE ON TRANSPORT BEHAVIOR

Kimberly Cook[1*], Carl Bolster[1], Kati Ayers[2], and Dale Reynolds[3]
[1]USDA-ARS, AWMRU, Bowling Green, KY 42104
[2]Western Kentucky University, Bowling Green, KY 42104
[3]Kentucky Division of Water, Bowling Green, KY 42104
*Presenting author

Escherichia coli (*E. coli*) is a dominant intestinal commensal organism, an important fecal indicator bacterium (FIB), a pathogen and a target for microbial source tracking (MST). Strain level differences (genotypic and phenotypic) in *E. coli* influence its fate and transport and therefore have important implications for its validity as an FIB and for MST. Strain survival and variation are regulated by environmental conditions and many of the factors that are important in virulence inside a host are also important when the organism is exposed to diverse and unpredictable environmental conditions outside of the host. Both environmental and cellular characteristics determine the fate and transport of microbial cells following deposition in soil or waters. Isolates that will be transported to water and sediments are the subset of the population that will be used for monitoring purposes. Therefore, the validity of the indictor paradigm and the feasibility of microbial source tracking can not be fully evaluated without a better understanding of the ecology of this important organism.

The goals of this study were to (1) evaluate the diversity of *E. coli* in manures from livestock and stream-water samples taken following dry and wet weather events; (2) evaluate the effect of strain level differences on the attachment and transport of *E. coli*. and; (3) compare the concentration of *E. coli* present in water samples taken following wet or dry weather events to that of other indicator groups (*Bacteroides*, enterococci, clostridia). To evaluate diversity, 1346 *E. coli* isolates were obtained from poultry, swine and dairy manures and from seventeen stream-water samples taken from the Bacon Creek Watershed located in western Kentucky. Bacon Creek is on the EPA 303(d) list of impaired streams for pathogen presence. The predominant land use within the 90.5 square mile watershed is agricultural, but there are also surrounding rural communities with straight-pipes or septic systems. Samples were collected from the same locations following one dry weather event (n = 9; 72 hours without any rain) and one wet weather event (n = 8; 72 hrs of no rain followed by enough rainfall to cause runoff that reaches the stream). Slurry and litter samples (10 g or 10 mL) were plated onto selective media. Stream-water samples (0.5ml, 5.0ml, and 10.0ml) were filtered and placed onto selective media. Strain diversity among the 1346 *E. coli* isolates was evaluated by BOX-PCR analysis. *E. coli* source sub-group isolates were evaluated for the presence of genes associated with adhesion (*afa/draBC*, *iha*, *agn*43, *eaeA* and *fimH*), toxin production (*hlyA*, stx_1, stx_2), capsular polysaccharide synthesis (*kpsMTII*) and siderophores ($iroN_{E.coli}$, *chuA*). Attachment efficiencies to quartz sand were calculated for 23 *E. coli* isolates following transport through saturated porous media. Concentrations of indicator groups were measured by quantitative, real-time PCR (qPCR).

Richness of genotype profiles for livestock samples was relatively low (25, 12 and 11 for swine, poultry and dairy, respectively) compared to that of *E. coli* isolates from stream-water following dry or wet weather events (115 and 126, respectively). Genotype profiles for *E. coli* isolates from stream-water clustered with isolates from livestock species; however, over 34% of *E. coli* isolates from stream-water had genotype profiles that were distinct from those of the tested livestock species. Furthermore, only 18% of the 84 *E. coli* isolates from the wet and dry events clustered together, suggesting a high degree of temporal diversity. Genes associated with virulence (adhesions, toxins and siderophores) were present in *E. coli* isolates from all sources. The most commonly detected genes were the adhesions *fimH* (present in 80% to 95% of isolates) and *agn43* (present in 40% to 100% of isolates). Bacterial attachment efficiencies among 23 *E. coli* isolates varied by an order of magnitude (0.039 to 0.44). The isolate with the highest attachment efficiency possessed the largest suite of targeted genes including those for adherence, surface exclusion and siderophores. The five *E. coli* isolates with the highest attachments efficiencies were all positive for *agn43*and *fimH*. Concentrations of *E. coli* were generally 1-2 orders of magnitude lower than those of other indicators. There were significant increases in most populations during the wet event as compared to the dry event. In fact, concentrations of enterococci increased by more than an order of magnitude in response to the wet weather event.

Data from this study underscore the large degree of genotypic and phenotypic variation that exists among *E. coli* isolates. The impact of this diversity on genetic exchange and the concomitant effect on the organisms' fate and transport under *in situ* environmental conditions require further investigation. Interestingly, each of the three livestock groups had at least two isolates with the highest attachment efficiencies, while *E. coli* isolates from stream-water had generally lower attachment efficiencies. Although studies of virulence genes present in *E. coli* isolates from water sources have been conducted, these have not been correlated with transport characteristics. This is an important factor that warrants further research given the importance of *E. coli* as an indicator organism. It is possible that current monitoring criteria select for the sub-set of the *E. coli* population that is more likely to be transported (i.e., non-adherent). This could lead to biases in data interpretation if, for example, ruminants are more likely to have *E. coli* isolates with fewer genes important to adherence while poultry are dominated by isolates with high levels of adherence. This speaks to the ultimate goal of these studies of genotypic and phenotypic diversity of *E. coli*, which is to address the ecology of this important indicator organism and to identify factors that influence its fate and transport in the environment. The validity of the indicator paradigm and the feasibility of MST can not be fully evaluated without a better understanding of the ecology of the targeted populations. These studies underscore the importance of assessing *in situ* environmental conditions and source inputs for purposes of monitoring, modeling, source tracking and/or risk assessment based on the occurrence of this important indicator organism.

A MULTIPARAMETER APPROACH FOR THE IDENTIFICATION OF LEAKING AND OVERFLOWING SANITARY SEWERS IN THE WOLF RUN WATERSHED

Tricia Coakley[1,2] and Gail Brion[1]
859-257-6757
tcoakley@engr.uky.edu
gbrion@engr.uky.edu

[1]Department of Civil Engineering, University of Kentucky, Lexington, Kentucky 40506
[2]Department of Earth and Environmental Sciences, University of Kentucky, Lexington, Kentucky 40506

The Wolf Run Watershed of Lexington is influenced by leaking sanitary sewer lines and combined sewer overflows. Smoke testing and imaging has been used to locate many of the problems, but data is needed before and after repairs to show effective remediation. The Environmental Research and Training Lab of the University of Kentucky has collaborated with LFUCG and the Friends of Wolf Run to develop an approach for risk characterization and relative ranking of locations within the watershed. The goals of the study are to pinpoint locations of leaking sewer lines and to provide microbial fecal data to show that remediation efforts have been successful. The approach proposed for use included indicators of fecal load, age, and source as well as a sampling plan that includes a wide spatial and temporal range. Samples were collected from twenty locations in the Wolf Run watershed on ten dates between April and August of 2010. These samples were analyzed for viable E.coli bacteria, the ratio of atypical colonies (AC) to total coliforms (TC), and the concentrations of general and human specific Bacteriodes DNA markers. Although all of these indicators were found at each of the sample locations throughout the watershed, and across time, the approach presented here allowed for not only the pinpointing of specific hotspots, but also allowed for the differentiation between sewer line breaches and combined sewer overflows.

NOTES