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PLENARY SESSION

JOINING FORCES TO TACKLE THE DEAD ZONE

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The Northern Gulf of Mexico Hypoxic Zone measured 22,720 square kilometers (8,776 square miles) in July 2017, the largest on record. The Mississippi River/Gulf of Mexico Watershed Nutrient Task Force (Hypoxia Task Force) was formed in 1997 to investigate the causes of and coordinate activities to reduce the size of the hypoxic zone in the Gulf. In 2013, land-grant university representatives from 12 Mississippi River basin states joined together to form a sister organization to the federal task force. Southern Extension and Research Activities committee number 46 (SERA-46) is one of a group of formal USDA-NIFA and land-grant university funded committees designed to promote multistate research and extension activities. SERA-46 was created to operationalize a Non-funded Cooperative Agreement between the Hypoxia Task Force and land-grant university Extension and Experiment Stations in the North Central and Southern Regions of the United States. SERA-46 brings together researchers and extension specialists sharing a common interest and expertise related to the environmental, social, and economic factors that contribute to nutrient loss from agricultural lands, state-level nutrient impairments, and hypoxia in the Gulf of Mexico.

SERA-46 and the Hypoxia Task Force established common shared priorities in May 2015. Shared priorities serve as a basis for projects involving SERA-46 members related to strengthening networks, conservation systems research and outreach, and monitoring and tracking progress toward achieving the goal of reducing the hypoxic zone to 5,000 square kilometers. Special project funds from US EPA, the Walton Family Foundation, and other partners have assisted in the progress of priorities such as developing social measures of impact for use in priority watersheds; strengthening a network of watershed leaders (including those that are farmers) to increase the effectiveness of strategies for reducing nutrient losses from agricultural lands; and developing a framework to report progress with nonpoint source nutrient reduction.

WATER RESOURCES APPLICATIONS OF KYAPED AIRBORNE LIDAR DATA: A NEW ERA FOR HYDROSCIENCE IN KENTUCKY

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Since late 2017, Kentucky has been one of the few states to have publicly available statewide airborne LiDAR topographic coverage. Both gridded digital elevation models (DEMs) and ungridded point clouds are available. With a 5 ft (1.5 m) cell size, the Kentucky LiDAR DEMs are approximately 44 times more resolute and provide substantially better vertical accuracy than previously available 10 m DEMs. Statewide LiDAR coverage will allow Kentucky water scientists, engineers, and planners to work at a level of detail and sophistication not previously possible. Potential applications of the statewide LiDAR data, illustrated in this presentation using examples from Kentucky and elsewhere, include:

- Watershed visualization to enhance communications and stakeholder engagement.
- Surficial geologic mapping for land use planning and hazard assessment.
- Geomorphological studies to understand the long-term evolution of fluvial systems.
- Watershed and channel network delineation.
- Surface and shallow subsurface water flow routing and wetland delineation.
- Aquatic habitat carrying capacity and population dynamics simulations.
- Forest canopy and wildfire fuel loading evaluations.
- Rainfall triggered landslide and sediment loading susceptibility modeling.
- Sinkhole and karst feature delineation.
- More accurate identification of flood-prone areas.
- Fracture trace mapping for bedrock aquifer system studies.
- Geomorphological change detection as multiple coverages become available.

Experience has shown that the biggest impediment to full utilization of airborne LiDAR topographic data may be lack of familiarity with the data and software capabilities coupled with preconceived notions about the potential uses of topographic data. Some users, for example, may see only the possibility for smaller contour intervals because they are not familiar with the variety of sophisticated analyses available using modern GIS and LiDAR software. To help alleviate that problem, the Kentucky Geological Survey has established a Digital Earth Analysis Lab to help promote and support the widespread application of airborne LiDAR data to practical and research problems within the commonwealth.

TEMPORAL PERFORMANCE ASSESSMENT OF WASTEWATER TREATMENT PLANTS BY USING MULTIVARIATE STATISTICAL ANALYSIS

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For wastewater treatment plants, many samples are obtained and tested to assess performance throughout the day. However, the analyzed samples often indicate conflicting results or trends whereby it is difficult to determine if the plant is performing as expected. The objective of this study is to create a framework where statistical techniques are used to quantitatively assess the overall quality of wastewater treatment effluent with respect to intended applications. To develop the procedures, the study evaluated the performance of the Floyds Fork Wastewater Treatment Plant in Louisville, KY and worked to address the following objectives:

1. Identify the temporal characteristics of each monitored parameter
2. Develop Wastewater Quality Index (WWQI) to quantitatively define wastewater quality
3. Define the statistical interrelationships between different parameters
4. Introduce a finite set of uncorrelated variables which, within a minimum loss of original information, can represent the overall characteristic of wastewater
5. Develop multivariate statistical models to numerically express and forecast the significant quality parameters based on the measured historical process database

To comprehensively analyze the composition of wastewater and assess the treatment process performance, data from Louisville MSD's routine monitoring program were utilized. Collectively 9,180 samples were obtained from twelve quality and quantity variables between 2010 and 2016. The measured parameters include BOD, TSS, P, N, DO, pH, MLVSS, flow rate and the recycled activated sludge rate.

Preliminary, descriptive statistics were used to identify temporal fluctuation of each monitored parameter. However, a single parameter or one set of parameters cannot appropriately characterize the waste stream or comprehensively assess the treatment system efficiency. To overcome this challenging issue, two approaches were implemented:

1) The Wastewater Quality Index (WWQI) was introduced to efficiently summarize the numerous monitored parameters into a single unit-less number.
2) Multivariate statistical techniques and exploratory data analyses were applied to provide a comprehensive methodology for long-term assessment of wastewater characteristics as well as treatment process performance. The incorporated technique includes:
    - Correlation analyses: to determine the extent specific parameters were statistically correlated.
    - Principal component analyses (PCA): to investigate the interrelationships between a large group of variables, and to convert a large number of original correlated variables into a finite set of uncorrelated components. The derived components represent the information of the whole dataset with minimal loss of original information.
    - Statistical modeling: to develop models that can predict important quality parameters based on input conditions. The modeling approach was carried out by combining three

statistical methods including correlation, multivariate regression, and ANOVA analyses.

By developing the WWQI, the quality of influent and effluent wastewater was ranked from zero to 100. For the Floyds Fork analysis, the influent WWQI value was between 45 and 60 indicating the water quality was frequently threatened or impaired and would be threatening or potentially damaging to a receiving water. After treatment, the effluent WWQI was consistently between 96 and 100 indicating that the stream could be released to receiving waters with little threat of impairment. The analysis showed that the treatment process average resulted in a 51 percent improvement of the wastewater quality.

Application of the Pearson product moment correlation analysis on each pair of influent and effluent variables showed that out of twelve measured quality parameters for influent and effluent, four parameters were responsible for the variation of quality indexes.

Performing the PCA technique, the dimension of the data set decreased from fifteen variables to five factors which represent influent quality characteristic, influent quantity loading, influent and effluent ion activity, effluent oxygen demanding, and effluent nutrient loadings. The derived components described approximately 75.25% of the total variability of the data set and represented the overall variation in wastewater quality during the period of study.

The forecasting model development was carried out by considering the measured parameters during 2010 to 2015 as the training data. As a result, six descriptive numerical models were developed to predict influent and effluent phosphorus, BOD, and WWQI parameters. The developed models were then subjected to validation processes based on the results from the monitoring program conducted in 2016. All the established models showed high levels of statistical significance in addition to admissible accuracy in terms of fitting with the training data parameters, with 81.8% average accuracy, and validating with the testing dataset, with average relative prediction error of 2.9%.

The presented techniques and procedures in this research provide an assessment framework for the water/wastewater infrastructure monitoring programs and can be applicable to different treatment plants.