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Presentation Abstracts of the Keynote Speakers

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The Texas Air Quality Studies: State of the Science of Air Quality in Texas and Implications for Air Quality Policy

David Allen
(Department of Chemical Engineering, Center for Energy and Environmental Resources, and The Energy Institute, University of Texas, Austin, TX)

The Texas Air Quality Studies (TexAQS I and II), conducted in the summers of 2000 and 2006 were the largest air quality field studies ever undertaken in Texas. During August and September of 2000 and 2006, approximately 300 air quality investigators from around the world converged on the eastern half of Texas. Multiple aircraft and a large research vessel were deployed; multiple ground sites were established for collecting meteorological and chemical data.

This presentation, by one of the lead investigators for the Texas Air Quality Studies, will provide an overview of the studies and will discuss, in more detail, both the overall policy implications of the studies and the enhanced understanding of urban atmospheric chemistry that emerged from the studies. Specifically, the role of routine and episodic emissions of highly reactive volatile organic compounds (HRVOCs) will be discussed, and the emission cap and trade program developed to limit the emissions of HRVOCs will be analyzed.

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Educating the World's Engineers: The Challenge of Sustainability

Cliff I. Davidson
(Departments of Civil & Environmental Engineering and Engineering & Public Policy, Carnegie Mellon University, Pittsburgh, PA)

Over 350 definitions have been published for "Sustainability" and the list keeps growing. Yet most of these definitions have a common theme: we need to consider the long-term future as we make decisions today. The discipline of engineering represents one of the best examples of where this philosophy is needed, as engineering decisions can have a marked impact on the future well-being of civilization.

Rapid changes in engineering to accommodate sustainability principles are already underway. Unlike demands in decades past, engineers are now being asked to consider broad implications of their work, such as how their practice affects society today, how it affects the environment today, and how it is likely to affect society and the environment in the future. Because there are new responsibilities implied in these requests, the engineering community needs to take a pro-active role in advocating changes in the profession that are consistent with training.

These changes are of special significance to those of us in the engineering education profession. Engineering educators have the responsibility to ensure that the education process functions well and satisfies societal needs for trained engineers at all levels. But as societal demands on engineers change, educators need to account for those changes and work with the community of practicing engineers to provide appropriate courses and curricula. It is especially important to bring together engineering communities across the globe to communicate on possible solutions to worldwide resource limitation and waste generation problems. The unequal distribution of resources and waste treatment capacities among countries of the world demands global decisions, and this requires training of engineers who understand such problems from a global perspective.

In this talk, we consider some of the key challenges facing engineering educators to satisfy changing demands, focusing on the role of environmental engineering educators in helping society transition to a more sustainable state. We also identify some ways to cope with these challenges.

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Clean Technology for Converting Waste Gases from Pulp Mills into Value-Added Chemicals

Endalkachew Sahle-Demessie
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There are approximately one hundreds of pulp mills in the U.S. and offshore. The pulp and paper industry is recognized as one of the nation's highly polluting industries, since it generates significant amounts of by-product like methanol, reduced sulfur compounds and small amounts of other compounds including an average of $4.5x10^5$ lb toxic substances per facility that can have potentially serious impacts on the environment. As part of the Pollution Prevention Acts of 1990 the U.S. EPA has issued a combined air and water "cluster rule" that not only went beyond end-of-pipe and add-on controls, but also with eliminating or reducing the formation of these pollutants at the source. The regulations set goals for reduction in annual emissions of hazardous air pollutants (HAPs), volatile organic compounds (VOCs) and total reduced sulfur compounds (TRSs) of the various sources of the industry. The conventional treatment methods of incineration or biological degradation for pulping waste gases are costly and inefficient use of inherently useful resource.

The U.S Environmental Protection Agency (U.S EPA) National Risk Management Research Laboratory has been conducting extensive research on ozone-enhanced catalytic oxidation of air pollutants at mild temperatures using a rang of nanoporous and nanoparticle catalysts that meet most of the stringent industrial demands of sustainable development and clean technology. The results obtained highlight the success and benefit of the technology in oxidizing air pollutants that are typically present in Kraft pulp mills. We have achieved 99+ % removal of individual hazardous air pollutants, and total reduced sulfur compounds, namely methanol, mercaptats, methyl sulfide and dimethyl sulfide. The process converts methanol, a highly flammable toxin produced by the pulping of wood, into methyl formate and completely removes odor causing TRSs. The process also eliminates most emissions of carbon dioxide, a greenhouse gas, and sulfur dioxide, an ingredient of acid rain. Both are by-products of current pollution-control methods at paper mills. Using this technology North America's paper mills could save millions of dollars a year while eliminating most emissions of pollutants contained in acid rain and greenhouse gases. The process is being tested by Weyerhaeuser Co. pulp mill in Hawsevill, KY in a mobile pilot plant. The successful development and pilot scale tests of this emerging technology will be presented.

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Resource Recovery in Waste Management: Conversion of Wastewater into Biofuel

Jay J. Cheng
(Biological and Agricultural Engineering Dept. North Carolina State University, Raleigh, NC)

With the increase in world population and energy consumption in developed and developing countries, the world is facing a big challenge in sustainable development and global climate change. On the other hand, humans are generating a huge amount of wastes that need to be properly treated before their final disposal back to the nature. Many chemical compounds are destroyed during the waste treatment and they can be recovered as renewable resources. In the last eleven years we have been working on growing duckweed, an aquatic plant, to recover nutrients from animal wastewater and utilizing the duckweed for fuel ethanol production. Swine wastewater was initially treated in an anaerobic digester to convert carbohydrates into biogas. Nutrients in the anaerobic effluent were recovered by growing duckweed which produced a significant amount of starch with much higher yield than corn. The duckweed starch was then converted via enzymatic hydrolysis and fermentation to ethanol that can be used as biofuel.

Duckweed strains that grew well on anaerobically-pretreated swine wastewater were screened in an *in-vitro* laboratory experiment. The selected duckweed strains were then tested for nutrient recovery under laboratory and field conditions. The rates of nitrogen and phosphorus uptake by the duckweed growing in the *in-vitro* system were as high as 1.36 g/m2/day and 0.20 g/m2/day, respectively. The highest nitrogen and phosphorus recovery rates in the field duckweed system were 2.11 g/m2/day and 0.59 g/m2/day, respectively. The highest observed duckweed growth rate was 31.9 g/m2/day in both conditions. Wastewater nutrient concentrations and seasonal climate conditions had direct impacts on the duckweed growth and nutrient recovery from the wastewater. A mathematical model was developed to describe nitrogen transport in duckweed-covered static ponds for nutrient recovery from anaerobicallypretreated swine wastewater. The key parameters determined in the model include the diffusion coefficient of ammonium in the wastewater and kinetic constant of nitrogen uptake by duckweed.

Our recent research focuses on development of a system utilizing wastewater to produce duckweed biomass high in starch that is then converted to ethanol using existing hydrolysis and fermentation methods. In our laboratory study, a North Carolina strain of duckweed, *Spirodela polyrrhiza,* was selected to grow on anaerobically-pretreated swine wastewater. The duckweed had a starch content of 45.8% (dry weight). Enzymatic hydrolysis of the duckweed biomass with amylases yielded a hydrolysate with a reducing sugar content corresponding to 50.9% of the original dry duckweed biomass. Fermentation of the hydrolysate solution using yeast gave an ethanol yield of 25.8% of the original dry duckweed biomass. These results indicate that duckweed biomass can produce appreciable quantity of starch that can be readily fermented into ethanol. Duckweed proliferates through clonal, vegetative budding of new fronds and accumulates biomass faster than field crops, almost 28 times faster than corn. Annual starch production from a duckweed system can be 5-6 times higher than corn per acre.