Environmental Institute of Houston
2006 Annual Report

COVER—The Watersmart School Habitat Demonstration Lab serves as a teaching tool for both students and teachers. EIH will conduct professional development workshops for pre- and in-service teachers throughout the year. Also, students enrolled in the Science Trek program will utilize the habitat during the school year.

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HABITAT—(*top*) A UHCL grounds crew prepares the area in front of the NOA building where the Watersmart School Habitat Demonstration Lab will be installed. (*middle*) Volunteers from Lyondell Chemical Company construct a pergola that will provide shade for visitors and workshop attendees. (*bottom*) Volunteers plant a variety of native aquatic plants.

Public Participation in the NEPA Process in Southeast Texas

Kathleen A. Garland, Lisa B. Gossett and Humaira Hazur

The National Environmental Policy Act of 1969 (NEPA) is considered the first of the major, modern environmental statutes. NEPA has been a unique tool for identifying environmental impacts of proposed major federal actions. The NEPA process requires agencies to solicit input from the public and other governmental agencies at various well-defined intervals in its process, including scoping to identify the stakeholders and issues of concern early in the process, and public comments on and meetings relating to draft environmental impact statements. Some projects attract little if any interest, while others result in multiple contentious hearings.

The implementation of NEPA has become controversial at times. During 2005, the House Committee on Resources chartered a bipartisan Task Force to investigate how NEPA was working nationwide and to make recommendations on potential improvements. In recent years, there also have been some highly contentious NEPA proceedings. While there were plenty of opinions based on anecdotal experiences about the success or failure of NEPA, there was little objective data analyzing and comparing the public participation processes under this statute.

This project is a step toward addressing that gap, and has the following objectives:

- Collect numerical and stakeholder opinion data about the NEPA public participation process on major federal actions that have undergone the EA/EIS process in Southeast Texas in recent years.
- Compare data and stakeholder attitudes in our region to those of the nation as presented to the Congressional Task Force on Improving NEPA
- Contribute a well-researched discussion on the public participation process to the current discussion of how NEPA is functioning.

An initial challenge was identifying the recent NEPA actions in this area, since numerous federal agencies are involved and there was no single repository for NEPA information. Through searches on the Internet, discussions with environmental professionals, and meetings with personnel in multiple governmental agencies, voluminous documentation was obtained on each project identified. In the first phase, 15 local projects at various stages in the NEPA process were evaluated. Additional projects continue to be identified and added.

In late 2005, the Congressional Task Force issued their draft report. Some of the comments in the draft report were consistent with the initial observations under this project, and others were not. For example, the inclusion of large amounts of technical information in NEPA documents makes it difficult for certain stakeholders to participate in a meaningful way. On the other hand, the draft report raised resentment to the "interference" of national environmental organizations as a concern, while the research project found that this was not an issue regionally.

Initial data was presented at the annual conference of the National Association of Environmental Professionals in April 2006, and created considerable interest among NEPA practitioners. The research is continuing with identification of additional NEPA projects and analysis of scoping and hearing comments and meeting transcripts. The researchers have had many discussions with agency personnel about their experiences under NEPA, and will proceed with more in-depth analysis and interviews on selected projects.

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NEPA proceedings, including scoping comments, draft and final environmental impact statements, meeting transcripts, and submitted public comments.

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Establishment of a Weather Station on UH Main Campus for Atmospheric Education and Research

Sharon Zhong

HOUSTON, WITH ITS SUBTROPICAL LATITUDE AND PROXIMITY to the Gulf of Mexico, is subject to the influence of a wide range of weather phenomena such as tropical storms, hurricanes, frontal systems, sea-land breezes, low-level jets, and heat waves. Heat island effects and other urban canopy layer processes are additional aspects which determine Houston's urban climate. Also, Houston has the dubious distinction of having the worst air pollution problem of any city in the Unites States because of its vehicle emissions and a broad range of industrial activities, including 60 percent of the nation's petrochemical industry.

There has been an increasing demand in expanding undergraduate and graduate education in weather and climate, climate change, and air pollution. To meet this demand, the College of Natural Science has recently established a college-level B.S. degree in Environmental Science with Atmospheric Sciences as one of its four areas of concentration. In addition, an M.S. and a Ph.D. degree program in Atmospheric Sciences have been established in the Department of Geosciences. Student enrollment in various introductory courses to meteorology, air pollution, and global climate change has increased substantially in the past two years.

To enrich the learning experience of students and satisfy their curiosity about the ever changing weather, it is important to have an on campus weather station that provides real-time observations of weather as it happens on our campus.

Two important criteria are used for selecting a site for the campus weather station. The first is that the site should be open with minimum obstructions and offers free exposure to both sunshine and wind, and second is that it can be easily accessed, well secured, and has access to power and communication sources. After a survey of several potential sites on campus, a decision was made to set up the weather station on top of the Astronomy Observatory in the Science and Research I building. A ground site would have been better than an elevated site on a seven-story building, but the concern for security and the requirement of easy access to a computer and the internet make the observatory site more attractive. The physics department graciously granted the access to the roof of the observatory and the use of the space within the observatory for the computer and data processing unit.

In order to gain access to a larger network and deliver real-time weather to more students and residents in the community, a decision was made to make the UH weather station a part of the Weatherbug network. The Weatherbug network is the world's largest weather network, which has more than 7,000 stations and over 1,000 cameras that generate neighborhood level weather reports in seconds. By joining this network, data, graphs, and weather images from the UH weather station camera can be easily viewed in real-time by anyone on the Weatherbug network.

Students can now know the local weather on campus as it changes. The weather camera allows graduate students who usually work in research labs and offices in basements know what the weather is like without having to go outside. More importantly, the data and graphs from the UH weather station have been used as an aid in teaching and learning in the Weather Information course, the Introduction to Meteorology course, and the Introduction to Atmospheric Sciences course. Students in these classes have a chance to see a weather station and how each instrument works, and can analyze their own weather data in class. The data from the UH weather station are also being used by graduate students and faculty in atmospheric sciences, in combination with other observations from the Second Texas Air Quality Study in summer of 2006 (TexAQS-II), to gain an improved understanding of the relationship between weather and air pollution in the urban area of Houston.

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Caliche: Description, Distribution and Origin (Biotic vs Abiotic)

Jie Zhou and Henry S. Chafetz

Caliches are a terrestrial carbonate deposit that develop, most commonly and to the greatest degree, on or near the surface in arid and semi-arid areas, generally in areas experiencing between 40 and 60 cm of rainfall annually. Consequently, caliches are common throughout much of Texas and form on approximately 13 percent of the total land surface of the Earth. The first phase of this study has been completed—it involved field descriptions and sampling of caliche from east Texas to the panhandle (caliche nodules form in the soils within the Houston area, its relatively high annual rainfall notwithstanding). Comparison of the abundances and gross morphological differences (e.g., individual nodules vs. hardpan surfaces) with regard to the arid western vs. the wet eastern part of Texas is now underway. Additionally, detailed microscopic (petrographic, SEM, etc.), elemental (ICP), and stable isotopic (oxygen and carbon) analyses are also in progress.

The vast bulk of all of the caliche is composed of calcite ($CaCO_3$). The caliche in the humid eastern part of the state consists predominantly of individual nodules, generally less than 2 cm in diameter (Figure 1). In contrast, caliche in the more arid regions of the state develop larger individual constituents as well as considerably thicker overall deposits (Figure 2). An "ideal" profile consists of a "hardpan" at the surface and progresses downward into a "platy" or "laminar" layer which is then underlain by a "nodular" to "nodular-chalky" zone and finally down into the "disrupted bedrock". Well developed caliche profiles are commonly up to a couple of meters thick in central and west Texas. These profiles take tens to hundreds of thousands of years to develop and because of shifts in climate, changes in depth to the water table, etc., one generally does not see the "ideal" profile. For example, the profile shown in Figure 2 must have been developed in response to changing climatic conditions, i.e., observe the repetition of zones. A goal of this study is to determine whether we can distinguish these shifts in climatic conditions by use of geochemical signatures, for example, can we see differences in the stable isotopic signatures between the different laminar zones. By establishing the differences between profiles in humid east Texas as compared to arid west Texas, we hope to establish criteria which will be useful and give us the tools so that we can recognize different paleoclimatic conditions under which ancient caliches originated.

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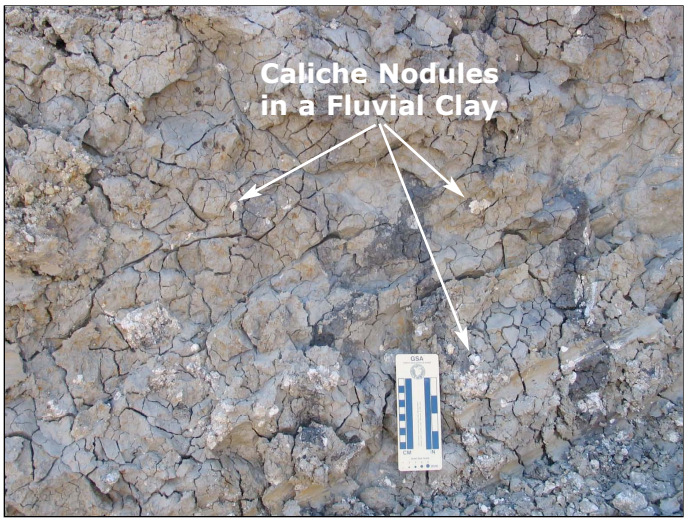

Figure 1. Common occurrence of isolated, small, soft incipient caliche nodules developed in humid east Texas, Quaternary clay pit near Alvin, Texas.

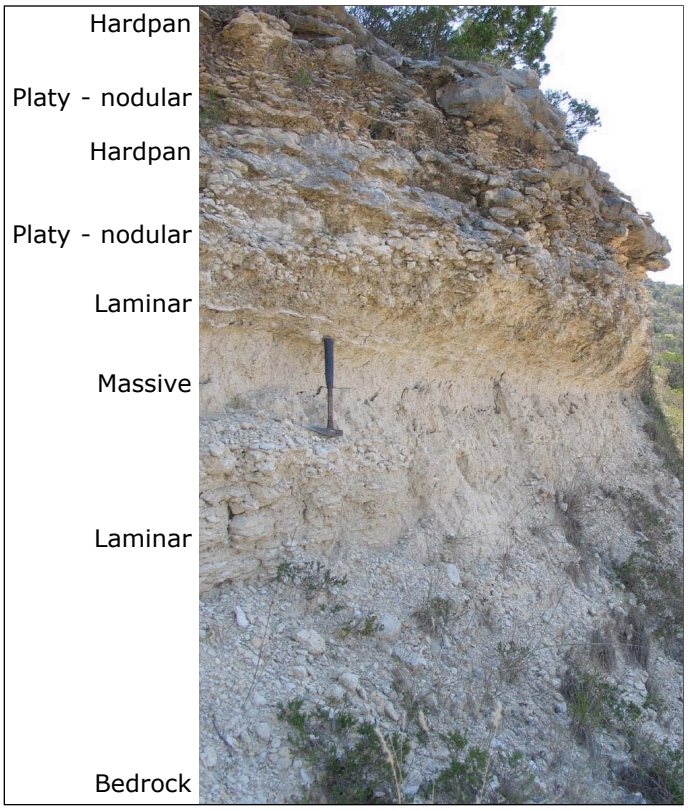

Figure 2. Typical outcrop in central Texas, approximately 50 km west of Austin, which shows development of a compound caliche sequence.

Mapping Active Faults in Houston Area Using LIDAR Data

Jaime Fernandez and Shuhab D. Khan

Many residential, commercial, and industrial structures in the Houston area are damaged by active faults.[1] Several researchers have studied the active faults in the Houston area.[1,2] University of Houston retired professor Carl Norman and his students worked on these faults,[3-7] but the exact number and location of all faults in the Houston area are not known.

Our work indicates presence of over 300 active faults intersecting the earth's surface in the Houston metropolitan area. They are a manifestation of current tectonics in the Gulf of Mexico basin. Salt tectonics and sediment influx have been suggested to be the primary driving factors. We used Light Detection and Ranging (LIDAR) (analogous to RADAR, but with laser light as a source) DEM images from the 2002 Tropical Storm Allison Recovery Project (TSARP) to map known faults and to search for others. Hill shading proved the best method for visualization of the faults that were then examined in the field. Results of our LIDAR survey are summarized in Figure 1. Further investigation is required to determine whether a particular fault is active or has been recently active in a particular area. Visible scarps, along with associated pavement or building cracks, provide a clear indicator of recent displacement. We recommend use of Interferometric Synthetic Aperture Radar (InSAR) to measure the rate of displacement on active faults; LIDAR and InSAR can be used together to study deformation. LIDAR fault locations can be superimposed on InSAR interferograms to indicate fault displacement.

This work shows the utility of LIDAR to be a highly effective tool for mapping faults in the Houston area. Making the results widely available in digital form will further aid usage. Published paper maps are either at too small a scale for locating faults or specific to a particular location. Publication of the location of active and potentially active faults will aid in appropriate site selection for structures.

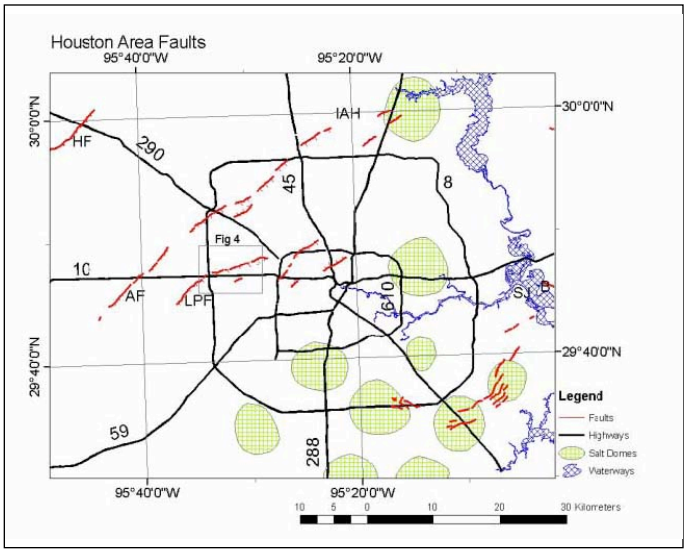

Figure 1. Houston area map showing active surface faults interpreted using LIDAR and the locations of salt domes.

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New MOFs For Drinking Water Pollution Control and Prevention

Aiwu Zhang and Jack Y. Lu

Investigation of functional MOFs (MOF = metal-organic framework) represents one of the new challenging areas of research in materials science and technology. It is known that microporous metal-organic polymers may have wide range of technological applications such as molecular separation and pollution prevention in air, liquid and water system, where they can be used as ion exchangers and molecular sieves. The incorporation of metal ions into organic polymers often significantly improves bulk properties such as thermal stability and dielectricity. The bonds formed in metal-organic polymers are stronger and more resistant to chemical and biological degradation. Additionally, inorganic elements have different valences that can form a variety of frameworks resulting in desirable pore sizes that can fulfill specific needs; organic molecules can be deliberately selected as building blocks for specific functions.

Our synthetic approach to MOF polymers has produced very promising results. Some new porous materials produced from our research have been found to have great potential in environmental applications. Among the new materials synthesized, OMOF-1[1] has a remarkably stable spiral open-framework structure. In addition to the zeolite-like structural features such as sturdy framework and porous channels with high stability, this novel spiral open-framework channel structure is even expandable. The inclusion polymers of this structure revealed that the spiral open-framework is not only highly stable in its original dimensions, capable of selective sorption, but also expandable. The expandability along the spiral open channel direction is quite like a tension spring. The structure displays attractive reversible and selective-sorption capability. The sorption properties of OMOF-1 to some volatile organic compounds have been investigated.

The research activities in our laboratory also produced other new materials.[2]

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Interactive Effects of Nutrients and Stress on the Strength of Top-down and Bottom-up Forces in Texas Salt Marshes

Juan M. Jimenez and Steven C. Pennings

Understanding the mechanisms which regulate the relative strength of top-down and bottom-up forces is central to understanding how biological communities are structured. Nutrient and stress levels are two important factors that might mediate the strength of top-down and bottom-up forces by altering the palatability, quantity, and nutritional quality of plant tissue. Although there are some studies exploring each of these factors separately, there are very few studies exploring their interactions. I will study how the interaction between nutrients and salinity affects the relative strength of top-down and bottom-up forces in a salt marsh.

The original goal of the study was to manipulate the presence of a top predator and the levels of nutrients and salinity stress and assess impacts at the four trophic levels shown in Figure 1. The experiment was designed to test three hypotheses: (1) nutrient addition to plants increases the strength of top-down effects;[1-3] (2) salt addition to plants decreases the strength of top-down effects;[4-7] and (3) nitrogen addition has stronger effects on top-down effects when plants are stressed by salt addition.[8-12] Plants were tagged and nitrogen and salt treatments were initiated in March. However, the sample size of the experiment was reduced due to the death (for unknown reasons) in June of several stands of Iva at the study site including a number of the experimental Iva plants. Replacement of these plants was not possible because the study plants had been exposed to nitrogen and salt treatments for over three months. Given this constraint, I decided to focus the experiment on the effects of nutrients and salinity (and their interaction) on the herbivore and plant trophic levels. This modified design will still provide important information on how nutrients and stress interact to influence plant quality, vigor, and vulnerability to herbivores. Therefore, on July 14, 2006, each of the remaining plants was stocked with three beetles (*Ophraella notulata*) and bagged with a net to isolate the plants from predators. The experiment will be monitored and harvested on August 14, 2006.

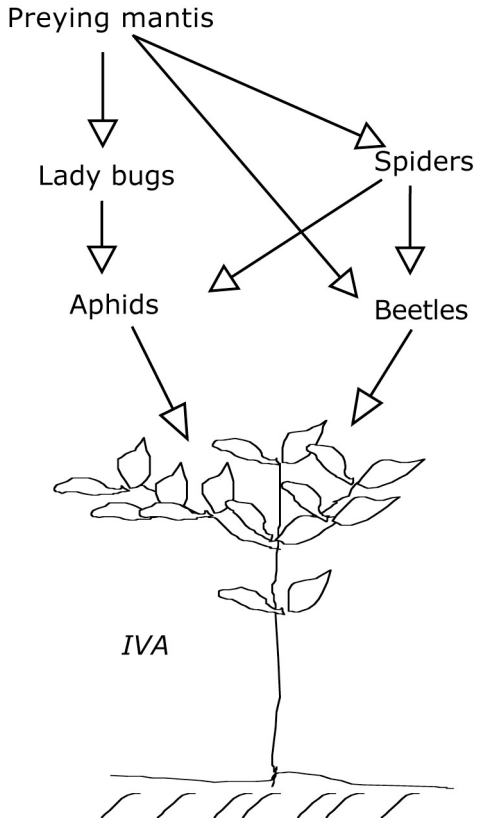

Figure 1. IVA Food Web Experimental Design

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Carbon Monoxide as an Important Tracer for Combustion Impacts on the Background Atmosphere of the Gulf Coast Boundary Layer

Shawna Boudreaux, Leonardo Pedemonte, Bernhard Rappenglück and Barry Lefer

PHOTOCHEMICAL SMOG EPISODES ARE COMMON PHENOMENA in Houston and other urban areas where enhanced values of non-methane hydrocarbons (NMHC), nitrogen oxides (NO_x), and carbon monoxide (CO) are found. In addition to the chemical environment, meteorological conditions fairly common to Houston (e.g. intense solar radiation, high temperatures, and suppressed atmospheric mixing), also favor photochemical processes leading to the formation of secondary pollutants like ozone (O_3) and peroxyacetyl nitrate (PAN) via the photochemical processing of NMHC, NO_x, and CO. As a consequence, cities like Houston frequently suffer from severe critical loadings of a variety of air pollutants as it was shown in the TEXAQS2000 campaign.[1-5] High concentrations of ozone (and related photooxidants) as well as particulate matter result in serious health effects, ecological damage and economic losses.

These impacts are not only restricted to the urban areas themselves, pollution plumes also stretch over larger regions downwind of the immediate metropolitan area[6,7] and may even be observed at surface sites hundreds of miles away from the emission sources.[8-12] Chemical compounds are emitted into the atmosphere by various biogenic and anthropogenic sources. These species are constantly removed from the atmosphere through oxidation followed by dry and wet deposition processes. The chemistry involved is complex.[13] The major initial step is the reaction with the hydroxyl radial (HO), also known as the atmospheric 'detergent,' which in turn is formed during the photodissociation of O_3 and subsequent reaction with water. The relative amounts of hydrocarbons and nitrogen oxides ($NO_x = NO + NO_2$) also play crucial and interrelated roles in the mechanism of the chemical oxidation of hydrocarbons. At very low levels of NO_x, hydrocarbon oxidation removes O_3 and consumes HO, while at higher NO_x levels, more O_3 and reactive radicals are produced. During the degradation process of VOCs in the atmosphere, a broad range of intermediate species are formed. Ultimately, the end of the reaction chains yield CO and carbon dioxide (CO_2). However, both species may also be emitted as primary pollutants in any kind of combustion processes, in particular traffic and biomass burning. CO has an atmospheric lifetime of several months. It is thus often used as a tracer species for combustion related processes, both of biogenic and anthropogenic origin, in long-range transport studies.[8,9,12] In the natural undisturbed atmosphere CO along with methane (CH_4) controls O_3 levels on the global scale. For the Houston-Galveston area no research has been undertaken so far which elucidates the possible impact of transport of polluted air masses to this area.

Results

Within the scope of this project, a continuously working CO instrument (Thermo Electron Corporation Gas Filter Correlation CO Analyzer 48C-TLE) has been purchased. Unfortunately, because of some instrumental malfunctions, this instrumentation had to be returned to the company for warranty repair which significantly delayed the laboratory preparations and the subsequent deployment of this instrument. In summer 2006 the CO analyzer was carefully calibrated in the Atmospheric Chemistry Lab at the University of Houston (UH) using a NIST traceable CO calibration gas mixture cylinder and tested against the UH CO analyzer at the Moody Tower site on the UH campus. After the laboratory preparations, the CO analyzer was set up at the Houston Coastal Center site where the Institute for Multi-Dimensional Air Quality Studies (IMAQS) already runs a meteorological tower and ozone measurements based on UV spectroscopy (Thermo Electron TE 49C) as part of the first stage of air chemistry measurements. The CO instrument was installed in the same air conditioned trailer which houses the O_3 analyzer.

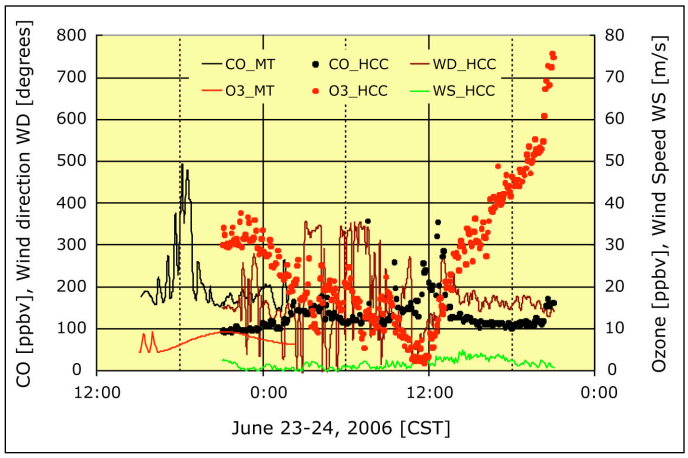

Figure 1. Times series for O_3 and CO mixing ratios measured at the Houston Coastal Center (HCC) and the Moody Tower (MT) on UH campus on June 23–24, 2006. Data of wind direction and wind speed at HCC is also shown.

Figure 1 displays the temporal behavior of ozone and carbon monoxide at the Houston Coastal Center site and on the Moody Tower site on the UH campus on June 23–24, 2006. Though there is only a short time of overlap between these two data sets some observations can be made based on this limited data. The CO background level at the Houston Coastal Center is about 100 ppbv and thus quite similar to tropospheric background conditions which are about 80 ppbv in the Northern hemisphere. Background conditions at the Moody Tower are about two times higher than at the Houston Coastal Center site. Contrary to the

UH campus site, where a broad evening hour rush hour *CO* peak occurs, only a few isolated higher *CO* values are observed at the Houston Coastal Center site. Overall, it seems that slightly elevated *CO* values at the Houston Coastal Center site coincide with northerly wind directions. Under these conditions, lower O_3 values are observed which indicates impacts from *NO* titration. Both observations support the influence of the urban plume with enhanced traffic related emissions. On the other hand, background *CO* values of about 100 ppbv at the Houston Coastal Center site are usually accompanied by southerly wind directions. In the afternoon of June 24, 2006, higher wind speeds of about 5 m/s were measured. This period of time reflects strong mixing of the troposphere. Under these conditions higher O_3 mixing ratios may be observed, possibly due to two reasons: (1) stronger mixing favors downward mixing of O_3 from the free troposphere where average values of 70-80 ppbv are usually present. (2) Higher O_3 values over the Gulf of Mexico can be maintained since deposition velocity of O_3 is less over water surfaces than over continental areas. This limited data set already indicates that *CO* can be used as an ideal tracer for the discrimination between the continental (and presumably anthropogenically polluted) air masses and the marine background atmosphere of the Gulf Coast.

Figure 2 displays additional analysis of the Houston Coastal Center site data set which includes the analysis of wind direction. The polar plot for the wind direction clearly shows the land sea breeze effect which is reflected in the high number of events when southeasterly (onshore) winds prevail. These winds usually occur during daytime and are stronger. Thus, these flow regimes tend to be well organized and clearly associated with distinctive wind directions. Offshore wind directions occur during nighttime and are less strong than onshore daytime winds. Figure 2 shows some enhanced numbers of northwesterly wind directions which represents the counterflow for the daytime onshore wind situation.

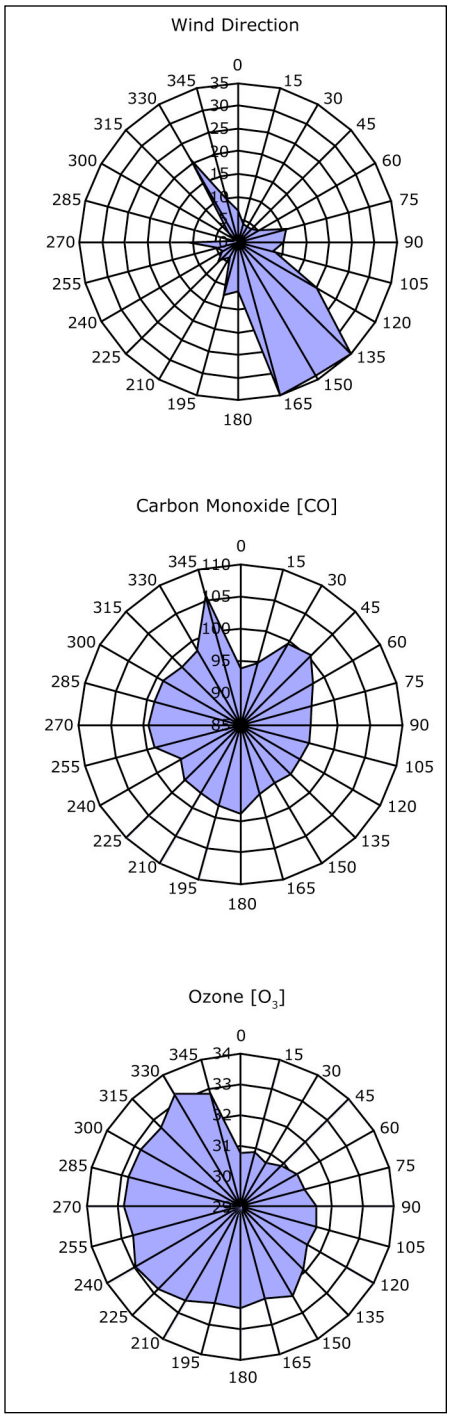

Figure. 2. Polar plots for the distribution of wind direction [counts/sector] (top), *CO* (middle) and ozone (bottom), both in [ppbv/sector]. Data is for June 23–24, 2006 and based on 5-min averages.

According to the polar plots *CO* shows minimum values under onshore and maximum values under offshore wind flows which coincide with the assumptions retrieved from Figure 1 which hints at marine background air under southerly wind directions and elevated *CO* values associated with outflow from the urban area north of the Houston Coastal Center. Though the polar plot for O_3 only reflects small differences among the different wind sectors which is mainly due to O_3, a secondary compound, is not clearly associated with emission sources and therefore tends to be homogeneously distributed. However, indirect observations can be retrieved from the O_3 plot. Since *NO* can efficiently titrate O_3, low values of O_3 are closely related to nearby *NO* sources, namely traffic exhaust. Therefore, the O_3 polar plot suggests the impact of I-45 to the northeast of the Houston Coastal Center site which runs from downtown Houston to Galveston.

Outlook

For the TEXAQS-II field campaign, which has started recently and will run through August and September 2006, the Houston Coastal Center will deliver a valuable baseline data set for ozone and carbon monoxide and describe the inflow of marine air masses into the metropolitan Houston area. Our preliminary study has already indicated some important relationships between the Houston Coastal Center site and the UH Moody Tower site. It is expected that the results of both UH sites will be analyzed together with other TEXAQS-II data sets obtained from other groups throughout the Houston-Galveston area and will be used in air quality modeling work. This work will contribute to forthcoming publications in peer reviewed journals.

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Clean, Efficient Hydrogen Generator

Raphael Thomas and James T. Richardson

CONVERSION OF HYDROGEN TO ELECTRICITY WITH FUEL CELLS is more efficient than combustion of fossil fuels and also reduces emissions. Fuel cells for automotive vehicles will require cost-effective, localized production of hydrogen from natural gas using catalytic steam reforming:

$$CH_4 + H_2O \leftrightarrows CO + 3H_2, \quad (1)$$

which is equilibrium-limited and highly endothermic at high temperatures (>800ºC), so heat management is a serious problem. Hydrogen production at local refueling stations are scheduled to be 250 kg/day, which is two to three orders of magnitude smaller than large-scale hydrogen plants. Scaling down current designs leads to unacceptable loss of efficiency, and there is a need for compact, efficient, and cost-effective hydrogen processors.

The objective of this research is to develop such a processor by integrating two technologies based on past research in this laboratory: (1) sodium heat-pipe reforming, which has been demonstrated to be compact and efficient during studies on solar energy, and (2) providing heat for the process with catalytic combustion using ceramic foam catalyst supports, which avoids the use of flame burners, decreases NO_x emissions, and is easier to control.

Based on our past experience with heat-pipe reformers and catalytic combustion systems, we designed a conceptual unit (Figure 1) using reactor computer models based on past research. Each unit has a central reforming section loaded with a ceramic foam catalyst and an outer annular section containing a foam-based combustion catalyst. Heat generated in the outer section by combustion is transferred to the reforming section via the sodium heat-pipe between them. Predicted axial and radial temperature profiles (Figure 2) show sharp endothermic and exothermic profiles at the beginning of each bed, but uniform levels for over half thereafter. Ten of these tubes deliver 250 kg/day, and preliminary calculations indicate an overall process efficiency of 92%, compared to DOE's target of 75% (DOE, 2003). Costs are $2.50/kg, compared to the DOE target of $3.00/kg for 2007 and $2.50/kg for 2010.

These optimistic projections are speculative estimates based on computer simulations. This is a novel concept with complex technical features that have never been tried before. It will be necessary to build a one-unit prototype to confirm performance and address unknown factors such as safety. Before this step is attempted, the predictions of the computer model, based on measured reaction and heat transfer parameters, must be verified with a small (1 kW compared to 12-15 kW) laboratory unit.

Work completed during the current phase of the project is as follows:

(1) The laboratory unit comprising a 1-kW sodium heat pipe, consuming 3-5 SLPM of CH_4 and producing 100 grams of H_2 per minute, has been designed, together with the necessary process units to deliver, control, and measure feed and products. Simulations confirm that validation of required parameters is feasible. We have received funding to acquire the heat pipe, construct the unit, and perform necessary experiments.

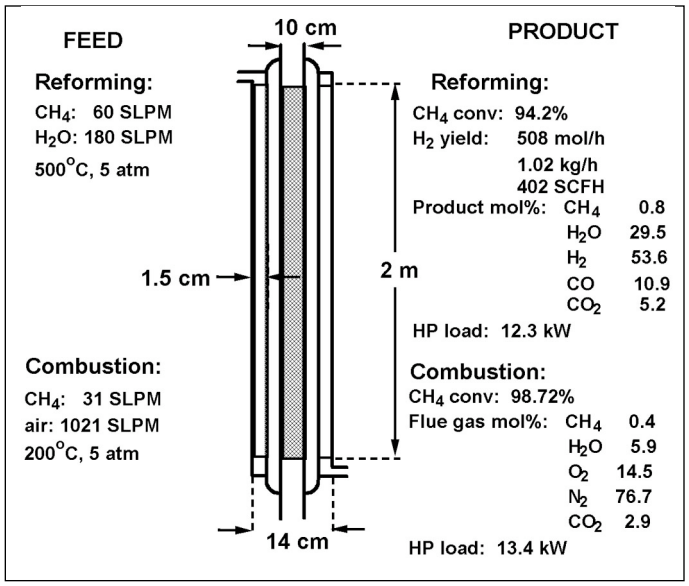

Figure 1. Conceptual design of a heat-pipe reformer for a hydrogen processor at a refueling station.

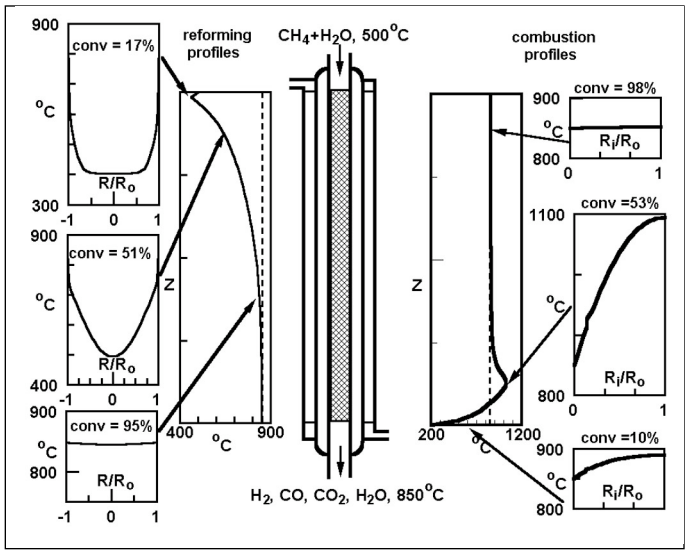

Figure 2. Simulations of the radial and axial temperature profiles in the heat-pipe reformer.

(2) The associated process (reactors, heat exchangers, pumps, controls) has been outlined, and we are detailing individual units to estimate exact costs.

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An In Situ Reactive Air Sparging Process for the Selective Removal of MTBE and TBA in Ground Water

Brent Stafford, Ranga Muthu and William G. Rixey

The objective of this research is the selective conversion of both methyl tertiary butyl ether (MTBE) and tertiary butyl alcohol (TBA) to environmentally acceptable compounds to be protective of ground water. This process is based on the simultaneous catalysis and air sparging of MTBE and TBA in groundwater. MTBE, a widely used oxygenated additive in gasoline, has been detected in surface and groundwater sources across the U.S. at greater than environmentally acceptable levels. TBA, a by-product of the biodegradation of MTBE, is also a contaminant of concern.

Experiments to date have been conducted in batch reactors containing strong acid catalysts to determine the reaction rates for the conversion of MTBE and TBA in dilute solution to isobutylene and methanol in dilute concentrations in water. These experiments used initial concentrations of either MTBE or TBA of 0.6 mM in water at 23°C. The experiments have been conducted with Amberlite IR-120, a sulfonated styrene divinylbenzene catalyst which was found to have the highest MTBE hydrolysis rates in previous research at UH with rates that are significantly greater than those observed for homogeneous acid catalysis.[1] MTBE, TBA, and methanol concentrations were determined by direct aqueous injection gas chromatography (GC) using previously developed methods. New methods were developed this year for measuring isobutylene in the headspace of the reactors using direct gas injection GC. In addition to the experimental work, a physicochemically-based mathematical model of the simultaneous reaction/air sparging process was developed to quantitatively describe both batch and continuous flow reactor processes. This model is currently being used to analyze the results of the batch reactor experiments. This model incorporates equilibria, kinetics, and mass transfer characteristics associated with the air sparging of isobutylene. An example of the application of this model to the conversion of MTBE to TBA is shown in Figure 1.

A proposal has been submitted to the Texas Hazardous Waste Research Center to extend this work to continuous flow reactive air sparging experiments. In addition, alternative catalysts will be investigated which are likely to be more active than the sulfonated styrene divinylbenzene catalysts, including the use of super acid catalysts.[2]

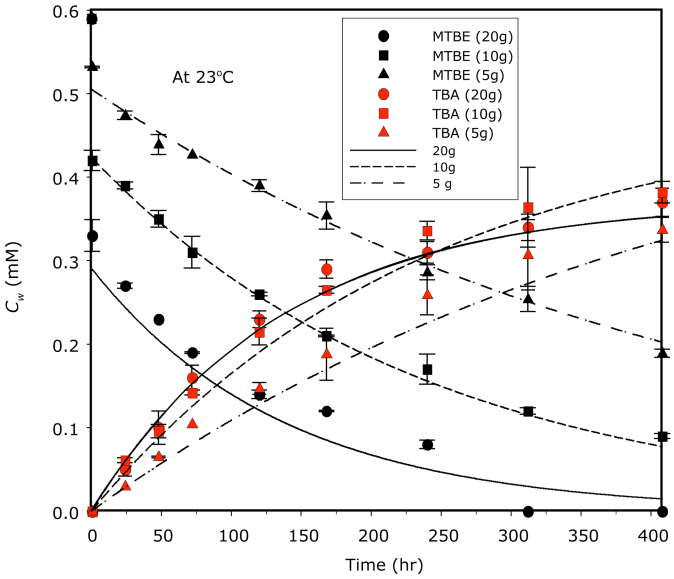

Figure 1. Application of Reactive-Air Sparging Model to Conversion of MTBE with various amounts of Amberlite IR-120.

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Investigation of Mg^{2+} as a Mechanism of Salt Tolerance in Anaerobes

Yanyu Wang and Deborah J. Roberts

Many industrial waste streams are brines that contain high concentrations of salts. Examples of these include produced water from drilling operations, membrane treatment residuals, and ion-exchange brines. The ability to treat these brines to remove contaminants is limited by an understanding of the availability of processes considered as effective in high salt solutions. Biological processes, which are typically able to transform organic contaminants to CO_2 and some inorganic contaminants to less harmful compounds, are rarely considered for high salt solutions.

In recent research at UH a salt-tolerant, anaerobic perchlorate- and nitrate-reducing mixed culture was developed to remove perchlorate and nitrate from ion-exchange brines.[1] In the course of this research it was determined that the salt tolerance of this culture was dependent upon the presence of a 0.11 mol/mol ratio of divalent ion to the monovalent Na^+ ion commonly used in ion exchange brines. Both Mg^{2+} and Ca^{2+} could serve as the divalent ion. The solubility of the Ca^{2+} ion was limited due to the presence of high concentrations of carbonates in the brines; magnesium was chosen for further study. The research showed that if the Mg^{2+}/Na^+ ratio was kept at 0.11 mol/mol, the culture was able to maintain its activity up to 10% *NaCl* (the highest concentration tested).[2] This observation has led to a question of whether the Mg^{2+} requirement is specific to this culture or may be an undiscovered general mechanism for Na^+ tolerance.

The effect of the addition of magnesium to high salt media on the growth of two unknown isolates from the UH cultures and eight known bacterial strains—*Orenia salinaria*, *Orenia marismortui*, *Halomonas halodenitrificans*, and *Bacillus halodenitrificans* as example halophilic bacteria; *Clostridium oceanicum* an example moderate halophile; and *Escherichia coli*, *Pseudomonas aeruginosa*, and *Staphylococcus aureus* as typical non-halophiles—was studied. *Staphylococcus aureus* is tolerant to *NaCl* but does not require high levels for growth. The results show that Mg^{2+} had a positive effect on the growth of *O. salinaria*, *C. oceanicum*, *E. coli*, and *S. aureus* in high salt medium and confirmed that two unknown strains isolated from the UH perchlorate-reducing culture needed high concentration of Mg^{2+} for growth. Table 1 presents a summary of the results.

Table 1. Summary Results

Microorganisms	Characteristics	Effect of Mg^{2+}	Optimal Mg^{2+}/Na^+ ratio
O. salinaria	halophilic, obligately anaerobic	positive effects	0.075 mo/mol
O. marismortui	halophilic, obligately anaerobic	no significant effects	Poor growth at all times
B. halodenitrificans	moderately halophilic, facultative anaerobic	negative effects	<= 0.05 mol/mol
H. halodenitrificans	moderately halophilic, facultative anaerobic	negative effects	<=0.02 mol/mol
C. oceanicum	anaerobic marine bacterium	positive effects	0.05 mol/mol
PCA	anaerobic, perchlorate-degrading	positive effects	0.075 mol/mol
ORG	anaerobic, perchlorate-degrading	positive effects	0.075 mol/mol
E. coli	non-halophilic, facultatively aerobic	positive effects	0.05 mol/mol
S. aureus	non-halophilic, aerobic	mixed effects (aerobic condition)	0.02-0.05 mol/mol
		positive effects	0.11 mol/mol

*Notes: 1. The recipes of the media are listed in Appendix A.[3]
2. The produced energy was calculated, and the captured energy = K (ΔG_R), K = 0.6.

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Applying Advanced Data Mining Methods for Ground-level Ozone Forecasting

Rachsuda Jiamthapthaksin, Zhenyu Yang, Xiaojing Yuan and Heidar Malki

Ground-level ozone concentration is an air pollutant that is harmful to human health and vegetation. Accurate ozone forecasting is important for warning the public of potential risks associated with heightened ozone levels. This project developed, implemented, and applied data-driven data mining methods. Six probabilistic estimation decision trees, to the ground level ozone concentration modeling and forecasting to provide more accurate and more efficient ozone advisory for the general public using data from Houston-Galveston area as a case study.

Seven years' (1998–2004) hourly ozone data, meteorological surface data, and daily upper air meteorological data were collected and used in the study. The ground level ozone concentration data was extracted from the Continuous Ambient Monitoring Stations (CAMS) database maintained by TECQ from the Houston-Aldine ozone monitoring site. The site was selected for the study based on the quality of data and the distance between it and the weather station at George Bush International Airport (IAH). It is one of ozone monitoring sites that has the longest ozone monitoring history. The site also provides the most comprehensive data set, i.e., less missing and erroneous values. Weather observations (meteorological data) were extracted from the National Climatic Data Center (NCDC) Surface Airways (SA) database for Bush International Airport (IAH) because of its location, record history, and coverage. The upper surface data were extracted from NCDC Radiosonde Data of North America. The research team chose the Radiosonde Observation station (RAOB) in Lake Charles, Louisiana from the six RAOB stations within Texas because it is nearest to IAH.

The probabilistic estimation decision trees have been shown to have much better performance than traditional parametric model for both stratified 10-fold cross validation experiments and the incremental experiments (month-by-month, and year-by-year) based on performance analysis using evaluation indices such as precision and recall. Precision and recall have been identified as well-suited for data sets with highly skewed distribution such as ground level ozone concentration data sets. In particular, in the annual (year-by-year) incremental test, bagged C4.4 and random decision tree (RDH) can achieve 10% to 20% higher recall and up to 10% precision improvement over the parametric model. Specifically, the result for the RDH with half depth provides recall as 0.608 and precision as 0.323. While the performance of parametric general linear model with recall as 0.568 and precision as 0.227. Assuming that each year has about 25 ozone alert days based on an eight-hour standard, results translated to RDH can correctly detect about one more ozone exceedance day and issue 25 less false alarms days. This is a significant improvement from air quality studies. For example, there were 52 high ozone days in the Houston area in 2004. Using the probability estimation methods will result in correctly predicting two more ozone exceedance days and fifty less false alarm days.

The findings have been summarized in both dynamic behavior analysis of various probability estimation trees and their application to air quality study. Related research on cost-sensitive learning has been applied to the medical diagnosis field. To extend the range of the project, the team submitted a proposal to the Texas Air Research Center (TARC) to utilize the weather/observation stations around the Houston-Galveston area so that researchers can model and simulate the dynamic behavior with spatial coverage; build models for each site to predict the local maximum ozone level; use these multi-site models to simulate the dynamic movement of ground level ozone concentration; explore the possibility of integrating spatio-statistical methods used in air quality study now and the spatio-data mining and clustering algorithms; and design a Web page that makes the algorithm available to the air quality study community.

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Funding and Proposals

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"Early Melanoma Detection System based on Automated Skin Lesion Imaging Analysis," co-PI, NIH, PA-06-371: *In vivo* Cancer Imaging Exploratory/Developmental Grants (R21) (*pending*).

"High Frequency Characterization of the Medium-Voltage Distribution Network for the Deployment of Broadband over Power Lines (BPL) Systems," CenterPoint Energy, $980,048 (*pending*).

"Integrated Air Quality Modeling and Forecasting based on Data Mining and Geo-Statistical Methods with Comprehensive Performance Study," Texas Air Research Center, $37,600 (*pending*).

"Intelligent Sensor Network Testbed for ISHM," co-P.I. NASA SSC Dual Use Program, $493,042 (*pending*).

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Biodegradation of Selected Endocrine Disrupting Chemicals in a Respirometer Simulating Activated Sludge Process

Chunlong Zhang and Zlata Grenoble

UHCL researchers focused on testing the sorption behavior of two selected endocrine disrupting compounds (EDCs)—estradiol and testosterone—and evaluating the effects of sorption to sludge on the biodegradation of estradiol and testosterone. Other factors simulating the conditions of activated sludge process included the effects of co-substrate (glucose) and the effects of EDC concentrations.

Sorption studies demonstrated that soil/water partitioning coefficients of these two compounds to a soil (Prairie View Texas A&M) is comparable to sorption coefficient values reported for these two compounds in other soils and sediments.[1-4] The Kd values obtained on sludge were 298 L/kg for testosterone and 471 L/kg for estradiol. The Kd value of 6257 L/kg for testosterone on clay is exceptionally high when compared to the Kd value of 171 L/kg for estradiol. The sorption behavior of these two compounds, in particular testosterone sorption to clay, is explained by two dominating mechanisms. Both compounds have the capability of hydrogen bonding with electronegative atoms of the sorbent material; the ketone functional group on the third carbon of testosterone likely provides additional bonding via a Lewis acid/base mechanism. The overall results from the sorption study indicate that the two EDCs tested exhibit significant sorption capacity to sludge as it is encountered in the aerobic biodegradation environment of wastewater treatment plants. It can be concluded that sorption is a viable mechanism for EDC removal from the environment.

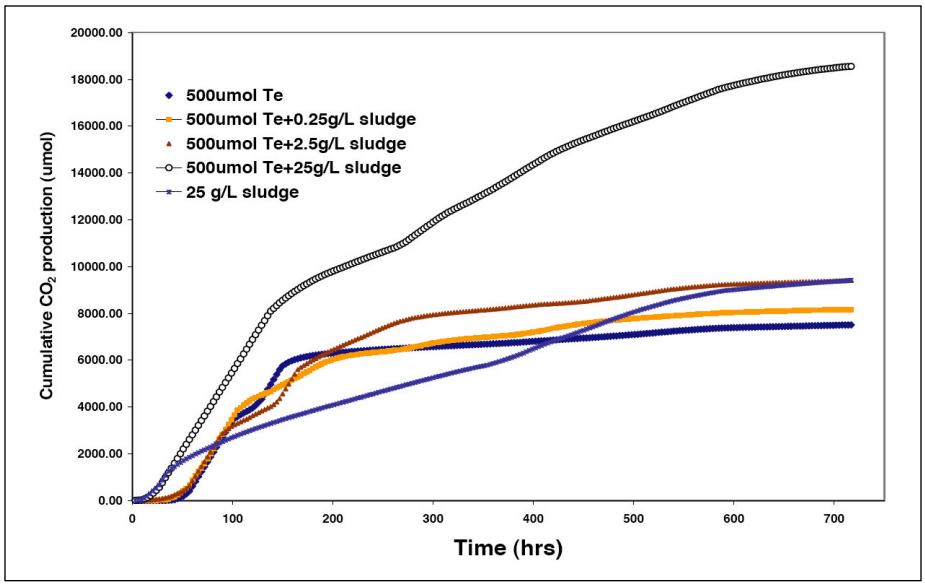

Figure 1. Biodegradation of Testosterone in the Presence of Various Amounts of Sludge

Studies on the effects of sorption on biodegradation were performed using a sludge obtained from a local wastewater treatment plant (Blackhawk WWTP, Friendswood, TX). The sludge was dried and sieved prior to utilization in the biodegradation experiment at three different sorbent levels—2.5 g/L, 5.0 g/L, and 25.0 g/L (see Figure 1 for testosterone). Results indicated that (1) the sludge from the drying belt of the wastewater treatment plant contains substantial amounts of organic components which are more readily biodegradable than the test EDCs; (2) the presence of sludge had two opposing effects on the biodegradation rates and mineralization of estradiol and testosterone. The biodegradable material in the sludge served as a co-substrate thus enhancing the rates of biodegradation, in particular, with testosterone. Sorption effects, however, delayed the biodegradation process during the second part of the experiment. It can be concluded from the overall results that the currently employed residence time in wastewater treatment plant is not sufficient to achieve optimum removal of EDCs.

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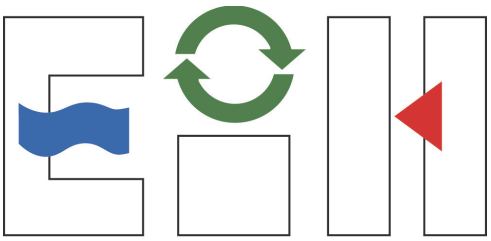

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