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annual report

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Contents

Interim Director's Message

The past year at the Environmental Institute of Houston has been a time of transition and challenge. My tenure as Interim Director at EIH has given me a greater appreciation of the contributions that EIH makes and the amazing staff and faculty that make them possible. It also has made me aware of the vulnerability of institutions such as EIH and the challenges faced by them.

The budget concerns faced by the State of Texas in 2003 dwarfed any other single issue at EIH during the past year. In January, several months into the fiscal year, EIH was hit with a surprise. Almost all of the base budget had been expended or committed for salaries and research grants when EIH, like other university offices, was asked to reduce its spending for the year by five percent. With the cooperation of researchers who deferred or reduced their grant funding, EIH was able to meet this mandate.

The 2003 legislative session was a bit of a roller coaster ride for EIH. At one time during the session, there was a serious proposal to eliminate all "special item" funding to state universities. This type of funding provides the core budget for EIH and several other research institutes at state universities. Fortunately, EIH survived, but its state-funded budget for the next biennium was reduced by almost 13 percent.

EIH was impacted by Governor Perry's line-item veto of Texas Excellence research funds to universities after the first legislative session concluded. For the past two years, EIH at UHCL has received Texas Excellence funding to support faculty research and special projects. Fortunately, UHCL President Staples and Provost Hayes found other funds to replace most of the lost funds.

The state financial situation appears to be more stable as the 2004 fiscal year begins. These financial challenges resulted in a slight decrease in the amount of research grants awarded to faculty, as well as a leaner approach to managing EIH funds. Fortunately, the reductions have not had a significant impact on EIH's ability to perform its mission.

The recent budget situation has reiterated the need for external sources of funding. EIH has an endowment earmarked to support environmental education. The Port of Houston Authority made generous donations to EIH's endowment, which were matched by a Houston Endowment challenge. This is a good beginning, but more is needed.

The Environmental Institute of Houston's activities impact not only the natural environment, but also contribute to improvements in the quality of life in the Gulf Coast region. The research projects supported by EIH and described in this report address reductions of air emissions, improvement of water quality, local flooding problems, evaluation of health impact from pollutants, and many other issues.

Dr. Brenda Weiser, EIH Director of Environmental Education, had another busy year. She partnered with the Clear Creek Independent School District, Harris County Pollution Control, and the Texas Commission on Environmental Quality to coordinate the installation of three ozone monitors at three high schools. The Air and Energy curriculum guide that was completed and copyrighted by EIH in 2003 has been very well received by educators. EIH conducted teacher workshops on this curriculum, EIH's school habitat curriculum, and PLT in the City, reaching many educators and their students. EIH hosted the 2003 Texas State Envirothon Competition for high school students.

Alecya Gallaway, EIH Environmental Historian, continues to enthrall audiences with her meticulously researched and fascinating presentations about resource development and use in the Galveston Bay region. Among many other presentations, she gave the keynote luncheon presentation at the State of the Bay Symposium in January 2003.

EIH continues to partner with resource agencies to address issues of local concern. One notable project is the Galveston Bay Invasive Species Risk Assessment, conducted with grant funds from the EPA through the Texas Commission on Environmental Quality. EIH and the Houston Advanced Research Center coordinated an extensive analysis of invasive species that impact or could impact the Galveston Bay area. Four risk assessment workshops brought together scientists from academia, natural resource agencies, industry and consulting firms, and nonprofit organizations to evaluate the relative risks presented by these invasive species. A final report on this project will be completed in 2004.

On campus at UHCL, EIH and Facilities Management worked together to improve recycling and resource use at UHCL. EIH also continued with its Brown Bag Lecture series, which presented not only scientific research, but also topics of interest to the community.

As I leave EIH to return to full-time teaching, I will continue to be an advocate for EIH and its mission. It has been a privilege to serve as Interim Director. Dr. Glenn Aumann, Co-Director of EIH, has been a valuable source of information and guidance. My thanks to the staff, advisory board members, faculty researchers, and community partners who are responsible to EIH's success. I urge all of you to continue your support of EIH as a new Executive Director takes its helm.

Lisa B. Gossett, J.D., is the interim director for the Environmental Institute of Houston, and an associate professor of environmental management, UHCL. Dr. Gossett can be reached at gossett@uhcl.edu.

School Habitat Curriculum Guide Grades K-8: Revisions and Development

THE PURPOSE OF THIS PROJECT WAS TO REVISE AND improve the current *School Habitat Curriculum Guide* for use by educators in their school habitats. The previous guide included multidisciplinary activities that were correlated to the Texas Essential Knowledge and Skills (TEKS) for grades K-5. The guide also included a section justifying environmental education as part of the school experience, a section offering suggestions for finding grants, field trips, etc. A section on case studies from other educators is also part of the guide. In addition to these sections, the new guide will offer multidisciplinary activities for grades 6-8, and an introductory section on ponds, animals, plants, and safety issues.

A student intern was hired in November 2002 to begin work revising the K-5 materials and to develop additional activities for grades 6-8. A seasoned teacher from Seabrook Intermediate School also developed activities for grades 6-8. The activities were then sent to local educators for review; some activities were field tested in the classroom by the student intern. The reviews and field-testing have offered helpful insight.

As a result of this project, teachers will receive a curriculum guide appropriate for grades K-8, which is correlated to TEKS. This guide can be used as a model for Texas schools that are attempting to link school habitats with current learning standards.

Brenda Weiser is the director of environmental education for the Environmental Institute of Houston, UHCL. Dr. Weiser can be reached at weiser@uhcl.edu. Wendy Reistle is a curriculum specialist at the Environmental Institute of Houston, UHCL. Reistle can be reached at reistle@uhcl.edu.

CONTENTS

Figure 1. The new curriculum guide will include information for grades 6-8.

Air Curriculum & Ozone Lite Sites

Houston is in a battle with Los Angeles for the city with the worst air quality. The air quality in Houston impacts many lives, especially the lives of children in the urban setting. The type of information students in public schools receive about air quality is limited because the seriousness of the problem was not recognized until Houston's air quality became national news. The Environmental Institute of Houston (EIH) embraced the challenge to develop an air quality education initiative designed for Texas Educators addressing the air education needs in Texas.

The Air Quality Education Initiative was a two-step program. The first step was the placement of ozone analyzers at middle and high schools linking the monitored results with the ozone data on the Texas Commission on Environmental Quality (TCEQ) website. Funding for the placement of the ozone analyzers was provided by TCEQ using Supplemental Environmental Project (SEP) funds and the Texas Environmental Education Partnership (TEEP) Fund Board.

The ozone warning system in the Houston-Galveston area was enhanced in 2003 with the addition of ozone data from new monitors being installed. The data appears on the TCEQ Web site <http://www.cleanairaction.org> and is included in the ozone e-mail alert system. EIH worked with the Clear Creek ISD (CCISD) in placing ozone monitors at three high schools—Clear Brook High School, Clear Lake High School, and Clear Creek High School. These schools are the first to have real-time, on-site ozone monitoring. Each school received instruments that measure outdoor ozone concentrations. The devices transfer data electronically to TCEQ.

Students have access to the readings on campus and via the Internet. CCISD plans to integrate their use into the curriculum. At Clear Lake High School, students have already been studying ozone problems on a global scale. For the athletic departments, the devices are especially important to safeguard the health of students during outdoor activities. Many times ozone alerts are based on readings taken inside the city of Houston but what may be true in Houston may not be true at the outlying high schools. The monitors give the schools the opportunity to keep a closer eye on ozone levels.

The second portion of the project was the development of an air and ozone curriculum. The curriculum was developed based on the needs of the population that will be utilizing it. In the Houston-Galveston area, 22 percent of the state's students live in seven counties being served by 54 school districts with 28 percent of the teacher population. The students demographically are African-American (22%), Hispanic (35%), economically disadvantaged (45%), and limited English proficiency (15%). These students benefit from hands-on laboratory activities and interactive lessons that are informative about air quality and are presented in a nonbiased format.

The curriculum has been developed to target teachers of middle school science, integrated physics and chemistry, and environmental systems. The lessons meet the North American Association of Environmental Educators (NAAEE) guidelines for good environmental education. This includes the methodology of the lessons and the nonbiased approach of the activities. Teachers throughout the Houston-Galveston area had an opportunity to perform activities from the curriculum and received copies to field test in their classrooms. This was accomplished through a series of teacher workshops. Some of the workshops were one to two hours in length at conferences while others were six hours with more intense training. The curriculum was offered and exhibited to a special strand of Houston Independent School District (HISD) teachers. These teachers who participate in the HU-LINC program for math and science educators attended a 30 hour workshop and received the Air-O-Dynamic curriculum and the Project Learning Tree curricula.

The curriculum covers the topics that were considered important by area teachers as follows:

What is Ozone and how does it form?
How does one contribute to everyday air pollution?
Conservation practices that impact the air quality
Green spaces and air quality
Environmental health issues as they relate to air
Air quality and ecosystems
Indoor air quality

The lessons contain background information and laboratory activities that teachers can use throughout the year, or they can be taught as stand-alone units.

Schools will use the air and ozone curriculum designed by EIH's Environmental Education department that teaches students about ozone and air pollution through lessons and laboratory activities. Workshops are being scheduled to demonstrate how the curriculum can be used in the classroom. In addition, the activities have been correlated to the appropriate Texas Essential Knowledge and Skills.

This curriculum provides accurate, balanced educator workshops that encourage teachers to incorporate air education into their classrooms. It teaches students how to think, not what to think. As with all good environmental action, it starts locally and is moving globally.

Brenda Weiser is the director of environmental education for EIH, UHCL. Dr. Weiser can be reached at weiser@uhcl.edu. Sally Wall is an air/energy curriculum specialist at EIH. She can be reached at wall@uhcl.edu.

Air Pollutants and Asthma Occurrences among Children in Galveston County

HIGH CONCENTRATION OF AIR POLLUTANTS IN THE Houston-Galveston Metroplex area precipitates more than usual asthma related emergency visits and hospitalizations.[1,2] The most common air pollutants are nitrous oxide (*NO*), nitrogen dioxide (NO_x), sulfur dioxide (SO_2), and non-methane volatile organic compounds (VOC). An interaction between these air pollutants and sunlight, particularly on hot and humid days with little wind, may raise the ground level ozone to an unhealthy level for those susceptible to experiencing shortness of breath due to their asthmatic conditions. Since children with asthma are more sensitive to unhealthy air,[3,4] the U.S. Environmental Protection Agency (EPA) has identified prevalence of asthma among children, which has been on the rise for the last few decades, to be a major health issue that EPA wants it to be addressed.[5]

The University of Texas Medical Branch (UTMB) located in the City of Galveston conducted a study to investigate the effect of community air toxicant levels on children's health and analyzed emergency room (ER) visits and hospitalization for asthma among children.[6] The emergency hospitalization data was obtained from the computerized billing records at UTMB, John Sealy Hospital. Air quality and toxic data were obtained from the community monitoring sites and stations located in the adjacent cities of Texas City and LaMarque. A preliminary analysis indicated an association between ground level ozone and ER visits of children with asthma.[7]

In the present study, we considered both weather and air pollutants data to determine the factors most contributing to the daily asthma related ER visits and hospitalization of children at UTMB. In all, there were five environmental variables (ozone, sulfur dioxide, nitrous oxide, nitrogen dioxide and non-methane volatile organic compounds) and five weather variables (wind speed, wind direction, temperature, barometric pressure and solar radiation). Their average daily values over the period of January 1994 through March 1999 were utilized in the analysis conducted. Figure 1 provides bivariate scatter plots of these data for the ten covariates depicting their underlying correlations. One finds a strong positive correlation between nitrous oxide and nitrogen dioxide as well as between temperature and solar radiation, and a strong negative correlation between temperature and barometric pressure. There is a fair amount of pair-wise correlation among several variables: a positive correlation between SO_2 and NO_x, between ozone and solar radiation and a negative correlation between ozone and *NO*, between temperature and SO_2, between temperature and NO_x, and between wind direction and barometric pressure.

Professor Raj S. Chhikara studies the factors that significantly affect the response variable of daily ER visits and hospitalization of children with asthma.

To discern a more meaningful pattern in terms of as few numbers of dimensions as possible, principal component

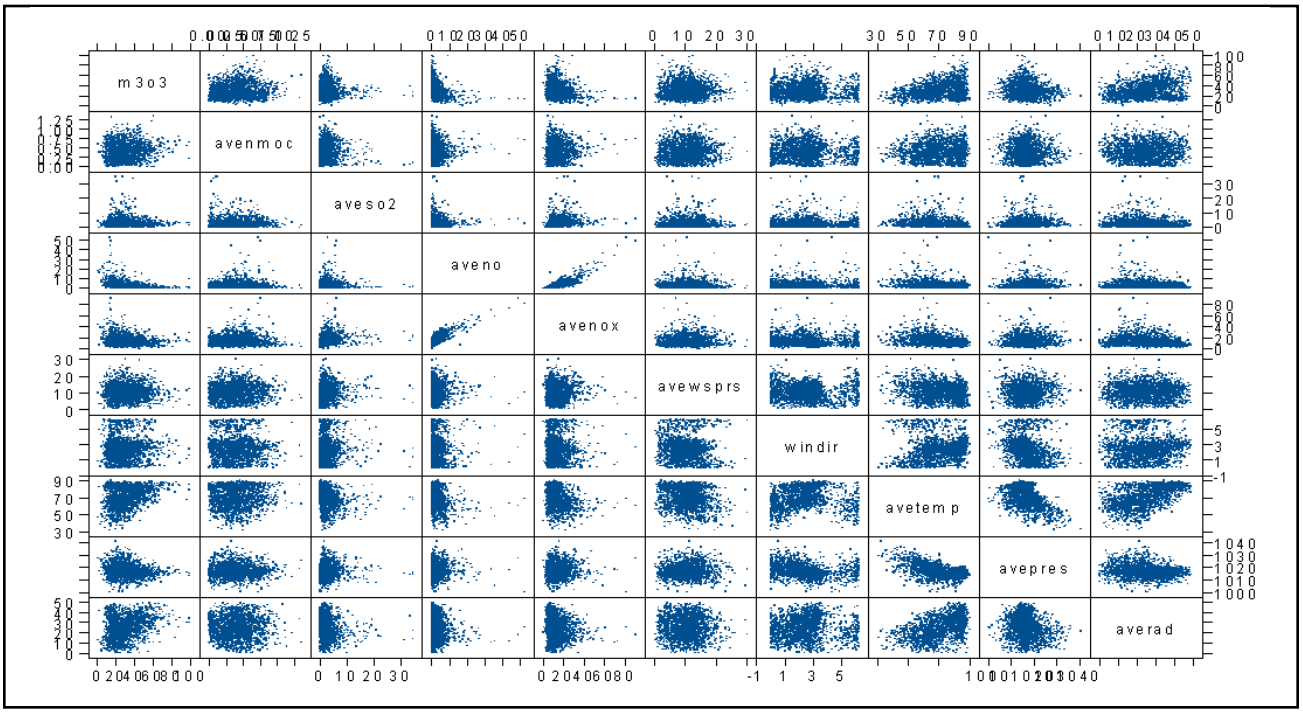
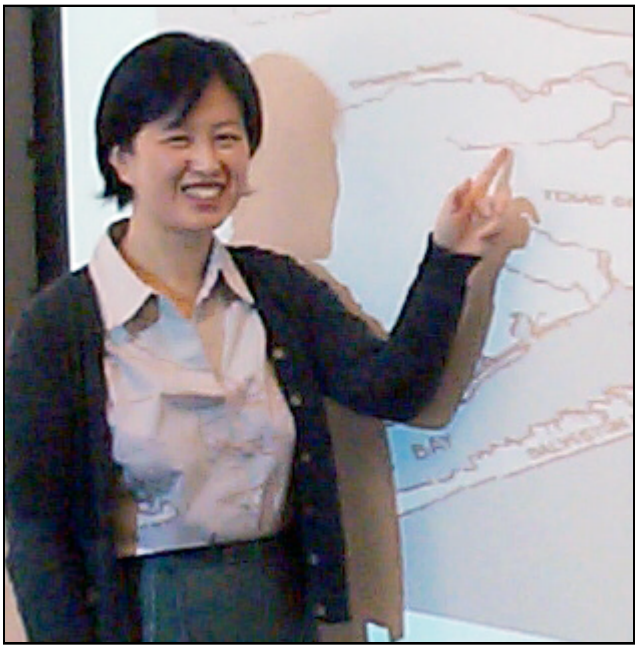


Figure 1. Bivariate scatter plots of ten covariates. The covariate names, which appear in the diagonal cells, are ozone (m_3o_3), average non-methane organic compounds (avenmoc), average sulfur dioxide ($aveso_2$), average nitrous oxide (aveno), average nitrogen dioxide ($aveno_x$), average wind speed (avewsprs), wind direction (windir), average temperature (avetemp), average pressure (avepres) and average radiation (averad).

and factor analyses of these data were conducted. These analyses[8] suggested that there were only five effective dimensions reflected in the data of these ten weather and environmental variables.[9] SAS software for Windows V8 was used in the data analyses.

The main objective of this study was to determine those factors that significantly affected the response variable of daily ER visits and hospitalization of children with asthma. A generalized linear model approach was used in developing a predictive model for the response variable. A number of model fits were carried out using different set of covariates in order to find the one that was the most economical (in terms of fewer covariates) and yet has the significance level (p-value) almost equal to that when all ten variables were used. The optimal predictive model for ER visits per day had the four significant factors with dominant covariates, (1) nitrous oxide and nitrogen dioxide, (2) ozone, (3) non-methane VOC and (4) temperature. When ranked, ozone was the most significant, next temperature, followed by non-methane VOC and then the *NO* and NO_x dominant factor. Although, the model was highly significant, speaking statistically, yet the dominant significant term in the model was the intercept. As such, the above four significant factors accounted for only a smaller percentage of the overall variability in the response variable.



Amara K. Jayewardene

The adequacy of the fitted model was examined using residual analysis.[10] A time series plot of studentized residual given in Fig. 2 shows random scatter of residuals and thus reflects an adequate fit. However, the residual distribution is heavier in tail than the normal distribution as seen in Fig. 3.

It suggests that residual tends to be larger than desired under an effective model and thus additional factors may need to be included in modeling the asthma related ER visits per day. For example, the daily pollen counts, fungal

spore counts, data for any of the viral infections in respiratory system for children, and exposure to indoor allergens such tobacco smoke, cleaning chemicals, dust and dust mites have been known to exacerbate asthma symptoms. Highest rates of asthma related ER visits were seen during fall, winter and spring than summer. During spring and fall seasons pollen levels are usually high in the air. In winter, less outdoor activities and thus more exposure to indoor allergens can be expected for children. Even though the ozone levels are high in summer, relatively low ER visits were observed. Therefore, some of these factors not included in the present study can affect the asthma incidence. In conclusion, if the indoor pollutant factor, the outdoor pollen levels, children's health condition and their family medical history are factored in, a more reliable predictive model can be developed.

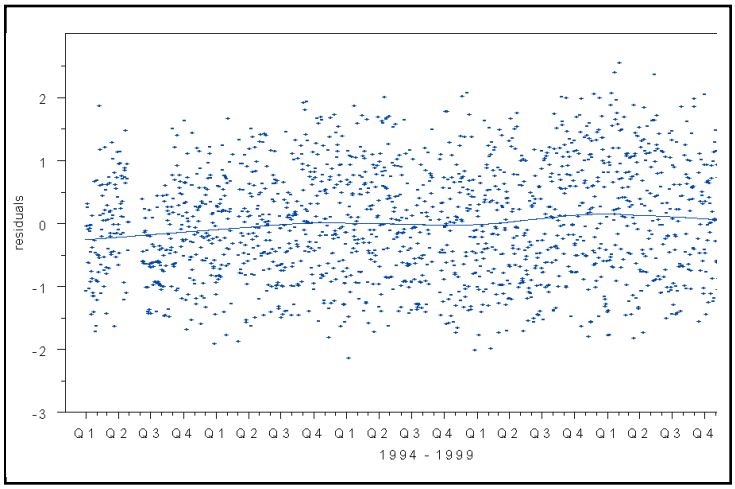


Figure 2. Time series plot of residuals from the model-fit

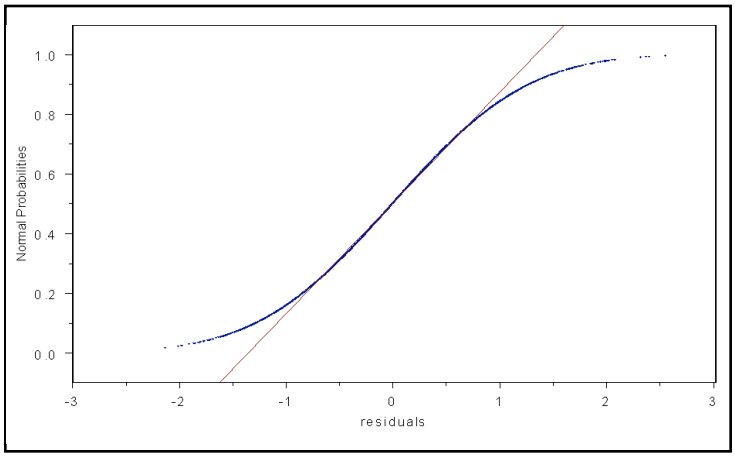


Figure 3. Normal probability plot of residuals, indicating a heavier tailed residual distribution

References

[1]A. D. Kyle. "Outdoor Factors in Childhood Asthma," Strategies to Reduce Environmental Factors that Impact Asthma in Children, Environmental Council of the States (ECOS), 2001.

[2]Galveston-Houston Association for Smog Prevention, 2002. <http://www.ghasp.org/issues/smog.html>

[3]B. Zimmerman, M. Gold, S. Lavi, S. Feanny, and E. Brownridge. *Canadian Allergy and Asthma Handbook*. Mississauga, Ontario, Canada: Random House, 1991.

[4]S. Moser. "How Environmental and Air Contaminants Affect Childhood Asthma," Citizens for a Safe Learning Environment, 2002.

[5]J.J. Fialka. "EPA Is Upbeat, but Seeks Study of Rise in Asthma," *Wall Street Journal* (June 2003).

[6]N.E. Martorell and E.G. Brooks. "Management of Pediatric Asthma," in *Strategies for Improving Patient Care, Interdisciplinary Case Studies in Health Care Redesign*. M.L. Parsons, C.L. Murdaugh, and R.A. O'Rourke, Eds. Gaithersburg, MD: Aspen Publishing, Inc., 1997.

[7]E.G. Brooks, R.M. Goldblum, S. Petronella, J. Ward, D. Freeman, and S. Sur. "Epidemiology of Asthma Exacerbation in Galveston County, Texas."

[8]R.A. Johnson and D.W. Wichern. *Applied Multivariate Statistical Analysis*, Fifth Edition. Prentice Hall, 2002.

[9]A.K. Jayewardene. "Analysis of Air Pollutants and Modeling of Asthma Occurrences among Children in Galveston County," research report, Graduate Program in Statistics, University of Houston-Clear Lake, Summer 2003.

[10]W.N. Venebles and B.D. Ripley. *Modern Applied Statistical with S-Plus*, Third Edition. Springer, 1999.

Funding and proposals

Goldblum, R.M. "Cohort Study of Virus/Pollutant Interactions in Asthma." N.I.H., May 2003. (Five years with R. Chhikara as consultant on the project.)

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Determination of Instantaneous Unit Hydrographs for Houston from HCOEM and USGS OFR 96-250 Data

UH Environmental Engineering Professor Ted Cleveland

Abstract

An instantaneous unit hydrograph (IUH) is a mathematical function that relates rainfall to runoff. IUH analysis was the subject of intensive research in the 1960s and 1970s, but has been relatively ignored in the last 20 years because of difficulties in relating measurable characteristics of watersheds to IUH functional properties.

A re-examination of the technology in cooperation with the Texas Department of Transportation suggested that the technology has merit and predictive calculations using near-real time updating may allow a reasonable advance in the art of early-warning in a probabilistic sense.

This research reformatted existing USGS Harris County data for IUH analysis, as well as HCOEM's (some stations are duplicates) historical records of rainfall-runoff at their gaging stations and includes these events into a Harris County database. Still on-going is the analysis to identify IUH parameters and test these against a censored set of real Harris County data to assess the ability of the approach to predict imminent flooding.

A longer term goal of the research is to generate probabilistic inundation forecasts using NWS rainfall forecasts and near-real time updating from the NWS Doppler network. This report examines the first component—initial reformatting of the data.

FLOODING IS A NATURAL DISASTER THAT IS OFTEN ignored as an environmental problem. However, flooding endangers human lives and public health, impacts essential services, and can transport pathogens over a wide area. It is largely impossible to prevent flooding, but it is possible to get out of the way and to estimate the magnitude of flows in the near future from current and past rainfall data.

In principle the physics of the rainfall-runoff process could be encoded for a region and the rainfall field input into a computer program and the near-term runoff and flow depth predicted using methods of computational fluid dynamics, however the computational resources needed to accomplish this task on the scale of Harris County don't yet exist. An accepted alternative is to use hydrologic methods (essentially highly simplified physics, often linearized) to make such predictions. Exact flow values and depths are not needed for design and early warning, thus

these methods are extremely attractive because of computational simplicity. This research is applying methods developed from existing research for small watersheds in central Texas to the Harris County region and evaluate the utility of the approach for imminent flood forecasting from current and past rainfall data.

Background

A hydrograph is a time-series of either water-surface elevation or instantaneous discharge, taken at a particular point on a stream. The point on the stream represents the outlet from a watershed, or the area topographically above that point from which all drainage passes through that point. The hydrograph represents the integrated response of the watershed to all hydrometeorologic processes extant on the watershed. Hydrologists and engineers use hydrographs to analyze the characteristics of a watershed and for design of engineering projects.

The instantaneous unit hydrograph (IUH) is a special case of a unit hydrograph where the precipitation duration is infinitesimally small (essentially an impulse). The functional form of an IUH is varied, but it has two important properties: the function must integrate to unity over the range zero to infinity and exhibit linearity with respect to the input depth.[1] The second requirement allows calculation of the response to a continuous precipitation signal by convolution of the instantaneous responses. Most probability density functions have the requisite properties, and the IUH can be interpreted as a residence time distribution of one unit of excess precipitation on the watershed.

These IUH functions are analogous to impulse-response approaches used in heat flow modeling, well functions, signal processing, potential flow modeling, chemical reactor modeling, and other areas of engineering where linear-systems theory produces usable predictions.[1] The attractiveness of an IUH is that the dependence of the hydrograph on the storm duration is decoupled from the analysis. This decoupling lets the analyst apply a storm of any duration over the watershed and calculate the direct runoff hydrograph.

The determination of an IUH for a particular storm event, where historical data exists (analysis) involves the following steps:

1. Baseflow separation.
2. Rainfall loss model to extract excess precipitation.
3. Conversion to consistent time and length units.
4. Interpolation of precipitation and runoff onto continuous functions.
5. Selection of candidate IUH functions.
6. Deconvolution of the observed signals to determine the IUH function parameters.
7. Aggregation of IUH parameters.
8. Non-dimensional representation and regionalization.

The determination of an IUH in the absence of rainfall and/or runoff data is called synthesis and is a fundamental problem in hydrologic research. Most current approaches are to use correlations and regressions from large sets of observed data and estimate IUH parameters from functional relationships of measurable properties (areas, lengths, slopes, shapes, soil classifications, etc.), the NRCS unit hydrograph methods are an example of this approach as is our current work.

The other approach, which is still in its infancy, is to use a physics-based hydraulic/hydrologic model to generate an equivalent unit hydrograph and then fit this hydrograph to some distribution. Generally this latter approach would represent unnecessary effort (if we can model the physics, why bother with a probability density function?) but these watershed models are extremely complicated and the computation of the response for a real rainfall time series can take hours, thus a scenario approach (run the physics model to generate candidate IUH functions and then use these functions for operational decisions) is still quite attractive. In either case, the synthesis of hydrographs in the absence of data is quite challenging.

The selection of candidate IUH functions that convert the rainfall signal into a runoff signal is a challenge. After considerable literature review effort we examined the classical Nash model, and a related model based on the Weibull probability distribution.[2-4] Other approaches based on digital signal processing (recursive filters, cross correlation, empirical orthogonal functions, etc.) were not examined in any detail, although cross correlation analysis appears to be a promising approach for gauged watersheds.

The Nash model can be demonstrated to be a special case of the Weibull distribution, so the results presented here are for the Weibull model.

$$q(t) = A\left[pz_0 \cdot \left(\frac{t^{p-1}}{t\_bar}\right)\left(\frac{(t^p)^{N-1}}{\Gamma(N)(t\_bar)^{N-1}}\right)\exp\left(-\frac{t^p}{t\_bar}\right)\right] \quad (1)$$

Equation 1 is the IUH discharge function used in this study. The model contains three parameters that are estimated for each watershed, a timing parameter *t_bar* that locates the center of the distribution, an exponent on the time, *p* that impacts the rate of decay (drainage) of the hydrograph, and a reservoir number, *N*, that impacts both the lag time (from end of precipitation to beginning of discharge) and the width of the hydrograph. In the Nash model the value of *p* is *1*. The watershed area is A and the excess precipitation rate is z_0 (actually a depth over a short time interval). The output of this function is the discharge from the watershed at any time *t* after the initial charge of excess precipitation is applied at time $t = 0$.

De-convolution of the observed signals to determine the parameters of the IUH model that best fit observations is a major and on-going computational effort. The technique to fit the distribution is a simulation-optimization method based on grid search. A set of ordered values (t_bar_i, p_i, N_i) for the undetermined parameters of the IUH is selected from a range of values for each element of the ordered triple as in Eq. 2. The ranges of values are divided into thirty uniform increments, and the exhaustive combination of these increments defines the total set of candidate values.

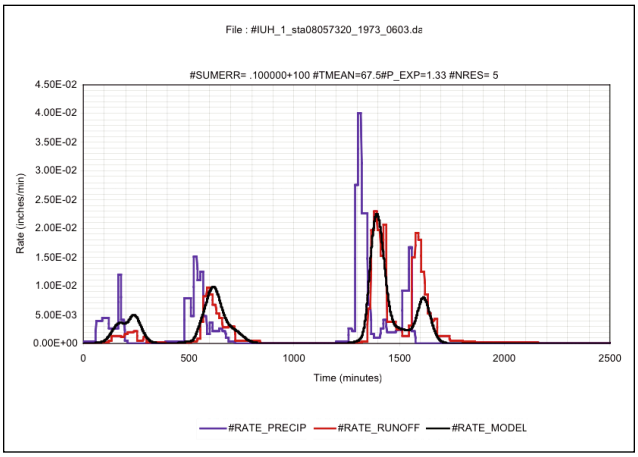

Figure 1. Plot of a Typical De-convolution Analysis Result. This particular result is the storm-optimal result for station 08057320, for the storm that began on June 3, 1973. To date, 1600 such storms at 90 locations have been analyzed in this fashion.

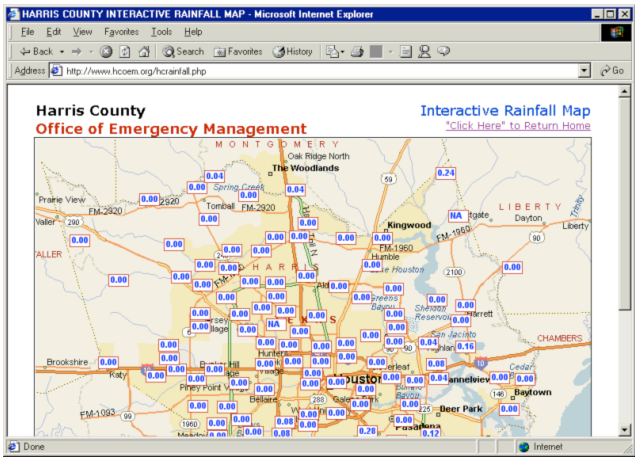

Figure 3. HCOEM Rainfall-runoff Sampling Network Map

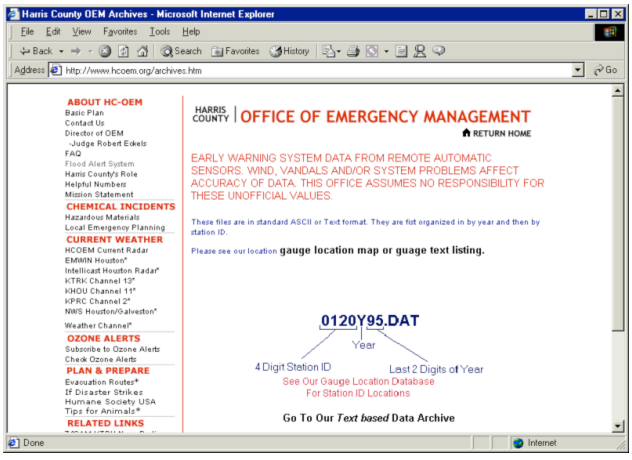

Figure 4. HCOEM ASCII Database Information Page

$$\{t\_bar, p, N\} \in \begin{cases} t\_bar \in [t\_bar_{low}, t\_bar_{high}] \\ p \in [p_{low}, p_{high}] \\ N \in [1,2,3,\ldots N_{high}] \end{cases} \quad (2)$$

The actual precipitation signal is convolved through the model to produce a DRH. This DRH is compared with the actual DRH using a square error criterion as in Eq. 3. The subscripts *s* and *o* represent the simulated (model) and the observed values, respectively. The index, *i*, is the particular value at each time in the series.

$$SSE = \sum_{i=1}^{N} (Q_S - Q_O)_i^2 \quad (3)$$

The value *SSE* is calculated and saved, then another element of the set is selected and the process is repeated. The set that produces the lowest value of the error criterion is saved as the "non-inferior" set of parameters. The process is repeated several times with smaller and smaller intervals to identify a good non-inferior solution. The grid search for each storm takes less than an hour, but with thousands of storms to analyze the time to search the entire grid (set of sets) takes a couple of days. Despite the lack of elegance, the process is simple to automate, and always produces a result. The final model DRH is plotted against the original DRH data to be sure the results are not absurd.

Figure 1 is a plot of a typical result of the grid search and the visual check of the storm-specific hydrograph results. This figure represents a comparatively good result with a complex (multiple burst storm). Not all the resulting hydrographs are of this quality, but a majority of the results are similar to this result.

These IUH parameters represent a storm-specific unit hydrograph for a given watershed. Each watershed experienced a number of recorded storms, some as few as two, many with at least 30. The parameters for all storms in a watershed are aggregated using the median value, and confidence intervals on this median are computed using order statistics as a way to quantify uncertainty. This watershed aggregate value is called the station median IUH. This quantification of uncertainty is in-progress and the results reported here ignore uncertainty.

EIH Research

Houston area precipitation and runoff data up to the mid 1990s is contained in the Open File Report (OFR) 96-250 (Fig. 2). The data are stored electronically but needs significant manual adjustment to fit the structure required for automated IUH analysis. One main task of the EIH supported work is to complete this reformatting.

There is also a significant database of Houston area rainfall-runoff data maintained on the Harris County OEM Web site. Figure 3 illustrates the coverage—most of the gages meet the criterion of "small watershed" as used in an on-going central Texas study and thus the techniques

already developed could be applied to the Houston area.

The HCOEM data are stored electronically in a fashion that should be readily transformed into the database structure of the central Texas study. Figure 4 illustrates the HCOEM structure. The second task to the EIH supported work is to download this data and reformat it into the central Texas structure.

Reformatting

During the project period both precipitation and runoff datasets were reformatted (Figs. 5 and 6). Currently the data are being assembled into an ASCII database to be publicly served on a university server so anyone can use these data for unit hydrograph (or other work where it is convenient to have a precipitation series and KNOWN discharge from that precipitation series already arranged). As of October 31, 2003 the data are not posted to the server, but this component is to be completed by the end of 2003. The server address is <http://129.7.204.231>.

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A   15    15                                                                  A
 100                                                                          1.27
208075600                    0004500006
B08075600      19650522061500   96          0.12  0.13  0.05        0.35
B08075600      19650522074500   96          0.20        0.05        0.10
B08075600      19650522091500   96          0.20        0.15  0.30  0.30
B08075600      19650522104500   96          0.20        0.10
9
208077100                    0006000011
B08077100      19650522061500   96
B08077100      19650522074500   96    0.30  0.50  5.1   9.6   22.   34.
B08077100      19650522091500   96    38.   42.   43.   44.   46.   47.
B08077100      19650522104500   96    49.   51.   59.   67.   75.   82.
B08077100      19650522121500   96    77.   71.   66.   60.   56.   52.
B08077100      19650522134500   96    48.   44.   42.   39.   37.   34.
B08077100      19650522151500   96    33.   31.   30.   28.   27.   26.
B08077100      19650522164500   96    25.   25.   24.   23.   22.   21.
B08077100      19650522181500   96    20.   20.   19.   19.   18.   17.
B08077100      19650522194500   96    17.   16.   16.   15.   15.   14.
B08077100      19650522211500   96    14.   13.   13.   12.   12.   11.
B08077100      19650522224500   96    11.   11.   11.   10.   9.9   9.6
9
```

Figure 2. Typical Data File from OFR96-250

Analysis of OFR and HCOEM Data

The IUH model for central Texas is a three-parameter Weibull-type model. It was constructed assuming a cascade of reservoirs. It is essentially identical to the generalized Gamma models of all prior researchers except we have identified a strong correlation between watershed area and aspect ratio and the timing parameter—making the model promising for synthesis of rainfall-runoff in ungaged areas. More importantly, the convolution of the rainfall process can be handled extremely rapidly by use of a finite difference analog to the actual process (a departure from past methods which convolve the actual kernel function). The extremely rapid convolution procedure makes to prospect of near-real time forecasting realistic.

An illustration of the single station (Fig. 7) is displayed on Fig. 8. The plot shows the observed results and a model result. The line scheme is the same as in the hydrographs in the introduction. The three-parameter model qualitatively is a reasonable prediction of the observed behavior, with the observation that the model time-to-drain is less than in the observed data, but the peak flow rates and overall shape is well described by this simple hydrograph model. It is especially important to observe that the precipitation signal is quite complex in that there are a series of bursts separated by short intervals of zero precipitation, classical unit graph analysis would likely replace the actual signal with a two or three pulse model to simplify the analysis—here we use the actual input series.

```
#_STATION.--08077100 CLEAR CREEK TRIBUTARY AT HALL ROAD, HOUSTON, TX
#_Lat 29`36'09", long 95`16'41"
#_AREA.--1.27 mi^
#_Thessien weights 100
#_analyst name: xin
DATE_TIME              600 ACCUM_WTD_PRECIP
05/22/1965@06:15:00          0
05/22/1965@06:30:00    0.12  0.12
05/22/1965@06:45:00    0.13  0.13
05/22/1965@07:00:00    0.05  0.05
05/22/1965@07:15:00          0
05/22/1965@07:30:00    0.35  0.35
05/22/1965@07:45:00          0
05/22/1965@08:00:00     0.2  0.2
05/22/1965@08:15:00          0
05/22/1965@08:30:00    0.05  0.05
05/22/1965@08:45:00          0
05/22/1965@09:00:00     0.1  0.1
05/22/1965@09:15:00          0
05/22/1965@09:30:00     0.2  0.2
05/22/1965@09:45:00          0
05/22/1965@10:00:00    0.15  0.15
05/22/1965@10:15:00     0.3  0.3
05/22/1965@10:30:00     0.3  0.3
05/22/1965@10:45:00          0
05/22/1965@11:00:00     0.2  0.2
05/22/1965@11:15:00          0
05/22/1965@11:30:00          0
05/22/1965@11:45:00          0
05/22/1965@12:00:00     0.1  0.1
```

Figure 5. Extracted Precipitation Data from the OFR (Note the OFR contains data for many years of events in a single file.)

The IUH displayed on the plot is

$$\frac{q(t)}{A} = [z_0 \cdot \left(\frac{(t\ )^{8.3}}{\Gamma(9.3)(21)^{8.3}} \right) \exp(-\frac{t}{21})]$$

where the runoff coefficient is 0.334 for the particular

#_STATION.--08077100 CLEAR CREEK TRIBUTARY AT HALL ROAD, HOUSTON, TX
#_Lat 29`36'09", long 95`16'41"
#_AREA.--1.27 mi^
#_Thessien weights 100
#_analyst name: xin

DATE_TIME	RUNOFF_CFS
05/22/1965@06:15:00	
05/22/1965@06:30:00	
05/22/1965@06:45:00	
05/22/1965@07:00:00	
05/22/1965@07:15:00	
05/22/1965@07:30:00	
05/22/1965@07:45:00	0.3
05/22/1965@08:00:00	0.5
05/22/1965@08:15:00	5.1
05/22/1965@08:30:00	9.6
05/22/1965@08:45:00	22
05/22/1965@09:00:00	34
05/22/1965@09:15:00	38
05/22/1965@09:30:00	42
05/22/1965@09:45:00	43
05/22/1965@10:00:00	44
05/22/1965@10:15:00	46
05/22/1965@10:30:00	47
05/22/1965@10:45:00	49
05/22/1965@11:00:00	51
05/22/1965@11:15:00	59
05/22/1965@11:30:00	67
05/22/1965@11:45:00	75
05/22/1965@12:00:00	82
05/22/1965@12:15:00	77
05/22/1965@12:30:00	71
05/22/1965@12:45:00	66
05/22/1965@13:00:00	60
05/22/1965@13:15:00	56

Figure 6. Extracted Discharge Data from the OFR (Note the OFR contains data for many years of events in a single file)

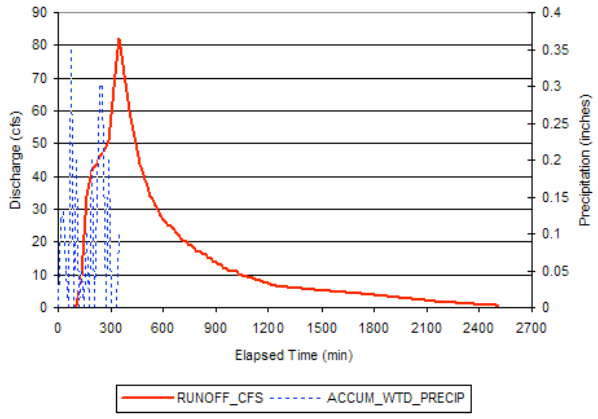

Figure 7. Plot of the Extracted Data

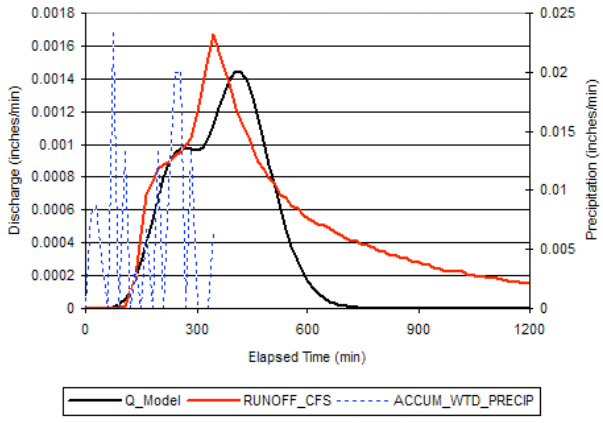

Figure 8. Illustration of the Single Station in Fig. 7

watershed (determined in the rainfall loss analysis mentioned in the introduction). Analysis of the remaining storms is in-progress, but the figure illustrates the expected results.

Future Efforts

The EIH portion of this work has produced the following products:

1) A Harris County Database in the same structure as the central Texas database. It is to be delivered by a University server by the end of 2003. The database contains both OFR and HCOEM data. Duplicates are not to be presented twice (many HCOEM stations are USGS stations and duplicate data occurs when the two datasets are merged).
2) An IUH analysis procedure of the Harris County Data with an aim to produce a predictive tool for short-term imminent flood forecasting from current and past rainfall signals.

Future efforts are to:

1) Perform a complete IUH analysis for the Harris County Dataset.
2) Test the IUH functions using censored data (remove portions before fitting and test against the censored portions).
3) Perform a geographic analysis to determine how to project gage data from one location to a downstream receiving location (this task is necessary for effective warning forecasting as well as probabilistic forecasting)
4) Develop a prototype alert model using these IUH and test both the predictive capability and the forecast failure rates.

References

[1]J.C.I. Dooge. "Linear Theory of Hydrologic Systems," *U.S. Dept. of Agriculture, Technical Bulletin 1468.* 1973.

[2]J.E. Nash. "The Form of the Instantaneous Unit Hydrograph," *Intl. Assoc. Sci. Hydrology, Pub 42, Cont. Rend. 3* (1958): 114-18.

[3]J.H. Lienhard and P.L. Meyer. "A Physical Basis for the Generalized Gamma Distribution," *Quarterly of Applied Mathematics* 25.3 (1967): 330-34.

[4]J.H. Leinhard. "Prediction of the Dimensionless Unit Hydrograph," *Nordic Hydrology* 3 (1972): 107-09.

Bibliography

Dooge, J.C.I. "A General Theory of the Unit Hydrograph," *J. Geophysical Research* 64.2 (1959): 241-56.

Dooge, J.C.I. and M. Bruen. "Unit Hydrograph Stability and Linear Algebra," *J. Hydrology* 111 (1989): 377-90.

Nash, J.E. "Systematic Determination of Unit Hydrograph Parameters," *J. Geophysical Research* 64.1 (1959): 111-15.

Soil Conservation Service (now NRCS). *National Engineering Handbook*. Washington D.C.: U.S.D.A., 1972. Chapter 4.

Presentations

Cleveland, T.G. and M. Smith. "Demonstration of Remote Wireless Access to a Database for Communicating Water Quality Data," Final Report, Houston Department of Health and Human Services, Environmental Health Division, 2003.

Cleveland, T.G., D. Thompson, and X. Fang. "Instantaneous Unit Hydrographs for Central Texas," *Proceedings*, Texas Section Spring Meeting, Dates, 2003, Corpus Christi, TX.

Funding and proposals

"Regional Characteristics of Unit Hydrographs." Texas Department of Transportation, $19,995.

"Regional Characteristics of Storm Hyetographs." Texas Department of Transportation, $34,758.

"Estimating Time Parameters of Direct Runoff and Unit Hydrographs for Texas Watersheds." Texas Department of Transportation, $34,198. (EIH shown as 15% credit.)

"Guidance for Design in Areas of Extreme Bed Mobility." Texas Department of Transportation, $43,950.

Ted Cleveland, Ph.D., P.E., is a professor of civil and environmental engineering. He can be reached at cleveland@uh.edu. Ionan Lazarescu and Xin He are graduate students in the Department of Civil and Environmental Engineering, University of Houston.

TexAQS Datasets Analysis and Assimilation for Design of Houston Sustainable Emission Control Strategies

Uncertainties in the Houston-Galveston emissions inventory lead to uncertainties in the prediction of air quality models (AQMs) for Houston ozone formation. Quantifying the effects of these uncertainties is one of the most important steps in the design of Houston emission reduction strategies. Toward this end, we have developed efficient data assimilation algorithms based on suboptimal Kalman filters for a comprehensive ozone-chemistry model. The focus was on theoretical aspects and practical analyses of the sensitivities of the predictions of AQMs to uncertainties in emissions inventory. The rationale of our efforts is to exploit observations with beneficial impact for analysis of non-observed species, which are chemically closely related to observed constituents. Our contribution is to the development of efficient suboptimal approximations to forecast error covariance evolution equations to overcome the large computational requirements of the Kalman filter based algorithms applied to chemistry data assimilation.

One of our objectives in this project was to simulate atmospheric dispersion of the reactive plume from a point source. As this project is preparatory for a larger project, research assistant Joel Wagner's Ph.D. thesis, this preliminary study continues to focus on establishing a basic but solid foundation for building up more complex models. In this direction we developed a method to solve numerically elliptic problems with multi-scale data using multiple levels of not necessarily nested grids. The method consists in calculating successive corrections to the solution in patches whose discretizations are not necessarily conforming. It resembles the FAC method and its convergence is obtained by a domain decomposition technique. However our method is of much more flexible use in comparison to the latter. We also proposed a family of iterative methods to solve numerically second order elliptic problems with multi-scale data using multiple levels of grids. These methods are based upon the introduction of a Lagrange multiplier to enforce the continuity of the solution and it s fluxes across interfaces. This family of methods can be interpreted as a mortar element method with complete overlapping domain decomposition for solving numerically multiscale elliptic problems.

The multi-physics aspect of air quality modeling was also considered in this study. We presented a comprehensive dynamical model capable of solving the condensation/evaporation equation of multicomponent aerosol. The equilibrium model UH-AERO is used to predict the physical state of the particle, i.e., whether the aerosol is liquid or solid. The mass transfer equations for the fluxes for solid atmospheric particles are developed. Our model is able to simulate aerosol deliquescence, crystallization, solid to solid phase transitions, and acidity transitions.

In the year 2003-2004, further developments are planned:

- implement the adjoint code by combining automatic differentiation tools with symbolic processing, which leads to exact computation of the gradients and allows flexibility for the chemical model;
- consider complicated models involved interaction between chemical reactions and turbulence diffusion;
- predict the dynamic response of marine aerosol entering an urban area.

In the near future, more and more observations of tropospheric species from the Texas 2000 Air Quality Study will become available, which may considerably improve the data assimilation results, possibly leading to new insights into the distribution of surface emissions of chemical species and on their spatial and temporal variability.

Publications

He, J.W., R. Glowinski, J. Rappaz, and J. Wagner. "Approximation of Multi-Scale Elliptic Problems Using Patches of Finite Elements," *C.R. Acad. Sci. Paris*, Ser. 1 (2003). (*Submitted*.)

Glowinski, R., J.W. He, J. Rappaz, and J. Wagner. "A Multi-Domain Method for Solving Numerically Multi-Scale Elliptic Problems," *C.R. Acad. Sci. Paris*, Ser. 1 (2003). (*Submitted*.)

He, J.W., K.Y. Yoo, and N. Amundson. "Mathematical Theory of PM Dynamics: Computation Framework," report, UH Environmental Modeling Institute, Aug. 2003.

Presentations

Workshop on Mathematics and Atmospheric Pollution, Nov. 13–16, Mexico City, 2002.

RTP Seminar, US Environmental Protection Agency, Jan. 10, 2003.

Atmospheric Science Seminar, Department of Chemical Engineering, California Institute of Technology, April 28, 2003.

Funding and proposals

He, J.W., R. Glowinski, I. Timofeyev, D. Sorenson, C. Antoulas, and J. Seinfeld. "Efficient Data Assimilation Methods and Applications to Air Quality Modeling." NSF Focused Research Group, 2003–2006, $1,050,000; *submitted*.

Jiwen He is a professor of mathematics at the University of Houston. He can be reached at he@uh.edu. Joel Wagner and Erell Jamelot are research assistants in the Department of Mathematics. Jacques Rappaz is a visiting scholar at in the Department of Mathematics, UH. Rappaz can be reached at rappaz@math.uh.edu.

Bayou Rising! People, Places, Politics, and Progress in Houston Area Flood Control Initiatives, 1935–2001

Bayou Rising! is a dissertation research project designed to examine the rise of environmental activism in response to flooding in Houston. Although modern environmental movements did not emerge until the 1960s, government entities began to address flood management in Houston after the 1935 flood. Between 1937 and the mid-1960s, the infrastructure of government management of flooding developed extensively, requiring that activism of the 1960s and beyond be understood in both local and national historical contexts. By the late 1960s, every structural alteration of Houston's urban waterways was challenged by local environmental watchdogs who demanded that the Harris County Flood Control District and the U.S. Army Corps of Engineers include the community in decision making processes. Although local environmentalists present an uneven success record, they have confronted and sometimes improved the public relations practices of government management of flood control initiatives in Houston.

Research focused on identification and collection of primary sources at individual, organization, city, county, state, and federal levels. Advances in acquisition of secondary source materials were made as well. Approximately seven linear feet of primary source documentation has been collected; unexplored individual and organizational sources of records were uncovered. In addition, individuals have been identified and contact information for interviews has been collected in every domain of the analysis. Interviews are planned to begin in 2004. Following are brief descriptions of accomplishments in specific collections.

Terry Tomkins-Walsh is completing research for a doctoral dissertation at the University of Houston.

Community Organizations

Terry Hershey Environmental Archives. Community environmental activist Terry Hershey opened her files to Terry Tomkins-Walsh early last fall. Working one day per week, Tomkins-Walsh collected a range of primary sources including Hershey's personal correspondence with local and national environmental organizations and government leaders at all levels. In addition, her environmental collection included many documents produced by county, state, and federal agencies. Survey of Hershey's records is nearing 50 percent completion, although an accurate assessment is difficult because of the scope of the documents. Work at Mrs. Hershey's house is ongoing.

Citizens' Environmental Coalition (CEC). Although their records were less directly related to flooding, CEC's archival collection included documents dating from 1968 that revealed the role of Houston's environmental community in local and state politics and provided valuable insight into the mechanics of building and maintaining non-profit environmental organizations and their interface with local government entities. CEC's records cover many organizations. Tomkins-Walsh identified important local environmentalists, including an active environmental lawyer, many of whom will be interviewed in 2004. Survey of CEC's records is about 90 percent complete. Tomkins-Walsh's work at CEC will continue through the end of October 2003.

Bayou Preservation Association (BPA). As an organization established to protect Houston's bayous, BPA's records are directly relevant to the research for this project. Evaluation of BPA records did not begin until late spring, but progress is moving apace. Records began in the mid 1970s and continue to the present. They include valuable technical reports and documentation on political initiatives to change USACE engineering priorities and community approaches to flood management. Survey and collection of BPA records is about 30 percent complete. BPA materials hold a number of secondary sources.

Minority Activism. To ensure a broad community approach, local minority activists were contacted. Although they were willing to assist, they have not provided sources of documentation to date. Work in that area continues as Tomkins-Walsh attempts to locate more representatives of minority communities directly affected by flood management and community development.

Other organizations active in bayou preservation and flood management during the 1970s are The Park People, League of Women Voters, and Houston Garden Club. Research in the Hershey records, CEC, and BPA resulted in

identification of contacts within these organizations, but interviews with identified representatives and examination of organization records await completion of the record collections currently under survey.

Local Government

City of Houston. Initial telephone contact was made with the city's floodplain manager who identified key personnel in city government. Tompkins-Walsh has not visited the offices because it appears that much information will come in oral form; interviews will be held after a thorough analysis of the collected documents.

Harris County. A brief written historical overview of flood management in Houston and watershed maps were aquired after initial contact with the Harris County Flood Control Engineer. Further contact will follow analysis of collected documents.

Several telephone conversations with the Harris County Records Manager revealed that exploration of county records in the Harris County archives must be preceded by written permission from the donating agency. Once interviews with HCFCD begin, the necessary permissons will be obtained.

Another important source of county information will come from Commissioners Court records. Several hearing transcripts have been obtained; however, more details are needed. Commissioners Court records are housed separately with a different records custodian than the Harris County Archives. This research will require a different approach.

State Government

Texas State Archives (TSA). Important legislative documents may be available only at the TSA. Although Tomkins-Walsh planned to travel to Austin during this grant period, the trip is postponed until local records have been analyzed. She has located certain state documents in local records, and a full understanding of the issues will allow her to make the best use of research time at the TSA. An archivist in Austin has been contacted and finding aids for the collections of several governors and state legislators have been obtained. After a review of all local documentation is completed, Tomkins-Walsh will design a research plan with the archivist in Austin to maximize the benefit from her travel.

Federal Government

US Army Corps of Engineers (USACE). Directly relevant to this project are the records of the USACE at the Galveston District office. During weekly trips to Galveston, Tomkins-Walsh has collected annual reports from 1970 through 2001, which is a little more than 1/3 of the years needed. She has also identified Galveston District reports in the Congressional Records-Rivers & Harbors volumes. Titles of about 20 secondary publications in the Galveston District office were recorded and most of them were located in more easily accessible libraries. Some necessary resources that are missing from the shelves in the Galveston District office might be available in the New Orleans District office. Tomkins-Walsh has contacted the New Orleans District librarian, and when she has completed all work in Galveston she will make a trip to New Orleans to find missing items and to research flood management on the lower Mississippi river. Work at the Galveston office is about 40 percent complete.

National Archives and Records Administration (NARA). Early USACE Galveston District records have been transferred to the regional NARA in Ft. Worth. Tomkins-Walsh has established contact with an archivist there and obtained a finding aid for the Galveston district records. Once Tomkins-Walsh has gleaned all the relevant information from the Galveston District Office, she will plan a trip to Ft. Worth.

Summary

Although this grant period resulted in tremendous progress, research for "Bayous Rising! . . ." remains in the early stages. Houston's history of flood management revealed a city responsive to a distinctive topography, but community ethos and government priorities that reflected national values and priorities. The federal government's role generally, and the Army Corps of Engineers particularly, emerged from an intervention philosophy characteristic of progressivism. Environmentalism in Houston followed the trajectory of national activism, although local concerns shaped direction and focus. In Houston, corporate influence on and support of local environmental groups put a cap on the growth of environmental responsibility and simultaneously ensured the survival of organizationally fragile and financially insolvent groups. Although further comparative research with other cities is needed, Houston's reputation as the *laissez faire* capital may be justified but only in degree rather than kind.

In general, Houston is home to a small but active environmental community with many ties to the corporate community. Houston's general population expresses (in annual surveys) belief in and desire for an environmentally stable environment but does not participate in widespread environmental activism. At both city and county levels, government depends on the financial support of business and development for election and responds to the demands of these supporters in decisions balancing public versus business interests. Recent practices revealed modest improvements in overall community and government environmental responsibility tempered by a powerful tendency to return to old practices and policies.

Martin V. Melosi, Ph.D., is a Professor of History at the University of Houston. He can be reached at mmelosi@uh.edu. Terry Tomkins-Walsh is a Ph.D. student in the Department of History at UH.

Understanding Spatial Distribution of Asthma in the Harris County Area

During the past several years, asthma has become a priority public health concern, especially among children in the United States. More Americans than ever before are suffering from asthma and it has become one of the most common and costly illness in this country. Besides AIDS and tuberculosis, asthma is the only chronic disease with an increasing death rate. Each day, 14 Americans die from asthma. Asthma death rates increased 58 percent from 1979 to 1992 and the death rate for children of 19 years and younger increased by 78 percent between 1980 and 1993. The cost of asthma in 1998 was estimated to be $11.3 billion. The purpose of this study is to determine whether income, race, and air pollution may influence the prevalence of asthma among the people living in the general area of Harris County, Texas.

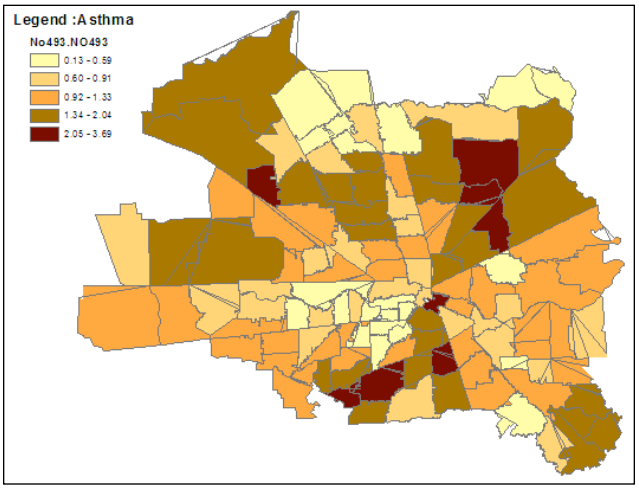

Figure 1. Map of Asthma by Zip Code

Data Collection

In this research, we mainly used five sets of data and they are input either in the form of maps or tables: (a) asthma data for the year 1999 that provides asthma rate per thousand of population per zip code in the Harris County area;[1] (b) income data that has median incomes per household for each zip code;[2] (c) Race table that consists of populations of Black, White and other races for each zip code;[2] (d) the zip code shape file of the Harris County area;[5] and (e) air pollution data per zip code.[2,3] Note that we have used Ozone and NO_2 readings from six monitoring stations as there are insufficient data due to lack of monitoring stations in most of the areas of Harris County area.

Data Analysis and Results

ArcGIS and Microsoft Excel tools were used to analyze the data. ArcGIS is a Geographic Information System (GIS) that can be used to analyze and display data. Determination of correlation for various input data and plotting of charts were done using MS Excel. GIS is basically a powerful computer mapping and analysis technology that allows large quantities of information to be viewed and analyzed within a geographic context. Using GIS, the scope of study can be limitless in the sense that it can be local, regional, countrywide, or worldwide. The maps act as a visual representation of data. In our study, a zip code shapefile was used to represent various zip codes of Harris County. Under one dataframe, various layers of data have been added to make comparative studies. We had layers such as asthma, income, race, ozone, and etc. Zip code column was considered as the primary key attribute while joining different data tables. The tables were imported from MS Excel in the form of database (.dbf) file and records with only matching attributes were considered in the final dataset. Once the layers were created by joining different tables, the Symbology property of each layer was changed to a Graduated color ramp. This color classification was done in order to compare and analyze the layers representing different input dataset. For instance, to see whether there is any correlation between average income and asthma in Harris County, we created a new layer for income by joining the zip code table and income table and choosing zip code as the common attribute from both tables. Then a comparison was made with a similar layer of asthma by changing the Symbology property to a Graduated color ramp. While making the comparison, it is important that the color ramp and its classification should be selected in such a way that any two layers under consideration should be able to compare and analyze. Figures 1 and 2 are examples of map that were created using this method.

Using MS Excel, the team found the correlation between the median household income and asthma as –0.2726. This shows an inverse correlation in the sense that the asthma prevalence rate is higher in lower income areas. We also found the correlation between race and asthma (see Table 1). It shows that the rate of asthmatic people decreases in a

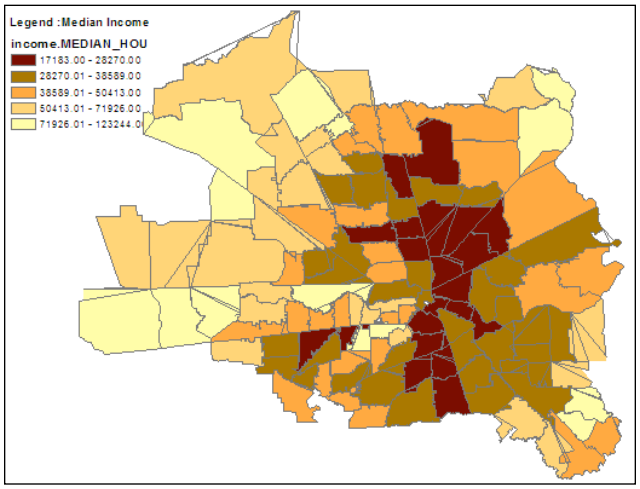

Figure 2. Map of Income Versus Zip Code

Table 1. Correlation of Coefficient for Asthma and Race

White & Asthma	0.5597
Black & Asthma	-0.5412
Others & Asthma	-0.0108

Table 2. Correlation Coefficient for Asthma and Ozone

1st_1hr	-0.3635
Avg_1hr	-0.1784
Day_1hr	0.0896
1st_8hr	0.011
Avg_8hr	0.243
Day_8hr	-0.1208
Ozone2000Annual	0.122
AllYrAveOzone	0.2688

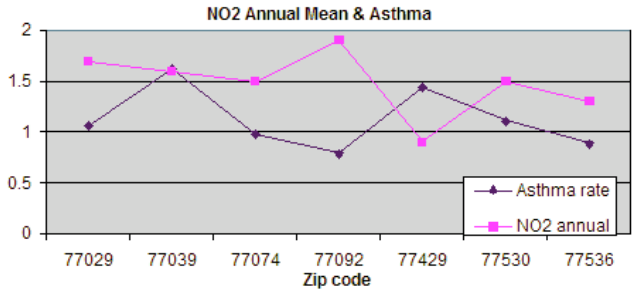

Figure 3. NO_2 Annual Mean and Asthma

White dominant locality, whereas it increases in a predominantly Black locality. There does not seem to be a good correlation between asthma and other races. Lack of detailed data of all races in the county prevents us from getting more accurate findings as to what is the exact relation between asthma and other races such as Hispanic, etc.

The correlation between ozone and asthma are shown in the Table 2. It shows that there is no direct correlation between asthma and highest one hour ozone data (1st_1hr). Similarly, we do not find any good correlation for the average one-hour (Avg_1hr) and the Day_1hr Ozone reading, the latter being the number of days in the year when 1-hour values are expected to exceed the 1-hour standard and 1st_8hr stands for the highest eight hour ozone data. However, the asthma rate is relatively influenced by Avg_8hr (average four highest eight hour readings) and AllYrAveOzone (all year average ozone). Though '0.243' and '0.2688' are not very high correlation coefficients, it is shown that asthma starts correlating with Ozone when the amount of Ozone sampling time increases. Lack of Ozone readings due to lack of monitoring stations in most of the Harris County area prevent us from getting desired results.

Nevertheless, further and more detailed study can be done if sufficient ozone data is provided. The correlation coefficient between the 1hr_Max of NO_2 and Asthma is -0.377 and that between annual mean of NO_2 and Asthma is -0.421. Both of them are negative and therefore have inverse relation between the prevalence of Asthma and NO_2. (See Fig. 3.) The study could not provide a cause for this phenomenon. Once again, lack of data due to lack of monitoring stations in most parts of the Harris County area prevented us from getting concluding results.

Conclusion

This study found that in Harris County, the asthma prevalence among people decreases as income increases. The rate of asthma is comparatively less in a White neighborhood than in a Black area. We could not find any conclusive answer for other races like Hispanic, Asian, etc. Further research can be carried out for all the races once detailed data is provided. Ozone density seems to have a strong correlation with asthma; however, NO_2 density seems to have an inverse relation with asthma. Lack of Ozone and NO_2 readings due to lack of monitoring stations in most of the areas of Harris County area prevented us from making concluding results.

References

[1]Texas Health Care Information Council. Texas Hospital Inpatient Discharge Public Use Data File.

[2]U.S. Census Bureau. <http://www.census.gov/>

[3]U.S. Environmental Protection Agency (EPA). "AirData: Access to Air Pollution Data." <http://www.epa.gov/air/data/index.html>

[4]Texas Natural Resource Conservation Commission (TNRCC). <http://www.tnrcc.state.tx.us/cgi-bin/monops/site_info>

[5]Texas Natural Resources Information System (TNRIS). <http://www.tnris.state.tx.us/>

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Chicot/Evangeline Aquifer of the Texas Gulf Coast, Groundwater Age and Pathways for Saltwater Contamination

Saltwater contamination of coastal aquifers is most often attributed to seawater intrusion;[1] however, previous work by Bourgeois[2] indicates that a source of saltwater contamination of the Chicot/Evangeline aquifer of the southeastern Texas Gulf Coast is also upwelling of brines from underlying sedimentary units. The Chicot/Evangeline aquifer is the main drinking water aquifer of this region and saltwater contamination is worsening with time leaving some areas without a source of fresh groundwater. The main purposes of this study are to evaluate if upwelling brine contaminates the aquifer over a broader area than that studied by Bourgeois,[2] and if this process is more effective in areas where the regionally extensive Beaumont formation that overlies and confines the aquifer has been deeply incised and replaced with more permeable fluvial sediments. The study area is in Brazoria County, just northeast of Bourgeois's[2] study area (Fig. 1). The results of this research can be used in managing groundwater use in this region and can be extended to understanding saltwater contamination of other coastal aquifers in a similar geologic setting.

Twelve water samples have been collected from wells penetrating the Chicot/Evangeline aquifer (Fig. 1). Electrical conductivity, pH, Cl, SO_4, HCO_3, CO_3, I, and Br analyses have been completed on the twelve samples. Additional samples and analytical work (anions and isotopes) will be completed during the second year of this two-year study.

While preliminary, we have had some interesting findings. As expected the main source of water in the Chicot/Evangeline aquifer, even for the saltiest samples with TDS (total dissolved solids) values of up 3100 mg/L, is meteoric water recharge. We found two sources of salt enrichment in the samples above that expected for simple meteoric water recharge into the aquifer. One sample collected from over a salt dome, showed evidence of elevated Br and Cl coupled with low I concentrations, suggesting the salt enrichment is from the dissolution of halite in the underlying dome but not from mixing with upwelling brine.[3] While the salt dome penetrates the Chicot/Evangeline aquifer in this area, the top of the dome occurs approximately 500 feet below the depth of 585 feet from which the water sample was collected. We plan to collect more samples in this region to evaluate the effect of the salt dome further. Of the water well samples, four show increased concentrations of Cl, Br, and I which are likely products of mixing with up to ten percent upwelling brine. These limited results show little correlation with upwelling brine contamination and regions where the Beaumont has been replaced by river alluvium. Additional samples and analytical work will provide more information.

References

[1]A.R. Dutton and B.C. Richter. "Regional Geohydrology of the Gulf Coast Aquifer in Matagorda and Wharton Counties, Texas: Development of a Numerical Model to Estimate the Impact of Water-Management Strategies," Lower Colorado River Authority (IAC (88-89) 0910), Bureau of Economic Geology, University of Texas at Austin, TX, 1990.

[2]F.M. Bourgeois. "Elemental and Stable Isotope Study to Determine the Source of Salt-water Contamination in the Chicot Aquifer of the Gulf Coast Aquifer System," Master's thesis, University of Houston, Houston, TX, 1997.

[3]B.C. Richter and C.W. Kreitler. *Geochemical Techniques for Identifying Sources of Ground-Water Salinization*. Boca Raton, FL: CRC Press, 1993.

[4]S. Aronow, W.L. Fisher, J. H. McGowen, and V.E. Barnes. "Geologic Atlas of Texas, Houston Sheet, Scale: 1:250,000," Bureau of Economic Geology, University of Texas at Austin, Austin, TX, 1982.

[5]T.E. Brown, J.L. Brewton, J.H. McGowen, C.V. Proctor, S. Aronow, and V.E. Barnes. "Geologic Atlas of Texas, Beeville-Bay City Sheet, Scale: 1:250,000," Bureau of Economic Geology, University of Texas at Austin, Austin, TX, 1987.

[6]"Northeast Texas Gulf Coast, Executive Reference Map 312." Geomap Company, Plano, TX, 1992.

[7]"Houston Quadrangle (NH 15-7), 1:250,000 Topographic-Bathymetric Map," U.S. Geological Survey, Reston, VA, 1975.

Publications

Banga, T., R.M. Capuano, and D.S. Van Nieuwenhuise. "Evidence of Compartmentalization from a Coupled

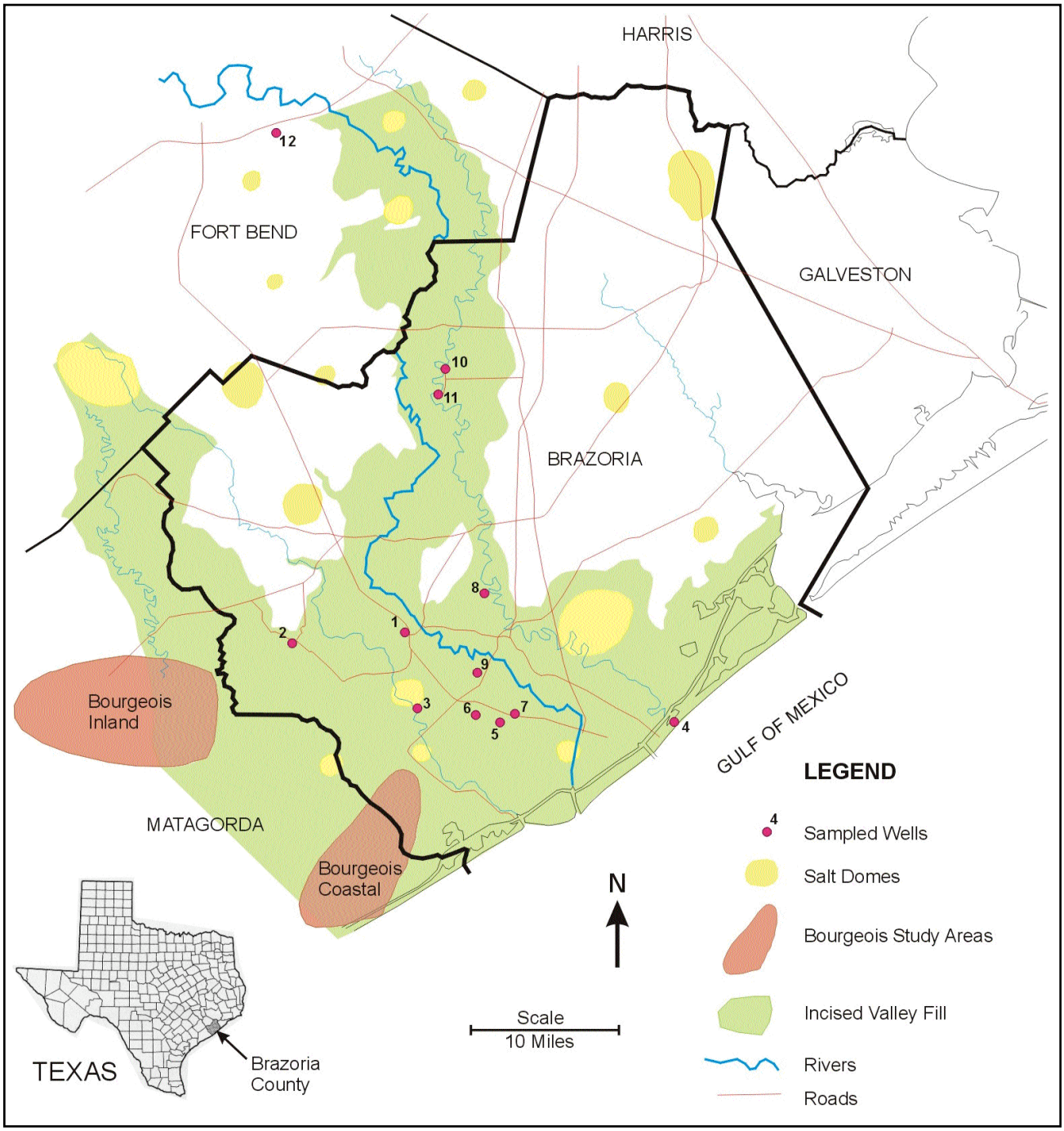

Figure 1. Location of wells sampled in this study, area studied by Bourgeois,[2] area covered with incised valley fill,[4,5] and salt domes.[6] Base map from the U.S. Geological Survey topographic map.[7]

Study on Brine Chemistry and Stratigraphy in and Around the South Liberty Salt Dome, Texas," American Association of Petroleum Geologists Annual Meeting *Abstracts* 12 (2003): A9. (*Invited*.)

Banga, T., R.M. Capuano, and D.S. Van Nieuwenhuise. "Fluid Flow, Stratigraphy, and Structure in the Vicinity of the South Liberty Salt Dome, Texas," Gulf Coast Association of Geological Societies *Transactions* 52 (2002): 25-36.

Hyeong, K. and R.M. Capuano. "Hydrogen Isotope Fractionation Factor for Mixed Layer Illite/Montmorillonite 0° to 150°C, New Data from the Northeast Texas Gulf Coast," Geological Society of Korea Annual Meeting 57 (2002): 32; *Geochimica Cosmochimica Acta* (2003). (*Accepted*.)

Hyeong, K. and R.M. Capuano. "Origin of Low Salinity Pore Water in the Seal Overlying the Geopressured Regime, Northeast Texas Gulf Coast," American

Association of Petroleum Geologists Annual Meeting *Abstracts* 11 (2002): A83.

Presentations

Banga, T., R.M. Capuano, and D. Van Nieuwenhuise. "Evidence of Compartmentalization from a Coupled Study on Brine Chemistry and Stratigraphy in and around the South Liberty Salt Dome, Texas," Presidents Choice Student Poster Awards Papers, American Association of Petroleum Geologists Annual Meeting, May 11–14, 2003, Salt Lake City, UT.

Banga, T., R.M. Capuano, and D.S. Van Nieuwenhuise. "Fluid Flow, Stratigraphy, and Structure in the Vicinity of the South Liberty Salt Dome, Texas," Gulf Coast Association of Geological Societies Annual Meeting, Oct. 29–Nov. 1, 2002, Austin, TX.

Hyeong, K. and R.M. Capuano. "Hydrogen Isotope Fractionation Factor for Mixed Layer Illite/Smectite 0° to 150°C, New Data from the Northeast Texas Gulf Coast," Geological Society of Korea Annual Meeting, 2002, City, Korea. 57 (2002): 32.

Hyeong, K. and R.M. Capuano. "Origin of Low Salinity Pore Water in the Seal Overlying the Geopressured Regime, Northeast Texas Gulf Coast," American Association of Petroleum Geologists Annual Meeting, March 10–13, 2002, Houston, TX.

Funding and proposals

Vipulanandan, C. and R.M. Capuano. "Use of Crushed Gravel in Concrete Paving." Texas Department of Transportation, 2003–2005, $170,000. (*Pending*.)

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The Use of Lipid Biomarkers in Deep-sea Gulf of Mexico Sediment to Reveal the Response of the Indigenous Microbial Community to Oil Drilling Activity

OFF-SHORE OIL DRILLING ACTIVITIES RESULT IN THE DISCHARGE of rock cuttings contaminated with synthetic base fluids (SBF) into the Gulf of Mexico. SBF are a component of drilling mud which act to lubricate the drill bit and help bring rock cuttings to the surface. SBF are typically unsaturated hydrocarbons, 16 or 18 carbons in length, and are similar in structure to other hydrocarbons which can be biodegraded by the activity of sulfate reducing bacteria.[1] Evidence of SBF biodegradation by microbial populations indigenous to marine sediment is being investigated by examining for signature lipid biomarkers in Gulf of Mexico sediment that had been contaminated with SBF. Signature lipid biomarker analysis provides a fingerprint of the composition of the microbial community[2] and can also reflects the utilization of hydrocarbon substrates by the microbes.[3] The use of signature lipid biomarkers was chosen for investigation because of the difficulty associated with incubating or culturing bacteria under conditions that are realistic to the deep-sea sediment environment, namely temperatures just above freezing and high hydrostatic pressure. Lipid biomarkers can provide the means to characterize indigenous microbial populations that are capable of biodegrading SBF, and can then be used to identify sediment sampling locations that are actively biodegrading SBF.

In order to complete our studies, it was necessary to make modifications to an established method for the extraction of lipid biomarkers[2] so we could be satisfied that the process is working optimally in our sediment samples. Table 1 shows the types of fatty acid biomarkers that were found in Gulf of Mexico sediment. Figure 1 reveals differences in microbial community structure between shoreline sediment (practice sediment) and sediment collected at 1135 m depth in the Gulf of Mexico. Note that in the sediment collected off-shore there is a decreased percentage of aerobic bacteria in favor of anaerobes, such as the sulfate reducing bacteria. Results to date reflect the potential use of lipid biomarkers, and work continues to identify lipids biomarkers that reflecting SBF-biodegradation in marine sediment.

References

[1]J. D. Coates, R.T. Anderson, J.C. Woodward, E.J.P. Phillips, and D.R. Lovely. "Anaerobic Hydrocarbon Degradation in Petroleum-Contaminated Harbor Sediments Under Sulfate-Reducing and Artificially Imposed Iron-Reducing Conditions," *Environ. Sci. Technol.* 30 (1996): 2774-89.

[2]D.C. White, C.A. Flemming, K.T. Leung, and S.J. MacNaughton. "*In Situ* Microbial Ecology for Quantitative Appraisal, Monitoring, and Risk Assessment of Pollution Remediation in Soils, the Subsurface, the Rhizosphere and in Biofilms," *J. Microbiol. Methods* 32 (1998): 93-105.

[3]C.M. So and L.Y. Young. "Initial Reactions in Anaerobic Alkane

Table 1. Phospholipid Fatty Acids Extracted from Galveston Bay Sediment†

Saturated	Unsaturated	Cyclopropyl	Polyunsaturates	Branched saturated	
				Mid -branch	Terminal branch
8:0	16:1w7c	cy17:0(w7,8)		brMe14:0	aMe14:0
10:0	16:1w9t	cy20:0(w9,10)		9Me16:0	iMe15:0
12:0	18:1w9c			brOH18:0	aMe16:0
13:0	18:1w8t				iMe16:0
14:0					
15:0					
16:0					
17:0					
18:0					
20:0					

†Saturated fatty acids are a general indicator of prokaryotes, while branched saturated fatty acids are an indicator of sulfate reducing bacteria, and unsaturated fatty acids indicate the presence of aerobes. Cycloproply fatty acids could indicate the presence of barophillic microbes.

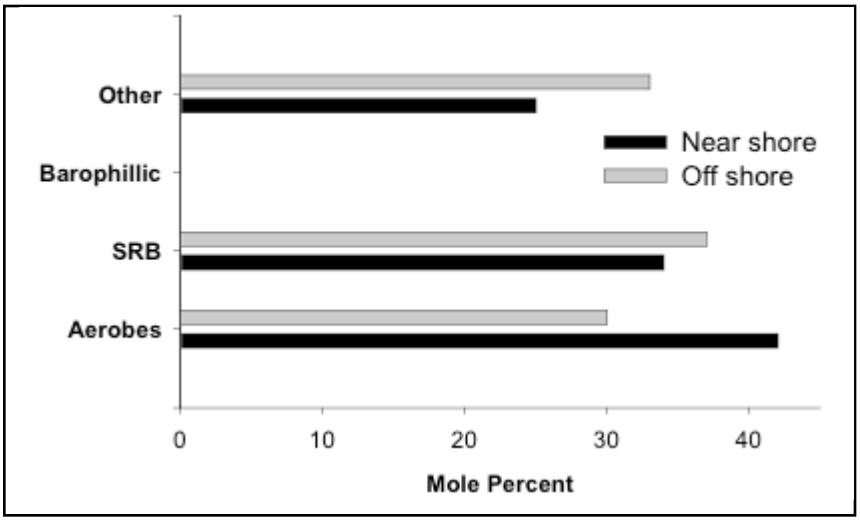

Figure 1. Comparison of microbial community composition between Galveston Bay sediment collected from a near shore location and sediment collected in 1114 m depth of water (off-shore)

Degradation by a Sulfate Reducer, Strain AK-10," *Appl. Environ. Microbiol*. 65 (1999): 5532-40.

Presentations

Roberts, D.J., D. Herman, D. Gangumalla, and V. Demir. "Biodegradation of Synthetic Drilling Mud Base Fluids in Gulf of Mexico Deep-Sea Sediments," International Petroleum Engineering Consortium, Nov. 11–14, 2003, Houston, TX.

Herman, D. and D.J. Roberts. "Biodegradation of Synthetic Base Fluids in Gulf of Mexico Sediments," International Petroleum Engineering Consortium, Nov. 11–14, 2003, Houston, TX.

Funding and proposals

Roberts, D.J., P. Lyons, and D. Herman. "Interactions Between Metal Contamination and Microbial Processes in Sediment from Water Ways of the Lower Rio Grande Valley." Advance Research Program, Texas Higher Education Coordinating Board, 2003–2004, $150,977. *Cancelled*.

Roberts, D.J., D. Herman, and P. Lyons. "Evaluating Intrinsic Bioremediation of Synthetic Drilling Mud Base Fluids in Drill Cuttings Discharged to the Gulf of Mexico." Advance Research Program, Texas Higher Education Coordinating Board, 2003–2004, $251,635. *Cancelled*.

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Coral Disease at the Flower Gardens and Stetson Bank, Northwest Gulf of Mexico

Global coral reef decline, especially in the Caribbean and tropical western Atlantic, is being greatly structured by increasing frequencies and distribution of coral diseases. Since 1992, the Texas Flower Garden Banks have been part of a nationally protected marine sanctuary encompassing the most northerly and isolated coral reefs on the North American continental shelf. The Flower Garden Banks have historically had a low incidence of coral disease, although rigorous surveys have not been performed. The purpose of this research was to carefully document and characterize disease prevalence at these sites.

Methods

Research was conducted at the East and West Flower Garden Banks (mooring buoys 4, and 2, respectively), and Stetson Bank. Thirty meter transects were run to establish quantitative measures of corals and coral condition. Timed swims were performed to assess all pathologies affecting corals in the area. Samples were collected of pathological conditions for analysis, as well as for work in joint collaboration with other researchers. Analysis and comparison of disease lesions using histological and molecular methods are currently in progress.

Results and Discussion

Disease levels at the Flower Garden Banks are "very low," especially in comparison to other areas of the tropical western Atlantic. Transect data may underrepresent disease levels because of the unusually large and flattened growth forms of colonies. Nonetheless, isolated coral (white plague) and sponge (sponge necrosis) disease is present at the Flower Gardens, as were uncharacterized pathologies known from other locations in the Caribbean. Additionally, several novel pathologies were found, and several assumed pathologies were determined to be a result of reef fish behaviors and not disease. Unusually high numbers of hyperplastic growths were found on several species, and samples were collected and sent to the Registry of Coral Pathology. Other disease samples are being examined histologically, with subsamples sent to various researchers for specific analyses.

Of particular interest were three novel pathologies affecting primary coral constituent species; a mottled bleaching and tissue loss condition in numerous *Colpophyllia natans* colonies at both banks, a spreading and localized bleaching condition in *Porites astreoides* on the west bank, and a pale ring condition affecting the three most common hermatypic species (*C. natans*, *Diploria strigosa*, and *Montastraea*

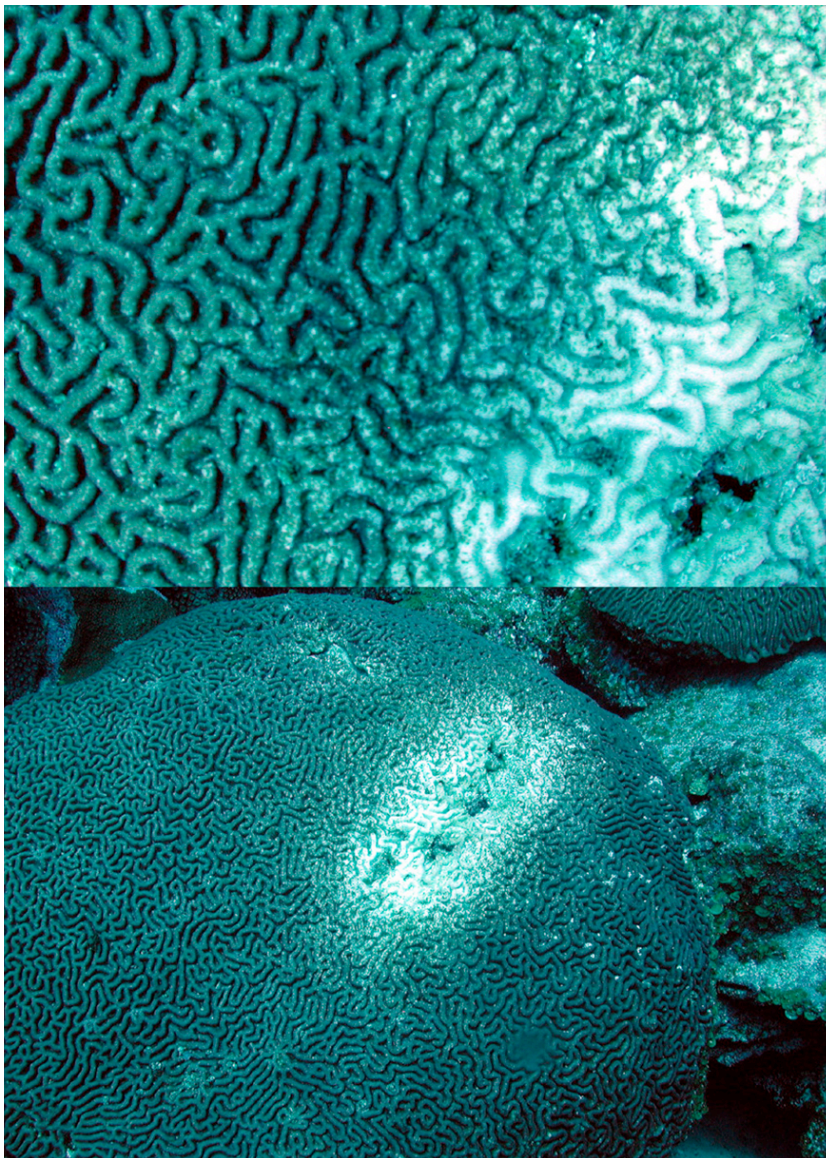

Figure 1. An unidentified mottling condition in *Colpophyllia natans* causes bleaching and tissue loss in large mature colonies.

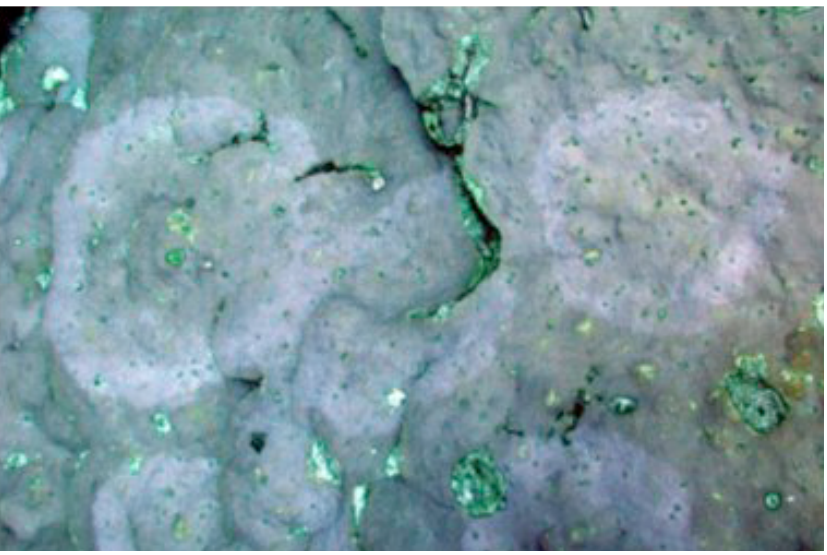

Figure 2. A pale opaque ring has been identified in three primary reef-building species at the Flower Garden Banks and is currently being investigated.

faveolata) at both banks. These pathologies require further study and managers are interested in beginning constant monitoring of affected colonies.

Overall, these reefs appear to be very healthy but should be monitored carefully for any outbreaks or increased reports of anomalous conditions affecting the benthic species. The nature of this reserve, both in habitat, location, environmental parameters, and isolation would suggest that any epizootic disease outbreak could have implications that would negatively impact reef diversity and structure perhaps to an even greater extent than most other more common and typical reef systems in the region. It is important to ensure that anyone involved in assessing coral disease at the FGNMS in the future be familiar with this reef system and with coral pathologies to avoid confounding reports that misidentify conditions and lesions, or misrepresent what is "normal" and what is not. Clearly, FGNMS managers must play an integral role with disease researchers because of the remoteness of this area and the limited familiarity that most persons have with the sanctuary.

Publications

Ren, L., B.K. Linsley, G.M. Wellington, D.P. Schrag, and O. Hoegh-Guldberg. "Deconvolving the $\delta^{18}O$ Seawater Component from Subseasonal Coral $\delta^{18}O$ and Sr/Ca at Rarotonga in the Southwestern Subtropical Pacific for the period 1726–1997," *Geochimicia et Cosmochimic Acta* 67 (2003): 1609-21.

Wellington, G.M. and W.K. Fitt. "Influence of UV Radiation on the Survival of Larvae from Broadcast-Spawning Reef Corals," *Marine Biology* (2003). (*In press*.)

Linsley, B.K, G.M. Wellington, D.P. Schrag, L. Ren, M.J. Salinger, and A.W. Tudhope. "Geochemical Evidence from Corals for Changes in the Degree of Spatial Coherence of South Pacific Interdecadal Climate Variability Over the Last 300 Years," *Coral Reefs*. (*Under revision*.)

Ren, L., B.K. Linsley, and G.M. Wellington. "Separating the Effects of Kinetics and Metabolic Fractionation on Coral $\delta^{13}C$," *Climate Dynamics*. (*Under revision*.)

Presentations

Grottoli, O.G. and G.M. Wellington. "Pre-Treatment Effects on Coral Skeletal $\delta^{13}C$ and $\delta^{18}O$ G," AGU Fall Meeting 2003, San Francisco, CA.

Funding and proposals

Wellington, G.M. "Investigation into Stress-Related Factors in White Band Disease." Caribbean Marine Research Center, 2004, $32,250. *Pending*.

—. "Controlled Investigations into the Potential of 'Adaptive' Flexibility in the Coral-Zooxanthellae Symbiosis." National Underseas Research Program, 2004–2005, $99,389. *Not funded*.

—. "Culture and Replenishment of Caribbean Acroporid Corals." National Fish and Wildlife Foundation, 2004–2005, $30,000. *Not funded.*

—. "Density-Dependent Movement of Coral Reef Fishes: An Experimental Approach Using Artificial Reefs with Shelter Limitation." Caribbean Marine Research Center, two years, $38,871. *Pending*.

—. "Establishment of a Caribbean Coral Reef Baseline Using Key Indicator Species in Remote Regions." Caribbean Marine Research Center, one year, $32,048. *Pending*.

Dunbar, R.B. and G.M. Wellington. "Southeastern Pacific Climate Variability Recorded by Multi-Century Easter Island Corals." NSF, Marine Geology and Geophysics, two years, $56,071. *Resubmitted*.

Linsley, B.K. and G.M. Wellington. "Developing a Network of Coral Records." Collaborative Research: NSF, four years, $88,637.

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Amino Acids in Drinking Water Supplies: Occurrence, Bulk Diffusivities, Disinfection By-product Formation, and Control

AMINO ACIDS, PEPTIDES, AND proteins are important structural components of all living organisms, and amino acids have been identified in a large variety of aquatic environments.[1] Even though amino acids—an important component of the dissolved organic nitrogen—typically account for only one to three percent of the dissolved organic carbon in surface waters, they can cause substantial problems in drinking water such as reducing disinfection efficacy, forming disinfection by-products, and fouling membrane filters.[2] Despite the geno- and cytotoxicity of disinfection by-products formed upon chlorination of waters containing certain amino acids, very little is known about their occurrence in drinking water supplies.

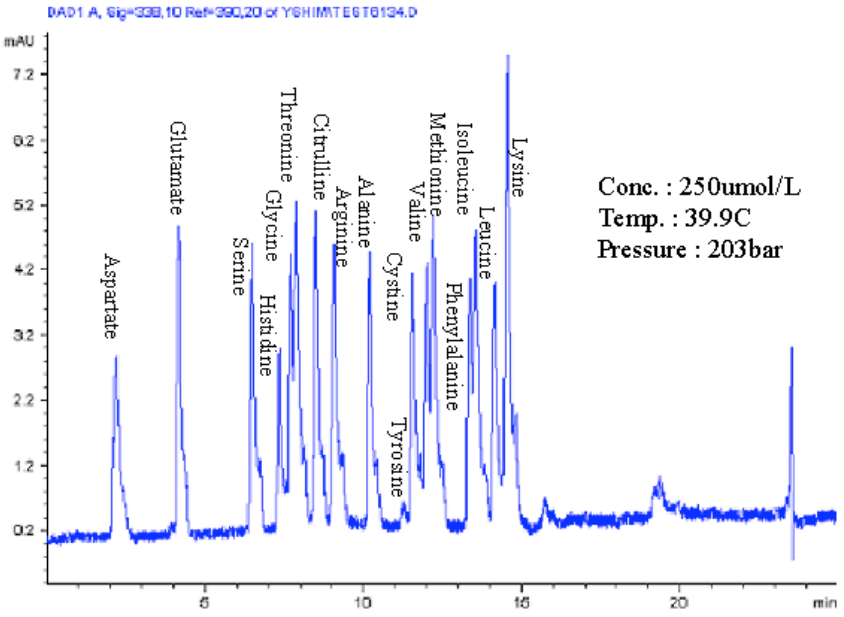

Figure 1. HPLC chromatograph depicting differences in retention times for several amino acids

Funding was obtained to support ongoing research directed toward building expertise in amino acid quantification by high-pressure liquid chromatography (HPLC). Progress towards this objective was made using a Hewlett Packard HPLC fitted with an ultraviolet light detector. First, automated on-line derivatization was performed with o-phthalaldehyde for primary amino acids and 9-fluorenylmethyl chloroformate for secondary amino acids. Direct derivatization of acid hydrolyzed samples was possible at a pH above 10. Separation was achieved at 40ºC using a Zorbax-Eclipse AAA column, which contains reversed phase material. The mobile phase consisted of a 40 mM Na_2HPO_4 solution at pH 7.8 and a 45:45:10 mixture (v/v/v) of acetonitrile, ethanol, and water.

An example of separations achieved for a mixed standard solution of 250 micromolar amino acid solution is depicted in Fig. 1. Substantial differences in retention times can be observed in Fig. 1 for several amino acids and excellent linearity of the calibration curve was achieved. Thus, an analytical method for pri-

Shankar Chellam

mary and secondary amino acids has been established; however, amino analysis measurement is only the first step in the examination of their environmental significance.

On-going research is focusing on their separation using nanofiltration membranes and direct measurements of their transport properties. A computer controlled crossflow nanofiltration apparatus has already been assembled for this purpose. Online data acquisition using LabVIEW (Version 5.1, National Instruments, Austin, TX) software is being used to continuously monitor the permeate flow rate, pressure, and temperature. These experiments have been designed to obtain intrinsic membrane parameters that quantitatively describe nanofilter selectivity using the irreversible thermodynamic model, i.e. reflection coefficient and permeability. A cylindrical two-chambered diffusion cell has also been fabricated for direct measurement of their diffusion coefficients. This cell has been calibrated, and the cell constants have been determined using electrolytes of accurately known bulk diffusion coefficients.

References

[1]E.M. Thurman. *Developments in Biochemistry: Organic Geochemistry of Natural Waters*. Dordrecht, Netherlands, Martinus Nijhoff/Dr. W. Junk Publishers. (1985)

[2]P. Westerhoff and H. Mash. "Dissolved Organic Nitrogen in Drinking Water Supplies: A Review," *J. Wat. Supp. AQUA* 51.8 (2002): 415-48.

Publications

Buzcu, B., M.P. Fraser, P.Kulkarni, and S. Chellam. "Source Identification and Apportionment of Fine Particulate Matter in Houston, TX Using Positive Matrix Factorization," *Environmental Engineering Science* (2003). (*In press*.)

Chellam, S. and D.A. Clifford. "Physical-Chemical Treatment of Groundwater Contaminated by Leachate from Surface Disposal of Uranium Tailings," *ASCE J. Environmental Engineering* 128.10 (2002) 942-52.

Kulkarni, P., S. Chellam, G. Ghurye, and M.P. Fraser. "*In Situ* Generation of Hydrofluoric Acid During Microwave Digestion of Atmospheric Particulate Matter Prior to Trace Element Analysis by Inductively Coupled Plasma Mass Spectrometry," *Environmental Engineering Science* (2003). (*In press*.)

Sharma, R.R., R. Agrawal, and S. Chellam. "Temperature Effects on Sieving Characteristics of Polymeric Nanofiltration Membranes: Pore Size Distributions and Solute Rejection," *J. Membrane Science* (2003). (*In press*.)

Shetty, G.R. and S. Chellam. "Predicting Fouling of Nanofiltration Membranes During Municipal Drinking Water Treatment Using Artificial Neural Networks," *J. Membrane Science* 217.1-2 (2003): 69-86.

Shetty, G.R., H. Malki, and S. Chellam. "Predicting Contaminant Removal During Municipal Drinking Water Nanofiltration Using Artificial Neural Networks," *J. Membrane Science* 212.1-2 (2003): 99-112.

Shetty, G.R., R.R. Sharma, and S. Chellam. "Scale-Up of Municipal Water Nanofiltration Based on Permeate Water Quality," *Environmental Engineering Science* 19.6 (2002): 545-62. (*Invited paper in the special issue on "Membrane Separations in Aquatic Systems."*)

Presentations

Agrawal, R.R. and S. Chellam. "Changes in Pore Size Distributions and Transport Parameters of Water Treatment Nanofiltration Membranes with Temperature," Student Paper for Texas Water 2003, WEAT and Texas Section AWWA Annual Conference April 1–4, 2003, Corpus Christi, TX. (Third prize winner in student paper competition.)

"Scale-Up Methodology For Municipal Water Nanofiltration Based on Permeate Water Quality," AWWA Membrane Technology Conference and Exhibition, March 2–5, 2003, Atlanta, GA.

Shetty, G.R. and S. Chellam. "Predicting Contaminant Removal During Nanofiltration Using Artificial Neural Networks," AWWA Membrane Technology Conference and Exhibition, March 2–5, 2003, Atlanta, GA.

Zhu, B., D.A. Clifford, and S. Chellam. "Virus and NOM Removal by Electrocoagulation-Microfiltration," AWWA Membrane Technology Conference and Exhibition, March 2–5, 2003, Atlanta, GA.

Funding and proposals

Chellam, S., S. Krasner, and B. Bergamaschi. "Nitrogenous Natural Organic Matter in Drinking Water Supplies: Occurrence, Disinfection By-product Formation and Control." U. S. Geological Survey, 2003–2005, $166,666. *Not funded*.

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Development of a Sulfur Tolerant Catalytic Adsorbent for NO_x Reduction in Diesel Exhaust

STUDIES OF NO_X SORPTION AND RELEASE INVOLVING simulated exhaust of a lean-burn diesel vehicle were conducted by UH researchers. EIH funds, together with State of Texas ATP funds, have been utilized for the design and assembly of a state-of-the-art multiple reactor system for studying NO_x storage and reduction (NSR), a promising technology for NO_x abatement heavy-duty diesel vehicles. The system comprises a thermogravimetric analyzer with differential scanning calorimetry (TGA-DSC), fixed-bed microreactor, and dual-stage monolith reactor (see Fig. 1). In addition, a Temporal Analysis of Products system (TAP reactor) has been installed and applied to this research.

We have carried out a comprehensive study of NO_x storage (adsorption) on model *Pt*/Barium Oxide on alumina catalytic sorbents. The time dependence of sample mass, heat flow, and effluent gas composition are collected for a range of sample temperatures and feed compositions. Long-time data provide sorbent capacitance. Feed samples containing the sorbing species (in this case *NO*) in nitrogen and nitrogen/oxygen mixtures provide non-oxidative and oxidative adsorption data. Typical data obtained with the TGA/DSC are shown in Fig. 2. A *Pt*/*BaO*/alumina powder was exposed to a mixture of NO/O_2 at 350ºC then heated to 650ºC in the TGA device. The reversible nature of the trapping and release are evident, as is the conditioning of the catalyst over a few cycles. We have elucidated the NSR thermodynamic and kinetics as a function of the temperature and NO_x concentration. The equilibrium NO_x storage capacity is shown to increase monotonically with decreasing temperature, whereas the kinetic NO_x storage exhibits a maximum at an intermediate temperature (ca. 350ºC).

These NO_x storage experiments have helped us understand the NO_x storage behavior of model NO_x trap materials. For example, the kinetic sorption maximum at an intermediate temperature indicates that NO_x storage is kinetically limited at low temperature. Therefore, measures to enhance the rate of adsorption rather than the capacity are needed to improve the productivity of the NO_x trap. The data enable development of kinetic models of the adsorption process, and constructing functional dependencies on partial pressures and temperatures. By comparing the

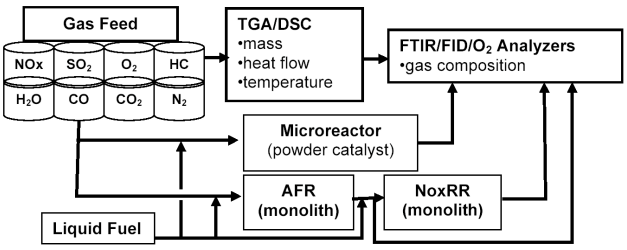


Figure 1. Schematic of Experimental Setup

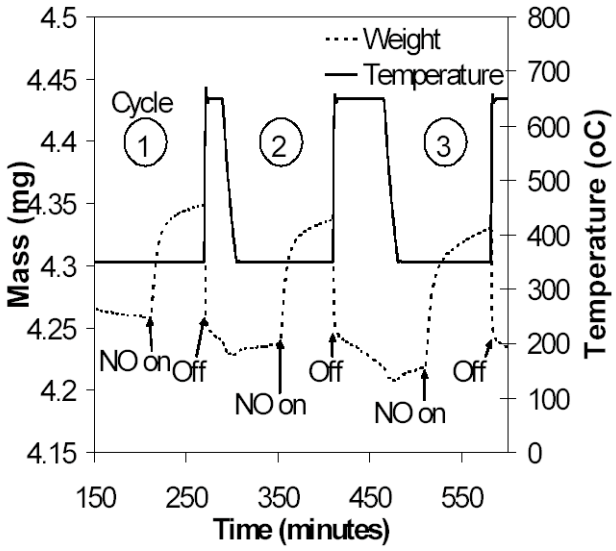
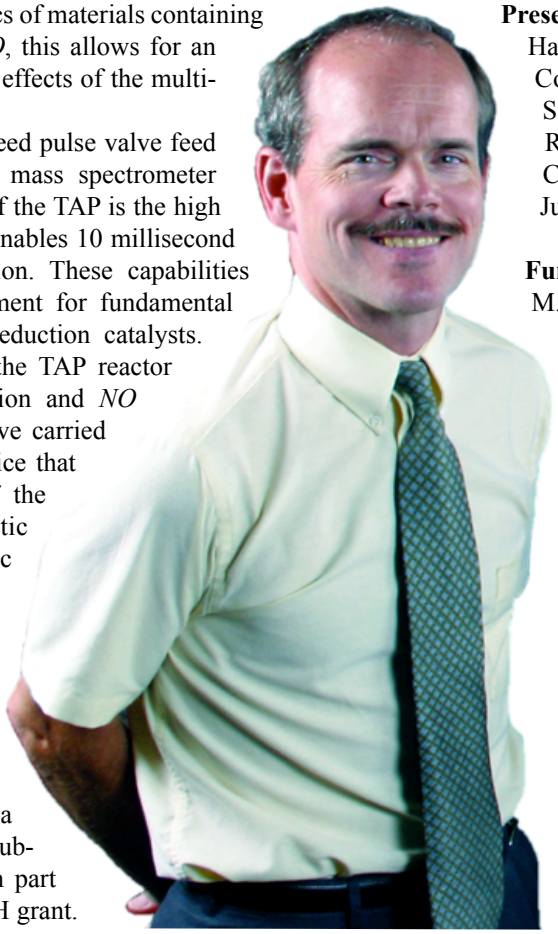


Figure 2. Typical Data Obtained with the TGA/DSC Unit

adsorption and desorption kinetics of materials containing varying amounts of *Pt* and *BaO*, this allows for an understanding of the synergistic effects of the multi-functional catalyst.

The TAP comprises a high-speed pulse valve feed system, reaction chamber, and mass spectrometer analysis system. A key feature of the TAP is the high speed pulsing feed system that enables 10 millisecond pulsing during vacuum operation. These capabilities make the TAP an ideal instrument for fundamental research of NO_x storage and reduction catalysts. Initial experiments employing the TAP reactor have involved *NO* decomposition and *NO* reduction on *Pt* powder. We have carried out simulations of the TAP device that simplifies the interpretation of the data and enables microkinetic model development and kinetic parameter estimation.

We are continuing our study of NO_x trap performance during the pulsing of different reductants, and in the presence of sulfur dioxide. To this end, our goal is to mitigate the detrimental effect of sulfur through a sulfur guard concept. We have submitted a NSF proposal based in part on research supported by the EIH grant.



Michael P. Harold

Publications

Muncrief, R., K. Kabin, and M.P. Harold. "NO_x Storage and Reduction Performance Studies on *Pt*/*BaO*/Alumina with Propylene as Reductant," *AIChE J.* (Sept. 2003). (*In preparation*.)

Presentations

Harold, M.P., R. Muncrief, and K. Coym. "Catalytic Engineering Studies of NO_x Storage and Reduction," North American Catalysis Meeting, Cancun, Mexico, June, 2003.

Funding and proposals

M.P. Harold. "Dynamics Studies of Coupled Adsorption and Reaction: NO_x Storage and Reduction for Diesel Emission Control." National Science Foundation, 2003–2006, $429,680. (*Pending*.)

Harold, M.P. and V. Balakotaiah. "Development of an Integrated Particulate and NO_x Trap System for Diesel Engines." State of Texas, Texas Air Research Center, 2003–2004, $99,520. (*Pending*.)

Harold, M. P. and V. Balakotaiah. "Design and Optimization of the NO_x Trap Reactor." State of Texas Coordinating Board, Technology Development and Transfer Grant, 2004–2006, $150,000. (*Pending*.)

Michael P. Harold is a professor of chemical engineering at the University of Houston. He can be reached at harold@uh.edu

Open-framework Polymers for Eliminating Volatile Organic Compound Pollution in the Houston Ship Channel

SIZE-SELECTIVE POROUS FUNCtional open-framework polymers may be used to control water and air pollution from volatile organic compounds (VOCs) in the Houston Ship Channel, which has been a great concern in the Houston area.[1] The separations of VOCs in the chemical process industry are largely confined to processing on high value, relatively low volume streams. This is due to the relatively high capital cost and low throughout capacity from separation materials degradation.[2] Stable open-framework metal-organic polymers suitable for these applications are attractive for VOC control in the Houston Ship Channel.

Among the new materials synthesized in Lu's UHCL laboratory, one compound has a remarkably stable open-framework structure (MOF-cl1). Initial studies on this material revealed that the open-framework is not only highly stable in its original dimensions, capable of selective adsorption, but also expandable. The structure displays attractive reversible and selective-adsorption capability for organic compounds. The inclusion of organic compounds in the channel structure is shown in Fig. 1. Further studies on this compound for adsorption properties to some VOCs in the Houston Ship Channel are being investigated in-depth.

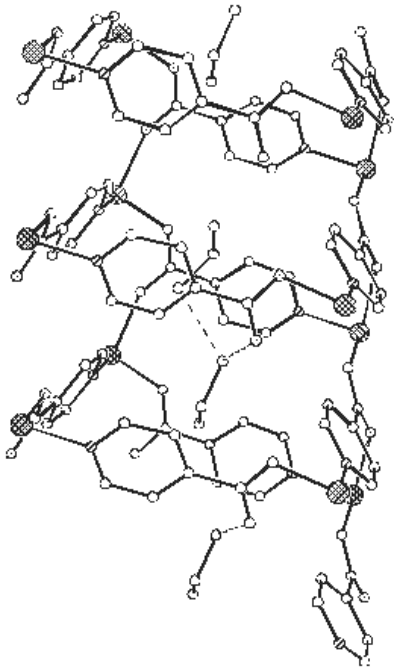


Figure 1. View of the MOF-cl1 Channel Structure with Linear Organic Molecules Inclusion

The research activities in Lu's laboratory also produced large pore containing porous materials for potential environmental applications.

$[Cu(N_2C_{12}H_{10})_2]$ is the largest diamondoid single-net 3-D open-framework coordination polymer observed in the field. This polymer displays very attractive anion exchange, as well as molecular exchange capabilities. Further research on their applications is in progress.

$[(H_2O)Cu(\text{BPDC})]$ (BPDC = 2,2'-biphenyldicarboxylate) is a new double-helical-chain coordination polymer (Fig. 2).[3] The helicate chain structure is of great interest in supramolecular coordination chemistry because of its structural similarities to DNA.[4] To the best of our knowledge, this complex is the first double-helical-chain 1-D coordination polymer constructed based upon the binuclear square pyramidal copper(II)-pair motifs.

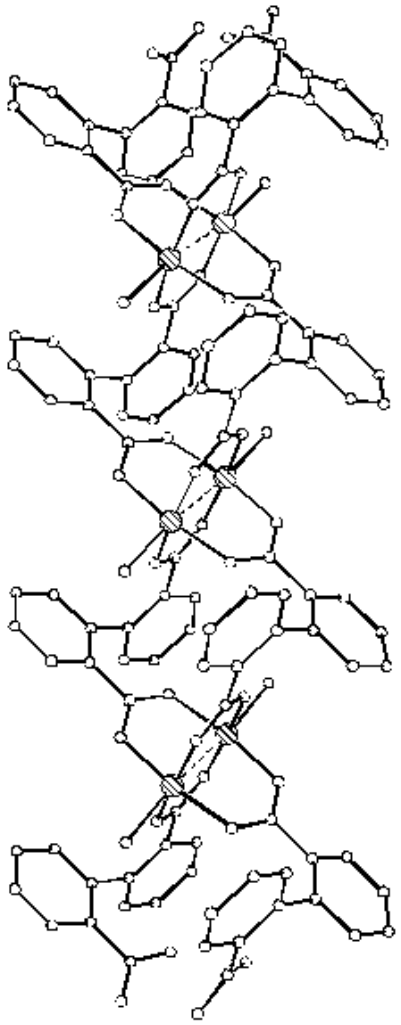
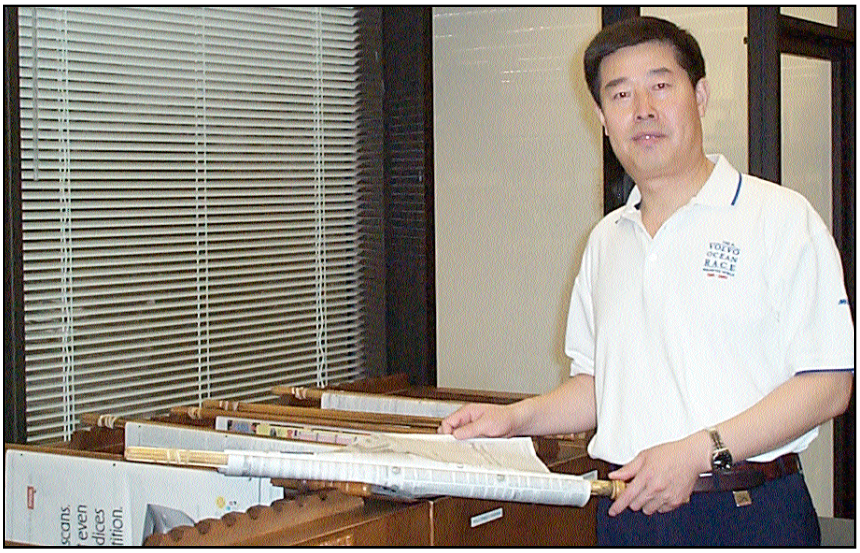


Figure 2. One Section of the Double-helical-chain Polymer that Runs Parallel to the *b*-axis

References

[1]Texas Commission on Environmental Quality. "Houston-Galveston Air Quality Science Evaluation,"



Jack Y. Lu

Aug. 31, 2003. <http://www.tnrcc.state.tx.us/air/aqp/airquality_science.html>

[2]See, for example: Y. El-Shoubary and N. Speizer. ICMAT 2001, 250.

[3]J.Y. Lu and V. Schauss. "A Novel Double-helical-chain Coordination Polymer Constructed from 2,2-biphenyldicarboxylate-linked Binuclear-copper Motif," *Inorg. Chem. Commun*. (2003). (*In press*.)

[4]J.-M. Lehn. *Supramolecular Chemistry—Concepts and Perspectives*. VCH Verlagsgasellschaft, Weinheim, (1995).

Publications

Armentano, D., G. de Munno, F. Lloret, M. Julve, J. Curély, A.M. Babb, and J.Y. Lu. "Oxalate and 2,2-bipyrimidine as Bis-chelating Ligands in the Honeycomb Layered Compound $\{[Fe_2(\text{bpym})(\text{ox})_2]\cdot 5H_2O\}_n$," *New J. Chem*. 27 (2003): 161.

Lu, J.Y. and A.M. Babb. "A Unique Eclipsed 2-D Coordination Polymer with Removable Iodine Molecules in the Open-channel Structure," *Chem. Commun*. (2003): 1346.

Lu, J.Y. and J. Macias. "An Unprecedented Tetrahedral Zinc Mutual-face-insertion Coordination Polymer with both Covalent and Double-hydrogen Bonding Interactions," *CrystEngComm*. 4 (2002): 17.

Lu, J.Y. and C. Norman. "Synthesis and Structure of Two New Coordination Polymers Featuring Noncentrosymmetric Inclusion of Hydrogen-bonded Species," *Polyhedron* 22 (2003): 235.

Lu, J.Y. and V. Schauss. "A Novel Double-helical-chain Coordination Polymer Constructed from 2,2-biphenyl-dicarboxylate-linked Binuclear-copper Motif," Inorg. Chem. Commun. (2003). (*In press*.)

Jack Y. Lu is an assitant professor of chemistry at the University of Houston-Clear Lake. He can be reached at lu@uhcl.edu. Vaughn Schauss is a research assistant in the School of Natural and Computer Science, UHCL.

Improved Combustion Catalysts for NO_X Emission Reduction

CATALYTIC COMBUSTION IS A MEANS FOR BURNING gaseous fuel without flames, thus avoiding generation of NO_x, a major air pollutant.[1] This is especially important in power generation using gas turbines. Figure 1 demonstrates how replacing a conventional burner with a catalytic bed the oxidation of methane at lower temperatures (<1,200ºC) than with homogeneous flames (1,800-2,000ºC), where excess amounts of NO_x form (> 200 ppm). Efficient burner design gives only 25 ppm, but catalytic combustion reaches levels as low as 2-3 ppm. Although NO_x removal from the effluent is possible with post-combustion treatment, catalytic combustion costs 25 percent as much.

However, this technology has not been implemented due to loss of catalyst activity, which must initiate the reaction at low temperatures (200-400ºC) yet be stable enough to withstand sintering at high temperatures (1,000-1,300ºC).[2] These two contradictory characteristics must be reconciled through careful design of the catalyst. Part of the problem is the extremely high gas velocities used in gas turbines. To avoid flow resistance, the catalyst must be coated on the inside of small channels in ceramic monolith structures. Due to poor mixing, flame ignition occurs and the resulting high temperatures (1,500-2,000ºC) destroy the catalyst. The objective of this research is to investigate using ceramic foams that are similar to monoliths but have a tortuous pore structure.[3,4] This provides better convective mixing, which promises to avoid hotspots and subsequent catalyst degradation.

The following are the most significant results:

1. Selection of an active, stable catalyst. Previous investigators found that hexa-aluminates with the composition $BaMn_xAl_{12-x}O_{19}$ (BMHA), where n = 1, 2, or 3, are active for methane combustion.[5] We confirmed this with measurements on an automated laboratory unit designed for long term combustion studies. Figure 2 shows typical results for a sample of $BaMnAl_{11}O_{19}$ prepared by coprecipitation from constituent salt solutions using ammonium carbonate and calcined at 1,200°C.
2. Development of washcoating procedures. Starting with 30-PPI α-Al_2O_3 ceramic foam cylinders (1.27 cm diameter, 2.54 cm length), a procedure for loading BMHA onto the foam surface using an alcohol slurry was optimized. An ultrasound test of the adherence qualities of the washcoat was developed and it was found that certain amounts of aluminum nitrate binder were necessary.
3. Optimization of the foam material. Different foam materials (α-Al_2O_3, ZrO_2, and corderite) were subjected to washcoating, adherence testing and activity runs, and the best performance was achieved with ZrO_2 foams.
4. Preliminary comparisons of foam and monolith structures. Experiments comparing a monolith structure with a foam, both loaded and tested under identical conditions, indicated the monolith is unstable, with evidence of excessive temperature and NO_x formation, whereas the foam, as predicted, has long term stability with zero emissions.

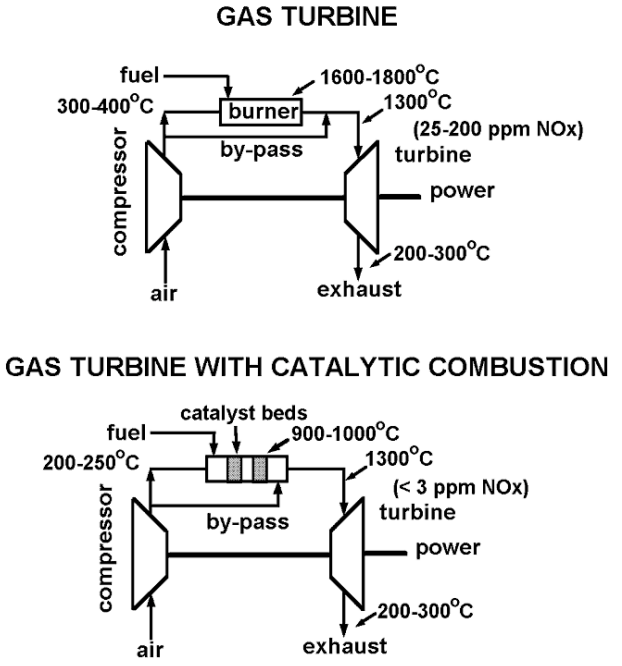


Figure 1. Concept of Catalytic Combustion for Natural Gas Turbines Used for Electric Power Generation

Future studies will now address the dynamics of the optimized foam system, determine kinetic expressions for model validation, and conduct long-term reliability runs. This will lead to prototype designs for large-scale testing and to economic studies.

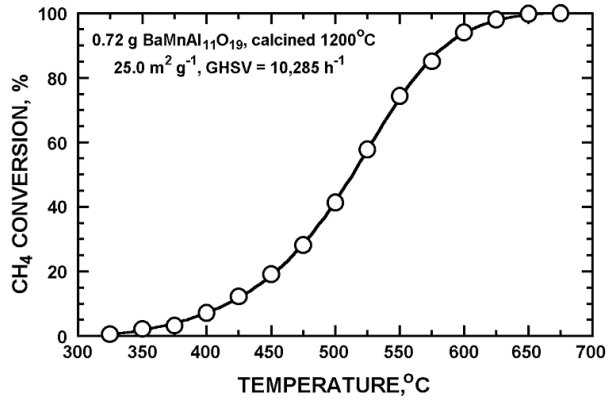


Figure 2. Conversion Curve for Methane Combustion Using Powdered $BaMnAl_{11}O_{19}$ as a Catalyst

Bibliography

[1]Beebe, W., K.D. Cairns, V.K. Pareek, S.G. Nickolas, J.C. Schlatter, and T. Tsuchiya. "Development of Catalytic Combustion Technology for Single-Digit Emissions from Industrial Gas Turbines," *Catalysis Today* 59 (2000): 95-115.

[2]Thevenin, P.O., A.G. Ersson, H.M.J. Kusar, P.G. Menon, and S.G. Jaras. "Deactivation of High Temperature Combustion Catalysts," *Applied Catalysis A*: *General* 212 (2001): 189-97.

[3]Gibson, L.J. and M.F. Ashby. *Cellular Solids, Structures and Properties*. Oxford: Pergamon Press, 1988.

[4]Twigg, M.V. and J.T. Richardson. "Theory and Application of Ceramic Foam Catalysts," IChemE Transactions. Part A, *Chem. Eng. Res and Design* 80 (2002) 183.

[5]Artizzu-Duart, P., Y. Brulle, F. Gaillard, E. Garbowski, N. Guilhaume, and M. Primet. "Catalytic Combustion of Methane over Copper- and Manganese-Substituted Barium Hexaaluminates," *Catalysis Today* 54 (1999): 181-90.

Publications

Richardson, J.T., M. Shafiei, T. Cantu, D. Machiraju, and S. Telleen. "Low NO_x Emission Combustion Catalyst Using Ceramic Foam Supports," *Natural Gas Conversion VII*. Amstedam: Elsevier, 2004 (s*ubmitted*).

Presentations

Richardson, J.T., M. Shafiei, T. Cantu, D. Machiraju, and S. Telleen. "Low NO_x Emission Combustion Catalyst Using Ceramic Foam Supports," VII International Symposium on Natural Gas Conversion, Dalien, China, June 2004 (a*ccepted*).

Funding and proposals

"Improved Combustion Catalysts for NO_x Emission Reduction." Gulf Coast Hazardous Substances Research Center, 2004–2007, $150,000.

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Microbial Populations Responsible for Perchlorate and Nitrate Degradation in High Salt Aqueous Phases

PERCHLORATE IS A STRONG OXIDIZING AGENT and the primary ingredient in the manufacture of most solid rocket propellants. It has been found in ground and surface waters in 14 states including Texas. One treatment process for the removal of perchlorate from drinking water that has been under investigation at UH is the combination use of ion exchange and biological processes. A culture that can reduce perchlorate and nitrate in synthetic high salt media was obtained, however, it is unstable in ion-exchange brine. This research will be directed at examining and identifying the microbes in the current mixed cultures and determining the required conditions to stabilize the rapid perchlorate-reducing culture in the ion-exchange brine. By identifying the best perchlorate-degrading organisms and the appropriate growth conditions that will allow them to compete, a new defined culture can be reconstituted that will be stable in the ion-exchange brine.

UH professors Dennis A. Clifford and Deborah J. Roberts are fine-tuning a new water treatment process for perchlorate that is much faster and far less expensive than those currently in use. Their method not only removes perchlorate from water, it converts the contaminant into a nontoxic chloride, a component of table salt.

Preliminary efforts have been to isolate the perchlorate-reducing organisms from bench-scale and pilot-scale cultures. The bench scale cultures investigated were 1) perchlorate-degrading culture growing on synthetic medium containing 3% salt, and 2) perchlorate and nitrate degrading culture growing on ion-exchange brine containing 3% salt. Culture samples were used to inoculate plate count agar (PCA) plates and grown aerobically. Cultures were transferred to fresh plates several times to ensure purity. Nine pure cultures were isolated and all isolates were shown to biodegrade nitrate but not perchlorate.

The pilot-scale facility was inoculated with culture 1 described above and was shown to degrade perchlorate and nitrate when fed ion-exchange brine containing 3% salt. Pure culture from platings of samples from the pilot-scale facility were also grown aerobically on PCA. Four pure cultures obtained from the pilot-scale facility were shown to degrade nitrate but not perchlorate. The colonies were identified based on 16sRNA sequencing (MIDI Labs). Colony A was identified as *Pseudomonas stutzeri*, and Colony C was found to belong to the genus *Marinobacter*. Colonies B and D could not be identified but were closely related to *Azospirillum* and *Agrobacterium stellulatum*, respectively.

Currently, an anaerobic liquid culturing technique is being tested to determine if isolates could be found that are capable of degrading perchlorate.

The number of perchlorate-reducing and nitrate-reducing bacteria in the pilot-scale culture during a brine recy-

Table 1. Enumeration of Perchlorate- and Nitrate-degrading Bacteria in the Pilot-scale Culture

Group Enumerated	1st* MPN/100 mL	2nd* MPN/100 mL	3rd* MPN/100 mL
Perchlorate-Reducers	2.3×10^2	4.5×10^1	2.8×10^3
Nitrate-Reducers	$>10^7$	1.6×10^8	1.7×10^{10}

* 1st, 2nd, and 3rd samples were collected at the beginning, in the middle, and at the end of the brine recycling experiment.

cling experiment were determined using the most-probable-number technique. Spent ion-exchange brine was cycled 20 times through the pilot-scale facility. The results (Table 1) show an increase in the number of perchlorate- and nitrate-degrading bacteria while these contaminants were being removed from the brine.

Funding and proposals

Roberts, D.J. and D. Herman. "Biodegradation of Perchlorate and Nitrate in Ion Exchange Brine." Advance Technology Program Program, Texas Higher Education Coordinating Board. 2003–2004. (*Pre-proposal submitted; full proposal not requested*.)

Roberts, D.J. and D. Clifford. "Minimization of Hazardous Ion-Exchange Brine Waste by Biological Treatment of Perchlorate and Nitrate to Allow Brine Recycle." Gulf Coast Hazardous Substance Research Center, 2003–2004, $43,500.

Deborah J. Roberts, associate professor of civil and environmental engineering, can be reached at djroberts@uh.edu. Dennis A. Clifford is a professor of civil and environmental engineering. He can be reached at daclifford@uh.edu. Xiaohua Lin is a graduate student in environmental engineering at the University of Houston.

Characterization and Desorption Kinetics of PAHs from Contaminated Sediment in Houston Ship Channel

POLYCYCLIC AROMATIC HYDROCARBONS (PAHs) originate from both natural and anthropogenic sources such as terrestrial deposit of coals, atmospheric input as a result of incomplete combustion (wood burning, forest fire, fossil fuel, coke oven), oil seeps and spills, and highway dust associated with vehicle exhaust (van Metre et al., 2000). Despite their widespread distributions, PAHs can be ultimately deposited and persisted in bed sediment (as a sink) in the aquatic system. This is due largely to the fact that most PAHs sorb strongly to sediment organic matter because of their high hydrophobicity, and are resistant to bacterial degradation under anoxic environment. When environmental conditions become favorable, however, PAHs will be released to the overlying water as a long-term source and pose potential threat to water quality and aquatic ecosystem via bioaccumulation in food chains. Year 2 study of this continued project focused on the characterization and desorption kinetics of contaminated sediments from Ship Channel.

Sediment PAH Adsorption Isotherms

Three of the six sediment samples collected in Year 1 have been tested for their adsorption isotherms of three probe PAH compounds. Isotherm data were fitted to linear, Freundlich and Langmuir isotherm models. Sediment adsorption isotherms were found to be linear in the range of concentration tested. The sediment-water partitioning coefficients K_d (L/kg) were determined according to the formula: $K_d = C_S/C_{aq}$, where C_S and C_{aq} are sediment phase concentration (mg/kg) and aqueous phase concentration (mg/L), respectively. A summary of K_d values is given in Table 1. The K_d value attributes to the organic contents of the sediment samples. The Horsepen Bayou is a clayed sediment with low organic content, while two others are silt with Clear Lake sediment being the most heavily contaminated.

Assuming an average sediment organic carbon (SOM) of 5% ($f_{oc} = 0.05$), the log K_{oc} values calculated from SOM-normalized K_d compare favorably (with an exception of pyrene) to those determined by Chio et al. (1998) who reported log K_{oc} values are 2.61-3.07, 4.10-4.64, and 4.96-5.45 for naphthalene, phenanthrene and pyrene, respectively. Analytical error may have occurred due to the very low concentration of pyrene tested in the sorption study.

The experimentally determined K_d value can be used to estimate the equilibrium concentration of PAHs in sediment pore water using historical data available for sediment PAHs. Our linear model is consistent with that reported by Chio et al. (1998), however, it may have limited utility as others suggested nonlinear Freundlish isotherm (Johnson and Weber, 2001). Note also that the slowly desorbing fraction of PAHs results in lower C_{aq}, and the K_d thus obtained in short-duration study (hrs-days) will be higher than the actual equilibrium K_d. Therefore, use of such K_d will probably underestimate aqueous phase concentration (C_{aq}) as well as PAH flux.

Sediment PAH Desorption Rate

Desorption of PAHs from soil/sediment is often biphasic – a rapid desorption from hours to days followed by a slow process from months to even years. The slowly desorbing fraction is related to intraorganic matter diffusion and hindered pore diffusion (Johnson et al., 2001), and can be expressed in the following three-parameter model:

$$\frac{q(t)}{q_o} = \phi_s e^{-k_s t} + (1-\phi_s)e^{-k_r t}$$

where $q(t)$ – the sediment phase PAH concentration at a given time, q_o – initial sediment-phase PAH concentration, f_S – slowly desorbing fraction, 1-f_s – rapidly desorbing fraction, k_s and k_r – apparent first-order rate constants for the slowly and rapidly desorbing fractions, respectively.

Figure 1 is a simulated desorption profile based on the typical values chosen from literature, *i.e.*, f_s = 0.7, k_s =

Table 1. Summary of Sediment-Water Distribution Coefficient (K_d in L/kg)

	Horsepen Bayou	Galveston Bay	Clear Lake
Naphthalene	K_d = 4.85 (R^2 = 0.975)	K_d = 2.30 (R^2 = 0.992)	K_d = 6.41 (R^2 = 0.963
Phenanthrene	K_d = 52.0 (R^2 = 0.880)	K_d = 298 (R^2 = 0.983)	K_d = 698 (R^2 = 0.983)
Pyrene	K_d = 52.7 (R^2 = 0.965)	K_d = 140 (R^2 = 0.967)	K_d = 477 (R^2 = 0.956)

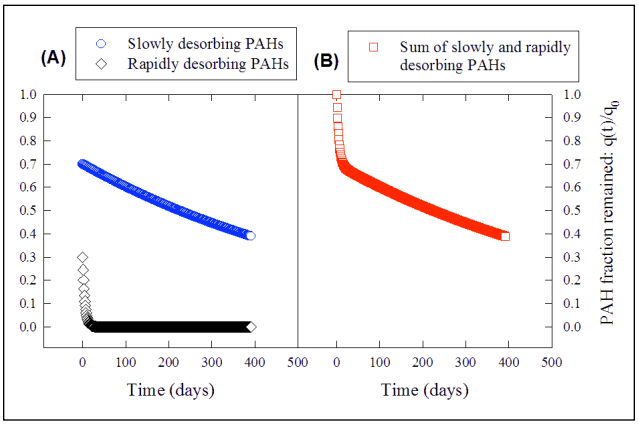

Figure 1. Simulated PAHs Desorption Profile from a Contaminated Sediment

$1.5x10^{-3}$ day^{-1}, and k_r = 0.2 day^{-1}. The difference in the kinetic rates between slowly desorbing and rapidly desorbing PAHs is evident. Figure 1 also implies that experiment duration commonly used in desorption studies (days to weeks) are inappropriate for PAHs when slowly desorbing fraction may be significant.

Sediment PAH Flux Rate

Contaminant flux from sediment is important especially in shallow water in Texas estuaries including bay waters (e.g., 6-12 feet in Galveston Bay). We have not been able to give rigid estimate of PAH flux from contaminated sediment, our effort herein is to provide an order of magnitude estimate on the flux rate based on the literature values. If the flux rate in Lake Michigan is assumed (90-1050 $\mu g/m^2/yr$), the mass flux rate of PAHs in Ship Channel (length: 51 miles; width: 400 ft) can be estimated in the range of 0.9 ~ 10.5 kg/yr. This is equivalent to the contribution of an elevated concentration in the range of 6.5 ~ 76.6 ppt in the overlying water assuming the average depth of 45 ft and a hydraulic retention time of one year. Note that the actual PAH concentration in the sediment pore water adjacent to sediment bed may be significantly higher than the estimated concentration due to the limitation of mass transfer to the overlying water. Elevated PAH concentrations in sediment porewater could pose additional stress to benthic organisms in the Ship Channel and bay area. Similarly, the total PAH flux in Galveston Bay can be estimated to be in the range of 140 ~ 1,630 kg/yr based on a surface area of 600 square miles. This is comparable to 371 kg/yr of PAHs contribution from the lower watershed nonpoint sources (The Galveston Bay National Estuary Program, 1994).

Publications

Daprato, R.C., C. Zhang, J.C. Spain, and J.B. Hughes. "Modeling the Aerobic Bioremediation of Dinitrotoluene Contaminated Soil in a Slurry Reactor," *Bioremediation J.* (*In review*.)

Fortner, J.D., C. Zhang, J.C. Spain, J.B. Hughes. "Soil Column Evaluation of Factors Controlling Biodegradation of DNT in the Vadose Zone," *Environmental Science and Technology* 37.15 (2003): 3382-91.

Zhang, C. and J.B. Hughes. "Biodegradation of 2,4-Dinitrotoluene: Bacterial Energetics, Stoichiometry And Kinetic Modeling," *Environmental Toxicology and Chemistry.* (*To be submitted*.)

Zhang, C. and J.B. Hughes. "Biodegradation Pathways of Hexahydro-1,3,5-Trinitro-1,3,5-Triazine (RDX) by *Clostridium acetobutylicum* Cell-Free Extract," *Chemosphere* 50 (2003): 665-71.

Zhang, C, J.B. Fortner, and J.B. Hughes. "Kinetics and Stoichiometry of Dinitrotoluene Mineralization to Support *In-Situ* Vadose Zone Bioremediation," *Proc*., 7th International Symposium on *In Situ* and On-Site Bioremediation. Eds. A. Leeson et al., Columbus: Battelle Press, 2003. (*In press*.)

Zhang, C., M. Law, and G. Zheng. "Sorption Behavior and its Effect on Biodegradation of 2,4-DNT," *Bioremediation J.* (*To be submitted*.)

Presentations

Fortner, J.D., C. Zhang, K.E. Finnessy, J.B. Hughes. "*In Situ* Biostimulation of Dinitrotoluene Mineralization in Vadose Zone Soils: Bench-Scale Analysis, Innovative Approaches to the *In-Situ* Assessment and Remediation of Contaminated Sites," NSF-Pan-American Advanced Study Institute, Rio de Janeiro, Brazil, July 22–Aug. 2, 2002.

Law, M.D., G. Zheng, and C. Zhang. "Sorption Behavior and its Effect on the Biodegradation of 2,4-Dinitrotoluene," SETAC South Central Regional Chapter Meeting, Armand Bayou Nature Center, Houston, TX, April 24–26, 2003. (*Platform presentation*.)

Zhang, C, J.D. Fortner, and J.B. Hughes. "Kinetics and Stoichiometry of 2,4-Dinitrotoluene Mineralization To Support *In-Situ* Vadose Zone Bioremediation," Seventh International Symposium on *In Situ* and On-Site Bioremediation, Orlando, FL, June 4–7, 2003.

Zhang, C., G. Zheng, G. Holston, G. Lambert. "Potential Release of Polycyclic Aromatic Hydrocarbons (PAHs) from Contaminated Sediment in Galveston Bay-Houston Ship Channel," SETAC South Central Regional Chapter Meeting, Armand Bayou Nature Center, Houston, TX, April 24–26, 2003. (*Platform presentation*.)

Zhang, C., G. Zheng, G. Holston, G. Lambert. "Potential PAH Release from Contaminated Sediment in Galveston Bay-Houston Ship Channel," Sixth Biennial State of the Bay Symposium, League City, TX, Jan. 14–16, 2003. (*Platform presentation*.)

Zhang, C., J.D. Fortner, and J.B. Hughes. "Respirometer Studies on 2,4-Dinitrotoluene and Implications to *In-Situ* Vadose Zone Bioremediation," Society of Environmental Toxicology and Chemistry, 23nd Annual Meeting in North America, Salt Lake City, UT, Nov. 11–15, 2002. (*Platform presentation*.)

Funding and proposals

"Acquisition of a Portable Ductless Fume Hood System for Environmental Chemistry Teaching and Research," UHCL Safety and Health Committee, 2002, $11,000.

"Nitroaromatic Pollutant Migration at Volunteer Army Ammunition Plant (VAAP)." Department of the Army, Baltimore District, U.S. Army Corps of the Engineer through Malcolm Pirnie, Inc., $20,000.

"Reactive Capping Using Elemental Iron to Enhance Reductive Processes in Anacostia River Sediments," US Environmental Protection Agency, Oct. 2002–Sept. 2004, $129,097. (*Pending*.)

"Remediation of *Cr*(VI)-Contaminated Sediment Using Reactive Capping: Redox Kinetics, Stoichiometry and Iron Placement Methods," Faculty Research Support Fund, Oct. 2002, $4,520.

"Teaching Environmental Sciences." Texas Commission on Environmental Quality (TCEQ), May 2003–Aug. 2003, $22,000.

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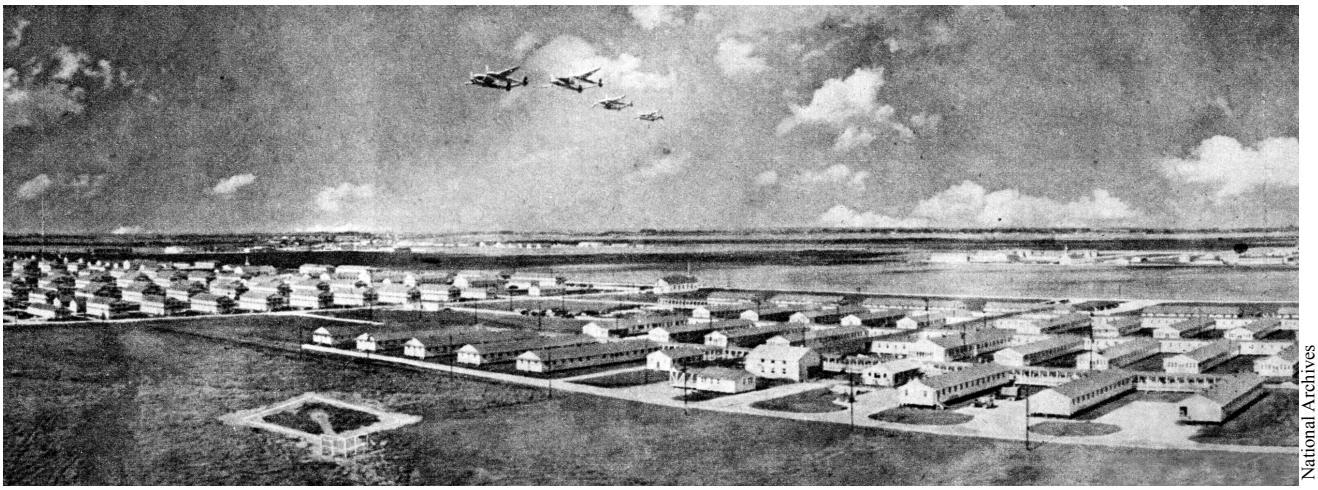
Coast Country Memories of Camp Wallace

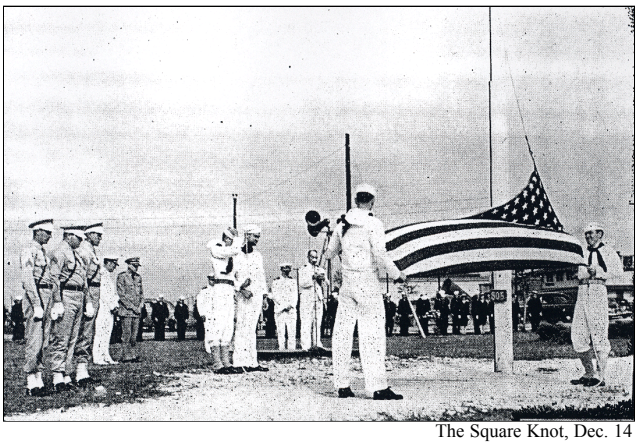


National Archives

On December 29, 1944, *The Square Knot,* a weekly newspaper for Camp Wallace, reviewed eight months of "Navy Wallace" and in closing listed these memories of Wallace that leave us with a vivid glimpse of the ecological past.[1]

Oleander and Cape jasmine
Dusty Shell Roads
Cattle Cars to Houston
Texas Oil Flares with Cattle Crowded Underneath to Keep Warm
Burning Prairies
How it Can Rain
Frogs that Sound Like Billy Goats
MOSQUITOS
Marching in Mud so Thick that Your Boots Weigh 20lbs Apiece
Cattle bunched up in a Mosquito Free Swath of a DDT Sprayed Prairie
August Dog Days
The "Amusement Park" Lights of Texas City Rising Above the Flat Prairie
Rattlesnakes, Jack Rabbits and Horny Toads
Clear Night Skies With Stars You Can Almost Touch

National Archives



The Square Knot, Dec. 14

Ten months before the bombing of Pearl Harbor, an army replacement center or basic training camp opened on the upland prairies of Hitchcock in Galveston County. Named Camp Wallace in honor of Col. Elmer J. Wallace,

From September 1945 to September 1946, Camp Wallace served as a naval separation center where Navy officers and enlisted men were debriefed before being discharged.

former commander of the 59th Coast Artillery Regiment, who was killed in France during World War I, the camp was built on 3,315 acres of cattle range. The land came into possession of the United States Military by a "Declaration of Taking" in October 1940 and consisted of the following acreage; Maco Stewart et al., 1,254.8 acres, George W. Fraser, 340.6 acres, James Belcher, 7.8 acres, and 1,712.7 acres that were leased from five adjacent landowners.[2]

Construction began in November 1940 with a 3.9-mile railroad spur off of the Gulf, Colorado and Santa Fe tracks, and 17 miles of oyster shell roads. The shell was dredged from Red Fish Bar, the last remaining vestige of the barrier reef across Galveston Bay, and was transported up Dickinson Bayou by barge and trucked to Hitchcock. The water supply came from the Galveston water supply wells at Alta Loma in 30" water mains, and a sewage plant capable of handling 1,050,000 gallons of raw sewage was erected. By the end of December 1940, construction began on the 399 buildings and 29 miles of electrical lines.[3]

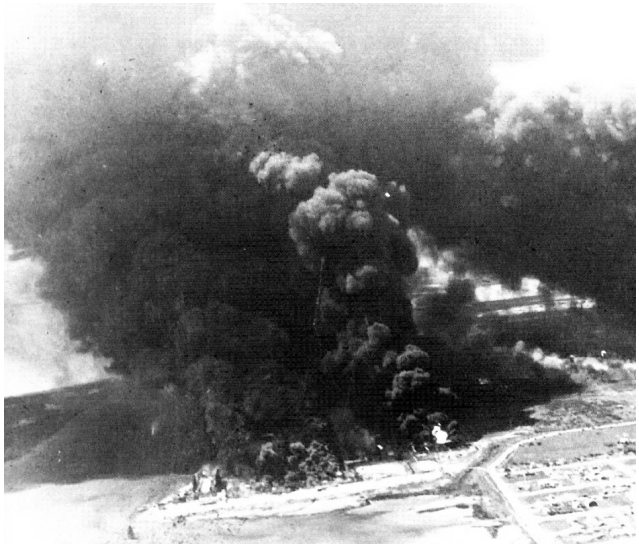
Camp Wallace opened on February 1, 1941, and by May 1941 approximately 10,250 military and civilians trained, worked, and lived there. It was also used as a German Prisoner of War detention camp throughout the war. In July 1943, Galveston Bay was struck head-on by a destructive hurricane that was classified a military secret. The storm even took the soldiers on training maneuvers by surprise. They could find no refuge on the flooded prairies between Hitchcock and Ellington where they were camped, and it took them two days to get back to Camp Wallace.[4]

On April 30, 1944, at a joint ceremony the control of Camp Wallace was transferred from the Army to the Navy, and it became a naval boot camp and distribution center.[1]

Japan surrendered on August 14, and September 2, 1945, became V-J Day. From September 1945 to September 1946, Wallace became a naval separation center where Navy officers and enlisted men were debriefed before being discharged. By April 3, 1946, 50,000 discharges had gone through the separation center.

On October 15, 1946, the site came under the custody of the War Assets Administration.

The Texas City disaster began on April 16, 1947, when two Liberty Ships, the Grand Camp and the High Flyer, loaded with ammonium nitrate caught fire and exploded. The first ship the Grand Camp went up at about 9:00 a.m. with a blast that knocked two small planes out of the sky, created a fifteen-foot surge of water that carried a barge



Texas City Disaster, 1947

Remnants of Camp Wallace, 1949

inland, and threw three-ton fragments of the ship into the sky to rain down on the city. Shortly after 1:00 a.m. on April 17, the High Flyer exploded with a blast that rivaled the power of the first. Burning chunks of steel fell from the night sky causing crude oil tanks to explode and refinery buildings to catch on fire.

Even before the second blast the residents of Texas City began a massive exodus with approximately 40 percent leaving, some for days and others until new housing could be built. Camp Wallace would become a refugee center for many of the victims of the blast. As more and more bodies were uncovered from the wreckage cold storage became a necessity; 150 bodies and numerous body parts were moved to the cold storage vaults at Camp Wallace. On May 11, the last body was removed from the dock and the victim lists compiled by the American Red Cross and the Texas Department of Public Safety contained 405 identified dead, 63 unidentified dead, 113 missing, and 3,500 hospitalized. Two thousand people were left homeless, 539 houses were condemned. Many of these refugees would call Camp Wallace home for many months as the city was rebuilt.[5-7]

That same year the United States Government declared Camp Wallace "surplus," and ordered the removal of its buildings. These buildings were moved throughout the area to become school annexes, community buildings, businesses, and homes. The land would either be returned to the original owners or declared surplus.[8]

The University of Houston held 915 acres of the surplus land until 1972 when 631 acres was released to Galveston County, and 45.6 acres was deeded to the Hitchcock Independent School District. Today the remaining 200 plus acres of land owned by the University of Houston is home to the UH Coastal Center.[9,10]

References

[1]United States Naval Training and Distribution Center, Camp Wallace Texas. *The Square Knot* 3.4 (Dec. 29, 1944).

[2]United States Military Declaration of Taking, Galveston County Clerk records, Dec. 28, 1942.

[3]"Production of Oyster Shell Is Important Local Industry," *Galveston Daily News* (April 11, 1942).

[4]"Camp Wallace Recruits do Battle with Hurricane," *Houston Chronicle* (Sept. 19, 1993): C12.

[5]American Red Cross. "Concise Report of the American Red Cross in the Texas City Disaster of April 16, 1947," Rosenberg Library, Galveston, TX.

[6]Archival Records, The Texas City Disaster. Moore Public Library, Texas City, TX.

[7]Stephens, H. W. *The Texas City Disaster, 1947*. Austin: University of Texas Press, 1997.

[8]M. Darst. "Camp Wallace, Once Bustling Military Facility has all but Disappeared," *The Galveston Daily News* (April 22, 1988): 10.

[9]J. Kirkpatrick. "Earmarked for Park Purposes Land in Camp Wallace Area Declared Surplus," *The Galveston Daily News* (Sept. 23, 1972): 1A.

[10]J. Kirkpatrick. "Camp Wallace Land Given to County, Schools," *The Galveston Daily News* (Feb. 17, 1973): 1A.

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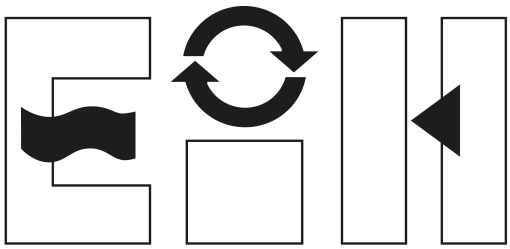

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