First L. Stephen Lau Water Research Scholarship Awarded

The first recipient of the L. Stephen Lau Water Research Endowed Scholarship is Mr. Sanjay Mohanty, a PhD candidate in the Civil Engineering Department at the University of Hawaii at Manoa.

Mr. Mohanty was chosen from among eight finalists on the basis of his application. In his application Mr. Mohanty outlined his proposed research into using biocarbon of soils on golf courses to attenuate the leaching of organic chemicals to groundwater.

Organic chemicals are known to adsorb to carbon in soil. Once thus bound to the soil many such chemicals are degraded to less harmful derivatives. By increasing the amount of carbon in soil we can increase that soil’s adsorptive capacity, retard the leaching of chemicals, and thereby increase the likelihood of degradation.

The carbon that Mr. Mohanty proposes to use in his experiments is derived from green waste transformed into carbon through a “flash carbonization” technique that reduces the amount of tarry residue which normally blocks the porous structure of biologically derived charcoal. Porosity is what gives activated charcoal (used in many liquid and gas purification applications) its prodigious adsorptive capacity. Green waste is abundant in Hawaii and, therefore, is potentially a cheap source of carbon. The flash carbonization technique has been developed by the Hawaii Natural Energy Institute here at the University of Hawaii. Thus Mr. Mohanty’s research project represents a collaboration between departments on campus.

Mr. Mohanty proposes to conduct soil column experiments to compare the breakthrough times of four chemicals mixed with deionized water passing through soil from golf courses with and without added carbon. The water coming through the columns will be analyzed for the spiked chemicals using a high-pressure liquid chromatograph with a photo diode array detector.

The Lau scholarship, which comes from an endowment given to WRRC by former Director L. Stephen Lau and his wife Virginia, is available to upper division undergraduate or graduate students in “any discipline related to water resources at the University of Hawaii.”

Reducing Oil and Grease Entering Hawaii’s WWTPs

Unfortunately, Oahu’s sewer system sometimes experiences overflows that result in spills into environmental waters with the associated public health concerns that such spills entail.

One reason for these spills is that Oahu’s sewer lines are under constant attack by the extremely corrosive brackish ground water that is present near sea level all around the system’s collection area. This can lead to cracks in the sewer lines that result in spills.

Another reason is Hawaii’s weather. During the extreme rainfall events that we typically experience on a regular basis on Oahu, millions of gallons of storm water find their way into the City’s sewer lines, occasionally exceeding the capacity of the pipes to carry it away and sometimes overwhelming the treatment plants’ ability to provide adequate treatment of this combined flow before discharging into the ocean through the outfalls.

Electrical outages sometimes cause pumping station failures that can end up with smaller spills around those stations. Ground shifting and tree roots also damage pipes.

Regardless of the cause, the City is liable for the resulting fines imposed by the EPA and the State Health Department and is also the target of the occasional lawsuit brought by non-governmental organizations. These fines and lawsuits cost all Oahu residents—if not directly in the form of increasing sewage disposal fees then as foregone services that the money paid in fines, lawyer’s fees, and settlements could have provided us.

Furthermore it is obvious that the well-publicized spills of sewage into the ocean are a disincentive to tourism, the principal industry in Hawaii.

There is, however, one thing that we, as users of the City system, can do to reduce the number of spills with their health and financial risks, and that is to ensure that we minimize the flow of grease, fats, and oils into the pipes.

continued on page 2
Researchers here at WRRC struggle mightily to figure out which water-related issues have highest priority. At that, finding issues is far easier than finding dollars. Thus I was a bit taken aback to learn that the federal government spends some $700 million annually on water research.

This figure comes from an enlightening National Research Council study, *Confronting the Nation’s Water Problems: The Role of Research* (National Academies Press, 2004 pp. 175-6). This report found that, in total, federal support for water research has been kept at roughly $700 million (in inflation-adjusted terms) since the mid-1970s. However, this amount represents a decline of almost one-third in per capita spending and more than one-half as a percentage of gross domestic product, with a similar decline in share of the federal budget.

Meantime, the field has expanded greatly. Water quality problems were just emerging into public awareness 35 years ago. Aquatic ecosystems were barely on the radar screen, but now they claim a significant portion of total research funding. Social science topics – such as water demand, water law, and other institutional subjects – now garner significantly less funding than 30 years ago, as do water conservation and methods of increasing water supply. Funding, the report concludes, is significantly out of whack with national priorities.

The study also concludes that current funding is heavily weighted toward short-term issues faced by mission-driven federal agencies, and it notes that solutions to these problems typically depend on making progress in long-term issues. Moreover, the knowledge to be created by this research is largely a public good. Without funding from government, this work will not be done.

I am not aware of any similar analysis of state funding for water research. Anecdotal evidence suggests that the economic doldrums of the 1990s led Hawaii state and county agencies to cut back significantly. For example, DLNR’s demonstration desalination plant near Campbell Industrial Park was shut down and has not been revived. The State Commission on Water Resource Management faces monumental decisions on water allocation but has very strained resources for research on which to base them.

The NRC committee recommends that “...funding would be needed on the order of $20 million per year for research related to improving the efficiency and effectiveness of water institutions and $50 million per year for research related to challenges and changes in water use.”

Anyone for a bake sale?

Many may not know the problems that fats, oils, and grease (FOG) cause in sewer systems. Think of the analogy of your arteries. Fats, oils, grease, and other byproducts of cooking come from meat, lard, shortening, butter, margarine, food scraps, sauces, and dairy products. As with your circulatory system they can present a significant clogging problem for sewer systems. FOG sticks to the walls of sewer pipes, reducing their diameter over time. This eventually causes clogged sewer pipes and sewage spills. In most American sewer systems clogging of pipes with FOG is the number one cause of spills.

Clogging is further caused by chunks of grease breaking away from the pipe walls and becoming stuck further down the line. Grease balls that form when grease combines with sand, grit, and other sewage debris can even become large and hard enough to clog sewage pumps. So just like delicious buttery food, oil and grease go down smooth but soon harden up into dangerous lumps of crud that clog up the works.

If it doesn’t glom onto the side of a sewer pipe (see Figure 1) FOG will flow down to the wastewater treatment plants where it disrupts operations and increases maintenance costs.

Honolulu has regulations that require restaurants and other commercial food handling facilities to install grease separation devices to protect sewers from grease problems; however, it seems this may not be adequate to protect our system. Households are completely unregulated in this regard, and we must try to educate our fellow residents about the desirability of not introducing FOG into the sewer system.

WRRC researchers are currently researching the implementation of best management practices in some food service establishments to see to what degree these can reduce FOG discharge.

Figure 1. Sewer pipe clogged with grease
Wind-Powered Reverse Osmosis Water Desalination for Pacific Islands and Remote Coastal Communities

Principal Investigator: Clark C.K. Liu, Ph.D., P.E., F.ASCE
Department of Civil and Environmental Engineering and Water Resources Research Center
University of Hawaii at Manoa

PROJECT DURATION
October 1, 2004 – September 30, 2005

FUNDING SOURCE

BACKGROUND
The DWPR program is authorized by the federal Water Desalination Act of 1996 and the Continuing Resolution. The Act is based on the fundamental need in the United States and world-wide for additional sources of potable water. The primary goal of DWPR is to develop more cost-effective, technologically efficient, and implementable means to desalinate water.

The Act defines the following important terms: (1) desalination or desalting means “the use of any process or technique for the removal and, when feasible, adaptation to beneficial use, of organic and inorganic compounds from saline or biologically impaired waters, by itself or in conjunction with other processes” and (2) saline water means “sea water, brackish water, and other mineralized or chemically impaired water.”

Water desalination processes are based on either thermal or membrane technology (Liu and Park, 2005). Multistage effect distillation (MED) and multistage flash distillation (MSF) are the two most popular water desalination processes using thermal technology. At one time, MED and MSF comprised about 70% of the world’s water desalination capacity. Because of major advancements in membrane technology, most water desalination plants built in the last 30 years employ membrane-based technologies such as reverse osmosis (RO), electrodialysis, and nanofiltration (Liu and Park, 2005).

Desalination processes are energy-intensive. The coastal groundwater of many Pacific islands is brackish and not suitable for potable use. At the same time these islands often experience consistent trade winds and intensive solar radiation. Considering these environmental characteristics, therefore, brackish-water desalination using an RO process driven by wind and solar energy would be an ideal solution to the problem of freshwater shortages on these islands.

The conceptual design of wind-powered RO desalination was developed in 1997 for a University of Hawaii research project, under the direction of Clark C.K. Liu. A prototype system of wind-powered RO desalination was subsequently constructed on Coconut Island, in Kaneohe Bay, Oahu, Hawaii. This system consists of four major subsystems: a windmill/pump subsystem, an RO and pre-treatment subsystem, a flow/pressure stabilization subsystem, and a data acquisition and control subsystem. Over the last few years, a series of experiments have been conducted to test this system’s feasibility and performance (Liu, Park, Migita, and Qing, 2002). This prototype system was also applied in a study of aquaculture wastewater treatment and reuse (Qin, Liu, Richman, and Moncur, 2005).

RESEARCH OBJECTIVES
This project will solve the following two remaining issues of the existing wind-powered RO desalination system and make it implementable to desalinate natural brackish water sources:

1. The existing system was not entirely energy independent, as conventional electricity was used to run the data acquisition and control mechanisms. Therefore, another source of natural energy should be applied.
Innovation in Automotive Pollution Reduction Tested

WRRC researcher Roger Babcock has recently begun examining the performance of a unique commercial device for reducing vehicular pollution. The Honolulu-based company Street Vac International has introduced “StreetVac™” pollution sorption pads that can be mounted within the wheel wells of vehicles where they are designed to capture pollutants generated by vehicles. The resin-impregnated filter pads used in the StreetVac system collect pollutants emitted by vehicles and those already present on roads.

Motor vehicles represent a considerable source of both air and water pollution. In a 1996 report entitled *Indicators of the Environmental Impacts of Transportation*, (US Environmental Protection Agency Office of Policy, Planning, and Evaluation, EPA 230-R-96-009, October 1996, http://www.epa.gov/otaq/transp/96indict.pdf. pg. 54) it is stated that:

Direct vehicle deposits are a major source of particulates and heavy metals: settleable exhaust, copper from brake pads, tire and asphalt wear deposits, and drips of oil, grease, antifreeze, hydraulic fluids, and cleaning agents.

According to the American Automobile Manufacturers Association (AAMA *Motor Vehicle Facts and Figures*, 1990) an estimated 46 percent of vehicles on U.S. roads leak hazardous fluids. Indirectly, vehicles also contribute by carrying solids from parking lots, urban roadways, construction sites, farms, and dirt roads. More than 95 percent of the solids on roadways originate from sources other than the vehicles themselves (Barrett et al., 1993).

From the perspective of those of us concerned with water-quality protection, vehicle-generated pollution is a matter of grave concern, particularly here in Hawaii, where runoff from roadways is almost immediately transported to the oceans. The significance of pollution in our nearshore recreational waters hardly needs to be emphasized in our tourism-dependent state.


“Tests conducted in Hawaii and Nevada, have demonstrated that the StreetVac™ technology system traps vapors, aerosols, metals, and rainwater runoff particulates”. It facilitates the “virtual vacuuming” of the roadway, collecting contaminants in filter media for periodic and environmentally safe disposal... The StreetVac system utilizes rotation of the wheel and contact of the tire on the road surface, along with the low pressure created in the wheel well, to collect pollutants by impaction and filtration.”

The device, according to Certified Industrial Hygienist Kerry Tomayose, of Industrial Hygiene Technologies, LLC, Honolulu, “readily absorbs Total Petroleum Hydrocarbons (oil), and it collects metals through mechanical entrapment.” Tomayose characterized hydrocarbon absorption as “dramatically significant.”

Dr. Babcock’s research will assess the pollutants collected by the StreetVac system, evaluate the collection efficiencies, and assist with product development of the technology.

WRRC Graduate Student Awarded Scholarship to Colorado State University

Microbiology graduate student and WRRC researcher Kathleen England Brostrom was recently awarded two scholarships to further her studies at Colorado State University in Fort Collins.

Ms. Brostrom’s work at WRRC was to investigate the use of a chemical indicator for human fecal pollution. The chemical indicator, coprostanol, is one of many fecal sterols naturally found in feces. Human feces contain a higher percentage of this sterol than do feces of other animals previously studied. Ms. Brostrom’s investigation was to determine if a method used by the Commonwealth Scientific and Industrial Research Organization, a leading research organization in Australia, would be useful, feasible, and reliable in our tropical recreational waters. To do this, experiments were conducted to determine the stability of the molecule in tropical water temperatures and conditions, to ensure that the molecule is detectable in sewage and the environment, and then use the method to monitor sewage pollution in environmental waters.

Ms. Brostrom’s conclusions were that fecal sterols are useful as a method for detection of sewage in Hawaii, if the sewage spill event occurred within the last 48 hrs and/or is from a continuous leak. She also found a strong positive correlation with coprostanol and other indicators: *C. perfringens*, FRNA coliphage, Bacteriodes, and the traditional fecal indicator bacteria (Enterococci, *E. coli*, and fecal coliforms).

Ms. Brostrom will be attending Colorado State University in Fort Collins as a doctoral candidate in the Microbiology, Immunology, and Pathology Department. She is planning on studying virology, specifically work involving new emerging viral diseases like avian influenza and West Nile.

Ms. Brostrom currently holds master’s and bachelor’s degrees in Chemistry from the University of North Carolina.
Wind Powered Desalination continued from page 3

(2) The existing preliminary wind-powered desalination system was designed as a closed system in which a brackish water of premixed sodium chloride solution is used as RO feed water. Additional pre-treatment of feed water such as chemical conditioning and multi-media filtration would be required when the system is used to desalinate natural brackish water sources such as brackish groundwater. These pre-treatment processes require different operating pressures than those used by the RO process. Therefore, the wind-powered pump must be able to generate and maintain water pressure at two different levels – one for pre-treatment and one for the RO process.

Objective 1: Utilizing solar energy as the auxiliary power supply

In order to allow the system to be independent of external energy requirements, system modifications and testing were conducted using solar energy to run the data acquisition and control mechanisms.

A Shell SQ75 photovoltaic solar module was installed and connected to the system (Figure 2). This module, which can generate a peak power of 75 watts at 17 volts, contains 36 series connected 125x125 mm “PowerPax” monocrystalline silicon solar cells.

A few experimental runs have been conducted with the photovoltaic solar module combined with the wind-powered RO desalination system. Results indicate that the brackish water desalination system as developed by the University of Hawaii can be operated using only natural energy; no conventional electricity is needed.

Objective 2: Two-stage pumping for pre-treatment

During the first stage the windmill drives a piston pump which raises the pressure of feed water to a range of 20-50 psi. The actual feed water pressure, depending on types and levels of pre-treatment, is controlled by a pressure/flow stabilizer. After pre-treatment the water flows to a tank of pre-treated water. The volume of water in this tank is controlled by a pressure transducer: when the water level reaches a preset value the control mechanism will shut off the first-stage pumping and start the second-stage pumping (see Figure 3).

During the second stage the windmill drives a piston pump which raises the pressure of pre-treated water to a range of 70-105 psi. At this pressure, the pre-treated water will flow through the RO module.

Several test runs were made using the modified two-stage pumping design, the results of which indicate that water at two different pressures can be generated and maintained by the modified windmill/pump subsystem.

Figure 2. Solar panel installed at the experiment

Figure 3. Revised design of a two-stage windmill/pump system

References Cited


The use of nematicides and herbicides over the decades of pineapple and sugar cultivation in Hawaii has resulted in the contamination of some bodies of ground water in the state. Ground water, of course, is uniquely important in Hawaii as the source of more than 95% of our drinking water. The discovery of agricultural chemicals in our primary sources of drinking water has led the state to implement a progressive approach to pesticide control and registration. In the early 1990s an assessment was made of the leaching potential of most of the pesticides normally used in Hawaii. As new pesticides are brought on the market and the nature of Hawaiian agriculture changes there is pressure to introduce new chemicals to Hawaii.

A team from the University of Hawaii’s Water Resources Research Center led by Dr. Chittaranjan Ray, and the State Department of Agriculture have been working together to assess the leaching potential of five such chemicals in Hawaii soils. The EPA-registered chemicals include three herbicides (s-metolachlor, sulfometuron methyl, and imazaquin), a fungicide (trifloxystrobin), and an insecticide (imidacloprid). These chemicals were applied to tilled soils per manufacturers’ instructions. The chemicals atrazine and bromide were also applied for reference because their transport and fate in Hawaii soils have been well-characterized. Bromide, which is known to be relatively inert and therefore a good tracer of water movement, was applied at a rate of 21.9 kg/ha.

The experiment comprised five test sites on Oahu (Kunia, Waimanalo, and Poamoho); Kula, Maui; and Mana, Kauai. Each site consisted of four test plots, two for herbicides and one each for insecticide and fungicide. Each site was designed as a rectangle of 18.3 m by 12.2 m (60 feet by 40 feet) divided into four identical plots of 9.15 m by 6.1 m (30 feet by 20 feet).

The presence of plants would have confused the issue of the fate and transport of the applied chemicals so no crop was grown on the plots. Weed growth and evaporation were discouraged by applying a thin layer of straw mulch.

Each plot was equipped with an irrigation system (see Figure 1) through which water was applied to the plots at a rate close to the potential evapotranspiration rate. This irrigation served to induce leaching of the applied chemicals.

Soil samples were collected from all the plots prior to the application of the chemicals to determine if there was any background contamination at any site.

Following the application of the test and reference chemicals using a calibrated sprayer (see Figure 2), loose soil samples were collected from the surface of the plots the following day and then periodically for the next four months. During this time period samples were also taken at increasing depths in a progressive fashion. At the first sampling two samples were taken, one being the soil from the surface to 6” depth and the second being from 6” to 12” depth. The following week the samples were taken from these depths and two deeper points. This pattern was continued for the duration of the experiment in order to see the vertical distribution of the chemicals as they made their way downward through the soil.
Soil hydraulic and climate data were also collected during the four months of the experiment. In-situ infiltration rates (hydraulic conductivity) were measured with a tension disk infiltrometer (Figure 3). Water flow dynamics were monitored with time domain refractometer (TDR) probes (Figure 4) and soil tensiometers. Soil water suction within the profile of each site was monitored by a set of six automated tensiometers, in two nests of three (Figure 5), in two adjacent plots, one located in the herbicides plot and the other located in the fungicide/insecticide plot. At each location, the tensiometers were installed at 30, 60, and 90 cm below the soil surface. All automated tensiometers were fitted with pressure transducers to continuously record soil water tension at 5 or 15 minute intervals. At each site, four nests of manual tensiometers were installed to serve as a control for the automated measurements. Installation of these manual tensiometers followed the arrangement of the automated ones.

At each site, soil temperature at 30 and 60 cm below the soil surface, and air temperature at the soil surface and at 2 m above the surface, were measured.

A number of laboratory experiments were done in conjunction with the field experiments to determine soil characteristics and the fate of the study chemicals in the different soil types found at the various plots.

Eighteen undisturbed soil cores were taken from various locations and depths at the plots. These were taken to the lab for the determination of water retention curves (Figure 6).

Another set of experiments looked at the adsorption capacity of the soils for the chemicals. This experimental set was extended to look at the adsorption characteristics of some of the metabolites of the pesticides. Other lab work focused on determining the rate at which the pesticides degraded in the soils.

This set of experiments produced useful hydraulic and hydrologic data. The chemical data from field and laboratory studies of pesticide degradation and sorption can serve as important information for mathematical modeling of the transport processes of selected chemicals. The results of these experiments will be reported to the Hawaii Department of Agriculture which sponsored this research.

Figure 5. Nest of Soil Tensiometers.

Tensiometers are water-filled tubes with hollow ceramic tips attached on one end and a vacuum gauge (or mercury manometer) and airtight seal on the other end. The device is installed with the ceramic tip in good contact with the soil at the desired depth. The water in the tensiometer eventually comes to pressure equilibrium with the surrounding soil through the ceramic tip. Water is pulled out through the ceramic tip into the soil, creating a tension in the closed tube. As the soil is re-wetted, the tension gradient diminishes, causing water to flow into the ceramic tip. As the soil goes through wetting and drying cycles, tension readings can be taken.

Figure 4. Installation of a TDR probe.

TDR probes indirectly measure water content of soil based on soils’ dielectric property. Soil dielectric constant is determined by measuring the time it takes for an electromagnetic pulse to propagate along a transmission line that is surrounded by the soil. Because this property of soil primarily depends on the amount of water present, soil water content can be inferred from the speed of conduction of a pulse along the rods of the TDR probe.

Figure 6. Soil cores to be taken to the lab for determination of water retention curves.

WRRC’s Fall 2005 Seminar Series Focuses on the October 2004 Flooding in Manoa Valley

The disastrous flooding of October 2004 which caused many millions of dollars in damage to both the University of Hawaii and other areas near Manoa Stream will be the subject of the WRRC fall seminar series. This series of seminars is a follow-up to the workshop held on February 28, 2005 where the Center brought together representatives of the USGS, the National Weather Service, the US Army Corps of Engineers, and members of the UH Meteorology and Civil Engineering Departments.

Seminars are held on the first and third thursdays of every month at 3:00 PM in room 127 of the POST building on the UH Manoa campus. Admission is free and all are welcome.