CIVIL AND ENVIRONMENTAL ENGINEERING NEWS AND VIEWS

Compiled by: M. Sabbir U. Chowdhury[1]

Microbes' 'Blueprints' Promise Insights into Oceans, More

The world's smallest photosynthetic organisms, microbes that can turn sunlight and carbon dioxide into living biomass like plants do, has recently been in the limelight. Three international teams of scientists, including a group from the Massachusetts Institute of Technology (MIT), announced the genetic blueprints for four closely related forms of these organisms, which numerically dominate the phytoplankton of the oceans.

Much like the sequencing of the human genome, the sequencing of the genomes of three strains of Prochlorococcus and one of closely related Synechococcus should crack many mysteries about these organisms and of phytoplankton in general.

A better understanding of phytoplankton, which play a critical role in the regulation of atmospheric carbon dioxide, will aid studies on global climate change. Further, the "metabolic machinery" of these single-celled organisms could serve as a model for sustainable energy production, as they can turn sunlight into chemical energy.

"It behooves us to understand exactly how, with roughly 2000 genes, this tiny cell converts solar energy into living biomass, basic elements into life," said Sallie W. (Penny) Chisholm, the Lee and Geraldine Martin Professor of Environmental Studies in MIT's Department of Civil and Environmental Engineering and Department of Biology.

"These cells are not just some esoteric little creatures," she said. "They dominate the oceans. There are some 100 million Prochlorococcus cells per liter of seawater, for example." Chisholm was part of the team that first described Prochlorococcus in 1988.

Raymond L. Orbach, director of the Department of Energy's Office of Science, which funded part of the research, said, "While many questions remain, it's clear that Prochlorococcus and Synechococcus play an immensely significant role in photosynthetic ocean carbon sequestration."

Utah Works to Make Capitol Quake-Proof

The Utah Capitol could be riding the next big earthquake like a ship at sea after engineers hoist the 67,500-ton marble building and drop it on a set of shock absorbers.

They can only hope to get it done in time. Salt Lake City, capital of Utah, USA, is due for a major earthquake that could knock the Capitol dome off its precarious perch, snap marble columns and collapse upper floors.

For a 59-member team of architects, engineers, construction and historic preservation managers, shoring up the four-story Capitol is a race against time. The digging will start in December 2004, and the work will last four years.

"If people can walk out alive, that's the objective we're after," says Jerod Johnson, a structural engineer for Salt Lake's Reaveley firm, among 14 companies that have a piece of the Capitol's $200 million restoration.

Together with Forell/Elsesser Engineers of San Francisco, the Reaveley group has the delicate task of hydraulically lifting the entire Capitol, a statehouse built of marble and concrete with almost no reinforcing steel.

The firms also are designing a set of internal walls that will let the Capitol sway at the foundation while keeping its upper half from snapping off. Forell/Elsesser retrofitted city halls for San Francisco, Oakland and Pasadena against California earthquakes. Salt Lake's City-County Building has been cushioned for earthquakes.

"We're expecting the next earthquake to hit anytime between now and 25 years from now," says David Hart, executive director for the Capitol Preservation Board.

The Capitol will be emptied by December 2004 and could reopen for business as soon as January 2008. The retrofit is so daunting lawmakers had to consider tearing down their Capitol and starting over. But engineers said it could be reliably fixed for about $200 million, including extensive renovations.

The engineers are shopping for a set of base isolators, which are rubber-and-steel mounts about four feet wide. They plan to use 280 of the mounts to support a steel and concrete grid holding up the Capitol - a chassis that will let the building pitch and roll in any ground upheaval. The building also will be able to slide two feet in any direction from deadweight.

In a feared earthquake the ground will abruptly move first, then the Capitol will slowly catch up, swaying

[1] Lecturer, Department of Civil and Environmental Engineering, The University of Asia Pacific

this way and that. It's still likely to rain debris, making occupants run for cover.

The quake may last only 30 seconds, but it probably will come without any warning. On the Wasatch bench where the Capitol sits, the shaking will be more violent than on the basin floor, where unconsolidated soils could liquefy, proving that no area would be considered safe.

Traffic Navigation Systems Linked to Accident Risk

Swift or safe? That may be the question drivers with navigation systems ask themselves in future.

A new study by researchers at the University of Toronto Intelligent Transportation Systems (ITS) Center and Testbed suggests in-car systems, designed to guide drivers around traffic jams and accidents quickly, could actually cause a temporary surge in the risk of accidents. "Discovering that traveler information systems may be good for travel time but not for overall safety was shocking because they are generally supposed to provide benefits," says Professor Baher Abdulhai, the director of the ITS Center and Testbed in the Department of Civil Engineering.

Using computer simulations of route guidance systems, Abdulhai's team found accident risks peaked immediately after drivers were informed of traffic congestion and changed their routes. "There was an increased level of activity as people 'bailed out' to bypass congestion," says Abdulhai. For example, as drivers left a jammed freeway for city streets and encountered accident-prone intersections. However, because drivers reach their destination sooner, the accompanying drop in accident risk eventually counterbalances the earlier surge.

When Abdulhai ran the simulation adding safety measures as criteria for selecting routes, such as a route involving the fewest number of turns, the accident risk dropped about 10 per cent. Traffic-responsive guidance systems could incorporate such safety-conscious measures in roughly a year, he says. The study, which was published in the July/August issue of the Journal of Transportation Engineering, received significant funding from private and public partners and the University of Toronto.

Staying Cool by Getting Plastered

A paraffin-based wall coating material will prevent heat build-up in modern homes and offices, making them more pleasant places in which to live and work, researchers said this week.

The material, developed in Germany by the Fraunhofer Institute for Solar Energy Systems (ISE) with the help of chemicals firm BASF, consists of micro-balls of paraffin distributed within wall plaster.

The material is designed to improve temperature control in modern buildings that have thin walls made of lightweight materials. Thin walls do not absorb much thermal energy, so rooms heat up rapidly in summer. The ISE material does not insulate the walls, but instead allows heat to be stored and discharged over a 24-hour cycle.

The paraffin is encapsulated in a plexiglass material to form tiny balls with a large surface area. Each capsule is around 100 nanometres in size. The paraffin balls are then distributed within a wall plaster, which is applied as usual. When the room temperature reaches 24 degrees Celsius, the paraffin melts, absorbing energy and storing it as latent heat.

At night as temperatures fall, the paraffin solidifies again, discharging heat that can then be released from the building through open windows or a ventilator.

"The material is ideal for use in Europe where there are large changes in temperature between day and night," said Peter Schossig, a researcher at the ISE in Freiburg, Germany.

Attempts to produce an energy-saving paraffin-based material began in the 1970's after the oil crisis but were abandoned, said Schossig.

The first products containing the paraffin capsules are now commercially available in Germany.

New Concrete is Environmentally Friendly

A new environmentally friendly concrete mix is being tried in South Mississippi, USA. The product sounds like a developer's dream. It's called the 'pervious concrete'. This new mix helps preserve trees and reduces drainage concerns.

It looks like thick gravel, the color of concrete. "Nothing more than rock bonded together with a mortar material that's actually letting the water to get down to the root system," explained Gulfport builder, John Ruble.

The permeable nature sets this mix apart. That also allows builders to pour much closer to large live oaks.

"The ordinance requires that you can't pour anything around the actual drip line of the tree. As you can see, here we're allowed to get right up to within about 10 to 15 feet of the tree," said Ruble, as he pointed to the work crew pouring mix near a large live oak.

The environmentally friendly mix offers a bridge between construction and conservation.

Greg Pietrangelo is with Gulf Concrete Company, which markets the product.

“With the pervious concrete, the water will actually penetrate through it and into the ground and let the ground do its natural thing and permeate through the soils,” he said.

With standard concrete, water simply runs off to the lowest point. With the new concrete, it soaks right through.

Along with helping water the trees, the new concrete also helps builders with storm water drainage. Pervious concrete in a parking lot can eliminate the need for a retention pond.

Iron-Clad Solution to Arsenic Poisoning

In a region that is no stranger to misery, 100 million people in eastern India and Bangladesh suffer from skin ulcers, tumors, and other debilitating and even fatal symptoms of arsenic poisoning caused by drinking contaminated groundwater.

The crisis, says Arup SenGupta, who grew up in the east Indian state of West Bengal, is “the biggest natural calamity of our time.” And like many environmental problems in developing countries, he says, this one cries out for a homegrown solution.

SenGupta, Professor and Chair of the Civil and Environmental Engineering department at Lehigh, believes he and his students and their counterparts at Bengal Engineering College in India have developed such a solution in the form of a cheap, simple wellhead unit that removes arsenic from water wells.

Since 1997, their system has been installed in 25 remote village drinking wells in eastern India, not far from the country’s border with Bangladesh. Over the next two years, engineers hope to install wellhead units in 50 additional villages.

Arsenic levels in the treated wells have plummeted from toxic levels of 100 to 500 parts per billion, SenGupta says, to well below the 50-ppb maximum considered safe by health experts and permitted by the Indian government.

Each system is built locally with indigenous materials in India and installed by students and professors from Bengal Engineering College in Howrah for a total cost of $1,200 to $1,500. Assembly takes about two to four weeks, and units are expected to last about 15 years, although the arsenic-removing materials need to be regenerated once or twice a year, and the arsenic itself requires safe disposal.

The systems, which are operated with a hand pump and need no electric power or chemicals, are maintained by villagers with help from Bengal Engineering College. Villagers are also trained to check wells weekly for arsenic levels. SenGupta visits the region once a year to supervise, discuss field data and collect samples to analyze in his laboratory.

The residents of Bangladesh and West Bengal once obtained their drinking water from rivers, streams and ponds polluted with human and animal waste. Cholera, typhoid, diarrhea and other water-borne diseases resulted and the surface water is still considered unsafe to drink. In the 1970s, UNICEF and other aid agencies helped the government of Bangladesh build wells to tap underground aquifers whose water was presumed to be safe for drinking.

Arsenic, although extremely toxic, does not add color, taste or odor to water. It was not until 1994 that toxic levels of arsenic were confirmed in those wells, SenGupta says (Arsenic is not present in the region’s surface water, he adds). Although the arsenic was not generated by human activity, scientists have not yet zeroed in on the mechanism by which it leaches from the soils into the groundwater.

SenGupta worked with John Greenleaf, a Master’s degree candidate in Environmental Engineering at Lehigh, to develop a way to ‘impregnate’ tiny, polymeric ion-exchange beads with ferric hydroxide. The iron transmits its affinity for arsenic to the beads. The beads, which are arranged in columns, provide a sturdy mechanism for the fine iron powder, which would otherwise form clumps and clog the column, creating a pressure drop and making removal inefficient or impossible. The result is a hybrid sorbent that can remove arsenic from water.

SenGupta and Greenleaf co-wrote an article about their method that was included in a book, *Environmental Separation of Heavy Metals: Engineered Processes* that was edited by SenGupta and published in 2001.

SenGupta says the villages where the first wellhead units were installed have seen a decrease in the number of new symptoms reported. Doctors say the poisoning cannot be treated, but that symptoms can be arrested if a person stops drinking tainted water.

The larger lesson, SenGupta says, is that scientists and engineers from developed countries must work closely with their counterparts in the developing world.

Smart Bricks could Monitor Buildings, Save Lives

A ‘smart brick’ developed by scientists at the University of Illinois at Urbana-Champaign could monitor a building’s health and save lives.

"This innovation could change the face of the construction industry," said Chang Liu, a professor of Electrical and Computer Engineering at Illinois. "We are living with more and more smart electronics all around us, but we still live and work in fairly dumb buildings. By making our buildings smarter, we can improve both our comfort and safety."

In work performed through the university's Center for Nanoscale Science and Technology, Liu and graduate student Jon Engel have combined sensor fusion, signal processing, wireless technology and basic construction material into a multi-modal sensor package that can report building conditions to a remote operator.

The prototype has thermistor, two-axis accelerometer, multiplexer, transmitter, antenna and battery hidden inside a brick. Built into a wall, the brick could monitor a building's temperature, vibration and movement. Such information could be vital to firefighters battling a blazing skyscraper, or to rescue workers ascertaining the soundness of an earthquake-damaged structure.

"Our proof-of-concept brick is just one example of where you can have the sensor, signal processor, wireless communication link and battery packaged in one compact unit," Liu said. "You also could embed the sensor circuitry in concrete blocks, laminated beams, structural steel and other building materials."

To extend battery life, the brick could transmit building conditions at regular intervals, instead of operating continuously, Liu said. The battery could also be charged through the brick by an inductive coil, similar to those used in electric toothbrushes and certain artificial heart pumps.

The researchers are currently using off-the-shelf components in their smart bricks, so there is "lots of room for making the sensor package smaller," Engel said. "Ultimately, we would like to fit everything onto one chip, and then put that chip on a piece of plastic, instead of silicon, to make it more robust."

Silicon is a rigid, brittle material, which can easily crack or break. "Sensor packages built on flexible substrates would not only be more resilient," Engel said, "they would offer additional versatility. For example, you could wrap a flexible sensor around the iron reinforcing bars that strengthen concrete and then monitor the strain."

Liu and Engel have already crafted such sensors by depositing metal films on flexible polymer substrates. Dubbed "smart skin" by its inventors, the sensor material can be wrapped around any surface of interest, such as a robotic finger. "While a typical tactile sensor can only measure surface roughness, our sensor material can determine roughness, hardness, temperature and conductivity," Liu said. "The combined input gives you a much better idea of the type of material being touched."

The researchers' smart skin is fabricated at the university's Micro and Nanotechnology Laboratory. Although the skin is not yet wireless, Engel is working on the analog-to-digital conversion process to utilize existing wireless technology.

The smart bricks, however, are fully wireless. In addition to keeping tabs on a building's health, applications include monitoring nurseries, daycares and senior homes, and creating interactive 'smart toys' that respond to the touch of a child.

Charting Seismic Effects on Water Levels Can Refine Earthquake Understanding

Through many decades, stories about earthquakes raising or lowering water levels in wells, lakes and streams have become the stuff of folklore.

Last year, the magnitude 7.9 earthquake in Alaska was credited with sloshing water in Seattle's Lake Union and Lake Pontchartrain in New Orleans, and was blamed the next day when muddy tap water turned up in Pennsylvania, where some water tables dropped as much as 6 inches.

But the relationship between seismic activity and hydrology is not well understood and is ripe for serious examination by scientists from the two disciplines, said David Montgomery, a University of Washington Professor of Earth and space sciences.

He and Michael Manga, Associate Professor of Earth and planetary science at the University of California, Berkeley, reviewed evidence of changes in stream flow and water levels in wells following earthquakes dating as far back as 1906, when a quake estimated at magnitude 7.7 to 7.9 struck San Francisco.

The scientists found that, generally, an earthquake's effects on water depend on the distance from the epicenter, the magnitude and the geologic conditions at the location where changes to a well or stream are noted. They also found that effects on wells and aquifers were likely to be recorded at substantially greater distances from an earthquake's epicenter than are changes to stream flow.

"Put the two together and what it says is that the stream-flow response is a completely different beast than the water-well response," said Montgomery.

Montgomery said the new analysis provides a framework for understanding the broad range of earthquakes' effects on hydrology, and should help guide the study of links between seismology and hydrology.

Montgomery and Manga found that a mild earthquake, around magnitude 3, could generate effects on subsurface water, such as in wells, as far as about 10 miles from the epicenter. But effects on well water from a magnitude 9 quake could be observed more than 6,000 miles away. In fact, the latter scenario played out in the 1964 Alaska earthquake that registered 9.2.

“Wells in South Africa, clear on the other side of the world, responded,” Montgomery said. “They didn't respond much, mind you, but the observations corresponded with the Alaska earthquake.”

In examining changes in surface water related to seismic activity, the scientists found that the maximum distance from the epicenter at which effects were noted corresponded closely with theories about the maximum distance from the epicenter that liquefaction could be expected in an earthquake of the same magnitude. In addition, those maximum distances were far less than for subsurface water. For example, a magnitude 9 quake produced surface water changes only as far as about 750 miles from the epicenter. Montgomery noted that stream flow changes could be detected at much greater distances if they were, in fact, occurring that far away from the epicenter.

When an earthquake occurs, well-water levels can change as energy from the quake compresses the rock containing the water, thus forcing water out of its pores. Similarly, the flow of streams on the surface can increase as the aquifer is compressed, or either liquefies or settles during strong shaking, and water rises to the surface, Montgomery said.

“It’s like squeezing a sponge because you're reducing the pore space and the water comes out. It has to go somewhere,” he said.

Changes to surface and subsurface water could be related to each other at very close distances from the epicenter, Montgomery said, but even then different processes control them. That becomes more evident by the way they react at greater distances.

“One gives us a window on connections between hydrology, seismology and deformation of the Earth's crust,” he said, “and the other gives us a better picture of connections between hydrology, seismology and geology at the surface.”

Using Frequency Waves to Measure Moisture in Soil

A more accurate and robust method to measure the water content in soil is now available, thanks to a study conducted by researchers from National Chiao Tung University in Taiwan.

Researchers have developed a numerical model for simulating the waveform in soil by using Time Domain Reflectometry (TDR) and a new calibration equation. Chih-Ping Lin, Assistant Professor of Civil Engineering, was the lead scientist on the research, conducted from 1999 to 2001 with support from the National Science Council, Taiwan.

“The TDR waveforms vary not only with the soil water content, but also with the soil types, bulk density, and probe parameters,” said Lin. “If these factors can be taken into account in the analysis, we can have a better algorithm for determining the soil water content.”

TDR measurement has become a widely adopted method for monitoring soil water content. The article examines the limitations of the traditional data reduction method for determining water content and proposed a new method. The result is a better automatic data reduction algorithm. Previous studies of TDR waveforms used sophisticated probes that were not appropriate for field applications and had limited values to the agronomy and geotechnical engineering community. The new finding connects the gap between the theoretical analysis and the field measurement.

“Now with almost any kind of probe and cable system, one can measure the frequency-dependent dielectric permitivity of the soil in the field,” Lin said. “This will not only improve the soil moisture measurements but also have impacts on the characterization of soil-water interaction.”

Ultra-Violet Light gives Clean, Cheap Water

A simple system that zaps disease-causing microbes with sunlight could provide an affordable solution to a worldwide health threat: contaminated water that claims more than 5 million lives each year.

The device, called the ultra-violet (UV) Tube, was developed at the University of California, Berkeley, as an inexpensive means to disinfect water in regions too poor to provide even this basic necessity of life.

A decade in the making, the system will be put to a yearlong test by households in rural areas of Mexico. Beginning in July, selected families will install the device, expected to retail for $30 to $50, which operates on about $1 of electricity a month. It is meant to remove from drinking water the organisms that cause diseases such as hepatitis, typhoid, cholera, dysentery and other major killers.

“One big issue for rural areas in Mexico has to do with a lack of a reliable infrastructure for delivering drinking water,” said Arturo González Herrera, project coordinator at the Mexican Institute of Water Technology, which will oversee the pilot testing. “We

want to know if the people find the UV Tube easy to use and prefer it to buying bottled water. If so, the UV Tube could save them money."

A Mexican household of eight, for example, would spend $4 to $5 a month on the system; the initial price of the device averaged over one year, plus the cost of electricity to run it, compared to paying $20 to $40 a month for bottled water, he noted.

If the UV Tube test succeeds, it would constitute important news at a time when the United Nations Children's Fund estimates some 1.2 billion humans lack access to clean drinking water. The UN expects that number to increase by at least 900 million over the coming decade due to population growth alone.

The World Health Organization blames dirty water for some 1.5 billion annual episodes of diarrhea, about 4 million of them fatal, among children under age 5.

"Diarrheal illnesses caused by unsafe drinking water and poor sanitation are the leading cause of death in developing countries," said Kara Nelson, Assistant Professor of Civil and Environmental engineering and the main technical adviser for the project. She listed the hardest-hit regions as Asia, Africa and Latin America.

"Between 2.2 and 5 million people die every year from diarrheal diseases," she told United Press International. "Up to 135 million may die by 2020 unless dramatic actions are taken to improve water and sanitation."

Health officials note 80 percent of fatal childhood diseases worldwide are caused not by shortages of food and medicine, but by drinking tainted water.

The UV Tube was born of the Berkeley group's conviction that sun's ultraviolet light, which can wreak havoc with any organism's genetic material and basic building blocks, can provide an essential weapon against bacterial and viral infestations of drinking water supplies.

"If the DNA gets damaged, the organism simply can't reproduce," said Nelson, a recent winner of the National Science Foundation's CAREER Award, who has been investigating how UV radiation can destroy pathogens in water. "Or, if the proteins are damaged, the organism may not be able to complete tasks essential to its metabolism."

Interest in water cleansing by UV light has increased in recent years along with health and safety concerns over the use of chlorine.

The UC Berkeley group said it wanted to do its part by providing a solution affordable enough even for a household struggling to make ends meet in a Third World nation. In designing the UV Tube, the engineers, along with energy and resources experts, targeted rural areas with access to electricity needed to run the device, urban regions with ineffective water distribution systems or unreliable centralized water treatment, and such non-household markets as clinics, schools and disaster relief agencies.

The new system consists of a 10-centimeter (4-inch) wide tube made of polyvinyl chloride, one of the most widely used plastics found in such products as raincoats, credit cards, cables and window blinds, and lined with stainless steel and aluminum foil. A UV bulb suspended from overhead aims its germicidal beam at water flowing through the 65-cm (26-inch) to 100-cm (39-inch) long pipe from either the kitchen faucet or a funnel.

The UV wavelength damages the genetic material of bacteria, viruses and protozoa, preventing them from replicating.

The device can be constructed for $25 from readily available off-the-shelf parts and is easy and inexpensive to operate and maintain, the researchers said.

The UV Tube, its developers point out, eliminates the need to boil or add chlorine. Most significant, they said, it is far less expensive than other options.

The researchers want to know whether the new and improved UV Tube works as well and easily in real life as it did in the laboratory.

Superfast Skyscraper

The city of Tilburg, a town in the southern part of the Netherlands, has got a new skyline in less than a year. At the amazing speed of one floor a week, Westpoint, a 150-metre high apartment building, has virtually shot up from the ground. The Dutch construction company Ballast-Needam used an innovative method for pouring concrete to make this possible.

To date there is no place in Holland where you can live higher up than 150 metres. Westpoint is an extremely modern building with all sorts of electronic devices for comfort, safety and outside communication. Furthermore the apartments on the floors 42 to 47 are truly spectacular. They are 300 square metres in size and since Holland is a flat country with nothing to obstruct the view, most of the province of Brabant can be seen from up there.

But it's not the impressive view nor the electronic gadgets that make Westpoint so innovative. Even the extreme rigidity of the building has been seen before (in a full hurricane, the top will sway no more than 10 centimeters). Westpoint's uniqueness lies in the way it has been built. By using the so-called tunnel-pouring method the builders poured one whole story per week

in concrete. The highest point was reached in just 47 weeks!

The method is as elegant as it is simple - two ready-made dies are placed on top of the floor, which was constructed the week before. These dies are made of sheets of steel and have roughly the shape as upside-down shoeboxes with the short sides cut out. Hence the name ‘tunnel-pouring method’: the steel shoeboxes look a bit like a tunnel. The ‘tunnels’ are positioned in a parallel way with the long sides next to each other. Together they cover half the surface of a floor. The concrete is then poured over the dies and left to set for a day or so. Once the concrete has hardened the tunnel-boxes are pulled out lengthwise, much as one might pull a drawer out of a cupboard. Then the concrete is poured for the second half of the story.

To get the tunnel-shaped dies on the next floor they are once again pulled out lengthwise (the ‘drawer’ is pulled out further, so to speak) and then lifted round the outside by using a crane. At the same time this crane positions them for pouring the next floor. The crane in turn is mounted on top of a whole ‘climbing factory’ - a huge ring-shaped construction. It contains several floors and workshops and even a canteen for the builders. Holding on to the bare concrete skeleton of the skyscraper, much like a napkin ring, it pulls itself up very slowly with steel hooks in the still open holes where the windows will be. The factory is used for placing the prefabricated facades, for putting in the windowsills, in short, performing the finishing touches.

Recently the top of Westpoint was reached. To celebrate this occasion four mountaineers climbed the building on the outside and the Mayor of Tilburg raised the flag on the roof. Soon the first owners can move into their new homes.