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Currents

A Newsletter of the UC Center for Water Resources

In This Issue

From the Medicine Cabinet:

Emerging Pollutants – Pharmaceutically Active Ingredients and Endocrine Disruptors in Water

By Andrew Chang

Results of a recent USGS survey published in *Environmental Science and Technology* showed that pharmaceutically active chemicals (PACHs) and endocrine disruptors were found in surface water bodies across the nation. Although their concentrations have been extremely low (1 ppb or less) and the detections have been infrequent, their presence is a contemporary issue of water quality management.

Much of the research today is focused on determining what problems such chemicals may pose to human health and what treatment method will best remove them. Three studies funded by the UC Water Resources Center (detailed on page 4) are helping to answer these and other questions.

A large number of drug residues, such as anti-phlogistics, lipid regulators and beta-blockers, have been found in treated wastewater effluents. Among the pharmaceutically active ingredients, the residues of antibiotics and hormone-like compounds have attracted the most attention. Although conventional wastewater treatment is not designed specifically for their removal, the processes nevertheless effectively reduce the concentrations in the treated effluents, but do not completely remove them. The concentrations of pharmaceutically active chemicals (PACHs) that

Continued on page 4

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The UC Center for Water Resources is a multicampus research unit and special program within the University of California's Division of Agriculture and Natural Resources. The Center is charged with stimulating and coordinating research and information dissemination on a wide variety of issues related to California's water resources.

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Director's Message *by John Letey*

I am using this space for a personal tribute to the late Professor Robert Hagan, who passed away July 3, 2002. I first met Bob when I was a graduate student attending the National Soil Science Society of America meetings. There was an open faculty position at UC Davis in the field of my study, and Dr. Hagan (as I knew him then) visited with me concerning the position. I was in the initial stages of my graduate studies and not eligible for the position. Nevertheless, I remember the experience because I felt that I was interacting with a very special person.

After completing my degree and first accepting a position at UCLA and later transferring to Riverside, I looked forward to the opportunity to associate with Bob. I have tried to emulate traits that I respect in my colleagues in my career. I admired Bob because he was not satisfied with simply interacting with his scientific colleagues. He used his knowledge to address societal issues and reach out to the public. He was not afraid to take a position on a controversial issue, which I admire.

Bob's main thrust was on irrigation management. Agricultural water use efficiency is one of the most confused and misunderstood concepts in water management. It is confused because many definitions are used, resulting in great differences in computed values. Further confusion arises because the values, by any given definition, differ if they are calculated on an individual field (the most negative assessment), a farm, or a basin (the most positive assessment). It is misunderstood because it is commonly assumed that increasing agricultural water use efficiency will increase the amount of water available to meet societal demands. Whether this is valid has to be determined on a site-specific basis.

I am very concerned that erroneous estimates are being made on the magnitude of increased water supply that can be achieved by increasing agricultural water use efficiency. This concern was reinforced during my recent trip to Tunisia to participate in the joint Iranian / U.S. symposium on water resources. (See page 9.) Reports from both Iran and Tunisia emphasized the national goal of greatly increasing the availability of water by investing resources to improve agricultural water use efficiency. Although there are cases where increased efficiency can lead to increased supply, it is not a univer-

sal result. Bob labored tirelessly to educate the public on this topic with some positive effect. Sadly, however, reports continue to perpetuate some of the false or misleading information that Bob worked to correct.

I believe that Bob would have been intrigued by the results of a recent study on urban outdoor water use in 14 U.S. and Canadian cities. The study found that, on average, irrigation systems on automatic timers used 47 percent more water than without timers, drip systems used 15 percent more water than non-drip systems, and hand moved hoses used 30 percent less water than fixed irrigation systems. The most surprising result was that xeriscape used slightly more water than others. The latter result was explained by the fact that xeriscape plants can tolerate drought conditions, but they also respond when supplied with ample water. The main conclusion that can be drawn is that the amount of water used for irrigation depends more on management decisions than on physical systems. This is a principle that Bob emphasized in his communications.

Bob also recognized that agricultural water was used to produce food and fiber to support urban dwellers, which now represent the vast majority of the population. He was the spark plug that led to the project of estimating the amount of water

Continued on page 9

The Amount of Water We Eat

By John Letey and David Birkle

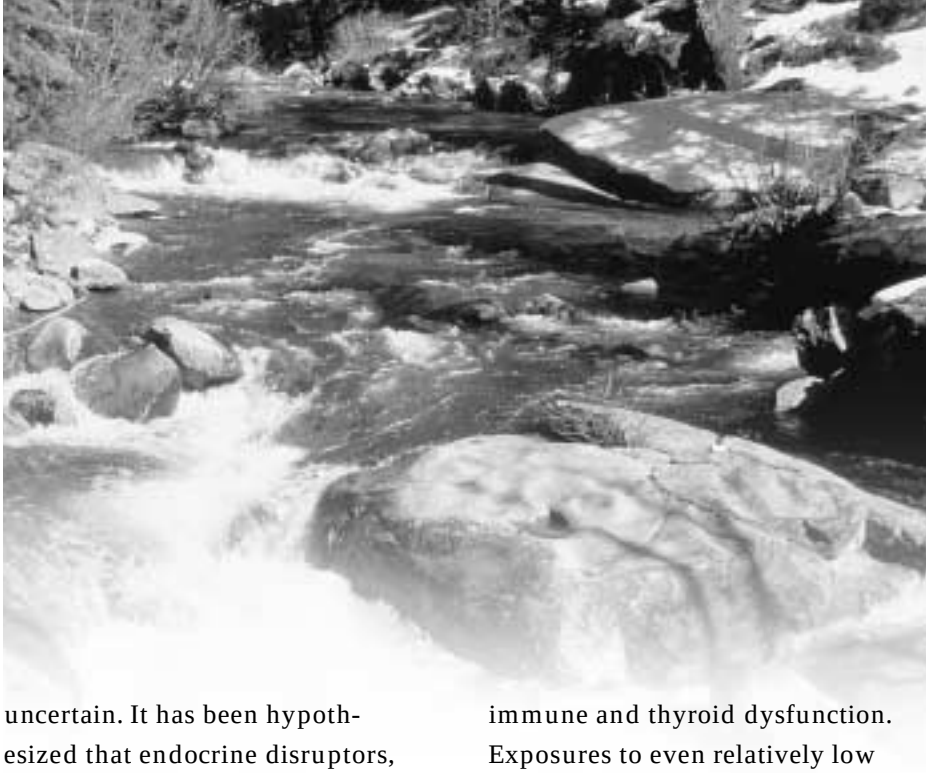
The fact that the amount of water used in growing agricultural crops in California is much greater than the amount of water used in cities is well publicized. Values of 80-85 percent of developed water going to agriculture are commonly reported. Less understood is the fact that large quantities of water are indirectly delivered to the city via food. The late professor Robert Hagan recognized this and was instrumental in initiating a study to quantify the water used to produce various foods in California.

Marcia Kreith, with guidance from an advisory committee, which Professors Robert Hagan and Henry Vaux Jr. co-chaired, prepared a report for the Water Education Foundation dated September 27, 1991, entitled "Water Inputs in California Food Production." The assumptions made for the analyses are reported in detail. The basic approach was to divide the weighted statewide average evapotranspiration by the weighted statewide average yield for a crop to determine the gallons of water per pound of food produced. Because it is impossible to irrigate so that all the water delivered to a farm is used for evapotranspiration, the calculated number was divided by 0.7.

We used the values from the report to calculate the amount of water used to produce the food for a specific daily diet. However, we multiplied each value by 0.7 before using them so that our numbers are conservative and represent only the water lost through evapotranspiration. We used a 2,200-calorie menu proposed by the U.S. Department of Agriculture Food, Nutrition and Consumer Service.

Breakfast was 1 medium orange, 1 banana, 1 bowl of dry cereal, 1 muffin, 2 pats of butter and 1/2 cup of milk, which totaled 130 gallons of water. Lunch was a taco salad and 2 ginger snaps which totaled 275 gallons of water. Dinner was chicken-vegetable stir-fry, cooked broccoli, 2 slices of bread, 2 pats of butter, and a fruit cup for a total of 220 gallons of water. Snacks consisted of 6 wheat crackers, 6 oz of yogurt and 1/2 cup of orange juice for a total of 83 gallons. The daily total was 708 gallons of water.

The daily amount of water used per person in a city home is variable, but 125 gallons/day is a typical value. For our scenario the city person uses a total of 833 gal/day of which 708 (85 percent) is for producing the food. The result that the percentage of water used to produce food is about the same as the percent of water delivered to agriculture is coincidental, but nevertheless illustrates the magnitude of the water delivered to agriculture that indirectly passes on to the urban dweller.



From the Medicine Cabinet

Continued from front page

have been measured in water do not pose a direct and immediate threat to the well being of the human population as their concentrations are considerably below the level commonly used for the therapeutic purpose.

Endocrine disrupting substances are, for the most part, synthetic chemicals that interact with the endocrine systems and result in the disruption of normal biological functions, including growth, development and maturation. When interacted with the endocrine system of an organism, these substances may act like a natural hormone and bind to a receptor, may interfere with the normal hormonal responses by binding and therefore blocking the receptor, or may interfere with the organism's synthesis and control of the natural hormones.

In addition to the natural hormones produced by animals and synthetic steroids found in the contraceptives, other substances exhibiting endocrine disrupting properties include organo-chlorine pesticides, surfactants, plasticizers, PCBs, dioxins, and tributyltin. When exposed to high concentrations, the adverse effects of selected chemicals on the development and reproduction, cognitive- and neuro-behavior, and immuno-responses of the exposed organisms have been demonstrated.

The extent of harm caused by the exposure to levels commonly encountered in the environment is uncertain. It has been hypothesized that endocrine disruptors, acting as weak estrogens, are capable, either alone or in combination, of producing a variety of adverse effects including cancers, reproductive and fertility disorders, learning disability, and immune and thyroid dysfunction. Exposures to even relatively low levels of endocrine disrupting chemicals are known to induce hormonal abnormalities in organisms. Results of laboratory experiments with aquatic organisms showed that these chemicals at

UC Research on Pharmaceuticals

Pharmaceutically-active Compounds in Alternative Water Supplies.

David Sedlak, Department of Civil and Environmental Engineering, UC Berkeley, 1997-1999

In this pioneering project, Professor Sedlak developed the analytical techniques for measuring low concentrations of pharmaceutically-active compounds in wastewater and polluted natural water. Using the procedures, he detected the estrogenic hormones 17b-estradiol and ethynyl estradial in wastewater effluents at concentrations high enough to explain endocrine disruption observed in fish in rivers that received significant amounts of wastewater effluents. Only ultra-filtration was effective to remove all of the hormone from the effluents. Additional studies found that hormonal compounds, frequently associated with the suspended solids, were found in water of the Colorado River. Data collected by this project was instrumental for Sedlak to secure additional funding from National Science Foundation to continue work on the fate of hormones in the aquatic environment.

Biodegradation of Estrogenic Compounds and Its Enhancement in a Membrane Bioreaction.

Slawomir W. Hermanowicz, Civil and Environmental Engineering, UC Berkeley, 2000-2002

Estrogenic compounds are present in very small concentrations in water. Their detection and

1–100 ppb concentration range have the potential to interrupt normal hormonal pathways that regulate reproductive functions and subsequently lead to decreased fertility and egg production in females and feminization of genetic male fishes.

While the presence of endocrine disrupting chemicals in the environment and the potential ecological consequences are alarming, their concentrations found in the surface water bodies and other environmental compartments so far are very low. Whether they are sufficiently elevated to affect the exposed organisms remain to be demonstrated. The human toxicity thresholds in the forms of no observed adverse effect level (NOAEL) or lowest observed adverse affect level (LOAEL) have not been established.

At this juncture, there is inadequate technical information to assess the potential adverse impacts of the endocrine disrupting chemicals released through land application of reclaimed wastewater or sewage sludge. In the U.S., the strategies for screening and testing endocrine disrupters and protocols for risk assessments are currently being developed.

Since 1997, the UC Water Resources Center has funded three projects that address this emerging issue. Those studies are outlined below.

quantification is difficult. A bioassay procedure using genetically modified yeasts for characterization of estrogenic activities of water has been developed. The procedure is used to study the kinetics of enhanced biodegradation of estrogenic compounds in membrane bioreactors.

Use of Bioassays to assess the Water Quality of Wastewater Treatment Plants for the Occurrence of Estrogens and androgens.

Daniel Schlenk, Department of Environmental Sciences, UC Riverside, 2001-2003

Professor Schlenk has showed that concentrations of androgens (anti-estrogens) and testosterone in secondary effluents are comparable to those of the estrogens. The current study is to assess the efficiencies of the County Sanitation Districts of Los Angeles County and Orange County Sanitation District wastewater treatment processes to remove these compounds. Schlenk's laboratory is also studying the relationship between exposure to environmental pharmaceutical agents and altered fish populations.

References

Kolpin, D.W., Furlong, E.T., Meyer, M.T., Thurman, E.M., Zaugg, S.D., Barber, L.B., and Buxton, H.T., 2002. Pharmaceuticals, hormones, and other organic wastewater contaminants in U.S. streams, 1999-2000: A national reconnaissance. *Environmental Science and Technology*, v. 36, no. 6, p. 1202-1211.

2001-2002 Salinity/Drainage Annual Report Available

Limited supplies of hard copies of the 2001-2002 Salinity/Drainage Annual Report are available from the U.C. Center for Water Resources at no cost. The report is also posted on the UC Center for Water Resources web site http://www.waterresources.ucr.edu/. The document contains comprehensive reports of 20 projects supported by the UC Salinity/Drainage Program and Prosser Trust Fund. A broad range of topics relevant to salinity, selenium, drainage and irrigation management are reported.

One example of research included in the report:

• A joint research effort, comprised of four specific projects, directed toward remediating selenium toxicity in evaporation basins. The investigators are evaluating the reduction of selenium risk from intensive commercial harvest of brine shrimp and other macro invertebrates; understanding algal dynamics to optimize selenium volatilization and shrimp harvest to reduce bioavailable selenium; and evaluating ecotoxic status of evaporation basins with varying salinity and other conditions so that general factors leading to reduced ecotoxic risk can be discerned.

Third Rosenberg International Forum on Water Policy Featured 21 Nations

By John Letey

The Honorable Sen. Margaret Reid, past President of the Austra lian senate, and Dr. Richard Atkinson, President of the University of California, welcomed 58 invited participants to the Third Biannual International Forum on water policy at Canberra, Australia on October 8, 2002. The formal two-day segment of the forum was devoted to oral presentations followed by extensive discussion on topics related to the theme "Innovation in the Management of Water Resources: Perspectives from the Developed and Developing World." Topics of discussion included integrated river basin management, obtaining integrated stakeholder input, innovations in salinity management, innovations in groundwater management, public and private options for water supply and wastewater treatment services, and institutional innovations. The forum was not intended to reach consensus or major conclusions; however, formal presentations will be published.

Attendees at the Rosenberg Forum included, L to R, UC President Richard Atkinson, Cal Fed Bank Vice President Fred Cannon, UC Associate Vice President Henry Vaux Jr., UC Vice President Reg Gomes and Water Resources Center Director John Letey.

The two-day meetings were sandwiched between a one-day pre-conference trip to the Murray-Darling Basin and a two-day field trip to the Snowy Mountains Scheme. Australia, like much of the western United States, is enduring an extended extreme drought, which was a major topic of discussion. Water resource management issues in Australia do not differ greatly from those in California so this trip was a valuable educational experience for me. The following represents some of my more intriguing experiences.

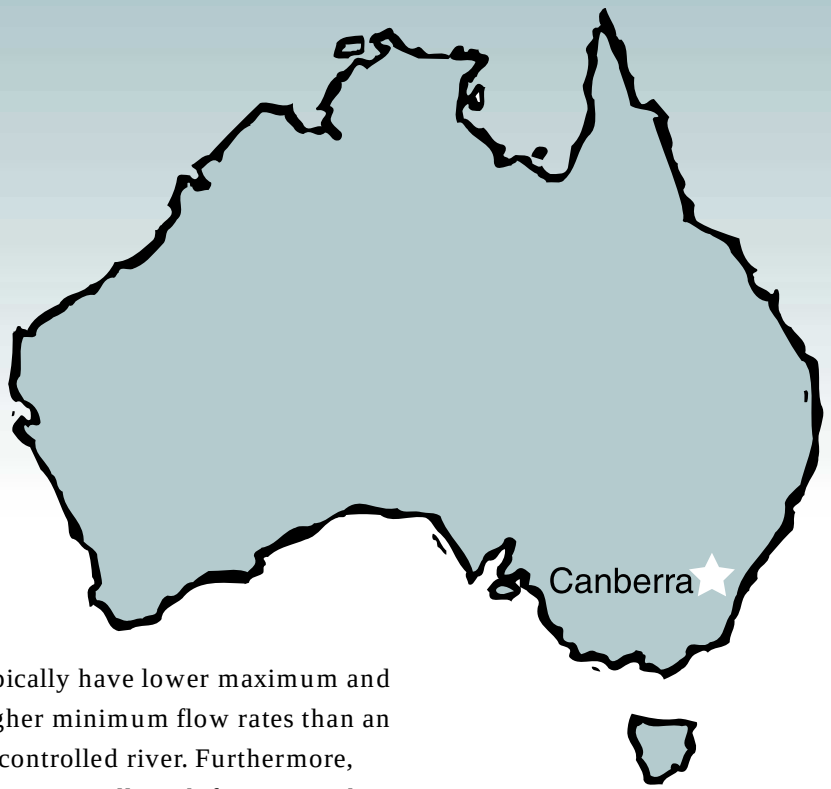
Fish Elevator

Apparently fish in the Murray River are not as athletic as the salmon in the western United States. A fish elevator rather than a ladder has been built at the Yarrawonga Weir. The fish enter through a relatively narrow passageway into a cage that is used to lift them up where they are placed into a trailer filled with water and deposited upstream. The fish are enticed into the elevator by adjusting the water current flow to a selected velocity so that the fish think they are swimming upstream.

High Technology Fruit Farm

We visited a family owned fruit farm, which was managed by using the most advanced farming technology. Microirrigation systems were used throughout the farm. The trees were pruned using the advanced Tatura trellis system to efficiently capture sunlight and facilitate farm operations such as picking. Irriga-

tion water availability during the drought was a major concern for the farmers. They stated that providing adequate water is a "must" for fruit trees because both present and future productivity is jeopardized if adequate water is not applied. Interestingly, they have the opportunity to bargain for water on the Internet. The hosts explained that they had not bid sufficiently high for water and that they would have to raise their bid the next time, because water had to be purchased no matter the price.



Red Gum Forest

The red gum is the most common tree along the river and streams of the Murray-Darling basin. The Barmah-Millewa is the largest red gum forest in the world and attracts numerous visitors. The forest is located in the central Murray Valley on the flood plain of the river. The well being of the forest is linked to the timing and extent of high flows in the river that inundate the flood plain. Engineered water systems typically have lower maximum and higher minimum flow rates than an uncontrolled river. Furthermore, there is usually a shift in time when the peak flows in the river occur. The down stream water uses are greatest in the summer which is not the optimal time for the red gum forest to be flooded from the high river flow. This is an example of the challenge to optimally manage water for both environmental and human purposes.

Snowy Mountains Scheme

The Snowy Mountains exist in the southeast part of the continent and receive much of the nation's precipitation. Precipitation on the eastern mountain range flowed a relatively short distance to the ocean with little human use. The Snowy Mountain Scheme was the most ambitious civil engineering project undertaken in Australia. Its purpose was to impound the waters of the Snowy and Eucumbene Rivers and divert them inland via tunnels for the production of electricity and augmentation of water supply for the Murry and Murrumbidgee Rivers. The water diverted inland for human utility was at the expense of natural flows in the Snowy River to the ocean. The hydroelectric plants are operated to meet spot demand for energy. Generators can be quickly turned on or off by delivery of water to the turbines. As such, with energy prices changing every five minutes and huge price difference between high and low demand periods, the hydro power plants can be operated to maximize profits. Downstream reservoirs from

Partially inundated red gum forest in Australia.

Continued on page 11

Laosheng Wu Appointed Associate Director of the UC Center for Water Resources

Dr. Laosheng Wu, Associate Professor of Soil Science and Associate Cooperative Extension Water Management Specialist at UC Riverside, has been appointed Associate Director of the UC Center for Water Resource effective January 1. At the center, Wu will serve as the California State Water Quality Coordinator for the USDA Cooperative State Research, Education, and Extension Service (CSREES) National Water Quality Program and administrate the California segment of the recently funded CSREES Regional (EPA Region 9) Water Quality Coordination Program.

Dr. Laosheng Wu

"California is a state with diverse climate, soil, land use and water resources. We face almost all the water quality issues that the nation faces," Wu said. "I look forward, with the support and advice of associates, to identifying key water quality issues and priorities, and determining the gaps in water quality programming so that we can optimize collaborative and efficient resource utilization among the existing federal, state and local water quality programs."

The goal of the Water Quality Coordination Program is to make research, education, and extension resources of the university system more accessible to federal, state and local water quality improvement efforts. Wu will work with other state, territory and tribal college coordinators / representatives to establish a collaborative, structured process that develops and shares new and existing information and management practices throughout the region. They will compile a database of existing state research, education, and extension information and data resources that can be accessed through a central database management system. They also intend to provide technology transfer programs to promote the use of appropriate water resource management tools by professionals, agricultural producers, and communities in agriculturally impacted watersheds.

The eight selected national topical themes are: (1) Animal Waste Management; (2) Drinking Water and Human Health; (3) Environmental Restoration; (4) Nutrient and Pesticide Management; (5) Pollution Assessment and Prevention; (6) Watershed Management; (7) Water Conservation and Agricultural Water Management; and (8) Water Policy and Economics.

Wu will continue his research, teaching, and extension responsibilities in the Environmental Science Department at UCR.

New Staff

Joann Braga

Joann Braga joined the WRC staff as an Administrative Assistant on December 2. She comes to us from Cooperative Extension where her latest assignment was with Consumer Economics as Administrative Assistant to Dr. Karen Varcoe. She replaces Melanie Carlson.

Joann Braga

At The Archives

Trina Pundurs and Nancy Novitski were recently hired as Technical Services and Public Services Assistants at the Water Resources Center Archives.

Pundurs joined the Archives with 12 years of library and cataloging experience. She has worked at Carnegie Mellon University Libraries in Pittsburgh, PA, Mills College in Oakland and, the San Francisco Public Library. Her primary responsibilities are copy cataloging, ordering new material, and serials maintenance.

Novitski is a 2000 graduate of Stanford where she earned a B.S. in biology. She worked as Special Projects Coordinator for the Natural Area Preservation Division in Ann Arbor, MI.

Retiring from the Archives after more than 15 years of service cataloging was Elizabeth Redies. She retired in July 2002.

Director's Message

Continued from page 3

used for producing various foods. As a tribute to Bob Hagan, we used the results of that project to estimate the amount of water needed to produce a one-day supply of food and report the results in an article that appears on page 3.

Some considered Bob to be pro-agriculture. I characterize Bob as having been pro-truth based upon his scientific knowledge and experience.

Bob Hagan

NOTE: Before he passed away, Bob donated $175,000 of his money toward endowing a faculty chair at UC Davis in water management and policy aimed at helping find solutions to today's water problems. Bob's legacy is half the amount of money needed to endow this chair, an amount UC Davis is honoring, although the cost of an endowed chair has increased substantially since the commitment to Bob several years ago. A campaign led by the Association of California Water Agencies, San Joaquin Valley Agricultural Water Committee and Water Education Foundation is now working to raise the other $175,000. If you are interested in contributing to this effort, please contact Rita Schmidt Sudman at the Water Education Foundation, 916-444-6240.

Joint Iranian/United States Symposium Focused on Water Resources

The National Academies of Science from Iran and the United States sponsored a joint symposium on water resources held in Tunis, Tunisia, December 10-12, 2002. Seven delegates from each country shared scientific and economic information on agricultural water use, water treatment technology, water quality, urban wastewater reuse, managing drought, water allocation and interbasin water transfers. The U.S. delegation was lead by Dr. Henry Vaux, Jr., Associate Vice-president of the UC Division of Natural and Agricultural Sciences and the Iranian delegation was lead by Dr. Mehdi Bahadori, Vice-president of the Iranian Academy of Sciences.

The participants enthusiastically concluded that the symposium was successful and, based on the discussions, recommended that the academies pursue future workshops on specific topics to exchange scientific information and foster collaboration between scientists of the two countries.

The Tunisian Ministry of Agriculture, Water Resources and Environment made local arrangements for the symposium in their country. They also organized pre- and post-symposium tours through the country covering a wide-range of water related activities such as a desalinization plant, urban wastewater use to irrigate crops, urban water treatment facilities, and geothermal energy to heat greenhouses in the winter.

Tunisian Minister Ameur Horchani bidding farewell to Henry Vaux.

Ameur Horchani, who serves both as the Tunisian Secretary of State and Minister of Agriculture, Water Resources and Environment, held a brief reception at the end of the tour. He expressed the interest of his country to pursue cooperation with the U.S. and Iranian Academies of Science on water resources, which are vital to all the countries.

The University of California delegates, in addition to Dr. Vaux, were Dr. John Letey, Director of the UC Center for Water Resources, and Dr. David Sunding and Dr. Kara Nelson from the University of California, Berkeley.

Ecology of a European River Recovers Rapidly Following Destruction by Toxic Chemicals

Confluence of River Szamos where the toxic spill of cyanide flowed into the River Tisza in January 2000.

Andrew C. Chang, Associate Director of the UC Center for Water Resources, was one of eight scientists from the U.S. who participated in a National Science Foundation and Hungarian Academy of Science Workshop to assess the ecological impacts and pollutant deposition two years following two major accidental chemical discharges on the Tisza River system in Eastern Europe. The workshop was held on September 16 to 19, 2002 in Budapest, Hungary.

The Tisza River flows from headwaters in Ukraine and Romania through Hungary and Yugoslavia before discharging into the Danube River near Senta, Yugoslavia. The river provides water supply, fishing, recreation and aesthetic enhancement for the residents of Hungary.

A structure on a tributary to the Tisza River retaining gold extraction wastewater storage at a gold mine in Baia Mare, Romania failed on January 30, 2000. The rupture released an 8 m high and 100,000 m^3 tidal wave of wastewater containing 120 tons of cyanide that moved down the tributaries and into the Tisza River. The cyanide concentration gradually decreased as it moved downstream by longitudinal dispersion, dilution and decomposition. The release of cyanide-contaminated water resulted in 1,250 tons of fish killed and wiped out much of the aquatic biota, water fowls and other animals along the way.

A subsequent event in March released 20,000 tons of heavy metal-laden slurry down a tributary of the Tisza River when heavy rains and snowmelt overflowed and caused a rupture of a dam retaining a mine

tail settling pond in Baia Borsa, Romania. The plume carrying lead, copper and zinc reached the Hungarian section of the Tisza River one day after the release and contaminated essentially the same section where the biota was wiped out by the cyanide less than two months previously. In the upper reach of the Hungarian Tisza, where contaminated sediments were deposited; the concentrations of lead, copper and zinc in the bottom sediment were 500, 900, and 1500 mg/kg, respectively.

A major finding of the science workshop was that the river ecosystem was very resilient and recovered rapidly from the massive destruction. The cyanide essentially destroyed phytoplankton and zooplankton communities of the Szamos and Tisza rivers. Through inoculation from the upstream, reestablishment started a few days after passage of the cyanide wave and the repopulation of the taxa occurred after several weeks. Despite massive kills, the macro invertebrate fauna also survived. The workshop participants toured the river section affected by the toxic discharges. Dr. Bela Csanji of the Hungarian Water Resources Center showed the group that 2-1/2 years after the catastrophic toxic chemical spills the river was again teeming with life and the aquatic ecosystem was completely restored.

The concentrations of lead, copper and zinc in the bottom sediments of the upper reaches of the Tisza River in Hungary were elevated several fold after the discharge. The concentrations were no longer elevated after the spring and summer flood seasons. The polluted sediments were resuspended and redistributed along the river and its flood plain. Analysis of the Tisza River pike muscular tissue revealed no impact from the discharge event. Occurrences of elevated heavy metal concentrations in pike were directly related to point source discharges from industries along the river.

Cyanide has been dissipated and the acute toxic impacts have quickly subsided. The metals, however, remain deposited along the stream, flood plains, and croplands and any impacts could be present for a long time. The workshop participants are developing collaborative research projects to track their fate and transport and to assess the bioavailability of the metals.

Rosenberg International Forum

Continued from page 7

the power plants are required to even out the flow of water into the rivers.

Environmental Water

Diversion of water away from the Snowy River has altered the ecology of the stream. By some process, it was determined that the flows into the river should be increased by 21 percent. No provision was made to adjust that value between wet and dry years, therefore, the impact is particularly great this year during the drought. One generator was operating at an off-peak time during our visit because the agricultural community had requested more water. The farmers had to pay a premium for that water.

Rosenberg Forum delegates boarding plane to return to Canberra following Murray-Darling field trip.

About the Rosenberg Forum

The Rosenberg International Forum on Water Policy was created by an endowment gift by the Bank of America to the University of California. The gift honors former Bank of America Chairman and Chief Executive Officer Richard M. Rosenberg who has an enduring interest in water resources and who successfully rallied the business community in California to the task of solving the state's water problems. The format for the forum was developed under the leadership of Dr. Henry Vaux, Jr., Associate Vice President of the UC Division of Natural and Agricultural Sciences, and Fred Cannon, former Bank of America Executive Vice President, serving as co-chairs to an advisory committee. The University of California, along with various entities within the country that the forum is held, cosponsor the event.

Mark your calendar!

March 26 Salinity / Drainage annual meeting at the Sacramento Red Lion Hotel

October 28-29 24th Biennial Groundwater Conference at the Double Tree Hotel in Ontario

Visit our web site, www.waterresources.ucr.edu, for more information about these conferences.

Directory of UC Water Expertise Updated

The water segment of the "Directory of Water and Wildland Expertise and Facilities in the University of California System" was recently updated, and is available on-line at http://www.nceas.ucsb.edu/exp.

To identify an expert, page down until you find the word "Experts" to click on. Click on OK and then YES to the two security questions, which will bring up the "Expertise Database Query Form." Most users of the directory are seeking individuals qualified to address specific subject matters, which are identified by KEYWORDS. Click on the keyword(s) of interest and the start search button to bring up names of individuals with expertise on that topic. Click on the individual names for more complete information on the individual.

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