WRRC ANNUAL CONFERENCE 2011

Salinity and Desalination in the Southwest: Challenges and Solutions

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Poster Abstracts

1. Salinity Tolerance and Productivity of *T. domingensis, S. americanus and P. australis* in Ciénega de Santa Clara

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This study evaluates the growth response of *Typha domingensis, Scirpus americanus and Phragmites australis* at different salinities. The three species were grown in a greenhouse and treated with a range of salinities (1, 3, 6, 9 and 12 ppt). I also measured the productivity of the three species in the Ciénega de Santa Clara (Sonora, Mexico) as a function of different salinities. The productivity of *T. domingensis and S. americanus* declines with increases in salinity, with *T. domingensis* productivity declining more rapidly. *P. australis* productivity was not significantly different among salinity treatments. Field productivity measurements for *T. domingensis* corroborated greenhouse findings. This study indicates that salinity affects the productivity of *T. domingensis* and *S. americanus*, and that a *T. domingensis* dominated wetland, such as the Ciénega de Santa Clara, might become dominated by *S. americanus* if the salinity of the system increases.

2. ZDD Process Improves Water Recovery in Groundwater Desalination

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We have employed a process called Electrodialysis Metathesis (EDM) to remove $CaSO_4$ from the concentrate stream produced by RO treatment of gypsum-rich groundwater. After the $CaSO_4$ is removed, the solution can be subjected to further RO treatment to recover more water. We call our technology Zero Discharge Desalination (ZDD). EDM utilizes a special arrangement of membranes in an electrodialysis stack with repeating cells of four membranes and four solution compartments, two depleting and two concentrating. The $CaSO_4$–rich RO concentrate flows though one depleting stream and a solution of NaCl flows through the other. The salts in the feed streams "change partners" and form concentrated solutions of mixed chloride salts (predominantly $CaCl_2$) and mixed sodium salts (predominantly Na_2SO_4. When the highly concentrated salt streams are mixed in a stirred reactor, $CaSO_4$ precipitate and NaCl-rich supernatant is produced. With RO alone, the yield of potable water is limited to about 75%.

3. Comparison of Microfiltration and Slow Sand Filtration as a Pretreatment to Desalination of CAP Water

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Sustainable water supply in the semiarid southwestern United States depends on the utilization of waters of impaired initial quality, including brackish and reclaimed water, or on exploiting new water resources that are geographically distant. The Colorado River is both geographically distant from major population centers in Arizona and, from the perspective of salt content, modestly impaired (total dissolved solids content ~800 mg/L south of Lake Mead). Arizona is entitled to withdraw up to 2.8 MAF of water from the Colorado River each year, of which 1.6 MAF is transported to the state's interior via the Central Arizona Project (CAP) canal. Each year, the CAP transports ~200,000 metric tons of salt to Tucson alone, and without salt management steps, accessible ground water and regional soils may accumulate salt at a rate that presents sustainability problems. A pilot study was conducted to establish the long-term feasibility of using reverse osmosis (RO) treatment to manage salt levels.

4. Effects of Water Management Decisions and of the El Mayor Cucapah April 4th 2010 Earthquake on the Colorado River Delta Tidal Inundation Patterns: Implications for Shorebirds Habitat Availability Colorado River

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The Upper Gulf of California and Colorado River Delta (CRD) provide feeding and resting areas for migratory and resident shorebirds. The Ciénega de Santa Clara receives saline water inflows from the United States, brackish effluent from the Santa Clara Slough and occasional tidal inundation on high tides. This transitional wetland is one of the main shorebird aggregation areas within the CRD. We documented the changes in the shorebird inland habitats in response to reduction in inflows due to water management, and the M7.2 El Mayor-Cucapah earthquake that caused changes in the tidal water inflows patterns in the delta. Preliminary results showed 80% decrease in the flooded area potentially used by shorebirds. Few shorebirds were visiting the new wetland area during spring migration. Seasonal patterns of abundance indicate that the intertidal zone had the highest use by shorebirds during winter and spring migration and anthropogenic wetlands like the Ciénega during the spring and fall migration. Further monitoring is needed to determine the importance of different types of wetlands along the year for shorebirds along with the main drivers for habitat availability.

5. The Importance of Hydrogen and pH Control

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When it comes to improving our ability to conserve water; prevent soil salinity; and optimize the efficiency of reverse osmosis filtration systems, our biggest problem may lie in the fact that the foundation of knowledge that we are using may be flawed as a result of starting at the wrong place. To begin anew, we must consider establishing and using the element of hydrogen (H+) as our starting point. Derived from the Greek words "hydro" and "genes", which together mean "water-forming," hydrogen is the major component in water, but also estimated to be 75% of all matter on the earth and 93% of all the atoms in the universe. Based on the proportion and magnitude of this single element, logic dictates that the only possible way to solve these water-related problems will be by understanding how this component is recycled in earth's natural acidification process. This poster will explain how this process works and why it must be integrated into our water-based systems to improve them.

6. A Simple System for Desalting Water

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We have developed a system where salt water is heated by solar energy until it produces dew. We put seawater into shallow pans under plastic, heating the water with solar energy until a dew forms. Experiments have demonstrated that this is fresh water. The dew is condensed into liquid water by an evaporative cooler, which produces a fresh water supply.

7. Desalination Powered by Entropy

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We describe in this poster a novel water distiller. The water distiller utilizes a thermal gradient device which spontaneously generates and maintains a thermal gradient through a process similar to osmosis. A theoretical derivation of the process which we call an entrochemical process is presented. The device utilizes the thermal gradient to induce a flow of energy through the system. This flow of energy is used to induce the distillation of water. The device may be recharged using a low-temperature evaporation process. We describe the design of the device, which has a distillation process that has an efficiency of 12.6 +/- 2.6 % in utilizing the energy that moves through the system.

8. Desalination and Development: The Technological Transformation of the Gulf of California

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The provision of potable water in urbanizing arid regions facing a projected reduction in precipitation and reduced water supply due to climate change, is a critical challenge worldwide. The state of Baja California Sur (BCS) is located in Mexico's most arid region. Desalination offers a potentially "limitless" supply and is becoming the preferred augmentation strategy in BCS. While desalination can reduce some vulnerabilities (e.g., future water supply), it may increase others (e.g., equity, affordability, environmental impacts, and energy demands). This project asks: What leads to the adoption of desalination technology as a climate change adaptation and development strategy and how does this technology affect the communities where it is implemented? Research will be carried out over a 9-month period in two research sites in BCS (Los Cabos and La Paz), using semi-structured interviews, focus groups, household surveys, and a time-series analysis of secondary data.

9. Images and Analysis Classification Procedure for Quickbird and WorldView 2 of Vegetation Dynamics in the Cienega de Santa Clara, 2008-2010

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High-resolution Quickbird and WorldView 2 images were analyzed to detect changes in the vegetation of Cienega de Santa Clara over seasons and years. Winter, spring and summer images for 2008 – 2010 were analyzed. Red and NIR bands were converted to NDVI values and an unsupervised classification program was used to separate values into ranges representing water, bare soil, and four vegetation classes corresponding to different foliage densities ranging from low to highest, depending on NDVI values. Interpretation of classified images showed that the overall vegetated footprint of the Cienega was stable over the study period, but that changes in vegetation density occurred.

10. Solar Membrane Distillation

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Water scarcity is among the most serious, long-term challenges in the world. To an ever increasing degree, sustainable water supply depends on the utilization of water of impaired initial quality. This is particularly true in developing nations and in water stressed areas such as the American Southwest. This poster discusses the development of a desalination pervaporation reactor designed as the core unit in a solar-driven, membrane distillation (MD) process. For this MD process, solar-heated, brackish water is fed to one side of a hydrophobic, hollow fiber membrane bundle, while ambient air is passed counter-current to collect the evolved water vapor. As the warm saturated air is cooled to room temperature, the water vapor condenses and is collected as pure product. Results show that purified water fluxes from 6 to 10 L/m2·d can be achieved with average transmembrane temperature differences of only 20 to 45˚C. The MD process has been shown to operate with a thermal differential as low as 10˚C with little dependence on the salinity of the feed at less than seawater TDS. The current MD apparatus being developed is designed to operate as an autonomous, off-the-grid, solar desalination unit amenable to implementation in remote, challenging environments.

11. Long Term Viability of Irrigation of *A. lentiformis* with RO Concentrate in an Agricultural Setting

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Water delivered from the Central Arizona Project (CAP) arrives in the Marana/Tucson, AZ Basin at 700 mg/ L of total dissolved solids (TDS). The EPA's Secondary Regulations advise a maximum contamination level (MCL) of 500 mg/L TDS. Currently a method of blending CAP water with Tucson ground water supply is used to dilute the CAP water. However, in the future Reverse Osmosis (RO) might be used to reduce salinity. This research explored a greener alternative method to evaporation ponds to manage the concentrate produced in an RO facility. We irrigated a native halophyte, *Atriplex lentiformis* (quailbush) with RO concentrate averaging 2,742 mg/L TDS. This low-technology process may provide feed for livestock and a way to control damage to the area when a desalination plant is no longer needed. The effect of the RO-derived salts on the soil were evaluated to determine possible constraints to a larger scale project. We demonstrate that this approach would be sustainable and environmentally friendly.

12. Evaluating Treatment Alternatives for the Yuma Desalting Plant

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Under a joint agreement between the Bureau of Reclamation and three western water agencies (Metropolitan Water District of Southern California, Central Arizona Water Conservation District and Southern Nevada Water Authority), the Yuma Desalting Plant (YDP) was operated for at one-third capacity (~25 million gallons per day) and produced ~30,000 acre feet of 'additional' Colorado River water (CRW). The plant was operated to develop cost, performance and other information necessary to consider potential long term sustained operation of the YDP as a means to augment CRW supply. Concurrent with plant operation, Reclamation and the agencies are conducting a comprehensive research project at Reclamation's Water Quality Improvement Center to evaluate alternative pretreatment technologies and reverse osmosis membranes for potential plant upgrade on both the plant's existing water supply (MODE - Main Outlet Drain Extension) and the Yuma Mesa Conduit, which collects groundwater-derived agricultural drainage water.

13. The Plumbing of the Colorado River Delta in Mexico

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The 1944 International Treaty between the United States and Mexico on the "Utilization of waters of the Colorado and Tijuana Rivers and of the Rio Grande" allocates 1.5 million acre-feet of water per year from the Colorado River to Mexico. In addition, groundwater sources in Mexico, in the Mexicali and San Luis Rio Colorado valleys, supply an additional 730,000 acre-feet per year for uses in Mexico. Where does this water go and what is the water used for? Our poster describes and shows how this water is distributed in Mexico. We use 2001-2008 data on water supply and use, and graphically illustrate the amounts and pathways of water used for agriculture, cities within and outside the Delta region and designated and incidental environmental flows.

14. The Forgotten Sector: Defining and Securing Water for the Environment

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Like other Western states, Arizona water law only protects the municipal, industrial and agricultural water using sectors of the state. To bring the environment to the table and give it a proper place as a water using sector, the University of Arizona Water Resources Research Center (WRRC) has developed two research programs with support from the U.S. Bureau of Reclamation and other contributors. The Conserve to Enhance mechanism (Schwarz and Megdal, 2008), being piloted in Tucson, Arizona, involves converting voluntary water conservation efforts into water for environmental purposes. A recently completed, complementary endeavor, the Arizona Environmental Water Needs Assessment, addresses the need for quantification of the environment's water needs.

15. Water Education for 21st Century Learning: Arizona Project WET

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From the tried and true Arizona Water Festival Program to the new School Water Audit Program (SWAP) and Water Investigations Program (WIP), Arizona Project WET (APW) engages students in relevant learning about a subject that is arguably the issue of this century: Water. These direct student outreach programs use the inquiry process to teach locally and regionally relevant content. The SWAP and WIP programs infuse the 21st century skills of communication, critical thinking and collaborative learning in to instruction and enable students to draw conclusions and make recommendations on their own data. Both of these programs also offer tangible ***S***cience ***T***echnology, ***E***ngineering and **M**ath (STEM) subject integration through relevant project-based learning and action education. Teacher professional development goes hand in hand with APW direct student outreach programs. Workshops infuse teaching technology into instruction and model effective multi-modal instructional practice utilizing APW's nationally acclaimed curriculum guides. These curriculum guides, all correlated to the Arizona Academic Standards include: *Project WET Curriculum & Activity Guide***,** *Healthy Water Healthy People Educators Guide*, *Discover a Watershed: The Colorado Educators Guide and Arizona Conserve Water Educators' Guide.*