Zuckerberg Institute for Water Research

WATER

IMAGINE. INVENT. INSPIRE.

Produced by American Associates, Ben-Gurion University of the Negev

Mission

Water is vital to life. With it, we thrive; without it, we cannot prosper. Lack of water hinders human potential and expands desert conditions. Even abundant water is sometimes impure and dangerous. Dwindling water supplies and deteriorating water quality impede the sustainable development of drylands and the well-being of their growing populations. Yet scarce water can be sustainably harnessed and impure water improved.

The Zuckerberg Institute for Water Research carries out cutting-edge interdisciplinary research in hydrology and water engineering, and is a leader in graduate education in water sciences. Its guiding mission is the improvement of human well-being, based on advanced scientific technologies, innovation and the sound and sustainable management of water resources in drylands.

Message from the Institute Director

The Zuckerberg Institute for Water Research is a vibrant young research institute with a true mission. Driven by a sense of urgency, our faculty members, technical staff and graduate students are engaged in fascinating and crucial avenues of research that will have implications for all humanity. We are striving to further understand fundamental water-related issues, meeting head-on the challenges of improving and better managing our deteriorating water resources, and solving practical problems through collaboration between science and industry.

Our faculty members are involved in projects around the globe, conducting cutting-edge multidisciplinary science and providing practical solutions for rural communities in Africa, farmers in California and global transnational industrial companies. Just as fundamental to our ethos and mission is the education of the next generation of water scientists and engineers through our unique graduate program in hydrology and water quality.

Noam Weisbrod

Prof. Noam Weisbrod, Director

About the Zuckerberg Institute for Water Research

The Zuckerberg Institute for Water Research was founded in January 2002 within the Jacob Blaustein Institutes for Desert Research at the Sede Boqer Campus of Ben-Gurion University of the Negev.

Zuckerberg Institute scientists use experimental and theoretical approaches to conduct fundamental research related to water. This research encompasses nanoscience and pore-scale phenomena, and extends to pilot projects and field studies. The Zuckerberg places particular emphasis on the research and development of water resources in drylands, in the interest of both the present and the future of the entire region. Its interdisciplinary team includes hydrologists, soil scientists, geologists, chemists, microbiologists, and engineers. The result is a unique scientific environment that facilitates the investigation of environmental challenges and the development of solutions for water-related problems.

As a young and dynamic institute, research topics constantly evolve as the state of the field and the population's needs change. At present, research areas include groundwater contamination, water engineering, environmental hydrology, hydrogeology, hydrobiology, hydrochemistry, vadose zone processes, wastewater treatment, desalination, the link between water and energy, and water resource economics and management, aimed at solving water-related problems at various scales and engineering water-related technologies.

Members of the Zuckerberg Institute are involved in basic and applied scientific theories and practices that are explored and implemented in Israel and internationally.

The Zuckerberg has many pilot- and field-scale facilities, including a membrane-based pilot plant for desalination and water treatment, which has been used to develop processes that are currently implemented in industrial settings around the world. These same facilities are used to train students in the operation of advanced desalination technologies.

Unique to the Zuckerberg Institute is a scientific advisory board (SAB) that is comprised of water experts from some of the world's most reputable institutions.

Two departments operate within the Zuckerberg:

- The Department of Environmental Hydrology and Microbiology
- The Department of Desalination and Water Treatment

The Zuckerberg Institute's one-of-a-kind international graduate program in hydrology and water quality helps meet the pressing need for hydrologists, water engineers and water planners in Israel, the Middle East and around the globe. Graduates go on to hold key positions in their countries' policy-making bodies and in the water desalination and treatment industry.

Department of Environmental Hydrology and Microbiology

The multidisciplinary faculty members of the Department of Environmental Hydrology and Microbiology include hydrologists, hydrogeologists, hydrobiologists, hydrochemists, and microbiologists, all working to develop a better understanding of hydrological systems in general, and in arid environments in particular.

Researchers investigate water resources in the field and in the laboratory, as well as create theoretical models. They focus on water resources in desert basins with scarce hydrogeological information, with an emphasis on the development of methods for water treatment, reclamation and remediation.

CURRENT RESEARCH INTERESTS IN THE DEPARTMENT INCLUDE:

- Identification and quantification of the sources of surface water-entering aquifers (groundwater recharge)
- Calculation and quantification of subsurface flow and transport mechanisms
- Remediation of water and soils using biotechnology
- Transport of contaminants to and within groundwater reservoirs
- Understanding of the ecology of flow systems in aquifers and underground water reservoirs
- Enhancement of groundwater collection (managed aquifer recharge and soil aquifer treatment)
- Management of regional and international transboundary groundwater reservoirs
- Development of biological treatments for industrial and domestic effluents
- Optimization of water production and transfer systems
- Upscaling of laboratory-scale treatment processes
- Exploration of the role of climate change in the hydrological cycle
- Exploration of the area interface between land and a river or stream (riparian zone) and its biogeochemical processes
- Development of decentralized solutions for water and wastewater problems in remote communities

FUTURE DIRECTIONS IN RESEARCH

Studies in which hydrologists, microbiologists and engineers work together to solve complex problems are an important emerging avenue of research.

Future topics of research include:

- Development of new solutions for remediating soils and groundwater, especially in saline and arid environments
- Enhancement of the understanding of the impact of climate change on evaporation and gas emission processes
- Development of decentralized systems for water treatment combined with energy production
- Development of new tools for monitoring the area of land between the surface and the saturated area of groundwater (vadose zone)
- Continuation of work to improve water quality and address water scarcity in rural areas in developing countries
- Increasing the understanding of biogeochemical processes in surface and subsurface water

Research in the Department of Environmental Hydrology and Microbiology

Situated in the heart of the Negev Desert, the Zuckerberg Institute's backyard is a living laboratory. A great deal of research is carried out in the field. Technical staff and students develop and manufacture their own tailor-made equipment required for this fieldwork.

The Marcus Artificial Aquifer Laboratory is an integral part of the Department of Environmental Hydrology and Microbiology. The lab replicates natural conditions in a controlled environment, and allows for the running of large-scale column experiments (over 16 feet long). Two flumes simulate river flow, enabling the exploration of biogeochemical processes that occur at the interface between flowing rivers and the sediments below.

Additionally, the department has state-of-the-art water and soil chemistry analytical laboratories. Cutting-edge microbial and isotope labs analyze water and contaminants.

Finally, a first-generation climate-controlled laboratory is being established, enabling studies of the links between climatic conditions, temperature variation, wind speed, and other variables on the hydrological cycle.

Department of Desalination and Water Treatment

The growing population of drylands makes it essential to expand community water supplies. Scientists, technicians and students in the Department of Desalination and Water Treatment explore high-tech desalination technologies for providing drinking water, as well as water for agricultural and industrial use.

Desalinating seawater has been made possible due to a process of reverse osmosis, which allows the salt to be extracted by being forcibly pushed through a porous membrane. Improving efficiency and minimizing costs of desalination is centered around improving the membranes.

CURRENT RESEARCH TOPICS INCLUDE:

- Improvement and development of new membranes for reverse osmosis and nanofiltration in seawater desalination
- Improvement of membranes for various types of wastewater and urban effluents after tertiary treatment
- Development of novel ion-conducting membranes
- Pre-treatment of water for reverse osmosis
- Development of methods to eliminate organic substances from industrial effluents and polluted groundwater
- Study of mechanisms in low/high-pressure desalination systems associated with reverse osmosis and nanofiltration
- Development of management practices and methods to reduce concentrate volume (water that cannot be used and requires costly disposal)
- Development of new techniques for the reuse of urban effluents
- Improvement of electrodialysis processes for desalination of brackish water and for use in industry

FUTURE DIRECTIONS IN RESEARCH

The Department of Desalination and Water Treatment is expanding its studies to examine new processes for water treatment and the remediation of groundwater and industrial streams. Scientists will explore forward osmosis technologies; the development of membranes from new materials; the use of anaerobic bacteria to organically clean waste; methodologies to reduce biological contamination called biofouling; and the manipulation of water chemistry and ion exchange processes to promote the removal of pathogens, chemicals and elements caused by detergents.

Since a significant portion of water use is for agriculture, the department is also working on methods to upgrade groundwater and wastewater treatment for this purpose. A greater effort to do bottom-up design of membrane surfaces, including patterned surfaces, biomimetic membranes and surface topologies, will lead to unique membrane properties and new water treatment surfaces that will generate innovative processes for water desalination and water treatment.

An understanding of biofouling, colloidal fouling and organic fouling mechanisms will inform the development of both new processes and membrane materials. In addition, new in situ methods are being developed to monitor fouling that could allow earlier, less severe, yet more effective, interventions to keep the membrane systems operating smoothly.

The Pilot Plant for Desalination and Water Treatment

The Pilot Plant for Desalination and Water Treatment tests, simulates and demonstrates – on a semi-industrial scale – various aspects of the processes used in water and wastewater treatment. These include:

- Desalination (seawater, brackish water, wastewater)
- Upgrading of industrial and municipal wastewater for reuse and recycling
- Minimization of effluents
- Pre-treatment and preparation of difficult-to-treat effluents for downstream treatment processes
- Separation and recovery of valuable components from waste and process streams

The pilot plant is instrumental in investigating and demonstrating solutions and improvements to existing industrial plants, and in assisting in the development of new methods of water treatment.

It is also used as a teaching and training facility for graduate students, as well as for personnel from companies and other institutes involved in water treatment, desalination and effluent treatment.

The plant is equipped with test units for carrying out the following operations:

- Reverse osmosis/nanofiltration at high pressure or low pressure
- Microfiltration
- Ozonation
- Electrodialysis
- Adsorption and ion exchange
- Wind-assisted intensified evaporation
- Sand filtration

The plant is also home to a hollow fiber water purification system (ZENON ultrafiltration) for simulating membrane biological reactor processes. It requires no chemicals and leaves the water's natural minerals, such as calcium and magnesium, intact.

Graduate Studies at the Zuckerberg Institute

All faculty at the Zuckerberg Institute for Water Research teach and supervise graduate students in the Albert Katz International School for Desert Studies, the teaching arm of the Jacob Blaustein Institutes for Desert Research.

The Albert Katz International School offers two graduate study programs, awarding both M.Sc. and Ph.D. degrees: Desert Studies, and Hydrology and Water Quality.

The hydrology and water quality program was developed at the Zuckerberg Institute to meet the increasing global need for hydrologists, water engineers and water planners. The program emphasizes the integration of science with engineering. It offers three specializations: water resources, desalination and water treatment, and microbiology and water quality.

Course subjects include hydrology, hydrogeology, hydrochemistry, flow dynamics and mechanics, transport of fluids, dissolved minerals and pollutants, environmental microbiology, treatment and recovery of sewage, water resources management, desalination of seawater and brackish water by reverse osmosis and electrodialysis, nanofiltration techniques, treatment of wastewater and effluents, and membrane technology and maintenance. Courses offer theoretical, technical and practical training. For example, a course addressing rural water development problems includes hands-on work in rural villages in Africa.

The Albert Katz International School for Desert Studies draws students from Israel, North and South America, Asia, Europe, and Africa. Many graduates have gone on to attain key positions in academia, research institutes, the water treatment and desalination commercial sector, consulting firms, and in policy-making and governmental bodies.

Ben-Gurion University of the Negev, founded in 1969, aspires to fulfill the vision of Israel's first prime minister, David Ben-Gurion, who believed that Israel's bright scientific future lay in the development of the Negev, Israel's vast southern desert.

Today, as it approaches its 50th anniversary, BGU is teaching 20,000 students, conducting research and driving development in the Negev. Students are enrolled in six faculties at its campuses in Beer-Sheva, Sede Boqer and Eilat. BGU engages in world-class research in biotechnology, cyber security, alternative energy, Hebrew literature, Jewish thought, nanotechnology, water and desert studies, robotics, neuroscience, and much more. BGU's special commitment to the community means that thousands of students take part in community-oriented activities and special mentoring projects while pursuing academic excellence.

The Jacob Blaustein Institutes for Desert Research is comprised of three research institutes, including the Zuckerberg Institute for Water Research. The Blaustein Institutes is an acknowledged leader in desert studies. Its multidisciplinary approach emerged in response to the lack of science-based solutions to the world's growing drylands and their increasing populations. Desert studies, as a discipline, is likely to grow into a distinct scientific field in its own right.

The French Associates Institute for Agriculture and Biotechnology of Drylands and the Swiss Institute for Dryland Environmental Research complete the Blaustein Institutes. Together, they are working to increase the value of drylands to humanity and reduce the damage to the global environment caused by desertification and over-development. Research and academic studies include desert agriculture and aquaculture, desert ecology, solar energy, and the study of how people live in drylands.

www.aabgu.org/water

אוניברסיטת בן-גוריון בנגב
Ben-Gurion University of the Negev

Jacob Blaustein Institutes
for Desert Research
המכונים לחקר המדבר ע"ש יעקב בלאושטיין