The Zuckerberg Institute for Water Research

MAKING IT WETTER
MAKING IT BETTER

"And the parched ground shall become a pool, and the thirsty land springs of water"
(Isaiah 35:7)

Ben-Gurion University of the Negev
The Jacob Blaustein Institutes for Desert Research
Mission

Drylands occupy more than one third of the land surface of the Earth, including most of the Middle East and Israel. Dwindling water supplies and deteriorating water quality impede the sustainable development of drylands and the well-being of their growing populations.

The Institute will carry out interdisciplinary, cutting edge research and graduate education in water sciences, aimed at improving human well-being in drylands through technologies and policies for sustainable use of water resources.
"I will open rivers in high places and fountains in the midst of the valleys: I will make the wilderness a pool of water and the dry land springs of water"

(Isaiah 41:18)

“...and broughtest forth water for them out of the rock for their thirst”

(Nehemia 9:15)
Water scarcity causes one-third of the Earth's land surface— including most of the Middle East and Israel—to be dry lands. It is in the drylands, where nearly a third of humanity lives, that dwindling water supplies and deteriorating water quality most dramatically impede sustainable development and impair the well-being of their growing populations. Yet, through hard work, good science and the drive to improve conditions, scarce water can be sustainably managed and its quality improved.

The mission of the Zuckerberg Institute for Water Research, founded in 2002, is to respond to these challenges. One of the Jacob Blaustein Institutes for Desert Research at the Sede Boqer Campus of Ben-Gurion University of the Negev, the Zuckerberg Institute for Water Research conducts advanced, interdisciplinary research and graduate studies in water sciences to improve human life in dryland regions. It also seeks to develop technologies and policies for sustainable use of water resources in drylands and elsewhere.

Out of Israel’s Negev Desert, the Zuckerberg Institute for Water Research extends a hand to the world.

Unlike many water-rich countries that use mostly surface runoff, drylands rely on groundwater, water that lies beneath the surface. The Zuckerberg Institute for Water Research works on two broad fronts: the sustainable use of potable groundwater and the revitalization of impure water.

The Zuckerberg Institute for Water Research unites under one roof all aspects of water resources research, ranging from groundwater production and desalination technologies to treatments for marginal water sources. Particular emphasis is placed on the research and development of water resources in drylands.

To meet an increasing need for hydrologists, water engineers and water planners in Israel and the Middle East, the Institute is developing a unique graduate studies curriculum in hydrology, water engineering and water resources management. Reflecting the Institute’s mandate to combine research with practical solutions, the program integrates science with engineering.

Two pilot plants operate within the Institute. The Pilot Plant for Desalination and Water Treatment enables upscaling and development of advanced desalination technologies and other water treatments. The Artificial Aquifer Laboratory is a physical model simulating water dynamics in real aquifers and facilitating the upscaling of flow, transport and biochemical evolution studies in groundwater reservoirs.

The work of the Institute is performed by two academic departments, a Department of Environmental Hydrology & Microbiology and a Department of Desalination & Water Treatment.
Water is obtained from one of three sources: rainfall, lakes and rivers, or water that lies beneath the surface. This last source, drawn from wells or springs – and ultimately replenished by rainfall, distant or near – is the only water typically available in dryland regions, where a combination of low rainfall and high evaporation driven by intense temperatures causes water scarcity.

Scientists call it groundwater, and it flows in aquifers – natural underground reservoirs – within subterranean beds or layers of earth, gravel or porous rock formations.

In Israel and the Middle East, where millions of people vie for a share of ever-diminishing supplies, groundwater is a critical resource. Annual renewable water resources are less than 20 percent of the global average, making Israel’s water know-how an essential element in husbanding a resource that disregards national borders. In fact, the successful development of the Middle East, and its political stability, rest in great part on the sustained supply of usable water to all countries of the region.

Total per capita water consumption in Israel is about half of that defined by the United Nations as the shortage red line (about 500 cubic meters of potable water per person per year). Yet consumption is still far beyond the annual rate of replenishment, and exceeds the safe yield of regional resources by causing depletion of groundwater storage reservoirs. All groundwater in Israel is shared with other countries: Israel and Jordan (Arava aquifers); Israel, Syria and Lebanon (Jordan River resources); Egypt and Israel (Nubian Sandstone aquifer); and Israel and the Palestinian authority (the Judean and Coastal aquifers). Such is the significance of groundwater in the Middle-East, that its allocation is prominent in Israel’s existing peace treaties with its neighbors and will play a major role in all future negotiations. Other regional aquifers are shared by Jordan and Saudi Arabia; Syria and Jordan; Egypt, Libya, Sudan and Chad; Oman and Yemen; and most of the Gulf states.

Scarce transboundary water resources in drylands can be a trigger for conflict. Yet they might also serve as a catalyst for cooperative development projects.

An imminent deficit of two billion cubic meters of freshwater west of the Jordan River must be met within the next 15 years. To assure the sustainable development of the region, new water sources of adequate quality must be introduced, namely desalinated seawater and/or salty (brackish) groundwater and treated effluents.
The Institute’s Department of Environmental Hydrology & Microbiology advances research into the identification, quantification and improvement of water quality in drylands. Its activities include studying and developing water resources in desert basins with scarce hydro-geological information, with particular emphasis on developing methods for the treatment, reclamation and remediation of water in drylands. Its academic staff includes hydrologists, hydro-geologists, hydro-biologists and hydro-chemists who pursue research into water resources at the laboratory and field levels, as well as practicing modeling approaches for elucidation of current dynamics and predicting future trends.

The Department’s ultimate goal is to propose and evaluate methods for the development and optimal utilization of limited water resources.

**Research topics include:**
- Calculation and quantification of sources of groundwater recharge
- Biotechnological remediation of water and soils
- Contaminant transport to and within groundwater reservoirs
- Biological treatment of domestic and industrial wastewater
- Optimization of water production, treatment and transfer systems

**Looking Ahead**

The Department will examine how to increase available groundwater resources and improve water quality. As well, new disciplines will be developed, including environmental isotope hydro-biology, and water policy, economics and management. This work will include:

- Evolution in water quality along flow systems in aquifers
- Groundwater collection and enhancement
- Biological treatment of industrial and domestic effluents, and up-scaling of laboratory treatment processes
- Management of regional and international transboundary groundwater aquifers
The Department of Environmental Hydrology & Microbiology operates a multi-disciplinary laboratory for investigating groundwater flow and transport. This initiative responds to growing water-related problems in Israel and the Middle East. It also echoes recent peace talks addressing regional water issues and the development of existing and new water resources.

Groundwater reservoirs are the most appropriate and efficient storage facilities for natural and artificial recharge in arid environments. However, as desert aquifers are sensitive to any interference, such as water withdrawal and artificial recharge, intensive laboratory and field tests and physical modeling are required before embarking on large scale endeavors. These necessary steps will lead to sustainable groundwater exploitation policies and safe economic management schemes.

Objectives of the laboratory:

- To study advanced physical, hydro-chemical and biological processes in aquifers, and to demonstrate methods and technologies for improving and maintaining groundwater quality
- To develop the most efficient groundwater exploitation technology
- To establish research, training and demonstration facilities for groundwater treatment
- To test hydrological schemes for management (production policy, recharge and quality control) of water resources in arid and semi-arid basins

The laboratory generates this knowledge and its supporting techniques and technologies, and disseminates them among young scientists, engineers and technicians in the Middle East. It promotes theoretical and applied research through an education program for water scientists, water engineers and water technicians. It will also attract researchers from the social, technological, environmental and natural sciences, including hydrology, hydro-chemistry, biology, water engineering, water management and water economics. Through a graduate training program, it will help develop the cadre of experts who are key to the provision of water in quantities and qualities that go towards satisfying the needs and aspirations of the region’s people.
The necessary additional water supply to the region will come from desalination of seawater and/or salty (brackish) groundwater, and from reclaimed treated effluents. Making bad water into good requires the treatment or removal of impurities, some of them induced by human activity, and others occurring naturally. Deterioration of water quality and salinization, often considered natural phenomena, can also result from anthropogenic activities such as seawater intrusion due to overpumping of aquifers that are near the sea.

The Institute’s Department of Desalination & Water Treatment is charged with investigating the desalination and treatment of different kinds of marginal and low-quality water. Its team of scientists and engineers specializes in the development of liquid phase separation of pollutants and desalination techniques. These include:

- Improvement and development of new membranes for reverse osmosis and nanofiltration for seawater desalination as well as for treatment of wastewaters and urban effluents after tertiary treatment
- Development of novel ion-conducting membranes
- Pre-treatment phases of water for reverse osmosis desalination
- Development of methods to eliminate organic substances from industrial effluents and polluted groundwater
- Understanding the mechanisms of low-pressure desalination systems associated with reverse osmosis and nanofiltration
- Development of management practice and methods to reduce concentrate volume
- Efficient techniques for reuse of urban effluents
- Improvement of electro-dialysis processes for desalination of brackish water and for use in industry
The Department of Desalination & Water Treatment operates an integral experimental facility for investigating desalination and water treatment issues. This pilot plant provides the means for characterizing, evaluating and demonstrating technologies and processes of desalination and wastewater treatment.

It is used to investigate and demonstrate solutions and improvements to existing industrial plants, and to assist in the development and commercialization of new methods in several areas of water treatment.

These include:
- Desalination of water and effluents
- Recycling processes for water and effluents
- Treatment of municipal and industrial effluents and their preparation for recycling or appropriate disposal
- Treatment of industrial effluents and by-products aimed at separating and recovering valuable materials
- Technologies to reduce liquid effluents from factories

The pilot plant serves as a teaching and training aid for Institute students and for personnel from any industry related to water treatment, desalination or effluent treatment. It can perform several operations, including reverse osmosis (high and low pressure); microfiltration and nanofiltration; ultrafiltration (including the ability to operate as a biological membrane reactor); ozonization; electro-dialysis; sorption and ion exchange; wind-aided intensive evaporation of solutions (a novel technology for reducing a liquid concentrate); and sand filtration. Most of the plant’s equipment is portable, which permits field experiments under real conditions. Additional facilities are planned following new developments in water treatment technologies.
Teaching at Ben-Gurion University of the Negev

Researchers at the Zuckerberg Institute for Water Research, all members of BGU’s academic staff, teach several related subjects in various university departments. These include hydrology, hydro-geology, hydro-chemistry, 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, membrane technology and maintenance.

All faculty members teach and supervise graduate students at the Albert Katz International School for Desert Studies, the teaching arm of the Jacob Blaustein Institutes for Desert Research. A graduate teaching program in hydrology, water engineering and water resources management has been developed at the Zuckerberg Institute for Water Research.
Institute Governance

Recommendations regarding the academic development of the Zuckerberg Institute for Water Research are made by a Scientific Advisory Board, which meets twice yearly to review the Institute’s activities and to ratify future academic development and plans for expansion. Its members are:

- **Prof. Avishay Braverman** (President, Ben-Gurion University of the Negev) – Chairman of the Board
- **Mr. Roy Zuckerberg** (USA) – Honorary Chairman of the Board
- **Prof. Eilon Adar** (Director, Zuckerberg Institute for Water Research)
- **Dr. Shawki Barghouti** (Retired Adviser, Agricultural Research and Portfolio Management, the World Bank, USA)
- **Prof. Menachem Elimelech** (Roberto C. Goizueta Professor and Director, Environmental Engineering Program, Yale University)
- **Prof. Peter Fritz** (Former Director of the UFZ Center for Environmental Research, Leipzig, Germany)
- **Prof. Shlomo Neuman** (Regents’ Professor, Department of Hydrology and Water Resources, University of Arizona, Tucson, USA)
- **Prof. Uriel Safriel** (Professor of Ecology, Hebrew University of Jerusalem, Israel)
- **Mr. Shimon Tal** (Israeli Water Commissioner)
- **Prof. Avigad Vonshak** (Director, Jacob Blaustein Institutes for Desert Research)

* Three members of the Board comprise an Executive Committee that meets more often to discuss more immediate issues and carry out actions agreed by the Board.

Water is Life

Water is vital to life. With it, we grow food, we drink and bathe, and use it in thousands of ways, from putting out fires to making paper to keeping our gardens green.

But water is not everywhere, and without it we wither. Its dearth hinders human potential and its want brings the desert near. At times, though abundant, it’s impure.

Yet scarce water can be sustainably harnessed and impure water improved. It takes hard work, good science and the drive to make things better.

“So they went up, and searched the land from the wilderness of Zin unto Rehob”

(Numbers 13:21)
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