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# Water & the Environment: Current Challenges and Solutions

## Course Syllabus

3 credits

**Course number** 001.2.5069

### Course Description

Water-related challenges are raising major concerns worldwide. These challenges are found at both ends of the pipe: the need to supply usable water of adequate quality for a rapidly growing human population, and the need to prevent pollution and diseases from wastewater discharge. In this comprehensive interdisciplinary course, top researchers from Israel's Ben-Gurion University of the Negev partner with experts from Yale University and Northwestern University (USA) to discuss pressing water issues and present innovative solutions and technologies for treating wastewater and ensuring safe reuse, mitigating water shortage globally, and reversing pollution of surface and subsurface water. The course features Israel, a global leader in water management and technology. Discover the newest technologies being developed at the forefront of research: Recovering nutrients from wastewater for use as fertilizers in agriculture, desalination of brackish groundwater, soil aquifer treatment (SAT), recirculated vertical flow constructed wetland (RVFCW), and more. We will learn about these technologies from an engineering perspective as well as the physical, chemical and biological processes involved. We will also see these technologies in use in several systems in Israel.

### Learning Outcomes

- Gain advanced knowledge and insights from foremost world water-research leaders.
- Develop a deep understanding of global water challenges facing human society.
- Become familiar with local water issues around the world: peer-to-peer learning.
- Explore technological solutions for ensuring water and sanitation for all.
- Design a wastewater treatment system: membrane permeability & performance analysis.
- Develop a multidisciplinary approach: physics, chemistry, biology, engineering, management & policy.

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## Estimated Effort

4-5 hours per week

## Prerequisites

Second/third year undergraduate students or graduate students in relevant fields:  
Environmental studies, natural sciences, geography, engineering, mathematics, etc.

## Course Schedule

**Start Date:** March 21, 2022

**End Date:** June 6, 2022

The course consists of 10 modules. The first module will open on March 21, 2022. The last module will open on May 30, 2022. Over 10 weeks, a new module will open every week.

**Each weekly module will open on Monday, 11:00, Israel time (09:00 UTC).**

The units can be watched and studied after they open, with no time limit, but the knowledge checks and quizzes must be completed before the course end date.

## Grading Policy

The final grade in the course is composed from:

<b>Online learning grade</b>	Knowledge checks, quizzes, online final exam	50%
<b>In-class final exam</b>	Exam which consists of 20 questions at the end of the course	50%

Passing grade for the course is **65%** in each component.

## Course Program

Week	Module	Date	Instructor
1	<p><b>Module 1: Global Water Related Issues and Solutions</b></p> <p>An introduction to the numbers behind the global water crisis and an overview of the most urgent water-related challenges and solutions.</p>	March 21, 2022	Prof. Edo Bar Zeev <i>BGU ZIWR</i>
2	<p><b>Module 2: Microbial Health Risks in Drinking Water</b></p> <p>Promoting safe and affordable drinking water requires knowledge about water-borne pathogens, their detection and their eradication methods, as well as the pros and cons of using microbial indicators.</p>	March 28, 2022	Prof. Osnat Gilor <i>BGU ZIWR</i>
3	<p><b>Module 3: Nutrients in Wastewater</b></p> <p>This module will show how nutrients in wastewater have the potential to act as major water pollutants, but, with the right technology, can serve as a vital resource.</p>	April 4, 2022	Dr. Oded Nir <i>BGU ZIWR</i>
4	<p><b>Module 4: Membrane-Based Water Treatment Technologies</b></p> <p>This module is all about membranes - one of the most significant technologies for advanced water treatment and desalination. These two applications increase water supply and help protect and restore water-related ecosystems.</p>	April 11, 2022	Prof. Menachem Elimelech <i>Yale University</i>
5	<p><b>Module 5: Seawater and Brackish Water Desalination</b></p> <p>Some of the knowledge gained in Israel, which is a world leader in the assimilation of desalination technology into the national water management system.</p>	April 25, 2022	Prof. Roni Kasher <i>BGU ZIWR</i>
6	<p><b>Module 6: Fouling in Water Treatments Technologies</b></p> <p>One major challenge in membrane technologies is fouling. Membrane fouling is a term for reduced performance of the membrane due to its clogging by accumulated material, such as bacteria or chemical residue. This module discusses the nature of membrane fouling and mitigation techniques.</p>	May 2, 2022	Prof. Moshe Herzberg <i>BGU ZIWR</i>
7	<p><b>Module 7: Onsite Water Treatment</b></p> <p>In this module you will learn how, in some cases, using on-site low-tech treatment solutions might give the best sustainable answer to water reuse and wastewater pollution.</p>	May 9, 2022	Prof. Amit Gross <i>BGU ZIWR</i>

8	<p><b>Module 8: The Vadose Zone</b> We discuss the forces governing the movement of water in the vadose zone and the processes that occur there. This understanding will help us recognize how we can effectively prevent or treat water pollution.</p>	May 16, 2022	Prof. Noam Weisbrod <i>BGU ZIWR</i>
9	<p><b>Module 9: Surface-Groundwater Interactions</b> Another zone that is extremely important to bio-geochemical processes is the hyporheic zone, which connects surface water and groundwater. Understanding the essential role of this zone for water quality and the health of aquatic ecosystems is highly important to managing freshwater systems.</p>	May 23, 2022	Prof. Aaron Packman <i>Northwestern University</i>
10	<p><b>Module 10: Transboundary Water Management</b> This module will raise some of the “politics” and debates involved with transboundary water management in water-scarce regions around the world.</p>	May 30, 2022	Prof. Eilon Adar/ <i>BGU ZIWR</i>

## Instructor bios

### Prof. Amit Gross

Director of the Zuckerberg Institute for Water Research (ZIWR), The Jacob Blaustein Institutes for Desert Research (BIDR), Ben-Gurion University of the Negev, Israel, (BGU)

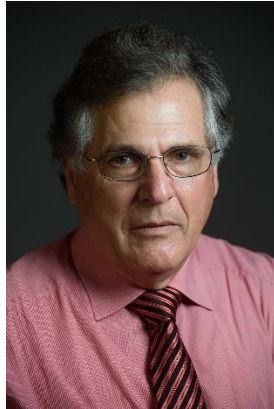


Prof. Gross completed his undergraduate studies in the Faculty of Agriculture of the Hebrew University of Jerusalem, Israel, in 1993. He earned his M.Sc. (1996) and Ph.D. (1999) from Auburn University, USA, studying nutrient cycles in earthen ponds. During his postdoctoral training in Australia and Ben-Gurion University of the Negev, Israel, he studied various environmental issues related to water treatment and reuse, and in 2003 he joined the faculty at Ben-Gurion University of the Negev, Israel.

[Prof. Gross's research](#) interests include conversion of waste to resource by treatment and efficient use of marginal water and sludge. He also studies environmental risks associated with contaminated water resources and sludge. Prof. Gross's current academic activities are focused on the reuse of greywater and wastewater for irrigation; treatment of wet organic waste for efficient reuse and minimization of environmental pollution; treatment of aquaculture effluent in recirculating aquaculture and aquaponic systems. Prof. Gross has supervised over 60 graduate students, authored/co-authored >100 peer reviewed articles and a monograph. In 2020, he received the Strage-BGU Award for Excellence in Environmental Sciences.

## Prof. (Emeritus) Eilon Adar

Department of Environmental Hydrology & Microbiology, Zuckerberg Institute for Water Research, The Jacob Blaustein Institutes for Desert Research, Ben-Gurion University of the Negev, Israel



Prof. Adar is an expert in arid zones hydrology and Middle East water issues. [Prof. Adar's research](#) activities focus on quantitative assessment of groundwater flow systems and recharge sources in complex arid basins with puzzling geology and scarce hydrological information. He developed the Mixing Cell Model approach in hydrology used in numerous basins worldwide. Prof. Adar is also dedicated to cross-border water resources in the Middle East and strengthening the R&D of water innovations within the industry. Prof. Adar completed his undergraduate studies in Geography, Geology, and Climatology at Hebrew University in Jerusalem, Israel, in 1974 and earned his M.Sc. in Physical Geography and Hydrology from the same institution in 1979. Prof. Adar earned his Ph.D. from the University of Arizona, Tucson, in the USA in 1984, with a Major in Hydrology and a Minor in Soil Water Engineering.

## Prof. Moshe Herzberg

Head of the Department of Desalination & Water Treatment, Zuckerberg Institute for Water Research (ZIWR), The Jacob Blaustein Institutes for Desert Research (BIDR), Ben-Gurion University of the Negev, Israel



Prof. Herzberg Prof. Herzberg received his B.Sc. in Chemical Engineering and Ph.D. in Agricultural Engineering from the Israel Institute of Technology (Technion) in Haifa. Prof. Herzberg joined Ben-Gurion University of the Negev, Israel, in 2007, after postdoctoral training in the University of Connecticut's Chemical Engineering Department and in Yale University's Environmental Engineering program as a BARD postdoc fellow .

[Prof. Herzberg's research](#) interests focus on microbial biofilms and include (i) conditions promoting biofilm formation on membranes in water and wastewater treatment facilities; (ii) mode of action of agents that interfere with biofilm formation; (iii) mechanisms by which biofilms affect membrane performance; (iv) conditions promoting initial bacterial attachment; and (v)

The inhibition of biofilm growth mechanisms on "anti-biofouling" modified-surface membranes . Prof. Herzberg is an author of more than 80 scientific publications and more than 100 presentations and seminars presented all over the world. He serves as a board member of the Israel Desalination Membrane Society. Prof. Herzberg is performing an enhanced synergistic collaboration with different water scientists and industries around the globe. In 2010 he received

the France-Israel Foundation award for academic excellence in water research.



## Prof. Osnat Gillor

Head of the Department of Environmental Hydrology & Microbiology, Zuckerman Institute for Water Research, The Jacob Blaustein Institutes for Desert Research, Ben-Gurion University of the Negev, Israel



Dr. Gillor Prof. Gillor completed her undergraduate and graduate (MSc) studies at the Faculty of Life Sciences at Tel Aviv University, Israel, 1997. She earned her Ph.D. (2002) from the Hebrew University of Jerusalem, studying cyanobacteria blooms in aquatic environments. During her postdoctoral training at Yale University and the University of Massachusetts (USA) she studied microbial ecology and evolution of antibiotics, and in 2006 she joined the faculty of Zuckerman Institute for Water Research at Ben-Gurion University of the Negev, Israel.

Prof. Gillor has a broad set of research interests that range from the role of antimicrobials in biofilm formation to the diversity of soil bacteria and their role in the ecosystem. What unites this disparate set of topics is the use of molecular and experimental methods to study the processes and patterns of microbial ecology and evolution. [Prof. Gillor's lab](#) is especially interested in understanding the role of perturbations like rain, irrigation, pollution, or mining on the soil microbial composition, structure, and function. Current work focuses on the effect of soil disturbances on trophic interactions within the microbial community as well as endophytes' role in enhancing plants' stress tolerance in desert environments.

## Prof. Noam Weisbrod

Director-Dean, The Jacob Blaustein Institutes for Desert Research, Ben-Gurion University of the Negev, Israel



Prof. Weisbrod earned his B.Sc. in Soil and Water Sciences in 1990, his M.Sc in Soil and Water Sciences in 1993, and his Ph.D. in Hydrogeology in 1999 from Hebrew University in Jerusalem, Israel.

Over the last decade, [Prof. Weisbrod's research](#) has focused on contaminant hydrology in general, and fracture flow and colloidal transport in particular. He has focused on studies related to the mechanisms controlling colloid, nanoparticles and colloid-facilitated transport in the subsurface, under a variety of environmental conditions. Another major research direction is related to the processes occurring within fractures and heterogeneous porous media in the vadose zone and their relation to evaporation, salinization and earth-atmosphere gas exchange, including the physics of GHG emission from soils. A large portion of Prof. Weisbrod's current research focuses on unsaturated-zone conditions, where processes at the air-fluid-solid interface play an important role. Some of his recent projects involve the study of contaminant transport below industrial zones, infiltration ponds and non-point sources.

## Prof. Roni Kasher

Department of Desalination & Water Treatment, Zuckerberg Institute for Water Research, The Jacob Blaustein Institutes for Desert Research, Ben-Gurion University of the Negev, Israel



Prof. Kasher is an associate professor at the Zuckerberg Institute for Water Research. Prof. Kasher obtained his Ph.D. in organic chemistry from the Hebrew University of Jerusalem, Israel, in 2000. After a postdoctoral fellowship at the Weizmann Institute of Science, Israel, Prof. Kasher joined the faculty at Ben-Gurion University of the Negev, Israel. [Prof. Kasher](#) is studying membranes for nanofiltration, reverse-osmosis and ultra-filtration processes. He develops efficient and non-fouling water treatment membranes with improved surface properties, selectivity, and solute transport. Other areas of expertise are scaling phenomena in water treatment processes, the mutual interactions between organic matter and scaling, effects of organic functional groups on fouling, and peptide synthesis and chemistry.

## Prof. Menachem Elimelech

Department of Chemical and Environmental Engineering, school of engineering and applied science, Yale University, USA



Prof. Elimelech Prof. Elimelech is the Sterling Professor of Chemical and Environmental Engineering at Yale University. He received his B.Sc. and M.Sc. degrees from the Hebrew University of Jerusalem, Israel, and his Ph.D. in Environmental Engineering from Johns Hopkins University. After serving as professor and vice chair of the Department of Civil and Environmental Engineering at UCLA, Prof. Elimelech joined Yale in 1998 and founded Yale's Environmental Engineering Program, now among the leading programs in the country.

Prof. Elimelech's research is in the general area of the water-energy nexus. Specifically, the research in his group involves membrane-based processes for energy-efficient desalination and wastewater reuse; advanced materials for next-generation water decontamination technologies; and, environmental applications of nanomaterials.

[Prof. Elimelech's research](#) has been recognized with numerous major awards, among them the Eni Award for Protection of the Environment (2015), election to the National Academy of Engineering (2006) and the Chinese Academy of Engineering (2017), and the Clarke Prize for excellence in water research (2005). He has authored more than 450 refereed journal publications, is a co-author of the book Particle Deposition and Aggregation (1995) and is a Highly Cited Researcher in Environment/Ecology and Chemistry. Many of the 80 Ph.D. and post-doctoral researchers Prof. Elimelech has advised now hold leading positions in academia and industry. His excellence and dedication in teaching and mentoring has been recognized with the W.M. Keck Foundation Engineering Teaching Excellence Award (1994), the Yale University Graduate Mentoring Award (2004), and the Yale University Postdoctoral Mentoring Prize (2012).

## Prof. Edo Bar-Zeev

Department of Environmental Hydrology & Microbiology, Zuckerberg Institute for Water Research, The Jacob Blaustein Institutes for Desert Research, Ben-Gurion University of the Negev, Israel



Prof. Bar-Zeev is an associate professor at the Zuckerberg Institute for Water Research, Ben-Gurion University, Israel. He has a Ph.D. in microbiology from Bar-Ilan University, Israel, and a Postdoc from the department of Environmental and Chemical Engineering at Yale University, USA.

[Prof. Bar-Zeev](#) is an applied and environmental microbiologist focused on a wide spectrum of water issues during an era of global climate change and severe water scarcity. Specifically, his interdisciplinary interests include: (i) Hydrogel dynamics in marine and freshwater environments, (ii) The role of planktonic aggregates in biochemical cycles, (iii) The nexus of desalination and the aquatic environment, and (iv) Biofouling, from biofilm formation on various artificial surfaces to innovative cleaning approaches.

Prof. Bar-Zeev is the Principal Investigator of the applied and environmental laboratory at the Zuckerberg Institute for Water Research, Ben-Gurion University of the Negev, Israel.

## Dr. Oded Nir

Department of Desalination & Water Treatment, Zuckerberg Institute for Water Research, The Jacob Blaustein Institutes for Desert Research, Ben-Gurion University of the Negev, Israel



Dr. Nir received his B.Sc. in Environmental Engineering from the Technion, the Israel Institute of Technology in Haifa. There he also earned his Ph.D., focusing on the behavior of acid-base species (focusing on boron) during the process of reverse osmosis. Dr. Nir conducted post-doctoral research with two world-leading membrane research groups in Europe at Leuven University, Belgium, and RWTH-Aachen University, Germany.

Since joining the Department of Desalination & Water Treatment at the Zuckerberg Institute for Water Research at the Jacob Blaustein Institutes for Desert Research at Ben-Gurion University in the Negev, Israel. Dr. Nir heads the [NirWaterLab](#) that focuses on sustainable processes for water treatment and resource recovery. The three main research themes at his lab are developing new sustainable processes for water treatment coupled with metals/nutrients recovery based on various physico-chemical separation technologies, with special focus on membrane technology; studying the mass-transfer and geochemical phenomena underlying these processes; and, developing new and improved process simulation tools, valid for large-scale, high recovery systems.



## Prof. Aaron Packman

Professor of Civil and Environmental Engineering and the Director of the Center for Water Research at Northwestern University, USA



Prof. Packman holds a joint appointment at Argonne National Laboratory as a Senior Fellow in the Northwestern-Argonne Institute of Science and Engineering. Dr. Packman is the U.S. Director of the U.S.-Israel Collaborative Water-Energy Research Center (CoWERC), managed by the Binational Industrial Research and Development Foundation (BIRD) and funded by the U.S. Department of Energy, Israel's Ministry of Energy, and the Israel Innovation Authority. Prof. Packman is an internationally recognized expert in water resources, surface-groundwater interactions, and biological and biogeochemical processes in aquatic systems. [Prof. Packman's research](#) team is working to solve a variety of problems, including nutrient pollution, urban flooding, ecosystem degradation & restoration, and waterborne disease transmission. He currently serves on the Leadership Team of the Smart Great Lakes Initiative, as well as its Science, Technology, and Innovation team.

Packman has received numerous awards and honors, including Fellow of the American Geophysical Union, a Fulbright Distinguished Chair in Hydrology and Hydraulic Engineering, the Huber Research Prize from the American Society of Civil Engineers, and Career Awards from the National Science Foundation and National Institutes of Health. He received a B.S. in Mechanical Engineering from Washington University in St. Louis, and an M.S. and Ph.D. in Environmental Engineering and Science from the California Institute of Technology.