International Water Summit

Lectures

Session A New perspectives in hydrology

Prof. John Selker / A critical role of transgenerational teams in advancing hydrological measurements

While thousands of new micro-sized sensors have been marketed, telemetry has become ubiquitous, and 3-D printing makes short-run production accessible to millions, we must wonder why water resources instrumentation is slow to change, to a large degree static for 20 years. We have had a culture of individuals making new sensor systems for their own work, which have not translated efficiently to the research community or industry. To break this cycle we need to create an efficient approach to design development which includes a collaborative exchange of innovations. Environmental sensing is a challenging field with respect to energy management, sensor selection and maintenance, and data collection and telemetry. At the OPEnS lab (Open-Sensing.org) for 6 years we employ 30 undergraduate engineers in teams that span ecological, electrical, mechanical and computer engineering who develop new sensor systems, and are trained in the challenges of this undertaking. With 8 student-led publications and a patent applied for, we think the OPEnS model demonstrates a way forward for your community, addressing both the short-term and long term needs for new sensor systems for water resources.

Prof. Efrat Morin / Floods in a warming climate: what are the missing puzzle pieces?

As the climate becomes warmer globally, precipitation patterns are changing and, consequently, altering flood regimes. Resolving the expected changes in flood properties requires examining projections of precipitation features most correlated with floods. While the redistribution of mean annual precipitation amounts is generally known (and described by the "dry gets drier, wet gets wetter" phenomenon), the trends in many other essential factors controlling floods are yet to be resolved. For example, flash flood magnitude is known to be very sensitive to space-time rainstorm properties such as areal coverage or storm speed. Still, knowledge of how these properties are affected by global warming is lacking. Maximal rain rates for duration relevant to the watershed's response time are also crucial parameters controlling the

flood discharge. There is some understanding of how extreme rain rates change, but the magnitude and sign depend on the duration. Thus, different watersheds may respond differently to global warming. Changes in the intra-seasonal distribution of precipitation events can also affect flood regimes through their effect on pre-storm soil moisture.

Prof. Petra Doell / Global-scale quantification of drought hazards

Droughts pose significant risks to humans and ecosystems, and their severity is expected to increase in large parts of our planet due to climate change. Global hydrological models (GHMs) compute time series of water flows and storages for all land areas of the globe, which enables the computation of drought hazard indicators for historic periods, near-real time and the future. In particular, GHMs can be used to quantify soil moisture, groundwater and streamflow drought hazards and thus support our understanding of drought risks, which are a function of hazard, exposure and vulnerability. However, there are a myriad of drought hazard indicators, and a systematic approach for guiding the selection of drought hazard indicators for characterizing specific drought risks is lacking. In this presentation, I will present a new classification for streamflow drought hazard indicators, where, for example, the assumed habituation to streamflow variability is taken into account. In addition, I will present global maps of drought hazards and risks based on different indicators.

Session B Frontiers in applied and aquatic microbiology

Prof. Joan Rose / From Polio to COVID: environmental virology at its best

Since the era of waterborne jaundice and polio, diseases spread by viruses were present prior to our understanding of these unique biological entities. Environmental virology attempts to understand the disease risk through the monitoring of viruses in wastewater, fresh and marine waters. The advent of molecular tools and high throughput sequencing technologies coupled with metagenomics has offered the opportunity to identify human viral pathogens including global spread of diseases such COVID-19. We now have the ability to monitor community health via the surveillance of our wastewater thus addressing global grand challenges including the implementation of world-wide vaccination programs.

Prof. Lisa, Alvarez Cohen / Biology of emerging contaminants, do they *really* eventually emerge?

Societal demand for new products promotes the production and release of new chemicals. Additionally, population growth and climate change have produced increased demand on water resources, resulting in greater reliance on direct and indirect water reuse. Advances in analytical chemistry enables us to detect environmental contaminants with increasing sensitivity, allowing us to discover new families of emerging contaminants that threaten our water resources. Understanding the biotransformation potential of emerging contaminants has been a challenge that' s been greatly assisted by means of molecular tools. This talk will describe lessons-learned and research aimed at discovering the biodegradation potential and pathways for a variety of important "emerging contaminants" , including MTBE, I,4-dioxane, NDMA, PBDEs and PFASs in aqueous film forming foams (AFFF).

Prof. Damia Barcelo / Macro- and micro-plastic litter and increased COVID-19 based plastic pollution in the aquatic environment and landfills: treatment, environmental risks and policy solutions

This presentation will cover in the first part different aspects of MPs and Macro-Plastic litter pollution in coastal waters , rivers ,sediments and lakes . Case studies of MP pollution in several coastal environments, sediments and catchments of China,. Saudi Arabia, India, Europe and Australia will be reported. It is well-known that microplastics affect communities, biological diversity, and ecosystem processes will be reported. In its second half I will discuss as well plastic litter and its increased use under Covid-19 outbreak. In this sense the excessive use and consumption of single-use plastics (including personal protective equipment such as masks and gloves) due to COVID-19 pandemic. This talk aims to provide an integrative and synthesized overview on the effects of COVID-19 on macroplastic pollution and its potential implications on the environment and human health in a long-term scenario; addressing the main challenges and discussing potential strategies to potentially overcome them. It emphasizes that future measures, involved in emergent health crisis or not, should reflect the balance between public health and environmental safety as they are both undoubtedly connected. Recommendations on the management side will be made like (i) law and waste management strategies, such as exploring new removal technologies and avoid landfilling if this is economically feasible (ii) education, outreach and awareness, (iii) source identification, (iv)increasing monitoring and risk assessment to better understand the threat to biodiversity by reporting additional case studies where showing the impact of MP around the globe and (v) further innovative research lines like the development of bioplastics to replace SUPs in our daily life.

Session C Desalination: old concepts, new horizons

Prof. Jack Gilron / The evolution of modern membrane desalination

An enormous world-wide scientific and engineering effort has been invested during the last 70 years into finding cost-effective solutions for generating new, affordable water sources. This is motivated by the desperate need of a world with dwindling fresh water supplies facing increasingly frequent droughts. Substantial progress has been made in developing membrane-based desalination and water treatment technologies such as Ultrafiltration (UF), Nanofiltration (NF), Reverse Osmosis (RO) and Electrodialysis (ED) to produce safe potable water. Particularly, RO seawater desalination has largely replaced older, energy-intensive, and environmentally unfriendly thermal technologies, effectively drought-proofing many countries with access to the sea.

In this talk, we highlight key achievements in this field, starting from the 1950s when new approaches were introduced in the preparation of membranes and understanding of membrane-based separations, to the present day when mega-scale membrane-based desalination plants constantly supply fresh water world-wide. A special emphasis will be given to the unique contribution of the scientific and engineering community in Israel to membrane water treatment and membrane-based desalination in particular.

Prof. Menachem Elimelech / Next-generation desalination and water purification membranes: where are we now?

Water scarcity is one of the greatest global crises of our time. Increasing water supply beyond what is available from the hydrological cycle can be achieved by seawater desalination and wastewater reuse. Highly effective, low-cost, robust membrane-based technologies for desalination and wastewater reuse are needed, with minimal impact on the environment. However, progress in current state-of-the-art water purification membranes has been limited. This presentation will critically discuss and evaluate recent research efforts in the past 15 years to (i) lower energy consumption for water desalination by improving membrane water permeability, (ii) reduce the cost of water desalination via increased water-salt selectivity, and (iii) enhance membrane ion selectivity for applications at the water-energy nexus. The presentation will focus on the

emerging area of ion selectivity where high precision ion separation is desired. We will highlight how insights from nanofluidics and ion-selective biological channels establish the basis for a new class of membranes with ion-ion selectivity. A few examples will be provided to elucidate the mechanisms of ion transport and selectivity in membranes with sub-nanometer pores. The presentation will conclude with a discussion on research directions and critical challenges for developing ion-selective membranes

Prof. Ori Lahav / Resource recovery from seawater: emphasis on selective separation of Mg(II) salts

The interest in separating valuable ions from seawater (Rb^{+}, Li^{+}, Mg^{2+}, Sr^{2+}, etc.) is on the rise. The talk will first focus on the incentive, and then on two different methods that were developed by us for selective separation of Mg(II) from seawater, where it is present at ~1400 mg/L. An example will be given for using the separated Mg(II) for promoting struvite precipitation from the anaerobic digester supernatant line in wastewater treatment plants. That said, most of the talk will address the option of using the separated magnesium for increasing its concentration in desalinated water, with as low as possible addition of unwanted seawater species. A case study will be presented, describing the results obtained from a recently erected full scale plant whose near-future aim is to add >20 mgMg/L to the water supplied to Kibbutz Maagan Michael (Israel) through its brackish water desalination plant.

Prof. Yoram Cohen / Autonomous optimal operation of distributed membrane-based water treatment and desalination systems

Water treatment and desalination via membrane-based separation processes are suitable for distributed deployment at various scales. However, operation of distributed water systems, particularly where 24/7 of operator availability is infeasible, requires system design and operational strategies that can autonomously respond (i.e., self-adaptive operation) to: (i) fluctuations in water feed quality, (ii) variability of product use patterns, (iii) real-time system performance monitoring, and (iv) regulatory requirements (setpoints) concerning product water quality and residual stream generation. Self-adaptive operation also requires: (i) mitigation of fouling and scaling,

(ii) handling of fault detection and isolation, (iii) data imputation to temporarily overcome limitations imposed by faulty sensors so as to allow for appropriate corrective actions, (iv) operation that provides for adjustable product water recovery that can be driven to minimize the volume of generated residual streams, (v) forecasting performance degradation, (vi) sensors fault detection and data imputation, and (vii) system configuration for energy optimal operation with considerations of system physical and operational constraints. In order to tackle the above needs a multi-pronged approach was undertaken that includes, but is not limited to, system design and configuration, local and supervisory control to handle and optimize operational strategies, and data-driven models of different modes of system operation capable of handling unsteady state behavior and water feed quality fluctuations. Accordingly, an integrated research effort will be described that considers the elements of autonomous operation of distributed water treatment and desalination systems. Specific examples will be provided of the development and implementation of flexible design and self-adaptive operation of integrated ultrafiltration (UF) and reverse osmosis (RO) for water desalination (seawater and brackish water) and purification, including the application of first-principle and machine-learning operational models.

Session D Water treatment and sanitation

Seth Siegel / Israel, water, and the world: how a small, dry country serves as an inspiration to nations around the globe

Israel is an unlikely role model for every country in water. It is small and, in the world' s, driest region. But whether a rich country or a poor one, a large country or a small one, a landlocked country or one with a long seacoast, every country has something to learn from the Israel experience in water. Increasingly, governments and others look to Israel for guidance and inspiration in what to do with their water resource concerns. As climate change leads to significantly altered precipitation patterns, and as the water resources needed to feed a growing global population become more pinched as more crops need irrigation, Israel' s model and technologies will continue to serve as a door-opener to Israel. This has had and will continue to have diplomatic and economic implications for Israel.

Prof. Pedro Alvarez / A renaissance for phage-based bacterial control

Bacteriophages (phages) are viruses that exclusively infect bacteria and utilize different life cycles to shape microbial communities through predation, transduction and reprogramming of bacterial metabolism. Phages are by far the most abundant, most diverse, and arguably the most underutilized biological resource in the biosphere. They offer opportunities for chemical-free bacterial control, which is attracting growing interest in environmental engineering due to concerns about the emergence of multidrug resistant bacteria and the need to mitigate toxicity from chemical disinfection byproducts. Examples of phage applications discussed in this seminar include mitigating the spread of multi-drug resistant superbugs from wastewater treatment plants, phage conjugation with superparamagnetic nanoparticles to enhance biofilm penetration and de-anchoring from its root under a weak magnetic field, and encapsulation for smart release. We will also discuss how recent advances in DNA sequencing, ecological network modeling and synthetic biology may provide novel opportunities for phages as highly precise agents to edit microbiomes and modulate critical bacterial activities important for sustainable development.

Prof. Jacob Moran-Gilad / Risk assessment and mitigation of legionellosis powered by genomics

Legionnaires' disease (LD) is a life threatening respiratory infection caused by waterborne strains of *Legionella*, particularly *L. pneumophila*. Molecular typing dramatically improved the investigation of Legionnaires' disease (LD) clusters and ability to link clinical cases with contaminated water systems. Microbial whole genome sequencing (WGS) is a promising modality for cluster investigations but analysis methods are neither standardized, nor agreed. Core Genome Multilocus Sequence Typing (cgMLST) has recently emerged as a phylogenomic typing approach that is portable, scalable and reproducible and could allow standardized and nomenclature-based typing for pathogens of public health importance. A cgMLST scheme for *Legionella* has first been proposed in 2015 (Moran-Gilad et al, Eurosurveillance). That scheme utilizes 1,521 core gene loci for typing and has successfully been implemented in several cluster investigations worldwide.

This talk will review the public health microbiology challenges associated with legionellosis and will focus on the use of methods and laboratory solutions such as WGS for epidemiological investigation and prevention.

Prof. Eberhard Morgenroth / Opportunities for greywater reuse at different scales

Water and wastewater treatment are key to protect humans in cities by providing safe water and urban hygiene and to protect the aquatic environment from pollutants. Over the past century, urban water management allowed for healthy and pleasant living conditions in ever-growing cities in many parts of the world. This presentation will discuss the potential for local reuse of treated greywater and drivers for implementation. What are the scientific and technological challenges? How can appropriate local water reuse be implemented in a way that it does not jeopardize today's achievements in urban water management and urban hygiene? Basic sciences for gravity driven membrane (GDM) filtration and technology development for reuse of hand washing water in informal settlements (http://www.autarky.ch/) or resource recovery at the building scale (http://www.eawag.ch/waterhub) will be discussed

Prof. Janet Hering / Overcoming the barriers to achieving the environmental Sustainable Development Goals (SDGs)

Together, 17 Sustainable Development Goals (SDGs) constitute an overarching and integrated concept for sustainability. Despite the many interlinkages across the SDGs, the complexity of addressing all 17 goals in concert is daunting. In addition, the apparent alignment of individual (or small sets of) SDGs with the mandates of various institutional actors (both in governments and civil society) works against an integrated perspective. I suggest that an integrated approach can be fostered through: promoting the appreciation of good ecological function as a necessary underpinning for human welfare and well-being, supporting multi-level (or polycentric) governance in which users can collaboratively develop feasible rules and organizations can work effectively at multiple levels, and fostering broad-ranging recognition of contributions made by diverse actors to mitigate competitive tendencies.