UNESCO-IWRA

ONLINE CONFERENCE

3RD IN THE IWRA ONLINE CONFERENCE SERIES

17-19 JANUARY 2023

EMERGING POLLUTANTS:

PROTECTING WATER QUALITY FOR THE HEALTH OF PEOPLE AND THE ENVIRONMENT

FINAL REPORT

International Water Resources Association
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We extend our highest appreciation to the contribution of rapporteurs, Najibullah Loodin, Dahlia Sabri, Cassiana Montagner, Mohamed Abdelkader, Tatiana Dmitrieva, Atikur Rahman, Nusrat Balouch, Achraf Tounsi and Piero Gardinali.

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FOREWORD
YUANYUAN LI, IWRA PRESIDENT

It is with great pleasure that I wish to congratulate the incredible team of people behind this, IWRA's 3rd Online Conference, "*Emerging Pollutants: Protecting Water Quality for the Health of People and the Environment*". This event would have been impossible without the generous support and sponsorship received from our friends at UNESCO-IHP. Around 1,500 people participated in the conference, attending from over 100 countries. I wish to thank IWRA's previous President, Gabriel Eckstein, and UNESCO's Sarantuyaa Zandaryaa, and all the members of the International Scientific Committee, with support from IWRA's Executive Office and Board, and from UNESCO personnel.

The world of water is awash with depressing statistics. Nearly a half of the world's wastewater is untreated, and two billion people worldwide are drinking water which has faecal contamination. Over 1 billion people are at risk in the current cholera outbreak. Water quality is one of the main challenges facing global societies in the 21st century. This is a problem which threatens not only human health, but also ecosystem functions, and food production. Water quality degradation translates directly into the availability of the world's scarce water resources, as well as into environmental, social, and economic concerns. The 2030 Agenda and Sustainable Development Goals (SDGs) bring water quality issues to the forefront of international action. Goal 6 in particular aims to respond to the pressing challenges posed by water quality issues by ensuring the "availability and sustainable management of water and sanitation for all". Other SDGs including health, ecosystem, and poverty reduction also address water quality issues, therefore demonstrating growing awareness of the urgent need to improve water quality worldwide.

It helps to focus on the challenges of one area that is now starting to capture public attention: PFAS, which are associated primarily with pesticides and pharmaceuticals, but can also be found in everything from plastic packaging to semiconductors. Research has established the link between PFAS and chronic toxicity, cancers, endocrine (hormone) disruption in humans and animals, and the development of bacterial pathogen resistance. As they are discarded in sewage and waste, they enter the water cycle. PFAS are also known as "forever chemicals". While their durability makes them incredibly useful, they are also extremely difficult to treat and remove using conventional water treatment processes. The European Commission has the estimated the total health cost to Europe alone as €52 to €84 billion annually. This was one of the motivations for a number of EU member states, led by Germany, to submit a proposal to ban PFAS this year. While a ban sounds like an easy solution, there needs to be viable alternatives to these chemicals, and the impacts of these alternatives need to be understood as well. Scientists and water resource professionals on the frontline have been grappling with this unfolding crisis, but policymakers and industry workers are also needed to develop solutions and create change.

As a result of these concerns, we chose this theme to contribute toward the goal of protecting water quality for human well-being and the integrity of ecosystems, as well as for the opportunity to integrate quality-quantity management of water resources backed by research. The research presented here and the discussions held during this 3-day event were both fascinating and timely. Issues focused on building awareness of emerging contaminants such as pharmaceuticals, microplastics, nanomaterial, Per- and Polyfluorinated Substances (PFAS) and PPCPs, and echoed a sense of urgency for policy makers, scientists, and industry workers to come together and find safer alternatives and better wastewater treatment options for these ubiquitous products.

Clearly, the implications of emerging pollutants are concerning for everyone. There are no easy answers, but there are principles that policy makers can follow; cross-sectoral collaboration is key. With this in mind, IWRA looks forward to continuing our work with UNESCO and with our other partners on this important topic.

INTRODUCTION
FROM THE CO-CHAIRS OF THE INTERNATIONAL SCIENTIFIC COMMITTEE (ISC)

Sarantuyaa Zandaryaa, Programme Specialist, Division of Water Sciences, Intergovernmental Hydrological Programme (IHP), UNESCO

Gabriel Eckstein, Professor, Texas A&M University School of Law; Immediate Past President, IWRA

Emerging pollutants are a wicked problem. We know that some of them can have harmful impacts on people and the environment. Yet, the sheer number and diversity of these contaminants, as well as the complexities of their origins, transport, toxicity, chronic effects, intermixing, cumulative effects, and elimination, make it especially challenging to formulate appropriate policies in response to them.

UNESCO defines emerging pollutants broadly as any synthetic or naturally-occurring chemical or microorganism that is not commonly monitored or regulated in the environment and which has known or suspected adverse effects on ecology or human health. The OECD extends this definition to include those contaminants that have only recently appeared in freshwater systems. These are of recent concern because they have been detected at concentrations significantly higher than expected and the risks they pose to human and environmental health are not fully understood. Examples of such pollutants include pharmaceuticals, industrial and household chemicals, personal care products, metals, surfactants, industrial additives and solvents, pesticides, manufactured nanomaterials, and also their transformation products. Many of these substances are used and released continuously into the environment, even in very low quantities, and may cause chronic toxicity, endocrine disruption in humans and aquatic wildlife, and bacterial pathogen resistance to develop.

Scientific knowledge and understanding of the potential risks to human and ecosystem health, as well as their pathways and accumulation in the environment, are still very limited. Most emerging pollutants found in the environment are not regulated through environmental, water quality, wastewater discharge, or health impact regulations. Similarly, regulations for monitoring or tracing the origin or fate of these substances is lacking.

As a result, there is an urgent need to develop better responses to the presence and impact of these emerging pollutants. In particular, we need to:

- strengthen scientific knowledge and adopt appropriate technological and policy approaches
- monitor emerging pollutants in water resources and wastewater;
- assess the potential human health and environmental risks posed by emerging pollutants;
- prevent and control the disposal of emerging pollutants into water resources and the environment; and
- develop appropriate regulations to address and mitigate, as well as prevent the introduction of such pollutants in the aquatic environment.

The UNESCO/IWRA Online Conference highlighted the ways the world can advance knowledge, research, and solutions for managing these pollutants with the goal of improving and protecting water quality in our changing world. The main objectives of the conference were to:

- Explore the impacts of emerging pollutants on water resources, considering the technical and policy solutions needed for mitigating and reducing human health and ecological risks–bearing in mind the increasing demand placed on water resources and the impacts of global climatic and demographic changes;
- Identify the appropriate water policies and technologies needed to motivate change in water management, business, and policy priorities for address emerging pollutants;

INTRODUCTION

FROM THE CO-CHAIRS OF THE INTERNATIONAL SCIENTIFIC COMMITTEE (ISC)

- Highlight the bold policy and institutional changes necessary for transforming water management and policy across other sectors, thereby ensuring better and more reliable water quality and protecting human health and ecosystems;
- Showcase successful innovative, nature-positive, and technological solutions for improved water quality and reduced water pollution;
- Examine the life cycle management of emerging pollutants to find solutions not only at end-of-pipe, but also based on a circular economy approach; and to
- Communicate the importance of collaborative action with industry, regulators, and local communities, as well as engage all relevant stakeholders (including under-represented groups).

This Report summarises the challenges and debates around these issues and highlights the conclusions reached throughout the conference, guided by presentations and open dialogues.

The UNESCO-IWRA Online Conference on "***Emerging Pollutants: Protecting Water Quality for the Health of People and the Environment***" was organised by the International Water Resources Association (IWRA) and UNESCO Intergovernmental Hydrological Programme (UNESCO-IHP) and took place from 17-19 January 2023. This event revolved around **five sub-themes or challenges** to be addressed and had the major objective of highlighting the ways the world can advance knowledge, research, and solutions for managing emerging pollutants in a changing world.

Thanks to UNESCO's support, participants from all geographic regions, including low-income countries, could register and the attend the conference free of charge.

THE ONLINE CONFERENCE IN BRIEF

2 700+
REGISTERED PARTICIPANTS

120+
COUNTRIES REPRESENTED, FROM AFRICA, ASIA, EUROPE, THE AMERICAS, AND OCEANIA

90+
SPEAKERS AND MODERATORS

14 SESSIONS HELD OVER TWO AND ONE-HALF DAYS, INCLUDING:
2 HIGH-LEVEL PANELS
5 THEMATIC SESSIONS
50+ POSTER PRESENTATIONS
70 ORAL PRESENTATIONS

THE INTERNATIONAL SCIENTIFIC COMMITTEE (ISC)

NAME	AFFILIATION	COUNTRY
Sarantuyaa Zandaryaa Co-Chair	**Programme Specialist, Division of Water Sciences, Intergovernmental Hydrological Programme (IHP), UNESCO**	**Mongolia / France**
Gabriel Eckstein Co-Chair	**Professor, Texas A&M University School of Law; Immediate Past President, IWRA**	**USA / Israel**
Suryakanta Acharya	Founder, PAY-W Clinic; Consultant Oncologist, Assam Cancer Care Foundation	India
Gisela de Aragão Umbuzeiro	The State University of Campinas - UNICAMP	Brazil
Robert M. DiFilippo	Lecturer of Hydrogeology, University of the Philippines	USA / Philippines
Ali Fares	Endowed Professor of Water Security & Water-Energy-Food Nexus, Texas A&M University	USA / Tunisia
Malcolm Gander	Environmental Manager, United States Department of Defense	USA
Piero Gardinali	Director/Professor, Freshwater Resource Division in the Institute of Environment, Florida International University / UNESCO Chair on Sustainable Water Security	USA
Rasha Hassan	PhD Candidate, University of Barcelona; Project Officer at H2O People	Syria / Spain
Nonhlanhla Kalebaila	Research Manager, South Africa Water Research Commission	South Africa
Robert Kalin	Professor, University of Strathclyde; Co-chair, IWRA Groundwater Taskforce	UK / USA
Marijn Korndewal	Policy Analyst, OECD Environment Directorate	France
Cassiana C. Montagner	Assistant Professor, Analytical Chemistry Department, The State University of Campinas - UNICAMP	Brazil
Dahlia Sabri	Deputy Resident Engineer, KEO International Consultants; Director, IWRA	Egypt
Mary Trudeau	Director, Envirings Inc.	Canada
Xinghui Xia	Professor, School of Environment, Beijing Normal University	China

THE ROAD
TO THE IWRA ONLINE CONFERENCE

Following successful IWRA Online Conferences held in 2020 and 2021, IWRA partnered up again with UNESCO's Intergovernmental Hydrological Programme to create a unique event for the international water community. Similar to the previous conferences, the intention for organising a third edition was to facilitate knowledge exchange, showcase the latest research by leading experts and professionals, and help bridge the science, policy and practice arenas, this time around a main topic affecting both developed and developing countries: Emerging Pollutants.

The presence of these pollutants in water resources, their pathways, and accumulation in the environment, were highlighted to be of particular importance as there is still very scarce information available and little global awareness. Most emerging pollutants are not regulated in environmental, water quality, or wastewater discharge regulations. Hence, this Online Conference was designed to address and support the urgent need to strengthen scientific knowledge and adopt appropriate technological and policy approaches for: monitoring these emerging pollutants in water resources; assessing their risk to potential human health and environments; preventing and controlling the disposal of these substances into water and elsewhere; developing appropriate regulations to address, mitigate, and prevent the introduction of these pollutants in the aquatic environment.

Under this theme, "Emerging Pollutants: Protecting Water Quality for the Health of People and the Environment", IWRA, together with UNESCO-IHP, aimed to shed light on the scientific knowledge and understanding of potential human and ecosystem health risks posed by these emerging pollutants. Moreover, IWRA wanted to ensure that people from all over the world could join and engage in these discussions without concern of cost, visa restrictions, or other personal restrictions. Because many countries are facing the impacts of the Covid-19 pandemic, which imposed additional restrictions on the participation of individuals in face-to-face events, IWRA sought to provide free and open access to all registered participants and to host a fully online conference programme with online access to all conference-related materials. Thanks to the generous support of UNESCO-IHP, this UNESCO-IWRA Online Conference was made possible, free for all to attend, and enabling participation from a diverse group including experts from Africa and other low income countries, and also women and young professionals. We are proud to say that there were more registered participants than in any previous conference.

On behalf of the IWRA Executive Board and Office, IWRA would like to thank our main partner UNESCO-IHP, as well as all the distinguished speakers, panellists, poster authors, moderators and co-moderators, rapporteurs, participants, and IWRA Board members for their dedicated efforts in developing this conference. Our sincere gratitude also goes out to the International Scientific Committee (ISC) co-chairs, the ISC theme leaders and members, and UNESCO's Communications Team. The efforts and support from IWRA Congress and Events, and Scientific, Technical and Publications Committees are also gratefully acknowledged.

The presentations and discussions of the programme participants. The views and recommendations do not necessarily reflect the views or recommendations of the International Water Resources Association and UNESCO.

THEMATIC FRAMEWORK
AND TOPICS

Scientific knowledge and the understanding of potential human and ecosystem health risks posed by emerging pollutants, as well as their presence in water resources and wastewater and their pathways and accumulation in the environment, are still very scarce. Most emerging pollutants are not regulated in environmental, water quality, and wastewater discharge regulations. Therefore, there is an urgent need to: strengthen scientific knowledge and adopt appropriate technological and policy approaches to monitor emerging pollutants in water resources and wastewater; assess their potential risks to human health and environment; prevent and control their disposal into water resources and the environment; develop appropriate regulations for addressing and mitigating, as well as preventing the introduction of these pollutants in the aquatic environment.

The overarching theme of the Online Conference was "*Emerging Pollutants: Protecting Water Quality for the Health of People and the Environment.*" This theme was selected help focus the conference on the science-policy interface when addressing emerging pollutants and on the steps and mechanisms that must be pursued to protect the health of people and communities as well as the natural environment.

ISC identified five sub-themes to help highlight the ways that the world can advance knowledge, research, and solutions for managing emerging pollutants to improve and protect water quality in our changing world. These sub-themes are summarised below.

SUBTHEME 1
EMERGING POLLUTANTS IN AQUATIC ECOSYSTEMS

Theme 1 focused on emerging contaminants in aquatic ecosystems. Emerging contaminants and their transformation products are being detected in waters from different regions and are now a worldwide problem.

Compounds of concern can be different depending on the level of treatment and the use of the compounds in each region, but it seems that pesticides and pharmaceuticals pose greater risks. In less developed regions, the emerging contaminants occur along with other long-standing water quality issues (e.g., E. coli, nitrates) indicating an urgent need for action.

Various recommendations were shared to address emerging pollutants. For one, low-cost and efficient wastewater treatments should be developed and implemented to mitigate the risks of emerging pollutants. This is especially the case for less developed countries. The effects of these mixtures should also be considered when performing risk assessment of emerging pollutants in water.

ISSUES DISCUSSED:

- **Identifying and assessing ecological risks**
- **Science informing policy / policy informing science**
- **Availability or lack of knowledge, data, and monitoring mechanisms**
- **Institutional, policy and regulatory challenges and approaches.**
- **Technological, nature-based, and regulatory solutions**
- **Sustainable Development Goals: challenges and opportunities**
- **Success stories and case studies**

THEMATIC FRAMEWORK
AND TOPICS

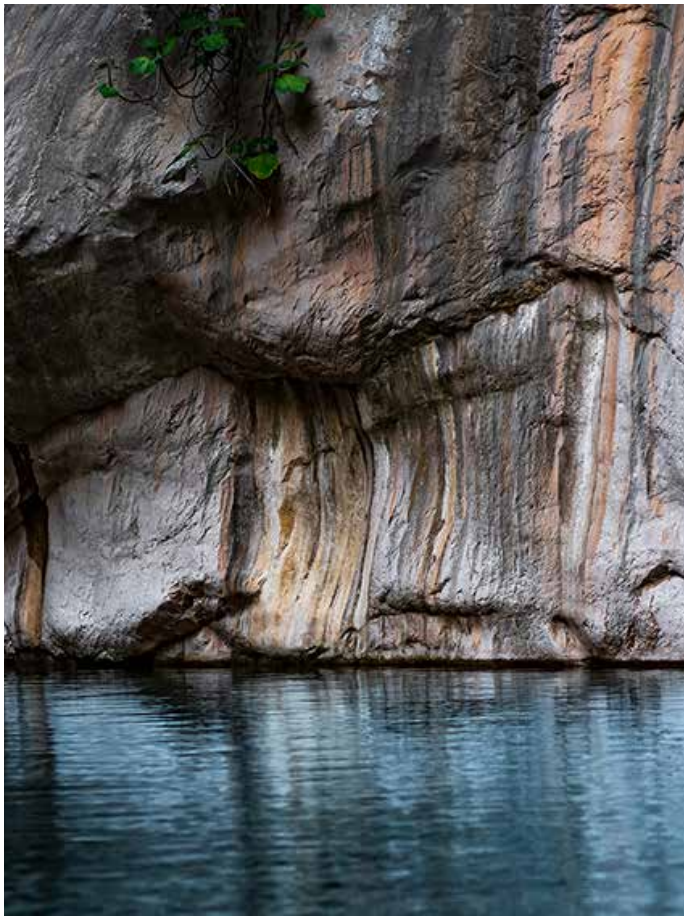
SUBTHEME 2
EMERGING POLLUTANTS AND GROUNDWATER

Theme 2 focused on contaminants of emerging concern (CECs) in groundwater, which are defined in six major groups: Industrial Chemicals (e.g., PFAS); Pharmaceuticals (e.g., anti-inflammatories); Personal Care Products (e.g., sunscreen); Cyanobacteria (algae); Flame Retardants (e.g., brominated compounds); and Nanomaterials. Theme 2 focused on CECs that are becoming more ubiquitous in the environment, particularly PFAS. There needs to be a resilient framework for monitoring priority CECs in groundwater so as to reduce future impacts from other CECs.

Most CECs in groundwater require regular monitoring and analytical testing to improve evidence available and to inform policy for groundwater protection. More data on CECs in groundwater must be regularly collected to understand concentration trends, source areas, and degradation products as CECs transform into other compounds of concern.

Theme 2 highlighted the example of the European Commission which is finalizing legislation to eliminate the widespread release of PFAS compounds in biosolids (produced during biological wastewater treatment) that are used as soil amendments for agricultural areas. The PFAS compounds continue to leach into underlying groundwater from biosolids soil amendments, and it was recommended during the conference that other countries should follow the lead of the European Commission to manage the use of biosolids on agricultural soils. Further, it was emphasised that legislation is required to hold manufacturers accountable for disclosing the use of CECs in products. There also needs to be more work globally to specifically define which CECs should be prioritized for regular groundwater monitoring.

Presenters provided tools to assess the presence, extent, and toxicity of CECs. One group of tools included chemical risk assessment tools to assess the relative health effects of all categories of CECs. A second group of tools



were based on Geographic Information System (GIS) technology to assess the location and source areas of PFAS contamination . Sustainable water resources management, capacity development, community engagement, and political will can accelerate achievement of the SDG6 goals and environmental improvements beyond 2030.

ISSUES DISCUSSED:

- **Identifying and assessing human health and ecological risks**
- **Sustainable Development Goals: challenges and opportunities**
- **Science informing policy / policy informing science**
- **Availability or lack of knowledge, data, and monitoring mechanisms**
- **Institutional, policy and regulatory challenges and approaches**
- **Success stories, tools and case studies**

THEMATIC FRAMEWORK
AND TOPICS

SUBTHEME 3
EMERGING POLLUTANTS AND MANAGING WASTEWATER AND WASTE

Theme 3 focused on emerging contaminants and wastewater management. Wastewater treatment technologies are necessary for mitigating the effects of emerging contaminants on environmental and human health. However, there are limitations to the effectiveness of wastewater treatment processes for removing emerging contaminants from the water column. Conventional wastewater treatment technologies were not designed to remove pharmaceuticals and other emerging contaminants, although some removals from wastewater may occur. A single additional treatment system will likely not be sufficient enough for all removal of emerging pollutants. Further, more research needs to be done regarding emerging contaminants and their fate in sludge, biosolids, and wastewater treatment process wastes.

Researchers during Theme 3 sessions presented the results of technological solutions for treatment, including the use of accessible and affordable materials. The results of experimental trials to remove pharmaceuticals using ceramic membrane filters in Ghana and bamboo sawdust to remove paracetamol (a fever and pain medication, also known as acetaminophen) in Ethiopia were promising in terms of effectiveness, affordability, and the potential for wide dissemination. Activated carbon, which was created by grinding and preparing waste date pits, improved the removal of ibuprofen and gemfibrozil (an anti-inflammatory pain medication and a lipid drug, respectively). Research results of the on-going investigations into advanced nanomaterials for emerging pollutant removals in Brazil were also profiled. The test results of laboratory cultured algal bacterial consortia to remove phenol, surfactants, and chemical oxygen demand (COD) were encouraging enough to plan future pilot studies. Preliminary test results of ultra-violet (UV) light (photo- Fenton process) indicate the potential of the technology to inactivate antibiotic resistant bacteria and genes. An on-site method to evaluate the effectiveness of UV advanced oxidation process performance rapidly and economically was also profiled and proposed methods showed promising results.

Managed aquifer recharge (MAR) quality risks were discussed and the test results of five materials that could be used as reactive barriers to promote sorption and biodegradation of organic molecules were presented for potential use during MAR. Experimental results to assess the risk of groundwater contamination from a select group of pharmaceuticals remaining in treated wastewater determined that the risk is low. This is due to the wastewater treatment process removal and the low percolation through soils of the contaminants where an adequate layer of soil protects the aquifer.

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Theme 3 also addressed what information is still needed for assessing the risks and management for emerging contaminants. Sources of emerging contaminants in Egypt were presented along with the multi-disciplinary approach needed to address health concerns for wastewater reuse as a nutrient-rich water source for food self-sufficiency. Research methods that use publicly available data, including pharmaceutical sales data in Brazil, were presented to better understand or estimate presence trends in wastewater. Models to assess river inputs of pollutants to the seas (the modelling acronym is MARINA) are used to identify pollution hotspots and to assess scenarios for risks of pollution controls on a watershed scale. A case study of industrial discharges in Botswana highlighted the need for coordinated and strategic management that included cross-disciplinary themes, such as triple bottom line, stakeholder engagement, leadership and governance, among others, to improve compliance rates with discharge requirements.

The posters on theme 3 covered a wide range of topics including current challenges and solutions, emerging contaminant separation by activated carbon, DNA damage by emerging pollutants, bibliometric analysis of pharmaceuticals, influence of industries on wastewater, use of ozone in removing pharmaceutical compounds, and the removal of PFAS removal with the help of zeolites.

ISSUES DISCUSSED:

- **Identifying and assessing human health and ecological risks**
- **Sustainable Development Goals: challenges and opportunities**
- **Science informing policy / policy informing science**
- **Availability or lack of knowledge, data, and monitoring mechanisms**
- **(Waste)water reuse and risks associated with emerging pollutants**
- **Institutional, policy and regulatory challenges and approaches**
- **Innovative infrastructure to reduce risk of trace contaminant release**
- **Success stories and case studies**

SUBTHEME 4
A CIRCULAR ECONOMY APPROACH: LIFECYCLE MANAGEMENT OF EMERGING POLLUTANTS

The classical linear economy generates waste that eventually makes its way into water, causing environmental and drinking water pollution. Theme 4 discussed the circular economy approach, where waste that is created in every step of the production process is considered for reuse. Water experts are familiar with circular approaches as the hydrological cycle is inherently circular.

Sessions under this theme highlighted innovation. For instance, pollutants can be processed to produce other products, e.g., biofertilizers from algae cyanobacteria or colorants from fungi. Presenters also discussed the role government can play in a circular economy approach. Governments play a crucial role in stimulating research and innovation. Communication around the safety of circular products, especially when derived from pollutants, is key.

When circular approaches are not yet feasible, such as when freshwater resources are too polluted, authorities should consider the following elements: Technological approaches (e.g., wastewater treatment technologies,

THEMATIC FRAMEWORK
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rainwater harvesting, groundwater recharge); Regulatory standards (e.g., effluents, drinking water, freshwater bodies); Lifecycle approaches involving producers, users, and other actors in the supply chain (e.g., pharmaceuticals, colorants, and drinking water); and interventions to stimulate innovation.

Another key suggestion from theme 4 pertained to the science-policy interface. Academia and regulators have a wealth of knowledge on the presence of pollutants in water. Multidisciplinary teams should be formed to address the challenges of implementing a circular economy as they are effective in bringing knowledge together and in formulating new policies and technological approaches.

ISSUES DISCUSSED:

- **Science informing policy / policy informing science**
- **Availability or lack of knowledge, data, and monitoring mechanisms**
- **Institutional, policy and regulatory challenges and approaches**
- **Sustainable Development Goals: challenges and opportunities**
- **The roles, responsibilities, and contributions of the private sector**
- **Success stories and case studies**

SUBTHEME 5
"PRIORITY" EMERGING POLLUTANTS IN THE HYDROCYCLE: MICROPLASTICS, NANOMATERIAL, PFAS AND PHARMACEUTICALS, AND PERSONAL CARE PRODUCTS (PPCPS)

Emerging contaminants are still "emerging" and dominate the current research queries. These include pharmaceuticals and perfluorinated chemicals. Environmental persistence, health and environmental effects, and treatment effectiveness are the key issues being investigated. It is clear that education and outreach activities are needed to bring awareness of these chemicals and their sources to the general public, to inform them about activities and frameworks needed to mitigate the release of CECs or to eliminate them.

Among the pollutants of emerging concern are microplastics. These have received great attention from the research community and were the main topic of one of the Subtheme 5 sessions. One of the key concerns discussed include the potential of these microplastics to be ingested and to transport other problematic substances that bind to their surface . Key points of inquiry driving microplastics research around the world include bioaccumulation, bioavailability, transfer in the food web, and toxicity. In addition, the challenges of treating water to ensure acceptable water quality for numerous activities or uses require significant investment.

THEMATIC FRAMEWORK
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Key science-policy elements highlighted in the Theme 5 were:

- Technology transfer, education, and outreach are critical issues affecting our ability to reduce or control the emissions of emerging contaminants. Information and resources need to flow globally.
- Water scarcity is a driver to developing new technologies, treatment, degradation, in situ removal. Direct potable reuse is being used in limited areas but faces a perception hurdle.
- Plastic pollution is still a point of divergence in terms of effects, source identification, and removal. Continued research is needed.
- We need to prioritize specific chemicals due to their toxicity, their environmental persistence, and their value as indicators; however, the list of concerning pollutants grow every day.
- Promising analytical technologies are "emerging" to identify pollutants. However, their applicability on a large scale is still quite limited.
- We are facing a global problem that requires a global call for action.

ISSUES DISCUSSED:

- **Science informing policy / policy informing science**
- **Availability or lack of knowledge, data, and monitoring mechanisms**
- **Institutional, policy and regulatory challenges and approaches**
- **Identifying and assessing human health and ecological risks**
- **Sustainable Development Goals: challenges and opportunities**
- **Roles, responsibilities, and contributions of the private sector**
- **When is the hazard/risk too high?**

SESSION SUMMARIES

THERE WAS A TOTAL OF 14 SESSIONS OVER TWO AND ONE-HALF DAYS IN THE FOLLOWING PROGRAMME

DAY 1 Tuesday, January 17th, 2023	DAY 2 Wednesday, January 18th, 2023	DAY 3 Thursday, January 19th, 2023
13:00-14:30 Opening Ceremony	09:00-10:30 Theme 5, Session 1: "Priority emerging pollutants in the hydrocycle: microplastics, nanomaterial, PFAS, and PPCPs"	09:00-10:30 Theme 3, Session 2: "Emerging pollutants and wastewater"
14:45-16:15 Theme 1, Session 1: "Emerging pollutants in aquatic ecosystems"	10:45-12:00 Theme 2, Session 2: "Emerging pollutants and groundwater"	10:45-12:00 Theme 1, Session 3: "Emerging pollutants in aquatic ecosystems"
16:30-18:00 Theme 2, Session 1: "Emerging pollutants and groundwater"	12:15-13:30 Theme 1, Session 2: "Emerging pollutants in aquatic ecosystems"	12:15-13:50 Theme 5, Session 2: "Priority emerging pollutants in the hydrocycle: microplastics, nanomaterial, PFAS and PPCPs"
	13:45-14:45 High Level Panel 1: "Science-policy measures to protect ecosystems from emerging water pollutants"	13:45-14:45 High Level Panel 2: "Science-policy measures to protect human health from emerging water pollutants"
	15:00-16:30 Theme 4: "A circular economy approach: Lifecycle management of emerging pollutants"	15:00-16:30 Closing Ceremony
	16:45-18:00 Theme 3, Session 1: "Emerging pollutants and wastewater"	

OPENING CEREMONY

MODERATOR:
Renée Martin-Nagle, IWRA Treasurer; CEO, A Ripple Effect LLC; Special Counsel, Eckert Seamans; & Visiting Scholar at the Environmental Law Institute, Treasure, IWRA

CO-MODERATOR:
Monica Garcia Quesada, Project Officer, IWRA

WELCOME MESSAGES:
Abou Amani, Director of Division of Water Sciences
Yuanyuan Li, IWRA President; Vice President of the General Institute of Water Resources & Hydropower Planning & Design, Ministry of Water Resources
Sarantuyaa Zandaryaa and **Gabriel Eckstein**, Conference ISC Co-Chairs

KEYNOTE SPEAKER:
Claudia Olazabal, Head of Unit of Sustainable Freshwater Management, DG ENV, European Commission

SESSION SUMMARY:
The conference began with welcoming messages delivered by the President of IWRA and UNESCO's Director of Division of Water Sciences, along with a keynote address from the Head of Unit of Sustainable Freshwater Management at the European Commission's DG ENV. Attendees were introduced to the conference theme and subthemes. The International Scientific Committee (ISC) Co-Chairs provided a comprehensive background on emerging pollutants, water security, water quality, and science-based policy.

Abou Amani, Director of Division of Water Sciences at UNESCO, underscored the importance of exploring freshwater resource accessibility. With two billion people lacking access to freshwater resources, the impacts of climate change and declining water quality further exacerbate water availability challenges. A call for further research was made to understand new and emergent pollutants in water resources. UNESCO is extending its scientific knowledge and funding support to countries, including African nations, to reduce pollutants in water resources by 2030.

Yuanyuan Li, President of IWRA, highlighted water quality as a significant challenge to water security. Issues related to water quality can lead to ecosystem degradation, water scarcity, and socioeconomic problems. The emergence of pollutants such as pesticides, industrial waste, and pharmaceuticals has the potential to cause chronic health issues. The COVID-19 pandemic has also contributed to an increase in emerging pollutants in water bodies.

ISC Co-Chair **Sarantuyaa Zandarya** emphasized the importance of the Online Conference in protecting water quality through collaboration between people and the environment. Limited scientific knowledge, inadequate regulation, and policy gaps pose challenges in studying emerging pollutants. The conference was presented as an intersection to science-policy and multi-sector perspectives. Five thematic areas were discussed, including emerging pollutants in aquatic ecosystems, groundwater, and a lifecycle management approach. Priority emerging pollutants in the water cycle were identified, such as microplastics, nanomaterials, PFAS, and PPCPs. ISC Co-Chair Gabriel Eckstein emphasized the need for science-based policy actions to minimize emerging pollutants in the hydrological cycle and called for increased participation and awareness among user groups and stakeholders.

Claudia Olazabal delivered a keynote presentation stressing the urgency of taking action against emerging pollutants. Referring to a report published two decades ago, she highlighted pollutants that emerged due to settlement, such as benzene compounds and sulfur dioxide.

KEY ACTION POINTS DISCUSSED INCLUDED:

- **The need for long-term monitoring to accurately analyse pollutants, the European Green Deal's Zero Pollution Action Plan (2019).**
- **The importance of developing a hierarchy of action plans for reducing emergent pollutants.**
- **The need for strengthening chemical legislation to ensure the safe and sustainable use of all market chemicals, particularly for vulnerable groups.**
- **Current efforts by the European Union to identify emergent pollutants, including pharmaceuticals, PFAS, and new chemicals in surface and groundwater; 24 chemicals were added to the list.**
- **The significance of policymaking for the environment and the goal of being toxic-free by 2030.**

All speakers emphasised the importance of precautionary principles and risk assessment in minimising the impact of emerging pollutants and mitigating their risks. They also discussed the need for integration among academic research and public and private sectors, as well as among stakeholders/user groups in activities.

ABSTRACT SESSION 1
THEME 1 "*EMERGING POLLUTANTS IN AQUATIC ECOSYSTEMS*"

MODERATOR:
Xinghui Xia, Professor, School of Environment, Beijing Normal University

CO-MODERATOR:
Gisela Umbuzeiro, Professor, Faculty of Technology at the State University of Campinas (UNICAMP)

KEYNOTE SPEAKER:
Damia Barcelo Culleres, Professor, IDAEA-CSIC, Spain; Director. Catalan Institute for Water Research (ICRA-CERCA)
"*Fate, risks, and remediation of emerging contaminants, antibiotic resistance genes and microplastics in surface waters and groundwaters at global scale: challenges and solutions*"

SPEAKERS:
Gabriely Groto Militão, State University of Campinas – The School of Technology
"*Mutagenicity evaluation of the rubber tire oxidant byproduct, 6PPD quinone, using the Ames assay*"
Natalia Soares Quinete, Florida International University
"*Assessing forever chemicals in South Florida aquatic environments and potential environmental and human health risks*"
Ramon Domingues, The State University of Campinas (Unicamp)
"*Occurrence of emerging contaminants in Pampulha Lake: anthropic pollution of a UNESCO heritage site*"
Nikola Rakonjac, Soil Physics and Land Management Group, Wageningen University, Netherlands
"*Transport of Veterinary Pharmaceuticals in Lowland Catchments: a Lumped Modelling Approach*"
Maryssa Fernanda Zecchin Simões, Programa de Pós-graduação em Recursos Naturais (PPGERN), Federal University of São Carlos (UFSCar), São Carlos, SP, Brazil
"*Bioremediation of Azo dye Tartrazine Yellow by three different microalgae genera*"
Hadassa De Souza Ramos Pontes Moura, University of Brasilia
"*Water contamination in a multi-industrial region in Brazil: Decision support for water quality evaluation and management of contaminants of emerging concern*"

SESSION SUMMARY:
During this session, Prof. Culleres introduced his research and in-depth review of the impacts of pharmaceutical pollutants (contaminations) on surface water and groundwater around the world, especially in developing countries such as China and India.

He presented the outcome of his and his colleagues' research on groundwater and surface water. Then, he presented some solutions for addressing pharmaceutical contamination of groundwater and surface water especially through eco-friendly technology and an Advanced Oxidation Process (AOP). Finally, he revealed the challenges that exist to these catastrophic problems at the global level. He specifically stated that innovations in

the areas of "good technology" are needed as well is "more legislation" from the government.

Gabriely Groto Militão presented on the mutagenicity evaluation of the rubber tire oxidant by-product, 6PPD quinone, on Salmonella using the Ames assay. She presented the Microplate Agar (MPA) analytical method. She highlighted that 6PPD quinone showed a weakly mutagenic response only with one strain of Salmonella and only in the presence of metabolic activation. She indicated more tests will be conducted to verify the mutagenicity result and aquatic invertebrate in vivo testing on the substance.

Natalia Soares discussed the assessment of forever chemicals in South Florida aquatic environments and potential environmental and human health risks. She discussed PFAS and how these substances are transferred to runoff and into water, specifically groundwater. She emphasized the following:

1. A shortage of research on this topic
2. The lack of research on short-chain PFA in Florida
3. A lack of research on the risks these substances pose to environment and humans

She shared how her team conducted its research in Biscayne Bay, Tampa Bay (on the Florida Coast). Biscayne Bay has been significantly affected by PFAS, in particular, military bases in Biscayne.

Ramon Domingues highlighted the chemical contamination concentration on a UNESCO Heritage Site within his presentation, "Occurrence of emerging contaminants in Pampulha Lake: anthropic pollution of a UNESCO Heritage Site, Pampulha Modern Ensemble (1940)." They found some chemical contamination concentrations at this site; research will continue to assess if there are any seasonal effects on levels of contamination.

The next presenter, Nikola Rakonjac, discussed the release of veterinary pharmaceuticals to the water environment. There is a lack of research on veterinary pharmaceutical (VP) contamination, in particular releases to surface waters. Through a modelling approach that uses an existing rainfall-runoff model with data on soil-applied VPs from the agriculture sector, his team built a VP transport model. The model provides insights to dominant surface water transport routes and VP residence times in surface waters. His research will lead to better understanding of the interactions between water quality and agriculture, will help to identify suspected risks, and will offer suggestions for regional policy improvements.

Maryssa Fernanda Zecchin Simões presented on the Bioremediation of Azo dye Tartrazine Yellow through a discussion of three different microalgae genera. The objective of the study was to analyze the growth and degradation of these three microalgal species in the presence of Tartrazine, which is a dye used in foods. Preliminary results indicate the dye was not toxic to the algal species and some degradation of dye occurred in a treatment test sample.

Hadassa De Souza Ramos Pontes Moura assessed the effects of industrial effluents on water quality in Brazil in her presentation, "Water contamination in a multi-industrial region in Brazil: Decision support for water quality evaluation and management of contaminants of emerging concern". She found that the environment around several industrial zones (e.g., river) has been contaminated with emerging pollutants and some conventional pollutants. She also found out that these industrial zones do not abide by the regulations and rule of governments related to the conservation and protection of the natural environment. She used an adapted Water Quality index (WQI) from Canada to assess the quality of water around the industrial zones and found that CECs are ten times higher than the concentrations found in receiving waters impacted by municipal wastewater discharges.

ABSTRACT SESSION 2
THEME 2 "*EMERGING POLLUTANTS AND GROUNDWATER*"

MODERATOR:
Robert Kalin, Professor, Strathclyde University, Glasgow Scotland

CO-MODERATOR:
Malcolm Gander, Environmental Manager, United States Department of Defense

KEYNOTE SPEAKER:
Daniel Lapworth, Principal hydrogeochemist, British Geological Survey
"*Emerging contaminants in groundwater: Improving the evidence base to inform policy and regulation*"

SPEAKERS:
Eliana Munarriz, University of Buenos Aires, Faculty of Agronomy, Research Institute in Agricultural and Environmental Biosciences/ CONICET
"*How to prioritize agrochemical pollutant evaluation in drinking water? RISK21 tools provide a framework for chemical risk assessment*"
Rachel Kaiser, Centro de Investigación Científica de Yucatán
"*Understanding the Prevalence and Occurrence of Antimicrobial Resistance in Urban Karst Groundwater Systems*"
Rosa Leal-Bautista, Research Associate, Environmental Law Institute
"*Assessment of emerging organic contaminants at the groundwater of Yucatán peninsula: recreational and water supply*"
Bentje Brauns, British Geological Survey, Environmental Science Centre; Hydrogeologist, Project Manager, Environmental Change Adaptation & Resilience
"*Emerging contaminants in groundwaters and their relation to recharge sources in Bengaluru City, Karnataka, India*"
Malcolm Gander, Consultant in Earth Sciences
"*An analysis of the main categories of the contaminants of emerging concern (CECs) in global groundwater*"
Tamiris Ferreira, Universidade Federal de São Paulo, Departamento de Ciências Ambientais
"*Microplastics in urban soil and groundwater in the city of Bauru, São Paulo, Brazil*"
Melissa E. Lenczewski, Institute for the Study of the Environment, Sustainability, and Energy; Northern Illinois University
"*Impact of changing tourist numbers on sunscreens and antibiotics in groundwater during the Covid-19 pandemic Riviera Maya, Mexico*"

SESSION SUMMARY:
The keynote address, presented by Daniel Lapworth, overviewed what has been done regarding emerging contaminants, the growing evidence base for these pollutants in groundwater globally, and also, surveillance monitoring. There is a demonstrated need for groundwater protection against key CECs, as well as stronger policies and changes in how society uses and views these chemicals. Several regional initiatives are in place to improve the monitoring of priority CECs, such as the European Groundwater Watch List. The most hazardous groups should be prioritized and,

at the same time, analytical capabilities and monitoring must be improved. Prioritization of CECs can be based on existing monitoring data, environmental exposure, mobility data, toxicity and relative risks posed to groundwater. Stakeholders need to work together to build a resilient framework to establish monitoring priorities for CECs in groundwater and to reduce future impacts from other CECs.

Eliana Munarriz discussed how RISK21 tools provide a framework for chemical risk assessment in her discussion. RISK21, or Risk Assessment in the 21st Century, is a committee with a mission to promote risk assessment based on key principles. It includes an in-depth review of chemical risk assessment tools to assess the relative health effects of all categories of CECs. As a coherent, science-based decision-making tool, it effectively uses all relevant information for an interactive and transparent evaluation of sufficient exposure and hazard information to inform a risk-based decision. Moreover, it also contributes to governance processes for priority-setting and analysis for potential future scenarios of chemical exposure and environmental and human health analyses.

Rachel Kaiser discussed the global crisis of antimicrobial resistance (ARB) and how it is significantly impacting human health. Water resources are a potential environmental reservoir and dissemination pathway for antimicrobial resistance. Karst groundwater supplies 1.18 billion people (16.5% of the global population) with drinking water. Understanding the occurrence and dissemination of antimicrobial resistance in urban karst groundwater systems is important. Sampling of karst aquifers in Kentucky and Florida found a consistent prevalence of ARB and antimicrobial resistant genes (ARG), regardless of karst feature type or seasonality. The research highlights an underprioritized reservoir and dissemination pathway for AMR that needs to be monitored and managed.

Rosa Leal-Bautista emphasised that since tourism is a predominant economic activity in Mexico, water quality in recreational areas is deteriorating. This, in turn, affects human health. Leal-Bautista highlighted the detection of faecal indicators such as E. coli in touristic and non-touristic sites.

Bentje Brauns discussed how emerging organic contaminants (EOCs) are becoming more ubiquitous in the environment, particularly PFAS. Few studies are available on EOCs in Indian groundwaters. The ubiquitous detection of sweeteners indicates groundwater age since their compounds were introduced only relatively recently. EOCs can be used to trace unique groundwater recharge sources in urban settings. Better information on dominant recharge sources can inform groundwater protection and monitoring efforts.

Malcolm Gander, showcased his work around Contaminants of Emerging Concern (CECs) in Global Groundwater. CECs are toxic; however, the nature and severity of the toxicity are undefined and unregulated. CECs are not adequately monitored in groundwater; periodic sampling and laboratory testing are needed. Of all CECs, PFAS have the highest likelihood of causing human health problems. Immediate action is needed to control the release and disposal of PFAS. Countries should follow the lead of the European Commission in taking the following steps: first, identify the presence and sources of PFAS; and second, implement legislation to eliminate the widespread release of PFAS compounds in biosolids (from wastewater treatment plants). Biosolids are used as soil amendments for agricultural lands, but PFAS compounds in biosolids leach into the underlying groundwater.

Tamiris Ferreira discussed a study of boreholes and monitoring wells in the urban area of Bauru which found microplastics. Microplastics were identified in soil and groundwater, predominantly in smaller sizes (0.063 to 1 mm). There was a predominance of coloured MPs in the saturated zone but transparent fibres in the unsaturated zone, indicating different sources of contamination for these zones.

Microplastics (MPs) are known to impact biota and pose a risk to human health, but they are not well-studied in groundwater.

Finally, Melissa E. Lenczewski discussed how Karst groundwater is easily contaminated by tourists and locals. The study used sunscreens and antibiotics as proxies to estimate human presence. Evaluation of a new drainage program in Puerto Morelos found that the system effectively reduces contamination of groundwater. Tourists contribute to the diversity of contaminants in groundwater but residents were associated with antibiotic diversity during the pandemic. Residents are major contributors to the total concentration of contaminants but not diversity.

ABSTRACT SESSION 3

THEME 5 "*PRIORITY EMERGING POLLUTANTS IN THE HYDROCYCLE: MICROPLASTICS, NANOMATERIAL, PFAS AND PPCPS*"

MODERATOR:
Robert DiFilippo, Lecturer of Hydrogeology, University of the Philippines

CO-MODERATOR
Piero Gardinali, Florida International University, Institute of Environment

KEYNOTE SPEAKER:
Theodore B. Henry, Professor of Environmental Toxicology, Institute of Life and Earth, Sciences, Acting Executive Dean of the School of Energy, Geoscience, Infrastructure and Society at Heriot-Watt University (HWU)
"*Microplastics in the Environment – Perspectives and Priorities*"

SPEAKERS:
Albert Contreras Llin, Department of Environmental Chemistry (ENFOCHEM); Institute of Environmental Assessment and Water Research (IDAEA-CSIC)
"*Determination of microplastics in wastewater samples from two wastewater treatment plants in Spain and in a managed aquifer recharge system*"
Hui Lin, Nanchang hangkong University JiangXi Province
"*Bioavailability quantification and uptake mechanisms of pyrene associated with different-sized microplastics to Daphnia magna*"
Camila L Madeira, State University of Campinas (UNICAMP)
"*Interaction of the pesticide fipronil and its biodegradation products with polyethylene microplastics in ultrapure and river water*"
Mbuyiselwa Moloi, Centre for Environmental Management, University of the Free State
"*Environmental exposure assessment of product-released engineered nanomaterials (PR-ENMs) from commercial products*"

SESSION SUMMARY:
Theodore Henry showed why MPs are considered a priority CEC. Reasons include the potential for ingestion and the potential transport of other substances with MPs. Researchers around the world are trying to understand better the bioaccumulation, bioavailability, toxicity, and transfer of MPs in the food web.

Albert Contreas Llin talked about the removal of MPs in WWTPs and a managed aquifer recharge (MAR) system in Spain. The WWTPs had secondary treatment technology and removed 90% of MPs from the water. Reactive barriers in the MAR system allowed further retention of MPs. Although 90% of MPs were diverted to sludge from water by WWTPs, high amounts of particles are still reaching the environment due to the very large quantities of MPs in wastewater.

Hui Lin's presentation discussed research on the bioavailability of pyrene to Daphnia magna due to hydrophobic organic contaminants and MPs. The bioavailability of pyrene increases as the size of MPs decreases, with the highest uptake associated with MPs in sizes up to 1.5 µm. Two other size groups of MPs were included in the study, 10-60 µm and 60-230 µm. Pyrene was assessed by the weight of ingested MPs and pyrene content in the gut of Daphnia.

Camila L Madeira discussed the complexities of evaluating sorption of pesticides into MPs and how important it is to test real environmental matrices in order to understand better the sorption potential.

Mbuyiselwa Moloi highlighted the increasing discharge of engineered nanomaterials into the aquatic environment. The study focused on titanium dioxide in sunscreens and zinc oxide in topical creams. It is important to have a protocol to measure and monitor nanoparticles in the aquatic environment to better understand factors influencing exposure and bioavailability for risk assessment.

ABSTRACT SESSION 4

THEME 2 "*EMERGING POLLUTANTS AND GROUNDWATER*"

MODERATOR:
Robert Kalin, Strathclyde University, Glasgow, Scotland

CO-MODERATOR:
Nikola Rakonjac, Wageningen University & Research, Netherlands

SPEAKERS:
Waseem Raja, Ph.D. Scholar in the Department of Civil Engineering Indian Institute of Technology Jammu
and **Akil Gupta**, Project Officer, Water Quality Lab, Indian Institute of Technology Jammu
"*Landfill Site selection and bioremediation of emerging contaminants in groundwater*"
Sabry Z. Wahba, Water Pollution Research Dept., Institute of Environmental and Climate Change Research, National Research Center, Cairo
"*Assessment of harmful Algae as an emerging pollutant of domestic water supply from rainwater harvesting facilities in Sudan*"
Silvia Díaz Cruz, Spanish Council for Scientific Research (CSIC); Institute of Environmental Assessment and Water Research (IDAEA); Dept. of Environmental Chemistry
"*Soil aquifer treatment application to improve the chemical quality and increase the quantity of groundwater*"
Suryakanta Acharya, PAY-W Clinic, Assam Cancer Care Foundation
"*An overview of endocrine-disrupting compounds in drinking water and human health*"
Kellen Karimi, University of Nairobi, Department of Public and Global Health
"*Contamination of groundwater with sulfamethoxazole and trimethoprim and spread of drug resistant Escherichia Coli in formal settlements of Kisumu, Kenya*"
Jane Thrasher, Jacobs, Water & Environment Director; Ground Contamination and Land Quality Global Community of Practice Leader
"*Development of a GIS based tool for the prioritisation of sites with the potential to be sources of polyfluoroalkyl and perfluoroalkyl substances (PFAS) impact to the water environment*"
Enrique Fernandez Escalante, Tragsa – SEPI, Spain
"*Monitored and Intentional Recharge (MIR) – The intensive observation as a key to achieve water quality improvement; A conceptual model to draft water quality regulations about Managed Aquifer recharge (MAR) and water reuse*"

SESSION SUMMARY:
Waseem Raja and Akhil Gupta discussed groundwater contamination in India. Groundwater is a primary source of water in India, but there is significant evidence that groundwater has been contaminated due to the leaching of pollutants from un-engineered landfills. Their study applied modern approaches like ArcGIS and multicriteria decision-making tools (MCDM) for suitable landfill site selection, considering various governing criteria. Microbes were cultured and acclimatized in the lab to assess microbial bioremediation of landfill leachate. Bench scale

results showed a removal efficiency of more than 90 % of ammonia, nitrate, BOD, COD, surfactants, and phenols. Removal efficiency of around 70 % was observed for iron and manganese.

Sabry Z. Wahba classified the types of algae and identified the toxin-producing algae species. Algae blooms produce chemicals or toxins called Harmful Algal Blooms (HABs). Laboratory analysis showed a variation in physiochemical quality between different sites and seasons. The population in the study area depends on surface rainwater harvesting from Hafil (Shallow Water Pond) and earth dam reservoirs for domestic and drinking water supply. These sources are susceptible to contamination due to surrounding livelihood activities.

Suryakanta Acharya highlighted how the aim of the research is to compile essential aspects of EDCs, especially human health effects. A review of recent publications revealed that potential health issues of EDCs are not fully understood due to a lack of research. In addition to water, EDCs are also present in the air and food. A holistic approach to these emerging issues is needed.

Silvia Díaz Cruz discussed how groundwater is threatened globally, and there is an urgent need to strengthen data collection protocols to know the current actual state of groundwater aquifers. Groundwater statistics can be improved by managing aquifer recharge, pollution attenuation, and the reuse of water. The reduction of CECs demonstrates that implementing soil aquifer treatment (SAT) can attenuate the toxic effects and reduce risks associated with WWTP effluents, allowing their safer potential use in aquifer recharge schemes.

Kellen Karimi investigated the contamination of groundwater with antibiotics. Antibiotic use is prevalent in the informal settlements in the study area in Kenya, which are densely populated, but do not have adequate sanitation facilities. The study area also has a higher prevalence of HIV/AIDS patients than the national average. Combined with the prevalence of antibiotic use, its misuse and improper disposal, it is difficult to determine the cause of antibiotic resistance in the environment. The amount of antibiotics that cause resistance in the environment is unknown.

Jane Thrasher discussed the ubiquitous presence of PFAS in surface water. It is challenging to prioritize a large number of potential PFAS source sites. The approach in this study results in the PFAS Risk Explorer. More than 30,000 sites of PFAS sources were mapped through surveillance monitoring. More than half of these sites had scores indicating a high risk of contamination due to the proximity to surface water or groundwater.

Enrique Fernandez Escalante highlighted how the MIR conceptual model provides a basis to formulate MAR guidelines applied to specific environmental conditions for each country. Due to intense and planned monitoring, the MIR concept and its methodology are key for developing water quality and security. MIR proposes a complete list of elements to consider when drafting guidelines and regulations on MAR. The MIR approach can improve water security worldwide.

ABSTRACT SESSION 5

THEME 1 "*EMERGING POLLUTANTS IN AQUATIC ECOSYSTEMS*"

MODERATOR:

Cassiana Montagner, Associate Professor, UNICAMP, Brazil

CO-MODERATOR:

Monica Garcia Quesada, Smart Water Cities Project Officer, IWRA

SPEAKERS:

Chunmiao Wang, Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences

"*Occurrence and source of typical odor-causing compounds in drinking water of major cities across China*"

Hikimat Saadi, Cheikh Anta Diop University (UCAD); Doctoral School on Water, Quality and Uses of Water (EDEQUE)

"*Impacts of anthropogenic activities on water quality in the Guiers Lake basin: a spatio-temporal evolution of emerging pollutants*"

Yuliya Vystavna, International Atomic Energy Agency

"*Multi-tracer approach for understanding emerging pollutants sources and behavior in aquatic systems to support national and transboundary water management*"

Lungelo Rejoice Nsibande, University of Zululand, South Africa

"*Exposure assessment of emerging pollutants in the uMhlathuze and uThukela River-Estuary, South Africa*"

Esra Şıltu, Advisor to the General Director, Republic of Türkiye Ministry of Agriculture and Forestry/DG State Hydraulic Works

"*Identifying the Emerging Pollutants in Aquatic Ecosystems: Turkey Example*"

Shangwei Zhang, Advanced Interdisciplinary Institute of Environment and Ecology, Beijing Normal University

"*Quantum Chemical Computations Promote Understanding of Microbial Reductive Dehalogenation*"

Maïté Fournier, ACTeon Environment

"*Assessment of stakeholders' demands on aquatic pollutants to support the transfer of research results*"

SESSION SUMMARY:

Chunmiao Wang discussed the main odour-causing compounds found in water samples and their sources. The study used a combination of GC-O and GC X GC-MS, as well as a quantitative method for simultaneous determination of 95 odorants based on liquid-liquid extraction combined

with GC-MS/MS and flavour profile analysis. Results showed that 77 odour-causing compounds were detected in the water samples; 90% of source water samples and 50% of finished water samples exhibited odour problems, with earthy/musty odours (31.8%) and swampy/septic odours (45.4%) being the dominant odour descriptors. The major odour types in Yangtze River, Taihu Lake, and Pearl River were found to be swampy/septic, while both swampy/septic and earthy/musty odours were present in the Yellow River. Possible sources of the odorants were identified as Pyrazines, biological production, petrochemical industries, and fine chemical industries. In China, thioethers were found to be the main cause of swampy/septic odour in source water.

Hikimat Saadi investigated the spatial-temporal evolution of pesticides and land use in Lake Guiers, Senegal. The study found an increase in pesticides in water samples, including organochlorines and organophosphates. The study also showed an annual increase of pesticide use and the occurrence of new molecules. Results indicate that the growing anthropogenic pressures combined with climate change threaten the lake's water resources. High to moderate pollution levels were detected at some sites for most of the targeted parameters. An interesting finding was that during the COVID-19 pandemic period, there was a decrease in agricultural land use. The study highlighted that the environmental degradation of the lake basin requires the monitoring of chemicals and emerging pollutants while integrating management practices, involving multiple stakeholders. Awareness also needs to be increased to avoid eutrophication.

Yuliya Vystavna highlighted the great risk that emerging pollutants pose to the quality of drinking water. The study proposed a new approach of combining emerging pollutants with environmental isotopes to improve the understanding of emerging pollutants sources and behaviour in aquatic ecosystems. The project aims to improve the understanding of nitrate sources in connected river and groundwater systems by linking nitrate isotopes and contaminants of emerging concern. The study found that compounds of emerging concern have been detected in water bodies and may cause ecological or human health impacts, but these are typically not regulated under current environmental laws. Physical tracers were used to identify nitrogen sources, flow paths, interactions between water bodies, and biogeochemical processes that alter nitrogen compounds and other chemicals. The study highlighted the benefits of linking physical and chemical tracers to trace specific pollution sources in groundwater and surface water, to improve understanding of pollutants pathways, to understand connections between components of the water cycle, and to identify biological processes that impact pollutants in waters. The speaker also emphasized the need for interdisciplinary and international cooperation, covering different geographical, socio-economic conditions, and temporal scales.

Lungelo Nsibande provided an overview of emerging contaminants and examples of emerging pollutants that can reach aquatic environments through point and non-point sources. The study aimed to investigate environmental exposure of various classes of emerging pollutants, including pharmaceuticals, lifestyle drugs, pesticides, microplastics, and engineered nanomaterials (ENMs) in surface water. The field study involved collecting surface water samples during high and low flow seasons in the uMhlathuze and uThukela rivers; detailed sample preparation and analysis methods were provided. The results of the study showed the presence of a significant number of pharmaceuticals and lifestyle compounds in the two rivers, and pesticides were attributed to waste water treatment plants, and runoff from industrial and agricultural activities near the study sites. The study also showed the presence of metal-based ENMs in both river systems. Findings confirmed that nano pollution in the study area is linked to anthropogenic activities. The study highlighted the need for robust monitoring to establish strategies for mitigating pollution and protecting water resource quality.

Esra Şıltu reviewed the ecological risk assessment of chemicals present in freshwater resources in Turkey. The study identified emerging aquatic pollutants and updated the specific pollutants listed in the Turkish By-Law on Surface Water Quality. The NORMAN prioritization framework for emerging substances was used and data was collected from ambient surface water monitoring databases from 13 projects and regular monitoring studies conducted by the Turkish State Hydraulic Works. The study found 45 pollutants to have high risk, but the speaker suggested that future studies should use more comprehensive

monitoring data. The conclusion was that risk assessment methodologies can be improved by integrating multimedia fate models in order to better understand the presence of emerging pollutants in Turkey's aquatic ecosystems.

Shangwei Zhang discussed the dangers of organohalides to health and ecosystems, and also discussed the biochemical process of dehalogenation and the catalytic site of reductive dehalogenase. The study found that microbial reductive dehalogenation (RDase) is a highly desirable approach to addressing organohalide pollution. The study consisted of three quantum chemical studies which aimed to understand the electron density and transfer in bacteria, the interaction mode between organohalides and the cofactor of RDase, and the outer-sphere electric transport by studying free energy barriers of 334 reactions. The results showed that outer-sphere electron transfer does not underpin microbial dehalogenation. The study provided a guide for dehalogenation experiments and a theoretical basis for bioremediation. The speaker emphasized that quantum chemical computations can facilitate both emerging pollutant control and management, as well as green chemical synthesis.

Maïté Fournier aimed to identify stakeholders and assess their demands related to aquatic pollutants. The study highlighted the challenges in transferring knowledge on aquatic pollutants, provided an overview of research projects funded under the call for papers on aquatic pollutants, and discussed the example of the European Research Area Networks (ERA-Net). The presenter highlighted the large gap between public and private organizations and presented a methodology for assessing stakeholders' demands on aquatic pollutants related to generic observations, measuring and analyzing persistent organic pollutants, antimicrobial resistance, pathogens in the aquatic environment, risk assessment and management of the aquatic pollution, and treatment and mitigation of the aquatic pollution. The study highlighted the importance of research projects and provided tools for identifying stakeholders, highlighting specific knowledge gaps related to persistent organic pollutants, antimicrobial resistance and pathogens, and barriers to knowledge transfer.

HIGH LEVEL PANEL 1

"SCIENCE-POLICY MEASURES TO PROTECT ECOSYSTEMS FROM EMERGING WATER POLLUTANTS"

MODERATOR:
Sarantuyaa Zandaryaa, Programme Specialist, Division of Water Sciences, Intergovernmental Hydrological Programme (IHP), UNESCO

CO-MODERATOR:
Karishma Asoodani, Multi-platform international journalist

PANELLISTS:
Omar El Hassan, Environmental Antimicrobial Resistance and Water Management Expert, FAO
Richard Elelman, World Water Quality Alliance (WWQA), United Nations Environment Programme (UNEP)
Jennifer Molwantwa, CEO, Water Research Commission of South Africa
Ting Ruan, Professor, State Key Laboratory of Environmental Chemistry and Eco-toxicology, Research Centre for Eco-Environmental Sciences, Chinese Academy of Sciences

SESSION SUMMARY:
In this High-Level Panel, the panellists started with discussion around **the different measures necessary to protect ecosystems from emerging pollutants**.

Dr. Omar Elhassan (FAO) highlighted the huge potential for these pollutants to transmit to humans, and shifted the traditional emphasis on human health to environment impacts. He introduced three ways of transmission. In agriculture, large amounts of AMR are found in animal production and runoff. Eighty percent are active compounds and are not treated. Rather than trying to cure the situation after release of contaminants, prevention is the best solution. There is need for better treatment, regulatory frameworks, the prioritizing of pollutants, and good practices for farmers.

Dr. Richard Elelman (WWQA UNEP): at WWQA UNEP, data is converted at national, sub-national, and supra-national levels to feed into national strategies. There is an emphasis on local communities, citizen science, as well as a culture to promote awareness which in turn creates interest and a desire to seek solutions. Culture is a means of information dissemination. Policy continuity, broad social consensus, effective and long-term citizen engagement are also key. There is also need for the creation of emergency/crises response. The European Commission programme is an example of science cultural diplomacy. Working together on water quality issues helps avoid conflicts.

Dr. Jennifer Molwantwa (South Africa): South Africa is a leading country in terms of collaborative development. Collaboration starts with participation, including researchers and technical people, as well as transboundary cooperation. (There is an example of five Universities that were not collaborating properly that can lead to duplicating efforts). Proactive thinking and convincing evidence are needed in order to influence legislation and regulation. There is also need for a cross-sectoral approach, inter-departmental approach, upstream-downstream approach, and open dialogue. It is important to work with private sectors and businesses to find beneficial, alternative solutions. Education and mobilization are important to encourage self-regulation. Scientific collaboration and knowledge sharing are key.

Dr. Ting Ruan (China): research on pollutants has a long history in China, dating back to the 1960s to 70s. Two categories of pollutants are of particular concern: organically persistent and endocrine disrupters. The national research programmes are important drivers. There is a lot of data available. The effectiveness of scientific programmes is reflected in established policies, inclusion in the 5-year Chinese national plan, and in consideration of other economy and development plans. The most important pollutants are regulated, but large-scale capacity-building is very challenging. The pollutants are prioritized at a ministry level. To focus on a few pollutants is not enough. There is a need for more data for better disaggregation according to different contexts.

The second question focused on how a scientific and policy consensus can be built on Emerging Pollutants:

Omar Elhassan (FAO) shared the importance of maintaining ongoing research and bringing all stakeholders together to promote sustainable production patterns. Developing national action plans with cross sectoral and inclusive approaches are important, as is a commitment of the global community to open research and the sharing of information.

Richard Elelman (WWQA UNEP) emphasised that it is critical to avoid the duplication of efforts. Supranational agencies should demonstrate that they build on available data and do not repeat the previous work. It is necessary to understand the justice and social political actors and to be generous with our knowledge-building. Practical solutions need to be applied. We must include the scientific needs in the agendas of politicians from the very beginning. Enforcement follows after decision-making, and for good decision-making, we need public opinion to be active and pushy.

Jennifer Molwantwa (South Africa) brought attention to education and awareness of the population and communities. The COVID pandemic demonstrated how important it is to break down knowledge into understandable pieces and to avoid sensationalizing. Collaborating with other departments and gaining consensus on human health impacts, academic freedom, and visible opinions of universities are key.

Ting Ruan (China) shared that emerging pollutants are not completely different from traditional pollutants. We can rely on existing methodologies and develop new ones to collect more data.

The panel then discussed the importance of Open Science.

Richard Elelman (WWQA UNEP) highlighted that it is important to have understandable data by all sectors (culture, citizens, etc.), to communicate in simple terms, and to target the products for specific, political audiences.

Jennifer Molwantwa (South Africa) shared that better use of smartphones, applications, and social media, the audio-visual balance, could be critical.

Ting Ruan (China) shared the need for developing different focus points for policies and scientists. It is important for scientists to have as much information as possible. A mechanism is needed to translate large amount of data into concrete small conclusions for specific regions and contexts, which would allow for better disaggregation and knowledge synthesizing.

Omar Elhassan (FAO) shared that scientific communication skills are very important for sharing data. There is a need for valid and comparable data to bring to each specific situation. FAO is providing free access to data for all and is working with other agencies to provide integrated data to specifically target policy makers.

In a discussion around how many countries still do not have regulations, Dr Richard Elelman (WWQA UNEP) highlighted that it is critical to convince national governments through the scientific evidence available from local communities (bottom-up approach).

Jennifer Molwantwa (South Africa) shared that it is important that everyone work toward common benefits and accurate, tested information that can be shared. Concerted efforts are needed for finding alternatives and consensus-based solutions.

The high-level discussion ended with all panellists sharing one word that they thought summed up the urgency of the issues; the words were: consensus, inclusion, collaboration, diplomacy, generosity, and data-sharing.

ABSTRACT SESSION 6

THEME 4 "*A CIRCULAR ECONOMY APPROACH: LIFECYCLE MANAGEMENT OF EMERGING POLLUTANTS*"

MODERATOR:
Marjin Korndewal, OECD Environment Directorate, France

CO-MODERATOR:
Dahlia Sabri, KEO International Consultants, Kenya, IWRA Board Director

SPEAKERS:
Júlia Carolina Braz de Freitas Bijos, Federal University of Bahia (UFBA), Industrial Engineering Department
"*Occurrence of antibiotics and psyquiatric drugs in brazilian municipalities: a data analysis approach*"
Kei Namba, Wissenschaftliche Mitarbeiterin in der Einstein Research Unit; Climate and Water under Change (CliWaC), Technische Universität Berlin
"*Bio-based and circular solutions for Harmful Algal Bloom (HAB) and water and climate change challenges in Berlin-Brandenburg*"
Farhad Bolouri, Ph.D. student and Doctoral Research Assistant Faculty of Civil and Environmental Engineering Near East University
"*Management Of Emerging Pollutants with a Circular Economy Approach; Lessons from Developed Countries in This Field, Suggestions for Northern Cyprus*"
Mehnaj Sheikh, Research Scholar, IASE University, Sardarshahar, Churu, Raj., India; Associate Professor (Geography) Govt. Lohia College, Churu, Rajasthan, India
"*Emerging Issues of Water and its Impact on Health: A Case Study of Jaipur City, Rajasthan, India*"
Mezanur Rahaman, Master of Science in Civil and Environmental Engineering, Bangladesh University of Engineering and Technology (BUET)
"*Spatio-Temporal Assessment of Chlorine Residual in the Water Distribution System of Dhaka City*"
Valéria de Carvalho Santos-Ebinuma, Department of Biotechnology, Engineering School of Lorena, University of São Paulo
"*Production and Life cycle assessment of microbial colorants*"

SESSION SUMMARY:
The session started with a keynote speech from Styliani Avraamidou, who explained the Circular Economy Systems Engineering Framework using a coffee case study. Her team suggested MICRON, a Circular Economy assessment framework, to assess the circularity of a production system or company.

Júlia Carolina Braz de Freitas Bijos followed up by sharing findings around Pharmaceutical Active Compounds (PhACs) predominantly found in the sewer water in Brazil. These are Azythromicin and Amoxicillin. They are present because of the low efficacy of wastewater treatment and the overuse of antibiotics due to poor legislation. Amoxicillin concentration is higher due to high human excretion despite Azithromycin being sold at higher rates. Stricter legislation could reduce the load in the waste stream.

Kei Namba then shed light on how Lake Tegel in northwest Berlin is polluted with algae cyanobacteria due to wastewater residue, pharmaceutical micro-pollutants, and due to climate change. Cyanobacteria can be removed through energy-effective treatments and used as a biofertiliser for crop production.

Farhad Bolouri then emphasised the need to determine where the contaminants come from and how they are impacted by lifestyle choices. Traditional treatment methods are not effective for removing pollutants. Advanced technologies and a multidisciplinary team must be employed for effective treatment and removal of pollutants.

Mehnaj Sheikh explained that dental fluorosis and nitrate pollution are occurring due to wastewater and water supply issues. Rainwater harvesting and groundwater recharge can augment the water supply and reduce health problems from contaminated water use.

Mezanur Rahaman discussed the chlorination of Dhaka city water supply, done at the pumping stations. Its residual concentration at spatial and temporal scales, however, is unknown due to a lack of monitoring. There was insufficient coverage of residual chlorine during a study in which 100% coverage of chlorine residuals could not be obtained within a 24-hour period.

Valéria de Carvalho Santos-Ebinuma, elaborated on how a red colorant (RC) by Talaromyces amestolkiae was produced in a bioreactor. A study estimated the environmental impacts of this process using a life cycle assessment. The environmental sustainability assessment indicated that the cultivation stage is a major hotspot in the production process by T. amestolkiae, mainly due to bioprocess time (168 h) and the associated energy requirement.

ABSTRACT SESSION 7
THEME 3: "*EMERGING POLLUTANTS AND WASTEWATER*"

MODERATOR:
Mary Trudeau, Project Officer, IWRA

CO-MODERATOR:
Suryakanta Acharya, Founder, PAY-W Clinic; Consultant Oncologist, Assam Cancer Care Foundation

SPEAKERS:
Cristina Valhondo, Institute of Environmental Assessment and Water Research of the Spanish National Research Council (IDAEA-CSIC)
"*Evaluation of Sustainable materials to boost Emerging pollutants sorption during Soil Aquifer Treatment for Water Reuse*"
Ahmed A. Rezk, M.Sc, Project Manager
"*Reuse of nutrient-rich treated wastewater for food self-sufficiency: Addressing health concerns of emerging contaminants of small-scale farmers through agro-ecological tools – A case study from Fayoum governorate, Egypt*"
Edith Nwakaego Okey, Kwame Nkrumah University of Science and Technology (KNUST), Kumasi
"*Removal of pharmaceutical contaminants from wastewater using ceramic membrane filter*"
Simão Urpia, Federal University of Bahia (UFBA), Chemical Engineering Department
"*Data Science applied to the sanitation sector: an investigation in open databases*"
Wondimu Kebede Wakejo, Africa Center of Excellence for Water Management (ACEWM), Addis Ababa University; Chemical Engineering Department, Wachemo University
"*High surface area chemically activated carbon derived from bamboo sawdust for the remarkable removal of paracetamol from water. Sorption kinetics, isotherm, thermodynamics and regeneration studies*"
Kene Dick, UNICAF University
"*Sustainable development: a strategic approach for sustainable business practices in trade effluent generating industries in Francistown Region in Botswana*"
Lanna Emilli Lucchetti, Universidade Federal do ABC, Bairro Bangu, Santo André
"*Niobum-based advanced nanomaterials for emergent pollutants removal from wastewater*"

SESSION SUMMARY:
Wastewater treatment technologies are important for mitigating the effects of emerging contaminants on environmental and human health. However, there are limitations to the effectiveness of wastewater treatment processes for removing emerging contaminants from the water column. Further, there are many gaps in the research on emerging contaminants' fate in sludge and other wastewater treatment processes.

Cristina Valhondo shared the results of testing five materials that could be used as reactive barriers to promote sorption

and biodegradation of organic molecules for potential use during managed aquifer recharge. All five materials – compost, woodchips, biochar, clay, zeolite – had higher sorption capacity than the reference material, sand. The materials have potential for use in the design of reactive barriers to reduce organic molecules in recharged water (MAR).

Ahmed A. Rezk examined the sources of emerging contaminants in Egypt. Also discussed was the need for a multi-disciplinary approach to address health concerns for wastewater reuse as a nutrient-rich water source for food and self-sufficiency. A framework to identify root cause, dynamic pressures, unsafe conditions, and the risk to economic and human health, while considering the hazards posed by emerging contaminants is a solution for policy development.

Edith Nwakaego Okey highlighted encouraging trial results for assessing the effectiveness of ceramic filters to remove pharmaceuticals. These filters are made from clay, a material that has been used worldwide from time immemorial. The ceramic filters were effective at removing paracetamol, tramadol, morphine, and codeine. The results were unfavourable for diclofenac and ibuprofen under normal wastewater conditions.

Simão Urpia reviewed research methods using publicly available data, including pharmaceutical sales data in Brazil, to understand trends in pharmaceutical presence in wastewater.

Wondimu Kebede Wakejo discussed difficult cost, safety, and operational factors that must be considered to remove CECs from wastewater. Adsorption technologies are low-cost, safe, and effective. Bamboo sawdust was used to create an activated carbon adsorbent. The initial results are encouraging, but they need to be tested on multiple contaminant removals. They are more effective when combined with other advanced oxidation process technologies.

Kene Dick highlighted the cross-disciplinary themes needed to work with industrial dischargers in Botswana to improve compliance rates within discharge requirements.

Lanna Emilli Lucchetti examined emerging pollutant removals using advanced nanomaterials at an experimental and theoretical study level.

ABSTRACT SESSION 8

THEME 3: "*EMERGING POLLUTANTS AND WASTEWATER*"

MODERATOR:
Suryakanta Acharya, Founder, PAY-W Clinic; Consultant Oncologist, Assam Cancer Care Foundation

CO-MODERATOR:
Dahlia Sabri, KEO International Consultants, Kenya, IWRA Board Director

KEYNOTE SPEAKER:
Gordon McKay, Hamad Bin Khalifa University in Qatar
"*Emerging Pollutants – Pitfalls in their Removal – A Case Study*"

SPEAKERS:
Ubhat Ali, Indian Institute of Technology Jammu
"*Algal-bacterial consortia, bioaccumulation, biodegradation*"
Obaid Alharbi, National Center for Water Technologies, King Abdulaziz City for Science and Technology (KACST)
"*The removal efficiency of pharmaceutical residues from three wastewater treatment plants in Saudi Arabia and their potential for pollution of groundwater*"
Maryna Strokal, Assistant professor Water Systems and Global Change (WSG) Wageningen University & Research
"*Multiple pollutants in rivers from wastewater: synergies and trade-offs in future pollution control*"
Yunus Ahmed, Australian Centre for Water and Environmental Biotechnology, University of Queensland; Dept. of Chemistry, Chittagong University of Engineering & Technology (CUET)
"*Removal of emerging pollutants from urban water: Alternation of existing tertiary treatment process by using heterogenous photo-Fenton process*"
Yanyan Huang, Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences
"*Facilitated prediction of emerging pollutant degradation by UV-AOPs in practical waters through combination of model simulation and portable measurement*"

SESSION SUMMARY:
The Keynote Speaker, Gordon McKay discussed how personal care pharmaceutical products are a potential threat to human lives and soil texture because they cause endocrine-disrupting chemicals that disinfect the estrogen process in the human body. Such regular discharge and a lack of regulation concerning emerging pollutants is a primary cause of water pollution. There are several methods to remove pharmaceutical compounds from water. These include chlorination, ozonation, adsorption, and catalytic ozonation. Catalytic ozonation and activated carbon adsorption are the best methods and give 100 % results for removing Ibuprofen and gemfibrozil from the effluent water of hospitals.

Ubhad Ali discussed how the presently adopted centralized schemes for wastewater treatments are not competent. Instead, the use of decentralized water treatment schemes for specific areas and sites can give promising results.

It was noted that after covid-19, hospital wastewater discharge contained epidemiology vectors that combine with sewage water and could lead to other pandemics. This situation is the main reason for an increase in demand for 4th generation drugs. Organic water treatment methods are more efficient and cost-effective. The author suggested that algae offer a bioaccumulation and intercellular degradation method to remove water pollutants from wastewater. It is also environmentally friendly and sustainable in the long term.

Obaid Ali highlighted how Saudi Arabia has limited availability of water due to scant rainfall, so the treated wastewater resources are used for irrigation purposes. The results of the study disclosed that oxidation ditches are more efficient when compared to other methods of wastewater treatment in the country.

Maryan Strokel brought attention to how urbanisation and population growth is the primary cause of water pollution. The results of the MRINA model have indicated that wastewater is expected to be a common source of multiple pollutants in river water. More swage connection means more water pollution; better wastewater treatment measures may prevent water pollution to some extent. Plastics, chemical pathogens, and other human activities are the main reason for emerging water pollutants in the 21st century, especially in North America, Europe, and South Asia. The same trend may continue until 2050, due to the high urbanisation and resulting sewage in Africa and Asia. Thus, better wastewater treatment methods are required to address water pollution.

Younis Ahmed highlighted how existing water treatment methods are incompetent because they are not cost-effective and they do damage to the environment. The heterogeneous photo Fenton process can help to remove water pollution.

Yanyan Huang shared that there are many limitations to removing emerging water pollutants from wastewater and freshwater resources, including heavy workloads (e.g., frequent sample transportation, lab-scale experiments), expensive advanced instruments and equipment, and requirements for advanced professional expertise. The use of the technology, such as ultraviolet advanced oxidation processes (UV-AoPs), has the potential to provide cost-effective results to decreasing emerging water pollutants from wastewater. Model simulation and portable measurement methods agreed that UV-AOP results performed quite well.

ABSTRACT SESSION 9

THEME 1: "*EMERGING POLLUTANTS IN AQUATIC ECOSYSTEMS*"

MODERATOR:
Cassiana Montagner, Associate Professor, UNICAMP, Brazil

CO-MODERATOR:
Callum Clench, Executive Director, IWRA

SPEAKERS:
Qing Zhang, Key Laboratory of Water and Sediment Sciences of Ministry of Education, State Key Laboratory of Water Environment Simulation, School of Environment, Beijing Normal University
"*Identification and occurrence of the chlorinated fipronil and fipronil degradates in municipal wastewater treatment plants*"
Joseph Alcamo, Director, Sussex Sustainability Research Programme (SSRP); Professor, Environmental Systems Science (School of Global Studies; Geography Dept.) University of Sussex
"*Global hot spot areas of antibiotics loading to aquatic systems*"
Mahesh Jampani, International Water Management Institute (IWMI)
"*Antibiotic resistance in aquatic environments: priorities and knowledge for water quality modelling*"
Elhadji Mamadou Sonko, Institute of Environmental Sciences, Cheikh Anta Diop University of Dakar
"*Marine pollution linked to wastewater discharges at the Soumbédioune wharf: Prospects for the implementation of a marine swimming water standard in Senegal*"
Mary Chibwe, Institute for Water Research (IWR), Rhodes University
"*Antibiotic Resistant Campylobacter as an emerging pollutant in the Swartkops River, Eastern Cape, South Africa*"
Paweł Jarosiewicz, European Regional Centre for Ecohydrology of the Polish Academy of Sciences u/a UNESCO; UNESCO Chair on Ecohydrology & Applied Ecology, Faculty of Biology & Environmental Protection, University of Łódź
"*Spatial-temporal monitoring of pesticides in the streams for the development of Ecohydrological Nature-based Solution*"

Yingqi Du, Department of Environmental & Ecological Engineering Guangdong University of Education
"*Transgenerational toxic effects of [Omim]Cl and [DPy]Cl on the water flea, Moina macrocopa*"

SESSION SUMMARY:
Qing Zhang highlighted that there are several contamination sources in urban environments. Disinfectants during the coronavirus disease used chlorine-based disinfectants, which is toxic for human beings. Fipronil is another example of a harmful pesticide. Although it is gradually prohibited for use, Fipronil is widely used around the world. He shared that

in his study, samples were collected from several locations within the PR of China. Chlorination products of fipronil were found in the samples. Concentration of fiproles was 1.52 times higher that fipronil sulfone and fiproles sulfone chloramine. The cumulative concentration of fiproles in the effluents was closed to the toxic dose for some sensitive species. Two Fiporonil byproducts were identified and detected in China. He concluded that chlorination products of fiproles need to be included in future environmental monitoring and ecological risk assessment.

Joseph Alcamo shared that antimicrobial resistance is one of the top 10 global public health threats and is associated with many deaths. It is present in aquatic systems around the world. Since we do not know the pathways for human exposure, his study has developed a new model for identifying hotspots (WaterGAP). Results show high concentrations in catchments compared to rivers and lakes. The hotspot areas are concentrated in east China, northeast India and central Europe, where high concentrations related to human antibiotic consumption. He concluded with the need to deepen study of hot spot areas, making linkages of loadings with water concentrations, and examining risk assessment for antimicrobial resistance being spread via rivers and lakes.

Mahesh Jampani provided an overview of global antibiotic consumption and how it shows high concentration of consumption in China, Brazil, and the USA (related to high concentrations of human populations). He shared that an increase in global consumption of antibiotics was observed during Covid-19, and it has now become an emerging challenge. Antibiotics are used globally in animal agriculture, and millions of deaths occur due to antimicrobial resistance (AMR). Consumption is predicted to increase by 67% by 2030. This study developed a framework for evaluating antibiotic resistance in aquatic environments. The model is complex and shows that AMR is affected by several natural factors (bacteria, sunlight, wind). He concluded that we need cost-effective combination solutions, including treatment technologies and effective management solutions. Water quality modelling plays a critical role in developing scenarios and management solutions.

El hadji Mamadou Sonko discussed his research and goal to evaluate the marine pollution related to effluent discharges from stormwater drainage canals. Several variables were measured, such as salinity, pH, and electrical conductivity. Swimming is not possible due to the high concentrations of water pollutants. Senegal is now developing standards for swimming. He concluded that several parameters need to be monitored, such as Fecal coliforms and the presence of microplastics and heavy metals, since all these pollutants are discharged into the sewer system.

Mary Chibwe emphasised Campylobacter pathogens as the leading etiological agents of gastroenteritis in humans worldwide. Rivers play an important role in the transportation of pathogens and antibiotic resistant bacteria. Campylobacter is present in rivers due to wastewater discharges. In an exploratory study, results showed a high concentration of Campylobacter in several types of water bodies. Various contributing factors can be categorised by field (society, technology, environment, etc.). Campylobacter was detected in most of the water samples taken in the study. Tetracycline resistant genes were also detected in samples that were positive for Campylobacter. This discussion highlighted how innovative technologies for removing/reducing ARB and ARG in effluent treatment is critical. Further, she spoke about the importance of policy measures for curtailing the spread of antibiotic resistance from environmental hotspots.

Pawel Jarosiewicz discussed planetary boundaries and how pesticides are toxic and still frequently used. Apple growing is a significant consumer of pesticides. In a study conducted by his team, 30 pesticides were found where land use is correlated with apple growing. Nature-based solutions are needed in water management.

Yingqi Du explored the impacts of ILs. Ionic liquids (ILs) have been called greener solvents but their effects on crustaceans is unknown. ILs have high water solubility and weak photo- and biodegradability. Moina macrocopa exposed to the ILs tested showed high toxicity, shortened life expectancy, repressed body development, and reduced fecundity. The effects of [Omim]Cl were overcome after 3 generations, but the effects induced by [DPy]Cl continued during the time span of the experiment.

ABSTRACT SESSION 10

THEME 5 "*PRIORITY EMERGING POLLUTANTS IN THE HYDROCYCLE: MICROPLASTICS, NANOMATERIAL, PFAS AND PPCPS*"

MODERATOR:
Cassiana Montagner, UNICAMP, Brazil

CO-MODERATOR:
Robert DiFilippo, Lecturer of Hydrogeology, University of the Philippines

SPEAKERS:
Hadi Toure, National School of Engineers, Mali
"*Nanofiltration of perfluorooctanoic acid and perfluorooctane sulfonic acid as a function of water matrix properties*"
Silvia Pedroso Melegari, Center for Marine Studies Federal University of Parana – UFPR
"*Toxicity and biodegradation of the pharmaceutical diclofenac employing the green marine microalga Tetraselmis sp.: a preliminary study*"
Vinicíus Diniz, Department of Analytical Chemistry, Institute of Chemistry, University of Campinas
"*Direct potable reuse: a prioritisation of emerging contaminants for monitoring strategies and pilot-scale advanced treatment*"
Piero Gardinali, Florida International University, Institute of Environment
"*Prioritisation of emerging pollutants used for fingerprinting specific water sources*"
Marcela Ravanelli Martins, PhD student in Technology with focus on Environment, Faculty of Technology, State University of Campinas (UNICAMP); Technologist in Environmental Sanitation
"*Toxicity of ciprofloxacin through generations of the soil invertebrate Enchytraeus crypticus*"

Juan Pablo Garcia Montealegre, Universidad de Alcala (Spain)
"*Investigating the infiltration of pharmaceuticals and transformation products through agricultural soils*"

SESSION SUMMARY:
Hadi Toure discussed the removal of PFAS (in particular PFOA and PFOS) using filtration techniques. Granular Activated Carbon (GAC) and Ion Exchange treatments seem to work, but membrane systems are more promising. The mechanisms involved for membrane technologies include both size exclusion and electrostatic interactions. The matrix of contaminants in the water affects the efficiency of treatment. There is a need to transfer these technologies and to increase education efforts regarding PFAS in West African countries.

Silvia Pedroso Melegari highlighted how emergent

contaminants are difficult to remove from environmental compartments. Exploring green degradation techniques is an option for these chemicals. Biodegradation tests with a common anti-inflammatory chemical (diclofenac) was tested using microalgae as the degrading organism. It showed that algae does grow in the presence of diclofenac, so they could be a viable organism to degrade the pollutant but efficiency needs to be improved.

Vinicius Diniz called attention to how water scarcity is related to our ability to clean it for potable use. Emergent contaminants create a limitation since treatment is not systematic. Water reuse and recharge is commonly used for water conservation. A selection of specific PPCPs were used for testing treatment and recharge. Reverse osmosis seems to be the most efficient treatment process. Direct potable reuse is a valuable option for fighting water scarcity.

Piero Gardinali shed light on non-target analysis (NTA) as a useful tool for understanding emergent contaminants through statistical analysis on well-defined time and geographical scales. NTA can be used to differentiate water sources in a system and to assess how water is influenced by its urban environment. Both NTA and traditional analysis are needed to understand sources of emerging contaminants.

Marcela Ravanelli Martins explored how the antibiotic ciprofloxacin (CIP) is accumulating in soils. It is not fully metabolised by humans or animals, but it is present in urban and agricultural wastewater streams. CIP is persistent and accumulative. The antibiotic seems to be toxic to soil organisms on a multi-generation scale; offspring seem to be more sensitive to the drug than the parent generation.

Juan Pablo Garcia Montealegre discussed his investigation into the infiltration of four pharmaceuticals and two of their transformation products through agricultural soils. Modelled attenuation of the contaminants with infiltration into the soils of the study area indicated positively that ionised compounds had higher sorption affinity. The field conditions of the test site, such as an absence of organic matter, may influence the results. Having a predictive model will help understand the fate of these contaminants in soils.

HIGH-LEVEL PANEL 2

"SCIENCE-POLICY MEASURES TO PROTECT HUMAN HEALTH FROM EMERGING WATER POLLUTANTS"

MODERATOR:
Gabriel Eckstein, Professor, Texas A&M University School of Law; Immediate Past President, IWRA

CO-MODERATOR:
Christian Fischer, Cofounder at Water Science policy

PANELLISTS:
Bruce Allan Gordon, World Health Organisation

Joan Rose, Homer Nowlin Endowed Chair in Water Research; Professor; Co-Director, Centre for Water Sciences and Centre for Advancing Microbial Risk Assessment, Michigan State University, USA
Mohamed El Banni, Professor of Molecular Toxicology, Tunisia
Cindy Wallis-Lage, Former President, Global Water Business, and Former Executive Director, Sustainability and Resilience, Black & Veatch (retired), USA

SESSION SUMMARY:
This high-level panel commenced with the Moderator asking a general question to all: **What is the greatest concern that keeps you up at night?** The panelists provided the following responses:

Joan Rose: Children dying from contaminated water is a major worry. Insufficient monitoring and neglect of groundwater are prevalent issues. Pathogen pollution is on the rise.

El Banni: Lack of awareness regarding emerging pollutants (EP) and macro plastics in drinking water (from plastic water bottles) is concerning. Human cells contain a significant amount of microplastics, which may be correlated with upcoming pathogens.

Wallis-Lage: The need for expedited identification of pollutants and sustainable solutions is crucial. Health problems serve as drivers for taking action. Timely identification and meaningful actions are key.

Gordon: Two billion people consume contaminated water, and there has been a 50% increase in contamination. Understanding the true risks from a total toxicity perspective is essential. A risk assessment model is needed that takes into account antimicrobial resistance (AMR) and climate change.

Gabriel highlighted the lack of knowledge, monitoring, and awareness. Rose emphasized that monitoring programs are fragmented, and inadequate databases are a concern.

However, building laboratory capacity can be fast, as exemplified by the COVID-19 situation. Cindy emphasised the need for more consistency among international organisations and data sharing.

How should efforts to manage numerous EP be prioritised?

Gordon: Low-resource countries and different contexts should be considered. Public concerns about specific pollutants often overshadow others. Understanding catchments and local monitoring are essential. Monitoring a few general pollutants and others locally is recommended.

Rose: Health and environmental concerns are significant. Moving faster and being more aggressive in finding solutions is important (faster monitoring for quicker decisions). Limitations still exist in improving lower detection. The question is whether we have more data thanks to better technologies or if water is genuinely more polluted. Partnership and collaboration, including private and public entities for increased funding, can expedite progress.

Rose: Compliance monitoring is not always the best approach for risk assessment. The hazard life cycle should be considered, and industries can do more. Investment in models and adaptive monitoring programs is needed. Communities and citizen science plays a valuable role. Collective thinking is crucial.

El Banni: It is important to define criteria in each country, considering the local context and establishing thresholds. Mixture plastic pollution should also be taken into account.

Wallis-Lage: Climate change exacerbates the issue of contaminants and requires rapid action.

Treatment technology versus prevention: Which approach is more effective?

Dr. Rose: Policies lag behind and require good science and data. Collectively, we can develop mapping models that scale from global to local. Selective monitoring and improved prevention through pretesting are vital. Considering the life cycle of hazards is important.

Bruce: Prevention is better. Treatment costs are significant and are ultimately borne by consumers. Non-cost-effective solutions exist, and preventive risk management is crucial. Regulation is necessary for both private and public entities.

Rose: The policy-making process is slow. To accelerate progress, we need to educate the public and raise awareness. A collective voice is needed for environmental policies and knowledge sharing. However, progress is often slow. Strong international organisations should discuss risk frameworks, preventive measures, and required investments.

Cindy: Different countries have different speeds and objectives. Public education is critical as it influences government and business actions. El Banni shared a case study in the Mediterranean where Europe progresses rapidly while North Africa lags behind. Coordination becomes challenging. Focusing on the real situation in one ecosystem is recommended. Bruce suggested moving from producing guidelines to broader knowledge. International regulations frameworks, including those addressing plastics, should be dealt with while considering competing priorities.

Q&A SECTION

What policy efforts should prioritise sub-products contamination?

Rose: Global industry alliances (such as the plastic alliance) and communities of practice can hold industries accountable for pre-testing. More scientists should be involved in these industries.

Cindy: Accountability is crucial. Cleaning up contamination is difficult and expensive. Private companies should be held accountable for the decisions they make.

Is there a gender component in EP and exposure to contamination?

Rose: We need more women in the profession, including women scientists, educators, and decision-makers in industries.

Bruce: The role of women in water management is currently very limited. It is crucial to involve more women in decision-making.

UN 2023 Water conference and Emerging Pollutants?
Bruce: The conference includes an interactive dialogue on water and health, with a focus on emerging contaminants. Water services should be continuous and cross-sectoral. Addressing pollution in the context of waste is a win-win approach.

Rose: Dialogues and publications related to water have a long history. The conference is of great importance and should be widely mediated. Water is interconnected with many other topics.

One-word answer: What is the most effective way to prevent the release of EP into the environment?
Rose: Treatment (WWT)

Gordon: Prevention

Wallis-Lage: Accountability

El Banni: Awareness

CLOSING CEREMONY

MODERATOR:
Renée Martin-Nagle, IWRA Treasurer; CEO, A Ripple Effect pllc; Special Counsel at Eckert Seamans; Visiting Scholar at the Environmental Law Institute

CO-MODERATOR:
Monica Garcia Quesada, Smart Water Cities Project Officer, IWRA

SUMMARY REMARKS FUTURE FOCUS:
Callum Clench, Executive Director, IWRA
Abou Amani, Director, Division of Water Sciences Secretary, Intergovernmental Hydrological Programme (IHP) UNESCO

CLOSING REMARKS:
Abou Amani, Director of the Division of Water Sciences and Secretary of the Intergovernmental Hydrological Programme – IHP

ISC PRESENTERS:
Gisela de Aragão Umbuzeiro, The State University of Campinas – UNICAMP

Dahlia Sabri, KEO International Consultants, Kenya\
Marjin Korndewal, OECD Environment Directorate, France
Piero Gardinali, Professor, Department of Chemistry & Biochemistry at Florida International University

CLOSING REMARKS:
Sarantuyaa Zandaryaa, Programme Specialist, Division of Water Sciences, Intergovernmental Hydrological Programme (IHP), UNESCO
Gabriel Eckstein, IWRA Past President; Professor of Law at Texas A&M University and Director of the law school's Program in Natural Resources Systems.

KEY MESSAGES:
- There is no food production without water resources.
- To achieve more equitable and secure access to water, we need to build a stronger knowledge of water governance and explore its linkages to the achievement of the diverse sustainable development goals, such as climate change resilience, gender equity, and sustainable life on land.
- A better understanding of water governance and water tenure is necessary for achieving major transformations, especially if we are progressing towards sustainable and

inclusive land and water management and use.

- Water is a vital resource; everyone, including smallholder farmers must be able to access and use it without excluding others .
- The national adaptation plans make very specific adaptation actions on water.
- Women constitute about 43% of the world's agricultural labour force, but they are much less likely than men to have control over their water resources.
- The fact that water laws are generally Gender-Blind means that, in practice, they often reinforce existing gender inequities and discriminatory cultural norms.
- Strengthening women's water tenure involves ensuring that women have access to a comprehensive set of rights that are crucial for their rights to water.

SESSION SUMMARY:

Water tenure is tied to water governance. This is important when considering global changes and challenges accentuated by the current pandemic situation, because the pressure over natural resources is intensified. This pressure calls for responsible governance of natural resources to promote economic development and livelihood for all communities and programs affected, to ensure food security. Water scarcity and land degradation could result in food insecurity.

The interdependencies between water, land, and food are visible through intense demand for these resources, due to the continuous growth of the population and changing consumption patterns. These challenges cannot be effectively confronted without appropriate and good governance arrangements that address these complex interdependencies and trade-offs across natural resources and across economic sectors. A responsible governance of water resources can articulate the interests of citizens, mediating the differences between communities and ensuring their rights and duties to water are exercised with transparency and equity. The concept of water tenure will help to elucidate these issues and identify, recognise, and ultimately protect all legitimate water rights. Doing so can work to eradicate hunger and ensure that no one is left behind.

Freshwater resources were identified as a priority area by enhancing water infrastructures through water resources planning, strategies, and systems. The aim is to achieve a good efficiency in irrigation and integrated water resource management, which also includes, for example, protection and restoration of water-related ecosystem forests, wetlands, and rivers, and also supply diversification.

Women around the world have important water management responsibilities, as well as unique water needs and differentiated priorities for water use and management, globally. Women and girls maintain much of the unpaid burden of household work, including water collection. Women also play critical roles in food production and water management for both household and productive uses. Therefore, satisfying the water and sanitation needs of women and girls is an important aspect of achieving positive reproductive health outcomes. Doing so would also aid in increasing educational opportunities for girls in order to realise the SDG 5 targets. However, men continue to dominate water governance and decision-making at all levels. This continued failure to represent women's water needs, knowledge, and skills in decision-making inhibits the establishment of truly equitable and sustainable water policies and practices. There is a critical need to more clearly recognise and protect women's water rights at the national and regional level. The fact that water laws are generally Gender Blind means that in practice, they often reinforce existing gender inequities and discriminatory cultural norms.

The water sector operates within a dynamic and complex environment, functioning as an ecosystem that provides various functions and services. It plays a crucial role in preserving biodiversity and maintaining a healthier environment. Tenure, when effectively developed, offers multiple perspectives to address the needs of diverse users, including indigenous women, farmers, fishermen, and others. Enhanced access to water for all these groups can lead to improved food security and overall well-being

CONCLUSIONS

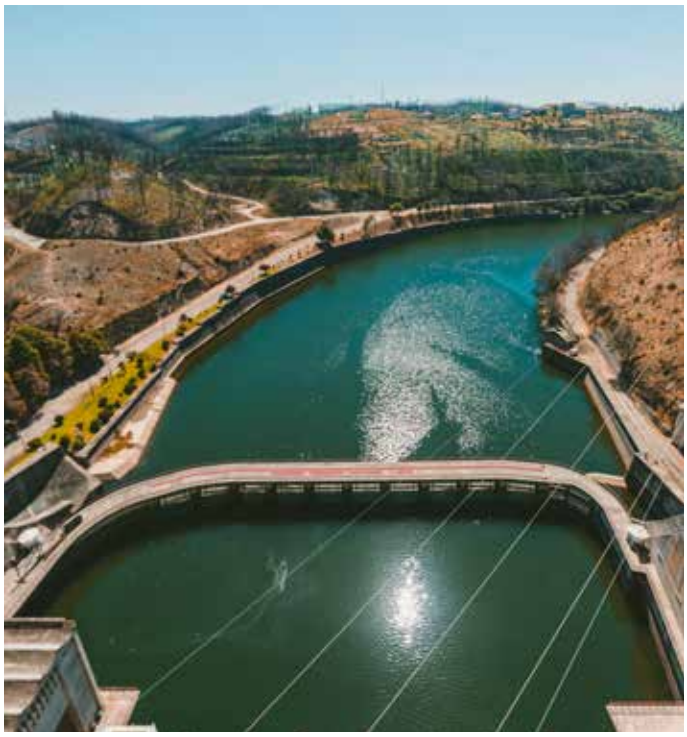
The UNESCO-IWRA Online Conference has successfully brought together the international water community and addressed the pressing issue of emerging pollutants in water resources. The overwhelming participation of over 2700 registered attendees, including women and young professionals, from more than 120 countries, including Africa and low-income countries, highlights the growing interest and urgent need to tackle this problem.

Throughout the conference, it has become evident that one of the biggest challenges in addressing this problem or formulating solutions has to do with knowledge-sharing and available research. This extends not only to the international water community, but to all stakeholders responsible for managing water resources, as well as the industries involved in the production and use of these chemicals. Raising public awareness about the implications of emerging pollutants is fundamental, as is establishing a common language around water resources management.

This conference shed light on numerous risks associated with these contaminants, including micropollutants, pharmaceuticals, and PFAS ("forever chemicals"). The European Union alone incurs billions of euros in annual costs related to assessing and addressing the impacts of these contaminants to human health, including the consumption of contaminated food and water. Such risks provide a strong argument for banning these chemicals; however, identifying safer alternatives also remains a significant objective requiring further exploration.

The conference also highlighted the need to sustain systematic study capacities in regions such as Africa, Asia, and Latin America, concerning the different types of emerging pollutants, their occurrences, transportation, and impact on various water bodies. By focusing on dedicated groundwater themes, the conference provided a unique opportunity to showcase scientific advances in untapped areas, shedding light on remediation and restoration aspects in different parts of the world.

The conference successfully incorporated discussions on technological and policy responses, as well as innovative approaches such as lifestyle management, circular economy principles, and nature-based solutions. However, it was evident that more policies need to be shaped or



developed to comprehensively address these issues, with a particular emphasis on prevention, treatment, regulation, and accountability.

While the UNESCO-IWRA Online Conference emphasised the urgent need to address the negative impacts of emerging pollutants, it also provided strong arguments that robust research, knowledge, and tools are available to overcome these challenges.

The wealth of information and research presented during the two-and-a-half days will be shared through IWRA and other international platforms, networks, and events, fostering participatory discussions and collaborations on this topic.

IWRA's core mission continues to focus on bridging the science, policy, and practice interface in a rapidly changing world for the betterment of human and environmental health. It is crucial that all involved emphasise the importance of interdisciplinary collaboration, incorporate specific examples and case studies to clarify the importance of building a common language, and promote education and capacity-building initiatives. By taking concrete actions and addressing emerging pollutants, collectively, we can work towards ensuring sustainable and safe water resources for future generations.

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