What is contaminating our waters next?

CONTAMINANTS OF EMERGING CONCERN (CECs) – NOVEL WAYS TO REDUCE THEIR HUMAN AND ENVIRONMENTAL RISKS

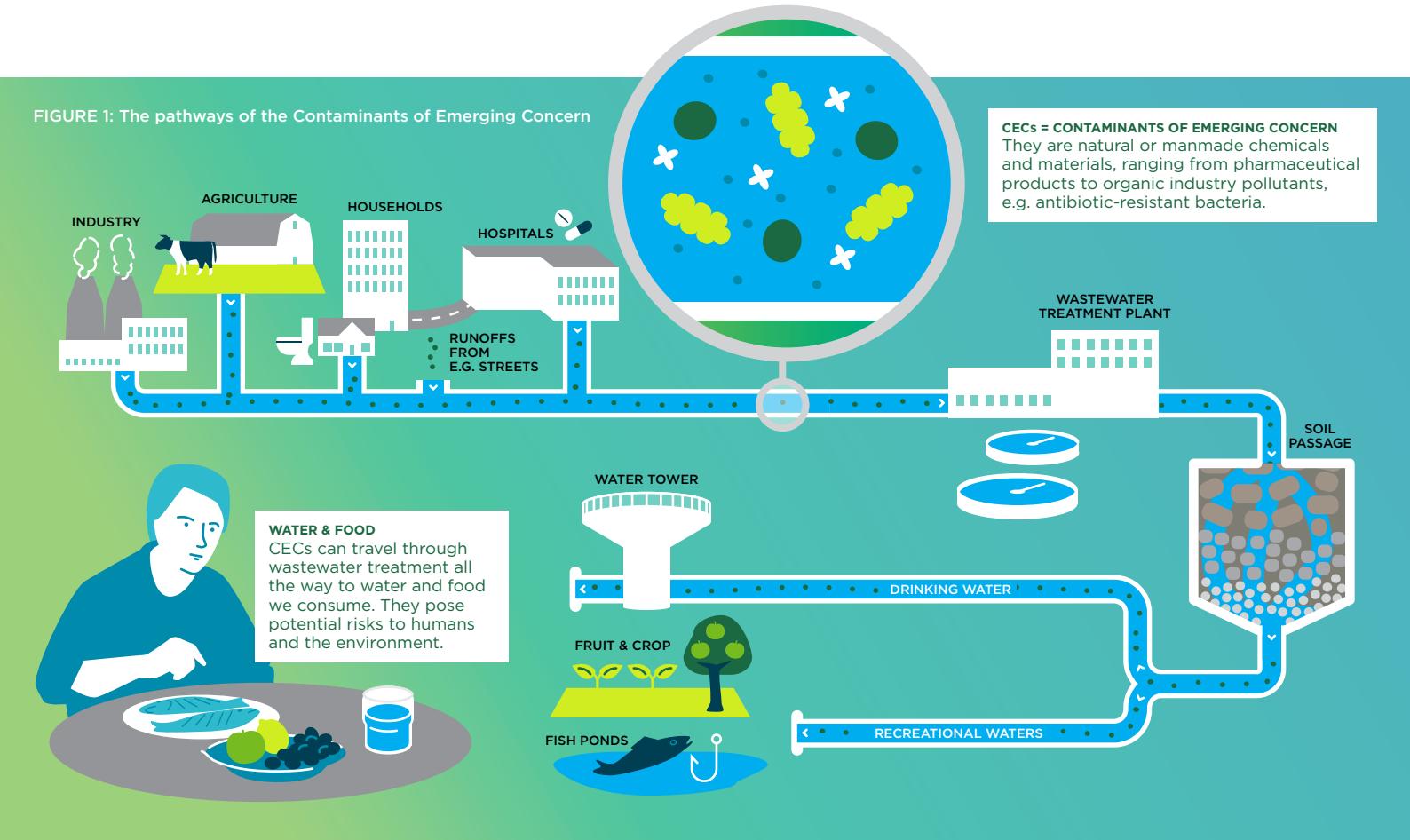
CECs are a rising problem in the waters we use! Contaminants of emerging concern (CEC) is a designation that can be attributed to contaminants that appeared recently or that are present in the environment for some years, but which only recently have raised the concern about their ecological or human health impacts. Although CECs refers most commonly to chemicals, the broad perception herein presented applies also to microorganisms, such as antibiotic resistant bacteria and their antibiotic resistance genes, or particles, such as nanoparticles or microplastics. All these contaminants can occur and diffuse through the water cycle mostly in ways we do not fully understand.

As society continues to generate these chemicals by e.g. creating and designing new compounds and new materials by industrial processes, as well as, by individual consumption behaviour, we find them more and more in the aquatic environment all over the world. There is a general concern that they pose threats to aquatic life and, thus to human and environment health.

The current body of evidence on the nature and behaviour of CECs is thin and new scientific knowledge is needed to improve the management of their potential risks that are related to humans and the environment.

It is necessary that current European Union (EU) legislation, chemical regulatory and water management agencies be fully capable to address the problem in a sustainable and efficient manner. To take full responsibility of the CECs we produce, policymakers and water management practitioners need clear guidelines to respond to this environmental and societal challenge. By 2030, we should reach the Strategic Development Goals (SDGs) of United Nations (UN), where Goal number 6 is "Ensure availability and sustainable management of water and sanitation for all".

FIGURE 1: The pathways of the Contaminants of Emerging Concern



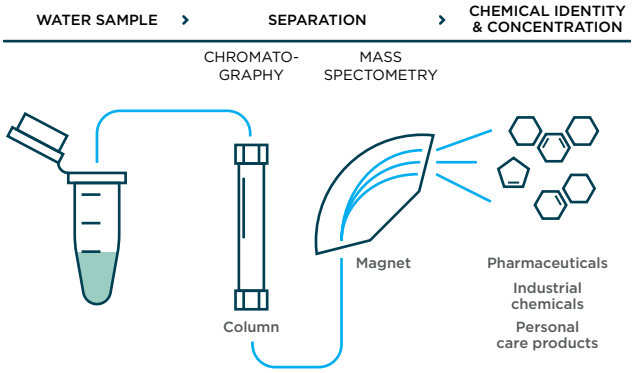
NEW RECOMMENDATIONS FROM WATER JPI – BACKGROUND

The aim of the Water JPI's first multi-national research Call (Pilot Call 2013) was to identify novel ways to efficiently assess, prevent, control and remove freshwater CECs, thereby preventing risks to human health, improving citizen's quality of life and securing the ecological functions of water ecosystems now. This aim responded directly to one of Water JPI's priority action defined in the Strategic Research and Innovation Agenda V2.0 (SRIA 2.0, Theme 2) to protect the health of citizens through the provision of safe water, with a special attention to the impacts of emerging pollutants.

In this policy brief, the seven projects funded by 10 countries during 2014–2017 present here a fresh evidence-based synthesis of their solution-oriented outcomes. It includes recommendations for policymakers and practitioners to deal with the problem of this globally important societal issue to make sure that wastewater reuse is safe for humans and environment.

The Water JPI plays an active role in this research field: The first Water JPI Knowledge Hub is being built around the topic of "Emerging Pollutants" and during the 2019 European Commission is opening an action for an ERA-Net Cofund with the scope: "Risks posed to human health and the environment by pollutants and pathogens present in water resources". This action is partly based on the SRIA of Water JPI.

FIGURE 2: A flow scheme of the highly sensitive analysis of CECs in aqueous samples using the method of liquid chromatography-mass spectrometry.



Key messages

PM = POLICYMAKERS, PR = PRACTITIONERS

IDENTIFY & PREVENT

How can we better identify and prevent contaminants of emerging concern in freshwater?

ANTIBIOTIC RESISTANCE MAY TRAVEL TO HUMANS VIA IRRIGATION OF READY-TO-EAT FRUITS AND VEGETABLES!

PM: Antibiotic resistant bacteria (ARB) and antibiotic resistance genes (ARB) must be addressed in water safety plans. The more we use antibiotics, the more we find antibiotic resistance genes (ARG) in the aquatic environment. But other drivers, such as climate conditions, are also important and will increase risks. Global and local action plans for prevention CECs release are recommended with particular consideration to treatment capacities and affordability.

PR: Metagenomics and targeted analyses of microorganisms in environmental waters have proved to be powerful tools for public heath surveillance.

MANY NEW MOBILE CHEMICALS[2] SLIP THROUGH CURRENT TREATMENT AND MONITORING!

PM: CEC mobility in groundwater and waterworks is crucial for the quality of drinking water and thus, needs to be considered in chemicals authorisation, regulation and legislation.

PR: Water quality monitoring should direct more effort towards persistent mobile substances to ensure drinking water quality.

THERE IS A NEED FOR SYSTEMATIC STRATEGY HARMONISATION AND DATA SHARING!

PM: We need a harmonised water control and legislation strategy (up to EU Water Framework Directive and its' daughter directives) that considers the entire urban water cycle from wastewater to drinking water, including treated wastewater reuse.

PR: The most advanced identification/detection methods of state as set in the State of the Art should be used for increasing prevention measures (FIGURE 2)[1].

PR: Curated databases on water quality with suitable metadata and analytical values (standard parameters and key contaminants) should be made accessible at water quality monitoring policies, in research infrastructures and in research projects.

CONTROL, TREAT & REMOVE

How to better treat and remove CECs in our wastewater?

INTEGRATION OF NEW MONITORING, TREATMENT AND ANALYTICAL TECHNIQUES LEADS TO IMPROVED MANAGEMENT OF CECS!

PM: Processes for wastewater and drinking water treatment, monitoring strategies, modelling approaches and the interpretation of data are all interconnected aspects and they should be combined in a holistic management strategy.

PM & PR: Source management to minimise the occurrence of CECs and multi-barrier treatment processes (e.g. ozone, activated carbon, soil passage) to reduce the concentration of CECs, are the most effective for adjusting / adapting to local contexts.

PR: Environmental buffers, such as soil passage, are useful in the treatment pathway, to plan the local treatment pathway, novel management tools (handbook, software for decision-support) for treatment options are already available.

PR: Effect-based tests to recognize e.g. antibiotic resistance genes (ARG) from cell-based to whole organisms can help provide environmental and human health assessments of treated wastewater.

IT IS WISE TO ADJUST MANAGEMENT OF CECS SITE-SPECIFITY!

PR: Indicators of CECs should/can always be tailored to the question and the site-specific situation.

PR: Local pollution source characterisation is needed to make effective investments where pollution loads are the highest.

ASSESS IMPACT & RISKS

How to assess the risks of the CECs for water resources in natural environment?

PM: PLAN YOUR MONITORING AND AQUIFER MANAGEMENT ACCORDING TO LOCAL CONDITIONS!

PR: Many CECs, such as pharmaceuticals and antibiotic resistant bacteria or resistance genes are highly persistent and they have high spatial and temporal variability of the occurrence in groundwater at catchment scale where they are affected by local conditions. Thus, the pathways of the contaminants should be locally recognized.

PR: Follow the trends of the most common CECs, as a chemical is never alone!

PR: New rapid on-site methods (LAMP and Au-nanoprobe approaches for ARG analysis) are soon available for large-scale deployment.

PM: CECS CAN TRAVEL EASILY FROM SURFACE WATER TO GROUNDWATER/DRINKING WATER! TRACK THEM WITH ADVANCED METHODS.

PR: To recognise the pathway, fingerprinting and geochemical isotopic methods can be used to assess the source and flow path of the CECs.

PR: Risk assessment models (for drinking, irrigation and recreational waters) can provide monitoring criteria for potential antibiotic-resistant micro-organisms exposure in pre-treated and drinking water. These models can set local guidelines for producers on maximum permissible contamination levels in irrigation water, too.

Reducing CEC risks is globally urgent – act now!

These findings and recommendations have a strong impact on how we manage CECs now and in the future. They must be considered by all relevant policy-makers, when developing all freshwater-related EU Regulations and Policies, especially considering the current Common Implementation Strategy (CIS) and the forthcoming renewal of EU Water Framework Directive 2000/60/EC. The results presented here strongly support work done in NORMAN network.

Reducing the risks caused by CECs is of global importance; the recommended policy actions here help us partially reach the set of water-related SDGs (3, 6, 11, 12 and 14) set by the UN.

Join forces! Water JPI with its wide range of expanding activities continues the production of timely policy briefs to achieve the critical mass of knowledge about how to respond to the global societal challenge of achieving sustainable water systems for a sustainable economy.

KEY QUESTIONS ADDRESSED BY THE WATER JPI PILOT CALL PROJECTS

IDENTIFY & PREVENT

PROMOTE: How to better protect drinking water from persistent mobile substances?
METAWATER: How to better evaluate the role of irrigation water in the transmission of CECs to human population?
StARE: What is the role of wastewater treatment plants (WWTPs) in the prevalence of clinical antibiotic resistance?

CONTROL, TREAT & REMOVE

FRAME: Can we improve and properly evaluate the wastewater treatment via running it through environmental buffers (indirect potable reuse, IPR)?
MOTREM: How to integrate better CEC monitoring and treatment in wastewater treatment plants (WWTPs)?

ASSESS IMPACT & RISKS

PERSIST: Do CECs travel from surface to groundwater?
TrACE: How to evaluate the health risks of antibiotic-resistant micro-organisms in surface water?

INTERNET SOURCES

Water JPI: http://www.waterjpi.eu
Water Framework Directive 2000/60/EC: http://ec.europa.eu/environment/water/water-framework/index_en.html
Common Implementation Strategy (CIS) for the Water Framework Directive: http://ec.europa.eu/environment/water/water-framework/objectives/implementation_en.htm
The NORMAN network: https://www.norman-network.net/
Strategic Development Goals of United Nations: https://sustainabledevelopment.un.org/?menu=1300

LITERATURE

Water JPI, Open project database: www.waterjpi.eu/index.php?-option=com_chronoconnectivity5&-cont=lists&ccname=Project_Database&Itemid=1030
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1. Hermes, N., Jewell, K.S., Wick, A. and Ternes, T.A. (2018) Quantification of more than 150 micropollutants including transformation products in aqueous samples by liquid chromatography-tandem mass spectrometry using scheduled multiple reaction monitoring. Journal of Chromatography A 1531, 64–73.
Manaia, C.M. (2017). Assessing the Risk of Antibiotic Resistance Transmission from the Environment to Humans: Non-Direct Proportionality Between Abundance and Risk. Trends in Microbiology, 25(3):173–181
2. Reemtsma T., Berger U., Arp H.P.H, Gallard H., Knepper T.P., Neumann M., Quintana J.B., de Voogt P. (2016) Mind the gap: Persistent and mobile organic compounds – water contaminants that slip through, Environ. Sci. Technol. 50, 10308–10315 (Feature Article).