EGU25-8167, updated on 30 Apr 2025
https://doi.org/10.5194/egusphere-egu25-8167
EGU General Assembly 2025

Resilience to Future Changes: Assessing the Impact of Human Wastewater Emissions on Microbiological Water Safety Along the Danube

Julia Derx[1,2], Peter Valent[1], Sophia Steinbacher[3,4,2], Ahmad Ameen[1,2], Anna-Maria König[1,2], Katalin Demeter[3,2], Rita Linke[3,2], Regina Sommer[5,2], Gerhard Lindner[5,2], Alois W. Schmalwieser[6], Julia Walochnik[7], Alexander Kirschner[4,8], Robert L. Mach[3], Sílvia Cervero-Aragó[5,2], Matthias Zessner[9], Steffen Kittlaus[9], Günter Blöschl[1], Margaret Stevenson[1,2], Alfred Paul Blaschke[1,2], and Andreas H. Farnleitner[3,4,2]

[1]TU Wien, Institute for Hydraulic Engineering and Water Resources Management, Vienna, Austria (derx@hydro.tuwien.ac.at)
[2]ICC Water & Health: Interuniversity Cooperation Centre Water & Health (www.waterandhealth.at)
[3]Institute of Chemical, Environmental and Bioscience Engineering, Microbiology and Molecular Diagnostics E166/5/3, TU Wien, Gumpendorferstraße 1a, A-1060 Vienna, Austria
[4]Division Water Quality and Health, Department of Pharmacology, Physiology, and Microbiology, Karl Landsteiner University of Health Sciences, Dr.-Karl-Dorrek-Straße 30, A-3500 Krems an der Donau, Austria
[5]Institute for Hygiene and Applied Immunology, Water Hygiene, Medical University of Vienna, Kinderspitalgasse 15, A-1090 Vienna, Austria
[6]Institute of Physiology and Biophysics, University of Veterinary Medicine, Veterinärplatz 1, 1210 Vienna, Austria
[7]Molecular Parasitology, Institute of SpecificProphylaxis and Tropical Medicine, Medical University of Vienna, Austria
[8]Institute for Hygiene and Applied Immunology, Water Microbiology, Medical University of Vienna, Kinderspitalgasse 15, A-1090 Vienna, Austria
[9]Institute of Water Quality and Resource Management E226, TU Wien, Karlsplatz 13, A-1040 Vienna, Austria

Transboundary rivers are crucial resources for drinking water, recreation, and irrigation. However, wastewater emissions and global environmental and demographic changes can impair raw water quality and pose risks to public health. This study aims to assess the impact of emissions from wastewater treatment plants, combined sewer overflows (CSOs), and inland waterway transport on microbiological water safety along the upper Danube River Basin (DRB).

To achieve this, we developed a stochastic mathematical model to trace pathogen load emissions throughout the river network. The model predicts concentrations of reference pathogens (*Cryptosporidium*, *Giardia*, *Campylobacter*, norovirus, enterovirus) in the river for current conditions and a future climate scenario represented by a selected CORDEX RCP 8.5 high emission scenario. The study estimates bathing water infection risks and determines the required pathogen logarithmic reduction in raw river water to ensure safe drinking water. The model accounts for exponential pathogen inactivation rates influenced by water temperature, solar ultraviolet radiation, and lake sedimentation (for protozoan cysts/oocysts). High-resolution navigational information based on automated identification system (AIS) data, detailing the number and location of ships, were used to model the impact of inland waterway transport. The data were

aggregated into monthly average daily ship volumes across three ship types (cruise, passenger, and freight) along a section of the Danube River. Model validation was conducted using monthly data sets spanning 2–4 years, including cultivation-based standard fecal indicators, human-associated genetic fecal microbial source tracking markers (HF183/BacR287, BacHum), and reference pathogens (*Cryptosporidium*, *Giardia*). Additionally, the study investigates whether the crAssphage marker (CPQ_056) serves as a suitable proxy for human viral fecal contamination in water quality modeling, compared to standardized viral indicators such as somatic coliphages. To understand the effects of future changes on water safety, various scenarios and combinations up to the year 2100 are analyzed, including population growth (affecting wastewater emissions), climate change (impacting river discharge and microbial inactivation), advanced wastewater treatment, reduction of CSOs (in line with the recast of the European Urban Wastewater Treatment Directive), and changes in inland navigation and ship wastewater handling.

The findings indicate that tertiary treated municipal wastewater currently has the greatest impact on river water safety. However, if additional disinfection (quaternary treatment) is implemented, other pollution sources, such as ship navigation and CSOs, as well as climate change effects, will play an increasingly significant role in determining microbiological water safety.