Title:
Hydrodynamic Model-Assisted Tracking of Antimicrobial Resistance Dynamics at the Wastewater-Lake Interface in Vidy Bay, Lake Geneva, Lausanne

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Abstract (300 words maximum): :
Antimicrobial resistance (AMR) is a global health threat driven by antibiotic misuse in medicine, agriculture, and aquaculture. The One Health approach recognizes the interconnectedness of human, animal, and environmental health. Lakes receiving treated and untreated wastewater are AMR dissemination hotspots, yet the underlying dynamics remain poorly understood. This study investigates AMR dynamics in Vidy Bay, Lake Geneva - a potable water source and a recreational area in Lausanne, underscoring the public health relevance of this study. Effluent from the Lausanne sewage treatment plant (STEP) is discharged into Vidy Bay at a depth of 30 m. It's further transport and fate is difficult to predict. Understanding the AMR dynamics in the Lake is useful to determine the AMR distribution and predict risk associated with wastewater plumes in 3D.

We developed a new approach, where sampling efforts were guided by hydrodynamic model assisted Lagrangian particle tracking predictions of the expected wastewater plume movement. Water samples were collected at varying depths (2, 25, and 30.5 m), distances from the STEP outfall, and across two seasons. Microbial communities and their Antimicrobial Resistance Genes (ARG) content were analyzed by 16S rRNA gene and ARG (intI1, sul1, sul2, tetW, tetM, qnrA, ermB, blaCTX-M-1, vanA) quantification using qPCR and 16S amplicon- and shotgun metagenomic sequencing with a GridION Oxford Nanopore Sequencer. We found that AMR indicator (intI1) and clinically relevant ARGs were at least two-log higher in STEP effluent and half-log higher at Lausanne Beach compared to lake samples. ARG abundance was elevated at the STEP outfall and transported along the model-predicted plume path. The presence of wastewater bacteria (Thermomonas, Aeromonas, Dechloromonas, Ferruginibacter, Zoogloea, Rhodobacter, etc.) further confirmed the plume influence. Seasonal and lake stratification effects on ARG distribution and dynamics were notable. These results show that the model-supported field investigation strategy is promising.