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Global assessment of antibiotics in river systems using a high-resolution contaminant fate model

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Recent studies have brought to attention how residual antibiotics from domestic, agricultural and industrial wastes have been found in alarming quantities in the world's rivers. Evidence is growing that significant concentrations of these substances may lead to the gradual development of drug-resistant bacteria, among many other potential impacts. Still, there is a lack of observational data in the field since these substances are not typically included in routine monitoring programs, especially in developing regions. In this work, we develop a model to estimate the emission of various antibiotics and their subsequent transport in river networks at high spatial resolution and global scale, enabling first-time estimates of the surface-water concentrations of these compounds for virtually any river in the world.

The transport in the river system is estimated using the contaminant fate module in the high-resolution, global river routing model HydroROUT. A key component of this research is the integration of three novel datasets in the modeling approach. These datasets include: (1) the average levels of consumption of antibiotics for each country in the world, which are used to estimate the release of the antibiotics in each region; (2) a global database of wastewater treatment plants (WWTPs); which are used to geo-locate point sources of the contaminant discharges into river networks and (3) a global compilation of measured pharmaceutical concentrations in river reaches that is used for model validation.

The WWTP global database includes detailed information (mostly from official regional or national sources) on 58,502 individual plants such as their facility and discharge locations, population served, flow rate of wastewater discharge, and level of treatment of processed wastewaters. Being essential to spatially explicit water quality assessments, in cases where this information was not available, auxiliary datasets such as a satellite-derived population grid and a DEM-derived river network were used to estimate missing attributes.

The high resolution (500-meters) predictions of the model can be used in a variety of subsequent applications. First, the model can be used to identify specific areas in river networks where high concentrations of contaminants are expected and where field studies should be focused. Secondly, scientists and regulators can use the model to develop screening methods to inform the development of guidelines or regulations designed to minimize the risks associated with the environmental release of pharmaceuticals. Thirdly, governments and operators of wastewater

treatment facilities can use the model to set appropriate treatment standards for individual wastewater treatment plants and to ensure that advanced treatment technologies, which are inherently resource-intensive, are deployed only in areas where they are needed. And, finally, wastewater treatment technology providers can use the results to drive the development and deployment of new treatment technologies with potential global markets.