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Prediction of household pharmaceutical concentrations in global rivers using a large-scale contaminant fate model

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The contamination of freshwater systems is increasing in many river basins globally due to industrialization and population growth. Emerging contaminants such as pharmaceuticals and personal care products, synthetic hormones, pesticides, nanoparticles, and industrial chemicals enter surface aquatic environments through point and diffuse sources, posing risks to ecosystems and human health. However, knowledge about the sources and fate of these chemicals along the river network is sparse, and information is particularly unavailable for contaminants present at trace levels (ng/L). In the absence of sufficient observations, contaminant fate models have been developed to serve as initial screening tools, to generate baseline estimates of concentrations, and to simulate the basic processes that lead to increases in contaminant concentrations through downstream accumulation or decreases through dilution or decay.
Here, we present two case studies estimating concentrations of pharmaceuticals as well as human-released estrogens in rivers of India and China, respectively. We developed a first version of a spatially-explicit, high resolution contaminant fate model that is an extension of the global river routing model HydroROUT. The model considers point-source contributions from wastewater treatment plants and accumulates contributions of rural and urban populations not connected to sewage treatment plants. Lake mixing is simulated by taking individual lake retention times into account. The findings demonstrate that HydroROUT can be used as a screening tool for conducting preliminary risk assessments of new and emerging contaminants and their spatial patterns in data-poor regions in order to identify concentration “hotspots” downstream of population centers. The information on spatial patterns of concentrations of pharmaceutical contaminants could serve to develop management strategies directed toward minimizing the exposure of those contaminants, improving water quality, and protecting water resources to ultimately help in ensuring the availability of clean water for present and future generations.