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The fate of pharmaceuticals in freshwaters: a global model for decision making

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Pharmaceuticals are broadly consumed and released in the environment where they largely flow into freshwater bodies. Some of these compounds arouse recognized threats on freshwater ecosystems and have been labelled as contaminants of emerging concern by governmental agencies such as the European Union and the US Environmental Protection Agency. Human and veterinary uses of pharmaceuticals lead to high concentration of these compounds in waste water which is often not sufficiently collected and treated in wastewater treatment plants, thus poured in fluvial network. The chemical behaviour of pharmaceuticals in freshwater has been well studied, but its environmental fate is unknown at global scale. However it is of primary interest for the prediction of future scenarios of global changes and the formulation of mitigation measures. We have developed a global model to identify hotspots of pharmaceuticals high concentration in the environment. The model accounts for the hydrology, the rivers and lakes hydraulics and the contaminant behaviour in wastewater treatment plants as well as in rivers and lakes. Taking advantage of an extensive database of consumption and occurrence in river network, the model is applied to the case of diclofenac as a common pharmaceutical for human use and successively generalized to other compounds.

Here we present the model and its capability to predict the current and future dilution of pharmaceuticals in freshwater ecosystems taking into account current and future scenarios of runoff and population growth. As a preliminary result we show that if no mitigation actions are taken the environmental threat will increase by 65% in 2050. We propose feasible mitigation strategies related to (1) consumption reduction, (2) sewer connection and (3) treatment technology improvements. Particularly strategies 2 and 3 are inspired by the Sustainable Development Goal 6 (UN General Assembly Resolution A/RES/70/1, 2015). We find that the technological improvement alone will not be enough even to recover the current concentration levels and if a substantial consumption reduction will not be implemented, a large part of the global river ecosystem will not be sufficiently secured.