Title MSc project: Modelling human pharmaceutical concentrations in a river at high temporal resolution and predicting future concentration changes under different scenarios

Assignment number: **Internal project**
21.23

Head graduation committee
Dr. Maarten Krol

Daily supervision
Dr. Lara Wöhler

Required courses: Water quality, water and climate, hydrological modelling and forecasting

Involved organisations: internal

Start of the project: flexible

Short description project aim and motive:
Human pharmaceutical residues are frequently detected in rivers around the globe (Wilkinson et al., 2022). To a large extend these stem from human consumption after which they are excreted into the sewage system, pass the waste water treatment (if available) and reach the environment, where they can cause severe ecotoxic impacts (Aus der Beek et al., 2016). This emission path has been modelled in manifold studies (e.g. Hanamoto et al. (2023), Lämmchen et al. (2021), Lindim et al. (2017), Oldenkamp et al. (2018), Wöhler et al. (2020)). However, generally the temporal resolution of these studies is in years, or seasons. Hence, there is no proper understanding of variation in concentration across time – despite observations proving temporal changes in emissions and concentrations (Morosini et al., 2017, Burns et al., 2018). Drivers for temporal variation are speculative (Burns et al., 2018) and lack quantification. Also, variations in concentrations are important for impacts, due to non-linearities in responses or peak levels potentially exceeding water quality thresholds. Moreover, no study exists that assesses potential future developments in terms of pharmaceutical concentrations in rivers. Circumstances such as climate change, demographics or lifestyle trends might however significantly influence pharmaceutical concentrations in rivers. Likely these changes (especially those related to climate change) are difficult to capture in annual assessments, which is why a higher temporal resolution would be required.

Research objective
The objective of the proposed research is to first assess human pharmaceutical concentration for a selected river (stretch) at a higher temporal resolution (monthly/weekly) compared to existing studies. The second study aim is to develop (plausible) future scenarios (either related to physical and/or societal model components) and assess their effect on pharmaceutical concentrations in a river.

Method
For the first research objective it is suggested to develop or adapt a model to assess pharmaceutical concentrations in rivers at high temporal resolution. Influential processes along the pharmaceuticals' life cycle (incl. processes before as well as after environmental emission) are well described in literature and the documentation of existing models (see references above). If data inputs at high temporal resolution are scarce (e.g. for pharmaceutical use), justified assumptions (e.g. considering flu season) should be taken. Hereto (as well as for model validation) literature, existing data bases and previous measuring campaigns capturing temporal variability, e.g. Burns et al. (2018), Duarte et al. (2022), can assist.
For the second objective plausible scenarios should be developed. As a starting point a conceptual overview of influential parameters at every stage along the pharmaceutical life cycle should be made, before evaluating if and what future developments (researched from literature) could have an effect on these. Based on this conceptual overview, scenarios should be developed. Their effect should be quantitatively assessed using before developed model. The conceptual model can also already serve as aid for the model development as it is important to include all processes that are relevant for the scenarios.

There is a high degree of freedom for the student on method choices. Here the student can follow personal interest, but at the same time is expected to make justified choices after a literature review about the study field(s). This concerns:

- Use (an) existing model(s) to estimate pharmaceutical emissions or develop an own approach based on processes described in literature

- Geographical scope and setting of the study
- Choice of pharmaceutical substances to assess
- Modelled scenarios

Expected result

The study will provide predicted pharmaceutical concentrations in a selected river (stretch) at high temporal resolution. Moreover, the study will deliver a set of plausible future scenarios that are influential for pharmaceutical concentrations in rivers along with a quantification of concentration changes under the different scenarios. These results (on small geographical scale) explore a new research field, which can indicate under what circumstances the risks from pharmaceuticals in the environment will increase or decrease. Insights can on the one hand serve as a starting point for research to explore this at larger scale, on the other hand they can indicate where and when measures to reduce risks from pharmaceutical emissions could be most effective. For ambitious students it is well-possible that the thesis report will later on result in a journal publication.

References

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