Application of a model for supporting risk assessment of emerging contaminant in the context of wastewater reuse for irrigation

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Introduction

About 17% of the European territories suffer from water scarcity. The situation is expected to worsen over the next years, with potentially severe socio-economic implications. Recently, EU member states agreed that agricultural reuse of reclaimed urban wastewater should be enhanced whenever this is safe, leading to the proposal of minimum requirements for safe reuse [1]. The proposal also recognized the need of including in the risk assessment (where relevant) contaminants of emerging concern, whose threat for environment and human health is well recognized. Given the general lack of measurements and the challenges inherent to field monitoring, integrated chemical fate models represent valuable tools to (i) predict exposure concentrations (for assessing the current risk) and (ii) to evaluate alternative scenarios (i.e. identify risk minimization strategies). However, these models are usually applied within the boundaries of urban areas or for hypothetical wastewater reuse scenarios [2], lacking significant validation for real cases. In this study, an integrated dynamic model was developed and tested for a highly urbanized area in northern Italy, where treated municipal wastewater is discharged into an irrigation canal. Calibration and validation were performed at different locations and risk indicators were calculated to assess environmental and human health safety associated to the exposure to several emerging contaminants.

Material and Methods

The IUWS-MP model library [3] was coupled with a dynamic plant-uptake model [4] and calibration/validation was performed at different locations (wastewater treatment plant inlet/outlet, along the irrigation canal) for conventional (COD. TSS, N, P) and emerging contaminants (e.g., pharmaceuticals, biocides). Site-specific input data (consumption, inhabitants, irrigation periods, type of soil and crops) were collected, while chemical properties (partitioning coefficients, biodegradation rates) and toxicity data were obtained from literature. Long-term (≥ 1 year) predictions of exposure concentrations were obtained in different sensitive recipients (irrigation water, edible crop tissues) and risk indicators were calculated.

Results and discussion

Figure 1a shows mass fluxes of carbamazepine (CBZ), ibuprofen (IBU) and diclofenac (DCF) across the integrated system, while Figure 1b describes the temporal variability of CBZ at the canal outlet. While IBU and DCF showed removal along the system, CBZ persisted (with slight concentration drops during irrigation periods). For the river compartment, estimated concentrations never exceeded the chronic predicted no effect concentration (e.g., risk quotient = 0.023 for CBZ), suggesting no risk. The expected daily dietary intake was also estimated based on predicted concentrations in edible crop tissues, being <1000 times lower than the acceptable daily intake for the three substances.

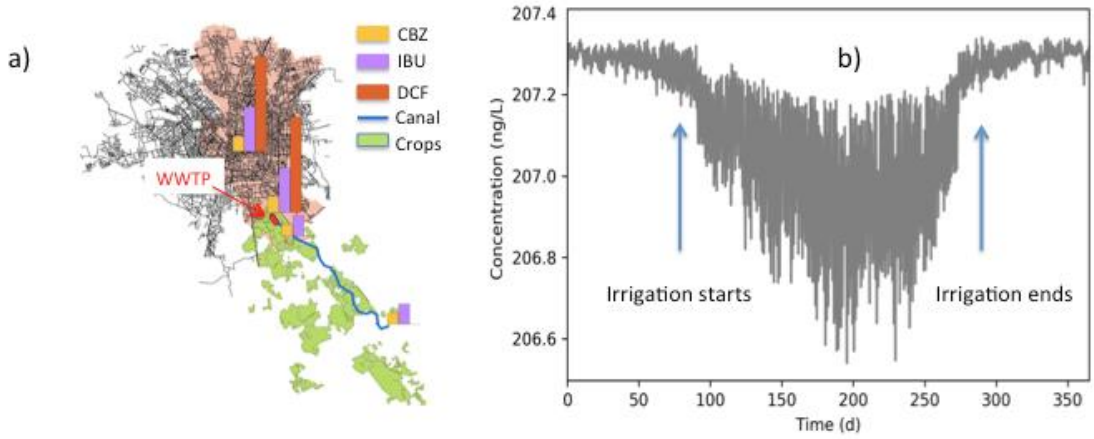

Figure 1 (a) Catchment and substance flow analysis; (b) temporal variation of CBZ at the end of canal.

Conclusions

An integrated fate model was tested for an existing case of urban wastewater reuse for irrigation. The presented approach can be useful in predicting environmental and human risk associated to the exposure to a wide array of emerging contaminants.

References

[1] European Commission, Proposal for a Regulation of the European Parliament and of the Council on minimum requirements for water reuse COM/2018/337 final - 2018/0169 (COD) 28 May 2018, Brussels, Belgium.

[2] Polesel, F., Plósz, B.G., Trapp, S. (2015). From consumption to harvest: Environmental fate prediction of excreted ionizable trace organic chemicals. Water Res.84, 85–98.

[3] Trapp, S. (2017). New release dynamic (numeric) coupled soil-plant uptake model for monovalent ionics.

[4] Vezzaro, L., Benedetti, L., et al. (2014). A model library for dynamic transport and fate of micropollutants in integssrated urban waste-water and stormwater systems. Environ. Model. Softw. 53, 98–111.