Biocides in paints in urban areas: Modelling an underestimated source of environmental contamination

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1. Introduction

Biocide contamination of receiving waters is generally linked with agriculture. However, recent studies have shown that urban contributions should be also considered [1,2]. One of the suspected biocide sources in the urban environment is building paint. Biocides like diuron, irgarol, terbutryn, carbendazim, etc., are conventionally used in paint to control fungi, algae, bacteria and other microorganisms that can colonize building façades.

The problem of biocides in urban areas is closely linked to meteorological conditions and in particular to rain events. As a consequence, it is important to understand how rainwater collects and transports biocides from façades and how these biocides are transported in sewer systems to receiving waters. In this study, we present a conceptual model describing façade leaching and couple it with a Wind Driven Rain model [1] and a classical hydrological model to compute the contribution of a city to the biocide load from building paint.

2. Modelling approach

A two-step approach was adopted. We first modelled experimental data on façade leaching, and afterward implemented this model into an urban hydrology model.

2.1. Modelling of laboratory experiments

The data set used to fit the façade leaching model was taken from [2], with a particular focus on Terbutryn, a classical biocide used in paints. The data set shows the evolution of Terbutryn concentration at the bottom of a wall for simulated rain events.

For modelling the data, we used the Hairsine-Rose model [4,5] (Equations 1 and 2). Although developed for soil erosion, it is the form of model that is important for this study. Governing equations are given by:

$$\frac{\partial p}{\partial t} + u\frac{\partial p}{\partial x} = -ap + bq \quad \text{(Eq. 1)} \qquad \text{and} \qquad \frac{\partial q}{\partial t} = ap - cq \quad \text{(Eq. 2)}$$

where *p* is biocide concentration in the rainwater flowing over the façade, *q* is the biocide concentration in the source (wall) and *a, b* and *c* are the rates of biocide detachability and deposition.

2.2. Extrapolation to the urban environment

The façade model was applied to Lausanne, a Swiss city of 200'000 inhabitants on the shore of Lake Geneva. At the city scale, the Wind Driven Rain model [3] and GIS tools provide the distribution of heights and orientation for all city buildings. Leaching of building façades during rain events of different characteristics (rain intensity, wind direction) was accomplished by adding the local façade model to the hydrological model (not presented here). Model results were compared with field experiments in a fully urbanized river catchment, as well as input water in the local waste water treatment plant.

3. Results and discussion

3.1. Fitting of the model to laboratory experiments

The model in §2.1 fitted well the peak in concentration measured at the bottom of the wall at the initial stage of the rain event (Figure 1). After 20 min of continuous rain on the facade, some differences are observed in the predicted concentrations, although the predicted concentrations (about 5 µg/l) were in reasonable agreement with the measured data.

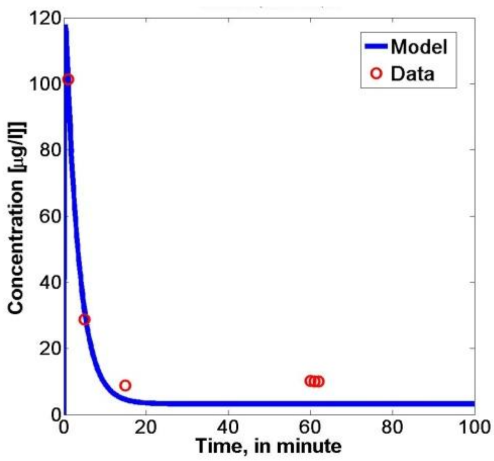

Figure 1: Example comparison of raw data with the fitted model.

3.2. Application of the model to Lausanne city

For the entire city of Lausanne, a global production of 2200 kg/year of terbutryn leached by rain was estimated considering local building characteristics and meteorological information. However, concentrations measured in an urban river in the watershed leads to the conclusion that most of this leachate does not reach directly receiving waters, but is infiltrated into soil or reaches the sewers after some delays in drainage pipes. This was confirmed by measurements of terbutryn in wastewaters a couple of days after rain events. Simulated concentrations of terbutryn at the bottom of the façade reached 170 µg/l, which is above acute ecotoxicological values for terbutryn (34 ng/l). After dilution in the urban river, the measured concentrations (23.3 ng/l range: 3.1 – 32.1) are below this value. As the concentrations vary over time during rain events, time-varying endpoint values are needed to better characterize the risk for the environment.

4. Conclusions

Release of biocides from façade leaching in the environment is systematic during rain event. It is of greater importance to estimate the dynamic of biocides during rain events and to compare these values with dedicated time varying environmental quality criteria. Efforts must be pursued for a better understanding of complex processes that occur during façade leaching itself, as well as on the way from buildings to open waters and waste waters.

5. References

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