AMPA and glyphosate in the Meuse – a modelling approach to distinguish pollution sources and conversion processes

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Introduction

In large river basins multiple sources can contribute to pollution and these sources are usually spread over the entire catchment. The cumulative effect of pollutants entering the river system in upstream areas and the formation of persistent degradation products can compromise downstream water use such as drinking water production. For assessments at catchment scale, fluxes coming from different sources and sub-basins need to be taken into account. A sound understanding of the sources, emission routes, transport, environmental fate and conversion of pesticides is needed to improve management strategies.

In the Netherlands, the Meuse river basin is an important source for drinking water production. The river suffers from elevated concentrations of glyphosate and aminomethylphosphonic acid (AMPA). For AMPA it is rather unclear to what extent the pollution is related to glyphosate degradation and what is the contribution of other sources, especially phosphonates in domestic and industrial waste water. Based on the available monitoring data only it is difficult to distinguish between AMPA sources in such a large river basin. This hampers interpretation and decision making for water quality management in the Meuse catchment. Here, application of water quality models is very useful to obtain complementary information and insights. Through a modelling approach variability in discharge and concentrations as well as mother-daughter product conversions can be taken into account.

Methodology

In this study, a model for the river Meuse was developed and applied to distinguish the contribution of tributary and transnational influxes, glyphosate degradation and other sources of AMPA pollution.

The Meuse catchment covers 32000 km² and from source to mouth the main river has a total length of more than 900 km. The river originates in France and flows across Belgium and the Netherlands where the delta ends in the North Sea. The study area (Figure 1) is the 250 km river stretch between Eijsden (Belgian-Dutch border) and Keizersveer (point of drinking water abstraction in the Netherlands).

The river was modelled using the River Water Quality Model N°1 implemented in the WEST® simulation platform. The required information about geometry and roughness was derived from the SOBEK-Maas model which encloses a large database of cross-section characteristics. Seven main tributaries of the Meuse were included in the model: Jeker, Geul, Geleenbeek, Roer, Neerbeek, Niers and Dieze.

Boundary conditions were obtained from available discharge (daily) and concentration data (biweekly or monthly) for the Meuse and its main tributaries (data from RIWA-Maas and Rijkswaterstaat). The model includes transport of AMPA and glyphosate, and conversion of glyphosate to AMPA through a 1st order degradation reaction. Simulated concentrations are compared with measured values at the downstream end of the 250 km river stretch (Keizersveer).
Results

Several degradation scenario runs were performed with the half-life time varying from 5 days to 25 days. The model result show that the observed AMPA concentrations cannot be reached when including only boundary influx (upstream inflow and influx from tributaries) and glyphosate decay. With a DT50 of 5 days, there is still a 20% difference between observed and calculated AMPA concentrations, while the difference between observed and calculated glyphosate concentrations is only 5%. This clearly indicates contribution from other sources of AMPA, which may include industrial discharges and effluent of waste water treatment plants (WWTPs).

The contribution of these sources was estimated based on available data about industrial discharges and WWTP effluents entering the considered river stretch. Industrial discharges can contribute to an additional increase in AMPA concentrations of 0.003 – 0.158 µg/L with minor effect on glyphosate concentrations (additional increase of only 0.0005 – 0.003 µg/L). WWTP effluents can contribute to an increase in AMPA concentrations of 0.019 – 0.021 µg/L with an additional increase in glyphosate concentrations of 0.011 – 0.018 µg/L. Comparison of these concentration ranges with the unexplained concentration levels, suggests that a major part of the unexplained loads might be assigned to industrial discharges. However, further investigation of the contribution of these sources is needed.