Effects of pumping strategies on pesticide concentration of a drinking water well

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ABSTRACT BODY: Groundwater is an important source of drinking water production in many countries including Denmark. This requires high quality groundwater that meets the standards of the European Water Framework Directive. Yet as a result of agricultural activitity, deposition and previous handling, pesticides are frequently found in groundwater and can raise a substantial problem for ground water abstraction. The concentration of this contamination may vary between different layers. The heterogeneity of the subsurface geology and the depth of the drinking water well's screen are important parameters that affect the resulting contamination of the abstracted groundwater. The pesticide concentration in wells may also be affected by the pumping strategy because pumping can alter the structure of the flow field, the flowpath of water going to the well and subsequently the age of water at the well.

The purpose of this study was to examine numerically the effects of pumping on pesticide contamination of drinking water wells using a reactive transport model in a hypothetical aquifer system resembling a typical Danish well field. The application history of the pesticides is crucial. This can be taken into account by assessing the effects of pumping on water age distribution along the well.

Three compounds with different application histories were considered: an old banned pesticide MCPP (Mecoprop) which is mobile and relatively persistent in deeper aquifers, and a highly applied, biodegradable and strongly sorbing pesticide glyphosate, and its degradation product AMPA. A steady state flow field was first computed. A well field was then introduced and different pumping regimes were applied for a period of 180 years; a low-rate pumping, a high-rate pumping and a varying pumping regime. A constant application rate at the surface was assumed for the application period of each pesticide. The pre-abstraction age distribution of the water in the system was first estimated using a steady-state flow and transport simulation. These water ages were then used as the initial conditions for the transient simulations.

The results of the simulations showed that the range of water ages contributing to the well increased during pumping and was substantially affected by the pumping rate. High pesticide concentrations were persistent in the well 40 to 100 years after they were banned, due to the high residence times in the aquifer. Large changes in simulated pesticides concentrations at the well occurred during pumping. The pesticide concentration reaching the well was affected by the pumping regime and the pesticide application history and properties. A higher pumping rate induced a higher pesticide concentration peak at the well of shorter duration, while a lower pumping rate induced a lower concentration peak of longer duration. The long term scenarios revealed that at high pumping rates MCPP would disappear 40 years after its application end year, while glyphosate concentrations increase and reach a plateau, which is

highly dependent on the pumping rate. The findings of the study help understand the results of groundwater monitoring programmes and can be used for the quantitative evaluation of management and pumping strategies for the long-term supply of safe potable groundwater.

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