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# Extended Abstracts

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title: **PESTO, a risk assessment of pesticide use on groundwater quality in the Chalk aquifer in the province of Limburg, the Netherlands**

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## INTRODUCTION

The use of pesticides has affected the groundwater quality within the catchment area of the River Meuse. The presence of pesticides in this catchment forms a potential risk for achieving the objectives of the European Water Framework Directive, in particular concerning the targets that have been set for groundwater destined for human consumption. The authorities of the Province of Limburg, the Netherlands, and the drinking water company of Limburg (WML) therefore instructed Witteveen+Bos, in cooperation with CLM Research and Advice and KWR Watercycle Research Institute, to investigate the fate and transport of pesticides in the Chalk aquifer of Limburg, the Netherlands, for seven drinking water production sites. Aim of the study was to assist in the identification and implementation of measures to reduce the risk of pesticide use on public water supply.

## PESTICIDES IN THE MEUSE CATCHMENT

Pesticides have been detected at significant concentrations in the groundwater of the Dutch part of the catchment area of the River Meuse during several sampling surveys. A survey by Haskoning (2008) revealed concentrations of atrazin ranging between 0 µg/l en 0.29 µg/l; bentazon concentrations of 0.1 and 2.6 µg/l; and dichloorbenzamide (BAM) of up to 0,6 µg/l. Other detected pesticides were diuron (up to 0.05 µg/l); glyfosaat (up to 0.2 µg/l) and simazin (up to 0.16 µg/l). These pesticides were detected in groundwater samples taken from springs and groundwater abstraction boreholes. A similar survey undertaken by KIWA in 2001 showed pesticide concentrations of bentazon of 0.04 µg/l; Mecoprop, or methylchlorophenoxypropionic acid MCPP of 0.03 µg/l and 0.04 µg/l; BAM varying between 0.01 µg/l and 0.17 µg/l; desethylatrazin 0.01µg/l; desethylsimazine 0.02 µg/l and isoproturon of 0.01 µg/l (Witteveen+Bos, 2003).

## RISK ASSESSMENT METHOD

Given the observed pesticides in spring water and boreholes, it was thought that the use of pesticides would form a risk to the groundwater quality in the Chalk aquifer. In addition, it was also expected that concentrations of pesticides would rise in the future and the main research question therefore was not “if” but “when” the groundwater quality would deteriorate.

To quantify the effect of pesticide use on groundwater quality, a risk assessment was undertaken using fate and transport characteristics of pesticides and information on the hydrogeological system. For this risk assessment the source-path-receptor concept was used. In this model, the risk of a (contaminant) source is assessed by identifying linkages (pathways) to a receptor. If one of these three (source, path, receptor) is not present there is no risk. The conceptual model we used is presented by a schematic cross section (Figure 2). In our application of this conceptual model, the contaminant source is the pesticides use, the path is the unsaturated and saturated flow of the water through the subsoil, and the receptor is the drinking water abstraction borehole (Figure 1).

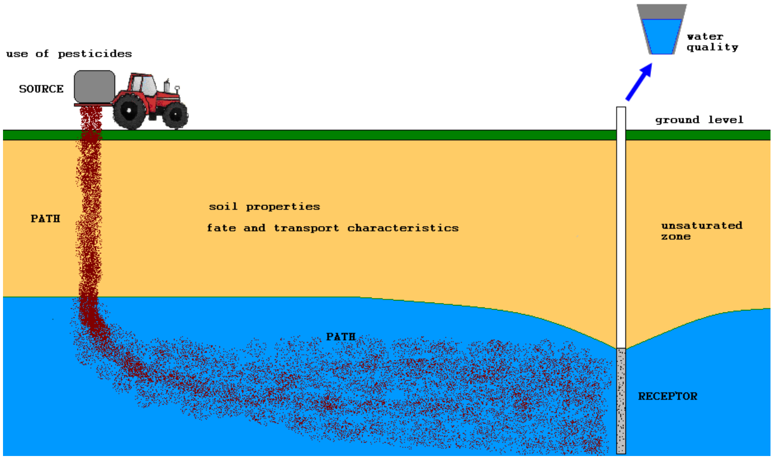


**Figure 1.** Schematic presentation of the conceptual model.

We calculated transport in the saturated zone using Van Genuchten and Alves, (1982) which is presented in detail by http://www.lmnoeng.com. This calculation simulates one-dimensional (flow line) transport of a chemical in a confined groundwater aquifer and is also valid for transport in an unconfined aquifer if the head gradient is nearly constant, which we assumed is the case in Limburg. The calculation includes advection, dispersion, and retardation. Decay of the pesticides was included by reducing the calculated concentration with a simple half-life equation. An example of the resulting concentration-distance graph for bentazon is presented in Figure 2.

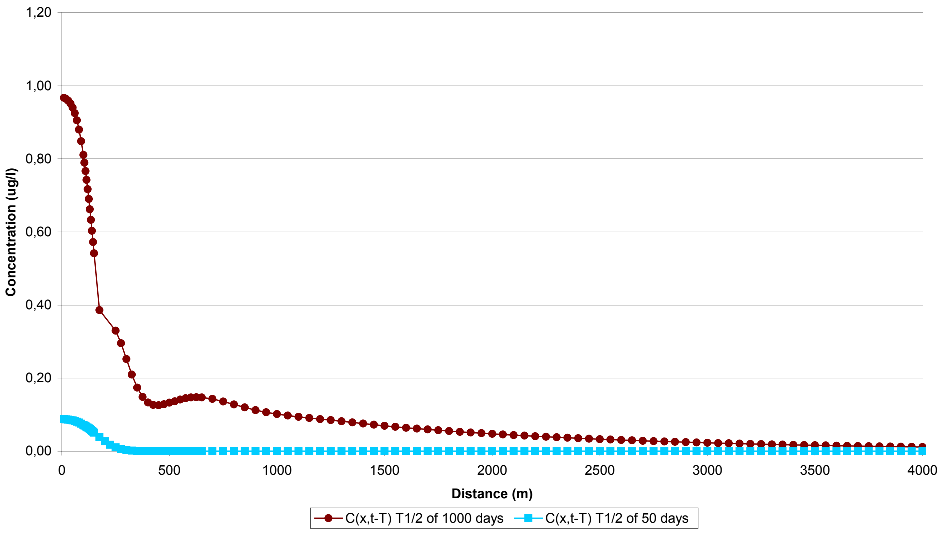


**Figure 2.** Calculated concentration of bentazon along a flow path.

By combining the results for both saturated and unsaturated flow we calculated "risk circles" which were defined as the circle in which the use of pesticides could affect the quality of the abstracted water. The radius of this circle represents the distance required to reduce the concentration of the pesticide to 0,1 µg/l (Figure 2).

## RESULTS AND DISCUSSION

As information on site specific transport characteristics of the subsurface was limited, we used a range of input parameters to calculate maximum and minimum radius risk circles (Figure 2). For all pesticides, the calculated minimum was very small, indicating that the use of pesticides does not pose a risk to the groundwater quality. For some pesticides, however, the maximum radius was large enough to pose a (theoretical) risk to the groundwater quality. However, we judged that the chemical and physical characteristics used to calculate these maximum radius risk circles were most likely too conservative, thus exaggerating the actual risk.

The risk assessment thus indicated that the risk for contamination of water abstraction wells in the Chalk area of the Netherlands is small, due to attenuation and decay of pesticides. In comparison with other regions of the Netherlands, the processes in the unsaturated zone are especially important in the Chalk region, as the unsaturated zone reaches much deeper. The risk is further reduced by an extensive protective cover of loess and flint deposits, overlaying the Chalk aquifer. In these loess deposits the water recharge system mechanisms are dominated by gravitational flows. Brouyere et al. (2004) conclude that in a similar case in Belgium, where chalk is also covered by a layer of loess and conglomerate, the water infiltration rate at the top of the unsaturated chalk is strongly attenuated compared to the actual recharge at the ground surface.

The findings of our study were confirmed by research undertaken in the Chalk areas of the United Kingdom. For instance, Chilton et al. (2005) concluded that the 'time bomb' scenario does not apply for pesticides as it does for nitrate. In their study, only low pesticide concentrations have been consistently observed at the water table, and there is no evidence of a cumulative rise in concentrations of specific compounds. Further dilution is likely within the saturated zone pathway to water supply sources and other receptors. Chilton et al. (2005) therefore concluded that it is unlikely that regular agricultural usage of pesticides in the UK would produce gradually rising concentrations of specific compounds in drinking water supplies.

A detailed reanalyses of all available data in the Chalk area of the Netherlands, showed that the pesticides presented in paragraph 2 were only detected in samples taken from shallow boreholes or springs. No pesticides were detected in any of the deep groundwater samples taken from the Chalk Aquifer, which confirms our findings that risk for contamination of water abstraction wells in this area is limited. In the past, pesticides were detected in the deep groundwater, but since more strict legislation has stopped the use of a number of these persistent pesticides.

## CONCLUSIONS

A qualitative risk assessment, in combination with reanalyses of measured data and a literature review, was undertaken to estimate the risk for pesticide contamination of drinking water abstraction wells. It is concluded that the use of pesticides is not likely to pose a risk to the deep groundwater in the Chalk aquifer of the Netherlands, as long as the pesticides are used according to current rules and regulations. During the next stage of the project, a field measurement campaign will be undertaken to confirm these conclusions.

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