# Assessment of atmospheric deposition onto surface waters

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## Introduction

A significant fraction of the dosage of Plant Protection Products (PPP) applied in agriculture can volatilize from the target area in the course of time. The gaseous PPP mass resulting from this post-application volatilization is subsequently dispersed in the atmosphere and may be removed by dry or wet atmospheric deposition. For the assessment of the risk to exposure to PPP of aquatic organisms this pathway of PPP input to surface waters has to be considered too. However, PPP loadings due to atmospheric deposition after volatilization are usually ignored.

## Deposition assessment tool

In this study, we developed a tool that allows assessment of the exposure of surface waters to volatilized PPP and subsequent atmospheric deposition at local to regional scales (up to tens of $km^2$). The consensus PEARL model (Van den Berg and Leistra, 2004), was coupled to the Operational Priority Substances (OPS) model (Van Jaarsveld, 2004). The PEARL model includes a description of the fate of a PPP in the canopy, that is, volatilization, transformation, penetration into the plant tissue and wash-off. In the context of our study, the computed volatilization provides the source strength to be used in the OPS part of the tool. OPS simulates atmospheric dispersion, and concentration and deposition in the area of interest. The model is based on a Gaussian plume formulation in combination with vertical wind speed and dispersion profiles. A special high-resolution OPS version is applied, allowing the use of hourly emission data, as well as dispersion calculations at local to regional scales. Deposition, $F$, is estimated using a standard micrometeorological approach, in which $F$ is driven by the concentration difference between a reference height and the surface, and modulated by a set of resistances. Aerodynamic resistance $r_a$ accounts for atmospheric turbulence, boundary layer resistance $r_b$ is used to describe transport in the quasi-laminar boundary layer, and surface resistance $r_s$ describes transport through the surface-air interface. The description of $r_b$ and $r_s$ in OPS was modified to account for differences in $r_b$ and $r_s$ between water and vegetation, following Jacobs et al. (2007). Also, for vegetation, the cuticular resistance that contributes to $r_s$ is now taken to be a function of the dimensionless Henry coefficient and the octanol-water partitioning coefficient of the PPP (Schönherr and Riederer, 1989).

## Sample simulations

The coupled PEARL-OPS model was run for the period 3-7 may 2003, for an area of about 1250 ha in the North-East of The Netherlands (see Fig. 1). The land use in the area is mainly agriculture, but some natural vegetation and built-up areas are present as well. About 2% of the area consists of open water bodies, mainly ditches and watercourses. It was assumed that the fungicide fenpropimorph was applied (1 kg/ha) to all sugar beet fields in the area (~156 ha; Fig. 1). The volatilization rate from the fields was assumed to be equal at all positions in the source areas.

## Results

In total, 28.9% of the applied product volatilized, mainly during the first days after application (27.3%), which stresses the need to consider volatilization at high temporal resolution (Fig. 1).

**Figure 1. Source definition in the sample simulations. Left: location of the source fields (sugar beet); right: volatilization rate computed by PEARL.**

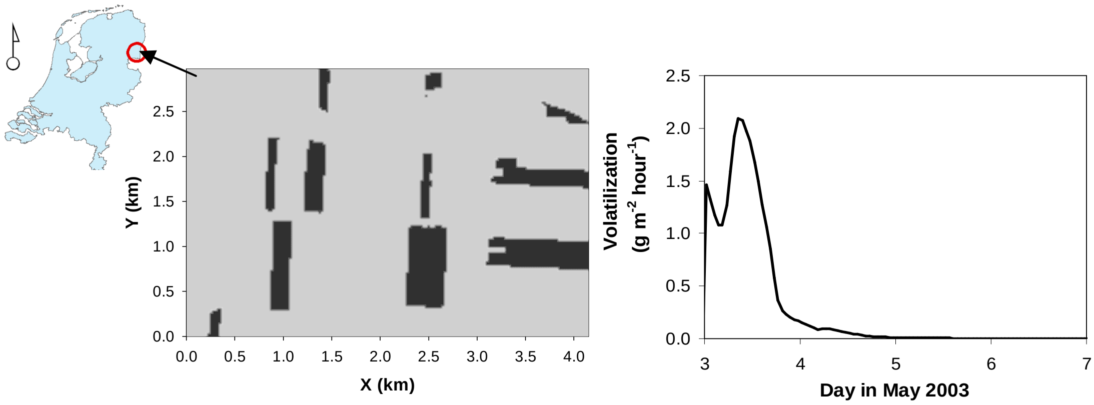
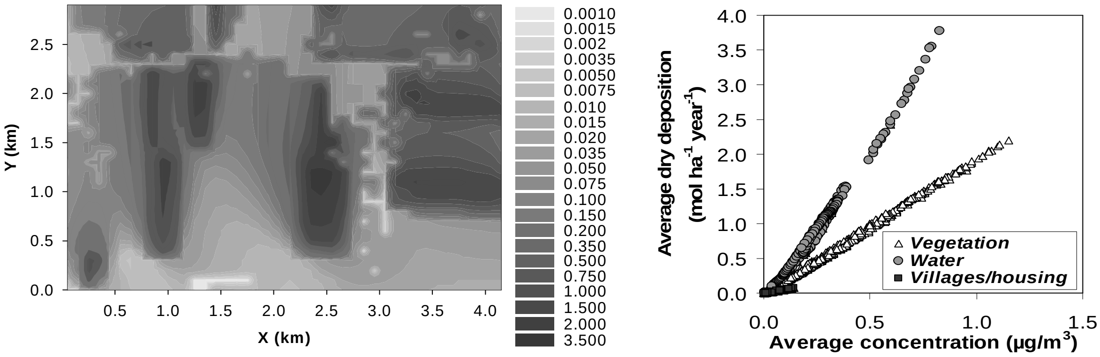


**Figure 2. Computed average deposition (mol ha$^{-1}$ year$^{-1}$; left), and deposition characterized by surface type (right).**



The subsequent deposition computed by OPS (Fig.2) is clearly largest nearby the sources, but a considerable amount of PPP may be deposited somewhat further away. The behaviour of the deposition over the different surface classes is investigated by plotting the average deposition as a function of the concentration in the air (Fig 2). It can be seen that, owing to the low $r_s$ and the differing $r_b$, the deposition onto water bodies is predicted to be much faster than over vegetation.

## Conclusion

The modified model combination PEARL-OPS appears to be a valuable tool to assess atmospheric deposition onto surface waters at a regional scale in PPP risk assessment studies.

## References

Jacobs CMJ, Van Den Berg E, Van Jaarsveld JA (2007). Principles and main uncertainties of a methodology to assess gaseous deposition of pesticides onto small water bodies. In: *Del Re AAM, Capri E, Fragoulis G, Trevisan M (Eds.). Environmental Fate and Ecological Effects of Pesticides.* La Goliardica Pavese s.r.l., Pavia, pp. 270-277.

Schönherr J, Riederer M (1989). Foliar penetration and accumulation of organic chemicals in plant cuticles. Rev. Environ. Contam. Toxicol., 108:1-70.

Van den Berg F, Leistra M (2004). Improvement of the model concept for volatilization of pesticides from soils and plant surfaces in PEARL. Description and user’s guide for PEARL 2.1.1-C1. Alterra, Wageningen.

Van Jaarsveld JA (2004). The Operational Priority Substances model; Description and validation of OPS-Pro 4.1. RIVM report 500045001/2004. RIVM, Bilthoven.