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A MODEL OF VOLATILIZATION AND SUBSEQUENT DRY DEPOSITION OF PESTICIDES TO SURFACE WATERS

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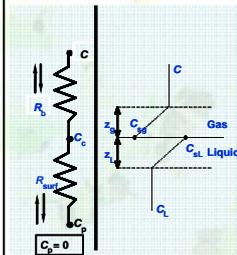
INTRODUCTION

- Contamination of surface waters by pesticides is widespread near agricultural areas (as in lakes, rivers, etc.).
- Dry deposition** of volatilized pesticides (gaseous) **may be higher than the drift** mainly due to longer emission periods.
- Volatilization from soil depends on** the thermodynamical properties of the pesticide (e.g. Henry's law constant), its persistence in the soil, environmental conditions (soil and air temperature, soil water content and soil organic matter) and agricultural practices.
- Dry deposition depends on** atmospheric concentrations of the pesticide and hence on the volatilization rate, environmental conditions, distance from the source and pesticides characteristics, as well as the nature of the surface (water, plant, soil).
- In this study** we use 2 models to estimate 1) the volatilization and 2) the local dispersion and dry deposition of pesticides to water bodies at the local scale (<1 km).

MATERIAL AND METHODS

The approach couples 2 models (Figure 1):

- a mechanistic model for pesticide volatilization following application on bare soil (Volt'Air-Pesticides, Bedos et al., 2009) which gives the source strength and the surface boundary layer characteristics to
- a local-scale dispersion and deposition model (FIDES-2D, Loubet et al., 2001), adapted for pesticides (Sameut, 2010). Dry deposition to water is modeled using the resistance analogy approach (Liss and Slater, 1974 further applied to pesticides by Asman et al. 2003)



$$R_b = \frac{1}{0.066 Sc_g^{-0.61} \cdot u_*}$$

$$R_{surf} = \frac{H(T_{surf})}{1.25 \cdot 10^{-6} \cdot \sqrt{\frac{600}{Sc_w}} \cdot U(10)^{1.6}}$$

- R_b (s m⁻¹) : surface boundary layer resistance
- R_{surf} (s m⁻¹) : surface resistance
- Sc_g and Sc_w : Schmidt numbers in air and water
- u_* (m s⁻¹) : friction velocity
- H : Henry's law constant
- T_{water} : water temperature
- $U(10)$ (m s⁻¹) : wind speed at 10 m above ground
- $H = P_{vap} / S_w$

A set of five pesticides were chosen to cover a wide range of chemical and physical properties, especially H, as a key property for the theoretical volatilization and deposition potential (Table 1).

The model was run over 13 days, from March 1, 2002 to March 13, 2002. The soil and climatic conditions of the Picardie region in France was chosen. The field was 100 m long and the application dose was 1 kg ha⁻¹.

MAIN RESULTS

- The drift at 250 m amounted around 0.15% of the applied dose (Rautmann et al., 2001).
- The modelled dry deposition of Acetochlor, Chlorothalonil, and Fenpropimorph roughly amounted to 0.5%, 1% and 2%.
- => The modelled gaseous dry deposition to water bodies was larger than the drift for 3 of the 5 pesticides (Figure 2).
- Under simulated conditions, and for the selected pesticides, the surface resistance to water R_{surf} was negligible when compared to the water boundary layer resistance R_b (Table 1).
- => Under these conditions, the main driver of the dry deposition was therefore the atmospheric concentration and hence the volatilization rate.

PERSPECTIVES

- This study should be extended to a larger range of conditions to check when R_{surf} is negligible against R_b .
- Scenarios should be build to cover a large range of environmental conditions and pesticides.
- Running the model on these scenarios will allow quantifying surface water contamination by gaseous pesticides.
- These scenarios will be used to identify good agricultural practices to limit surface water contamination.

LIMITATIONS

- Such a modelling study needs to be validated against experimental datasets.
- Volatilization from crop surfaces should also be considered in the future.

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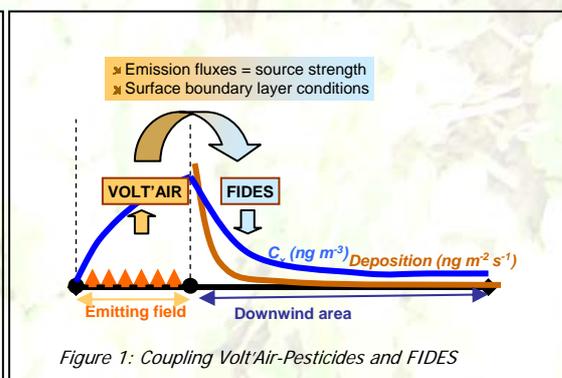


Figure 1: Coupling Volt'Air-Pesticides and FIDES

Table 1: Thermodynamic characteristics and surface resistances of the selected pesticides

Substance	Henry's law constant H [-]	Vapour pressure P _{vap} [Pa]	Water solubility S _w [mg L ⁻¹]	Koc [m ³ kg ⁻¹]	DT50 soil [day]	R _{surf} [s m ⁻¹]	R _{surf} /R _b [-]
Bentazone	2.00E-13	1.70E-04	570	0.051	14.0	2.06E-3	2.22E-05
Ethofumesate	9.00E-08	6.50E-04	50	0.147	56.0	2.15E-2	2.31E-04
Acetochlor	8.64E-09	2.20E-05	282	0.156	12.1	1.31E-1	1.41E-03
Chlorothalonil	1.36E-05	7.60E-05	0.81	0.850	44.0	7.61E-1	8.18E-03
Fenpropimorph	5.50E-05	3.90E-03	4.32	2.401	25.5	8.95E-0	9.62E-02

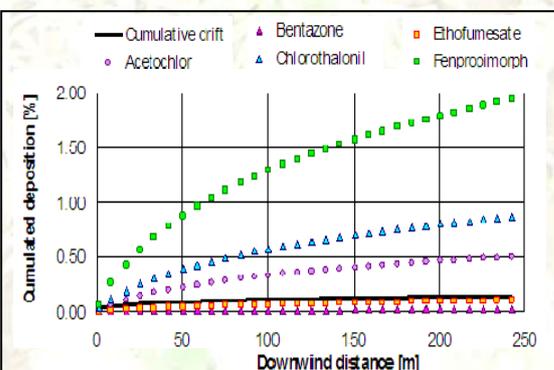


Figure 2: Cumulated dry deposition after 13 days and cumulated drift deposition of pesticides onto water. Curves are normalized by the amount of pesticides applied (1 kg ha⁻¹). The drift curve is from Rautmann et al. (2001).

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