A biological system to mitigate the pesticide point contaminations

G. Fait
M. Nicelli, J. Fragoulis, M. Trevisan and E. Capri

Universita Cattolica del Sacro Cuore
Istituto di Chimica Agraria ed Ambientale
Piacenza - Italy

Background

Pesticides are already highly regulated under the Directive 91/414/EEC.

The Water Framework Directive (WFD) expands the scope of water protection to all waters and it is intended to bring an integrated and coordinated framework for the sustainable management of all waters and requires them to achieve “good status” by 2015:

- implementing best practice measures
- minimizing the hazard and risk on human health and environment
- using low input pesticides
Sources of water contamination by pesticides

- DRIFT
- RUN OFF
- LEACHING
- VOLATILISATION
- DRAINAGE
- FARM YARD
- ROAD/RAILWAYS

(Mason PJ, et al. 1999. Relative importance of point source contamination of surface waters: River Cherwell catchment monitoring study, Proc XI Symp Pestic Chem, 11-15 September, Cremona, Italy)

Point sources of water contamination by pesticides

- tank filling
- spillages
- leaks from faulty equipment
- washing and waste disposal
- soakaways and drainage
- direct contamination
- consented discharges

(Carter AD. 1999. Pesticide contamination of water sources and the monitoring data across the EU, Proc XI Symp Pestic Chem, 11-15 September, Cremona, Italy)

In Italy, for vineyard farms, it has been calculated an average value of 700L of water used to wash the spray equipment after each pesticide application; 60% of this waste water is distributed directly in the field or in the farmyard.
The Biobed development

In Sweden


In United Kingdom


Goals

1) to develop a system to mitigate water point-source contamination adapted to Italian conditions. The Biomassbed.

2) to demonstrate the ability of Biomassbed in decreasing the concentration of pesticides in waters coming from washing the spray equipment.

3) to measure the long term performances of the Biomassbed.
Biomassbed mixture

Vine-branch 40%
Compost 40%
Topsoil 20%

C/N 28,7
Bulk density 525 g/l

Dimension parameters:

- fleet of cars (tractors, tanks)
- treatments (number, volume)
- volumes of final washing
**ORGANICS 2003**

- Mancozeb 79%
- Flufenoxuron 1%
- Fludioxonil 1%
- Cyprodinil 2%
- Cymoxanil 3%
- Penconazole 1%
- Metalaxyl 3%
- Iprovalicarb 3%
- Fenitrothion 7%
- Fludioxonil 1%

**ORGANICS 2004**

- Mancozeb 87%
- Fludioxonil 1%
- Iprovalicarb 0.4%
- Penconazole 0.6%
- Chlorpyrifos 2%
- Metalaxyl 5%
- Fenitrothion 5%

### PESTICIDES LOADING

<table>
<thead>
<tr>
<th></th>
<th>Number of application in 2003</th>
<th>Number of application in 2004</th>
<th>amount of a.i. entered in the biomassbed in 2003 (g)</th>
<th>amount of a.i. entered in the biomassbed in 2004 (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>cymoxanil</td>
<td>1</td>
<td>-</td>
<td>10.9</td>
<td>-</td>
</tr>
<tr>
<td>chlorpyrifos</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>25.0</td>
</tr>
<tr>
<td>cyprodinil</td>
<td>1</td>
<td>-</td>
<td>6.3</td>
<td>-</td>
</tr>
<tr>
<td>fenitrothion</td>
<td>1</td>
<td>1</td>
<td>27.5</td>
<td>48.3</td>
</tr>
<tr>
<td>fludioxonil</td>
<td>1</td>
<td>1</td>
<td>4.2</td>
<td>12.0</td>
</tr>
<tr>
<td>flufenoxuron</td>
<td>1</td>
<td>-</td>
<td>2.6</td>
<td>-</td>
</tr>
<tr>
<td>iprovalicarb</td>
<td>1</td>
<td>1</td>
<td>11.0</td>
<td>3.2</td>
</tr>
<tr>
<td>mancozeb</td>
<td>3</td>
<td>3</td>
<td>310.8</td>
<td>874.7</td>
</tr>
<tr>
<td>metalaxyl</td>
<td>2</td>
<td>2</td>
<td>12.6</td>
<td>37.3</td>
</tr>
<tr>
<td>penconazole</td>
<td>3</td>
<td>3</td>
<td>4.8</td>
<td>6.4</td>
</tr>
</tbody>
</table>

### WATER AND TEMPERATURE

- Temperature °C 2003
- Water height (cm) in the tank in 2003
- Temperature °C 2004
- Water height (cm) in the tank in 2004
2003 load 12.6 g dissipated 100 %
2004 load 37.3 g dissipated 99 %

METALAXYL

LOD 0.1 µg/l

23-apr 12-giu 1-ago 20-set 9-nov 29-dic 17-feb

µg/l 2003  µg/l 2004

2003 load 12.6 g dissipated 100 %
2004 load 37.3 g dissipated 99 %

LOD 0.1 µg/l

Fait G. Degree thesis. 2003
Santos C. Degree thesis. 2004

Hockey-stick model

Application $M_0$ → Input compartment → Output compartment

$K_1$

$K_2$

FOCUS (2004) "Guidance Document on Deriving Degradation Kinetics from Environmental Fate Studies in EU Registration"
Report of the FOCUS Work Group on Degradation Kinetics
### PESTICIDES CHARACTERISTICS

<table>
<thead>
<tr>
<th></th>
<th>water solubility (mg/l)</th>
<th>Koc</th>
<th>Henry’s constant law (Pa m²mol⁻¹)</th>
<th>vapour pressure (mPa)</th>
<th>DT50 in soil (d)</th>
</tr>
</thead>
<tbody>
<tr>
<td>fenitrothion</td>
<td>14</td>
<td>2000-7150</td>
<td>0.246</td>
<td>18</td>
<td>12-28</td>
</tr>
<tr>
<td>mancozeb</td>
<td>6.2</td>
<td>6000</td>
<td>5.9*10⁻⁴</td>
<td>&lt;0.0133</td>
<td>6-139</td>
</tr>
<tr>
<td>metalaxyl</td>
<td>8.400</td>
<td>30-300</td>
<td>1.6*10⁻⁵</td>
<td>0.75</td>
<td>10-40</td>
</tr>
<tr>
<td>penconazole</td>
<td>73</td>
<td>802-3500</td>
<td>6.6*10⁻⁴</td>
<td>0.17</td>
<td>133-343</td>
</tr>
</tbody>
</table>

#### fenitrothion

- $K_1 = 0.145$
- $K_2 = 0.007$
- $T_b = 33d$

- $K_{soil} = 0.012-0.058$
- $K_{hydr} = 0.006$ at pH 4
- $0.008$ at pH 7
- $0.009$ at pH 9
mancozeb

\[ K_1 = 0.074 \]
\[ K_2 = 0.0018 \]
\[ Tb = 30d \]

K soil: 0.005-0.116
K hydr: 0.46 at pH 5
0.30 at pH 7
1.04 at pH 9

metalaxyl

\[ K_1 = 0.18 \]
\[ K_2 = 0.0154 \]
\[ Tb = 33d \]

K soil: 0.017-0.069
K hydr: 0.008
penconazole

K₁ 0.059
K₂ 0.11
Tₜ 32d

K soil 0.002-0.005
K hydr stable

Copper residue in water 2003-2004

2003 load 419g (87 %)
2004 load 385g (67 %)

LOD 1µg/l
**MASS BALANCE**

**metalaxyl (12.6 g)**
- Water: 97.5%
- Sediment: 2.2%
- Biomass: 0.3%
- Dissipated: 0.2%

**fenitrothion (27.5 g)**
- Water: 58%
- Sediment: 1%
- Biomass: 40%
- Dissipated: 0.4%

**iprovalicarb (11 g)**
- Water: 72%
- Sediment: 25%
- Biomass: 3%
- Dissipated: 0.1%

**cimoxanil (10.9 g)**
- 100%

**MASS BALANCE**

**MANCOZEB (311g)**
- Water: 2%
- Dissipated: 97%
Conclusions

1) If used in the correct way, Biomassbed can mitigate pesticide point contaminations.

2) The Biomassbed performed very effectively retaining and/or degrading the pesticides (water decontamination 86-100% of the loading) and reducing the concentrations below the 0.1µg/l EU standard set for pesticides in drinking water.

3) Biomassbed is a closed system which avoid any risk of leaching of the water entered in the system.

4) Possibility to release the waters in SWB already after the first cycles (depending on pesticide)

5) Opportunities for using the Biomassbed as a tool for green/ecological certification of the farms.

6) Copper accumulate in the biomass, so it can represent a problem in the second year.
Acknowledgment

The "Azienda viti-vinicola La Pusterla" (Piacenza- Italy)