Reduction Of Diffuse Pesticide Contamination For A Sustainable Use Of Pesticides

Leticia Pizzul, Karin Önneby, John Stenström
Department of Microbiology
Swedish University of Agricultural Sciences (SLU)
Uppsala, Sweden
Bioprophylaxis – The Microbial Pro-Active Solution To Pesticide Pollution

Remediation  Act of correcting an error or a fault or an evil

- 20 000 contaminated sites pose a large or a very large risk for humans and the environment in Sweden

- 4-5 billion € for remediation of the 1 500 most polluted sites

Prophylaxis  The prevention of disease
Sources Of Pesticides In Surface- And Ground Waters

Point Sources

- Filling
- Parking

1 g active substance

1 dm$^2$ = 1 ton/ha

0.1 µg/L water

10 000 m$^3$
Biobeds Bind And Degrade Pesticides

Biobed mixture
- Straw 50%
- Peat 25%
- Top-soil 25%

Handling of concentrates
- Below the tank:
  - foaming
  - wash-off of residues

Dripping nozzles

Sources Of Pesticides In Surface- And Ground Waters

**Diffuse sources**

- Spraying
- Surface transport
- Leaching
Microorganisms And Chemicals In Soil
Chemicals “Age” In Soil

Young and available

Aged, low bioavailability
Risk for surface transport and leaching, especially when the microbial activity is low

New concept:
Fast degradation after addition of active bacteria or enzymes that degrade pesticides before they “age”

How Reduce Contamination From Diffuse Sources?
Metabolic and cometabolic degradation of herbicides in the fine material of railway ballast

Harald Cederlund*, Elisabet Börjesson, Karin Örneby, John Stenström

Department of Microbiology, Swedish University of Agricultural Sciences (SLU), Box 7025, SE-75007 Uppsala, Sweden

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Functional microbial diversity of the railway track bed

Harald Cederlund*, Tomas Thierfelder, John Stenström

*Department of Microbiology, Swedish University of Agricultural Sciences (SLU), Box 7025, SE-75007 Uppsala, Sweden
bDepartment of Energy and Technology, Swedish University of Agricultural Sciences (SLU), Box 7032, SE-75007, Uppsala, Sweden.
Railway Embankments
- small microbial biomass, activity and diversity
- heterogenous (sterile spots)

![Graph with data points and lines showing CO₂ production and organic matter (%)]

<table>
<thead>
<tr>
<th>Microbial biomass</th>
<th>No. of degraded carbon sources (of total 30)</th>
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<tr>
<td>Agricultural</td>
<td>Railway 0-10 cm</td>
</tr>
<tr>
<td>100-1500</td>
<td>28.5 (28-29)</td>
</tr>
<tr>
<td>&lt;1-20</td>
<td>10.5 (2-17)</td>
</tr>
</tbody>
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Model Substances

MCPA

- Metabolic degradation (used as substrate)
- *Sphingomonas sp. T51*
  - Active at 2-30°C
  - Also degrades 2,4-D, 2,4-DP and MCPP

Glyphosate

- Cometabolic degradation (not used as substrate)
- Enzymatic (laccase, manganese peroxidase)
Effect Of Adding An MCPA-Degrading Sphingomonas sp. T51 On MCPA-Degradation

Different Amounts Of Bacteria In The Presence Of Plants

Pesticide Properties DataBase: 50% degradation in 7-41 days in arable soil
One can predict with 85% probability if it will rain within 24 hours. The degradation should thus be complete within 24 hours in order to eliminate the risk for transport to surface- and ground waters.

A normal initial concentration of MCPA is 20\(\mu g\) MCPA per g of soil in the top cm. One bacterium degrades at least 0.25 pg MCPA per hour at 10\(^0\)C.

Degradation of all MCPA in 24 h then requires:

- \(3.3 \times 10^6\) bacteria per g of soil
- \(3.3 \times 10^{14}\) bacteria per ha
- 33 liter fermentate with \(10^{13}\) bacteria per liter
For a useable product, it is also necessary to...

- **Cultivate**
- **Formulate**
- **Risk assess**

Domestication of Microorganisms
Cultivation

• Development of new culture procedures
  – high biomass yield
  – stress-tolerant organisms
  – high viability

• Industrial cheap substrates
Safety Profile Of Microbes

- Collection and evaluation of scientific literature and other information
- Determination of antibiotic resistance pattern
- Determination of temperature range for growth
- *In vitro* testing of production of toxic substances

The phagotrophic (particle feeding) unicellular ciliate *Tetrahymena pyriformis* is used as a biosensor for detection of toxic substances produced by microorganisms.
Facilitate packaging
Extend shelf-life
Render the preparation easy to handle
Protect against compounds in pesticide product
Protect against UV-light and desiccation
Delay degradation until intended pesticide effect obtained
Freeze drying
- Well studied dehydration method
- Expensive

Fluidized bed drying
- Bed with fluid properties
- Carrier
- Harsh
- Less expensive
Survival After Freeze-Drying And After Storage At Different Temperatures

- Freeze-drying of *Sphingomonas sp. T51*
- 15% sucrose + 1.5% PVP90 (polyvinylpyrrolidone)
Ligninolytic Enzymes Degrade Many Different Pesticides ...

Degradation of glyphosate and other pesticides by ligninolytic enzymes

DOI 10.1007/s10532-009-9263-1

... inclusive glyphosate
Formulation With CaptiGel

Nanoparticles for encapsulation of e.g. bacteria and enzymes

A bacterium encapsulated in CaptiGel

Encapsulated bacteria and enzymes are protected against UV-light and chemicals

Kessler, Seisenbaeva, Unell & Håkansson, 2008
Almost no laccase activity after encapsulation of the enzyme in CaptiGel and 100% recovery of activity after dispersion of the gel in citrate buffer.

Formulation Of Laccase With CaptiGel

![Bar chart showing laccase activity](image-url)
Degradation Of Glyphosate In Sand By CaptiGel-Encapsulated Laccase

- Addition of CaptiGel-encapsulated laccase and Roundup to sand
- Incubated for 48h at 35°C

Pesticide Properties Database: 50% degradation in 4-180 days in arable soil