Mitigation of agricultural nonpoint-source pesticide pollution and phytoremediation in artificial wetland ecosystems

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www.artwet.fr
From Natural to Artificial Wetlands

**Natural Wetlands (NW)**
Wetlands are areas where water is the primary factor controlling the environment and the associated plants and animal life. Under the text of the RAMSAR Convention (Art. 1.1), wetlands are defined as:
“Areas of marsh, fen, peat land or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six meters”.

ArtWET doesn’t deal with natural wetlands but aims to duplicate and enhance the processes occurring in natural wetlands with human skill and technology.

**Nonpoint-source pollution**
Nonpoint-source (NPS) pollution is one of the major causes for deterioration of water bodies. Among NPS pollution, agriculture is considered to be the major agent. Pesticides are one of the most ubiquitous agricultural NPS pollutants.

**Mitigation**
Mitigation works to reduce or eliminate long-term risks to human life and property from disasters. Environmental mitigation describes projects or programs intended to offset known impacts to an existing natural resource.

Non point source pesticide mitigation means to reduce concentration and loads of pesticides in surface water from the cultivated areas.

**Pesticides**
The term pesticide designates products intended to treat plant organisms. They consist of a mixture of chemical substances in which the active ingredient acts against a target population (rodents, insects, weeds, etc.) by killing or repelling them. In agriculture, pesticides are used as herbicides, insecticides and fungicides. The application of pesticides on European soil is estimated at 320,000 tons per year.

**Artificial Wetlands (AW)**
Artificial wetlands are engineered constructed systems designed to simulate the water quality improvement functions of naturals wetlands in order to treat and retain surface water runoff pollutants (pesticides, copper ...) and thus decrease loadings to surface waters.
The ArtWET project: Objectives

Part of the implementation of the Water Framework Directive 2000/60/EC, the ArtWET project aims to:

- Replicate, mimic and reproduce the ecosystemic services offered by wetlands in artificial and controlled areas.
- Enhance ecosystem services delivered by wetlands to reduce non-point source pesticide pollution and ensure sustainable use of water resources.
- Prevent and reduce nonpoint source pesticide pollution, promote sustainable water use.
- Decrease pesticide concentrations from agricultural catchments and improve the quality of aquatic ecosystems.
- Best practices at the landscape scale, complementary to the farm scale and to the best practices management.
- Optimize the hydraulic properties and biochemical processes in different tested systems involved in the ArtWET project.
- Disseminate knowledge and make the technologies accessible to the European Community.
- Provide additional mitigation spots in the landscape.
Mitigation Processes: action in Artificial Wetlands

Nonpoint-source pesticides pollution
Significant research effort has been dedicated to understanding the fate and transport of pesticides in the environment and their relationship with specific environmental parameters such as water content, organic carbon and pH in soils.

Artificial wetlands action on pesticides is twofold: either as a sink due to storage, transformation and elimination or as a source as molecules may be transferred to receiving media like surface and ground water, or intercepted and temporary stored due to sorption into sediment, soil or suspended matter.
The ArtWET Artificial Wetlands

Collecting surface water containing pesticides carried out by runoff and/or drainage from upstream catchment and to mitigate pollutants.

Surface water crossing vegetated ditch in forested or agricultural areas.

Demonstration sites

Landau, Germany

Eichstetten, Germany

Loches, France

Colmar, France

Piacenza, Italy

Experimental sites

Rouffach, France

Landau, Germany

Antony, France

Loches, France
Results and recommendations

Artificial wetlands implementation should not replace measures taken upstream from systems at the farm scale (as pesticide input reduction) at the plot scale (vegetated areas, buffer strips…) or at the watershed scale.

Main figures

- **100%** of the runoff may enter constructed wetlands with a permanent or a non-permanent flow (except for drainage)
- **90%** of the rainfall-runoff events can be treated
- **76 ±19 %**: Mean mitigation efficiency (total concentrations, all pesticides) during two agricultural seasons (2009 and 2010)
- **73 to 98 %**: Mitigation efficiency (total load estimates) during two agricultural seasons (2009 and 2010)
- Seasonal load reductions ranged from **39 %** (simazine) to **100 %** (cymoxanil, glufosinate, kresoxim methyl and terbuthylazine).
- **1 hour**: Maximal hydraulic retention time needed with a short vegetated ditch to reduce peak concentrations during runoff by a mean of 52% after storm events of 3-20mm.
- **8 hours**: Minimal hydraulic retention time needed within a detention pond to reduce peak concentrations during runoff by a mean of 87% after a very heavy storm event of 30 mm.

Refined Strategy: drained subsurface area

- Strategy aimed at trapping maximum pesticide loads in minimum drained water flows: implementation of an artificial wetland in parallel of an arterial ditch, with a manually operated open-close device.

Conditions to enhance the efficiency of the artificial wetland:

- Optimization of the contact time between water/sediment and microorganisms increasing the residence time of pesticides into the Artificial Wetland;
- Well-oxygenated systems;
- Recirculation of water (99.8% efficient for pesticide mitigation);
- Linked to pesticide properties: mitigation capacity for mobile pesticides is less than for sorptive ones;
- Keep water depth shallow water (30 to 40 cm) depths and maintain dense vegetation;
- At least one year after artificial wetland system implementation is necessary to establish efficient pesticide mitigation;
- Sand-sediment mixture used as sorbent in microcosms offers good retention of pesticides.
- To increase the hydraulic residence time, various solution can be proposed: implementation of a vegetated ditch in the AW, implementation of a gravel filter, implementation of a series of detention ponds separated by ecological barriers filtering and treating the water, implementation of baffles in order to slow the flow, addition of adsorbent material to increase the pesticides retention time into the AW.
Recommended locations of artificial wetlands in the landscape

Implementation and / or development of such devices requires to answer to several questions:
✓ Is the work of retention and remedial procedure under the water law ?
✓ What are the dimensions of the artificial wetland to implement?
✓ Is there an area of nature conservation?
✓ Where does the discharge of the artificial wetland take place?

Artificial wetlands implementation is recommended at strategic interfaces:
✓ Foothills / plains
✓ Rural / urban
✓ Production / storage
✓ Dryland / wetland
✓ Nonpoint source / concentrated pollution
✓ Near a road (for maintenance)
✓ At the upstream of the landscape

Costs and regulation

Three posts of expenses have to be taken in consideration: preliminary studies, implementation costs and maintenance of the artificial wetland.
Also to be considered, are the expenses linked to the location of the artificial wetland:
✓ Purchase of the land or possible dialogue with the owner ?
✓ Crop losses ? (can be avoided by the choice of a less productive location)

These various costs can be compensated by requests of subsidies of diverse origins: CAP, governmental structures or local authorities.

The problems of public security concerning the artificial wetland are linked to its function of retention and to the quality of water polluted by pesticides.

To avoid any accident, it is recommended to undertake measures of protection like fences or "no swimming" panels...

For more details: see the guidance documents available on www.artwet.fr

Artificial wetlands are not “the miracle solution” and not a license to pollute. They have to be implemented in addition to local actions such as best management practices pesticides reduction plans. Together all these measures should help to reach "good chemical status".
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