European Commission

Science for Environment Policy

Herbicide run-off reduced by grassy ditches in Italy — recommended for agri-environment schemes

Pesticides used on agricultural land can leach into nearby surface water; this is called run-off and can harm aquatic ecosystems. This study evaluated the potential of ditches to reduce run-off, using Italy's Po Valley as a case study. Grassy ditches were able to significantly reduce the concentration of herbicides, even during extreme flooding. The researchers therefore suggest that the promotion of vegetated ditches via agri-environment schemes would be beneficial for pesticide mitigation.

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Pesticides have enabled increased agricultural productivity worldwide, but may also have negative impacts on ecosystems, through their effects both on land and via water. Effects via water occur when rain washes away pesticides from the surface of agricultural land into nearby bodies of water. As part of its common legal framework for achieving sustainable use of pesticides, which takes into account precautionary and preventative approaches, the EU has recommended measures to avoid the pollution of water with pesticides, such as establishing buffer zones or planting hedges alongside surface waters[1].

This study investigated the mitigation options in the Po Valley, northern Italy, a fragmented landscape containing many small farms, where it is important to remove pollutants before they enter a nearby large body of water. Vegetated ditches are common in the Po Valley, and a traditional feature of field margins. Although originally designed for drainage, the ditches also mitigate the effects of run-off chemicals entering the water cycle by reducing the speed of water flow and removing chemicals, sediment, organic material and nutrients from the water. However, their effectiveness varies and depends on the characteristics of the individual ditch, such as its size and vegetation cover. It is, therefore, important to conduct site-specific field trials to determine effectiveness.

The researchers performed experiments on a 500-metre ditch, designed for irrigation and the main drainage channel for 20 hectares of cropland (where maize is grown). The banks of the ditch were entirely covered by vegetation, mainly by grasses.

In April 2015, the ditch was flooded with 52 000 litres of water containing 60 grams of Lumax, which is commonly used for weed control in maize fields and contains the herbicides mesotrione, S-metolachlor and terbuthylazine.

The conditions were designed to simulate extreme run-off, and concentrations of herbicides were around 100 times higher than ordinary run-off. However, the experiment is still environmentally relevant as almost all herbicide leaching in the valley (98%) is due to extreme events, and heavy run-off is more likely to represent a large threat to surface water in the valley under future climate change projections (based on the COSMO-CLM model system).

After 27 and 82 days, the area was again flooded, but this time with uncontaminated water, to assess the amount of the herbicide released by the ditch. Alongside the field measurements, the researchers applied a 'fugacity' model — an environmental chemistry model which can be used to accurately predict the concentrations of pesticides in different environmental compartments (such as sediment and water).

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1. Directive 2009/128/EC establishing a framework for Community action to achieve the sustainable use of pesticides: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:309:0071:0086:en:PDF

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After the first flood, the concentration of the herbicides decreased throughout the ditch. Concentrations were at around half their initial level 250 metres from the inlet (where the water first entered the ditch), while at the outlet (where the ditch ended) mitigation levels were between 91% and 99%. Thus, almost all of the herbicides were removed by the ditch after the first flood.

After the second flood, only two of the herbicides could be detected in the water and at very low concentrations — within the safe limit for drinking water (0.1 micrograms per litre) and of low risk to the aquatic ecosystem based on their Predicted No Effect Concentration (PNEC), a level below which there are no adverse effects of exposure in an ecosystem.

Mitigation — reduction in pesticide loss at outlet — was close to 99.9% after the second flood, and by the third flood, herbicides could not be detected along either the ditch or at the outlet. As a general rule, the researchers say a run-off of 1 millimetre from an area of cropland of 5 hectares can be mitigated by 99% within 100 metres of a vegetated ditch, based on their observations and the findings of the fugacity model.

Analysis using the fugacity model showed that herbicide adsorption to the solid part of sediment begins rapidly and is likely complete when the ditch returns to normal, dry conditions. The model calculated that up to 51% of the herbicide is dissolved in water at the inlet, and only a minor amount of herbicide reaches the outlet because by this stage the vast majority (up to 73%) has adsorbed onto the solid part of the ditch (e.g. soil and sediment).

This study suggests that vegetated ditches have great potential for preventing herbicide run-off from reaching waterways, although it is important to remember that only regular maintenance of the ditch can prevent negative effects on the ditch itself. As a result of their findings, the researchers recommend that shallow vegetated ditches be included in agri-environment schemes to reduce pesticide run-off. They say ditches are already present in the landscape and, by proper management, could generate important environmental benefits.

They say that the effectiveness of ditches depends on their height and length. In typical north-eastern Italian ditches, for example, (and for the main herbicides applied to maize) the distance required to halve the concentration of herbicides is approximately 250 metres. However, the effectiveness of ditches is site-specific and the authors recommend further research into different plants and herbicides.

As combinations of mitigation measures can be most effective, the researchers also recommend a scheme based on a combination of ditches (for the immediate reduction of direct run-off from fields), wetlands (which can purify water) and buffer strips (running alongside high-quality water courses).

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