VFSmod – A comparison with field derived values of runoff removal efficiency under controlled conditions

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Introduction

Vegetative filter strips (VFS) are one of the most widely implemented mitigation measures to reduce the loss of pesticides and other pollutants (e.g. sediment) transported in surface runoff to surface waterbodies. The risk mitigation provided by VFS is implemented in regulatory risk assessments using either (i) a scenario based approach underpinned by fixed, conservative, empirical FOCUS landscape and mitigation VFS removal efficiencies [widely accepted] or (ii) a dynamic simulation approach using VFSmod [accepted by a small number of Member State regulators]. VFSmod[1] (Vegetative Filter Strip Modelling System) is a finite-element, field-scale, storm-based model developed to route the incoming surface flow hydrograph and sedigraph from an adjacent source area through a VFS and to calculate the resulting infiltration, outflow and sediment trapping. The recent addition of a contaminant transport routine allows for the assessment of pesticide attenuation by VFS.

Given the limited regulatory acceptance of VFSmod, and in support of a number of regulatory submissions, a series of replicated field studies have been carried out where the removal efficiency of VFS for specific compounds and specific VFS widths has been tested under controlled conditions representative of a selected worst case FOCUSsw R scenario event covering the intended pesticide use and exposure profile. The replicated field plot test system applies pesticide in "run-on" water calculated to match the selected rainfall/runoff event and measures infiltration and removal of compounds across differing widths of buffer strip.

Aim

This study compares the observed runoff attenuation from four standardised "run-on" field tests carried out in the UK, with pesticides of differing physicochemical characteristics under a range of soil moisture conditions, with that simulated by VFSmod parameterised to represent each study design and each of the replicated plots. The aim was to assess the robustness of VFSmod results, with a view to expanding the validation evidence base and promoting wider regulatory acceptance of the model.

Methodology

Each of the 32 individual field tests (4 experiments, 8 replicates) were modelled using VFSmod parameterised with site and study specific plot data. These covered a range of soil moisture conditions in the spring/autumn, and differing storm/runoff event magnitudes, duration and intensities (Table1). Full soil/site characterisation was carried out where required to provide model input parameters.

Table 1 - Variation in storm/runoff events tested

Experiment	Rainfall depth (mm) / duration (hr)	Runoff depth (mm) / duration (hr)	VFS width (m)	Number of tests	Month
1	71 (5)	11 (1)	10	4	April
1	71 (5)	11 (1)	20	4	April
2	64 (3)	15 (2)	5	4	November
2	64 (6)	15 (2)	10	4	December
3	43 (4.2)	22 (3)	10	8	March
4	45 (4)	21 (3)	10	4	October
4	45 (4)	21 (3)	10	4	December

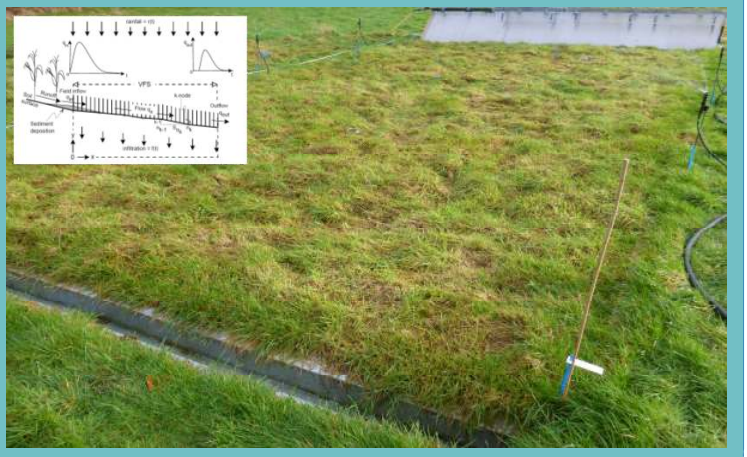


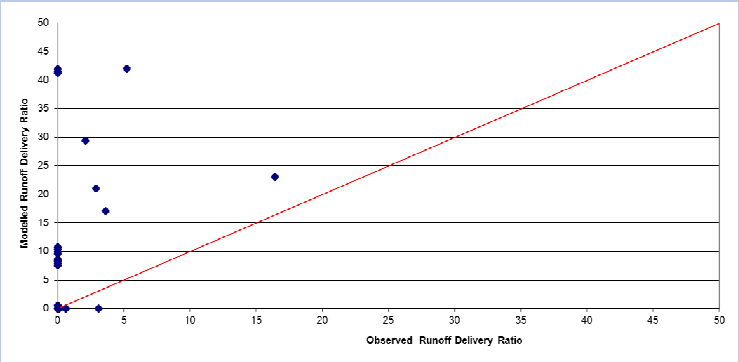
Figure 1 – Field trial plot showing "run-on" application rig, irrigation system and collection gutter. Inset – VFSmod conceptual design [1].

Results

The field studies demonstrated that the predominant mitigation mechanism was infiltration, with a large proportion of the run-on water retained by the grass buffer strip under all combinations of event size and buffer length. Infiltration losses represented between 84 and 100% of the applied runoff.

Observed and modelled runoff delivery ratios are not correlated, with VFSmod overestimating the observed runoff delivery ratio by up to a factor of 40. As such, uncalibrated VFSmod results are precautionary when compared with real world observations as they over-estimate the amount of runoff breaching buffer strips – at least for the large rainfall and runoff events considered in these studies.

Figure 2 – graph of modelled versus observed runoff delivery ratios (red line indicates the 1:1 relationship)



Conclusions

- VFSmod runoff reductions are highly precautionary for large rainfall and runoff events, even when soils are close to field capacity
- VFS provide significant protection for surface waterbodies even in marginal spring/autumn times of the year when soils are near saturation
- "Run-on" field studies provide a valuable means of gathering compound specific VFS removal efficiency in support of VFSmod simulations for regulatory submissions
- The results provide further evidence for regulators looking to accept simulation results from VFSmod coupled to FOCUSsw R scenarios

Further Work

- Saturated hydraulic conductivity explains most of the variation in VFS performance modelled by VFSmod, yet it is one of the most difficult to measure reliably and is known to vary in a single field with the same soil texture by as much as an order of magnitude. Further testing of the spatial variation on the study site is required.
- VFSmod currently does not model multiple soil horizons explicitly. Further simulations with various "averaged" soil profiles are planned.

[1] http://abe.ufl.edu/carpena/vfsmod/