MANOR FARM BIOBED, SALLE PARK ESTATE, NORFOLK

River Wensum DTC

Research update 3

SEPTEMBER 2017

On-farm biobed degrades waste pesticide residues

A three-stage on-farm biobed facility for treating pesticide contaminated wastewater (>15,000 litres per year) was constructed at Manor Farm, Salle in 2013. Financial support for the scheme came from a CSF Capital Grant and the DTC measures budget, but the great majority of the cost was paid by the Salle Estate. The facility consists of three main components:

- **Wash-down unit**: a 20 m x 9 m enclosed wash-down unit is used to both remove pesticides residues from farm machinery and to contain any pesticides spilt during the filling of the pesticide sprayer. A drain running down the centre of the unit channels contaminated washings into a concrete storage tank (the input sump);
- **Biobed**: the biobed itself is an uncovered, indirect, lined (impermeable geomembrane) design covering an area of 49 m² (7 m x 7 m) to a depth of 1.2 m, thus providing a large surface area for biological and photo-degradation. The organic bio-mix matrix material is composed of a 1:2:1 mix of peat-free compost, chopped wheat/barley straw and local topsoil. The surface is seeded with grass. Contaminated water from the input sump is pumped onto the biobed surface via a trickle irrigation system, with the leachate collected at the base of the biobed in a concrete output sump;
- **Drainage field**: the leachate from the output sump is pumped onto a 200 m² (20 m x 10 m) drainage field via a second trickle irrigation system buried just below the surface to promote further removal of residual pesticide residues. This drainage field is covered with grass and is surrounded by mature trees. A network of 20 porous pots were installed (30° angle) across the drainage area at 45 cm and 90 cm depth (ten pots for each) to monitor soil water pesticide concentrations at depth for signs of further removal or accumulation.

Pesticide concentrations were analysed in water samples collected fortnightly between November 2013 and November 2015 from the biobed input and output sumps and from the 20 porous pots to monitor rates of pesticide degradation.

Wensum Alliance

University of East Anglia

DEMONSTRATION TEST CATCHMENTS

The Demonstration Test Catchments (DTCs) are a £7.5 m research platform established by DEFRA in 2010 to investigate the extent to which on-farm mitigation measures can cost-effectively reduce the impact of diffuse water pollution on river ecology whilst maintaining food production capacity.

Four DTCs were established across the UK to provide an evidence base for farming in contrasting agricultural systems. These were:

- River Wensum, Norfolk (arable)
- River Eden, Cumbria (upland)
- River Avon, Hampshire (mixed dairy)
- River Tamar, Devon (livestock)

FURTHER DETAILS:
http://www.wensumalliance.org.uk/

FAST FACTS

68-98%

Reduction in individual pesticide concentrations post-treatment

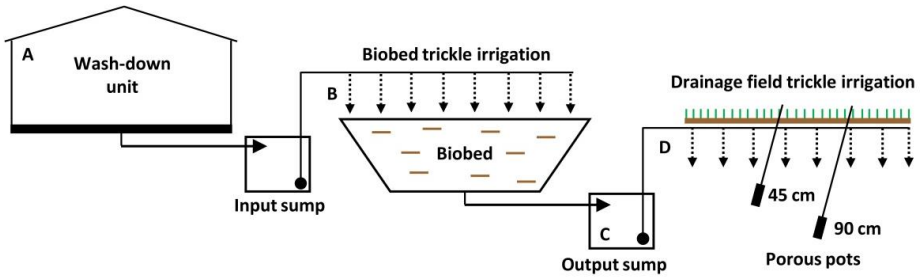

Figure 1: Schematic of the biobed unit installed at Manor Farm, Salle. Letters refer to photos.

Performance

The results of the monitoring programme revealed that the biobed removed 68–98% of individual pesticides within the contaminated washings, with mean total pesticide concentrations reducing by 91.6% between the biobed input and output sumps **(Figure 2; Table 1)**. Drainage field irrigation removed a further 68–99% of individual pesticides, with total mean pesticide concentrations reducing by 98.4% and 97.2% in the 45 cm and 90 cm depth porous pots, respectively. The average total pesticide concentration at 45 cm depth in the drainage field (57 µg L^{-1}) was **760 times lower** than the mean concentration recorded in the input sump (43,334 µg L^{-1}). There was no evidence of seasonality in the efficiency of biobed pesticide removal, nor was there evidence of a decline in removal efficiency over the two-year monitoring period.

However, higher mean total pesticide concentrations at 90 cm (102 µg L^{-1}) relative to 45 cm (57 µg L^{-1}) depth indicated an accumulation of pesticide residues deeper within the soil profile which could indicate interaction with the shallow groundwater table. Overall, these results demonstrate that a three-stage biobed can successfully reduce pesticide pollution risk from contaminated machinery washings on a commercial farm.

Costs

The approximate construction costs for the three main components of the Manor Farm biobed at listed in **Table 2**. Whilst total costs were £96,827, the majority of this (£90,454) was for building the large, insulated, wash-down unit and equipping it with mains electricity and steam cleaning equipment.

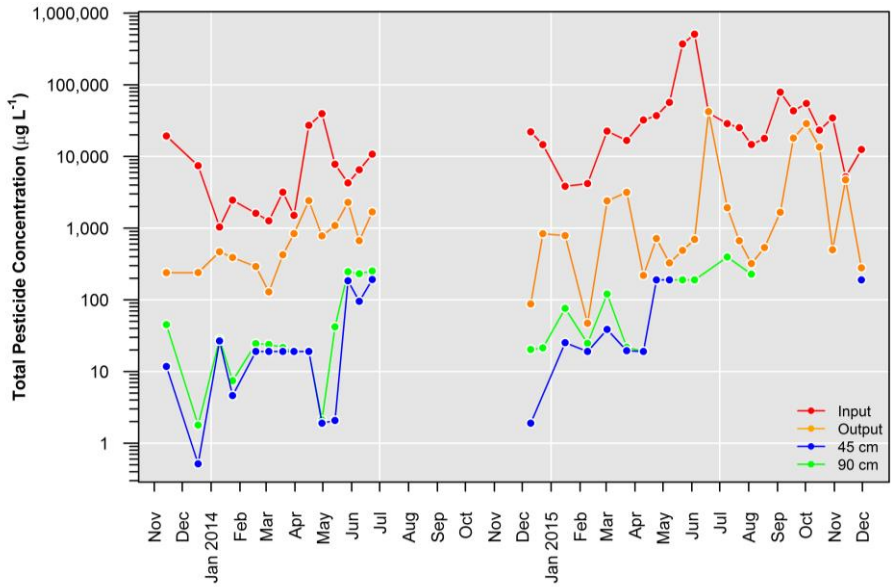

Figure 2: Time series of total pesticide concentrations in the Manor Farm biobed at the input and output sumps and at 45 cm and 90 cm depth within the drainage field.

A. sprayer wash-down unit

B. biobed operational area

C. output sump

D. drainage field

Table 1: Biobed pesticide removal efficiency for the 15 most abundant pesticides. Data are for the period November 2013 to November 2015. The efficiency of the biobed sumps refers to the reduction in pesticide concentration between the input and output sumps. The efficiencies of the porous pots reflect the reductions in pesticide concentration between the output sump and the 45 cm and 90 cm porous pots. Missing values relate to non-detected pesticides.

Pesticide	Biobed Sump Mean Concentration (µg L^{-1})			Porous Pot Mean Concentration (µg L^{-1})			
	Input	Output	Efficiency (%)	45 cm	Efficiency (%)	90 cm	Efficiency (%)
Propyzamide	2551.3	60.0	**97.6**	-	-	-	-
Chloridazon	2547.7	81.9	**96.8**	-	-	-	-
Triclopyr	958.5	32.8	**96.6**	1.2	**96.3**	2.5	**92.4**
Ethofumesate	26935.1	980.9	**96.4**	-	-	-	-
Chlorotoluron	150.4	6.9	**95.4**	-	-	-	-
Bromoxynil	167.3	11.3	**93.2**	1.1	**90.3**	1.6	**85.8**
2,4-D	2944.9	213.7	**92.7**	2.2	**99.0**	6.5	**97.0**
Mecoprop	803.7	112.7	**86.0**	3.0	**97.3**	6.6	**94.1**
MCPA	30.4	4.8	**84.2**	1.1	**77.1**	1.6	**66.7**
Fluroxypyr	1162.0	224.6	**80.7**	9.3	**95.9**	16.0	**92.9**
Dicamba	223.5	43.8	**80.4**	9.1	**79.2**	13.9	**68.3**
Carbetamide	15.3	3.0	**80.4**	-	-	-	-
Clopyralid	1025.5	238.1	**76.8**	5.5	**97.7**	16.2	**93.2**
Metsulfuron-methyl	32.9	8.1	**75.4**	-	-	-	-
Metazachlor	5561.0	1754.9	**68.4**	-	-	-	-

Such a high quality design is not essential to achieve good operational performance and much simpler facilities would be more appropriate for wider deployment across multiple farms within a catchment. The cost of the biobed itself, which included the pipework, pumps, liner, matrix material and labour was relatively inexpensive (£4,311). Replenishment of the matrix material two years after construction cost £8 m^{-2}. The cost of the drainage field infrastructure was approximately £1,684, of which the porous pots accounted for £1,466. Installing porous pots in other commercial biobeds would not be necessary as their installation here was purely for research purposes. Much simpler designs could likely be constructed for £5,000–10,000, increasing the feasibility of uptake by a larger number of farms, particularly if such measures were financially incentivised under government agri-environment schemes.

Table 2: Approximate construction costs (including labour) for the Manor Farm biobed installed in 2013.

Component	Area (m^2)	Cost (£)	(£ m^{-2})
Sprayer wash-down area	270	90,454	335
Biobed	49	4,311	88
Drainage field	200	1,684	8
Matrix replenishment after 2 years	49	378	8
	Total cost	**96,827**	

FOR MORE INFORMATION

For general enquiries please contact:
wensumalliance@uea.ac.uk
http://www.wensumalliance.org.uk/

For specific enquiries please contact:

Prof. Kevin Hiscock
School of Environmental Sciences
University of East Anglia
Norwich, NR4 7TJ
+44(0)1603 593104
k.hiscock@uea.ac.uk

Prof. Andrew Lovett
School of Environmental Sciences
University of East Anglia
Norwich, NR4 7TJ
+44(0)1603 593126
a.lovett@uea.ac.uk

Dr Richard Cooper
School of Environmental Sciences
University of East Anglia
Norwich, NR4 7TJ
+44(0)1603 592922
Richard.J.Cooper@uea.ac.uk

FAST FACTS

760 x lower

Pesticide concentrations in the drainage field *vs.* input sump