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Sediment trapping by a tree belt Implication for pollution filtering

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Introduction

Vegetative filter strips are often used to trap agricultural diffuse pollution transported by overland flow. Located between agricultural land and waterbodies, filter strips are designed to improve the quality of surface water. Experiments have shown a significant decrease of the sediment load in overland flow following passage through such a structure (Dosskey, 2001). However this reduction of the sediment load does not translate to a proportional decrease of the pollutants delivered to the surface water. As shown by the few known studies that include sediment composition analysis (e.g. Loch et al. 1999; Ghadiri et al. 2001), the most polluting particles (fine sized and low settling fractions) are less efficiently trapped.

Tree belts are an agroforestry tool implemented for a wide range of benefits. These benefits include pollution filtering but also balancing the water budget to avoid salinisation and water logging, improving nitrogen cycling, providing stock and crop shelter, producing timber and fodder, enhancing biodiversity (e.g. see Kang et al. 1990; Stirzaker et al. 2002). In parts of Australia, where salinisation is a significant concern, tree belts have been promoted for adjusting the water balance of agricultural land (Stirzaker et al. 2002). However, the filtering capacity of tree belts has receive far less attention than other buffer strips (Dosskey, 2001) and, to our knowledge, only Loch et al. (1999) investigated their effect on the different sediment fractions.

The general objective of this work was to determine the impact of tree belt on sediment fluxes and more precisely:

- to identify the processes which interact with sediment fluxes,
- to quantify their impact,
- to assess the potential pollution reduction.

Experimental design

The experimental work was conducted on a sheep farm near Boorowa, New South Wales, Australia. The site was a pasture (12 $^{\circ}$ slope) upslope of a 15 y. old tree belt (*Acacia sp.* and *Calistemon sp.*), aligned perpendicular to the slope. A rainfall simulation was performed on this site in July 2004 in order to assess the trapping efficiency of the tree belt. A detailed description of the rainfall simulator is given in Motha et al. (2002) and Wilson (1999).

The 200 m^2 experimental plot comprised a 15 $\times$ 38 m^2 pasture part and a 15 $\times$ 12 m^2 tree belt part. The plot was divided in three sampling areas of pasture, tree belt, and the whole slope length comprising both pasture and tree belt. Each area had its own sampling point for overland flow. Two rainfall events of respectively 45 and 75 mm.h^{-1} and 30 min duration were simulated on the whole 200 m^2 plot.

At each sampling point, two samples of overland flow were taken every 3 min during the whole runoff event, i.e. during the rainfall as well as during the hydrograph recession period once the rain ceased. The first set of samples was processed to determine water discharge and soil loss rate. The second set was used to measure aggregate size and settling velocity distributions of the sediment.

For each rainfall event, budgets were computed for the total volume of runoff (in l) and the total mass of sediment (in g) with the following equation:
Q$_{trap} = Q_{est}(p) + Q_{est}(b) - Q_m(p+b)$,
where Q_{trap} is the computed trapped quantity. $Q_{est}(p)$ and $Q_{est}(b)$ are the estimated quantities for respectively, the pasture and the tree belt parts within the pasture + tree belt sampling area. They were computed by adjusting the measured quantities for the area of the pasture + tree belt sampling surface. $Q_m(p+b)$ is the total quantity measured at the outlet of the pasture + tree belt sampling area.

Main results

Approximately 50 % of the water produced by the pasture area was trapped within the tree belt during the first rainfall event of 45 mm.h^{-1}. However at least 95 % of the eroded sediment was caught in the tree belt. During the second 75 mm.h^{-1} event, apparently no water was trapped but at least 90 % of the eroded sediment was caught.

The observations made during the events highlighted the trapping processes:

- deposition in the backwater area upslope of the tree belt,
- infilling of the macropores open at the soil surface,
- micro-terracing due to the accumulation of coarse organic residue in the tree belt.

Within the tree belt, coarse organic debris from the tree litter was detached and exported from the belt. Loch et al. (1999) and Ghadiri et al. (2001) have also observed similar erosion process inside a vegetative filter strip.

The outgoing sediments had a slower settling velocity distribution and obviously contained a higher proportion of fine soil fragments and organic matter.

Conclusion

The results showed that:

- the large majority of the sediment produced by the agricultural plot was caught by the tree belt even with such high rainfall intensities;
- the finer soil fragments were not efficiently trapped;
- there was generation of organic sediment from the tree belt.

The tree belt has a high capacity of sediment trapping, however its efficiency to protect water quality from diffuse pollution appears to be quite lower. The sediment fractions with the highest pollutant potential (fine particles and organic matter) either were not efficiently trapped or were eroded from the tree belt. To protect surface water from the pollution due to sediment exported from agricultural areas, other control measures may need to be considered.

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