Treatment of dairy soiled washwater using a woodchip filter

E Ruane[1], E O'Reilly[2], P French[1], P Murphy[1], M Rodgers[2]
[1]Teagasc Dairy Production Research Centre, Fermoy, Cork, Ireland, [2]National University of Ireland, Galway, Ireland
Email: eimear.ruane@gmail.com

Introduction Soiled water is produced on dairy farms through the washing-down of milking parlours and holding areas and contains nutrients and other constituents that pose a potential threat to water quality if not managed correctly. In Ireland, soiled water is generally applied to land, but the risk of nutrient loss to surface and ground waters from land application has attracted increased attention and legislation in the form of the EU Nitrates Directive and Water Framework Directive. Treatment and re-use of soiled water may negate some of these risks. This study examines the potential of woodchip filters to treat soiled water.

Materials and methods Laboratory filter units were constructed from 300 mm diameter plastic piping filled with woodchip. A stainless steel frame held the units in position so that soiled water could be applied to the top and effluent collected and sampled at the base. Sitka Spruce (*Picea sitchensis)* logs were de-barked and chipped (10-50 mm). There were three filter unit heights (0.5, 1 and 1.5 m) and two suspended solids (SS) loadings (1 % (S1) and 3 % (S3)). However, total nitrogen (TN) concentrations were low for S1, at an average of 235 mg/l. S3 gave an average TN concentration of 519 mg/l, which is close to the average found in a farm survey. There were three replicates, giving a total of 18 units. Fresh manure was dried down on-site and, once received in the laboratory was reconstituted with water and used as the influent. Soiled water was applied in equal volumes of 0.67 l three times daily (hydraulic loading rate was 28 l/m^2/d). A 100 ml sub-sample of effluent was collected three times weekly after four hours drainage. Units were sampled for 277 days for S1 and 197 days for S3. Samples were analysed within 24 hours of collection for chemical oxygen demand (COD), SS, filtered and unfiltered TN, NH_4-N, NO_2-N, NO_3-N and PO_4-P. Grab samples of woodchips, from different heights along the filter columns, were ground down and analysed for C using the CHN test before and after the experiment. NH_3 gas was trapped in HCl for one hour periods over a week and analysed using a Konelab Aquakem discrete spectrophotometric analyser. Statistical analysis was carried out using two-way factorial with replication using Statistical Analysis Software (SAS).

Results and Discussion Woodchip filters achieved considerable decreases in SS, TN and COD concentrations (Table 1). Over 99% of SS were removed for all heights at both loading rates ($p>0.05$), indicating that woodchip is an effective physical filter medium. A build up of solids on the top of the filters further indicated and aided filtration. There were significant decreases in the level of influent TN versus effluent TN, ranging from an 88% decrease for the 0.5m columns in S1 to 92% for the 1.0m and 1.5m columns. For S3, the percentage removal rates for TN were 93%, 92% and 93% for the 0.5m, 1.0m and 1.5m columns, respectively ($p>0.05$). A comparison between the unfiltered and filtered concentrations of TN for the influent and effluent indicated that filtration was the main treatment mechanism. The C content of the woodchip decreased from 49% to 45%, indicating that C in the woodchip may have contributed to biological nitrogen removal. Circumstantial evidence from the literature indicates that the woodchip can adsorb some nitrogen through physic-chemical absorption (Bolan et.al., 2004). Nitrification is indicated by the increase in NO_2-N and NO_3-N. Analysis of NH_3 gas indicated that there was no significant volatilisation. Percentage removal rates of COD for S1 were 96% for all three heights and for S3 removal rates of 98% for the 0.5m columns and 97% for the 1.0m and 1.5m columns were observed ($p>0.05$). COD removal likely also occurred primarily due to filtration but filters were aerobic so biological oxidation of organic compounds is also possible.

Table 1 Mean water quality parameters (mg/l) (± standard deviation) for wood-chip filter influent and effluent loaded at 1 % SS (S1) over a period of 277 days and 3% SS (S3) over a period of 197 days.

	Influent		Effluent					
	S1	S3	S1			S3		
			0.5m	1.0m	1.5m	0.5m	1.0m	1.5m
COD	12167 ± 1882	34418 ± 4982	523 ± 164	526 ± 115	518 ± 152	795 ± 160	999 ± 161	941 ± 145
TN	235 ± 56	542 ± 192	27 ± 12	24 ± 10	19 ± 9	40 ± 10	43 ± 11	40 ± 12
NH4-N	3.69 ±0.49	0.98 ±0.06	7.15 ±4.56	6.54 ±4.01	5.97 ±3.58	6.69 ±4.33	6.90 ±4.49	7.27 ±4.68
NO2-N	0.00 ±0.00	0.00 ±0.00	0.52 ±0.94	0.61 ±0.98	0.26 ±0.39	0.13 ±0.17	0.08 ±0.13	0.09 ±0.1
NO3-N	0.00 ±0.00	0.54 ±0.15	4.07 ±3.97	3.20 ±4.54	1.92 ±2.90	2.23 ±2.25	2.44 ±3.22	1.76 ±2.19
SS	10000 ±0.00	30000 ±0.00	6.77 ±5.30	6.54 ±6.79	4.83 ±3.83	9.23 ±5.52	8.56 ±6.10	6.32 ±3.74

Conclusions Woodchip was shown to be an effective filter medium for decreasing the concentrations of COD, SS and nutrients in dairy soiled washwater at two different loading rates.
Filtration, adsorption, nitrification, biological oxidation and biological removal may all have contributed to the treatment process.
The effect of filter unit depth on filter performance was found to be negligible.

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