Contaminant Losses in Overland Flow from Cattle, Deer and Sheep Dung

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Abstract. The loss of contaminants (phosphorus, nitrogen, sediment and faecal bacteria) in overland flow represents a risk to surface water quality. This study examined the loss of contaminants in overland flow after application of cattle, deer and sheep dung at an equivalent stocking rate (15 su ha\(^{-1}\)) to field plots. After 1, 3, 7, 12, 19 and 30 days three replicate intact samples of the control and each dung treatment were excavated using a cutting blade (100 cm long \(\times\) 20 cm wide \(\times\) 10 cm deep), placed into boxes and simulated rainfall used to generate flow. Data indicated that P fractions, NH\(_4\)-N, suspended sediment (SS) and E. coli concentrations generally decreased with time since application due to chemical and physical breakdown of dung. The exceptions were E. coli from sheep dung (relatively constant at 5.25 log\(_{10}\) cfu 100mL\(^{-1}\)) and NO\(_3\)-N for all dung (constant between 0.5 and 1.0 mg NO\(_3\)-N L\(^{-1}\)). Integrating data with time and expressing this relative to current limits for lowland surface water quality gave an estimate of the potential risk posed by dung released into overland flow during a grazing period of 30 d. This showed that the greatest risk was for E. coli > dissolved reactive P > total P > NH\(_4\)-N, while NO\(_3\)-N and SS risk was negligible. However, since most risk was accounted for by the first few days after deposition when dung was wet, risk could be minimised by not grazing on areas likely to produce overland flow (e.g., wet soils).

Keywords: E. coli, phosphorus, ammonium, nitrate, sediment, risk

1. Introduction

Loss from dung of phosphorus (P) nitrogen (N), suspended sediment (SS) and harmful bacteria represent a significant cause of impaired water quality and could thus be termed contaminants (Wilcock, 1986; Wilcock et al., 1999). In New Zealand, dairy cattle, deer and sheep graze and defecate on pastures for most of the year. This, in-turn, may lead to the loss of contaminants from dung to surface waters via overland flow. For instance, McColl and Gibson (1979) found that sheep grazing hill pastures in the North Island of New Zealand greatly increased the likelihood of N, P, calcium (Ca) and potassium (K) in overland flow compared to ungrazed pastures. McDowell et al. (2003, 2005a) found that grazing by dairy cattle in winter in southern New Zealand greatly increased the concentrations and loads of P, suspended sediment (SS) and E. coli in overland flow compared to ungrazed control plots, and that limiting the grazing time and hence the number of dung pats significantly decreased losses. McDowell and Paton (2004) also showed that in areas near the fence-line paced by deer, the potential for contaminant loss in overland
flow was greater than the rest of the paddock due to increased dung deposition and compaction. However, the concentration and form of contaminants varies among the dung of different grazing animals. For instance, Williams and Haynes (1995) found that P in the dung of cattle, deer and sheep was 5.7 g kg\(^{-1}\) dry matter (DM) of deer and sheep dung, but 8.2 g kg\(^{-1}\) DM of cattle dung. For N, cattle dung contained 27 g kg\(^{-1}\) DM, deer dung 12 g kg\(^{-1}\) DM, and sheep dung 15 g kg\(^{-1}\) DM. Consequently it stands to reason that the potential for contaminant loss will vary among the types of animal dung.

Recent work has also shown that the bioavailability of P varies between dung types and moisture content; drier dairy cattle, deer and sheep dung was less bioavailable than fresh dung (McDowell and Stewart, 2005). Furthermore, McDowell et al. (2005b) showed that the potential for N, P, \textit{E. coli} and SS loss in overland flow from cattle dung deposited on a cultivated and pasture soil decreased with time since deposition. These factors are important for rotationally grazed pasture where grazing occurs for 1–2 d, livestock are removed, and the pasture typically grazed again 14 to 30 days later, but up to 90 days in winter. If modelling contaminant losses due to dung deposition from grazing animals are to be successful then data on the pattern of contaminant loss by dung type with time since deposition is needed. Our objective was to determine the potential for P, N, SS and \textit{E. coli} losses in overland flow derived from dairy cattle, deer and sheep dung deposited on pasture plots. Secondly, we determined the relative risk of losses up to 30 days, commensurate with a typical grazing rotation in spring.

2. Materials and Methods

2.1. Soil and Preparation

The trial site was located at the AgResearch Invermay sheep farm, Mosgiel, New Zealand. The soil at the site was a Wingatui silt loam (weathered Fluvial Recent soil, NZ classification) with a prior Olsen P concentration of 13 mg kg\(^{-1}\). Approximately 0.2 ha of one paddock was fenced off from stock 3 months prior to the start of the experiment, pasture mown to 5 cm height and cuttings removed from the site. In Spring 2004, 72 one by 0.25 m sub-plots were marked out within 12 two by 1 m plots (6 sub-plots per plot), with each plot receiving one of the following treatments: cow dung, sheep dung, deer dung or no dung (Control). The trial was a randomised complete block design with 3 replicates of each dung treatment plus a control. Deer and sheep dung were obtained during a regular grazing rotation from the Invermay farm, where farmed sheep and deer graze pasture dominated by ryegrass (\textit{Lolium perenne} L.), and white clover (\textit{Trifolium ripens} L.), with a minor component of browntop (\textit{Brachiaria fasciculate} L.). All dung samples were taken within 1 hr of excretion and applied to the plots within 4 hr. On the same day, 20 dung pats were subsampled from a nearby (1 km away) dairy farm and bulked together (10 kg). Soils