AN INVESTIGATION INTO REPELLENCY-INDUCED RUNOFF AND ITS CONSEQUENCES IN A NEW ZEALAND HILL COUNTRY PASTURE SYSTEM

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ABSTRACT

Soil water repellency affects a wide range of soils within diverse environments. In agricultural systems, it has the potential to reduce infiltration of water into the soil and enhance surface runoff processes. Accordingly, soil water repellency may have significant consequences in hill country. In these landscapes, repellency-induced runoff has the potential to result in a marked reduction in the quantity of water available to pasture in summer and autumn, and to increase the impact of summer storm events on stream flow.

The objective of this thesis is to examine repellency-induced runoff and to study its consequences in New Zealand hill country pasture systems, with a particular focus on the East Coast of the North Island as represented by the research area at Alfredton and a catchment near Waipawa.

Detailed meteorological data, surface runoff measurements from small plots (1.0 x 2.0 m), and soil moisture values gathered over two years at the Alfredton catchment were used to determine the effect of soil water repellency on the infiltration rate of the soil and surface runoff, and to assess its importance as a hydrological process in that catchment. The persistence of repellency was further investigated on soil slabs in the laboratory. A soil water balance model, which incorporates the observed throttling effect of repellency in the top 50 mm of soil, was developed to help assess when this phenomenon was most likely to occur. Output from the model using 8 years of rainfall and stream flow data from the Waipawa catchment was used to help gauge the effect of repellency-induced runoff on peak stream flow and total stream flow. The effect of repellency on pasture production was also measured at the Alfredton site.

The Alfredton soils had high intrinsic infiltrability (at least 2 mm min^{-1}), but this property was compromised by water repellency under dry soil conditions. However, analysis of detailed meteorological, soil moisture, and surface runoff data at the Alfredton catchment indicated that plot-scale repellency-induced runoff events occurred less than 10 times a year and that over two years these events equated to less than 5 % of the mean annual rainfall of 1517 mm. Observations and modelling showed that repellency-induced runoff occurred whenever

both the rainfall intensity exceeded 0.1 mm min^{-1} and the soil water content in the 0-50 mm topsoil was less than 0.28 m^3 m^{-3}. Although repellency reduced the infiltration rate of the Alfredton soils by a factor of 10, it disappeared less than 44 hours after significant rainfall, and only reappeared once the soils had again become sufficiently dry. The rapid disappearance of water repellency was confirmed by the laboratory study using large soil slabs. The implication is that repellency-induced runoff is not a significant hydrological process.

The soil water balance model was used to predict repellency-induced runoff over 8 years in the Waipawa catchment. It predicted on average about 50 mm yr^{-1} of repellency-induced runoff from both the North catchment and South catchments over the 8 years, during which time the catchments received an average rainfall of 793 mm yr^{-1}. This suggests that even in this drier climate, repellency-induced runoff plays a relatively minor role in the soil water balance of these hill country catchments.

Examination of Waipawa stream flow data on those days when more than 10 mm of repellency-induced runoff was predicted, revealed a maximum stream flow of 1.1 mm and an average flow that was only 3.3 % of the modelled repellency-induced runoff. Additionally, on those days, peak stream flow was less than 3 % of peak rainfall intensity. These values suggest that at least 95 % of repellency-induced runoff infiltrated the soil before reaching the stream and thus contributed very little to both peak and total stream flow at Waipawa over the 8 years.

Repellency-induced runoff appears to have had little effect on pasture production at the Alfredton site. Employment of the refined soil water balance model in combination with a pasture production model suggested that repellency-induced runoff would be responsible for less than 1 % reduction in pasture production per annum. Statistical analysis of production data over the 2010 and 2011 years showed that shallower (20^o) slopes significantly out-produced steeper (30^o) slopes by 2.7 t ha yr^{-1}, with North and South aspect production being similar.

In summary, repellency-induced runoff does not appear to play a major role in the soil water balance of the study catchment at Alfredton. Furthermore, repellency-induced runoff does not seem to have a marked impact on stream flow under the drier Waipawa climate.

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