Assessment of the transport and transformation of nitrogen in the unsaturated and saturated zones under two dairy farms in the Manawatu River catchment

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Abstract

The importance of dairy farming in New Zealand is reflected in the country's export and gross domestic product earnings. While the economic and food production benefits are evident, there is an increasing concern about the effects of excess nutrient runoff on water quality and ecosystem health. Studies on the transport and transformation of nutrients, specifically nitrogen, are limited or mainly focused on the management and reduction of nutrient losses from the root zone. This is also the case in the Manawatu River catchment of New Zealand. The goal of this study was to assess the transport and transformation of nitrogen in the unsaturated (below the root zone) and saturated zones using field measurements, a tracer test, and identification of redox conditions in the shallow groundwater.

Two sites were chosen in the Manawatu River catchment: Site 1 (Massey Dairy Farm No. 1, Palmerston North) and Site 2 (Te Matai Road, Whakarongo). Soil-water and groundwater were extracted using 12 porous cups (0.3, 0.6, 1.0, 2.0 m bgl) and four piezometers (5.8, 6.3, 7.4, 8.7 m bgl) installed at Site 1, and six piezometers (12, 18, 33, 51, 66, 87 m bgl) installed at Site 2. The extracted water samples were analysed for nitrate-nitrogen (NO_3-N) and other water quality parameters. The average NO_3-N concentrations in the unsaturated zone (0.3 – 2.0 m bgl) decreased with depth.

At Site 1, a tracer test was conducted in November, 2013, using an application of urea (467 kg N/ha) and bromide (206 kg Br/ha). After fertiliser application, NO_3-N concentrations increased in the root zone. The bromide reached only until the 2-m depth porous cup in January, 2014, after a total irrigation depth of 478 mm. The early appearance of bromide in the 0.3 m depth root zone suggested preferential flow, a pathway that speeds up transport of potential contaminants in the groundwater.

The observed data of NO_3-N, dissolved oxygen (DO), iron, manganese, and sulphate were utilised to assess the redox condition in groundwater at both sites. The decreasing NO_3-N concentrations with increasing depth indicated dilution and/or the occurrence of denitrification in the groundwater. The groundwater redox conditions were mixed oxic-anoxic in the 5.8 – 51 m bgl and mainly anoxic below 51 m groundwater depth.

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