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Tracing runoff- and erosion-driven transport of slurry-derived pollutants in soil systems using molecular-scale organic biomarkers

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Understanding how cattle slurry is partitioned and transported through a soil system via different pathways is extremely important given that in the EU alone ca. 1 billion tonnes of dung and slurry are produced annually, and recycled by applying to land. Much research has highlighted the potential for contamination caused by slurry application, for example ammonium and nitrate leaching and the transport of pathogens such as *E. coli*. However, further research is required to determine the timing and extent of contamination as influenced by hillslope topography and hydrology. To achieve this, organic and inorganic biomarkers were used to investigate the transport in soil-water systems of potential pollutants deriving from additions of cattle slurry to land. This biomarker approach allows differentiation of pollutants transported through sediment-bound and dissolved pathways.

A series of experiments were carried out using University of Bristol's TRACE experimental facility. The dual axis soil slope ($6 \times 2.5 \times 0.3$ m^3) accompanied by a 6-nozzle rainfall simulator, enables manipulation of the slope to simulate different topographic and rainfall scenarios. Cattle slurry was applied to the top of the experimental soil slope at a rate of 5 L m^{-2} and rainfall simulations were carried out, where the slope gradient (5° and 10°) and the rainfall intensity (60 and 120 mm h^{-1}) were varied. A no-slurry treatment acted as the experimental control. During each rainfall simulation, samples of water were collected via outlets below the slope and spatial soil cores were taken from the slope after each experiment. Ammonium, nitrate and protein fluorescence were monitored in the water samples to investigate the fate of dissolved components of slurry through different hydrological pathways: surface runoff, sub-surface through-flow and vertical percolated flows. In addition, lipid biomarkers 5β-stigmastanol and 5β-epistigmastanol (5β-stanols) were quantified in the soil cores and used to trace the transport of sediment-bound pollutants from the slurry. These faecal waste-specific biomarkers, determined using GC/MS, derive from microbially-mediated biohydogenation of plant sterols in a ruminant gut, providing a robust method to trace the transport of bovine faecal matter via eroded sediment pathways.

The results show that contributions of potential pollutants from the surface and sub-surface flow pathways and from the eroded sediment differ according to slope gradient and rainfall intensity. Therefore, as the contribution of each of these pathways changes in response to rainfall and topography, the pollution risk also changes accordingly as different organic compounds are mobilised at varying rates. Rapid hydrological response to rainfall results in erosion and transport of sediment-bound and dissolved pollutants, creating an immediate contamination threat. However, conditions resulting in a slow hydrological response, while leading to lower erosion rates and sediment-bound pollutant transport, results in higher rates of dissolved pollutant transport through the soil layers which poses a threat of contamination of the soil sub-surface.