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Use of rare earth oxide tracers to determine source areas for sediment eroded from arable hillslopes

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Soil erosion from arable hillslopes has both on-site and off-site effects. On-site, erosion and redistribution of sediment can lead to the loss of productive field area and a reduction in organic matter and nutrient content in topsoil. Off-site, the transport and deposition of eroded sediment in downstream waters is associated with turbidity, sedimentation and reduced water quality, as sediments are associated with the transport of nutrients, particularly phosphorus (P) and nitrogen (N), heavy metals and pesticides. Arable land is a major source for these sediments, with studies in the UK estimating the cultivated fields may be responsible for up to 80% of particulate P in rivers. Previous studies at Loddington in Leicestershire, UK have demonstrated that most of the P and much of the N eroded from hillslope is in particulate form, transported in association with sediment suspended in runoff. Results also suggest that tramlines are the principal pathway for erosion from arable fields containing combinable crops. As tramlines are regularly spaced over the whole field, they potentially act as conduits for runoff, sediment and sediment-associated nutrients to be lost from the hillslope. However, it is not yet clear where the source areas are for sediment eroded via this pathway. To understand the movement of sediment on arable hillslopes, a hillslope-scale tracer experiment was undertaken in one year at the same site. The aims of this study were (1) to develop an application method for rare earth oxide tracers suitable for using on a hillslope scale to assess sediment movement over a number of storm events, (2) to determine the erosion rates of different contributing hillslope areas, (3) to determine the relative contributions of sediment eroded from each of these areas in order to assess the importance of different hillslope source areas for soil erosion. Different rare earth oxide tracers were applied in solution using a knapsack sprayer to four areas of the hillslope, the topslope, midslope, and downslope hillslope segments without tramlines, and the tramline areas. Erosion rates were measured from a number of hillslope areas, and sediment samples were collected from the hillslope areas after a series of rainfall events, and analysed for rare earth element concentrations in order to determine the amounts of different tracers eroded in each event. The results of the paper provide insights into the transport of sediment within arable hillslopes. For example, the upslope section of the hillslope is more important as a sediment source than the downslope area, and much of the applied tracer remained on the hillslope and was not eroded in the monitored rainfall events, suggesting that much of the hillslope area was not connected to the downslope runoff transport pathways.