



## **How important is the unsaturated zone in the terrestrial nitrogen budget?**

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Inputs of nitrogen to agricultural land have had significant effects on aquatic and marine ecosystems through eutrophication, algal blooms and habitat loss. In order to manage this problem, terrestrial nitrogen budgets at the national scale have been developed. However, explicit representation of nitrate transport in the subsurface is seldom considered. Using derived estimates of unsaturated zone travel time and nitrate loading at the base of the soil zone, we quantify the total mass of nitrate held in the unsaturated zone of aquifers in the United Kingdom. In the unsaturated zone of moderate and highly productive aquifers of the UK this is estimated to have peaked in 2008 at 1400 kt N; substantially greater than previous approximations. Currently 70% of the nitrate mass in the unsaturated zone is in the Chalk, with the remainder split between the Permo-Triassic Sandstones, Oolitic Limestones and other less important aquifers. The UK unsaturated zone is now a source of nitrate and in 2014 we estimate the net nitrate flux from the unsaturated zone to groundwater and surface water to be approximately  $70 \text{ kt N a}^{-1}$ . The mass of nitrate in the unsaturated zone should be considered in future terrestrial nitrogen budgets to improve national scale ecosystem management.