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Minimising nitrogen losses from agricultural soil using a nitrogen-doped nanocomposite

Jessica Chadwick[1,2], Peng Zhang[1], Iseult Lynch[1], Sami Ullah[1], and Ryan Mushinski[2]
[1]University of Birmingham, Life and Environmental Sciences, Geography, Earth and Environmental Sciences, United Kingdom of Great Britain – England, Scotland, Wales (jxc1326@student.bham.ac.uk)
[2]University of Warwick, Life Sciences, United Kingdom

Nitrogen emissions from agricultural soils have been increasing over the past century due to improved accessibility of nitrogen fertilisers. These fertilisers have unbalanced the global nitrogen (N) cycle, with far-reaching effects on soil acidification and biodiversity, eutrophication, and ozone depletion. The high yields achieved by modern agriculture must be maintained but this cannot come at the cost of the earth. Nanomaterials have been proposed as a viable alternative to improve conventional fertilisers and have been tested on a range of crops, with analysis of their effects on N cycling also common. Nanofertilisers have one or more dimensions on a nanoscale, and their high surface area to volume ratio causes them to adsorb to biomolecules around them, changing their reactivity and stability as they enter new environments. Previous work (Ramirez-Rodriguez et al. 2020) showed the nanocomposite, urea-doped amorphous calcium phosphate (U-ACP), was able to maintain wheat yield at a much lower concentration as compared to urea alone. Our study compared U-ACP to urea treatment on lettuce growth, N-cycle community size, N leachate concentration and reactive N-oxide (NO_Y) emissions. Urea and U-ACP treatment both produced more lettuce biomass than the control. However, U-ACP treatment significantly reduced NO_Y emissions from soil as compared to urea-treated soils, reducing emissions down to the same concentration as control soils. This pattern was also seen in aqueous emissions of reactive N species (ammonium, nitrite, and nitrate), with urea treated soils consistently producing higher concentrations than U-ACP treated soils. Denitrifying bacteria were more prevalent in U-ACP treated soils, potentially reflecting that the nanocomposite is able to aid in more complete denitrification, reducing production of intermediary, polluting N species. Our work focussed on NO_Y over other forms of volatile N, the high levels of NO_Y production by urea-treated soils indicate this may be an area of research that is deserving of greater attention in the future. This work illustrates that U-ACP, and other composite nanocarriers like it, may be good fertiliser candidates going into the future to reduce agricultural pollution, while maintaining crop yields.