

Ammonium contamination of shallow groundwater beneath vegetable fields in Central Vietnam

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Nitrogen contamination in shallow groundwater occurs in a coastal area in Central Vietnam. In agricultural fields close to the residential area, high concentrations of NH_4^+ and NO_3^- in groundwater was attributed to unintended inflow of livestock wastes and/or domestic wastewater. On the other hand, NH_4^+ concentration reaches to several milligrams N per liter even in vegetable fields away from the residential area. The objective of this study was to determine NH_4^+ contamination mechanisms of the shallow groundwater without domestic wastewater inflow. In this study, we tested three hypotheses: (i) NH_4^+ derived from fertilizer or manure applied to the fields was transported to groundwater thorough soil, (ii) nitrate (NO_3^-) produced as a result of nitrification in topsoil was transferred to deep soil and again transformed to NH_4^+ , or (iii) nitrogen mineralization occurred in deep soil. Soil samples were collected up to 240 cm from a vegetable production field in Quang Thang Commune, Central Vietnam in June (dry season) and November (rainy season) of 2016 and 2017. The groundwater table existed at 57 or 67 cm in June and 33 cm from the soil surface in November. Concentrations of NH_4^+ in PVC pipe wells fluctuated between 1 and 3 mg N L⁻¹ in accordance with the detection of soil NH_4^+ content (5-20 mg kg⁻¹) in the 150-240 cm layer. On the other hand, soil NH_4^+ was not detected in the 30-80 cm layer whereas it was 2-6 mg kg⁻¹ in the 0-10 cm layers, indicating that NH_4^+ was not transferred to layers deeper than 30 cm. The absence of a functional gene of dissimilatory nitrate reduction to NH_4^+ (DNRA) in the 150-240 cm soil layer shows that DNRA did not occur in this deep layer. Natural abundance values of ¹⁵N (δ¹⁵N) for soil NH_4^+ (+3.6 to 5.5‰) were similar to those in soil total N (+1.9 to 3.6‰) in the 150-240 cm layer. In addition, anaerobically incubated soil from the 140-160 cm layer was mineralized by 1-2 mg NH_4^+ -N kg⁻¹ for 8 weeks. These experimental results suggest that the high concentration of NH_4^+ found in wells was originated from mineralization of deep soil.

Keywords: ammonium, dissimilatory nitrate reduction to ammonium, nitrogen mineralization