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Can subsoil denitrification reduce groundwater nitrate pollution and atmospheric N_2O emissions?

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Denitrification, a biological nitrate removal pathway, can control the availability of NO_3^- for leaching to the receptors but it is not only a natural pathway for excess NO_3^- elimination but also contributes to the emissions of N_2O, a potent greenhouse gas. Denitrification potential and N_2:N_2O+N_2 ratios were investigated in intact soil cores collected at 0-10, 45-55 and 120-130 cm soil depths where groundwater table was approximately 2 m below ground level. The soil was a moderately well drained loam to clay loam Gleysol under a grazing pasture in South Eastern Ireland. Three individual experiments were carried out by amending the soil with (i) 90 mg NO_3^- −N as KNO_3, (ii) -(i) + 150 mg glucose-C, (iii) -(i) + 150 mg DOC, kg^{-1} dry soil. An automated laboratory incubation system was used to simultaneously measure N_2O and N_2 at 15°C at 3% moisture content above field capacity. N_2O fluxes differed significantly ($p<0.05$) in the three soil depths, emitting the highest from the top soil, and the added C sources had significant ($p<0.05$) influences. The N_2 fluxes differed significantly ($p<0.05$) only between the top and lowest soil depths. During a 17-day incubation, total denitrification losses of the added N significantly ($p<0.01$) decreased with soil depths and increased by the addition of either C source. The corresponding amounts lost were 25, 61, 45% in 0-10 cm depth; 12, 29, 28.5% in the 45-55 cm depth and 4, 20, 18% in the 120-130 cm depth for T1, T2 and T3, respectively. The ratios of N_2 to N_2O+N_2 differed significantly ($p<0.05$) only between soil depths being lower in the top soil (0.41, 0.40 and 0.25 in T1, T2 and T3, respectively) than in lower depths (0.88, 0.90 and 0.64 in 45-55 cm and 0.76, 0.94 and 0.90 in 120-130 cm depths for T2, T2 and T3, respectively) clearly indicating the potential of subsoils for more complete reduction of N_2O to N_2. Contrasting to the added DOC, the glucose-C released higher N_2O in the top layer postulates to be an effective stimulator to produce N_2 through denitrification in subsoils. Results suggest that under management intensive grazing pasture, subsoil denitrification could profoundly reduce groundwater nitrate contamination and atmospheric N_2O emissions.