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Probing soil nitrification and nitrate consumption using  $\Delta^{17}\text{O}$  of soil nitrate

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# 1 **Probing soil nitrification and nitrate consumption using $\Delta^{17}\text{O}$ of soil nitrate**

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## 7 **0. Abstract**

8         Recent analytical and conceptual advances related to the nitrate ( $\text{NO}_3^-$ )  $^{17}\text{O}$  anomaly ( $\Delta^{17}\text{O}$ ) have  
9 opened the door to a new method that probes soil nitrification and  $\text{NO}_3^-$  consumption using  $\Delta^{17}\text{O}$  of soil  
10  $\text{NO}_3^-$ . Because biological  $\text{NO}_3^-$  production and consumption processes in soil obey the mass-dependent  
11 fractionation law,  $\Delta^{17}\text{O}$  of soil  $\text{NO}_3^-$ , an index of excess  $^{17}\text{O}$  over that expected from  $^{18}\text{O}$ , can be used to  
12 trace gross nitrification and  $\text{NO}_3^-$  consumption in a way analogous to the  $^{15}\text{NO}_3^-$  tracer typically employed  
13 in studies of soil  $\text{NO}_3^-$  cycling. Moreover, coupling  $\Delta^{17}\text{O}$  with the dual  $\text{NO}_3^-$  isotopes ( $\delta^{15}\text{N}$  and  $\delta^{18}\text{O}$ ) at  
14 natural abundances offers additional valuable insights into mechanisms that underlie soil  $\text{NO}_3^-$  dynamics.  
15 In this study, we conducted both laboratory and field experiments to assess the use of  $\Delta^{17}\text{O}$ - $\text{NO}_3^-$  for  
16 tracing soil nitrification and  $\text{NO}_3^-$  consumption. Soil samples spanning a wide range of physical and  
17 chemical properties were sampled from four sites for batch incubations and amendments with a  $\Delta^{17}\text{O}$ -  
18 enriched  $\text{NO}_3^-$  fertilizer. After amendments, the triple isotopes ( $\delta^{15}\text{N}$ ,  $\delta^{18}\text{O}$ , and  $\Delta^{17}\text{O}$ ) of soil  $\text{NO}_3^-$  were  
19 measured periodically and used in a developed  $\Delta^{17}\text{O}$ -based numerical model to simultaneously derive  
20 gross rates and isotope effects of soil nitrification and  $\text{NO}_3^-$  consumption. The measured  $\Delta^{17}\text{O}$ - $\text{NO}_3^-$  was  
21 also used in the classical isotope dilution model to estimate gross  $\text{NO}_3^-$  turnover rates. *In situ* field soil  
22 sampling was conducted in a temperate upland meadow following snowmelt input of  $\Delta^{17}\text{O}$ -enriched  
23 atmospheric  $\text{NO}_3^-$  to assess the robustness of  $\Delta^{17}\text{O}$ - $\text{NO}_3^-$  as a natural tracer. The results show that the  
24 temporal dynamics of  $\Delta^{17}\text{O}$ - $\text{NO}_3^-$  can provide quantitative information on soil nitrification and  $\text{NO}_3^-$   
25 consumption. In the laboratory incubations, a wide range of gross nitrification and  $\text{NO}_3^-$  consumption  
26 rates were estimated for the four soils using the  $\Delta^{17}\text{O}$ -based models. The estimated rates are well within

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