The Changing Sulfur Cycle: Effects and consequences of human-impacted sulfur cycling

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A Changing Sulfur Cycle

The amount of bioavailable sulfur (S) cycling through the biosphere has more than doubled since pre-industrial times. The negative effects of S pollution from fossil fuel emissions have been well-studied. S emissions cause the formation, transport, and deposition of sulfuric acid in rainfall. In the 1970s, acid rain caused the dramatic decline of many ecosystems, which led to regulations on S emissions. These regulations were extremely effective at reducing the negative effects of S pollution from the atmosphere. However, despite this success, human impacts on the S cycle are far from over; instead, they have now shifted to other sources. Factors like climate change and agricultural intensification have produced new and significant sources of excess S in the environment.

Alpine Wetlands are Key Areas of Sulfate Reduction

We found that alpine wetlands have very high concentrations of sulfate and high rates of sulfate reduction. Although the Niwot landscape is remote and unpolluted, sulfate concentrations in periglacial solifluxion lobe 3 (PSL3) pools even exceeded concentrations found in S-polluted systems (fig 2). This data suggests that PSL3, a hydrologically isolated wetland, is capturing sulfate runoff from bedrock weathering at Niwot Ridge. We also observed high rates of sulfate reduction in Niwot alpine wetlands (fig 1). The rates measured in these small wetlands were comparable to systems that are considered key areas of sulfate reduction.

Evidence of Sulfate Reduction In and Downstream of CA Vineyards

My measurements in Napa Valley show high rates of sulfate reduction in a stream receiving vineyard runoff (fig 1). Additionally, vineyards and vineyard streams showed higher concentrations of sulfate than natural sites. This suggests that sulfate runoff from vineyards may be stimulating sulfate reduction activity in downstream areas.

Mapping Sulfate Reduction and Microbial Communities Across the Napa Valley Watershed

Could sulfate runoff from vineyards be increasing sulfate reduction on a landscape scale, and could these sulfate inputs be affecting the soil microbial community? My ongoing work is sampling across the Napa Valley watershed to determine this. Samples are currently being measured for sulfate reduction rates and 16S RNA marker gene sequencing will be used to determine microbial community structure.

Comparing California, U.S. with New Zealand Vineyard Sites

Do our findings in Napa Valley apply to other vineyard sites across the world? My upcoming work will compare sulfate runoff and soil microbial communities between Napa Valley and the Marlborough wine region in New Zealand. This information will tell whether soil and climate type affect the fate of S pollution and will allow us to adapt our model to address different environments.

Can We Mitigate S Pollution?

Is there a way to capture sulfate in vineyard runoff? My future work will look at modifying existing sulfate capture methods for use in vineyards.

Fig 1: Measured Sulfate Reduction Rates

Fig 2: Measured Sulfate Concentrations

References

3 Lamarque, J. et al. Multi-model mean climate and sulfur deposition from the atmosphere - heres C (2020).

Excess sulfate in the environment can stimulate the activity of sulfate reducing microorganisms, leading to a variety of environmental consequences.