

Chemical Speciation: Defining the Niche of Hot Spring Ammonia-Oxidizing Archaea

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The availability of chemical energy supplies is fundamental to environmental and planetary habitability. However, the presence of a chemical energy supply does not guarantee the presence of microorganisms capable of consuming it. In this study, chemical energy supplies available in Yellowstone National Park (YNP) hot springs were calculated, and the results indicate that ammonia oxidation, calculated using total dissolved ammonia, is one of the major energy supplies. Nevertheless, known ammonia-oxidizers (AO) are only present in a small fraction of the hot springs tested. Where AO are present, they do not dominate the microbial communities (relative abundances <5%), even in cases where total dissolved ammonia oxidation is the richest energy supply. The AO in YNP hot springs are predominantly ammonia-oxidizing archaea (AOA), which tend to favor environments with low total ammonia (sum of NH_3 and NH_4^+) concentrations, despite the requirement of ammonia (NH_3) as a substrate. Hot spring pH and temperature determine the ratio of NH_3 to NH_4^+ and, consequently, NH_3 availability to resident AOA. In this study, total ammonia measurements were collected from YNP hot spring samples using ion chromatography in coordination with biological sampling. DNA was extracted from simultaneously collected samples for 16S rRNA gene sequencing and analysis, and for the identification of known AOA. The WORM-portal (<https://worm-portal.asu.edu/>) was used to speciate the total ammonia measurements into ammonia and ammonium activities. By performing speciation calculations, we identified a potential lower limit for substrate (NH_3) availability and a potential upper limit for NH_4^+ concentrations for the YNP hot spring AOA. Thus, the niche for AOA across YNP hot springs is dictated by the form of the total dissolved ammonia present, not by the energy supply available for total dissolved ammonia oxidation.