Assessing transformation processes of sulfate using stable sulfur and oxygen isotopes in acid mine drainage streams

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Acid mine drainage (AMD) is one of the major environmental concerns due to its negative impacts on surface and subsurface waters. Hydrogeochemical data and dual isotope of sulfate ($\delta^{34}S\text{-}SO_4^{2-}$ and $\delta^{18}O\text{-}SO_4^{2-}$) for stream water samples were analyzed to understand the transformation processes of sulfate in streams in Sandong, Korea. Abandoned coal mines were located in the upstream of the study area and yellowish-red precipitations were observed at the bottom of streams. High concentrations of sulfate (505 ~ 801 mg/L) and low pH (2.19 ~ 3.26) were observed in the upstream water indicating AMD impacts on the stream water. The values of $\delta^{34}S\text{-}SO_4^{2-}$ ranged from -8.8 ‰ to -8.5‰ in the upstream water indicating that sulfate was derived from the oxidation of reduced sulfate from pyrite in coal mines. In the downstream water, the concentrations of sulfate ranged from 26 to 37 mg/L and pH were increased from 2.19 ~ 3.26 to 7.0 ~ 8.1. The values of $\delta^{34}S\text{-}SO_4^{2-}$ in the downstream water showed -2.4 ~ 2.5‰ toward the values of soil sulfate ranging from 0 to +6‰. The values of $\delta^{18}O\text{-}SO_4^{2-}$ increased from -6.2 ~ -3.7‰ (upstream water) to 0.2~0.4‰ (downstream water) suggesting that high concentrations of sulfate from coal mines in the upstream water were diluted with the distance away from the source with minor sulfate reduction. Hydrogeochemical and dual isotope values of sulfate data provide a better understanding of sources and fate of sulfate in the study area and suggest useful remediation plans for the systems.