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Influence of atmospheric acid deposition on coastal ocean acidification: A two-year study in Busan, Korea

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Atmospheric deposition of acidic substances has the potential to influence coastal ocean acidification, yet its quantitative contribution remains poorly constrained. To quantify this impact, we conducted continuous sampling of wet and dry atmospheric deposition over a two-year period at the Korea Institute of Ocean Science and Technology (KIOST), located near the urbanized Busan Port, Korea. This site is directly influenced by both continental outflow and regional anthropogenic emissions.

Time-series analyses showed that the acidity of wet deposition was primarily controlled by precipitation intensity and frequency, whereas dry deposition exhibited pronounced seasonal variability associated with fossil fuel combustion. Seawater reaction experiments further revealed that acidity estimates for dry deposition derived solely from ionic composition deviated from experimentally determined values, while wet deposition estimates were consistent. This finding highlights the necessity of direct acidity measurements via seawater titration when evaluating the acidification potential of atmospheric particles.

Nitrate (NO_3^-) and sulfate (SO_4^{2-}) were identified as the dominant contributors to acidity in wet deposition, whereas sulfate was the principal contributor in dry particulate matter. Backward-trajectory analyses indicated that elevated acidic loads were strongly influenced by long-range transport from eastern China accross the Yellow Sea, as well as by local emissions under atmospheric stagnation conditions.

The annual mean acidity was estimated at 18 μmol kg^{-1} for wet deposition and 6 nmol m^{-3} for dry deposition. When introduced into the coastal surface ocean, these inputs correspond to an annual alkalinity reduction of approximately 1.03 μmol kg^{-1}, accounting for roughly 33% of the observed pH decline rate in adjacent coastal waters. These results indicate that atmospheric deposition is an important contributor to acidification in urbanized coastal environments.