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Total nitrogen and phosphorus in aerosols, sea fog and rain over the western North Pacific

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Nitrogen (N) and phosphorus (P) are essential nutrients for the growth of phytoplankton in the ocean. They can be transported as aerosols or as gas phase and delivered to the surface of the ocean through atmospheric wet and dry depositions. The supply of N and P from atmosphere to ocean could be an important source of nutrients. Few studies, however, have been carried out to investigate distribution of atmospheric total (inorganic + organic) N and total P, simultaneously, over the North Pacific Ocean. In this study, atmospheric total N, total P and major ion species were determined in aerosol, sea fog and rain over the western North Pacific Ocean between 29 July 2008 and 19 August 2008 through the KH-08-2 cruise of R/V *Hakuhomaru*. Particle number concentrations (0.1 μm < D < 5 μm) of aerosols and size spectra of fog droplets (2 μm < D < 50 μm) were also measured.

During over a dozen fog events, ammonium (NH_4^+), nitrate (NO_3^-) and organic nitrogen (Org N) in aerosols were found to represent ~56% (6.5 ± 1.9 nmol N m^{-3}), ~21% (2.5 ± 1.7 nmol N m^{-3}) and ~23% (2.7 ± 1.6 nmol N m^{-3}) of total N, respectively. Similar distributions of N species in aerosols were observed during non-fog events. In comparison, contributions of NH_4^+, NO_3^- and Org N to total N in fog water (in rainwater) were ~26% (~48%), ~60% (~15%) and ~14% (~37%), respectively. These results indicate that NO_3^- was more effectively scavenged by fog water than by rainwater. It is suggested that scavenging mechanisms between fog and rain are different (e.g. in-cloud scavenging, below-cloud scavenging and hygroscopic property). In addition, the continuous particle number measurements illustrated that sea fog scavenged coarse particles (D > 0.5 μm) more effectively than fine particles (D < 0.5 μm).

Concentration of P species in aerosols during non-fog events were 0.06 ± 0.03 nmol P m^{-3} for water-soluble phosphate (PO_4^{3-}), 0.34 ± 0.19 nmol P m^{-3} for acid-leachable inorganic phosphorus ($IP_{acid\text{-}leachable}$), 0.59 ± 0.17 nmol P m^{-3} for organic phosphorus (Org P), accounting for ~6%, ~35% and ~59% of total P, respectively. On the other hand, in fog waters, contributions of PO_4^{3-}, $IP_{acid\text{-}leachable}$ and Org P to total P were ~1%, ~77% and ~22%, respectively. These results suggest that Org P is oxidized and transformed to $IP_{acid\text{-}leachable}$ under the condition of acidic fog water.