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Atmospheric input of N, P, Fe and trace metals to north Indian Ocean

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The air-sea deposition of chemical constituents to the north Indian Ocean is influenced by seasonal continental outflow during the late NE-monsoon (December-April). Our recent studies have focused on deposition of mineral dust, nutrients (N, P and Fe) and toxic trace metals to the Arabian Sea (ARS) and Bay of Bengal (BoB), two important limbs of the north Indian Ocean. The chemical composition of $PM_{2.5}$ in the continental outflow to the marine atmospheric boundary layer reveals dominance of nss-SO_4^{2-} (as high as 25 μg m^{-3}) and abundance of dust varies from 3 to 20 μg m^{-3}. A striking similarity in the temporal variability of total inorganic acidity (TIA = NO_3^- + nss-SO_4^{2-}) and fractional solubility of aerosol-Fe (Fe_{Tot}: 60 – 1145 ng m^{-3}) provides evidence for chemical processing of mineral dust during atmospheric transport. The enhanced solubility of Fe has implications to further increase in the deposition of this micro-nutrient to ocean surface. The mass ratio of nutrients (N_{Inorg}/N_{Tot}, N_{org}/N_{Tot} and P_{Inorg}/nss-Ca^{2+}) also suggests further increase in their air-sea deposition to the surface BoB. The dry-deposition flux of $P_{Inorg}$to BoB varies by one order of magnitude (0.5 – 5.0 μmol-P m^{-2} d^{-1}; Av: 0.02 Tg P yr^{-1}). Based on atmospheric deposition of P and Fe, C-fixation in BoB ($\sim$1 Pg yr^{-1}) is dominated by anthropogenic sources and that in ARS (0.3 Pg yr^{-1}) is limited by P and Fe. This is attributed to poor fractional solubility ($\sim$1%) of mineral dust over the Arabian Sea. However, N-fixation by diazotrophs in the two oceanic regions is somewhat similar (0.03 Pg yr^{-1}). Our estimate of N-deposition (0.2 Tg yr^{-1}) to the northern Indian Ocean is significantly lower than the model results ($\sim$800 – 1200 mg-N m^{-2} yr^{-1} $\approx$ 5.7 – 8.6 Tg yr^{-1} by Duce et al. (2008); $\sim$4.1 Tg yr^{-1} by Okin et al. (2011); and $\sim$0.8 Tg yr^{-1} by Kanakidou et al. (2012). The increase in aerosol toxicity is also evident from high enrichment factors of anthropogenic trace metal (Pb, Cd, Cr, Cu and Mn). The enhanced solubility of anthropogenic fractions of trace metals, relative to their dust derived component, is an important issue for assessing factors that influence the marine ecosystem in the north Indian Ocean.

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