Planetary Boundary Layer Height Controls the Transport of Heavy Metals to the Himalayan Glaciers

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Particulate impurities in form of windblown mineral dust and soot darkens the ice surface and as a result directly increases the heat absorption, and by response causes ice melting. These impurities are accreted on the ice surface by wet precipitation or aeolian deposition. Currently, our understanding of the processes that controls the atmospheric transport of particulate impurities in the southern slopes of the Himalayas is limited, despite the fact, that Himalaya is surrounded by some of the world's largest emission sources. Here, we report on heavy metal concentrations and $^{208}Pb/^{204}Pb$, $^{207}Pb/^{204}Pb$ and $^{206}Pb/^{204}Pb$ of airborne particles (≤10-micron sized atmospheric particulate matter~PM_{10}) collected in Harsil (Lat: 31.1° N; Long: 78.73° E), a remote village on the Himalayan mountain range. The sampling site is a high altitude site (2634 m amsl) and close (~35 km) to the snout of the Gangotri glacier. The PM_{10} samples were collected on 20 cm x 25 cm quartz fiber filters in 7 days intervals between April 2016 and March 2017. In general, $^{208}Pb/^{204}Pb$, $^{207}Pb/^{204}Pb$ and $^{206}Pb/^{204}Pb$ data varies between 37.494-37.728, 15.582-15.609, and 17.603-17.931, respectively and overlaps with aerosols collected from the Indo-Gangetic plains (IGP). The heavy metal and Pb isotope dataset indicates a large temporal variability, with winter aerosols showing a more crustal signature. The Pb isotopes show strong intra-correlations but they do not correlate with meteorological data such as the temperature, humidity, wind speed, and wind direction. Instead, there is positive correlation between Pb isotopes and planetary boundary layer (PBL) height that varied between 1300 and 3100 meters.

We interpret the correlation between Pb isotopes and PBL height in terms of extent of aerosol dispersion and transport from the IGP. We propose that as the PBL height in IGP were lower during winter times, the process acted as a lid and restricted the dispersion and transport of aerosol from IGP to Himalayas. As a result, the winter aerosols in Harsil shows a more crustal signature since it tapped local crustal sources. On the contrary, the non-winter months witnessed more dispersion and transport of IGB aerosols because of higher PBL height. Our data strongly suggests that PBL height controls the atmospheric transport of heavy metals in the Himalayan glaciers.