COLD TRAPPING OF PERSISTENT ORGANIC POLLUTANTS IN THE HIMALAYAS AND ON THE QINGHAI-TIBETAN PLATEAU

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Persistent organic pollutants (POPs) can travel long distances in the atmosphere and can be deposited in remote regions, where they may affect wildlife and humans[1]. Temperature gradients and their impact on gas phase/condensed phase partitioning play a crucial role in the cold-trapping of organic contaminants at high latitude and high altitude[1,2]. In the case of global-scale cold-trapping the temperature dependence of partitioning between the Earth's surface and atmosphere results in the preferential accumulation in polar regions[1]. In the case of mountain cold trapping the temperature dependence of partitioning between the atmospheric gas phase and particles, rain droplets and snow flakes is governing the extent of enrichment at higher altitudes[2].

The Himalayas and the Qinghai-Tibetan plateau are truly unique in terms of their extremely high altitude and low temperatures. They are also wedged between two of the most populous and most densely populated nations globally, with a concomitant high release of organic contaminants, both presently and historically[3]. Is there a possibility those contaminants could be subject to cold-trapping in the Himalayas and on the Qinghai-Tibetan plateau? And if yes, does it resemble the cold trapping observed in other mountain regions, with which the region shares high altitude and steep elevation gradients, or does it resemble cold trapping observed in the Arctic, with which the region shares a large size, low temperatures and very low precipitation rates?

From a highly simplified perspective, the Qinghai-Tibetan Plateau is a high-altitude desert surrounded by a ring of very high precipitation, especially along its southern and, less so, eastern edge. Different cold-trapping mechanisms may thus be operating on the plateau and on its slopes. We hypothesize that the southern and eastern slope of the plateau is susceptible to mountain cold-trapping caused by temperature dependent precipitation scavenging as described in Wania and Westgate[2], and many organic contaminants advected into the region of the Qinghai-Tibet Plateau will be deposited during the ascent of air masses to higher altitudes[4]. Because of higher precipitation rates and the prevailing synoptic air mass flow relative to source areas, lower elevations of the southern slope, in particular North of the Bay of Bengal, are expected to receive higher rates of contaminant deposition than locations along the eastern slope facing central China. We further hypothesize that only organic contaminants that are relatively persistent in air and are not subject to efficient precipitation scavenging will be advected onto the plateau itself and may, if they have the right partitioning properties, be subject to a cold trapping process that resembles mechanistically the one that is operating in polar regions.

The results of three recent studies on the contamination of the atmosphere of the Qinghai-Tibetan plateau with POPs are used to test the plausibility of these hypotheses. Two of these studies investigated the distribution of POPs along the southern and eastern slope of the plateau, by sampling air and soil along transects in central Nepal and Sichuan, respectively. Both studies used XAD-based passive air samplers to obtain long term average air concentrations[5]. A third study relied on a newly developed flow through sampler[6], installed at a remote site close to Nam Co lake on the plateau itself, to obtain monthly resolved air concentrations over the time period October 2006 to February 2008.

Air concentration along the slopes are much lower than in the highly populated plains and foothills to the South and the Chengdu basin of Sichuan to the East, but, in the absence of local sources, tend to be relatively uniform along the slopes itself. Whereas the Eastern slope reveals clear indication of mountain cold-trapping with POP concentrations in soils increasing with elevation[7], the pattern is less clear along the southern slope, presumably because precipitation rates along the measured transect decline greatly at higher elevations. Levels of most POPs in air along both slopes are higher in summer than in winter. Similarly strong seasonal variations in the air concentrations of DDT, hexachlorocyclohexanes, and endosulfan on the plateau itself, with higher summer time levels coinciding with air mass origin across the Himalayas in the plains of India and Bangladesh, reveal the role of the monsoon in the air mass transport of these pesticides into and across the Himalayas. Very low concentration of polychlorinated biphenyls and brominated flame retardants at Nam Co, that do not display a clear seasonal variability, reflect truly global background contamination and suggest that regional sources may be less significant for these industrial compounds than for organochlorine pesticides.

Organic contaminants used currently or in the past on the Indian subcontinent, and especially in the plains of the Ganges and Brahmaputra, may be deposited preferentially in a band of high precipitation along the southern Himalayan foothills. The potential effects on local wildlife or on human populations that rely on food grown in that region remains to be assessed.

References

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