Snow amplification of organic pollutants at coastal Antarctica

JORDI DACHS[1], PAULO CASAL[1], GEMMA CASAS[1], MARIA VILA-COSTA[1], ANA CABRERIZO[1], MARIANA PIZARRO[1], BEGOÑA JIMÉNEZ[2]

[1]Institute of Environmental Assessment and Water Research (IDAEA-CSIC), Barcelona, Catalonia 08034, Spain.
[2]Department of Instrumental Analysis and Environmental Chemistry, Institute of Organic Chemistry (IQOG-CSIC), Madrid 28006, Spain.

Many legacy and emerging persistent organic pollutants (POPs) have been reported in polar regions, which act as sentinels of global pollution. The maritime Antarctica is recipient of abundant snow precipitation, implying an un-characterized amplification of concentrations of POPs. Air, snow, the fugacity in soils and snow, seawater and plankton were sampled concurrently from late spring to late summer at Livingston Island (Southern Shetlands, Antarctica). Polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), organophosphate esters (OPEs), perfluoroalkyl substances and organochlorine pesticides (OCPs) concentrations were quantified. PCBs and PAHs in snow and air were close to equilibrium. POPs in soils showed concentrations close to soil-air equilibrium or net volatilization of POPs depending on chemical volatility. Seawater-air fugacity ratios of semivolatile POPs were highly correlated with the product of the snow-air partition coefficient and the Henry's law constant (K_{SA} H'), a measure of snow amplification. Therefore, coastal seawater mirrored the PCB and PAH pattern in snow-melt, further evidenced by the correlation between net volatilization fluxes and seawater salinity. Such amplification of concentrations and fugacities was partially dissipated in seawater for those chemicals undergoing biodegradation. A meta-analysis of reported simultaneous field measurements of POP concentrations in air and snow, or K_{SA}, showed that snow amplification is relevant for diverse families of POPs, independently of their volatility. We claim that the potential impact of atmospheric pollution on aquatic ecosystems receiving snow inputs has been severely under-predicted by only considering air-water partitioning, as snow amplification may control the POP occurrence in cold environments.