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Persistent Organic Pollutants in Antarctica; System Input from Distant and Local Contaminant Sources

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1. Introduction

Persistent Organic Pollutants (POPs) are ubiquitous toxic compounds that are incorporated into food chains with high efficiency. Polar Regions have long been established as receiving environments for POPs[1]. In order to manage environmental contamination by POPs in Antarctica, information regarding system input to this remote region is required.

The primary input of POP contamination to the Antarctic is expected to be via Long Range Atmospheric transport (LRAT)[1-2]. In addition, hydrospheric Long Range Environmental Transport (LRET) as well as *in-situ* chemical usage and to a lesser extent, migratory biota, must also be considered[3-4].

Our research has recently sought to provide information regarding the respective input pathways of POPs to the Antarctic region. Here we summarise our findings regarding long range atmospheric input; the implications of the unique oceanographic features of the Antarctic Circumpolar Current (ACC) for long range hydrospheric input of ionic perfluorinated compounds (PFCs); as well as local contamination from Casey station, an all-year research station in the Australian Antarctic Territory (AAT).

2. Materials and methods

A high-volume flow-through atmospheric sampler[5] was installed throughout 2010 approximately 3km upwind from Casey station. Atmospheric samples were analysed for organochlorine pesticides, polybrominated diphenyl ethers (PBDEs) and polychlorinated biphenyls (PCBs). Samples were analysed at the Norwegian Institute for Air Research (NILU), using methods described elsewhere e.g.[6]

We sourced 57 tissue samples from all trophic levels and from a broad geographical range for perfluorinated compound (PFC) analysis. Tissue samples represented Antarctic Krill (*Euphausia superba*), Adélie Penguin (*Pygoscelis adeliae*), Antarctic Petrel (*Thalassoica antarctica*), White-chinned Petrel (*Procellaria aequinoctialis*), Antarctic Fur Seal (*Arctocephalus gazella*), Weddell Seal (*Leptonychotes weddellii*) and Humpback Whale (*Megaptera novaeangliae*). Tissues were analysed for: Perfluorooctane sulfonate (PFOS); perfluorohexanesulfonate (PFHxS); perfluorooctanesulfonamide (PFOSA); Perfluorooctanoic acid (PFOA); perfluorononanoic acid (PFNA), perfluorodecanoic acid (PFDA); perfluoroundecanoic acid (PFUnA); perfluorododecanoic acid (PFDoA) and perfluorotridecanoic acid (PFTrA). Samples were analysed at the Danish National Environmental Research Institute (NERI) according to the methods of Bossi et al. 2005[7].

Indoor dust, soil, and amphipod (*Paramoera walkeri*) samples were collected within Casey station perimeter and analysed for polybrominated diphenyl ethers as described in Bengtson Nash et al (2008)[8].

3. Results and discussion

3.1. Atmospheric Profiles

Atmospheric chemical profiles were dominated by hexachlorobenzene (HCB), polybrominated diphenyl ethers (PBDEs) and endosulfan I. These findings for HCB are in accordance with previous reports which have shown HCB to be a dominant compound accumulating in Southern Ocean food webs. The dominance of PBDE congeners BDE-206 and -209 was surprising as these heavier congeners are not expected to undergo long range atmospheric transport (LRAT). A local source is therefore proposed. The detection of endosulfan I is notable in light of its inclusion under the Stockholm Convention in April, 2011.

3.2. PFC accumulation in Antarctic biota Determined by Foraging Range and Antarctic Circumpolar Current

Two of fifty-seven tissue samples analysed in the current study revealed detectable concentrations of PFOS, namely liver of an adult Antarctic Fur Seal collected from sub-Antarctic Bird Island (2.0 ng/g w.w.) and pectoral muscle of a White-chinned Petrel collected from the sub-Antarctic Heard and McDonald Island region (1.2 ng/g w.w).

PFCs have not yet been detected in Antarctic biota that remain south of the Antarctic Circumpolar Current throughout their lifetime. PFCs have occasionally been detected in organisms that forage within and north of the ACC, namely Adelie and Gentoo Penguin and southern elephant seals from the Antarctic Peninsula[9-10]. This distribution of PFC contamination is congruent with the pattern expected via governance of the overturning circulation of the Southern ocean which results in export of surface waters to the north and replacement with older, currently PFC-free waters upwelling south of the ACC.

3.3 Stations as sources

The PBDE congeners BDE-206 and -209 dominated congener profiles around Casey station providing further evidence for a local source of these compounds as these heavier congeners are not expected to undergo long range atmospheric transport (LRAT).

4.0 Conclusions

These are the first results of atmospheric input of POPs to the AAT in over a decade. Further, we present the first audit of an Australian research base as a local emmitter of newly listed POPs and explain biota accumulation of PFCs in terms of species foraging ecology and the dynamics of the Antarctic circumpolar current.

It has recently been shown that climate change is beginning to mobilise global POP reservoirs[11-13]. Our findings therefore also provide a baseline for temporal monitoring of how input to this remote region stands to be impacted as global secondary sources are perturbed.

5.0 References

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