An Antarctic research station as a local source of perfluorinated organic pollutants

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1. Introduction

Persistent organic pollutants (POPs) are industrial chemicals and ubiquitous global contaminants. They share properties of persistence, toxicity, bioaccumulation potential and propensity for long-range environmental transport. POPs are recognised as posing a threat to environmental and human health and are subject to the Stockholm Convention on Persistent Organic Pollutants. Since the first group of POPs were listed under the Stockholm Convention, an increasingly diverse range of chemicals from consumer products have been included under the Convention[1].

With the increasing ease of transportation to polar regions, research activity, tourism and industrial exploitation have escalated. The combination of increased diversity of chemicals fulfilling the criteria associated with POPs, and increasing human activity in polar regions have enhanced the potential for such pollutants to be directly introduced to these regions from local sources. Many day-to-day consumer products, including textiles and furnishings contain perfluorinated compounds (PFCs), including perfluorooctane sulfonic acid (PFOS) recently annexed under the Stockholm Convention. PFOS and its related compounds have been heavily used as waterproofing agents and in many non-stick or polytetrafluoroethylene (Teflon™) containing products. PFOS and other PFCs have been linked to a range of negative health effects[2]. Although highly stable, these compounds can leach out of products that they are added to and may be released into the surrounding environment where they can accumulate. The first evidence of Polar research stations acting as sources of POPs to the local environment was first presented by in 2008 Hale et al. [3] and Bengtson Nash et al. [4], however there has been no investigations of PFCs in this regard to date.

In this study we investigate Casey Station, one of Australia’s permanent Antarctic research stations, and evaluate emissions of PFCs to the local environment and accumulated burdens in various surrounding biological matrices. The study provides evidence of human activity introducing recently listed POPs directly into the Antarctic environment.

2. Materials and methods

Casey Station (66°16'56"S 110°31'32"E) is situated in Wilkes Land in Eastern Antarctica. The station is home to up to 90 visitors during summer and 16-20 people during winter. Samples of five different abiotic and biological matrices were collected from Casey Station and the surrounding environment using a variety of methods over the 2008/09, 2009/2010, 2010/11, 2011/12 and 2012/13 summer field seasons. Sample matrices were indoor dust, secondary treated wastewater, lichen, moss, and marine amphipods. Dust samples were collected from indoor locations within Casey Station including both the old and new sections of the living quarters. Samples of secondary-treated wastewater were collected from the station’s onsite wastewater treatment facility outfall. Five samples of moss and lichen were collected at increasing distances from the station. Five amphipod samples were also collected from coastal marine areas near Casey Station.

Samples were analysed for 16 different perfluorinated carboxylates, sulfonates and sulphonamides. The extraction method was based on ion pairing as described by Hansen et al. [5]. Instrumental analysis was by liquid chromatography–tandem mass spectrometry (LC-MS-MS) with electrospray ionisation (ESI).

3. Results and discussion

3.1. Indoor Dust

Of the 16 PFCs analysed for in the indoor dust collected at Casey Station, 15 were detected. PFOS was detected in the highest concentration, more than 10 times higher than any other compound. The highest concentration of PFOS (2368 ng/g) was detected in dust from the station’s general store. Perfluorooctanoic
acids (PFOA) was also found at notable levels in most samples, and dominated most of the samples from the stations living quarters. Casey Station’s Science Building tended to have the lowest concentrations of PFCs. The levels of PFOS and PFOA, as well as the other PFCs detected in this study, are in the upper range of concentrations reported in houses, offices and other buildings from countries around the world[5]. When dust from the old and new wings of the station’s living quarters are compared, it is evident that dust from the new wing has lower levels of PFOS and the other PFCs detected, compared to the old wing. This may indicate a decrease in usage of PFOS in recent years since it was annexed under the Stockholm Convention in 2010[2].

3.2. Secondary Treated Wastewater

Secondary treated wastewater samples from Casey Station were dominated, in both the dissolved and particulate phases, by PFOS, with PFOA and perfluorodecane sulfonate (PFDS) being the next most dominant. The concentration of these PFCs in the dissolved phase was two to six times higher than in the particulate phase of the wastewater. This is in accord with the physicochemical properties of ionic perfluorinated compounds as they tend to be more water soluble than traditional POPs[5].

Various studies have shown wastewater treatment plants to be sources of perfluorinated compounds in the environment. Primary and secondary wastewater treatment has been shown to be ineffective in removing these types of compounds[7]. The levels of perfluorinated compounds found in wastewater from Casey Station are similar to, though at the higher end of the range, of those seen in primary and secondary treated wastewaters from Australia[5] and other developed countries. The fact that the levels are of a higher range may be a result of the industrialised nature of the stations themselves, the high utilisation of waterproofing products, and the increased demands on the treatment system during the higher summer occupancy (during which time the system may be put on by-pass).

3.3. Biological Matrices

Of the moss and lichen samples collected, only the two moss samples collected from the site closest to the station had any detectable PFC burden, indicating that the station may be a local source of pollutants to the terrestrial as well as marine environments. Despite PFCs being found in wastewater, no amphipod sample revealed detectable levels, suggesting that no bioaccumulation above the method level of detection is currently occurring in these benthic foraging invertebrates.

4. Conclusions

These results indicate that Antarctic research stations such as Casey are acting as local sources of perfluorinated organic pollutants into the Antarctic environment.

5. References