PRESENCE OF LEGACY PERSISTENT ORGANIC POLLUTANTS IN THE REMOTENESS PLACE OF THE EARTH: THE ANTARCTIC PLATEAU

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Introduction

The Antarctica is usually perceived as a symbol of the last great wilderness and remoteness. Although natural "barriers" such as oceanic and atmospheric circulation protect this region from lower latitude water and air masses, previous assessments on concentrations of persistent organic pollutants (POPs) such as polychlorinated biphenyls (PCBs) and organochlorine pesticides (OCPs) evidence its ubiquitous presence in air, snow, water, vegetation or food webs organisms in the Maritime Antarctica, thus, the outermore region of Antarctica. The occurrence of these man-made synthetic chemicals in Polar Regions is just another manifestation of the multiple anthropogenic perturbations on the composition of the biosphere. Their long half-lives facilitate repeated cycles of volatilization and deposition resulting in progressive movement away from temperate and tropical source regions towards colder climate areas and remote regions. Ultimately, these compounds may experience "cold-trapping" at the Polar Regions, where the colder temperatures further prolong persistence and enhance their accumulation in snow. In addition, this cold trapping in the outermost regions of Antarctica could prevent or retard their transport to the Antarctic Plateau.

The extreme persistence, semi-volatility, biacummulation potential and adverse effects of some POPs in wildlife and humans have led to develop international protocols regulating their use, such as the Stockholm Convention and the UNECE LRTAP POPs protocol. Most of the studies available in the antarctic atmosphere reporting data of PCBs and OCPs were mainly performed using active samplers mostly located close to research stations (close to coastal areas) since power supply is usually a limiting factor [1-3]. This limitation together with the extreme conditions of performing an atmospheric sampling campaign over the Continent result in a lack of information regarding the levels of PCBs and OCPs, or any other POPs, over the Antarctic Plateau. Therefore the main objectives of this work are: i) to assess for the first time, in an Antarctic Expedition, the occurrence of PCBs and OCPs over a latitudinal gradient, from Novolazarevskaya Station (75 km from the coast) to Glaciar Union (see right pannel of Figure 1) crossing the South Pole during 35 days (total 3500 km) using a passive sampler coupled to an exclusively wind-power kite-drawn sled and ii) to prove if the eco-friendly vehicle developped by Larramendi and moved with big comets could be a useful a tool for adventorous Antarctic research.

Materials and methods

A passive sampler consisting in a polyurethane foam (PUF) (10 cm x 12 cm) located inside an aluminium tube was deployed on the Polar Catamaran as shown in Figure 1. The aluminium tube also holds an anemometer and temperature sensor connected to a data logger in order to concurrently monitor wind speed and outside temperature during all the Antarctic expedition. Before the deployment of each PUF, PCB65 and PCB200 were added as depuration compounds. Air was passing through the passive sampler as the sled was moving although strong winds of up to 30 m s^{-1} were registered during the sampling campaign. Each sample consisted in an integration of 5 to 10 days of sampling, resulting in 5 samples taken over the 3500 km of expedition. Blanks (from both laboratory and field campaign) at a rate of one per sample were also used for in study (see Figure 1). After the sampling, samples were shipped to the IDAEA-CSIC were they were extracted with acetone:hexane 3:1 and analysed for PCBs and OCPs using GC/EDC. In total 5 samples and 5 blanks were used for this study. Recoveries were routinely monitored using PCB54 and PCB155 and they were in the range between 75 to 115 % for air samples, so samples were not corrected for recoveries.

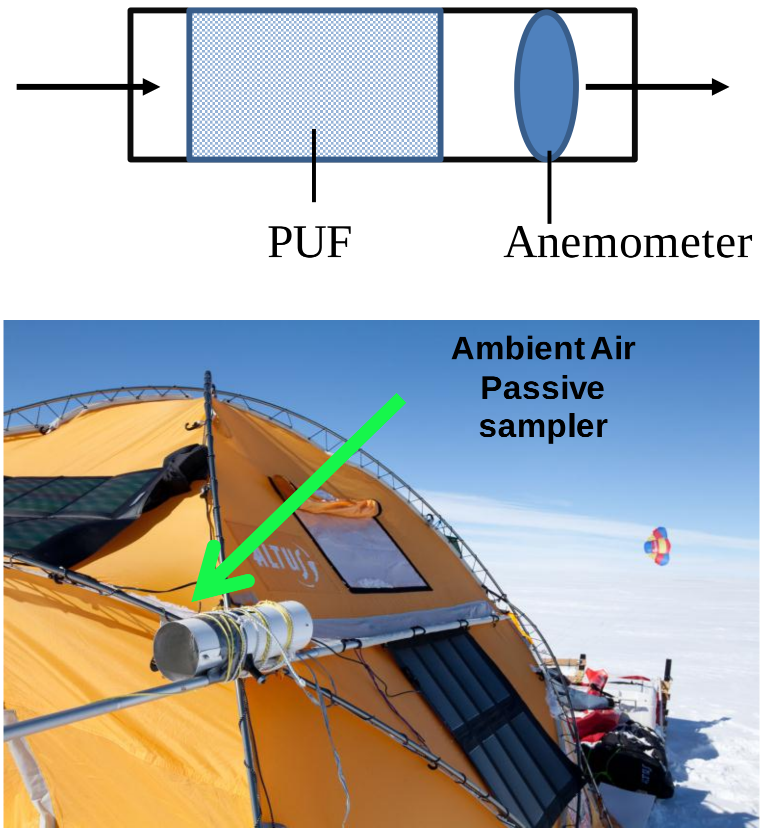

Figure 1. Scheme and passive sampler attached to the wind-driven sludge

Results and discussion

More volatile PCBs (those having between 3-6 Cl) and hexachlorobenzene (HCB) were detected in the five samples collected. The presence of those more volatile PCBs together with the occurrence of HCB in the antarctic atmosphere suggests that these pollutants have reached the Antarctica due to long range atmospheric transport. Depuration compounds added to each PUF previously to the exposure, showed losses of less than 20%, probably due to the lower temperatures detected (up to -27 C during most of the sampling expedition) so they were not used to estimate the sampling rates. Different studies [4] have shown that sampling rates are very dependent on wind speed [4]. Tuduri et al, 2006 [4] estimated that for air velocities in the range 0 to ~0.9 m s^{-1}, uptake rates are in a 'semi-plateau phase' (~6.35 m^3 d^{-1}) and increased gradually, while sampling rates showed stronger wind dependency above 1.0 m s^{-1} with a sharply increased sampling rate to 40 m^3 d^{-1} at an air velocity of 1.75 m s^{-1}. Unfortunately, to best of our knowledge no studies have reported sampling rates at stronger wind speed as those reported in the Antarctica.

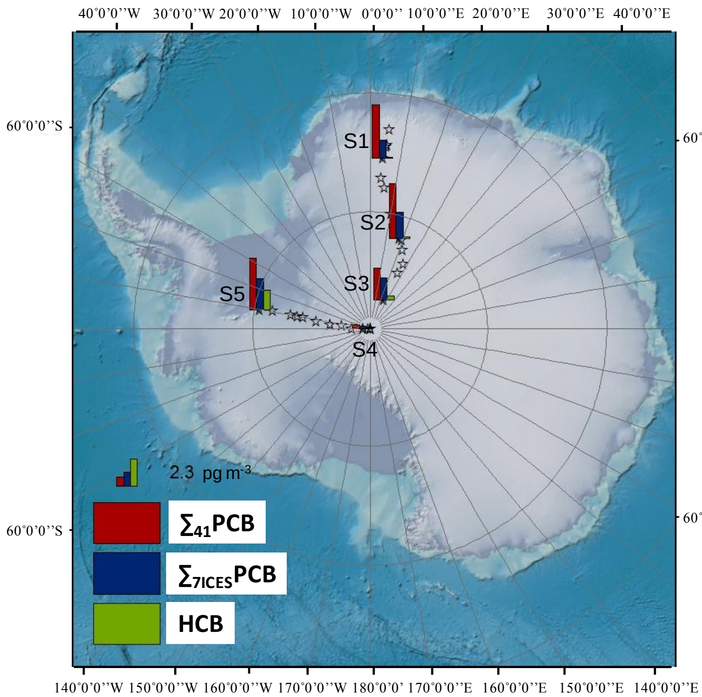

Figure 2. Concentrations of total PCBs, sum of the 7 ICES PCB congeners and HCB in the Antarctic Plateau's atmosphere.

During the Antarctic expedition wind speed were in the range from 6 to 30 m s^{-1} which suggests sampling rates higher than 40 m^3 d^{-1}. Sampling rates in this study were estimated using two approaches, 1) using the depuration compounds and 2) using the relation between the internal and external wind speed suggested by Xiao et al 2008 [5]. Both approaches gave sampling rates with a factor of 2 of diference. Estimated sampling rates were used to estimate the concentration of PCBs and HCB as shown in Figure 2. Concentrations of ΣICES PCBs was in the range of 0.24-2.6 pg m^{-3} and between 0.1-1.6 pg m^{-3} of HCB. The predicted concentrations are among the lowest ever reported for the atmosphere, even considering the uncertainties associated with the calibration.

Conclusions

This study demostrates for the first time the presence of PCBs and HCB in the Antarctic Plateau using a simple and cost-effective passive sampling methodology coupled into an sled moved by the antarctic winds. This results also highlight the importance of the Polar Catamaran developed by Larramendi as an important vehicle (zero emissions) for increasing antarctic research in the sense of monitoring pollutants under extreme conditions and potentially support scientific community in the realization of their projects in the Antarctic Continent.

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