detritus | Multidisciplinary Journal for Waste Resources & Residues

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Editorial

ANTARCTICA AS A GLOBAL POLLUTION SENSOR: THE ANTAGPS PROJECT

Pollution knows no borders, it travels the globe and crosses national frontiers in many forms, reaching the most remote areas of the planet. Whilst Antarctica, the only continent that is not permanently anthropized, represents the southernmost part of the planet, this geographic segregation provides no protection against the harmful impact of human activities. This continent therefore, characterized by limited internal sources of pollution but high-burden external routes of contaminants, represents a unique natural laboratory for ecotoxicology studies. The project "Antarctica as a global pollution sensor: aquatic and terrestrial organisms as bio-indicators and meta-analysis of pollutant trends", supported by the Italian National Antarctic Research Program (PNRA), aims to employ Antarctica as a valuable source of information relating to both local and global pollution using its endemic organisms as bio-indicators (Figure 1).

Antarctica, the fifth largest continent after Africa, Asia and the two Americas, is located in the southern hemisphere and features an enormous ice cap covering practically the entire region (59.000 km²), at times exceeding 4.500 m in thickness, and constituting 90% of the fresh water reserve on the planet. The temperature varies from around 0°C during the austral summer on the coast, to approximately -90°C in winter at an altitude of 3000 m in inland areas. Providing an intensely hostile environment for human life, Antarctica constitutes an ideal location for environmental studies as the only region on the planet characterized by an almost total absence of anthropogenic activity and sources of local pollution. Although natural "barriers", such as oceanic and atmospheric circulation, protect Antarctica from lower latitude water and air masses, data relating to the concentration of pollutants detected in several organic and inorganic samples (air, snow, terrestrial and marine organisms) highlight the presence of persistent contaminants derived from other continents in the Antarctic environment (Bargagli, 2008; Roche et al., 2019).

Due to the presence of the Antarctic Polar Front, marine transport of pollutants is modest, whereas long-range atmospheric transport constitutes the main means of their reaching this remote environment. Pollutants such as metals and emerging contaminants, including endocrine-disrupting chemicals, brominated and perfluorinated compounds, pharmaceuticals and personal care products, represent the major pollutants in ecosystems, posing a serious threat to aquatic and terrestrial organisms. Since

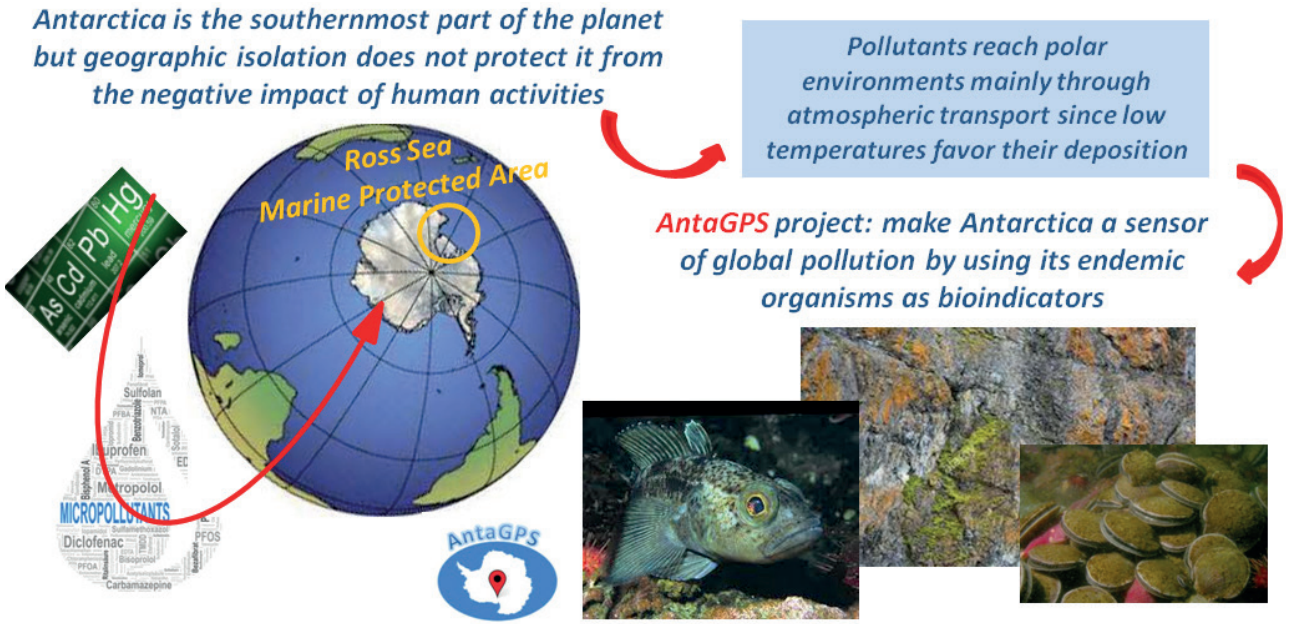

FIGURE 1: Graphical abstract of the AntaGPS project.

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Detritus / Volume 19 - 2022 / pages 1-2
https://doi.org/10.31025/2611-4135/2022.15190

2000, the risks posed by metals have induced numerous countries worldwide to ratify protocols aimed at reducing emissions, while emerging contaminants are currently not included in monitoring programs and their environmental fate and biological impacts are poorly understood. Significant accumulations of metals and emerging contaminants have been identified in Arctic and Antarctic areas despite the considerable distance from pollutant sources (Emnet et al., 2015; González-Alonso et al., 2017). Warm temperatures favor pollutant evaporation (tropical and subtropical land surface), while cool temperatures (high latitudes) favor deposition from the atmosphere on land/water. Climate change may moreover facilitate transport/deposit of contaminants in Polar areas.

Preliminary results obtained from research activities carried out by the AntaGPS project focused on the biomonitoring of metals in the livers of endemic Antarctic fish over a period of 12 years (Marrone et al., 2021). The two fish species used, icefish Chionodraco hamatus and red-blooded Trematomus bernacchii, were collected from the same area in the period 2002 to 2014. Fish are considered to be a particularly apt organism for the monitoring of pollution in aquatic ecosystems, with Antarctic organisms constituting excellent bioindicators for analysis of the trend of metal bioaccumulation over time, due to both endemism and singular adaptation to conditions. The liver was identified as an appropriate target organ for analysis of bioaccumulation and detoxification phenomena of metal pollution. The results obtained showed a significant increase over time in the bioaccumulation of numerous metals, such as Pb, Cd, Sr, Ni, Zn, which displayed a remarkable escalation in bioaccumulation in both species considered. The observed increase in lead bioaccumulation, despite its removal from gasoline at the beginning of the time period considered, is of particular interest (Figure 2). Furthermore, analysis of liver metallothionein-1 expression revealed a significant increase in this biomarker of metal pollution in both species, although with varying degrees, thus indicating a potential species-specific response to the presence of metals in seawater. The results of these studies will contribute to a better-targeted monitoring of the fragile Antarctic ecosystem and to obtaining critical clues indicating the global trend of metal pollution. The data thus obtained will be used to drive future conservation strategies for Antarctic and non-Antarctic ecosystems.

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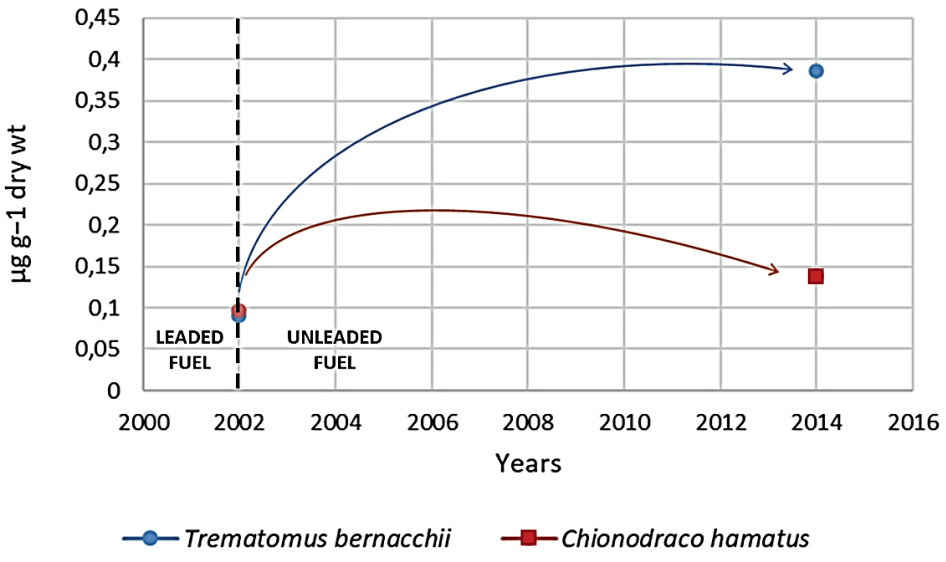

FIGURE 2: Pb bioaccumulation in two Antarctic fish species, from 2002 to 2014.