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Short Communication

Do microplastics accumulate in penguin internal organs? Evidence from Svenner island, Antarctica

Shrayan Bhattacharjee [a], Chayanika Rathore [b c], Akshata Naik [b], Mahua Saha [b c], Praveen Tudu [a], Prabir Ghosh Dastidar [d e], Subarna Bhattacharyya [f], Jacob de Boer [g], Punarbasu Chaudhuri [a]

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Highlights

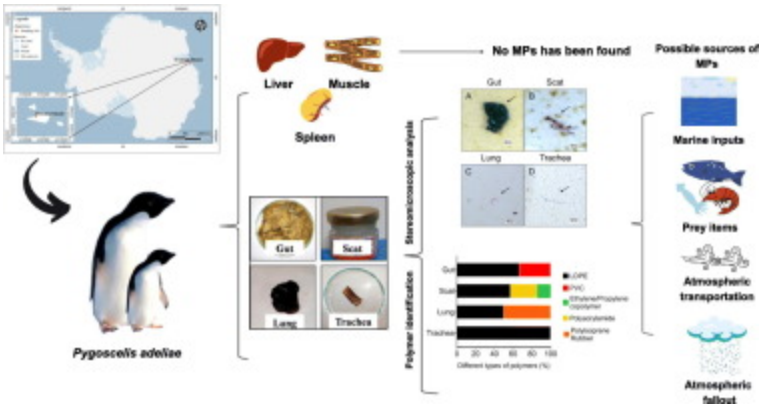
- Microplastics (MPs) were identified from GI tract and internal organs (lung and trachea) sample of Adelie penguin.
- No MPs were observed from liver, muscle and spleen sample of Adelie penguin.
- Blue-coloured microfibers (>50%), <1mm sized (38%) and LDPE (~63%) MPs were detected.
- Identified polymers were categorized as high danger (group V) hazardous particle.

- Atmospheric MPs may contribute in MP deposition on Adelie penguin.

Abstract

The prevalence of microplastics (MPs, <5 mm) in natural environments presents a formidable global environmental threat MPs can be found from the Arctic to Antarctica, including glaciers. Despite their widespread distribution, studies on MP accumulation in apex predators inhabiting Polar Regions remain limited. The objective of this study was to conduct a comprehensive examination, for the first time, of MP bioaccumulation in various organs and tissue of Adélie penguins. This investigation comprehends the gastrointestinal tract (GIT), scat, internal organ (lung, trachea, spleen, and liver) and tissue (muscle) samples collected from Svenner Island, Antarctica during the 39th Indian expedition to Antarctica in 2019–2020. Our analyses revealed the presence of 34 MPs across the GIT, scat, lung, and trachea samples, with no MPs detected in muscle, spleen, or liver tissues. Blue-colored microfibers (>50%) and MPs smaller than 1 mm (38%) in size were prominently observed. Polymer characterization utilizing μ-FTIR spectroscopy identified low-density polyethylene (LDPE) (~63%) as the predominant polymer type. The accumulation of MP fibers in the gastrointestinal tract and scat of Adélie penguins may originate from marine ambient media and prey organisms. Furthermore, the presence of LDPE fibers in the trachea and lungs likely occurred through inhalation and subsequent deposition of MPs originating from both local and long-range airborne sources. The identification of fibers ranging between 20 and 100 μm within the trachea suggests a plausible chance of cellular deposition of MPs. Overall our findings provide valuable insights into the organ-specific accumulation of MPs in apex predators. Adélie penguins emerge as promising environmental bio-monitoring species, offering insights into the potential trophic transfer of MPs within frigid environments.

Graphical abstract



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Introduction

Microplastics (MPs, <5mm) have pervaded even the most pristine environments, such as Antarctica, with their presence in almost all layers of the Antarctic Ocean. These pollutants are subject to local anthropogenic inputs from both terrestrial and marine sources, including land-based coastal activities, riverine inputs, and sea-based sources (Waller et al., 2017). Land-based sources alone contribute over 9 million tons of plastics annually, with a significant portion settling on the sea floor (Jambeck et al., 2015; Thushari and Senevirathna, 2020). Despite being distant from major human settlements, polar environments like the Arctic and Antarctic regions are not spared from MP contamination. MPs have been identified in various environmental matrices in these regions, including shore sediments, seawater, snow, and ice, originating from activities such as hydrocarbon exploration, aquaculture, shipping, tourism, fisheries, and research station effluents (Bergmann et al., 2022; Reed et al., 2018). The plastic particles, propelled by the Stokes drift phenomenon, can traverse the strong Antarctic Circumpolar Current (ACC), entering the Southern Ocean (Huang et al., 2022).

On the Antarctic Peninsula, MPs have infiltrated biotic components, from basal species to apex predators, potentially exacerbating bioaccumulation risks (Primpke et al., 2024; Fragão et al., 2021). Various species, including Adélie (*Pygoscelisadeliae*), chinstrap (*Pygoscelisantarcticus*), gentoo (*Pygoscelispapua*) (Fragão et al., 2021), and, king penguin (*Aptenodytes patagonicus*) (Le Guen et al., 2020), Antarctic fish (Actinopterygii, Perciformes) (Zhang et al., 2022a, Zhang et al., 2022b), and, Antarctic seabirds (*Pachyptila* spp.) (Caruso et al., 2022) have been affected by MP pollution. The ingestion of MPs by these organisms is primarily due to their inability to differentiate between plastic and food particles (Bessa et

al., 2019). Additionally, MPs can act as carriers for hazardous pollutants such as polycyclic aromatic hydrocarbons (PAHs), additives and heavy metals, potentially leading to secondary deleterious effects on organisms (Puasa et al., 2021).

Despite the widespread occurrence of MPs in the Antarctic region, limited research has focused on their direct analysis in gastrointestinal components and tissue samples from Adélie penguins. While previous studies have identified MPs in various organisms, the accumulation of MPs in internal organs of penguins and associated risks remain unclear. Penguins, as prominent bio-indicators of the Antarctic ecosystem, serve as a key species for understanding the ecological impacts of MPs in this sensitive environment (Metcheva et al., 2006). Addressing this knowledge gap, this study aims to 1) investigate and scrutinize MPs in the gastrointestinal tract (GIT) and scat samples of Adélie penguins, 2) examining the accumulation of MPs in various organs including the liver, lung, trachea, spleen, and tissue (muscle) samples, and 3) assessing the associated risks within the penguin population by shedding light on the extent of MP bioaccumulation in a key organism within the Antarctic food chain. This research provides crucial insights into the potential ecological impacts of MPs in this region.

Section snippets

Study area and sampling

The sampling site, Svenner Island, Antarctica (S69°08′12″, E76°44′45″), located near the Bharti Research Station (a permanent research station of India), serves as a breeding colony for Adélie penguins (Fig. 1). Given the intimate association between adult Adélie penguins and their chicks, where adults commonly feed digested food (crop milk) to the young, this location presents a critical area for studying the scenario of MP pollution in penguins (Kooijman, 2020). The potential accumulation of…

Abundance

This study presents a comprehensive identification of MP particles in various organ samples collected from Adélie penguins, including the gastrointestinal tract (GIT), scat, lung, and trachea. Through meticulous stereomicroscopic analysis, depicted in Fig. 2, the presence of MP fibers and one film was confirmed across these samples. Scat samples exhibited the highest count of MPs (19 fiber, 3.8 MPs/g w.w), followed by the respiratory organ lung (6 particles, 1.2 MPs/g w.w) and trachea (4…

Conclusion and way forward

The preliminary investigation conducted represents a first endeavor, and comprehensive examination of MPs across various tissue types, gastrointestinal tracts, and scat samples obtained from Adélie penguins inhabiting mainland Antarctica. Across all samples analyzed, fiber-shaped MPs prevailed, with a majority exhibiting a blue color (>50%) and measuring <1 mm in size (38%). Among the five identified polymer types, LDPE emerged as the most prevalent one, in approximately 63% of the total…

CRediT authorship contribution statement

Shrayan Bhattacharjee: Writing – original draft, Formal analysis, Data curation. **Chayanika Rathore:** Writing – review & editing, Writing – original draft, Data curation. **Akshata Naik:** Formal analysis, Data curation. **Mahua Saha:** Writing – review & editing, Supervision, Methodology, Investigation, Conceptualization. **Praveen Tudu:** Formal analysis. **Prabir Ghosh Dastidar:** Conceptualization, Investigation. **Subarna Bhattacharyya:** Investigation. **Jacob de Boer:** Writing – review & editing. **Punarbasu**…

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.…

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