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Review article

Occurrence of microplastics (MPs) in Antarctica and its impact on the health of organisms

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Abstract

Antarctica, and its surrounding environment, is considered untouched, and it is thought that it is free from microplastic (MP) pollution. However, recent studies and science projects have reported MPs in both water and sediment in the South Polar Regions. These reports state that MP pollution occurs in this region due to fishing, tourism, and research activities by the nearby countries, with natural circulation also part of it. The Antarctic Treaty System (ATS) has given attention to MP pollution and has initiated research on it. MPs are tiny plastic particles with a size of less than 5 mm. They have two types: 1. Primary MPs, which have been manufactured directly from various applications like cosmetics and scrubbing, etc. 2. Secondary MPs, which are generated by the photochemical degradation of large plastics. Although several studies have been done, there is a quite gap in our understanding of the concentration, characteristics, and impact of plastics on the ecosystem of the Antarctic Region. The impact of MP pollution in this region may be very high. The presence of MPs is a serious issue that is affecting not only the aquatic environment but also humans. It is an alarming situation that causes environmental damage. The main objective of this paper is to review MP introduction, occurrence in biotic and abiotic components, sources, harmful effects, and detection methods/techniques. This review highlights the various methodologies and analyses like density separation, microscope observation of MP's properties Fourier-transform infrared spectroscopy (FTIR), and Raman spectrometer, respectively, and urges for more research in the future, giving several recommendations to maintain the pristine region near Antarctica.

1. Introduction

Antarctica is an unpopulated continent and is regarded as the very last extreme wilderness on Earth (Bhardwaj & Jindal, 2019; Bhardwaj & Jindal, 2020; Bhardwaj & Jindal, 2022a). It is separated geographically from the other continents, has unique biodiversity (Bhardwaj et al., 2021; Bhardwaj et al., 2023), and is endowed with glaciers. Plastics are a chemically diverse group of artificial polymers that are obtained from different chemical and physical processes (Bhardwaj & Sharma, 2021a; Bhardwaj, 2022). The use of plastics is increasing with the increase in the population (Bhardwaj & Sharma, 2021b). More than 90 % of plastics are finished from fossil fuels and form ~ 90 % of marine litter (Rota et al., 2022).

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Plastics can be divided into six major types: polypropylene (PP), polyvinyl chloride (PVC), polyethylene (PE), polyethylene terephthalate (PET), polyamide (PA), and polystyrene (PS) (Van Cauwenberghe et al., 2015). Plastics are found in the world's oceans, and polyamide (PA) and polyurethane (PU) are the major plastics found in the Antarctic Ocean (Plastics Europe, 2015). PU is used in surface coating at research vessels and research bases. do Sul et al. (2011) and Reisser et al. (2013) reported PA (used in fishing nets and ropes) and PS (used in fishing and packaging) in Antarctica.

Microplastics (MPs) are ubiquitous within all oceans (Bergmann et al., 2015), including the Antarctic Ocean (Waller et al., 2017). In spite of their nature, there is little research available on MPs in the Polar Region (Obbard, 2018). Lee et al. (2013) defined the class of plastics as follows: large MPs (1 - 5 mm), mesoplastics (5 - 25 mm), and macroplastics (> 25 mm) while Crawford & Quinn, (2017) classified MPs as large MPs (1 - 5 mm), small MPs (1 µm - 1 mm), and nanoplastics (< 1 µm). MPs are expected to continue fragmenting and reach up to nano sizes (Tirkey & Upadhyay, 2021). They are heterogeneous in size and shape (Phuong et al., 2016). Barrows et al., (2017) reported MPs of size $0.1 \geq 1.5$ mm in marine environments. Cole et al. (2013) reported MPs in the ranges from 1.7 - 30.6 µm in zooplankton by using coherent anti-Stokes Raman Scattering (CARS) and fluorescence microscopy.

Lasee et al. (2017) divided MPs into five groups: micro-pellets (hard and round particles), fragments (hard and jagged-edged particles), films (thin and 2-dimensional plastic films), foam (Styrofoam type material), and fibers (thin plastic strands or fibrous). MPs have been categorized in different colors; for example, blue, black, green, etc. They persist in the natural environment for a long time and can remain doing so for hundreds to thousands of years. They have covered air, water bodies, and sediments, have been reported from different parts of the earth, and are inextricable. They are insoluble in water and are almost impossible to remove with available techniques (Bergmann et al., 2015).

The discarded plastics float in the ocean water and may be degraded through chemical and physical processes (da Costa et al., 2016). The rate of degradation is slow in floating plastics compared to terrestrial plastics. Hammer et al. (2012) reported that plastic particles are degraded by ultraviolet (UV) radiation. In the deep ocean, low temperatures and the absence of UV radiation are the main factors for the reduction of the degradation rate (da Costa et al., 2016).

MPs can be transported through currents across ocean basins. They do not sink due to their buoyancy. After traveling a long distance, they may also be retained in ice for many years. They can re-enter the ocean due to ice melting, wind transport, rising or falling ocean levels, and other meteorological events (Lacerda et al., 2019). Those MP particles which are less dense than oceanic water float on the surface, while those particles which are denser than oceanic water tend to settle in deep water and appear in benthic organisms (Kozak et al., 2021; Long et al., 2019).

Low-density floating PS lumps, plastic bottles, and fishing buoys have been reported in the Antarctic Region (Lacerda et al., 2019; Suaria et al., 2020). Pollution through MPs is higher in undeveloped areas due to the lack of appropriate waste management, and this may cause an enormous number of MPs to enter from land to oceans by 2025 (Jambeck et al., 2015). Recently, the Scientific Committee on Antarctic Research (SCAR) and United Nations Environmental Programme (UNEP) observed the issue of MPs in Antarctica and are trying to prohibit the use of plastics globally (Leslie, 2015; Waller & Hughes, 2018).

The increasing MPs in the Antarctic Region are cause for concern, as they may affect the Antarctic ecosystem (Tirelli et al., 2022). Several researchers reported MPs of size > 25 mm from the Ross Sea and the West Antarctic Peninsula (Barnes et al., 2009; do Sul et al., 2011; Ryan, 2014; Caruso et al., 2022). The author considered approximately 100 research/review articles for this review focused on the Antarctic Region. The author searched for these articles from Google Scholar and Research Gate after inputting keywords like South Polar Region, MPs, Antarctica, and Antarctic Ocean. Most of the articles were written from 2009 to 2023. The presence, sources, harmful effects, and detection methods/techniques of MPs in Antarctica and its surrounding environment are described in this review.

2. Occurrence of microplastics (MPs) in abiotic and biotic components

Different studies investigated MPs in abiotic components such as sediments, water, snow, and ice, and biotic components such as krill, and penguins of the Antarctic Region. The presence of different types of MPs in biotic and abiotic components, with their concentrations and detection methods/techniques, are presented very well in **Tables 1** and **2**. The location map of the MPs study in the Antarctic Region is shown in **Figure 1**.

2.1 MPs in abiotic components

The presence of fibers, films of polyester, and polytetrafluoroethylene (PTFE) were reported in the freshwater of Livingston Island, West Antarctic Region (González-Pleiter et al., 2020). MPs of size > 0.1 mm were reported on the surface of the Antarctic Ocean (Cowger et al., 2020). Materić et al. (2022) studied MPs in the sea ice core of the Ross Sea, Antarctica, and reported higher concentrations (67 ng/ml) by using Thermal Desorption-Proton Transfer Reaction-Mass Spectrometry (TD-PTR-MS). These tiny particles are transported by wind and were reported at King George Island (González-Pleiter et al., 2021).

Habib et al. (2020) studied MPs in the soil samples that were collected from Victoria Land, East Antarctica. Cunningham et al. (2020) analyzed 30 samples of sediments that were collected from South Georgia Island and reported MPs of size > 2 mm. Perfetti-Bolaño et al. (2022) researched the occurrence of MPs in the soil and sediment samples that were collected from King George Island, Antarctica, and reported higher amounts of MPs in the soil (20 - 500 µm) and sediment sample (500 - 2,000 µm). Munari et al. (2017) reported a high portion of MPs (5 - 1,705 particles/m^2) in sediment samples of Terra Nova Bay, Ross Sea, Antarctica. Lacerda et al. (2019) studied MPs on the Antarctic Peninsula and reported flexible and hard fragments of PU, PA, and PE.

Absher et al. (2019) collected 60 water samples from Admiralty Bay, Antarctic Peninsula, and reported MPs in the range of 10 - 22 µm. Suaria et al. (2020) studied macroplastics, mesoplastics, and MPs around the Southern Ocean and reported 5 MPs and 17 macrolitter items. Cincinelli et al. (2017) reported MPs such as fragments (71.9 ± 21.6 %) and fibers (12.7 ± 14.3 %) from Ross Sea, Antarctica. Jones-Williams et al. (2020) collected surface water samples during the austral summer of 2018 from Adelaide Island, Antarctica, and reported low-density (PE and PP) and high-density (phenoxy & epoxy resins) polymers.

Leistenschneider et al. (2021) collected surface water from the Weddell Sea, West Antarctic Region, and studied MPs with the help of Attenuated Total Reflection Fourier Transform Infrared (ATR-FTIR) spectroscopy. They reported MPs of size > 300 µm. Kelly et al. (2020) reported PE, PP, and PA in the sea ice of East Antarctica. Aves et al. (2022) collected snow samples from 19 sites of Ross Island, Antarctica, and stated that PET was the most common polymer. Reed et al. (2018) reported MP particles from the sediment samples which were collected from 20 different locations of Rothera Research Station, Antarctica.

2.2 MPs in biotic components

Penguins could act as a vector for the MPs (Sfriso et al., 2020). Fragão et al. (2021) collected scat samples from Adélie, chinstrap, and gentoo penguins from the Antarctic Peninsula and reported 15, 28, and 29 % MPs in those samples, respectively. Bessa et al. (2019) collected 80 penguin scat samples from the Antarctic region and reported plastic fragments and fibers with different sizes and polymer compositions within them.

Zhu et al., (2023) reported PE (37 %), PP (22 %), and PS (21 %) in the samples of Antarctic krill (*Euphausia superba*) which were collected from the South Shetland Islands and the South Orkney Islands, Antarctica. Erikson and Burton (2003) stated that seals may be used as biomonitors for MP contamination. They reported 164 plastic particles of length 4.1 mm from 145 fur seals of the Antarctic Region. MP particles were found in the gut of the Antarctic collembolan (*Cryptopygus antarcticus)* (Bergami et al., 2020).

Table 1 Occurrence of different types of microplastics (MPs) in abiotic components (water, floating plastic debris, ice, snow, and sediment) in the Antarctic Region.

S. No.	Sample Matrix	Locations	Detection Methods/Techniques	Concentration of Microplastics (MPs)	Types and Color of Microplastics (MPs)	References
1	Ocean water	Antarctic Ocean	Microscopic	0.55 to 56.58 gm/km^2	Dark color and small size	Eriksen et al. (2014)
		King George Island (West Antarctic Region)		16 - 766 particles/m^2	Synthetic fiber, and fragments	Waller et al. (2017)
		Antarctic Ocean	Stereoscopic microscope and FTIR spectroscopy	46, 000 to 99,000 particles/km^2	PS and fibers	Isobe et al. (2017)
		Antarctic Peninsula	FTIR spectroscopy	1,794 items/km^2	PU, PA, and PE	Lacerda et al. (2019)
		Admiralty Bay, King George Island (West Antarctic Region)	Scanning electron microscopy (SEM) and Raman spectroscopy	2.40 (± 4.57) microfibers 100/m^3	Microfibers (blue, red, and black), PEG, PU, PET, and PA	Absher et al. (2019)
		Antarctic Ocean	μ-FTIR spectroscopy	188 ± 589 particles/km^2	PE, PP, PS, PVC, PA, and PMMA	Suaria et al. (2020)
		Ross Sea (Antarctic Region)	FTIR spectroscopy	0.17 ± 0.34 particles/m^3	Fragments and fibers	Cincinelli et al. (2017)
		Adelaide Island (West Antarctic Region)		0.013 ± 0.005 particles/m^3	Fragments and film	Jones-Williams et al. (2020)
		Weddell Sea (West Antarctic Region)	ATR-FTIR spectroscopy	0.01 ± 0.01 particles/m^3	Fragments and lines	Leistenschneider et al. (2021)
2	Fresh-water	Livingston Island (West Antarctic Region)	μ-FTIR spectroscopy	0.47 to 1.43 items/1000 m^3	Polyester fibers, acrylic fibers and transparent PTFE films	González-Pleiter et al. (2020)
3	Floating plastic debris	Antarctic Ocean	Raman spectroscopy	0.100 to 0.514 gm/km^2	PE and industrial resin pellets	Cózar et al. (2014)
4	Sea ice	East Antarctica	μ-FTIR spectroscopy and TD-PTR-MS	11.71 particles/l	PE, PP, and PA	Kelly et al. (2020)
		King George Island, Antarctica		0.17 to 0.33 items/m^2	EPS	González-Pleiter et al. (2021)
		Ross Sea (Antarctic Region)		67 ng/ml	Fibers, fragments, and films	Materic et al. (2022)
5	Snow			29.4 ± 4.7 particles/l		Aves et al. (2022)
6	Sediment	South Georgia Island (West Antarctic Region)	Visual identification, microscopic and μ-FTIR spectroscopy	1.30 ± 0.51 particles/gm 1.09 ± 0.22 particles/gm 1.04 ± 0.39 particles/gm	Polyester and blue in color	Cunningham et al. (2020)
		Rothera research station, Adelaide Island (West Antarctic Region)	FTIR spectroscopy	< 5 particles/10 ml	White, vibrant red, and green	Reed et al. (2018)
		Terra Nova Bay, Ross Sea (Antarctic Region)	FTIR spectroscopy	5 - 1,705 particles/m^2	Fibers, film, and fragments	Munari et al. (2017)

***** μ-FTIR = micro-Fourier Transform Infrared Spectroscopy, ATR-FTIR = Attenuated Total Reflection Fourier Transform Infrared Spectroscopy, PE = Polyethylene, PU = Polyurethane, PA = Polyamide, PEG= Polyethylene glycols, PP = Polypropylene, PET = Polyethylene terephthalates, PS = Polystyrene, PVC = Polyvinyl chloride, PMMA = Poly methyl methacrylate, PTFE = Polytetrafluoroethylene, EPS = Expanded polystyrene, TD-PTR-MS = Thermal Desorption-Proton Transfer Reaction-Mass Spectrometry.

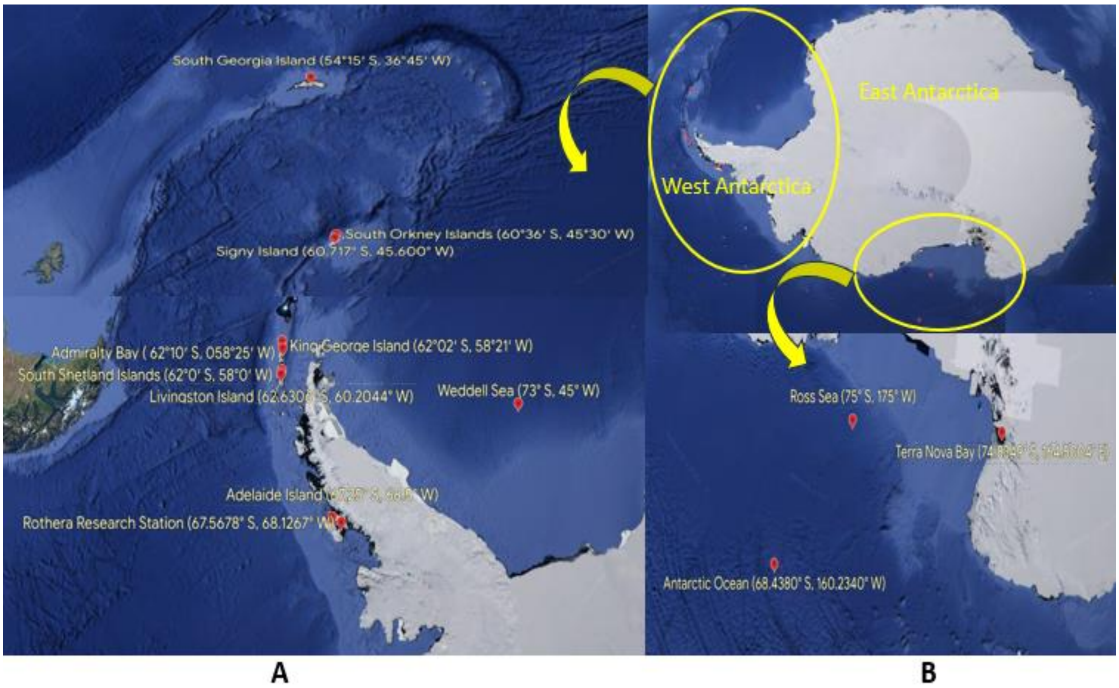

Figure 1 Location map of MP studies in the Antarctic Region: (A) South Georgia Island (54°15′ S, 36°45′ W), Signy Island (60.717° S, 45.600° W), South Orkney Island (60°36′ S, 45°30′ W), Admiralty Bay (62°10′ S, 058°25′ W), King George Island (62°02′ S, 58°21′ W), South Shetland Island (62°0′ S, 58°0′ W), Livingston Island (62.6306° S, 60.2044° W), Adelaide Island (67.25° S, 68.5° W), Rothera Research Station (67.5678° S, 68.1267° W), and Weddell Sea (73° S, 45° W); (B) Terra Nova Bay (74.8349° S, 164.5004° E), Ross Sea (75° S, 175° W), and Antarctic Ocean (68.4380° S, 160.2340° W).

Table 2 Occurrence of different types of microplastics (MPs) in biotic components (krill and penguins) in the Antarctic Region.

S. No.	Sample Matrix	Locations	Detection Methods/Techniques	Concentration of Microplastics (MPs)	Types and Color of Microplastics (MPs)	References
1	Antarctic Krill (*Euphausia superba)*	Antarctic Peninsula	Enzyme digestion, and microscopic	149 beads/ml, 2063 µg/l	PE beads and PE fragments (6.0 ± 5.0 S.D. µm)	Dawson et al. (2018)
		South Shetland Island and South Orkney Island (West Antarctic Region)	FTIR spectroscopy	0.29 ± 0.14 and 0.20 ± 0.083 items/individual	PE, PP, and PS, (Blue, black, and red color particles with < 150 µm)	Zhu et al. (2023)
2	Gentoo Penguins (*Pygoscelis papua)*	Antarctic Peninsula	µ-FTIR spectroscopy	0.23 ± 0.53 items/individual	Fibers and fragments (76 to 4945 µm) Green, transparent, red, blue, and black	Bessa et al. (2019)
3	Adélie Penguins (*Pygoscelis adeliae*), chinstrap Penguins (*Pygoscelis antarcticus*) and Gentoo Penguins (*Pygoscelis papua*)			92 particles	PE, and PS,	Fragão et al. (2021)

***** µ-FTIR = micro-Fourier Transform Infrared Spectroscopy, PE = Polyethylene, PP = Polypropylene, PS = Polystyrene

3. Sources of microplastics (MPs) in the Antarctic Region

MPs may originate from different sources. Primary microplastics (PMPs) are formed from the direct ejection of small particles (e.g., toothpaste, skin cleansers, shampoos, shower gels, synthetic clothing, car tires, and cosmetics), while secondary microplastics (SMPs) are formed from the obstruction of larger plastic particles (Li et al., 2016) (**Figure 2**). Larger plastics are dumped into the ocean from terrestrial sources (Nerland et al., 2014). Due to lower resistance to degradation, single-use plastic is a significant source of SMPs, and persists in surface water, deep water, and sediments around the world's oceans (Abreu & Pedrotti, 2019).

The sources of MPs may be direct or indirect. Waller et al. (2017) described the direct sources of MPs as disposal, waste produced by research stations, tourist vessels, and ships, while transport by marine currents is the indirect source (Fraser et al., 2018). The local sources of MPs in the Antarctic Region may be fewer due to the lack of human population and low volume of shipping. Most of the MPs enter the Antarctic Ocean through the waste stream (Obbard, 2018).

3.1 Microplastics (MPs) released in wastewater from Antarctic Research Bases

The Antarctic Region had been considered unaffected by plastic pollution due to the strong circumpolar frontal systems, even though the debris of plastics have been washing up in Antarctica for decades (Eriksson et al., 2014). ~ 90 % of MP particles may be preserved through wastewater treatment plants (WWTPs) (Ziajahromi et al., 2016), while non-retained particles can be discharged into the Antarctic environment (Gröndahl et al., 2009). Out of 71, 39 research stations in Antarctica have WWTPs, but their effectiveness for removing MPs from effluent is mainly unknown (Waller et al., 2017). There is very little research available related to the MPs that are released through wastewater in the Antarctic Region.

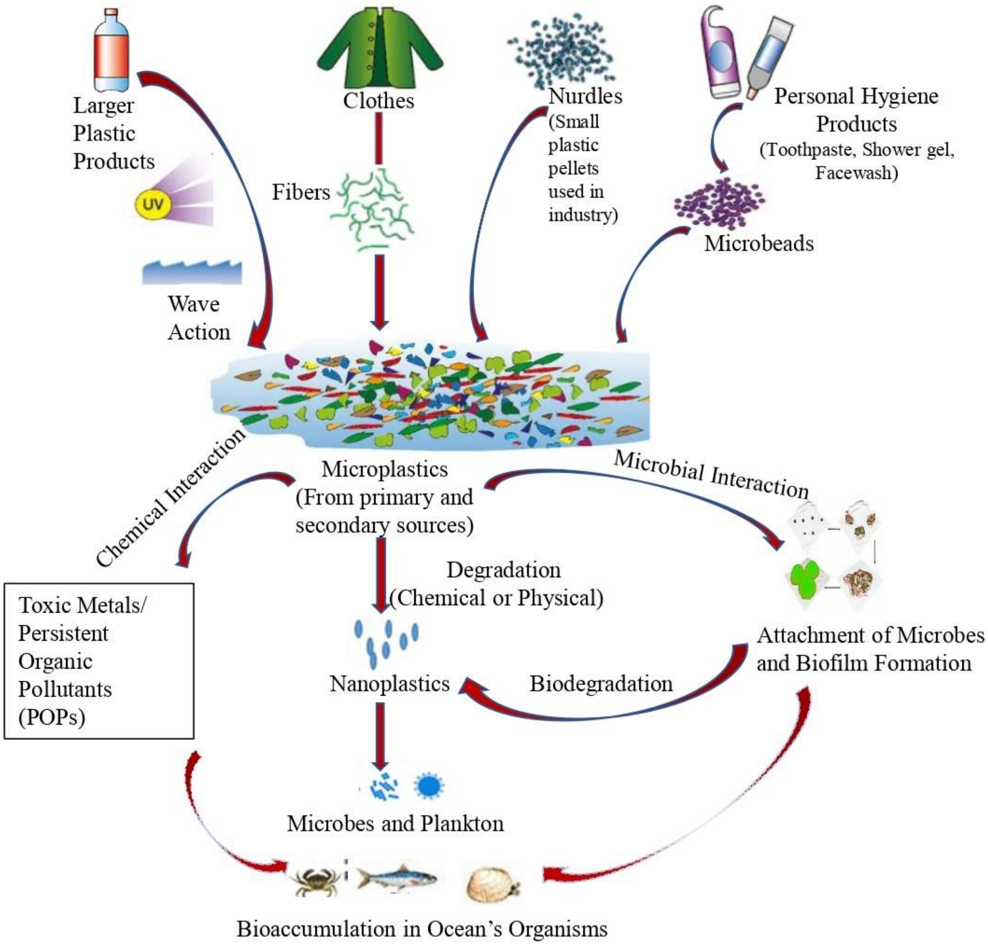

Figure 2 Microplastics (MPs) and their degradation and bioaccumulation in different organisms.

3.2 Microplastics (MPs) released from personal care products (PCPs) and laundry

Use of plastics in the form of PCPs ranged between 2.40 - 27.50 mg/day per person, and were released into the ocean (Waller et al., 2017). During the washing of synthetic clothes, MPs may be released in the wastewater of research stations and tourist vessels. Synthetic fibers were released from shirts, fleeces, and polyester blankets in the range of 680 - 1,900 fibers per wash (Browne et al., 2011). 0.5 - 25.5 billion synthetic fibers were released into the Antarctic Ocean over a decade (Waller et al., 2017). A large number of nylon line fragments were reported around Antarctica (do Sul et al., 2011). Microfibers that are released from laundry to wastewater may be a chief source of MPs as compared with PCPs. Very few studies are available on the occurrence of microfibers in the sediments and waters of the Antarctic Region. The detection of microfibers in the ocean is very difficult due to the dilution of effluent in wastewater.

3.3 Microplastics (MPs) originating from the degradation of macroplastics

In the Antarctic Region, high UV radiation is the chief source of the degradation of floating plastic debris through the photo-oxidation reaction (Andrady et al., 2022). Most plastic wastes are dumped into the environment, where they fragment into MPs that pollute water and air and damage marine wildlife (Tian et al., 2023).

4. Harmful effects of microplastics (MPs)

MPs may be carcinogenic and act as endocrine disruptors in nature. After a single use, the disposal of plastics is the destiny of most of the plastics produced. It has been observed that all marine ecosystems have been affected by plastic pollution. MPs may be harmful to marine organisms when mistakenly consumed as a food source (Wright et al., 2013). Their small size may make them accessible for ingestion and accumulation by a wide range of marine organisms and lead to physical and toxicological effects (Waller et al., 2017). Aquatic fauna ingests MPs through direct consumption (Cole et al., 2013). Watts et al. (2014) reported that MPs can be taken up in aquatic organisms by oral ingestion or through the gills. The accumulation of MPs in the gastrointestinal system can cause internal abrasions and blockages.

After entering organisms, MPs could reach the human body and show several health effects. However, the fate of these particles in the human body remains unknown. Harper and Fowler (1987) reported that MPs were ingested in the first instance by the *Pachyptila* species of seabird in the Antarctic Ocean, while other scientists have reported ingestion of MPs in other species of seabird (Le Guen et al., 2020; Suaria et al., 2020) and fur seals (Ryan et al., 2016). The effect of MPs has been reported in ~ 700 different marine species (Gall & Thompson, 2015). MPs can adsorb contaminants, such as persistent organic pollutants (POPs) and heavy metals, from the surrounding environment, and can have many consequences, such as reduction of fertility, alteration of growth, and oxidative stress (Chen et al., 2018). These particles are suspected of interacting with the immune system and can lead to change in the deoxyribonucleic acid (DNA) of organisms (Brown et al., 2011). These particles reduce the energy of the organisms and potentially lead to their death (Wright et al., 2013).

5. Detection methods/techniques of microplastics (MPs)

The methods/techniques for the identification and quantification of MPs are limited, and are described below.

5.1 Visual identification

This is the most common and inexpensive method for the identification of MPs (Lee et al., 2013; Mathalon & Hill, 2014; Primpke et al., 2020). Parameters such as shape, color distribution, length, width, and surface properties are identified by this method (Lusher et al., 2020; Marti et al., 2020).

5.2 Density separation

This is the most reliable and economical method and is used to segregate MPs from sediments and water. The density of MPs is affected by the concentration of additives and polymer types (Claessens et al., 2013; Masura et al., 2015). In this method, sodium chloride (NaCl), zinc chloride ($ZnCl_2$), sodium bromide (NaBr), and sodium iodide (NaI) solutions are used for the separation of MPs from samples (Coppock et al., 2017; Maes et al., 2017; Masura et al., 2015; Quinn et al., 2017).

5.3 Raman spectroscopy

This technique is performed on the particle surface and produces vibrational spectra (Schymanski et al., 2018; Sobhani et al., 2019). It is used for the determination of element numbers, size (< 1 µm), and shape (Cabernard et al., 2018). It delivers the chemical and structural characteristics of MPs (Crawford & Quinn, 2017). It is a time-consuming technique and can take from several days to weeks for the analysis of samples. Raman spectroscopy and FTIR techniques are complementary to each other.

5.4 Fourier Transform Infrared spectroscopy (FTIR)

This technique is the most widely used for the estimation of MPs (Cincinelli et al., 2017; Fu et al., 2020; Morais et al., 2020). It produces a spectral pattern known as the IR spectrum. It has three optimizing technologies- focal plane array (FPA), micro-FTIR, and Attenuated Total Reflection (ATR). It can detect MPs up to 10 µm.

5.5 Near-Infrared Spectroscopy (NIRS)

This technique is more advanced over FTIR, as it enters deeper into plastic materials (Paul et al., 2019; Corradini et al., 2019; Pakhomova et al., 2020). In this technique, sample formulation is not required, and the majority of samples can be tested easily.

5.6 Nuclear Magnetic Resonance (NMR)

This is a fast and size-independent technique. Signal intensities are directly proportional to the proton numbers that give rise to a unique resonance (Peez et al., 2019; Peez & Imhof, 2020). It is a more advanced technique over Raman spectroscopy and FTIR.

5.7 Thermo-analytical methods combined with gas-chromatography and mass spectrometry (GC-MS)

This technique is used in forensic science and the polymer industry (Kusch, 2014). In this technique, polymers are first degraded at the temperature of 600 °C in an oxygen-free environment; then, volatile products are separated through the GC-MS.

6. Conclusions and recommendations

The production of plastics started 60 years ago, and now most useful items are partially made of them. The presence of MPs in the Antarctic Region has been recognized as a major preservation issue and a precedence for investigation. However, the main question concerning plastics in this region remains unanswered. MPs are transported to Antarctica by several anthropogenic activities and subsurface currents. Most of the MPs in the Antarctic Region come from the fragmentation of macroplastics. The presence of MPs in the Antarctic Region is clearly seen, and this region is not exempted from plastic pollution as considered previously.

Due to the small size, sampling and identification of MPs are very difficult. Therefore, the total concentration of MPs on the surface water of the Antarctic Ocean is not yet confirmed. This plastic pollution is having detrimental impacts on organisms. However, it is not clear which species are more affected, due to the lack of data. The transport and fate of MPs are strongly dependent on the physicochemical properties of the plastics and water. Policymakers are starting to pay attention to the potential risks of MPs, leading to the banning of some plastic products. This is an important concern, as MPs have been accumulating in the environment for decades. The understanding of the behavior of MPs in the environment is the first step toward mitigating the impacts of these contaminants. The present study can help provide baseline data for MPs in the Antarctic Region for future research.

The author suggests several recommendations for the minimization of MP pollution. These are as follows:

- There should be augmented research in the proximity of the Antarctic Region to upsurge the understanding of the impacts of plastics on the Antarctic ecosystem.
- A proper strategy should be made by the Antarctic Treaty System (ATS) to prevent and mitigate the problem of MPs in the Antarctic Region.
- There is an urgent need for the implementation of waste management and treatment to avoid plastic input into the Antarctic Ocean.
- A better step can be to spread environmental awareness among tourists, researchers, and ship crews who use areas in the proximity of Antarctica.
- New guidelines/policies should be made globally; for example, banning the use of single-use plastics and regular monitoring of plastic pollution in the ocean should be done.
- Government bodies, communities, and industries can work together for the reduction of the amount of plastic litter seen in oceans and beaches.
- Use of items made from waste material, or the refusal to buy plastics, should be encouraged.
- New analytical techniques for the detection of MPs should be developed and standardized by researchers.

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