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MICROPLASTICS IN MUSEUMS: POLLUTION AND PALEOECOLOGY

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Background: With the advent of the creation, production, and continuous use of plastic in both industrial and domestic spaces, plastic materials have become an integral part of human daily life, resulting in a range of impacts, both positive and negative. More recently, their resistance and refractoriness, once considered significant advantages, are now understood as a threat to the balance of ecosystems and, ultimately, to human health. The particular composition of plastic grants it great malleability and durability. On the other hand, it includes a series of potentially toxic compounds that, over time and through environmental action, can become bioavailable at various levels of the trophic chain through tiny particles known as microplastics. Research has increasingly revealed various types of damage across multiple sectors of the environment and society. **Objectives:** This article attempts to find out the impact of microplastics on the atmospheric layer and the consequences for historical heritage as a result of interactions in the indoor environment. **Methods:** The sources, types, migration mechanisms, and impacts of environmental MPs and heritage items are analysed and summarized, and it is also considered how the presence of these small particles in preserved organisms and tissues in museums and other collections can serve as indicators of the mechanisms and environmental dynamics of the Anthropocene. **Results:** Microplastics have been detected in the atmosphere and artefacts in natural history and other collections, as well as sediment cores, leading to the conclusion that the plasticene era began in the 1950s. Such research studies, and potential similar investigations on historical stored tissue samples, require optimization before the information stored in these sources can be fully mined. **Conclusion:** Microplastics are present at high levels in both outdoor and indoor air. Together with their adsorbed pollutants they can cause deterioration of the artefacts and health problems for conservators in museums. In museum specimens like preserved animals and in stored tissue collections they can act as historical proof of the distribution of microplastics in living things throughout time and this has confirmed the beginning of the Plasticene as the early 1950s.

Keywords: microplastics; Anthropocene; environment; artifacts; aesthetic degradation; corrosion; pollutant; dust; natural history collections; indoor environment.

INTRODUCTION

Microplastics (MPs) have captured the attention of scientists, the authorities and the public since the name was suggested in 2004 (Thompson et al., 2004). They are ubiquitous environmental pollutants that can become incorporated into all environmental compartments and the organisms living within them; their effects on the latter are manifold and potentially lethal.

Considered indicators of the Anthropocene (Rangel-Buitrago et al., 2022), MPs and nanoplastics (NPs) have been detected in organisms from protozoa and algae to mammals, including humans (Nałęcz-Jawecki et al., 2021; Sun et al., 2021; Arif et al., 2024; Wang et al., 2024). There has been much work on the presence and importance of MPs in fish (Wootton et al., 2021) and their recognition in a wider variety of animals, including non-human mammals, continues (Yong et al., 2020; Alvarez-Andrade et al., 2023; Diaz-Santibañez et al., 2023; Pérez-Flores et al., 2024; Borroto-Paez et al., 2024).

After confirming the potential for bioaccumulation of these particles and their potential transfer along trophic chains (Carbery et al., 2018), other areas of study have emerged. Their morphology, composition, and diffusion capacity have led to MPs posing serious risks to environmental and, ultimately, human health.

Studies have addressed topics such as the damage caused by MPs to environmental balance by disrupting the biogeochemical equilibrium (De Almeida et al., 2023), as well as harming productive and commercial chains, such as food production. An underdeveloped area is the study of MPs in museums. They can result in deterioration of the exhibits, both historical and modern and can affect conservators, who spend their days working closely with specimens with accompanying risks to health. Museums are places of interaction between different eras, where microplastics from the past can be found in preserved exhibits. Thus relationships between microplastics in past, known and registered times can be determined, as well as the progression of microplastic pollution through time and, in some cases, space. Museums and similar curated collections of tissues from the animal and plant world can be of interest for studying the influence of the specifically human activity of plastics production on environmental change. Both biological and historical/social fields are involved in the study of these anthropogenic particles.

This article aims to discuss aspects related to the presence, importance and diffusion of microplastics in museums – environments where invaluable collections store records from various research fields, providing complementary information for ongoing laboratory studies.

DUST IN MUSEUMS

Over the past few decades, research on the impact of environmental factors on cultural heritage has grown significantly. Air pollution is recognized as a major risk to heritage artifacts stored in cultural institutions (Karbowska-Berent et al., 2011). Dust, a significant component of atmospheric aerosols, plays a role in air quality, climate regulation, and surface deposition (Fuzzi et al., 2006). Its particles, which include MPs, originate from both natural and human-related activities, varying in composition, concentration, and size based on geographic region, pollutant transport, and meteorological conditions (Adams et al., 2015; Rintala et al., 2012). Indoors, dust results from outdoor sources, human activity, and building materials (Godish, 1989). The accumulation of diverse dust particles can create conditions favourable for microbial proliferation (Nevalainen et al., 2015; Saiz-Jimenez, 1995). Once microorganisms settle on cultural heritage objects, they may establish colonies and contribute to material degradation (Gadd & Dyer, 2017; Mesquita et al., 2022). The deposition of dust and its components can result in physical damage, chemical transformations, and biological deterioration of cultural artifacts (Cappitelli et al., 2020; Scheerer et al., 2009). The MP components of dust are currently one of the major areas of atmospheric research.

Within closed rooms, dust is dispersed by air currents, movement of people and equipment, and natural processes such as particle sedimentation and resuspension. This dispersion can be influenced by ventilation, humidity, and electrostatic surface charge. Dust circulation in enclosed spaces is caused by:

– *air movement*: airflows generated by fans, air conditioning, open windows, and breathing and movement of living beings (Dinis et al., 2020; Gaylarde et al., 2024);

– *human activities*: walking, sitting on sofas or mattresses, and opening doors can lift settled particles from the floor and surfaces, reintroducing them into the air (Wang et al., 2021);

– *electrostatic charge*: some surfaces can attract and retain dust particles, either facilitating or hindering their dispersion depending on environmental conditions (Lotfalipour et al., 2025);

– *sedimentation and resuspension*: smaller particles tend to remain airborne longer, while larger ones settle quickly. However, surfaces like carpets, curtains, and furniture can store dust and release it again when disturbed (Wilson & Platts-Mills, 2018).

In museums, dust originates from multiple sources and poses a significant challenge, as it can contribute to the deterioration of historical and artistic collections. When dust accumulates, it attracts insects, which in turn draw other pests. It clings to artifacts, promotes the growth of mould, and accelerates corrosion (Shah et al., 2011).

A major source is the building itself – walls, ceilings, and floors gradually wear down, releasing fine particles from materials such as plaster, paint, wood, and concrete (Prasittisopin et al., 2023); many of these materials generate MPs, which may become a major contributor. Ventilation and climate control systems play a role by accumulating dust over time and redistributing it throughout the space (Gaylarde et al., 2024). Additionally, maintenance work, whether small repairs or large renovations, can introduce significant amounts of dust from plaster, cement, and paint residues (WHO, 2004). The latter are important sources of MPs (Gaylarde et al., 2021a; Fang et al., 2024).

Visitors and staff contribute to dust by continuously shedding skin particles, hair strands, and fibers from (often synthetic) clothing (Yoon & Brimblecombe, 2000). Shoes track particles from outside, and objects like bags and backpacks can introduce dust from other places. The museum collection itself is another source, as aging materials deteriorate over time. Old books and documents release fine paper particles, while textiles such as historic clothing, upholstery, and tapestries shed fibers. Wooden sculptures and furniture, as well as paintings and varnished surfaces, can break down gradually, contributing to airborne particulates; not all of these contain MPs. External environmental factors further complicate the situation. Fine dust from urban pollution, nearby construction, and natural elements can enter through ventilation systems, while organic matter, such as insect remains and fungal spores, also accumulates over time.

MICROPLASTIC DIFFUSION IN THE AIR

Since the initial identification of MPs in atmospheric deposition in France in 2015 (Dris et al., 2015), research on airborne microplastics has expanded significantly, garnering increasing interest in recent years (Liu et al., 2020, Jahedi et al., 2025; Chen et al., 2025). Early studies focused on identifying both environmental sources – such as the air-water interface and wind abrasion – and anthropogenic sources, including human activities and industrial emissions, to understand how plastics enter the atmosphere. MPs are frequently present in household dust. They originate from various sources (Figure 1), including:

– *synthetic textiles*: clothes and fabrics shed plastic microfibers into the air, especially during handling and washing (Gaylarde et al., 2021b);

– *degraded plastics*: worn-out plastic objects such as furniture, toys, and packaging release microscopic particles;

– *personal care product residues*: shampoos and creams, for example, may contain MPs that can disperse into the environment (Hernandez-Soriano, 2024).

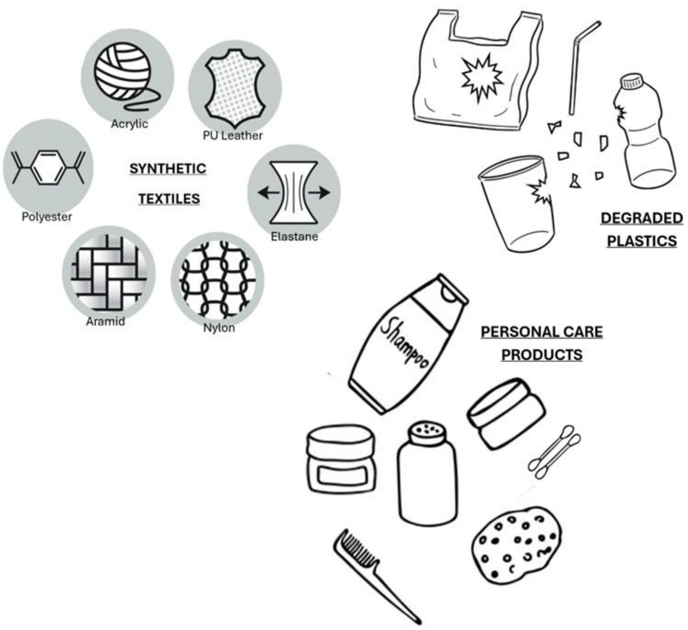

Figure 1. Potential plastic sources to household dust

Because MPs have low density, they can remain suspended for long periods and be inhaled or deposited on surfaces, contributing to human exposure (Ziani et al., 2023). Continuous inhalation of these particles may pose risks to human health.

Urban dust can indeed intensify the degradation of historical artifacts in museums (Mašková et al., 2020). It contains particles of air pollutants (including MPs), heavy metals, soot, and salts, some of which can chemically react with the materials of the objects, accelerating processes such as corrosion, oxidation, and organic degradation. Additionally, dust can retain moisture, promoting the growth of fungi and bacteria that attack sensitive surfaces like paper, textiles, and wood (Khan & Karuppayil, 2012).

From the moment plastic microparticles began to constitute a significant fraction of urban dust, this new component potentially started to influence the chemical and physical interaction of dust with the surfaces on which it settles. Various chemical additives—including plasticizers, flame retardants, antioxidants, UV stabilizers, heat stabilizers, slip agents, curing agents, biocides, pigments, and other compounds – are integrated into plastics during production. Under unstable conditions, such as strong shear forces (Lambert et al., 2014; Paluselli et al., 2019), prolonged or intense UV radiation (Lambert et al., 2014), and environmental weathering (Lambert et al., 2014), these substances can be released, potentially impacting the surrounding environment.

Most museums, galleries, libraries, and archives, along with many historical palaces and houses, are situated in urban centres, exposed to a dynamic and complex urban atmosphere (Mašková et al., 2020). Over the past two decades, emissions of traditionally recognized harmful pollutants affecting heritage materials have significantly decreased. However, scientific focus has increasingly shifted toward other pollutants such as MPs, with particular attention on particulate matter and its potential impact on cultural heritage (Grau-Bové & Strlič, 2013).

The interaction between airborne MPs and artwork materials can occur in various ways, often influenced by temperature and relative humidity conditions (Rednikin et al., 2024). The presence of dust and other pollutants contributes to these processes, ultimately leading to surface disfigurement and material degradation.

As stated in many articles, the high durability and versatility of the plastic matrix are due not only to its basic composition of long-chain synthetic molecules made from repeating units of monomers, but also to the addition of various chemical compounds in its composition (Hahladakis et al., 2018; Verla et al., 2019; Oliveira et al., 2020; Cverenkárová et al., 2021; Zhang et al., 2024). Regarding the polymers that make up the plastic matrix, each polymer has unique affinities to sorb and release heavy metals, persistent organic pollutants, pharmaceutical products, and antibiotics (Menéndez-Pedriza & Jaumot, 2020). Additionally, MP microfibers possess extensive surface areas, which enable them to effectively adsorb highly toxic pollutants. The primary retention mechanism for these substances is hydrophobic interaction, particularly for organic compounds, although electrostatic forces, van der Waals interactions, hydrogen bonding, and π-π interactions also play a significant role (Li et al., 2023).

MPs can contribute to the acidification of water, albeit indirectly. Although MPs themselves are not the primary cause of freshwater acidification, their presence can enhance processes that lead to this condition. MPs may thus contribute to the corrosivity of humid air through all the following mechanisms:

1. *Release of chemical compounds* – MPs in the air can contain chemical additives such as phthalates, flame retardants, and heavy metals (Huang et al., 2021), which can be released making the air more reactive and potentially corrosive. Some plasticizers, such as phthalates (e.g., DEHP, DBP), can undergo hydrolysis in the presence of water, releasing organic acids. Alternatively, certain plasticizers can react with dissolved minerals in water (such as carbonates and bicarbonates), altering the chemical balance and potentially decreasing the pH. Finally, microorganisms in water can biodegrade plasticizers, producing acidic by-products, such as carboxylic acids, which gradually lower the water pH.

Plastics may also contain residual monomers, solvents, and catalysts from the production process, along with non-intentionally added substances (NIAS), such as impurities and degradation by-products that form during or after manufacture. The majority of additives and NIAS are not chemically attached to the polymer matrix, allowing them to gradually leach out over time during use and after being discarded into the environment (Hahladakis et al., 2018). Some authors have suggested that the release of compounds present in the plastic matrix may contribute to ocean acidification (Romera-Castillo et al., 2023). The degradation of MPs by UV radiation and oxygen can also generate compounds like aldehydes and organic acids (Priya et al. 2022; Ibrahim, 2024), which may dissolve in humid air, lowering the pH and enhancing corrosive effects. Thus, it would not be unreasonable to consider that humid air could become more acidic and corrosive as a result of the increasing concentration of suspended MPs in the atmosphere.

2. *Adsorption and transport of pollutants* – Smaller plastic particles have a higher surface-to-volume ratio, enhancing the effectiveness of capturing and releasing chemical compounds (Sutkar et al., 2023); hence they can act as carriers of acidic substances and other corrosive contaminants (Fu et al., 2021). The adsorbed contaminants can be moved across surfaces by processes of MP rolling (traction/surface creep) and saltation (rolling and jumping) (Ogbuagu et al., 2022 and Figure 2), prior to secondary transport and redispersion (Musso et al., 2024). Fu et al. (2021) highlight that hydrophobic interactions serve as the primary mechanism through which MPs capture organic contaminants, significantly influencing the extent of pollutant retention. Alongside this, other non-covalent forces – such as electrostatic attractions, hydrogen bonding, halogen bonding, and π-π interactions – also contribute to the adsorption of organic substances onto MPs. Several factors play a crucial role in determining adsorption efficiency, including the size and surface area of the particles, their degree of aging, crystallinity, and polarity. The chemical characteristics of the pollutants, particularly their hydrophobicity and ionization states, impact their interaction with MPs. Thus more hydrophobic polymers, such as polyethylene (PE) and polypropylene (PP), can interact with nonpolar organic compounds, while polymers containing polar functional groups, such as polyurethane (PU) and polyester (PE and PET), may have a greater affinity for slightly polar compounds, including some light organic acids. The presence of biofilms on the surface of microplastics can influence this adsorption either positively or negatively (Martins et al., 2024).

Light organic acids, such as acetic and formic acids, are present in the atmosphere from natural sources and human activities. They can dissolve in atmospheric moisture, forming acidic solutions that contribute to the reduction of precipitation pH, a phenomenon known as acid rain. Although organic acids are considered weak acids, their presence in the atmosphere can influence the acidity of atmospheric moisture and rainfall. Acid rain results from the dissolution of acidic gases in atmospheric water, leading to the formation of acidic solutions that can have harmful environmental effects. While light organic acids are not the primary contributors to atmospheric moisture acidification, they can help lower the pH of atmospheric moisture and precipitation (Kobal et al., 2020). There is a scarcity of studies describing the interaction of organic compounds in the atmosphere and their effects on historical collections. Fu et al. (2021), for example, explored the impact on artifacts of volatile organic compounds (VOCs) emitted by wood. The impact on artifact materials varied significantly depending on the wood species and was influenced more by specific compounds, such as hinokitiol or acetic acid, rather than the total concentration of volatile organics. MPs can interact with aerosols and other suspended particles, altering their chemical composition (Zhang et al. 2020) and potentially promoting reactions that increase the acidity of moist air. Thus, based on all this information, it is not absurd to consider that the densification of atmospheric material promoted by the addition of MPs also influences the physicochemical conditions of atmospheric moisture. Nevertheless, specific studies should be conducted.

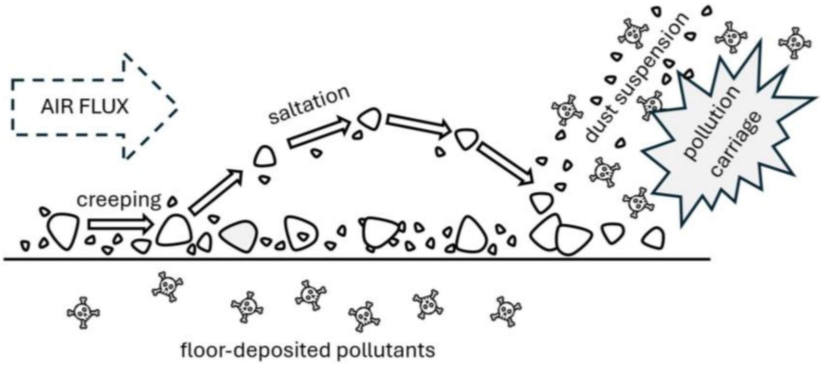

Figure 2. Movement of microplastics and its spreading of pollution

In museums, beyond the chemical and physical impacts caused by the release of compounds from the degradation of the plastic matrix, MPs also pose a potential risk as carriers of microorganisms (Yan et al., 2024), potentially affecting conservation efforts and the preservation of cultural heritage. Microbial deposits on cultural heritage objects not only contribute to surface aesthetic deterioration but also frequently lead to chemical corrosion, biodegradation, and mechanical damage (Sterflinger & Piñar, 2013). For instance, bacteria carried by airborne MPs can settle on exposed metal surfaces in the atmosphere, promoting corrosion of the structures. The polymers produced by the bacteria, mostly polysaccharides, act as adhesives, trapping dirt and other particles, intensifying the damage caused by the biofilm and resulting in increased corrosion of the metal surface (Rajasekar et al., 2017). Bacteria and other microorganisms can also degrade ancient textiles by breaking down the fabric structure and chemical composition, especially in museum collections, where ancient textiles are among the most delicate artifacts due to their natural composition and vulnerability to environmental conditions (Gutarowska et al., 2016). Made primarily from natural fibers such as cotton, linen, wool, and silk, these fabrics degrade over time, particularly when exposed to humidity, fluctuating temperatures, and microbial activity (Taha et al., 2019). Linen and cotton, composed mostly of cellulose, are susceptible to fungi and bacteria that break down plant-based materials, while wool and silk, made of proteins like keratin and fibroin, can be damaged by enzymatic activity from many microorganisms. Most of these textiles were originally dyed using natural pigments extracted from plants, insects, and minerals. Indigo from Indigofera tinctoria plants, Tyrian purple from marine molluscs, and carmine red from cochineal insects created vibrant hues, while saffron and turmeric produced shades of yellow (Alegbe & Uthman, 2024). Although these dyes enhanced the beauty of fabrics, some contained organic compounds that inadvertently provided nutrients for microbial growth, accelerating deterioration.

In museum settings, textile preservation requires meticulous environmental control. Because these artifacts were often stored in humid or poorly ventilated conditions before being acquired by museums, they may already have suffered significant degradation. This process can cause discoloration, loss of strength, and unpleasant odours. There are various ways in which microorganisms can degrade ancient textiles. For instance, cellulolytic enzymes and pigment production. Fungi are regarded as responsible for the most significant deterioration of ancient fabrics (Taha et al., 2019). Most museums use climate-controlled storage, with regulated temperature and humidity levels to slow degradation. Periodic assessments by conservation specialists help ensure that these irreplaceable textiles remain intact for future generations.

With the advent of plastics and the industrial production of this material, the challenges of maintaining ideal conditions for the preservation of historical collections have become even more complex. In addition to being effective sources of micropollutants that can directly and indirectly threaten the quality of materials preserved in museums, plastics also have the ability to transport microorganisms, further intensifying the need for careful management of surrounding atmospheric dust.

Obviously, the storage of plastic objects as museum specimens is a topic deserving of separate discussion and special conservation strategy. This has been considered recently by Colliander (2024).

MPs IN MUSEUM SPECIMENS

Plastics, including MPs, have been collected by birds and built into their nests (Hartwig et al., 2007; O'Hanlon et al., 2021) as well as being used by other animals to construct and decorate their bowers (Jagiello et al., 2023). These constructions and their photos have been collected by humans and may be found as dated exhibits in museum collections, helping to determine the timeline of the relationships between MPs and living things (Potvin & Townsend, 2024). Plastics themselves can be museum specimens and, in fact, are an increasing preoccupation of conservators (Urbanová et al., 2024). Considering their probable positioning within protective casing, however, rather removes them from the list of MP sources in museum air. MPs in museum specimens should only be regarded as a problem if they pose a threat to the conservators who may have to work closely with the exhibits. The wearing of appropriate masks and standard anti-contamination measures can deal with this. Rather, MPs in natural history artefacts can be of assistance to humankind as markers of the historical progress of the Anthropocene.

Relevance to paleoecology

The presence of MPs in sediment cores is one way of determining when the "microplastic era", perhaps the best indicator of the Anthropocene, began (Matsuguma et al., 2017; Turner et al., 2019). Several articles have collected evidence from published MP levels in sediments to indicate the various stages of the Anthropocene (Bancone et al, 2020; Chen et al., 2022; Alves et al., 2023; Yin et al., 2024). Kuwae et al. (2022) first detected MPs in cores from Beppu Bay, Japan, that corresponded to the year 1954 and Ruiz-Fernández et al. (2024) analysed three ^{210}Pb dated sediment cores from a Mexican coastal lagoon, with maximum deposition dates determined as 1883, 1909 and 1915, detecting no MPs before the 1950s. However, evidence from such sources, as well as from peat samples and ice cores, is subject to a number of interferences and other disadvantages, pointed out by Bancone et al. (2020) and Praet (2023). Rotchell et al. (2024) detected MPs in archaeological sediment samples in York, UK, suggesting that MPs may even transport between archaeological layers, compromising the value of such deposits. Earthquakes and tsunamis are obvious examples of natural disasters that may disturb the geological record.

The presence of MPs in preserved animals and plants in natural history collections, whilst still subject to the same potential types of interferences, has the advantage of indicating when these anthropogenic particles began to spread throughout the Earth's biota, incorporating living things into their dispersal mechanisms. Large animals and plants may be stored in the dried condition, insects often simply pinned to card and larger, soft-bodied animals stuffed by taxidermists; in these cases, possible MP contamination during preparation and storage must be considered. Kirkinen et al. (2023), for example, discuss the possibilities of MP fibre contamination in Finnish archaeological soil samples, which could not be discounted in their analyses. All biological specimens, on the other hand, may be stored wet, in alcohol or formalin, when external and internal contamination may be less. MPs can be detected in both types of specimen, using appropriate methods. Dursun et al. (2025) used FTIR to detect MPs in the GI tracts of 25 out of 300 specimens of a terrestrial lizard which had been preserved in 95% ethanol at a Turkish university research centre between 1986 and 2013 and Gül et al. (2022) showed that MPs (mainly microfibers) could be detected in the gastrointestinal tracts of snakes stored in a herpetological museum in Turkey.

The detection of MPs in the internal tissues of such museum exhibits proves that there was no chance of interference from superficial contamination that could have occurred at any time during the specimen's museum life, but that MPs were prominent in the environment during the lifetime of the organism. MPs are environmentally durable and resistant to the protective, "anti-stranger" mechanisms of living things, so that their presence over long time periods makes them suitable as such markers.

There was little research into the environmental importance of MPs prior to 1970; such information can be inferred from stored specimens from before this time. Biological specimens from over 200 years ago are available in the World's museums (Schmitt et al., 2018) and they are normally stored with information about the place and time of collection. This allows the gathering of detailed knowledge about the spread of MPs throughout time and space, always remembering that these particles are dispersed in many ways, including by wind, water and living organisms, over large distances.

Museum specimens do not always show increases in MP over the years. Studies in plankton and fish from the Baltic Sea in 1987 – 2015, for example, showed no increases in MP contamination over this time period (Beer et al., 2018), while Courtene-Jones et al. (2019) found no increase in MPs in deep-sea invertebrates between the 1970s and 2015, and Ehlers et al. (2022), examining in rocky intertidal habitats in Germany, France and Italy, found no change in MP loads between 2007/9 and 2019/20. However, Table 1 shows that several studies have indicated the increase in MP content of museum specimens over the years following 1950. In the majority of cases, the main types of plastics detected have been PET (polyethylene terephthalate) and polyester (Ilechukwu et al., 2023), the main fibres produced since the 1950s (Geyer et al., 2017). The first study in freshwater (as opposed to marine) fish (Hou et al., 2021) reported MPs in stored specimens of largemouth bass and sand shiner from the early 1950s. MP levels (0.2 ± 0.45 and 1.4 ± 1.67 particles/ individual, respectively) increased to 2.50 ± 1.87 and 5.17 ± 2.40, in contemporary fish caught in the same areas. This statistically well-controlled study showed that time, and not, for example, fish weight, was the major factor influencing MP content. Local human population and production and use of plastics increased considerably over the same timescale.

The study of MPs in natural history specimens is still in its infancy and reliable methods have yet to be developed. Around 3 billion specimens are, however, available in the world's archives (NASEM, 2020), and the refinement of techniques prior to testing is certainly a worthwhile undertaking, although the need to preserve historically important information, in terms of the specimens themselves, must be recognised. Dettling et al. (2024) discuss in detail the problems and possibilities of MP detection methods in collection specimens. They consider that bioindicator species should be emphasized in monitoring past MP pollution, as well as in predicting future trends.

The identification of the vast majority of MPs in stored museum specimens as microfibers, similar to evidence from sediment cores (Brandon et al., 2019; Dong et al., 2020), indicates that these are secondary MPs, resulting from the breakdown of manufactured plastics and primary MPs. Nurdles, the small microplastic pellets used as raw material for plastic products, are found as polluting primary MPs in the modern world, but are present in smaller quantities than secondary MPs and mostly near plastics-producing industries or through transport accidents (Karlsson et al., 2018; Jiang et al., 2022; Cocozza et al., 2025). Although they have been detected in modern day marine fish (Day et al., 2024), we have found no published evidence of nurdles in freshwater fish, but Gad et al. (2023) confirmed their absence in fish sampled from the Mississippi River, which is used for transportation of these particles. Bancone et al. (2020) suggest that these microbeads may be less suitable as markers of the Anthropocene than secondary MPs, since their presence in domestic materials such as toothpaste and body sprays developed at different times in the Northern and Southern hemispheres, making them unsuitable as global markers.

Future investigations could include the examination of stored histological specimens for the presence of MPs. If plastic-solubilising fixatives (strong organic solvents) have not been used, then these preparations could provide evidence of MPs in the tissues of many animals, including humans.

Table 1. Some microplastics studies on biological specimens stored in collections

Organism	Location of specimens	Details of MPs detected (where available)	Site within organism	Date and location of collection (if known)	Reference
Marine sponges (benthic)	Cantabrian Sea Maritime Museum	In 54%	Animal surface	S. Gulf of Biscay: 1996 – 1999	Modica et al., 2020
Marine sponge Cinachyrella alloclada	Bahia Natural History Museum, Brazil	In 10% in 1981, 80% in 2017	Whole animal	Coast off Salvador City, Brazil: 1981 and 2017	Soares et al., 2022
Plankton	Preserved routine plankton samples; Sir Alister Hardy Foundation, Devon.	Mainly fibers. Abundance increased with time.		Sea between Aberdeen and Shetlands, Sule Skerry and Iceland: 1960s	Thompson et al., 2004
Freshwater fish	Field Museum Illinois and University of Tennessee	Fibers from 1950 onwards	Digestive tract	Illinois and Lake Michigan areas: 1900 – 2017	Hou et al., 2021
Various (plankton to vertebrates)	Various.	Various	Various	NE Atlantic: 1976 – 2015	Ilechukwu et al., 2023 (a review)
Siganus fish	Tel Aviv and Hebrew Zoological University Museums	-	Guts	Israel coast: 1960s – late 1980s	van der Hal et al., 2018
Blue mussels	German Environmental Specimen Bank	PET, levels increased continuously with time	Whole organism (cryomilled)	North Sea: 1986 – 2015; Baltic Sea: 1992 – 2017	Halbach et al., 2022
Lanternfish	Scripps Institution of Oceanography and Ichthyology and Burke Museum of Natural History and Culture, Washington	Fibers. Increased over time	Stomachs	1962 – 2016	Boisen et al., 2024
Leatherback turtles	Various (published necropsy reports)	Total plastics, not just MPs, in 33.8% of total. First report in 1968. Plastics in 37.2% thereafter	Gastrointestinal tract	1885 – 2007	Mrosovsky et al., 2009

Such samples are available in biobanks in various institutions, including hospitals (Botling & Micke, 2011), and nucleic acids within the specimens have been shown to remain accessible for amplification for a number of years (Lagging et al., 2002; Liu et al., 2002), suggesting that MPs would also survive. Gonçalves et al. (2018) considered that histological specimens may remain suitable for MP detection if appropriately prepared and Zarantoniello et al. (2024) detected MPs in tissues from fish fed a diet containing microplastic microbeads; MPs were found in intestine and liver, and in muscle and adipose tissue. Benthic polychaetes have also been shown to contain MPs, mainly microfibers, in histological sections of their muscles, peritoneum, nephridia, gonads and blood vessels (Pascual-Parra et al., 2025). Such stored histological specimens could be usefully employed in the future as palaeoecological tools. Similarly, tissues stored in formalin can be used to assess changes in MP levels; Nihart et al. (2025) used instrumental analyses and microscopy to show that MP levels in formalized decedent human brains increased significantly from 1997 to 2024.

Finally, it must be recognised that normal handling procedures in museums and collections, although with controlled cleanliness levels (Dalla Mora et al., 2025), will not, in the past, have considered MP contamination from the atmosphere or, equally importantly, from the curators' or handlers' clothing over the years. Necessary precautions in sampling and processing of materials for MP analysis, including those required when collecting samples, are discussed by Gwinnett & Miller (2021).

Museum specimens are essential for the documentation of the Anthropocene, not only regarding changes in pollution, but also in climate and disease. As more analytical techniques become available, these attestations of our past will yield ever increasing information about the influence of humans on their environment.

CONCLUSION

This review has covered two important aspects of microplastics in the ambit of museums and other collections of historically important specimens. The first area is the damaging activities of atmospheric microplastics on museum exhibits and the people who work closely with these artefacts. Although museum staff are gradually becoming aware of these hazards, there are, as yet, no standard preventative precautions in place, although staff normally use protective face masks. The second aspect is the use of materials in stored collections of preserved tissues, cells, plants and animals, to determine the past history of microplastics on our planet. These particles have not been detected in any such collections prior to 1950, defining this date as the beginning of the Anthropocene era.

The article discusses the gaps in the historical records and suggests as yet investigated collections of various types that might be used to fill them.

Author's statements

Contributions

The authors contributed equally to all aspects of the current study and preparation of the manuscript.

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Additional information

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