Sustainable Communities and Waste

National Environmental Science Program

Methodology for Identifying Locations to Investigate Sources and Characteristics of Microplastics

IP2.02.01 Understanding Microplastics

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Methodology for Identifying Locations to Investigate Sources and Characteristics of Microplastics

IP2.02.01 – Understanding Microplastics

This report presents a methodology for identifying suitable locations for case studies aimed at investigating the sources and characteristics of microplastics. By carefully selecting study sites, the goal is to better understand how microplastics enter and accumulate in different environments, as well as the nature of the particles themselves. These insights will contribute to a more comprehensive understanding of microplastic pollution, supporting efforts to mitigate its impacts. This methodology has been informed by practitioners and practical considerations for collecting high-quality samples.

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The Sustainable Communities and Waste Hub acknowledges all Aboriginal and Torres Strait Islander Traditional Custodians of Country and recognises their continuing connection to land, sea, culture, and community. We pay our respects to Elders past, present, and emerging. We support Aboriginal and Torres Strait Islander peoples and their aspirations to maintain, protect and manage their culture, language, land and sea Country and heritage.

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Understanding Microplastics

The "Understanding Microplastics" project, part of the National Environment Science Program (NESP) Sustainable Communities and Waste Hub, aims to deepen knowledge about the sources, pathways, and impacts of microplastics in Australia's environment. This research is critical to identifying how microplastics are entering ecosystems, their distribution across land and aquatic systems, and the potential risks they pose to wildlife and human health. By advancing scientific understanding, the project aims to support the development of evidence-based policies and strategies to mitigate microplastic pollution and promote more sustainable waste management practices across Australia.

Case studies are essential to the "Understanding Microplastics" project as they provide detailed, location-specific insights into how microplastics enter and spread through different environments. By examining a variety of settings—such as urban areas, waterways, and coastal regions—these studies will help identify the primary sources of microplastic pollution and the unique factors influencing its distribution. Furthermore, the case studies will inform targeted mitigation strategies, offering practical solutions tailored to specific environments. This approach ensures that interventions are evidence-based, effective, and adaptable to varying regional challenges in addressing microplastic pollution.

Objectives of the Case Study

1. Validate Major Sources of Microplastics: Determine the key contributors to microplastic pollution within a specific region, such as urban runoff, industrial processes, or wastewater discharge and compare to findings from literature.

2. Characterise Microplastic Types and Composition: Analyse the size, shape, material, and chemical properties of microplastics found in the environment to better understand their origins and behaviour.

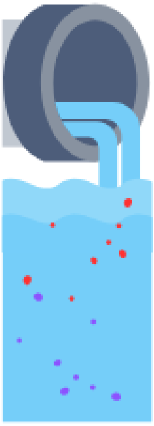
3. Evaluate Mitigation Strategies: Preliminary tests of the effectiveness of mitigation approaches, such as improved filtration systems, to reduce microplastic emissions.

4. Develop Policy Recommendations: Based on the findings, provide evidence-based recommendations to guide decision makers in implementing strategies to minimise microplastic pollution.

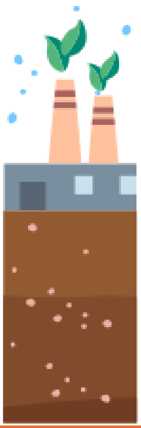
Methodology for Identifying Locations for Case Studies

This methodology outlines a systematic approach to selecting locations for case studies aimed at understanding the sources and characteristics of microplastics. The process involves a combination of data gathering, site assessment, and prioritisation based on environmental and logistical factors.

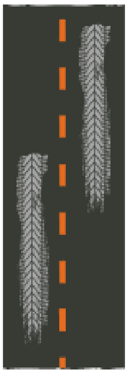
The approach adopted by researchers within Impact Priority 2 (IP2) was to firstly conduct a comprehensive survey of current literature on microplastic sources and sinks, identifying potential types of sites for case studies that could effectively contribute to minimising the impact of microplastic pollution. The findings are summarised in the Figure 1.



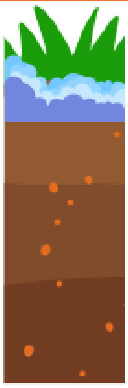
In wastewater, tiny plastic particles can come from various sources, including synthetic fabrics, personal care products, and degrade plastic waste. When wastewater is processed, these microplastics often pass through treatment systems and end up in reivers, lakes, or oceans. Similarly, storm water outlets collect runoff from urban areas, which can carry microplastics from sources like litter, tyre dust, and degraded road markings. Both pathways lead to the release of microplastics into natural waster bodies, where they can harm aquatic life and disrupt ecosystems.



Plastics recycling and manufacturing facilities can also be sources of microplastics pollution. In recycling plants, plastics are shredded, washed and processed into smaller pieces, which can create microplastics. During manufacturing, processes like grinding, cutting and mixing plastics can release tiny particles into the air or wastewater. These microplastics can escape into the environment, contaminating soil and water, and potentially impacting wildlife and ecosystems.



Tyre dust and road markings both contribute to microplastics pollution. Tyre dust comes from the wear and tear of vehicles tyres, which shed tiny particles of rubber, carbon black and other chemicals as they roll. Tyre dust can waste into waterways or be carried by the wind, contaminating soil and water. Road markings, made from paints containing pigments and plastics additives, also bread down over time. Over time, these marking swear down and release small particles and microplastics into the environment.



Synthetic turf, commonly used in sports fields and landscaping, is made from plastic fibres that mimic real grass. These fibres are often made from polymers like polyethylene or polypropylene. Underneath the grass, there's usually a layer of rubber or plastic granules to provide cushioning. The problem with synthetic turf is that over time, the fibres and granules can break down into microplastics. These microplastics can spread into the environment, potentially harming wildlife and contaminating soil and water.

Figure 1. Summary of findings from Literature Survey

When selecting potential sites, the following criteria was also considered:

- Proximity to Known Microplastic Sources: Locations near industrial zones, wastewater outlets, and urban centres are prioritised.
- Ecosystem Diversity: Sites representing various ecosystems (e.g., coastal, freshwater, urban) are preferred to gain a comprehensive understanding of microplastic behaviour across environments.
- Human and Ecological Impact Potential: Areas where microplastic pollution may affect local communities or endangered species are considered.
- Logistical Feasibility: Considerations include accessibility, availability of local support or partnerships, and cost implications.

The Sustainable Communities and Waste (SCaW) Hub has partnered with Ocean Protect to strategically evaluate the logistical feasibility of sampling at key sites of significance. This collaboration allows SCaW to systematically collect and analyse microplastic samples from critical interception points within our communities. By focusing on these targeted locations, the partnership aims to provide comprehensive insights into the types and prevalence of microplastics circulating in various communities. Additionally, this approach will help to pinpoint potential sources of these contaminants, enabling more accurate identification of contributing activities and facilitating the development of targeted mitigation strategies.

The initial phase of the project will span a 12-month period, focusing on sampling microplastics from gully pit traps within the Blacktown Local Government Area (LGA) in New

South Wales. Blacktown has been strategically selected due to its extensive stormwater infrastructure, which includes over 5,000 OceanGuard devices installed throughout the area making it an ideal location for in-depth study. By focussing on a single LGA, the project aims to minimise variability that could arise from differing climate conditions across multiple regions, allowing for more consistent and reliable data collection and analysis. This targeted approach will provide insights into microplastic sources and accumulation within a controlled environmental context, strengthening the study's findings and their applicability.

Ocean Protect have selected sites where they have installed their OceanGuard technology, have access to these assets through active maintenance contracts with these sites, and fall within one of the following land use categories; industrial, commercial, or residential. The sites made available by Ocean Protect are downstream or connected to the microplastic sources identified in our previous study.

Waste and pollution trapped by the OceanGuards will be collected during scheduled maintenance every four months at 9 locations and IP2 will analyse the materials to quantify, characterise, frationate and identify the microplastics.

What are Microplastics?

Across the scientific community, the definition of microplastics remains subject to ongoing discussion (Hartmann, et al., 2019). Microplastics can be defined as plastic particles, less than 5 millimetres in size, that are found in various environments, including oceans, rivers, soils, and even the air. In other studies, definitions incorporate material properties and polymer compositions. For the purposes of this research, materials including plastics and rubbers have been included in the study as the literature has shown that rubber microparticles can carry potentially toxic additives and materials with similar modes of transport when compared to other microplastics (Sieber, et al., 2020).

Microplastics originate from the breakdown of larger plastic and/or rubber debris (referred to as secondary microplastics) or are manufactured at small sizes for use in products like cosmetics and industrial abrasives (primary microplastics). Due to their small size, microplastics are easily transported through ecosystems, posing risks to wildlife and potentially entering the human food chain. Understanding the sources, distribution, and impacts of microplastics is a critical step in addressing plastic pollution and creating policies to intercept them at the source. There are various definitions of what ‘micro’ means but it typically refers to particles that are as large as 5mm down to a few micrometres in diameter. To be more precise, microplastics can be broken down by size fraction (Andrady, 2017).

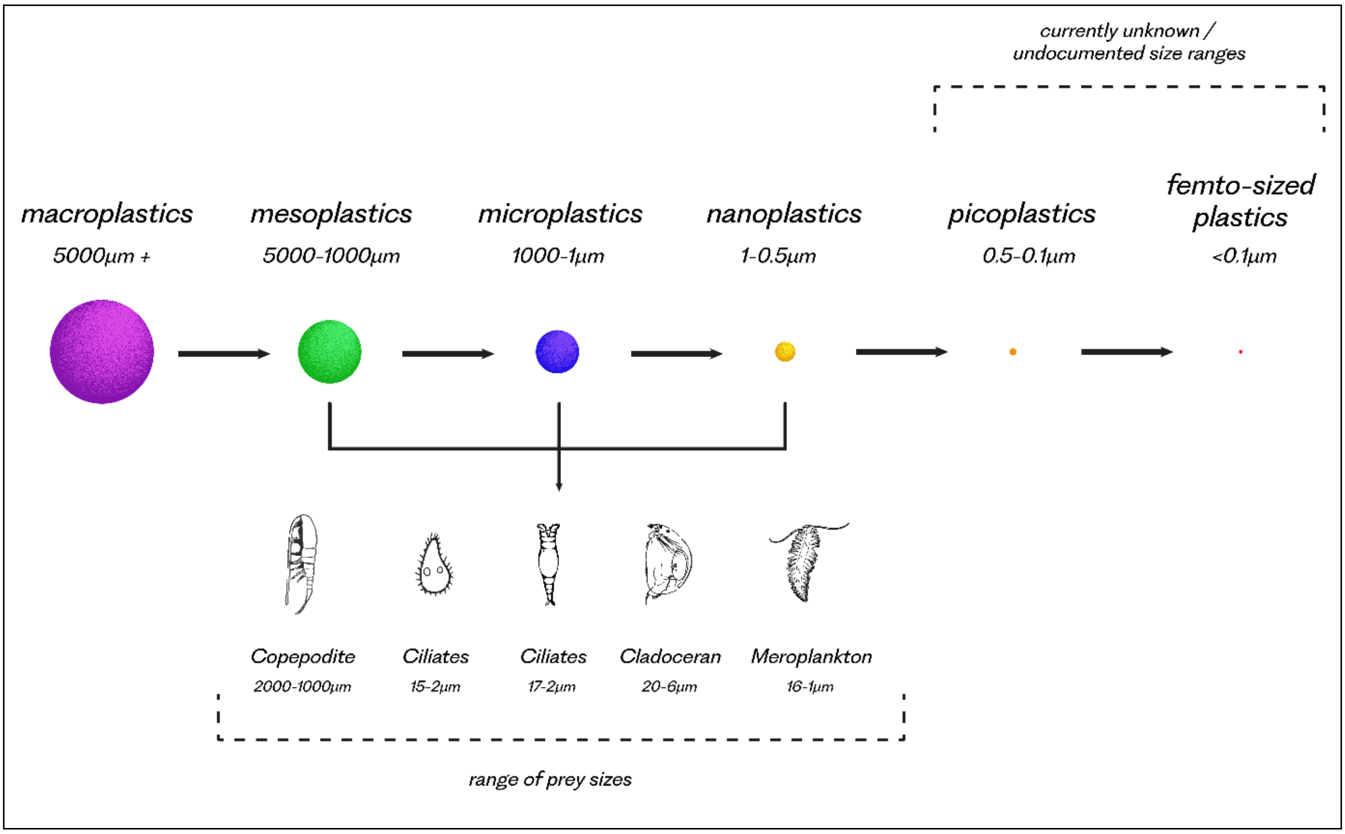


Figure 2. Microplastic size classification (Arkley-Smith, et al., 2024) (Andrady, 2017)

There are many challenges to understanding, categorising and monitoring microplastics, including:

- Almost all plastics used commercially have been treated with additives to improve their functions. However, these can leach out of the plastics and become toxic or hazardous.
- As plastics degrade, their 'signatures', or spectra, degrade as well, making it harder to identify accurately.
- Understanding where a microplastic has come from can be difficult as there could be any number of potential sources both near and far.
  There are few regulations on tracking or capturing microplastics and our understanding of where they are coming from and where they end up is still growing.

Our Partnership with Ocean Protect

Figure 3. Stormwater Pollution trapped using an OceanGuard

Ocean Protect have over two decades of experience in the design, installation and maintenance of stormwater treatment assets and infrastructure. Over 72,000 of their assets have been installed across Australia, capturing an estimated average of 10.9 tonnes of pollution every day. Ocean Protect actively maintain these assets and play a key role in education and advocacy for better stormwater management practices.

One of their key technologies is the OceanGuard® which can be inserted into stormwater drains both new and old to capture waste as it is picked up by stormwater. With two options for filtration bag liners available, they can prevent particles as small as 200 microns from entering our waterways where they have direct access to our marine environments.

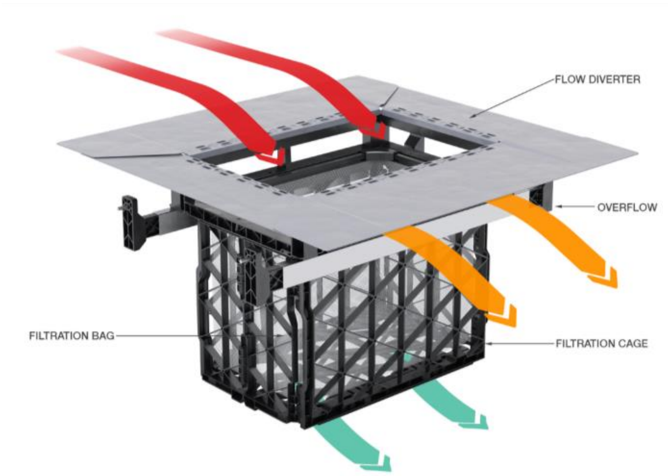
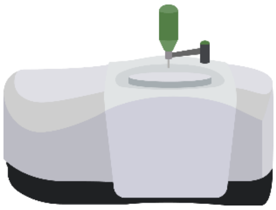
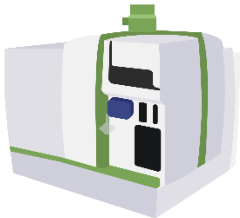


Figure 4. OceanGuard systems can prevent stormwater pollution (e.g. plastic waste) from directly entering our marine environments (Ocean Protect, 2024)

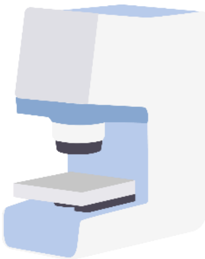
The Centre for Sustainable Materials Research and Technology (SMaRT Centre) brings with it 16 years of innovative environmental solutions that target some of the world's biggest waste challenges. The Centre has access to a diverse range of analytical techniques and equipment to conduct a thorough characterisation of microplastic waste. These techniques are capable of analysing plastics at the micro and nano scale to complement Ocean Protect's work that intercepts and removes pollution from stormwater. A summary of the analytical techniques is provided in the following table.



FTIR (Fourier Transform Infra-Red) identifies polymer types and functional groups for plastics

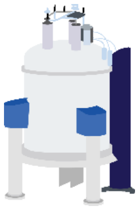


ICP-MS (Inductively Coupled Plasma Mass Spectrometry) analyses trace elements in plastics, useful for assessing contaminants or additives.

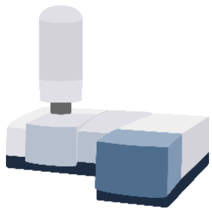


Micro FTIR allows for localised analysis of small microplastic fragments, helping to identify specific polymer types and their characteristics at a microscale.

NIR (Near-Infrared Spectroscopy) assesses the composition and quality of plastics, often used in recycling to sort materials.

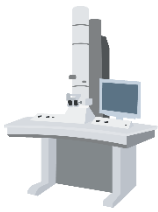


NMR (Nuclear Magnetic Resonance) provides information about the molecular structure of polymers, which can help understand their degradation processes and interactions with other substances.



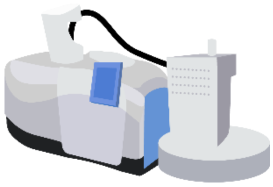
Raman identifies specific polymer types and additives through their vibrational modes, ideal for samples with complex mixtures.

SEM (Scanning Electron Microscopy) analyses the surface morphology and structure of plastics, revealing defects, coatings, or composite structures.



TEM (Transmission Electron Microscopy) allows for high-resolution imaging of the internal structures of plastics and microplastics imbedded in other materials.

TGA (Thermogravimetric Analysis) evaluates the thermal stability and decomposition behaviour of plastics



Pyro-GC-MS (Pyrolysis Gas Chromatography Mass Spectrometry) analyses the thermal decomposition products of microplastics to identify polymer types, determine sources, quantify concentrations, and study degradation pathways

Figure 5. Analytical Techniques for characterising Microplastics

Through the interception of microplastics at the sinks and subsequent analysis, the SCaW Hub aims to build its understanding of microplastics and test the techniques for their suitability for analysing microplastic waste. Generating reliable and actionable results will be a key priority given the challenges with characterisation and the degraded nature of microplastics. Standards such as ISO 24187:2023 (Principles for the analysis of microplastics present in the environment) and ISO 4484-2:2023 (Textiles and textile products — Microplastics from textile sources, Part 2: Qualitative and quantitative analysis of microplastics) may prove to be important sources of information for further developing the hub's microplastics sampling and analysis protocol.

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