PML | Plymouth Marine Laboratory

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Escaping the Plastic Trap: The Need for Research on Alternatives

Science for sustainable solutions

Plastic pollution is widely recognised as a global environmental crisis. Over 400 million tonnes of plastic are produced annually, with a significant portion polluting the marine environment. Beyond environmental damage, plastic-related chemicals pose risks to human health, and plastic pollution contributes to economic losses, food insecurity, and social inequality. Tackling this issue requires addressing plastic production at its source and ensuring new and recycled plastics are truly sustainable.

The rise of 'bio-based' and 'biodegradable' products as eco-friendly alternatives highlights the urgent need for rigorous scientific evaluation of their true environmental and societal impacts. Without this understanding, efforts to reduce plastic pollution could be ineffective.

What about bio-based plastics?

Traditional plastics are made from crude oil. Whereas bio-based plastics are derived from renewable biological sources, such as vegetation or microbes. Given they stem from natural products, a common misconception is that bio-based plastics are biodegradable. In reality, very few readily biodegrade.

What is a 'biodegradable'?

Materials labelled as biodegradable are manufatured to breakdown under specific conditions, such as industrial composters. Most 'biodegradables' will not readily breakdown in the natural environment. As a result, labelling these products as 'biodegradable' is often misleading and ineffective in promoting sustainability.

Are bio-based plastics better?

Bio-based plastics can contaminate traditional recycling and are not compatible with a circular economy approach. Like traditional plastics, bio-based plastics can be consumed by animals and contain a range of chemical additives that can cause toxicological effects.

Science for reliable solutions

The plastic crisis is a complex global challenge that requires the application of diverse scientific disciplines to fully understand the **environmental impacts of all types of plastics** and their broader implications for society and the economy. PML are conducting world-leading research exploring the risks posed by traditional oil-based plastic and bio-based plastic alternatives.

PML brings together expertise in key disciplines to provide the scientific insights needed to develop effective and impactful solutions

Key priorities for action

Sustainable investment in scientific research of plastic and their alternatives to properly understand the impacts and risks

Environmentally relevant testing and labelling of 'bio-based plastics' and 'biodegradables' to enable better choices

Legislation to support the use of the least polluting materials in products and packaging

Providing the knowledge to make informed choices by engaging with schools, public and policymakers

Nature based solutions that enable real world action, that works with nature, to tackle the environmental impact of plastic and bio-based plastics.

Real solutions and alternatives that don't just exacerbate the problem i.e. products that have been scientifically proven to have minimal environmental impact

Robust scientific evidence of the drivers of plastic toxicity allowing 'greener-by-design' alternatives

Research for a Changing World

Unveiling Emerging Threats of Plastic Pollution

Bio-based plastics

New scientific insights into the effects of traditional and bio-based plastic particles on marine life are revealing the similarities in their impacts. By simulating real-world conditions in seventy-litre tanks filled with natural sediment, seawater, and invertebrates, our researchers observed how continuous exposure to microplastics influenced the ecosystem. Early findings reveal that both plastic types disrupted the microbial community, while traditional plastics impaired the health and functionality of invertebrates. These results deepen our understanding of plastic pollution's ecological impact and highlight the need for further research into sustainable alternatives.

Toxic Tyre Particles

Cars shed tens of thousands of microplastic particles every year—just from tyres! In partnership with the University of Plymouth, PML is uncovering how these particles travel from roads to the ocean. Lab experiments are demonstrating that tyre particles are highly toxic and can disrupt marine life, such as the feeding and burial habits of lugworms and cockles.

Harmful Marine Coatings

Antifouling paint particles are a hidden threat to marine life. Research at PML has revealed that these particles, which contain biocidal metals, are released into the environment and are highly toxic at real-world concentrations. Used on vessels and marine structures to prevent corrosion and biofouling, these paints may protect ships—but at a serious cost to ocean ecosystems. Our research found paint particles containing biocidal metals are highly toxic to marine life at environmentally relevant concentrations.

PML is at the forefront of scientific discovery. **Scan for more details about our plastics research.**

Inspiring Future Marine Research Leaders

Natalie Smith is investigating the plastic pollution risk of cigarette butts

Cigarette butts are one of the most littered items worldwide and a source of plastic pollution, with filters comprising thousands of fibres made from a bio-based plastic. Natalie is undertaking an interdisciplinary PhD, using social science to understand the drivers of littering behaviours and natural science to determine the fate and toxicity of these butts. Her early results have shown the bio-based plastic filters do not readily degrade and can remain intact for over two-years.

Emily Stevenson is revealing the antimicrobial resistant microbes hitching a ride on plastic pollution

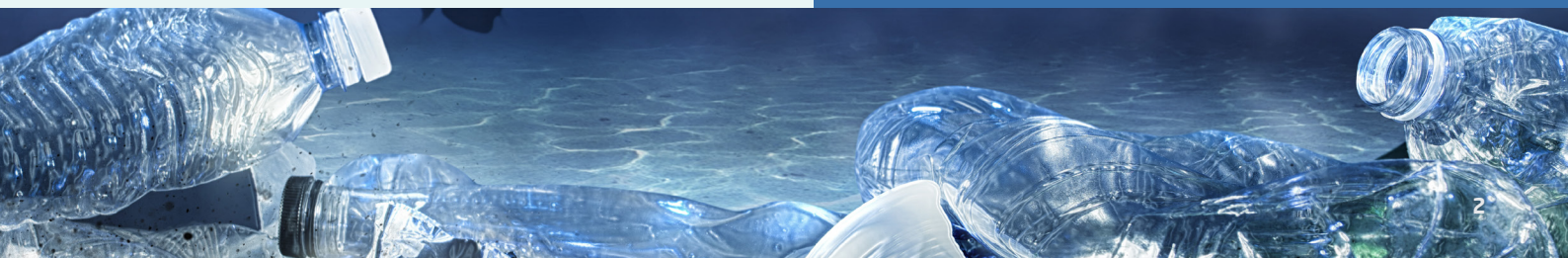
Plastic debris can quickly develop unique microbial biofilms, termed the 'Plastisphere'. Emily's PhD has demonstrated that the plastisphere may harbour and accelerate the spread of antimicrobial resistant microbes that make pathogens harder to treat.

Hayley McIlwraith is seeking solutions using nature

Nature-based solutions describe ecological interventions to address environmental issues. At PML we have been exploring the extent to which mussels can remove waterborne microplastics via their biodeposits. Hayley's PhD is focussed on the role coastal vegetation – such as salt marshes - may play in capturing microplastics.

Charlotte Woodhouse is studying the biological effects of tyre particles in marine invertebrates.

Rubber tyre particles are a major source of marine plastic pollution. Charlotte's PhD with PML and the University of Exeter is revealing the threat of tyre pollution to marine life, especially to organisms that live in estuaries where tyre particles can accumulate.



Expertise

Tackling a global problem and informing meaningful solutions requires scientists spanning a broad range of disciplines. PML conducts world-leading, transdisciplinary research to understand impacts and identify solutions, including: Ecotoxicology, degradation, social science, nature based solutions, education and awareness raising, sources and pathways.

Global research

PML works on a global scale with extensive networks and collaborations, for example:

Central America

In the "Pacific Plastic, Science to Solutions" project, PML is working with partners in Peru, Ecuador, and the Galapagos Islands to study the sources, impacts, and drivers of plastic debris on local ecosystems and economies. The project includes training workshops, researcher exchanges, and collaborations with local institutes, which have already revealed high microplastic concentrations in mangroves and seafood.

South-East Asia

SE Asia is a marine plastic pollution hotspot, with almost 30% of land-based global mismanaged plastic waste arising from this area. PML are collaborating with researchers in the Phillipines to develop an ecosystem service risk assessment for coral reefs affected by plastic debris, and working with islanders to establish how plastic pollution impacts upon the benefits humans get from nature.

Applying our research

Ecological implications: PML identified that microplastics are damaging zooplankton, the most numerous animals on Earth and a key link in oceanic food webs. This pioneering work underpinned UK legislation to ban microplastic beads from the manufacture of wash-off cosmetics and supported bans in at least four other countries.

Societal implications: In a ground-breaking study, PML evaluated the cost each tonne of marine plastic debris can have on marine ecosystem goods and services. These findings have been used by organisations across the world, such as Defra, the World Bank, UNEP and WWF, contributing to the evidence base for the Global Plastics Treaty.

Detecting plastics from space: PML has led the development of pioneering satellite techniques to detect aggregated plastics floating on the sea surface. This approach enables global monitoring of different marine environments, essential to realising the aims of the Plastics Treaty and evaluating its success.

Modelling: PML has developed particle tracking software, which can be used with hydrodynamic models to study the movement and fate of different types of plastic in both the coastal and open ocean. These tools are being used to identify hotspots for plastic in the ocean, and to quantify the impact of transboundary fluxes on local areas.

Urgent research needs

Further research is needed to better understand the problem, identify emerging risks and scope solutions. PML is seeking funding to address the following priorities:

- Explore what chemicals drive plastic and tyre-particle toxicity to inform 'greener-by-design' products.
- Scope nature-based solutions - from saltmarshes to mussel power - in limiting the flow of plastic from source to sea.
- Test the true biodegradability and toxicity of emerging plastic alternatives, including bio-based plastics.
- Investigate the toxicity of emerging plastics - from paints to polymers - under present and future climate scenarios.
- Work with polymer scientists and industry to co-develop materials that are benign by design and their end-of-life considered.
- Determine the risks plastic and microplastic pollution poses to sensitive ecosystems, including the polar regions

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Recognition

PML researchers have been recognized among the **World's Most Highly Cited Researchers** in Environment and Ecology by Clarivate, earning this distinction in 2019, 2020, 2021, 2022, 2023, and 2024. This honor reflects their contributions to multiple highly cited papers, ranking in the **top 1% by citations** for their field and year in Web of Science.

Group lead Professor Pennie Lindeque was one of three laureates for the **2022 Volvo Environment Prize** and a recipient of the prestigious **Blue Planet Prize 2023** for her role in a groundbreaking Southwest microplastics research collaboration. PML's pioneering microplastics research, conducted alongside the Universities of Exeter and Plymouth, won the **NERC Societal Impact Award** and was named the **Overall Winner** in December 2018.

These accolades highlight **PML's global impact**, bringing the causes and consequences of plastic pollution to the forefront of policy discussions, industry action, and public awareness.

Please share with us your thoughts and experiences of plastic pollution, and how our research, can inform meaningful adaptation and mitigation measures.

If you would like to talk to the researchers behind this innovative work please contact: impact@pml.ac.uk

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