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CORDIS Results Pack on

ocean plastic pollution

A thematic collection of innovative EU-funded research results

February 2024

Tackling marine litter from source to sea

Research and Innovation

Contents

Editorial

The EU aims to bring back a healthy ocean by 2030, in line with its commitment to protecting and restoring the marine environment. This results pack highlights 12 EU-funded Horizon projects that are helping to clean up aquatic ecosystems, paving the way to a thriving ocean.

Marine litter can be found on our coastlines as well as far out at sea, thousands of kilometres from land, at the bottom of the deepest ocean trenches, and even in the polar regions among the sea ice. Marine life can be harmed if they ingest marine litter, become entangled in it or are exposed to other pollutants transported by litter, while the impacts of exposure on human health are not yet fully understood.

Marine litter is defined as all human-made solid items that end up in the coastal or marine environment. Plastics, including bags, bottles, and discarded fishing gear, form the largest, most harmful and persistent fraction of marine litter. Each year an estimated 19-23 million tonnes enter aquatic environments, and this volume is expected to increase to 54 million tonnes until 2030 unless urgent action is taken.

Over time, plastic waste is weathered and breaks down into tiny fragments – with those measuring less than 5 mm in diameter defined as microplastics. Nanoplastics are smaller still, with a diameter of less than one thousandth of a millimetre.

Microplastics and nanoplastics pose a global threat to the environment and to human health. While the impacts are not yet fully known, microplastics and nanoplastics as well as the additives they contain and pollutants that sorb onto these particles affect marine organisms and ecosystems. Innovative strategies and tools are therefore needed to tackle this challenge.

The goal of the EU Mission: Restore our Ocean and Waters by 2030 is to reduce plastic litter at sea by at least 50 % and cut microplastics released into the environment by 30 %, in line with the EU Zero Pollution Action Plan. By developing, demonstrating and deploying innovative solutions, the Mission will help to prevent and eliminate pollution and protect and restore aquatic ecosystems and biodiversity.

The Marine Strategy Framework Directive aims at achieving 'good environmental status' of the seas, where marine litter no longer harms the environment. In addition, the 2030 EU Biodiversity Strategy, which forms a core part of the European Green Deal, aims to restore ocean health. The target is to protect 30 % of EU seas by 2030, including 10 % under strict protection.

To meet these challenges, EU-funded researchers are investigating how plastics are transported to the ocean, sustainable biodegradable alternatives for plastic packaging, enhanced waste and wastewater management, and innovative solutions for monitoring, collecting, and degrading plastics.

A plastic-free ocean

This new CORDIS Results Pack presents 12 EU-funded Horizon research projects that are helping to reduce the impact of marine litter through prevention, elimination, mitigation and monitoring, from source to sea.

The Pack showcases their potential for exploitation, scale-up, replication and uptake by different stakeholders responsible for implementing measures to reduce pollution at the local and regional levels. The results will contribute to the EU's goal of cutting plastic pollution to levels no longer considered harmful to health and natural ecosystems, respecting the boundaries within which our planet can cope, thus creating a toxic-free environment.

Biopolymer architecture company tools up for production

World leader in replacing petroleum-derived plastics, Belgium-based B4Plastics is preparing two biopolymer families – TriggerPlastics and FortePlastics – for market launch.

In 2019, the world produced 460 million tonnes of plastic, including 353 million tonnes of plastic waste. To make plastic products more circular companies are researching, developing and bringing to market replacements for conventional plastics. The introduction of biopolymers can help to make the life cycle of plastics more sustainable and the plastics economy more circular, keeping it in line with the EU Plastics Strategy. The EU-funded B4PNOW project helps the biopolymer architecture company B4Plastics transition from research and development to commercial supplier.

Demonstration, validation and production

B4PNOW has overseen the creation of multiple products that pair biopolymers with microbes that degrade material. Materials vary in strength, durability and duration of biodegradation, and they have a multitude of applications in the market.

Demonstration facilities in Limburg, Belgium, are under way, and by 2026 the company expects to execute its first multi-tonne orders for targeted materials. Market validation is under way too. Supported by B4PNOW funding, the company is nurturing the growth of scale-ups in the biopolymer industry. Fostering communication with globally renowned brands to secure markets for their high-performance, cost-effective and eco-friendly bulk materials has been integral to the company's transformation.

B4Plastics finds itself in a favourable position to secure its inaugural multi-tonne orders from global clients. This marks a significant milestone in the company's evolution from a research-focused endeavour to a full-fledged production entity, aligning precisely with the objectives set forth by B4PNOW.

Becoming a commercial supplier requires investment in new production equipment. It also necessitates a significant increase in staffing. B4PNOW has facilitated the hiring of new human resource advisors as well as programme, production and purchasing managers. Personnel has increased three-fold during the company's transformation.

All these efforts position the company for entry into the commercial market. According to CEO Stefaan De Wildeman, "B4Plastics finds itself in a favourable position to secure its inaugural multi-tonne orders from global clients. This marks a significant milestone in the company's evolution from a research-focused endeavour to a full-fledged production entity, aligning precisely with the objectives set forth by B4PNOW."

TriggerPlastics and FortePlastics

Commercial validation, demonstration and production are tailored to specific products. With the help of B4PNOW, two new plastic products, TriggerPlastics and FortePlastics, have been through this development process. TriggerPlastics allow for the best controlled and most rapid biodegradation. They are used in various applications such as in agriculture and horticulture (fertilizers | agricultural clips, which are used to tie vines such as tomatoes or grapes to supporting structures), personal care and cosmetics products, medications, ointments, fillers for tablets, etc.

As the TriggerPlastics family developed, the company branded one of the segments under its own name, RUBRAN®. This material is known for its elastomeric properties, and has applications in shoes, hoses, bicycle hand grips and more.

FortePlastics are noteworthy for their strong mechanical properties. B4PNOW is supporting applications in fishing gear and various types of technical textiles, such as protective gear, sports equipment, and agricultural materials like mulch mats and shade nets. FortePlastics are durable, but they biodegrade over time.

With full market uptake, the launch of these two biopolymer families will have a significant impact. Fully biodegradable, TriggerPlastics and FortePlastics products could diminish the generation of plastic waste by 8 million tonnes annually and could reduce the amount of microplastics leaking into the ocean each year by 1.5 million tonnes.

These products have economic as well as ecological value. The market for plastics with the characteristics of TriggerPlastics and FortePlastics polymers has a combined value of over EUR 300 billion. With the groundwork supported by B4PNOW, B4Plastics is on track to become the world's first bioplastics 'unicorn' company by 2030.

PROJECT
B4PNOW – B4P No-Waste Polymers: Architected for performance, loaded with circularity

COORDINATED BY
B4PLASTICS in Belgium

FUNDED UNDER
H2020-EU.3., H2020-EU.2.3., H2020-EU.2.1.

CORDIS FACTSHEET
cordis.europa.eu/project/id/101010454

PROJECT WEBSITE
b4plastics.com/projects/b4pnow/

Cellulose to replace plastics in market-ready applications

A new biomaterial produced by biotech start-up Cellugy replaces single-use plastic packaging with cellulose. Other applications are just on the horizon.

With a growing awareness of the climate, biodiversity and pollution crises, European consumers are seeking eco-friendly goods like never before. In particular, there are evolving market opportunities for products that replace plastics. The EU-funded EcoFLEXY project has enabled Cellugy to advance the technological readiness level of EcoFLEXY – a versatile, recyclable and fully compostable plastics replacement – to pilot production.

The Cellugy start-up

Danish start-up Cellugy was founded in 2018 and focuses on replacing petroleum products with 100 % natural cellulose. Unlike conventional efforts at plastics replacement which rely heavily on the use of food crops and often result in end-of-life challenges, Cellugy's products face none of these issues.

Instead, the company produces cellulose from bacteria, building on the natural process of fermentation. Low-energy production conditions and the use of secondary feedstocks such as plant waste make Cellugy products optimal candidates in the pursuit of plastics replacement.

Features of EcoFLEXY

EcoFLEXY is a material that functions as a three-in-one barrier, offering protection from air, water and grease. It can be used in combination with paper and cardboard, and while it is fully compostable, it can also enter the circular economy via paper recycling streams. Current estimates indicate that EcoFLEXY cuts CO_2 emissions by 94 % compared to conventional plastics.

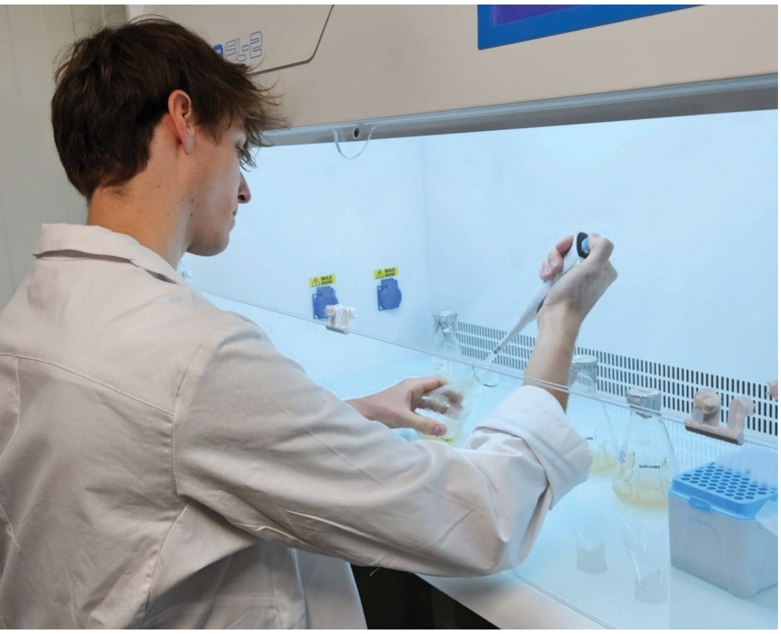
The product underwent a thorough validation process to determine its best commercial outreach. This process was impacted by commercial disruptions related to the global pandemic, global inflation and the outbreak of armed conflict in 2022. Project manager Isabel Alvarez-Martos says: "We overcame that challenge by focusing our strategy on chemical companies and distributors. That strategy achieved exposure across multiple markets and industries due to their broader market base."

While production efforts currently focus on packaging and chemical companies, EcoFLEXY has potential for many other applications. Examples include uses as a rheological modifier in cosmetics and as a coating agent in textiles, paints and inks.

Cellugy has submitted three patent applications related to EcoFLEXY. The product has garnered much positive attention. Efforts to build awareness have reached a wide audience and led to recognition, including first prize in the special 'Sustainable Living' category in the Social Innovation Tournament hosted by the European Investment Bank Institute. EcoFLEXY is also noted among the top 10 solutions in the Ray of Hope Prize sponsored by the Biomimicry Institute. Furthermore, Cellugy is named on multiple lists heralding biotech start-ups.

EcoFLEXY is a versatile material that can be tailored to fit countless industrial needs. Its future, and that of Cellugy, is just getting started. Alvarez-Martos states: "We at Cellugy envision a future where cellulose emerges as a dominant solution, unlocking its full market potential and transforming global industries."

We at Cellugy envision a future where cellulose emerges as a dominant solution, unlocking its full market potential and transforming global industries.



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Each tonne of EcoFLEXY is capable of replacing 200 000 square metres of non-recyclable plastic-coated packaging. The project's plan for bringing this product to market is an exciting development in the packaging industry. Cellugy's vision for the future is sure to shape commercial response to climate change.

PROJECT
EcoFLEXY – A natural and biodegradable nanocellulose alternative to plastic barrier coatings

COORDINATED BY
CELLUGY in Denmark

FUNDED UNDER
H2020-EU.3., H2020-EU.2.3., H2020-EU.2.1.

CORDIS FACTSHEET
cordis.europa.eu/project/id/101010323

PROJECT WEBSITE
cellugy.com/

Evaluating analytical methods to support a pollution-free tomorrow

The surge in plastic pollution in the environment demands immediate action. Comparable analytical methods and protocols are necessary to transform plastic pollution monitoring on a global scale.

Plastic pollution is a significant environmental issue caused by the accumulation of plastic litter in various ecosystems, notably the ocean and rivers. This stems from the widespread use of single-use plastics, inadequate waste management and recycling infrastructure, or simply accidental loss of plastic materials to the environment.

The repercussions of plastic pollution resonate deeply within ecosystems. Marine life suffers immensely from plastic pollution, often mistaking plastic debris for food or becoming entangled in it, causing injury or death. In addition, plastic breaks down into smaller particles called microplastics as a result of weathering and degradation processes. These microplastics may infiltrate the food chain, threatening the health of terrestrial, freshwater, and marine life.

Setting the basis for an EU plastics strategy

To monitor plastic pollution, there is an urgent need for comprehensive strategies. However, efforts are fragmented which leads to a lack of harmonised methods and inefficient evidence on plastic pollution across different regions.

The EU-funded EUROqCHARM project emerged as a pivotal initiative to tackle plastic pollution. With a focus on establishing harmonised analytical methods, the project aimed to support pollution monitoring and risk assessment programmes, and enhance waste management through optimised strategies.

Our key objective was to assess the technical readiness of the methods necessary for monitoring plastic pollution in the EU, in support of an EU plastics strategy.

"Our key objective was to assess the technical readiness of the methods necessary for monitoring plastic pollution in the EU, in support of an EU plastics strategy," outlines project coordinator Bert van Bavel.

Standardising protocols in plastic waste analysis

EUROqCHARM brought together stakeholders including policymakers, monitoring bodies, researchers and regulatory entities. The project concentrated on harmonising protocols for various stages of plastic pollution monitoring – from sample collection and handling to analysis and data management.

Microplastics in water are analysed either by counting particles by spectroscopic identification of the different polymers or by weight using mass spectroscopy. Both methods require extensive sample pre-treatment by filtration, density separation or digestion of biological material to avoid potential interference.

Addressing the complexities arising from diverse polymer types and particle dispersion, EUROqCHARM has developed benchmark reference materials essential for global comparison. These materials ensure consistency and accuracy in microplastic analysis and were validated through international inter-laboratory comparisons involving nearly 100 laboratories worldwide. This was undertaken in close collaboration with the NORMAN network and QUASIMEME. This study also facilitated the collaboration and comparison of methodologies used in different regions and laboratories.

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Global inclusivity

"We wanted to ensure that the validated methods and harmonised protocols for assessing plastic contamination were accessible to countries which have logistical, financial or ethical constraints," highlights van Bavel.

This inclusivity underscores the project's commitment to global collaboration and unified efforts in combating plastic pollution. Employing reproducible analytical pipelines, EUROqCHARM identified methods of a sufficiently high technical readiness level, ready to be implemented effectively.

Shaping future environmental protection policies

Overall, EUROqCHARM has contributed to advancing global efforts against plastic pollution. The project's expertise has contributed significantly to the development of directives, such as the Marine Strategy Framework Directive.

By validating methods, creating reference materials, and advocating for harmonised protocols, the project has laid the groundwork for consistent, accurate and inclusive strategies in combating plastic pollution. Its comprehensive approach particularly addresses regions with limited data, such as the Black Sea area, paving the way for a plastic-free future.

PROJECT
EUROqCHARM – EUROpean quality Controlled Harmonization Assuring Reproducible Monitoring and assessment of plastic pollution

COORDINATED BY
The Research Institute for Water and the Environment in Norway

FUNDED UNDER
H2020-EU.3.5., H2020-EU.3.5.4.

CORDIS FACTSHEET
cordis.europa.eu/project/id/101003805

PROJECT WEBSITE
euroqcharm.eu/en

Tackling microplastic ocean pollution with marine-friendly polymers

The EU-funded Glaukos project researched a circular solution for bio-based textile and fishing gear production to fight ocean plastic pollution.

There is an urgent need for a holistic approach to mitigate plastic solutions. The EU-funded Glaukos project takes up this challenge by valorising industrial side streams and setting up a circular approach to the textile industry. Inspired by the Greek god who protected the fishermen and the sea, Glaukos researched the development of alternative polymers for fishing gear and clothing to prevent and mitigate pollution of the oceans and waterways.

From biomass fermentation to eco-polymers, fabrics and coatings

The Glaukos team turned industrial side streams containing sugars via a fermentation process into polymer building blocks. The fermentation process was successfully developed and upscaled through microbial strain selection and strain engineering.

The building blocks were subsequently used to produce new-generation bio-based polymers, and were further tested for spinnability.

These polymers formed the base of yarn and coating for clothing and fishing net applications with a low carbon and plastic footprint.

Through a successful spinning process, 9 kg of bio-based yarn was achieved.

Glaukos established assessments and technologies concerning biodegradation, mechanical degradation and ecotoxicity, covering the different types of impacts of plastics for marine life to ensure a healthy marine environment.

Bio-recycling as end-of-life solutions

Glaukos intends to make the new material biodegradable without compromising its technical performance and endurance.

Methods to assess the biodegradability of plastics, particularly in marine environments and at the micro scale, however, are still insufficiently standardised or available. “Glaukos established assessments and technologies concerning biodegradation, mechanical degradation and ecotoxicity, covering the different types of impacts of plastics for marine life to ensure a healthy marine environment”, states project coordinator Zsófia Kádár. “They can be used in the future to assess new polymers produced by our partners, or in the context of new materials development.”

To convert end-of-life plastic into value-added chemicals or materials, they must first be depolymerised. Therefore, researchers search for and develop enzymes that break down plastics. By engineering bacteria to grow on these plastic hydrolysates, we can convert them into value-added chemicals or materials through biotechnological processes.

This ‘bio-upcycling’ would be especially suitable for composites or mixed waste streams which are currently not recyclable due to their complexity. “Our bio-recycling aims at a new outlet for plastic waste: to use it as a feedstock for biotechnology,” explains project partner Nick Wierckx.

The project is also developing a new methodology for Life-Cycle Assessment, circularity and plastic leakage, as well as a multidimensional model to map the challenges to be addressed for unlocking the potential of bio-based and biodegradable plastics.

To assess the environmental burden and benefits of the Glaukos polymers and to allow a comprehensive comparison to conventional alternatives, a multi-indicator perspective will be provided after its completion.

Glaukos research results and next steps

Currently, the project is in its last phase and a prototype will be available by the end of May 2024. However, the Glaukos team highlights that the production price of bio-based materials remains high compared to their non-bio-based counterparts, as the use of bio-based materials is not yet mandatory in the textile clothing and fishing gear markets.

Glaukos published two relevant market studies, both available on the project's website.

In addition, a final stakeholder event will be arranged in the spring of 2024, where the outcomes of the project will be presented.

PROJECT
Glaukos – Circular solutions for the textile industry

COORDINATED BY
BIO BASE EUROPE PILOT PLANT VZW in Belgium

FUNDED UNDER
H2020-EU.3.2., H2020-EU.2.1.4., H2020-EU.3.2.6.

CORDIS FACTSHEET
cordis.europa.eu/project/id/887711

PROJECT WEBSITE
glaukos-project.eu/

Massive clean-up technologies in marine ecosystems

Marine litter is a mounting threat to our oceans' biodiversity. With EU funding, Europe's centres of excellence have mounted a multidisciplinary initiative to counter this – from social efforts to a range of high-tech applications.

Plastic is persistent and toxic, hence its unprecedented threat to ecosystems. Plastic and chemical leakage arises at various points in the life cycle and resulting pollutants are carried around the globe through air and ocean streams.

Marine life can also become entangled in plastic and their digestive tracts blocked, preventing feeding and causing changes in behaviour. In addition, invasive alien species like crabs, molluscs and even fish can cross the ocean by hitching a ride on or in plastic waste.

Our strategies target not only macroplastics but also microplastics and nanoplastics in different aquatic ecosystems.

A recent study found that 170 trillion plastic particles are afloat in the world's oceans. A total of 17 partners in the project In-No-Plastic have adopted a totally holistic approach to this problem. "Our strategies target not only macroplastics but also microplastics and nanoplastics in different aquatic ecosystems," says project coordinator Ben Alcock. Moreover, he continues, "our processes remove macroplastics as well as microplastics and nanoplastics."

Removal of plastic waste reduces pollution, helps protection and preservation of marine habitats, safeguards vulnerable species and promotes biodiversity.

The aim, therefore, is to remove plastic waste to prevent it from accumulating in pollution 'hotspots', and avoid negative impacts on ecosystem function and ecological processes.

To prevent the accidental removal of marine organisms during clean-up initiatives, In-No-Plastic uses environmentally responsible techniques and practices. Implementing proper waste management strategies, such as using selective and non-destructive manned and unmanned collection methods, can help minimise harm to marine organisms.

Social strategy

There are incentives for local populations via a crowdsourcing smartphone app that include financial compensation. Perhaps the greatest incentive comes with the social awareness fostered by workshops and virtual reality-based demonstrations of the benefits to local economies when marine litter is removed from our coastal areas. Businesses, local communities and tourists alike thrive on cleaner, more varied ecosystems.

Engagement of local communities was achieved through social media with voluntary clean-up activities and the testing of marine litter recycling with tangible outputs such as garbage bins, garbage bags, etc.

It is worth noting that the Dutch royals participated in a project workshop on the Caribbean island of Sint Maarten for the In-No-Plastic science fair 'Nature Under Threat', one of the in-field activities organised by partners.

Technical approaches

It's well known that plastics attack the ecosystem at the macro level where they can be ingested or entangled by debris. However, under the influence of solar UV and physical factors such as wind and waves, plastics can break down into microplastics smaller than 5 mm and nanoparticles smaller than 100 nm.

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"Depending on the aquatic environment and the type and size of the plastic litter, different technologies are applicable," Alcock informs us. "Technical strategies include agglomeration systems to collect nano- and micro-particles, environmentally friendly chemistries to help micro-particles stick together, and filtration systems to remove macro- and microplastics from water."

Additionally, the use of autonomous collection robots for removing plastic litter from beaches and shores has shown great promise. These robots can operate independently, using their vision systems to identify plastic debris and their robotic arms to collect and transport the litter for recycling. Hand picking of litter is also encouraged through social rewards and the use of data-driven monitoring systems.

The importance of monitoring

In-No-Plastic has incorporated a monitoring system to gather data on its activities every 6 months for 2 years. Project protocol includes monitoring the area, the biological activity and its natural assets before taking action. The effectiveness of the new technologies and clean-up activities can therefore be monitored along with the effects on the marine ecosystem.

Importantly, a range of biodiversity and ecosystems have been studied in pan-global, iconic testing sites, including Venice, Italy, the Croatian island of Krk, the Caribbean island of Sint Maarten in the Dutch Antilles, and the River Thames in London, United Kingdom.

Already, two popular misconceptions about marine pollution – that tourism is mainly responsible and that macroplastics are the primary problem – have been overturned. "Monitoring also provides a measure of the level of public awareness from citizen science experience," adds Alcock, "and reveals the shocking impact litter has on our shores!"

"As for sustainability, an important factor in maintaining biodiversity, the project aims to allocate private-public funds to continue its activities, ensuring that community engagement is sustained even after the termination of In-No-Plastic," Alcock concludes.

PROJECT
In-No-Plastic - Innovative approaches towards prevention, removal and reuse of marine plastic litter

COORDINATED BY
SINTEF AS in Norway

FUNDED UNDER
H2020-EU.3.2., H2020-EU.3.2.5.3., H2020-EU.3.2.5.1.

CORDIS FACTSHEET
cordis.europa.eu/project/id/101000612

PROJECT WEBSITE
innoplastic.eu/

Quieter tyres for cleaner air and microplastic-free environments

To reduce traffic noise, particulate emissions and microplastic pollution originated from tyres, an EU-funded project investigates and develops a new sustainable tyre technology.

Tyre wear is considered one of the largest sources of microplastic emissions. We are working on estimating the transport and transformation of these tyre wear particles through the environment.

The wear and tear of car tyres is a major source of microplastic pollution in the ocean, according to research by The Pew Charitable Trusts. Through road friction and exposure to environmental conditions, the tyre material degrades into small particles that are carried into the environment by air or rain.

One of the goals of the EU-funded LEON-T project is to better understand tyre-generated microplastics. "Tyre wear is considered one of the largest sources of microplastic emissions. We are working on estimating the transport and transformation of these tyre wear particles through the environment," states Juan J. García, LEON-T project coordinator.

To achieve this objective, the LEON-T consortium is investigating the differences and influencing factors on tyre abrasion rate and particle emissions.

Airless tyres: a possible solution

LEON-T is designing and testing heavy goods vehicles' airless tyres, which should result in less rubber being worn away. But the main scope of the project is to investigate the particulate and noise emissions generated by tyre-road interaction, which should also be addressed by the new tyre technology.

A first prototype of the airless tyre had a successful driving test on a truck. "There is considerable potential for rolling resistance reduction and we also believe this design will significantly reduce noise emission," affirms García.

In a future commercial production, this airless tyre should last as long as the heavy vehicle it is used on, provided there is a proper exchange of the rubber tread when it is worn down to minimum tread depth. Fundamentally, it will be a retread product that will need much less rubber than air-filled tyres. A retread is defined as a used tyre that has been repaired and recycled, with a new layer of tread applied to its surface.

Analysis of tyre-road interaction

Through laboratory simulators, analytical techniques and tests on real roads, the project provided several insights on tyre wear and tear. In general, non-studded winter tyres wear faster and release more particles than summer and all-season tyres.

These differences are related to the hardness of tyre rubber mixes, which are softer in winter tyres.

Tests showed that volatiles such as benzothiazoles and other tyre-related particles are also emitted. Regarding size, most of the particles generated from tyre wear were bigger than 2.5 µm, while 10 % were smaller than 0.2 µm.

LEON-T also examined the potential effects of tyre noise on cardiovascular health, using waking tests and sleep studies. "Tyre noise induced acute event-related sleep fragmentation. This did not lead to an overall change in average sleep across the night but led to increased cardiovascular arousal and some indications of change in cardiometabolic pathways," reports García.

As a result of a combination of lower noise levels and difference in the spectral content, airless tyres proved to be less disruptive to physiological sleep and cardiovascular arousal than traditional air-filled tyres.

Real effects on policies

Based on its comprehensive studies, LEON-T will recommend policy measures to limit the contribution of tyre-road interactions to microplastics in the environment, airborne particulate exposure and traffic noise.

These recommendations include ways of preventing or reducing particle formation, such as improved tyres and better fleet maintenance, as well as means to collect particles upon emissions and to treat particles once they are in the environment.

PROJECT
LEON-T - Low particle Emissions and lOw Noise Tyres

COORDINATED BY
Idiada Automotive Technology SA in Spain

FUNDED UNDER
H2020-EU.3.4.

CORDIS FACTSHEET
cordis.europa.eu/project/id/955387

PROJECT WEBSITE
leont-project.eu/

Tracing the paths of microplastics in European freshwater

EU-funded researchers explored the sources and impacts of microplastics on freshwater ecosystems to give a new understanding of the challenge and provide innovative solutions.

Around 145 000 tonnes of microplastics are used in Europe each year, according to the European Chemicals Agency. Preventing them from entering and polluting waters remains a challenge, where they are a threat to aquatic ecosystems.

To better understand the sources, pathways and impacts of microplastics and to develop potential solutions for preventing pollution in Europe's freshwater ecosystems, the LimnoPlast project was established.

Undertaken with the support of the Marie Skłodowska-Curie Actions programme, the research applied a transdisciplinary approach across the life cycle of plastics, combining environmental, technical and societal sciences to track the pathways of microplastic pollution in freshwater environments, analysing its impacts and innovating solutions. "Freshwater ecosystems are not mere transport pathways that bring microplastics to the ocean – they also act as a sink," asserts Christian Laforsch, LimnoPlast project coordinator.

Sources, pathways and effects of microplastics

LimnoPlast traced the sources of microplastics in urban freshwater systems in the regions of Aarhus in Denmark, Amsterdam in the Netherlands and in the Greater Paris area in France. "We were able to prove that the general wear and tear of cities, such as from textiles, tyres and litter, is the major source of microplastic pollution in freshwaters," claims Laforsch. "Microplastics enter the aquatic environment via multiple diffuse pathways, such as runoff, atmospheric deposition and sewer systems especially overflows."

The study confirmed that microplastics adversely affect freshwater organisms. However, this cannot be generalised, since microplastics encompass different contaminants of a variety of polymers, sizes and shapes.

When microplastics have already entered the environment, there are no environmentally friendly approaches to remove them. Thus, the best way to tackle this issue is to prevent (micro) plastics from entering the environment.

Solutions to microplastic pollution

"When microplastics have already entered the environment, there are no environmentally friendly approaches to remove them. Thus, the best way to tackle this issue is to prevent (micro)plastics from entering the environment," advises Laforsch.

LimnoPlast dug deep into the solutions for addressing microplastic contamination. The research team studied end-of-pipe solutions, which are methods to retain microplastics before they reach water bodies. These include electrostatic electric fields applied in wastewater treatment plants that separate microplastics from wastewater, an approach that was successfully tested in the project and does also enable the separation of even smaller plastic particles, so-called nanoplastics.

"Although it is important to develop new techniques to reduce the emission of microplastics at point sources, end-of-pipe solutions are not sufficient to reduce microplastic pollution," he notes.

To achieve changes in the long term, the project's recommendation is that, along with end-of-pipe solutions, top-down processes, such as government measures for extended producer responsibility, should be combined with bottom-up approaches, which can include industry voluntary actions and consumer behaviour changes.

LimnoPlast also conducted ecotoxicological tests of biodegradable plastics. The results show that their effects depend on the polymer material, the particle properties and the chemicals present in the polymer.

"This means that biodegradable plastics can have no effects, the same effect as conventional plastics or pose even higher ecological impacts," explains Laforsch. "Biodegradable plastics can be part of the solution but currently do not live up to the expectations for their sustainability and safety."

Raising awareness on microplastics

During its extent, the project promoted knowledge on microplastic pollution through scientific publications, conferences, social media posts and a webinar series with renowned experts in the theme.

In the final LimnoPlast conference hosted by UNESCO in Paris, specific policy recommendations were given to strengthen evidence-based decision-making.

"As for sustainability, an important factor in maintaining biodiversity, the project aims to allocate private-public funds to continue its activities, ensuring that community engagement is sustained even after the termination of In-No-Plastic," Alcock concludes.

PROJECT
LimnoPlast – Microplastics in Europe's freshwater ecosystems: From sources to solutions

COORDINATED BY
University of Bayreuth in Germany

FUNDED UNDER
H2020-EU.1.3., H2020-EU.1.3.1.

CORDIS FACTSHEET
cordis.europa.eu/project/id/860720

PROJECT WEBSITE
limnoplast-itn.eu/

Fighting the proliferation of plastics with early career training and detection technologies

Training early-stage researchers helps develop innovative lab-on-chip technology for the detection of microplastics and nanoplastics in the water supply and beyond.

Over 300 000 tonnes of plastic are released into the environment every year. Alarmingly, much of this waste is in the form of particles too small to see. Micrometre- and nanometre-sized plastic particles, or microplastics and nanoplastics (MNPs), have been found in soil, water, air and even our bodies. These particles are either intentionally added to industrial processes (primary MNPs) or originate from being broken down from larger-sized plastic in the environment (secondary MNPs). To protect water supplies, a main pathway of pollution in the environment, the 2021 revised Drinking Water Directive tasks water companies with increased inspection responsibilities. The MONPLAS project, funded with the support of the Marie Skłodowska-Curie Actions programme, supports the detection of plastic in waters by developing innovation technologies.

Training in microscopy and spectroscopy

With microplastics becoming more ubiquitous and increasingly prevalent in the environment, more data is needed on the sources, quantity and types of MNPs humans are exposed to and the associated health risks. For that, researchers are looking to develop low-cost tools for assessing MNPs in water samples and beyond.

Existing methods for detecting MNPs involve expensive equipment and highly trained personnel. By providing expert-level training, MONPLAS enables researchers to develop innovative, low-cost technology and detection tools. MONPLAS prepares early stage researchers (ESRs) by giving them hands-on experience with existing methods. The 14 MONPLAS ESRs receive training in microplastic sampling, sample preparation and general photonic techniques used for analysis.

Conventional techniques for MNP detection include an array of microscopy and spectroscopy tools. Raman spectrometry, similar to Fourier-transform infrared spectrometry, uses light to identify the chemical composition of the MNPs. Other techniques ESRs are trained to use include fluorescence microscopy and atomic force microscopy-infrared spectroscopy.

Innovative methods and technologies

Training personnel in conventional methods is only part of the answer. The principal objective of MONPLAS is the development of technologies for efficient and cost-effective instruments designed to support the implementation of the EU legislation through detection of MNPs. The second step of preparing scientists is thus the development of a wide range of possible solutions, including the evolution of existing techniques and the development of novel technologies.

We designed an AI-based workflow specifically for recognising and categorising microplastic particles. This system significantly enhances our efficiency and accuracy in identifying and analysing microplastics in various samples.

For that, the participants explore optics, acoustics, and the development of sensors and chips. One fruitful avenue is the incorporation of deep learning to identify MNPs. According to project fellow Clementina Vitali, "We designed an AI-based workflow specifically for recognising and categorising microplastic particles. This system significantly enhances our efficiency and accuracy in identifying and analysing microplastics in various samples."

MONPLAS fellows show great ingenuity in tackling the challenges for securing a safe water supply. In one case, problem-solving to improve the detection of MNPs through Raman spectroscopy led to the inexpensive and elegant solution of using metallic foils to boost signals through plasmonic nanostructures. In another study, research focuses on the creation of nanomaterials with enzyme-like properties for biosensing. The goal guiding this research is the integration of molecular diagnostic methods and nanotransducers onto small lab-on-a-chip devices for more accessible and efficient testing.

In reference to 2019 levels, the global production of plastic is expected to triple by 2050. MONPLAS, with a focus on technical innovation and ESR training, is working to better understand the risks associated with microplastics and nanoplastics and to strengthen the detection and protection of clean water supplies.

PROJECT
MONPLAS – The training of early stage researchers for the development of technologies to monitor concentrations of micro and nanoplastics in water for their presence, uptake and threat to animal and human life.

COORDINATED BY
Aston University in the United Kingdom

FUNDED UNDER
H2020-EU.1.3., H2020.1.3.1.

CORDIS FACTSHEET
cordis.europa.eu/project/id/860775

PROJECT WEBSITE
monplas.eu/

Young Europeans investigate plastic pollution in rivers and the ocean

EU-funded PlasticPiratesEU empowers school children across Europe to join the fight against plastic pollution as citizen scientists.

The 'Plastic Pirates – Go Europe!' citizen science initiative engages young Europeans aged 10 to 16 as citizen scientists. They explore rivers, waterways, and coastal areas to collect scientifically valuable data on waste pollution, with a particular focus on macroplastics and microplastics.

Researchers across Europe validate and analyse this data, contributing to scientific excellence and supporting the monitoring of EU policy objectives.

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These include the Zero Pollution Action Plan, the Marine Strategy Framework Directive and the EU Single Use Plastics Directive.

The initiative is part of the EU's Mission Restore our Ocean and Waters by 2030. It contributes to the Mission's objectives by empowering young Europeans to take action against plastic pollution and supplying data aimed at reducing macro- and microplastics in our waterways and seas by 2030.

The PlasticPiratesEU project, funded by the EU, aims to expand the 'Plastic Pirates – Go Europe!' citizen science initiative across the continent. Since 2022, nine additional European countries have joined the initiators Germany, Portugal and Slovenia, bringing the total to 12, with more expected to join in 2024. Since June 2022, about 7 000 teenagers have participated in the 'Plastic Pirates' campaign across Europe, sampled 121 rivers or waterways, and found over 16 000 plastic items. Researchers are now consolidating the data for further scientific investigation.

The Plastic Pirates approach and its data, most notably the 7-year experience of the Plastic Pirates partners in Germany, have been noted in scientific publications.

A whole-of-society approach against plastic pollution

"A key success factor of the project is the centrally harmonised protocol for collecting samples with citizens implemented by

A key success factor of the project is the centrally harmonised protocol for collecting samples with citizens implemented by experienced, local partners.

experienced, local partners," reveals scientific advisor Simone Berk.

The local partners leverage their networks to actively involve schools, teachers and participants in the 'Plastic Pirates' initiative. In addition to engaging citizen scientists, these partners extend the initiative's reach nationally, by organising complementary local activities like coastal clean-ups and aligning with activities of the Mission Ocean and Waters.

The project's materials are designed to directly engage citizens with science and increase their ocean literacy. The Plastic Pirates Action Booklet serves as a hands-on protocol for participants to collect scientifically valuable data to monitor plastic pollution in waterways.

The project also provides educators with teaching materials on the risks of plastic pollution in rivers and the ocean, as well as guidance on responsible consumer behaviour. These resources are available in the 12 languages of participating countries and can be freely accessed on the PlasticPiratesEU website.

A sustainable citizen science action

To contribute to excellent science and monitoring of EU directives, the project will provide consolidated data sets for all countries in international data repositories by mid-2024.

In line with the Mission Ocean and Waters' objectives, the protocol will also be expanded by a coastal booklet to better enable data collection on coastlines and beaches.

By November 2024, at the conclusion of the project, PlasticPiratesEU aims to publish a report detailing the insights gained from the scaling up and Europeanisation of the Plastic Pirates citizen science initiative. This report is intended to serve as a valuable resource, providing guidance and best practices for scaling up other citizen science initiatives at European level.

In the months following the completion of the project, the team aims to sustain and continue the 'Plastic Pirates' initiative across Europe. To secure national follow-up funding to this end, PlasticPiratesEU and local partners are engaging national ministries and other funding agencies.

PROJECT
PlasticPiratesEU – UPSCALING THE PLASTIC PIRATES CITIZEN SCIENCE INITIATIVE

COORDINATED BY
German Aerospace Center in Germany

FUNDED UNDER
HORIZON.2.6

CORDIS FACTSHEET
cordis.europa.eu/project/id/101088822

PROJECT WEBSITE
plastic-pirates.eu/en/

Robots detect and collect litter in marine environments

A team of robots empowered by machine learning operates autonomously from the air, underwater and on the surface to identify, map and remove waste from the sea.

Litter is a major and growing threat to marine ecosystems. For many organisms, interaction with litter can lead to suffocation, an inability to feed, a change in behaviours and entanglement, with impacts on individual species, inter-species relations and assemblages, and the functioning of a whole ecosystem. The most common type of litter is plastic, but other materials include glass, metal, wood and clothing. Currently, the Earth's ocean contains between 26 and 66 million tonnes of waste, 94 % of which is located on the seafloor.

Currently, most waste collected from maritime environments is retrieved from the surface. Sometimes divers are employed to remove waste from underwater, but the procedure is costly and inefficient. The EU-funded project SeaClear leverages robotic and AI-driven technologies to provide a novel and effective solution to the problem of collecting unseen, underwater waste.

Specialised robots work together

Multiple robots coordinate to collect waste from the bottom of the sea. Aerial and underwater robots scan the water for litter using image and acoustic sensors. A surface vehicle is the hub of the operation, with underwater units and drones tethered to the hub. Tethering enables better communication and addresses the power and computation needs of the robots.

A smaller underwater robot functions as an observation unit, while a second, larger underwater robot is used to collect litter. New technologies have helped in the design of components for the underwater collecting unit. For example, the waste-collecting robot is equipped with an innovative grabber and a suction device for picking up litter. A litter-carrying basket, designed to protect marine life, is also lowered into the water. The waste-removing robot can safely dock and release the litter from the gripper into the basket.

While the goals and processes envisioned by SeaClear are easy to comprehend, achieving success with autonomous robots is much more difficult and requires the application of AI. In particular, training robots to accurately identify litter and to avoid misidentifying living organisms is a critical matter. Complicating this endeavour is the fact that some forms of litter, such as a cinderblock on the seafloor, become rich habitats and should not be removed.

The SeaClear team seeks an 80 % success rate in litter identification coupled with a 90 % success rate in litter collection.

Working towards market-ready deployment

SeaClear focuses efforts on coastal areas, as that is where the inflow of litter is concentrated. They demonstrate the efficacy of the multi-robot platform in two case studies. One study focuses on port cleaning and worked with the end user Hamburg Port Authority, Germany. The other site is a touristic area in Dubrovnik, Croatia, with the end user Regional Development Agency of Dubrovnik Neretva County.

The consortium aims to introduce the litter-cleanup system to the market, making it accessible for public authorities, coastal organisations, NGOs, tourist resorts and any other businesses that may find this solution beneficial.

A follow-up project, SeaClear2.0, has already kicked off. This second project will focus on waste collection in deeper, darker waters. It will also endeavour to pick up larger debris, equipping the collection robot with a grapple. The follow-up project will include surface litter collection and efforts to raise public awareness and reduce litter input.

SeaClear has made great strides in collecting litter from the seafloor. According to project coordinator Bart De Schutter, "The consortium aims to introduce the litter-cleanup system to the market, making it accessible for public authorities, coastal organisations, NGOs, tourist resorts and any other businesses that may find this solution beneficial."

The SeaClear consortium includes the two end users, an SME that provides the hardware, four academic institutions to develop the methods, and a marine system integrator to bring everything together. The consortium mirrors the coordinated team of robots in its complementarity. In addition to being well-positioned to provide a marketable solution to the problem of sea litter, SeaClear has collected data that will aid in studying the correlation between surface and seabed litter distribution. The project's endeavours are making the seas a safer, cleaner place for industry, recreation and marine life.

PROJECT
SeaClear - SEarch, identificAtion and Collection of marine Litter with Autonomous Robots

COORDINATED BY
Delft University of Technology in the Netherlands

FUNDED UNDER
H2020-EU.2.1.1.

CORDIS FACTSHEET
cordis.europa.eu/project/id/871295

PROJECT WEBSITE
seaclear-project.eu/

Combating plastic pollution with bio-based alternatives

The innovative use of biomass sources to create eco-friendly alternatives can help fight plastic pollution for a greener world.

Plastic is durable and versatile, making it a popular material in various industries. However, its durability also means it takes hundreds of years to decompose, leading to its widespread accumulation in the environment. Plastic pollution has serious consequences on ecosystems, wildlife and human health. Marine life often mistakes plastic for food, while chemicals in plastics and microplastics can also enter the soil, air and water.

Novel bio-based plastics

Addressing plastic pollution requires a holistic approach involving public awareness, effective waste management strategies, innovation including in materials and packaging, effective policies and international cooperation.

SEALIVE does not stop at technological developments; it considers the entire life cycle of the bio-based products, including disposal and end of life management and defines business models to guarantee the implementation at industrial scale.

The EU-funded SEALIVE project focuses on the development of new biodegradable and compostable materials as alternatives to plastics. The consortium leverages cutting-edge technologies to convert biomass sources such as microalgae, organic waste, and other sustainable plant feedstocks into bio-based materials. These materials have been used in a range of products from recyclable food packaging and cutlery to fishing nets and crates.

"SEALIVE does not stop at technological developments; it considers the entire life cycle of the bio-based products, including disposal and end of life management and defines business models to guarantee the implementation at industrial scale," outlines project coordinator Miriam Gallur.

This approach ensures that the products created are not just efficient but also sustainable and environmentally friendly when produced on an industrial scale.

Real-world product validations

SEALIVE actively engages stakeholders, conducts real-world field validations, and disseminates knowledge through training and events. The aim is to encourage the adoption of sustainable bioplastic products, particularly in land and marine-related sectors.

"We sought validation of SEALIVE products under real conditions by engaging end users and industry stakeholders," explains Gallur.

For instance, fishing nets are undergoing a 12-month pilot test in Cyprus, oyster mesh bags have been validated in France for nearly 2 years, and fishing crates will be evaluated in Ireland by fishers and fishmongers. Early engagement with fishers in Cyprus allowed for tailored product development based on their insights. Moreover, reusable cutlery will be tested in supermarkets with real consumers. Stakeholders involved in testing received prior training on plastic pollution, waste management and circular economy principles from the SEALIVE consortium.

Policy recommendations

Furthermore, SEALIVE organised interactive exhibitions showcasing project products and engaging stakeholders from industry, policymaking, academia and civil society in Bulgaria, Greece, Croatia and Montenegro. These events not only showcased the potential of bioplastics but also identified hurdles and gaps in standards for testing such materials.

The research carried out by SEALIVE has led to the creation of five policy briefings, contributing to ongoing efforts to shape EU and international policies. The consortium worked closely with the Directorate-General for Environment on the communication regarding bio-based, biodegradable and compostable plastics.

To support the entire policy development process, SEALIVE has focused on establishing guiding principles for policymaking rather than making specific proposals.

"These principles are designed to address persistent challenges like littering and to ensure adaptable policies for the future," highlights Gallur.

The principles aim to leave a lasting impact beyond the project's timeline and are intended for universal application over an extended period. They will ensure relevance and efficacy in the fight against plastic pollution as well as in the development of new sustainable alternatives that could fit with specific market applications.

PROJECT
SEALIVE – Strategies of circular Economy and Advanced bio-based solutions to keep our Lands and seas alIVE from plastics contamination

COORDINATED BY
ITENE Research Centre in Spain

FUNDED UNDER
H2020-EU.3.2., H2020-EU.3.2.5.3.

CORDIS FACTSHEET
cordis.europa.eu/project/id/862910

PROJECT WEBSITE
sealive.eu/

Oceanic microbes in the fight against plastic waste

Marine plastic pollution remains a critical environmental concern, prompting investigations into how oceanic microbes can degrade plastic.

The versatile properties of plastics make them attractive materials for numerous applications, from clothing to packaging. However, plastic waste mismanagement has led to the ocean filling with plastics, posing a significant threat to the natural environment. Moreover, microplastics and nanoplastics which may emerge from plastic degradation are known to enter the food chain with negative consequences for organisms.

Plastics are believed to persist in the environment for hundreds of years. However, accumulating evidence underscores a role for microbes in plastic degradation which may reduce the half-life of plastic products.

Ocean microorganisms that degrade plastics

The key objective of the EU-funded VORTEX project is to identify specific microorganisms capable of degrading plastics and to determine the rate of this process. To achieve this, Helge Niemann and colleagues have developed a stable isotope tracing technique using ^{13}C-labelled polymers.

"We placed these polymers in oceanic environments and monitored microbial colonisation," he outlines.

This method unequivocally confirmed the existence of plastic-degrading microorganisms or 'degraders' within oceanic settings. Notably, the study brought to the spotlight certain microorganisms, such as the marine fungus *Rhodotorula mucilaginosa*, that effectively degrades polyethylene, providing a tangible demonstration of microbial plastic degradation.

Moreover, the investigation revealed distinctive microbial communities associated with different plastic types, indicating a selective colonisation pattern and degradation preference among various plastic substrates.

"Physicochemical pre-treatment of plastics, particularly by UV light, seems to accelerate degradation, by rendering polymer molecules more susceptible to enzymatic breakdown", explains Annika Vaksmaa, a postdoctoral researcher in the VORTEX team.

Ecological impact of plastic degradation

Field experiments uncovered compelling evidence that microbes in biofilms set on wild plastics include plastic degraders. This observation underscores the broader ecological impact of microbial plastic degradation.

Collaboration with atmospheric physicists led to the detection of substantial quantities of nanoplastics in marine environments using mass spectrometry techniques originally designed for aerosol measurement. This discovery raises critical questions about the sources, fate, and interactions of nanoplastics with microbial life in the ocean.

The rate of ocean microplastic degradation was estimated at a few percent per year, suggesting a natural resilience of the ocean against plastic pollution over extended periods. However, the accumulation of plastic debris continues to outpace these natural degradation rates, exacerbating the overall plastic pollution problem.

If plastic pollution were to cease today, it would take several generations for the existing plastic in the ocean to degrade.

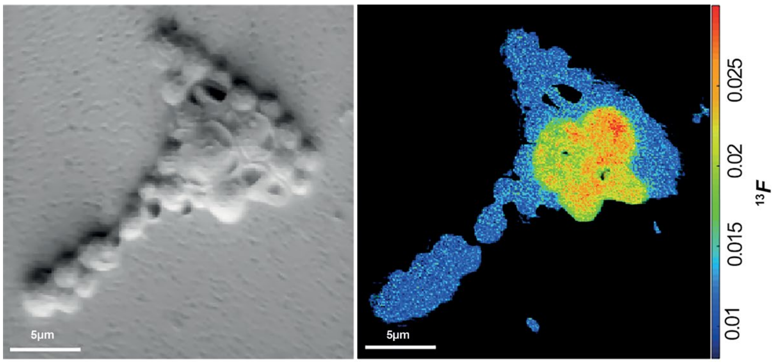
“If plastic pollution were to cease today, it would likely take several generations for the existing plastic in the ocean to degrade,” emphasises Niemann.

Future insight into nanoplastics

Looking ahead, VORTEX aims to map potential plastic degraders across diverse oceanic habitats and delve into unravelling the biochemical pathways and enzymes involved in plastic degradation. The ongoing investigation into nanoplastics and their origin and interactions with microbial life is expected to offer crucial insights into the fate and impacts of these minute plastic particles in marine ecosystems.

“Our findings so far have implications that extend beyond the scientific realm, urging policymakers to consider informed strategies for mitigating plastic pollution,” concludes Niemann.

Targeted interventions at different stages of plastic life cycles, informed by a deeper understanding of degradation pathways and microbial interactions, are essential to safeguarding oceanic ecosystems from the threat of plastic pollution.



PROJECT
VORTEX – Plastic in the Ocean: Microbial Transformation of an ‘Unconventional’ Carbon Substrate

COORDINATED BY
Foundation for Dutch Scientific Research Institutes in the Netherlands

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H2020-EU.1.1.

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RESULTS PACK ON OCEAN OBSERVING

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