Federation of Veterinarians of Europe

The Plastisphere as a vector for pathogen enrichment and horizontal gene transfer (HGT) of antimicrobial resistance (AMR) in the food chain.

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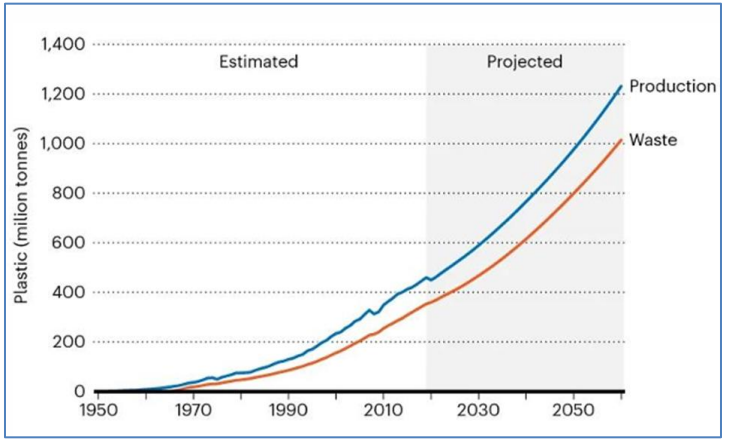
35th Stakeholder Discussion Group on Emerging Risk (StaDG-ER). Grenada, 11-12 June 2026

What I'll Talk About

- the Plastic trajectory: Origin, Production, and Waste
- Decoding the Plastisphere: Biofilm mechanics, microbial hotspots, and AMR transfer.
- Empirical Evidence: Key findings from the IZSVE Northern Adriatic Sea study
- Public Health Impacts: Pathogen transmission through the agricultural and marine food chains
- Future Perspectives: The EFSA mandate, risk mitigation, and strategic recommendations.

The Plastic Context & Mediterranean Sea

- Global plastic production exceeded 390 million tonnes in 2021 and could surpass 1,000 million tonnes by 2050.
- This exponential growth has led to massive accumulation in aquatic and agricultural ecosystems.
- WWF report (2018): The Mediterranean Sea is currently one of the most plastic-polluted water bodies globally; plastics account for 95% of waste found in the open sea, seabed, and along beaches.

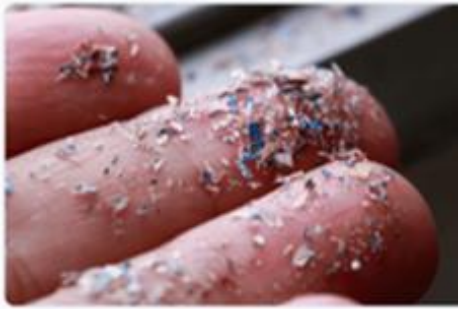


Definition of Microplastics

- Primary MP (15-31% sea)
  - released directly into the environment. Intentionally manufactured small pieces, such as non-biodegradable industrial pellets or microbeads found in cosmetics and abrasive cleaning agents.

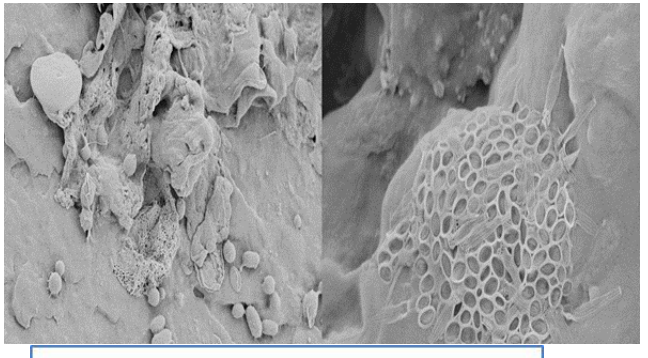
- Secondary MP (68-85% sea)
  - micro-fragments produced by the degradation of larger objects (such as UV radiation or mechanical breakdown),

- Most MP contain organic polymers
  - Polyethylene (PE), Polypropylene (PP) among the most represented polymers with a density lower than that of seawater and therefore float.



Defining the Plastisphere

- The Plastisphere (conied by Zettler et al. 2013) is a distinct microbial ecosystem that develops on the hydrophobic surfaces of floating polymers like Polyethylene (PE) and Polypropylene (PP).
- Microorganisms attach to these MPs forming stable, resilient biological biofilms encased in Extracellular Polymeric Substances (EPS) (Wu et al. 2019).
- selectively recruits specific taxa like *Vibrio* spp. and ernrichment of *Pseudomonas* spp. *Salmonella* & *Listeria*
- This physical shield protects internalized pathogens from standard food-safety interventions (UV, radiation, chlorine) and gastric acidity, thereby increasing infectivity.



Review Article | Published: 14 January 2020

Ecology of the plastisphere

Linda A. Amaral-Zettler, Erik R. Zettler & Tracy J. Mincer

Nature Reviews M

(2020) | Cite this

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Published: 12 November 2024

Microplastic diversity increases the abundance of antibiotic resistance genes in soil

Yi-Fei Wang, Yan-Jie Liu, ... Dong Zhu

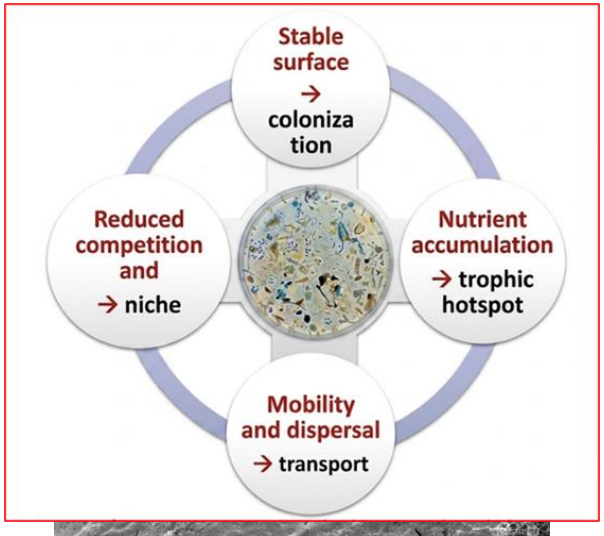
+ Show authors

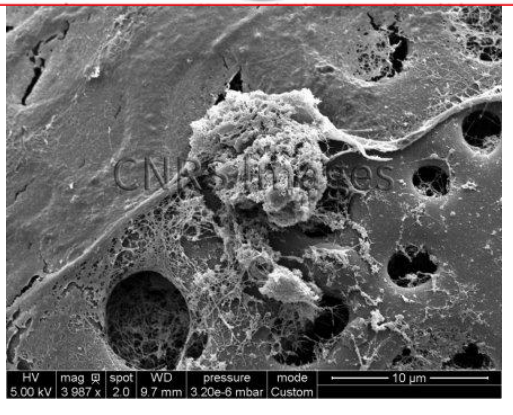
Nature Communications 15,

Article number: 9788 (2024) | Cite this article

Biofilm Mechanics & Microbial Hotspots

- Surface Stability & Nutrient Trap: MPs provide a permanent substrate that adsorbs nutrients and contaminants, creating a trophic hotspot.
- High Mobility (The "Trojan Horse"): Buoyancy facilitates the long-distance transport of microbial communities across previously isolated zones.
- AMR Transfer: the close proximity of species in the biofilm, combined with absorbed heavy metals and antibiotics, creates a high-pressure environment that accelerates Horizontal Gene Transfer (HGT) (Zheng et al. 2023).





Empirical Evidence (The IZSVE Study)

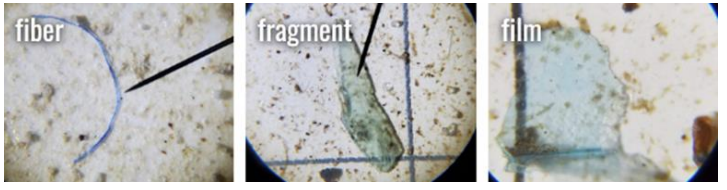
- Characterizing the Microbial Ecology and Resistome in the Northern Adriatic Sea
- Study Objectives & Methodology
  - Objective: to analyze the interaction between MPs and microorganisms in marine ecosystems (Northern Adriatic Sea near Pellestrina Island).
  - Sampling: Manta net collection of surface floating microplastics (environmental MPs and experimentally aged MPs).
  - Molecular Tools: 16S rRNA amplicon sequencing for community composition, shotgun metagenomics for resistome analysis, and droplet digital PCR for ARG quantification.

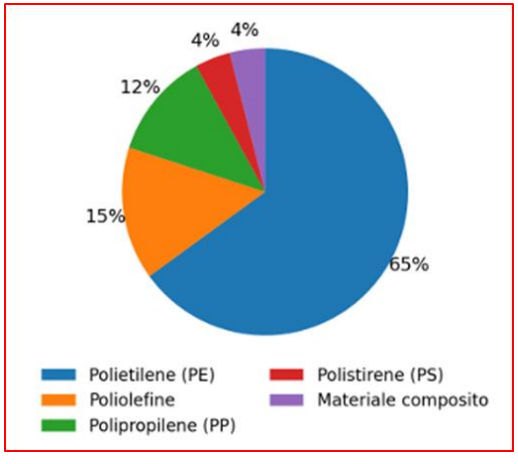
Empirical Evidence (The IZSVE Study)

- The study considered two categories of MP
  - environmental MP collected at sea
  - MP produced in the laboratory and subsequently subjected to experimental 8 month aging.

Environmental MP Profile

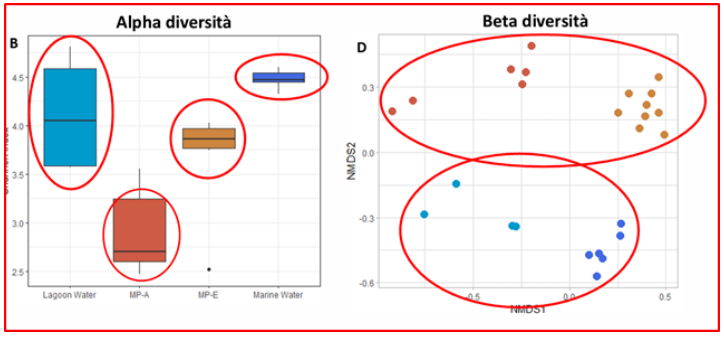
- Environmental particles collected were primarily fibers and fragments.
- Polyethylene was the most represented polymer, consistent with global data.
- Concentrations varied significantly depending on meteorological conditions and riverine inputs

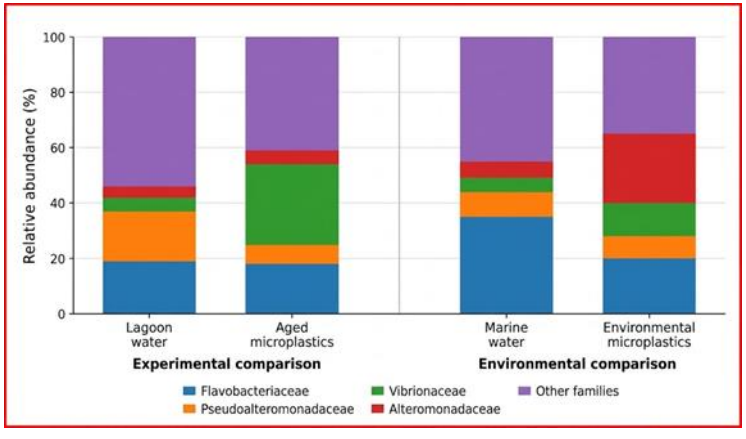


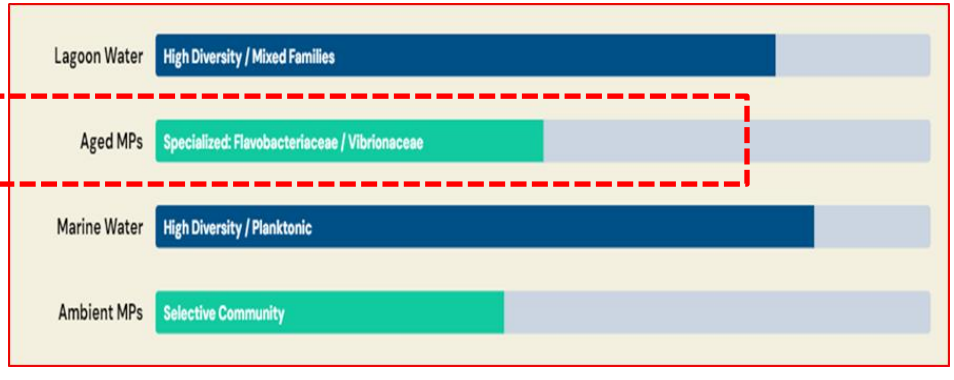


Microbial Biodiversity

- Microplastics act as a selective ecological niche, exhibiting lower diversity than ambient water due to biofilm formation.
- MP biofilms favor specific bacterial families distinct from the surrounding aquatic planktonic community (e.g. Vibrionacee).
- Experimental aging confirmed the formation of unique ecological niches on the plastisphere.

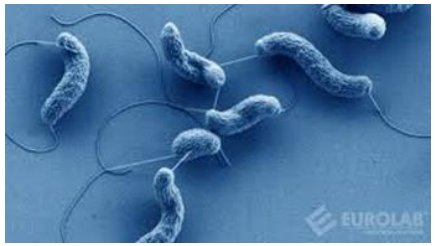




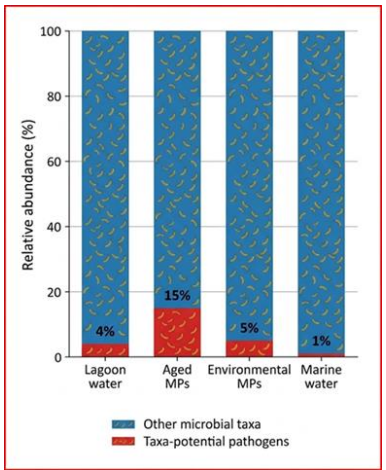


Pathogenic Taxa Enrichment

- MPs showed a greater abundance of Gammaproteobacteria, including foodborne pathogens like *Salmonella, Listeria,* and *Vibrio.*
- The genus *Vibrio* was significantly more dominant among potential pathogens on MPs than in the lagoon water.
- Aged plastics showed a notably higher representation of pathogenic taxa compared to surrounding water.



Bacterial genus	Lagoon Water	MP-A
Vibrio	32%	97%
Legionella	4%	2%
Flavobacterium	0%	1%
Bacillus	0%	0%
Psychrobacter	0%	0%
Salmonella	36%	0%
Pseudomonas	16%	0%
Alistipes	5%	0%
Lactobacillus	3%	0%
Coxiella	3%	0%
Photobacterium	1%	0%
Escherichia	0%	0%
Enterococcus	0%	0%
Listeria	0%	0%
Moraxella	0%	0%
Staphylococcus	0%	0%



AMR Hotspots & Metagenomics

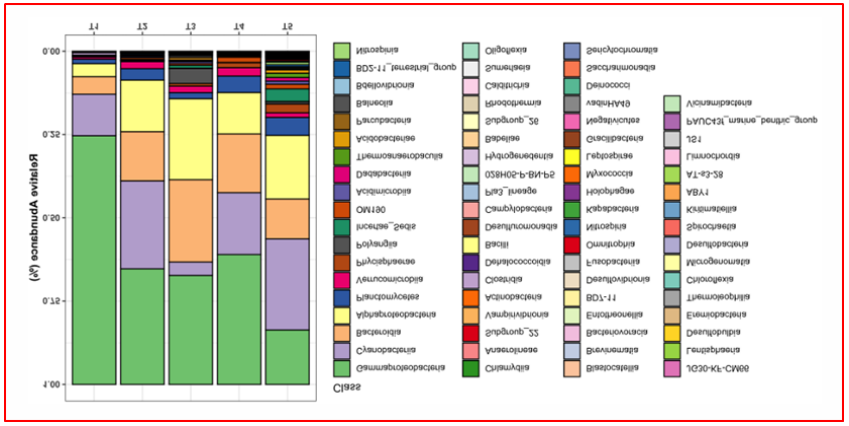
- Metagenomic analysis identified an enrichment of antibiotic resistance genes (ARGs) on environmental MPs, including aminoglycoside, fluoroquinolones, macrolides, and carbapenems.
- Droplet digital PCR quantified 245 different ARGs belonging to 26 different classes.
- some resistance genes were more abundant or more frequently detected on MP than in water samples.
- Pseudomonas and Vibrio were mapped as the primary holders of these identified ARGs

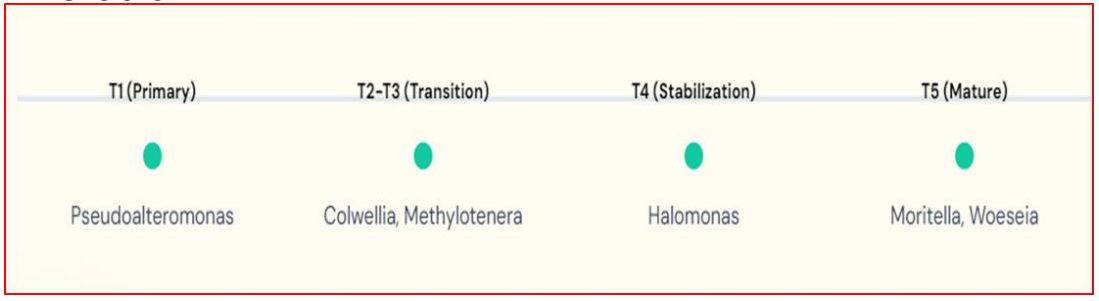
Class	Abundance (%)	Implication
Aminoglycosides	41.8%	Dominant resistance profile
Fluorochinoloni	36.7%	High clinical relevance
Macrolidi	7.6%	Widespread in Plastisphere

Resistome Gene	Environmental MPs	Aged Lab MPs	Ambient Water
tetA / tetM	Very High	High	Low
sul2 / sul3	High	High	Moderate
qnrA / qnrS	Moderate	High	Low
ermB	High	Moderate	Low

IZSVE Study Conclusions

- MNPs act as active vectors for spreading clinically relevant AMR not typically found in free-living water communities.
- The enrichment of enrichment of Vibrio AND pathogenic taxa on aged plastics poses a severe sanitary concern for fishing and aquaculture zones.
- MPs serve as persistent hotspots for ARGs in marine environments, highlighting the need for molecular monitoring.
- Experimental aging: trends in microbial biodiversity





Impact on the Food Chain: Marine & Aquaculture

- MPs act as vectors for the spread of zoonotic agents in the food chain.
- There is a high risk of bioaccumulation of plastic-shielded pathogens in the edible tissues of seafood.
- Consumption of uneviscerated seafood (e.g., mussels, clams) is a primary human exposure route, supported by high concentrations of *Vibrio* spp. in European coastal seafood.

Impact on the Food Chain: Agriculture

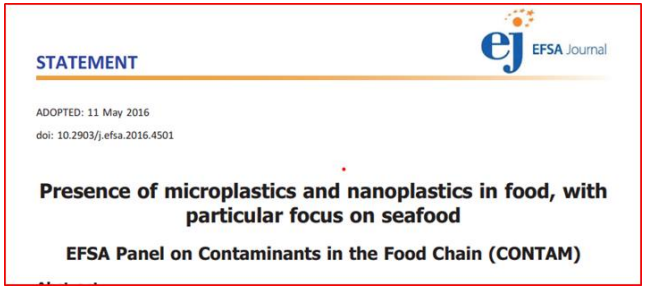
- Animal feed: pathogens spread through contaminated aquatic derivatives incorporated into livestock diets.
- Fresh produce: MNPs in irrigation water carry AMR-enriched biofilms onto crops.
- This introduces plastic-shielded pathogens directly into the fresh agricultural food supply.

The RF PLASTI@Risk Project

- Aim: Provide a comprehensive assessment of the microbiological risk to human health associated with MP exposure through bivalve and filter-feeding molluscs.
- Mitigation: Map out risk mitigation strategies for both standard circulating plastics and future bioplastics.
- Focus: Track new pathogen and AMR variant transmission route.

The Regulatory Horizons: The EFSA Perspective

- (2016) Early scoping by EFSA focused on seafood, highlighted the lack of standardized analytical methods and toxicological data for proper risk assessment.
- (2021) Publication of the proceedings of EFSA's 25th Scientific Colloquium
- (2025) Recent Scrutiny: EFSA's literature review on MNP release from FCMs
- (2026) The European Parliament has mandated EFSA to deliver a scientific opinion by 2027 on the potential health risks of MP in food, water, and air.
  - One of the six key focus areas is specifically addressing MPs as vectors for microbial hazards.


STATEMENT

EFSA Journal

ADOPTED: 11 May 2016

doi: 10.2903/j.efsa.2016.4501

Presence of microplastics and nanoplastics in food, with particular focus on seafood

EFSA Panel on Contaminants in the Food Chain (CONTAM)


Technical Report

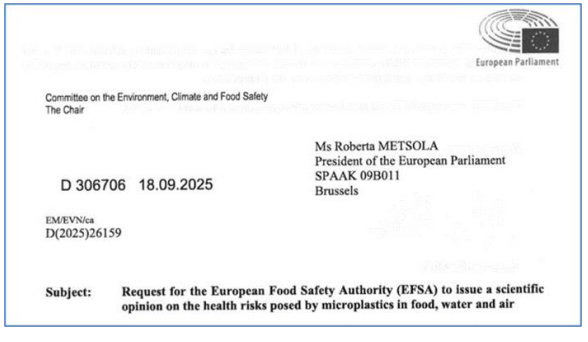
APPROVED: 15 October 2025

doi: 10.2903/sp.efsa.2025.EN-9733

efsa SUPPORTING PUBLICATIONS

Literature review on micro- and nanoplastic release from food contact materials during their use

European Food Safety Authority (EFSA),


European Parliament

Committee on the Environment, Climate and Food Safety
The Chair

Ms Roberta METSOLA
President of the European Parliament
SPAAK 09B011
Brussels

D 306706 18.09.2025

EM/EVN/ca
D(2025)26159

Subject: **Request for the European Food Safety Authority (EFSA) to issue a scientific opinion on the health risks posed by microplastics in food, water and air**

Strategic Needs: "What to do?"

- Extend current MP Risk Assessments, which focus almost exclusively on chemical and physical toxicity, to include microbial vector potential.
- Resolve the biological data gap by properly quantifying microbiological risks.
- Revise current regulations that largely ignore the biological load and genomic evolution of plastic-shielded pathogens.

Recommendations

- Recommendations 1: Close the Data Gap & Metagenomic Surveillance
  - Shift the regulatory focus to include the biological and genomic evolution of biofilms on MPs.
  - Metagenomic Surveillance: Implement standardized Next-Generation Sequencing (NGS) protocols.
  - Routine quantification of pathogens and ARGs in aquatic matrices and food substrates is essential for safeguarding the European food chain.
- Recommendation 2: One Health Integration
  - Recognize the Plastisphere as a critical environmental reservoir in the emergence of new resistant strains.
  - Integrate this understanding of environmental plastic pollution into broader human and animal health strategies.
- Recommendation 3: Novel Substrate Safety
  - Proactively assess risks in emerging food sectors, such as insects and cell-culture industries.
  - Monitor how MPs act as disruptive vectors within these novel agricultural and technological environments.

Questions?

Thank you for your attention.

Maurizio Ferri