

Le microplastiche tra diagnosi, terapia e prevenzione

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Milano, 12 Aprile 2025

UN PIANETA DA PROTEGGERE

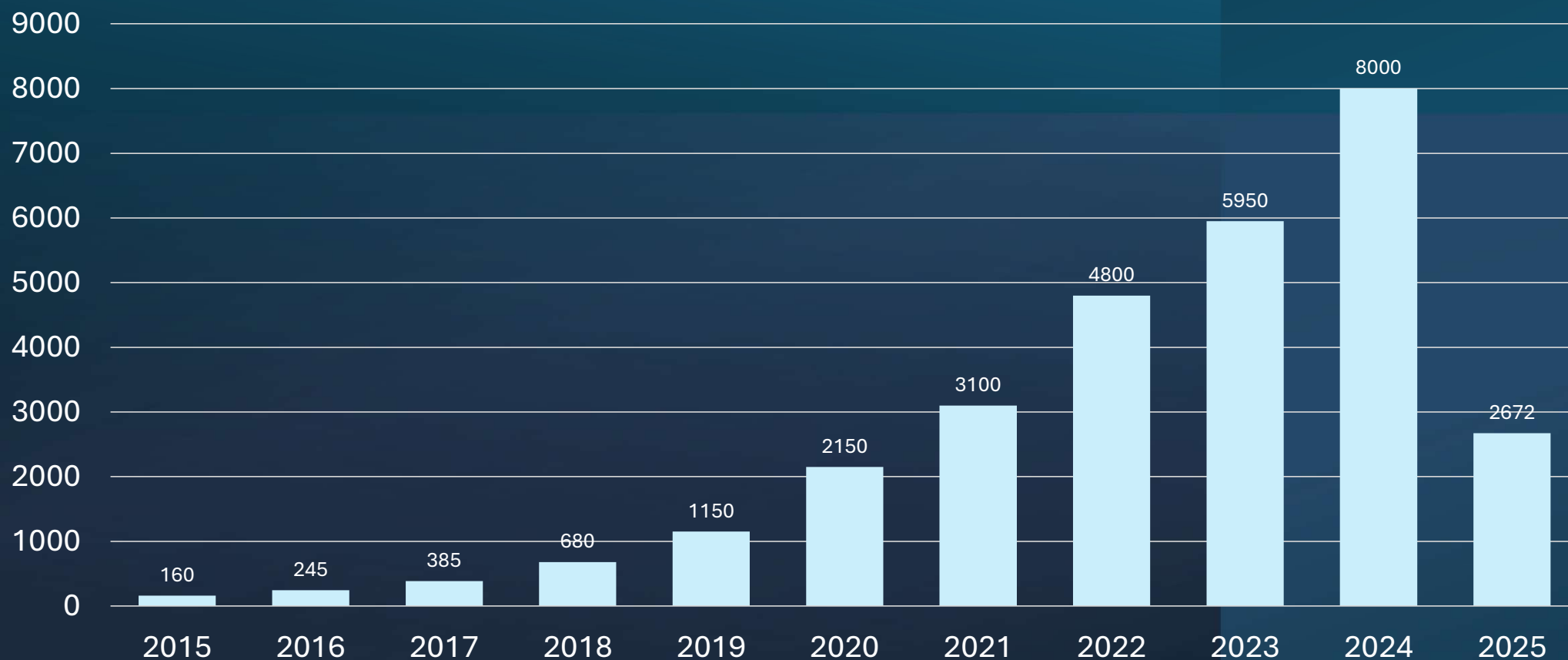
Le microplastiche – problematiche e soluzioni



Quanto sono studiate le microplastiche?

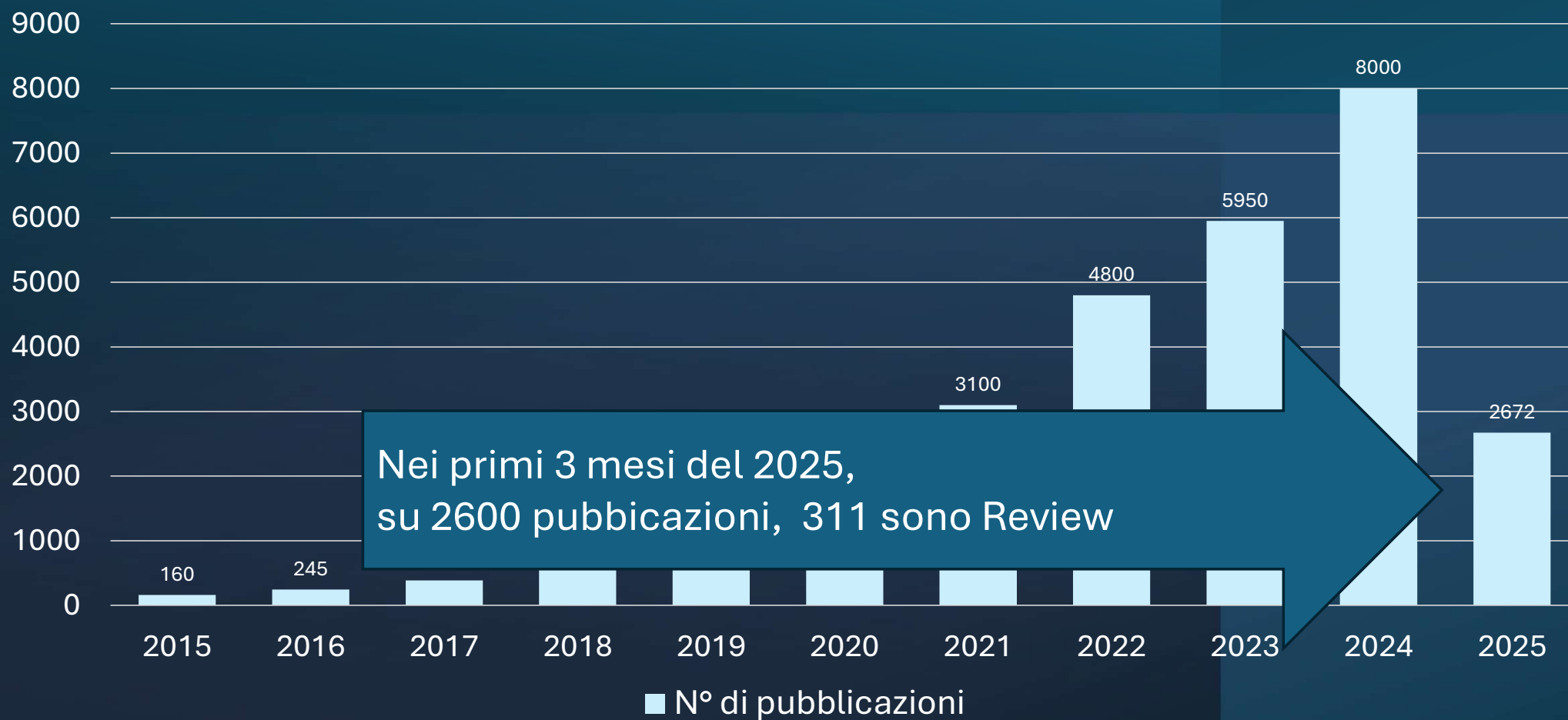
#Microplastics

■ N° di pubblicazioni



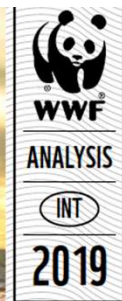
Fonte: scopus

#Microplastics



**Quindi sarà stata
una rivista
scientifica a dire
che mangiamo
una carta di
credito alla
settimana?**





NO PLASTIC IN NATURE:
**ASSESSING PLASTIC
INGESTION FROM
NATURE TO PEOPLE**

Kala Senathirajah and Thava Palanisami

The University of Newcastle, Australia

Summary of the study methodology

Microplastics have been defined as plastic particles with an upper size limit of 5 mm. This is a significant concern as they may pose a direct threat (by ingestion), or indirect threat (as stressors or vectors of contaminants) to humans. Mismanagement of primary and secondary waste may be accumulated and/or transferred through the food chain and reach our digestive system and bloodstream. This paper attempts to provide a snapshot through a systematic review of the available literatures, and calculate an ingestion rate for humans considering various exposure pathways. The study analysed the available literature as a method for data collection and synthesis to allow for an estimation of the amount of microplastics ingested by humans. A critical research of the available literature and subsequent unit normalized calculation of the amounts of microplastics ingested by humans through various exposure pathways suggest that on average, humans may be ingesting as much as 5 g/week of microplastics.

Several databases were interrogated to obtain the most recent relevant publications. The metadata was extracted and recorded. The literature review presented information on many different methods for sampling and analysing microplastics to identify and quantify them. Reporting units also varied greatly among studies. In order to compare the data, several conservative assumptions were made. The conservative approach was adopted to minimise the risk of over-predicting and from alarming the public, or risking incredulity from decision-makers and other stakeholders. The data was extrapolated to infill and populate missing data to derive a total number of microplastic particles (particles) and total mass particles (kg) to then allow for the calculation of ingestion rates (kg/week/person) based on estimated individual particle mass (kg/particle). A

News del 2019





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Pubblicazione del
2021



Research paper

Estimation of the mass of microplastics ingested – A pivotal first step towards human health risk assessment

Kala Senathirajah^a, Simon Attwood^b, Geetika Bhagwat^c, Maddison Carbery^c, Scott Wilson^d, Thava Palanisami^{a,*}

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individual microplastic.

Consumable Category	AMIMP to consider	Rationale for choice of AMIMP	GARMI (g/yr)
Shellfish	AMIMP _{aquatic}	Microplastics found in aquatic organisms mirror the microplastics in the aquatic environment (Kim et al., 2018; Catarino et al., 2018; Qu et al., 2018b)	26.4
Salt (aquatic and terrestrial: sea salt, rock salt, lake salt)	AMIMP _{consumable} (sphere)	Studies suggest that salt are heavily concentrated with microplastics. The refining process of salt can remove particles, however, conversely, add particles if cleaning agents with microbeads are used in the processing plants (Kim et al., 2018).	
Water	AMIMP _{consumable} (cube)	Easy to underestimate fine particles (Toussaint et al., 2019b; Oßmann et al., 2018b) in liquids from small volume of samples (Mintenig et al., 2019), use of cube to compensate	
Beer	AMIMP _{consumable} (cube)	Easy to underestimate fine particles in liquids from small volume of samples and PSD, cube to compensate	
TOTAL INGESTING ALL CONSUMABLES			34.4 (0.7 g/wk)



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TOTAL INGESTING ALL CONSUMABLES			34.4 (0.7 g/wk)

34 g/anno =
0,7g/settimana

4.11. Medley approach

Improved analytical methods, and an increased number of studies, will allow for more accurate PSD analysis for various categories of consumables ingested, allowing for the GARMi to be updated. Until such time, the consideration of the three scenarios discretely projects a GARMi that somewhat accounts for the identified underestimations. A combination approach of the scenario resulted in a GARMi of 0.7 g/week (Table 9). Hence pending further availability of data, our preliminary estimates indicate that humans could potentially be ingesting between 0.1-5g of microplastics per week.

An individual's susceptibility to ingestion of microplastics based on

Kala Senathirajah^a, Simon Attwood^b, Geetika Bhagwat^c, Ma
Thava Palanisami^{a,*}

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Rationale for choice of AMIMP	GARMi (g/yr)
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Beer

AMIMP_{consumable}
(cube)

TOTAL INGESTING ALL CONSUMABLES

Lifetime Accumulation of Microplastic in Children and Adults

Nur Hazimah Mohamed Nor,^{*} Merel Kooi, Noël J. Diepens, and Albert A. Koelmans



Cite This: *Environ. Sci. Technol.* 2021, 55, 5084–5096



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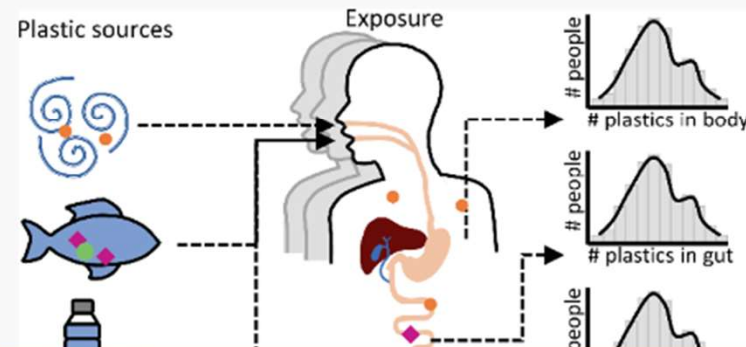


Article Recommendations



Supporting Information

ABSTRACT: Human exposure to microplastic is recognized as a global problem, but the uncertainty, variability, and lifetime accumulation are unresolved. We provide a probabilistic lifetime exposure model for children and adults, which accounts for intake via eight food types and inhalation, intestinal absorption, biliary excretion, and plastic-associated chemical exposure via a physiologically based pharmacokinetic submodel. The model probabilistically simulates microplastic concentrations in the gut, body tissue, and stool, the latter allowing validation against empirical data. Rescaling methods were used to ensure comparability between microplastic



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Metrics & More



Art

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580 nanogrammi/giorno =
4 microgrammi/settimana



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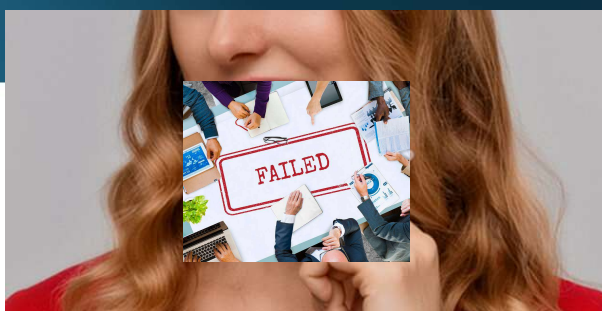


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1 milione di volte meno di quanto dichiarato dal WWF





Lifetime Accumulation of Microplastic in Children and Adults

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1 carta di credito
ogni 23000 anni



#Microplastics

■ N° di pubblicazioni



Fonte: scopus



La DIAGNOSI

1.11.2011

REVIEW

Open Access

Recent advances and future technologies in nano-microplastics detection



Ajinkya Nene^{1,2†}, Sorour Sadeghzade^{3†}, Stefano Viaroli⁴, Wenjie Yang^{1,5,6}, Ucheaga Paul Uchenna¹, Abhishek Kandwal⁷, Xinghui Liu⁸, Prakash Somani⁹ and Massimiliano Galluzzi^{1,5*}

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Negli ultimi anni si sono osservati grandi **progressi nella rilevazione di nano- e microplastiche (NMPs)**.

Il lavoro si focalizza su metodi di campionamento, pretrattamento, separazione, misurazione e identificazione, con l'obiettivo di **migliorare l'efficacia dell'analisi ambientale di NMPs**.

Recent advances and future technologies in nano-microplastics detection

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Evoluzione nel tempo delle tecniche di **separazione**: filtrazione, centrifugazione, spettroscopia IR/Raman, microscopie SEM/TEM/AFM.

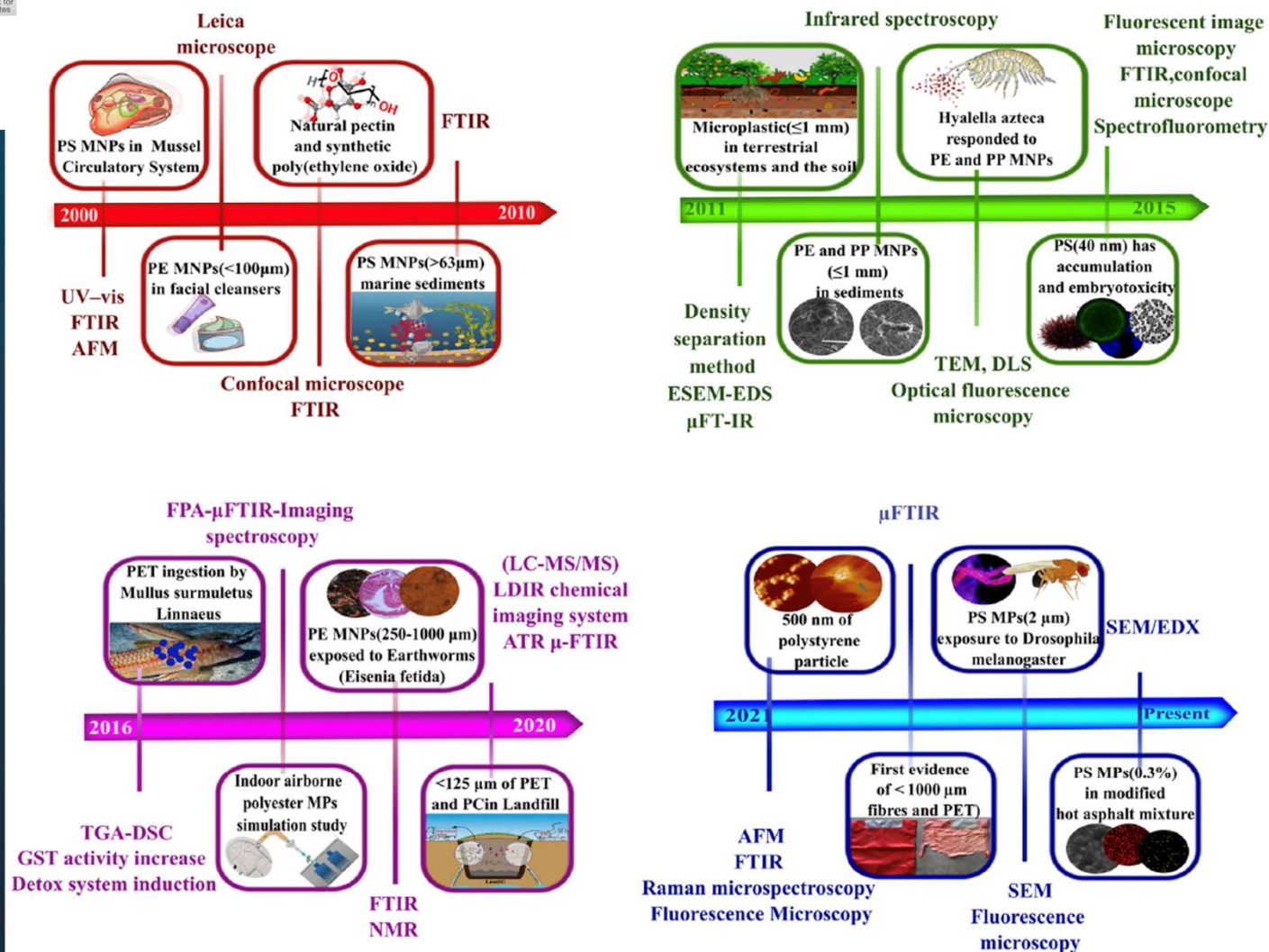


Fig. 1 Timeline of improvements in NMP detection

LA SEPARAZIONE

Filtrazione: efficace per MPs; limiti nella separazione di NPs a causa della porosità delle membrane.

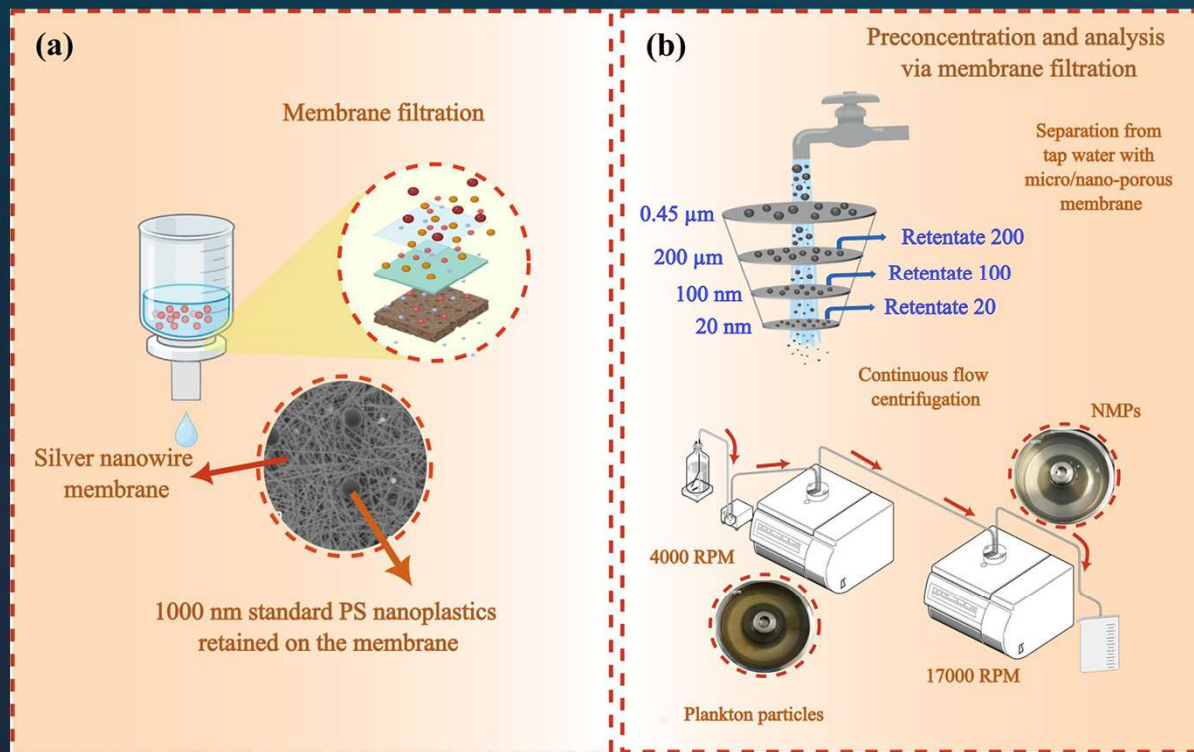
Centrifugazione: metodo a basso costo e ad alta efficienza (fino al 98%) per preconcentrare NMPs

Digestione: metodi chimici (Fenton, perossido, enzimi) per rimuovere materia organica, ma possono degradare alcune plastiche.

Separazione per densità: uso di soluzioni saline a diversa densità (NaCl , ZnCl_2 , NaI) per separare plastiche in base alla densità.

Recent advances and future technologies in nano-microplastics detection

Ajinkya Nene^{1,2*}, Sorour Sadeghzade^{3†}, Stefano Viaroli⁴, Wenjie Yang^{1,5,6}, Ucheaga Paul Uchenna¹, Abhishek Kandwal⁷, Xinghui Liu⁸, Prakash Somani⁹ and Massimiliano Galluzzi^{1,5*}



Recenti progressi nella filtrazione e centrifugazione:

- a. membrana costituita da nanofili d'argento per la filtrazione di NMPs
- b. separazione di NMPs dall'acqua di falda
- c. centrifugazione a flusso continuo per NMPs

REVIEW

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Le MICROSCOPIE

Microscopia ottica: utile per MPs >200 nm; bassa risoluzione e scarsa capacità di identificazione chimica.

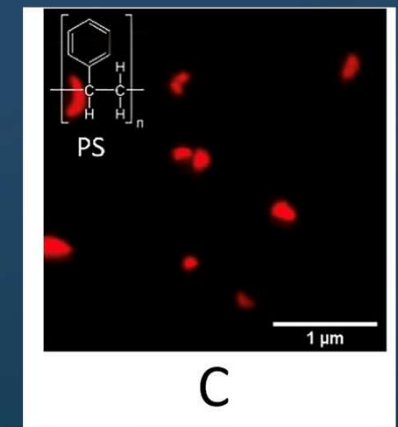
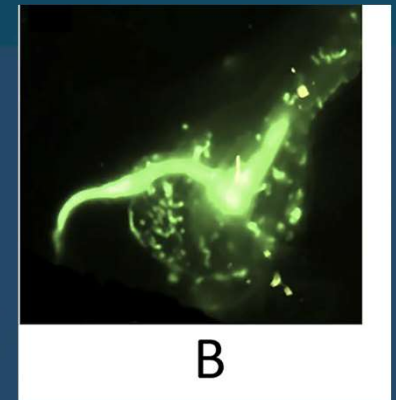
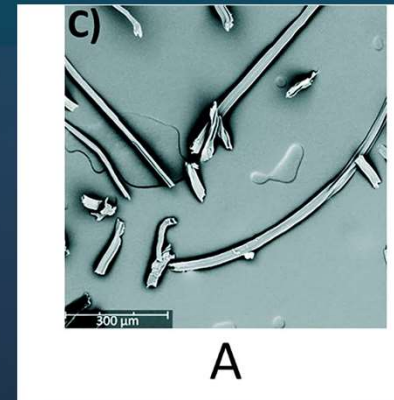
SEM/TEM: imaging ad alta risoluzione (SEM: superficie, TEM: struttura interna); combinabili con EDX per l'analisi elementale.

AFM: caratterizzazione topografica e meccanica al nanoscala; lenta e costosa, ma molto precisa.

Le MICROSCOPIE

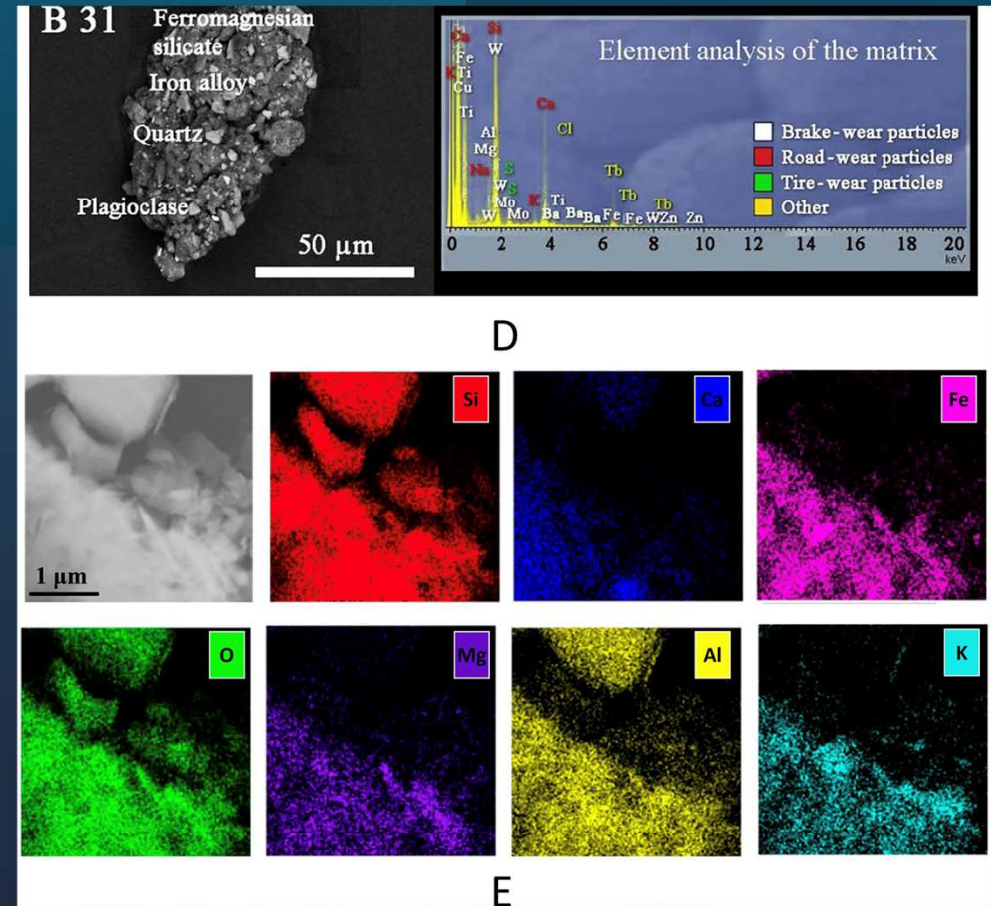
Analisi SEM di nano-fibre (ingrandimento 350 ×)
a fotografia in campo chiaro della parete della
cavità viscerale che mostra particelle di **PS**
fluorescenti nelle **gonadi**

b immagine di detriti di **fresatura di PS**
c immagine SEM di una particella
rappresentativa di **usura di pneumatico**
con un carico > 50%vol



Il diagramma EDX mostra la sovrapposizione di 25 spettri di una particella da usura di pneumatico con la successiva classificazione delle particelle

d immagine TEM e le corrispondenti mappe EDX di una particella di polvere minerale rilevata nel campione

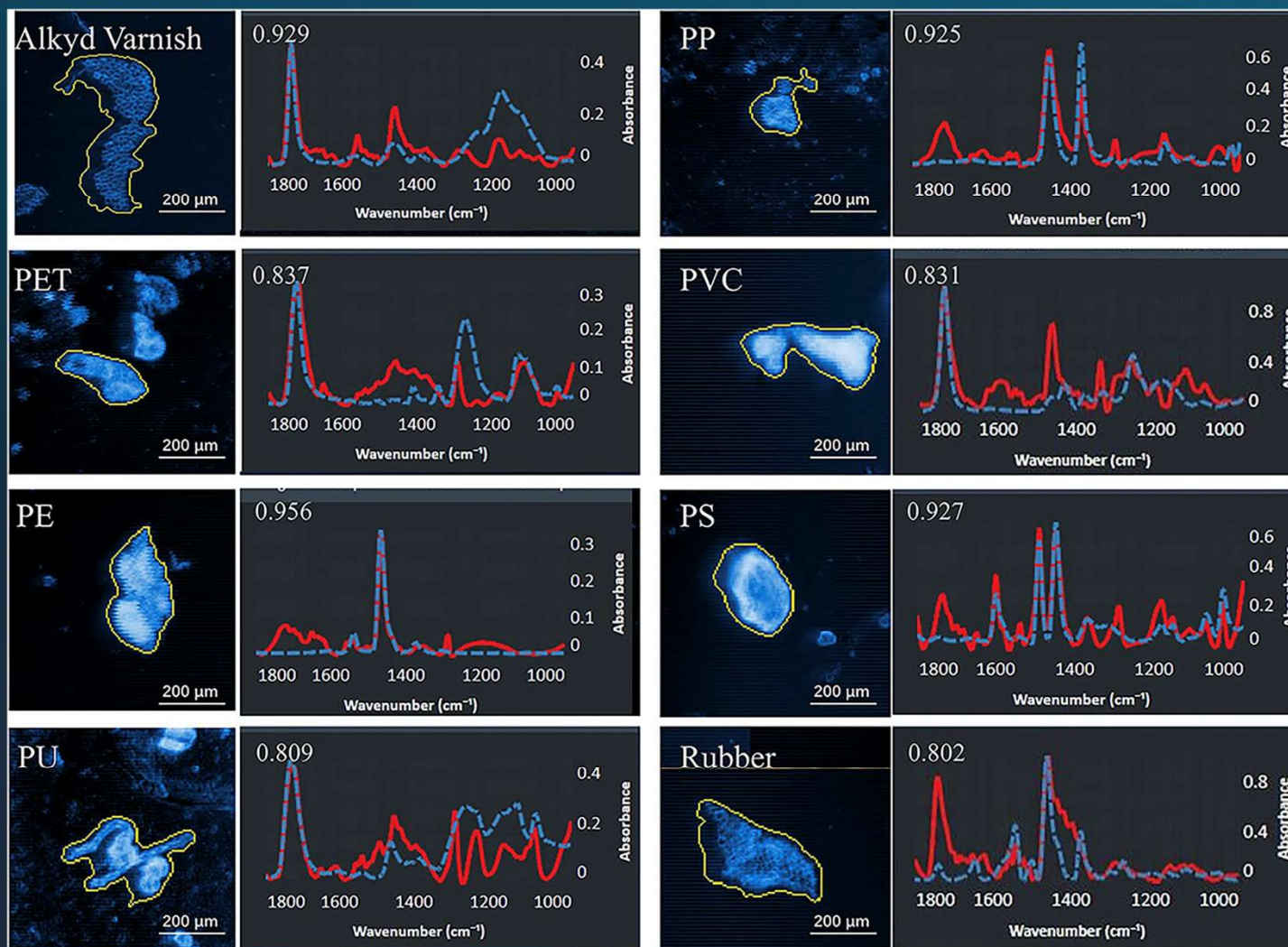


Le SPETTROSCOPIE

FTIR: identifica legami chimici; efficace per MPs $>10\text{ }\mu\text{m}$; ATR-FTIR adatto a campioni complessi.

Micro-FTIR: analisi a scala micrometrica; utile per particelle fino a $6\text{ }\mu\text{m}$.

Raman: risoluzione più alta di FTIR, rileva NPs fino a $1\text{ }\mu\text{m}$ o meno; possibilità di SERS e TERS per analisi avanzata.



Spettri tipici LDIR di otto MP identificati come vernici alchidiche: PET, PE, PU, PP, PVC, PS e gomma.

La tecnica di spettroscopia laser a infrarossi diretti (LDIR) combina la precisione della spettroscopia a infrarossi con la risoluzione spaziale dell'imaging basato sul laser.

Le SPETTROSCOPIE



Attenuated total reflectance fourier transform infrared spectroscopy

Pros

Spatial resolution
Down to 2 μm because of its surface penetration limitation

Cons

Has a limitation of surface penetration



Fourier-transform infrared (FTIR) microscopy

Pros

Spatial resolution
1-5 μm

Cons

u-FTIR is very fast and has a short analysis(a few minutes)



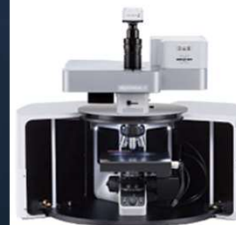
Laser direct infrared

Pros

Spatial resolution
Down to 1 μm in size
Useful if the sample contains a lot of pigments

Cons

Results interpretation is hard, so needs experts



Raman spectroscopy

Pros

Spatial resolution
Down to 500 nm

Cons

Slow speed

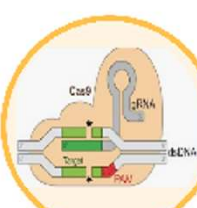
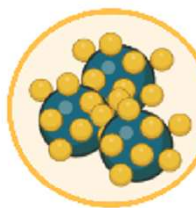
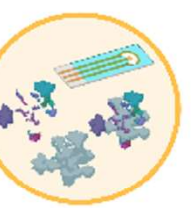
AI e machine learning utile per classificazione automatica da immagini e spettri, riduzione errori umani, analisi predittiva.

L'intelligenza artificiale (AI) è emersa come strumento trasformativo nell'analisi dei NMP, offrendo una maggiore precisione e scalabilità.

Le NMP possono essere rilevate, classificate e quantificate automaticamente grazie a tecniche basate sull'IA come la computer vision, il deep learning e il machine learning. Queste tecniche sono in grado **di elaborare grandi volumi di immagini e dati spettrali**, identificando schemi e correlazioni che approcci convenzionali potrebbero non cogliere.

Nella ricerca sulle NMPs, **l'analisi basata sull'AI accelera l'identificazione di plastiche chimicamente differenti**, migliora **l'accuratezza** della differenziazione tra i tipi di polimeri e aiuta a comprendere il loro comportamento ambientale.

Tecniche di caratterizzazione diverse per ambienti diversi

Different environments	Soil	Water and sea	Organisms	Air	Plant	Human body
Analytical method	 FTIR Raman Spectroscopy Gas Chromatography-Mass Spectrometry (GC-MS) SEM	 Nano-Scale Flow Cytometry DLS FFF-MALS Neutron Activation Analysis	 Fluorescent Tagging Nano-Scale Flow Cytometry Confocal Microscopy AFM	 Micro-Raman μFT-IR TD-GC-MS	 Confocal Laser Scanning Microscopy AFM	 XRF HPLC
Novel method	 Soil column leaching Nanoplastic transport behavior	 Autonomous underwater vehicles (AUVs) equipped with in situ nanoplastic detection sensors.	 CRISPR-Cas9 gene editing nanoplastic as biological sensor	 Drone air sampling Portable spectroscopy nanoplastics detection	 Stable isotope labeling Nanoplastics uptake	 Molecularly imprinted polymers on sensor for nanoplastics detection in human body



La TERAPIA

1.11.2021

Superhydrophobic Materials and Intermolecular Forces for Microplastics Removal

*Published as part of ACS Materials Letters **special issue** "Emerging Investigators in Materials Science".*

Oriol Rius-Ayra,* Anhua Ren, and Alisiya Biserova-Tahchieva

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Molti studi stanno indagando sui metodi per rimuovere le microplastiche dall'acqua, ma mentre queste tecniche sono efficaci per le **microplastiche** più **grandi**, spesso hanno difficoltà a catturare le particelle più piccole. Recentemente, per affrontare questa sfida, sono stati esplorati materiali **superidrofobici**.

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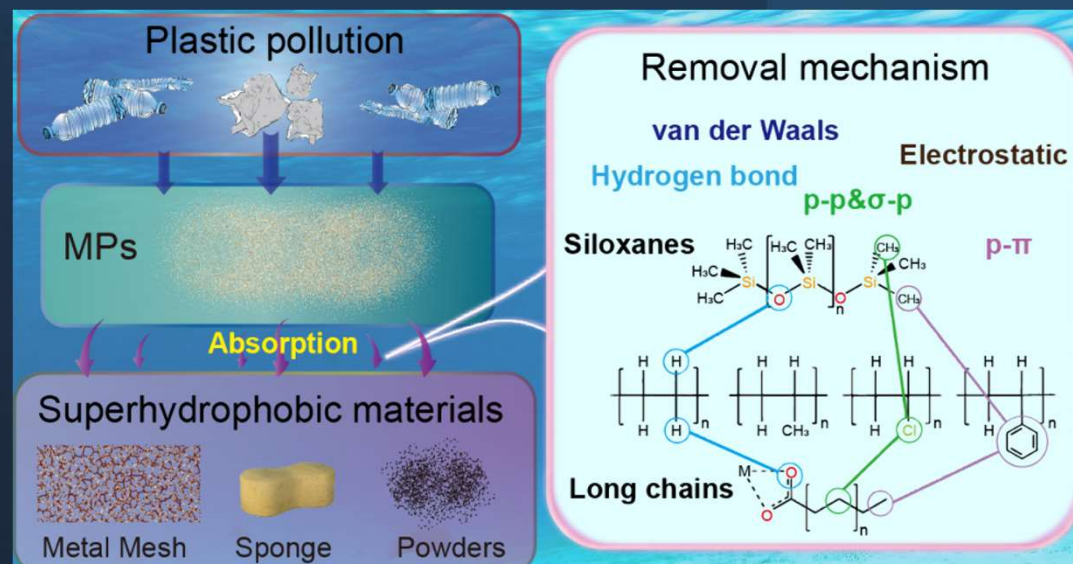
Questi materiali possono rimuovere efficacemente le microplastiche dall'acqua grazie alle loro proprietà uniche di bagnatura, raggiungendo efficienze di rimozione vicine al 100%.

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Vari tipi di materiali superidrofobici, come spugne, reti e materiali particolati, sono stati utilizzati per rimuovere le microplastiche in condizioni e ambienti diversi.





La Prevenzione

1.11.2021

EU action against microplastics



Main sources of unintentional microplastics release to the EU environment

Lower and higher estimates
(2019 - tonnes/year)



Paints



Tyres



Pellets



Textiles



Geotextiles



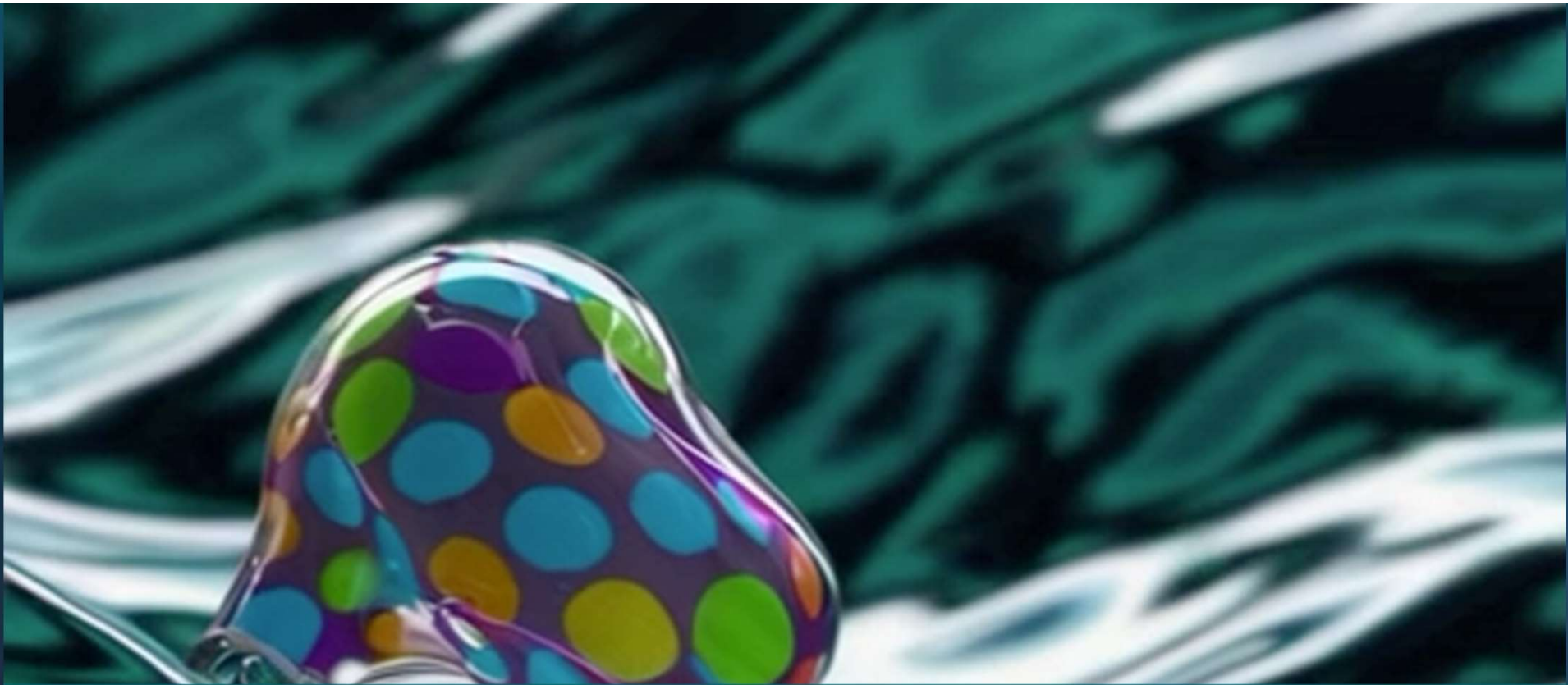
Detergent

**Microplastics released
into the environment**

-30%



**RIPENSA
RIDUCI
RIUSA
RICICLA**



Poche certezze...

A close-up photograph of a small, teardrop-shaped plastic object with a purple base and large, colorful polka dots in shades of blue, green, yellow, and orange. The object is floating on a surface of water, which is dark green and shows ripples and reflections. The background is blurred, emphasizing the object in the foreground.

La plastica è ovunque...

Le microplastiche sono un inquinante comune, ampiamente diffuso e insidioso, è quindi di FONDAMENTALE definire buone pratiche di laboratorio in grado di evitare o ridurre al minimo la **contaminazione** da MP ubiquitarie.

Eliminare il rischio di contaminazione dei campioni da parte delle MP è una pratica estremamente complessa, dato che i materiali di consumo più comuni sono **oggetti a base di plastica** (ad esempio guanti, fiale, puntali, filtri, ecc.), ma anche indumenti, contenitori per liquidi, e la gran parte delle parti degli strumenti di misura che vengono a contatto con i campioni contengono parti o componenti di plastica.

Per questo si sta lavorando a nuovi approcci, che potrebbero essere implementati con il supporto del machine learning, i quali prevedono di raccogliere la più ampia libreria possibile degli spettri generati da tutti i materiali di consumo in plastica del laboratorio, da sottrarre successivamente ai risultati delle analisi.

•

La comunità medica e scientifica sta ora concentrando i propri sforzi sulla contaminazione da microplastiche, poiché potrebbe rivelarsi una nuova minaccia silenziosa e persistente per la nostra salute.

Tuttavia, anche la varietà incoerente dei modelli sperimentali in vivo/in vitro ostacola la formulazione di un messaggio chiaro da divulgare.

.

Dimensioni, concentrazioni, geometrie e polimeri diversi sono variabili non **standardizzate** che sono pressochè impossibili da confrontare fra loro e con la letteratura, anche se riflettono certamente un reale e complesso inquinamento da plastica.

La questione non è facile da affrontare, ma la definizione **di nuovi protocolli internazionalmente riconosciuti, non è più procrastinabile.**

A close-up photograph of a small, teardrop-shaped object with a purple base and large, colorful polka dots (blue, green, yellow, and orange) floating on the surface of water. The water is dark teal with white highlights from ripples. A dark teal banner is positioned at the bottom of the image, containing the text 'Correlazione non è Causalità' in white, bold, sans-serif font.

Correlazione non è Causalità

Il concetto di **correlazione** si riferisce a una relazione statistica tra due variabili che tendono a variare insieme. Tuttavia, la presenza di una correlazione non implica necessariamente che una variabile sia la causa dell'altra.

Al contrario, la **causalità** implica che una variabile (la causa) produca un effetto su un'altra variabile (l'effetto).

Per determinare la causalità, è spesso necessario condurre studi sperimentali controllati, come gli studi clinici randomizzati, che possono isolare l'effetto di una variabile su un'altra riducendo al minimo l'influenza di fattori confondenti.

Al contrario, gli studi osservazionali possono identificare correlazioni, ma non possono stabilire con certezza relazioni causali a causa della possibile presenza di variabili confondenti.

ORIGINAL ARTICLE

Microplastics and Nanoplastics in Atheromas and Cardiovascular Events

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ABSTRACT

BACKGROUND

Microplastics and nanoplastics (MNPs) are emerging as a potential risk factor for cardiovascular disease in preclinical studies. Direct evidence that this risk extends to humans is lacking.

METHODS

We conducted a prospective, multicenter, observational study involving patients who were undergoing carotid endarterectomy for asymptomatic carotid artery disease. The excised carotid plaque specimens were analyzed for the presence of MNPs with the use of pyrolysis–gas chromatography–mass spectrometry, stable isotope analysis, and electron microscopy. Inflammatory biomarkers were assessed with enzyme-linked immunosorbent assay and immunohistochemical assay. The primary end point was a composite of myocardial infarction, stroke, or death from any cause among patients who had evidence of MNPs in plaque as compared with patients with plaque that showed no evidence of MNPs.

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Lo studio ha analizzato 257 pazienti sottoposti a endoarterectomia carotidea.

Nel 58% dei casi, le placche aterosclerotiche contenevano micro- e nanoplastiche.

I Materiali rilevati sono principalmente polietilene e PVC.

Si è osservato un rischio maggiore nei pazienti con microplastiche nelle placche:

Ictus

Infarto del miocardio

Morte nei 34 mesi successivi

Si osserva che.

Le microplastiche sono assorbite ma non degradate.
L'accumulo provoca uno stimolo infiammatorio continuo.
L'infiammazione contribuisce alla progressione
dell'aterosclerosi.

Gli autori riconoscono che
La correlazione non implica causalità.

Esistono infatti possibili **variabili confondenti**:

- Stato generale di salute
- Esposizione a inquinanti (PM10, PM2.5)

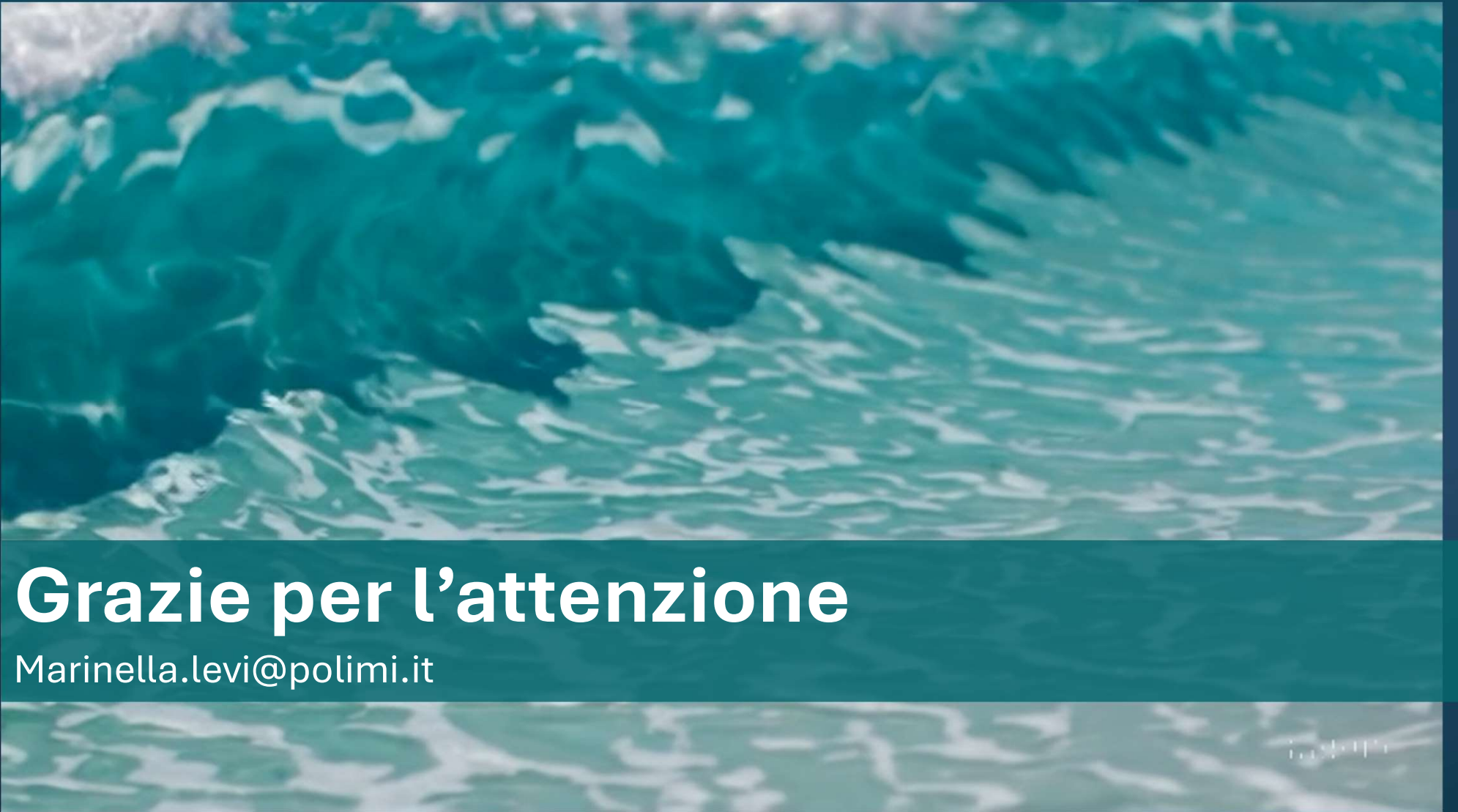
Si impone dunque la necessità di ulteriori studi per confermare i risultati, verificando rigorosamente le variabili coinvolte e riducano al minimo l'influenza di fattori confondenti.

Un esempio rilevante riguarda la ricerca sulle microplastiche. Uno studio ha identificato una correlazione tra la presenza di microplastiche nelle placche arteriose e un aumento del rischio di infarto e ictus.

Tuttavia, gli stessi autori dello studio sottolineano che questa correlazione non prova una relazione causale, poiché potrebbero essere coinvolte altre variabili, come l'esposizione a inquinanti atmosferici o lo stato generale di salute dei soggetti. In conclusione, mentre la correlazione può suggerire una possibile relazione tra due variabili, è fondamentale non interpretarla automaticamente come prova di causalità. Per stabilire una relazione causale, sono necessari ulteriori studi.



Abbiamo ricevuto la terra in
dono dai nostri **padri** e in **prestito** dai nostri **figli**.



Grazie per l'attenzione

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