Blue Lakes

No microplastics, just waves.

NO MICROPLASTICS, JUST WAVES.

Deliverable ACTION B4

Teaching Material and Lessons

info@lifebluelakes.eu

BENEFICIARIO COORDINATORE
LEGAMBIENTE
BENEFICIARI ASSOCIATI
Autorità di Bacino Distrettuale dell'Appennino Centrale
arpa UMBRIA Agenzia Regionale per la Protezione Ambientale dell'Umbria
ENEA AGENZIA NAZIONALE PER LE NUOVE TECNOLOGIE, L'ENERGIA E LO SVILUPPO ECONOMICO SOSTENIBILE
Global Nature Fund
Bodensee Stiftung Lake Constance Foundation
UNIVERSITÀ POLITECNICA DELLE MARCHE
PROGETTO COFINANZIATO DA
PlasticsEurope

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Executive summary

Four different training courses editions were carried out during the B4 action. This deliverable includes:

a) Detailed Program of each edition;

b) Numbers and general affiliation of the participants;

c) Mini photo report of the courses;

d) Final Survey results from the participants;

e) Teaching materials.

1. First Edition: Ancona 05th-07th December 2022-In person for Italian stakeholders

a) Detailed program

Blue Lakes

Le Microplastiche nel Servizio Integrato

Corso Teorico- Pratico finanziato nell'ambito del progetto europeo Life Bluelakes https://lifebluelakes.eu/

Prima edizione **05 – 06 – 07 Dicembre 2022 (Italiano)**

Modalità **In presenza**

Luogo **Lezioni teoriche**: Università Politecnica delle Marche (UNIVPM), Scienze (Edificio 3) Aula B6-Blocco Aule Sud, Via Brecce Bianche 12, 60131, Ancona https://goo.gl/maps/KGD98tG8dUNYJjzi6 **Sessioni tecnico-pratiche**: impianto di potabilizzazione-impianto di depurazione-piattaforma sperimentale SIMAU e Laboratori Didattici DISVA (LS1) – Università Politecnica delle Marche

Programma

05 Dicembre	13.30	Inizio registrazione
	14.15-14.30	Saluti Istituzionali
	14.30-15.20	Le Microplastiche: aspetti generali conoscitivi
	15.20-16.10	Le microplastiche nel servizio idrico integrato: stato dell'arte e casi studio
	16.10-16.30	Coffee Break
	16.30-17.20	Metodologie di campionamento
	17.20-18.15	Metodologie di caratterizzazione
06 Dicembre	09.00	Incontro presso UNIVPM e trasferimento in Pullman per la sessione pratica
	09.30-12.30	Sessione di campionamento in campo
	12.30-13.00	Trasferimento ad UNIVPM
	13.00-14.00	Light Lunch
	14.00-15.00	Impianti di depurazione e di potabilizzazione: ruolo dei processi e delle tecnologie nella rimozione delle microplastiche, esempi numerici di bilanci di massa a scala impianto.
	15.00-16.00	Controllo e ottimizzazione della rimozione delle microplastiche nel servizio idrico e nelle diverse unità di trattamento: linee guida gestionali e configurazioni progettuali ottimali, casi studio ed esempi pratici.
	16.00-16.15	Coffee Break
	16.15-17.00	Analisi di rischio associato alla presenza delle microplastiche nel settore idrico e prospettive nella legislazione tecnica e ambientale
	17.00-18.00	Processamento dei campioni per l'analisi della microplastica da matrici del Servizio Idrico Integrato
07 Dicembre	9.00-13.00	Descrizione della strumentazione tecnica di laboratorio Sessione di pre-processamento dei campioni Sessione di separazione e caratterizzazione delle MPs
	13.00-14.00	Light Lunch
	14.30-15.30	Visita Opzionale alla Piattaforma Sperimentale di Ingegneria Chimica Ambientale e Sanitaria

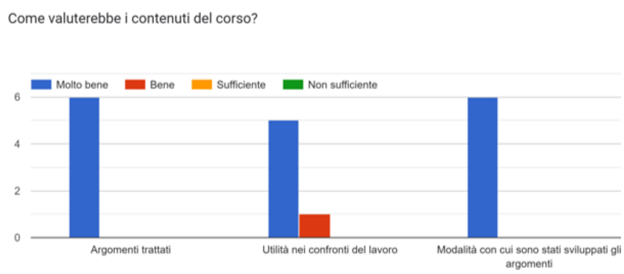
La partecipazione al corso è gratuita e comprensiva dei materiali didattici e formativi e di eventuali trasferimenti presso gli impianti per le sessioni tecnico-pratiche.

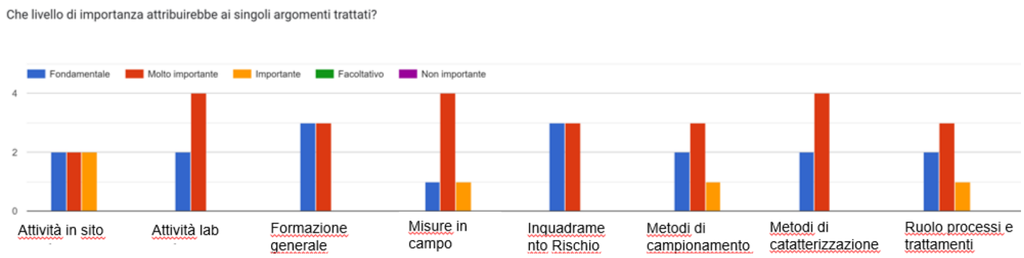
Per qualsiasi informazione si prega di contattare i seguenti indirizzi: s.radini@univpm.it; a.l.eusebi@univpm.it; a.foglia@univpm.it; l.pittura@univpm.it; s.gorbi@univpm.it. Per contatti telefonici 0712204530.

b) Numbers and general affiliation of the participants

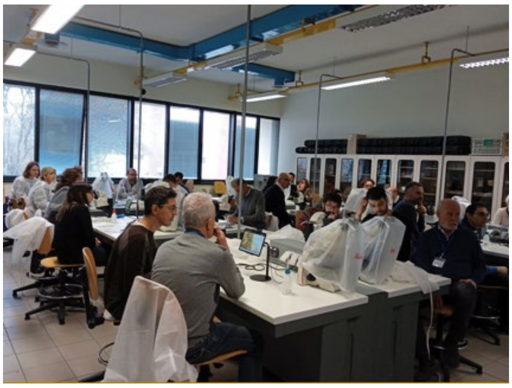
Total Participants	**N°**	**30**
Water Utilities	N°	15
Private Labs	N°	3
Health and Environmental agencies	N°	7
Environmental Companies/Associations	N°	2

c) Final Survey results





d) Mini photo report



2. Second Edition: 19th-21st April 2023-Ancona-In person for German Stakeholders

a) Detailed program

Microplastics in the Integrated Water Service

Theoretical- Practical Training course organised in the context of the European project Life Bluelakes https://lifebluelakes.eu/

Second edition	19 – 20 – 21 April 2023
Modality	In presence
Language	Practical sessions in German, theoretical sessions with live translation Italian/German
Place	**Theoretical sessions:** Università Politecnica delle Marche (UNIVPM), Via Brecce Bianche 12, 60131, Ancona **Practical sessions:** wastewater treatment plant (Ancona or Jesi), UNIVPM Laboratories and (optional technical visit) UNIVPM pilot hall

Program

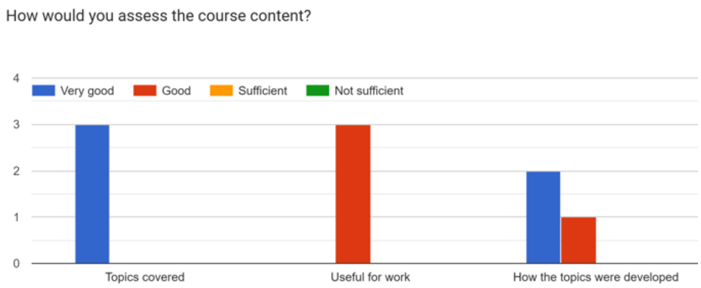
19 April	Do be defined	Arrival
	19.30	Welcome dinner
20 April	09.00 – 10.30	- Microplastics in urban water cycle: Origins – Pathways – Fate - Microplastic determinations: Literature and state of the art, critical aspects and challenges
	10.30 – 10.50	Coffee break
	10.50 – 13.00	- Sampling methodologies - Analytical characterisation methodologies
	13.00 – 14.00	Light lunch
	14.00 – 16.00	- Risk considerations associated with Microplastics in water and in environment - Examples and case studies
	16.00 – 16.20	Coffee break
	16.20 – 18.00	- Results and protocol from Blue Lakes project - Benchmark assesment
21 April	9.00-13.00	- Technical visit to wastewater treatment plant/potabilization plant - Experimental demonstrations using different sampling methods - Sample pre-processing and preparation
	13.00-14.00	Light Lunch
	14.00 – 16.00	- Description of the Lab equipment / instrumentation - Lab activity for sample sorting
	16.00 – 16.20	- Coffee break
	16.20 – 18.00	- Lab activity for sample characterization

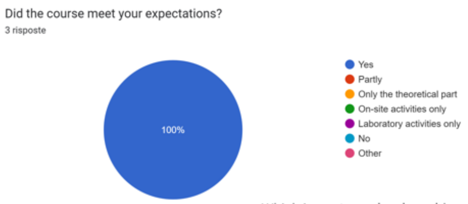
For any details please contact: s.radini@univpm.it; a.l.eusebi@univpm.it; l.pittura@univpm.it; s.gorbi@univpm.it. Telephone: 00390712204530.

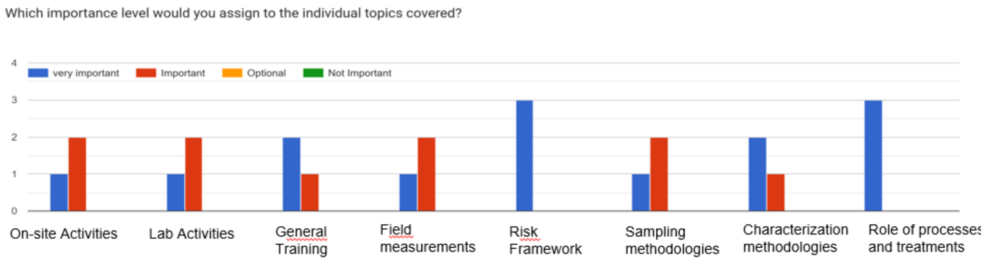
b) Numbers and general affiliation of the participants

Total Participants	**N°**	**23**
Water Utilities	N°	10
Environmental Companies/Association	N°	13

c) Final Survey results







d) Mini photo report

3. Third and Fourth Edition: 12nd June 2023 -Ancona Online for Italian Stakeholders and 23rd June 2023 Ancona in Person for Italian Stakeholders

a) Detailed program

ORDINE DEGLI INGEGNERI DELLA PROVINCIA DI ANCONA

Le Microplastiche nel Servizio Idrico Integrato - Terza edizione

Seminari Teorico-Pratici nell'ambito del progetto europeo Life Blue Lakes www.lifebluelakes.eu

SEMINARIO: MICROPLASTICHE NEL SISTEMA IDRICO INTEGRATO

Modalità e data: Online -12 Giugno 2023 (Lingua Italiano)

Luogo: Piattaforma Teams

Crediti rilasciati dall'Ordine Professionale degli Ingegneri della Provincia di Ancona: 6 CFP

Modulo 1: Lezioni Teoriche

9.00-9.15 Saluti Istituzionali

9.15-12.30 Modulo 1.1:

- Il Progetto Bluelakes
- Le Microplastiche: aspetti generali conoscitivi
- Le microplastiche nel servizio idrico integrato: stato dell'arte e casi studio
- Metodologie di campionamento e di caratterizzazione

14.00-16.00 Modulo 1.2:

- Impianti di depurazione e di potabilizzazione: ruolo dei processi e delle tecnologie nella rimozione delle microplastiche, esempi numerici di bilanci di massa a scala impianto.
- Controllo e ottimizzazione della rimozione delle microplastiche nel servizio idrico e nelle diverse unità di trattamento: linee guida gestionali e configurazioni progettuali ottimali, casi studio ed esempi pratici.
- Cenni di analisi di rischio associato alla presenza delle microplastiche nel settore idrico e prospettive nella legislazione tecnica e ambientale.
- Sintesi dei protocolli e delle attività tecnico-pratiche del Modulo 2.

La partecipazione al corso di formazione è gratuita e comprensiva dei materiali didattici e formativi e di eventuali trasferimenti presso gli impianti e i laboratori per le sessioni tecnico-pratiche.

Il corso ha disponibilità limitata di partecipanti. Le iscrizioni dovranno essere finalizzate entro il 31 Maggio 2023, inviando una e-mail ad uno dei seguenti indirizzi: chietimariagrazia@gmail.com; a.l.eusebi@univpm.it; a.foglia@univpm.it e specificando Nome, Cognome, Ruolo, Azienda, Contatto e Modulo di Interesse.

www.lifebluelakes.eu / info@lifebluelakes.eu

Le Microplastiche nel Servizio Idrico Integrato - Terza edizione

Seminari Teorico-Pratici nell'ambito del progetto europeo Life Blue Lakes www.lifebluelakes.eu

SEMINARIO: METODOLOGIE DI CAMPIONAMENTO E CARATTERIZZAZIONE DELLE MPs

Modalità e data: In presenza -23 Giugno 2023 (Lingua Italiano)

Luogo: impianto di potabilizzazione / impianto di depurazione / piattaforma sperimentale UNIVPM e Laboratori di UNIVPM

Crediti rilasciati dall'Ordine Professionale degli Ingegneri della Provincia di Ancona: 6 CFP

Modulo 2: Lezioni Tecnico-Pratiche- 23 Giugno 2023

23/06/2023 mattina	9.30	Arrivo all'impianto di depurazione di Jesi e Inizio registrazione – Via della Barchetta, 60035 Jesi AN - https://goo.gl/maps/MXJVvHyTU82yV5Tt9
	9.45-10.30	Saluti del Gestore e descrizione impianto
	10,30 – 11,15	Metodologia di campionamento MPs con setacci
	11,15 - 12,00	Metodologia di campionamento MPs con campionatore automatico
	12,00-12.30	Descrizione sulla fase di recupero del campione
	12.30-13.00	Trasferimento ad UNIVPM - Via Brecce Bianche 12, 60131 Ancona - https://goo.gl/maps/16WcCwbNuQLegz3E7
Pausa pranzo	13,00-14,00	Light Lunch → Aula Azzurra, Edificio Scienze 3
23/06/2023 pomeriggio	14.00-15.00	Descrizione della strumentazione tecnica di laboratorio
	15,00-16,00	Sessione di pre-processamento dei campioni
	16.00-17.00	Sessione di separazione e caratterizzazione delle MPs

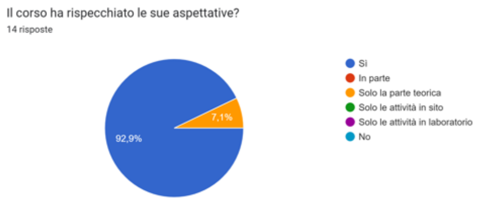
L'appuntamento mattutino per la sessione tecnico-pratica del corso è prevista direttamente all'impianto di depurazione di Jesi. Nell'eventualità di problemi logistici per gli iscritti preghiamo di mandare un'e-mail per tempo ai seguenti indirizzi: chietimariagrazia@gmail.com; a.l.eusebi@univpm.it o di chiamare ai numeri: 3420447463 e 3209666407.

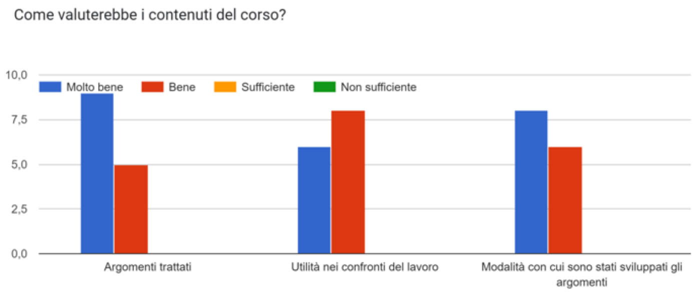
www.lifebluelakes.eu / info@lifebluelakes.eu

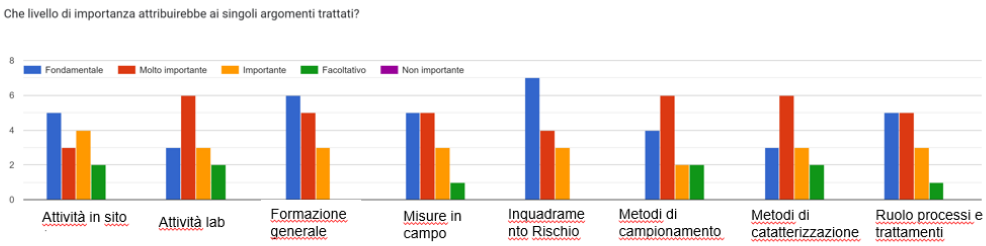
b) Numbers and general affiliation of the participants

Total Participants	**N°**	**166**
Water Utilities		
Environmental Companies/Association		
Self-employed engineers mainly of civil/environmental infrastructures		

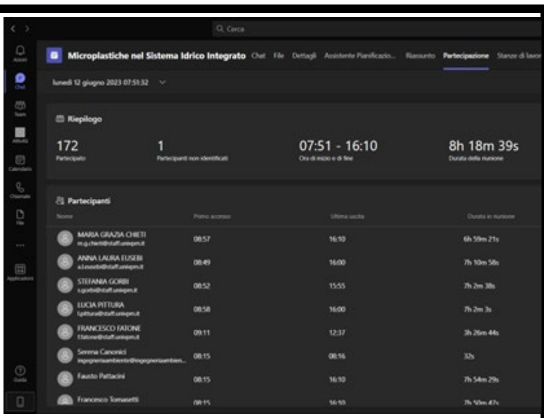
c) Final Survey results

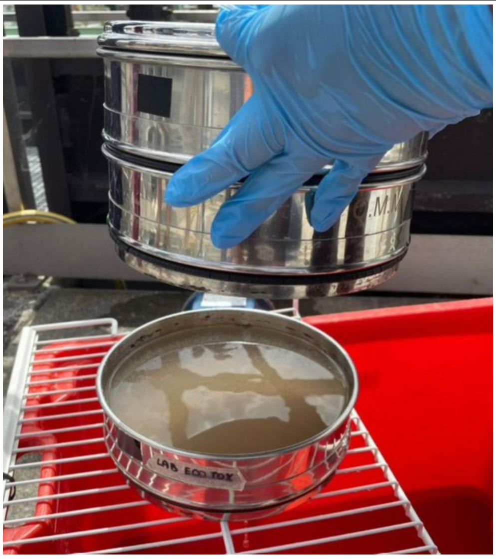






d) Mini photo report





Teaching Material

The project LIFE BLUE LAKES

Università Politecnica delle Marche

BENEFICIARIO COORDINATORE
BENEFICIARI ASSOCIATI
PROGETTO COFINANZIATO DA

www.lifebluelakes.eu / info@lifebluelakes.eu

Università Politecnica delle Marche- UNIVPM-www.univpm.it

The Università Politecnica delle Marche (UNIVPM), established in **1971** in Ancona (Italy), has a clear scientific and technological focus and is very active and performant in the European R&D&I.

The organization of the teaching is handled by 5 faculties and 12 departments.

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No microplastics, just waves.

Water and Waste Environmental Engineering

LAB

ENGINEERING FACULTY- Department of Science and Engineering of Materials, Environment and Urban Planning – SIMAU

The research fields can be divided into the following 5 macro-areas:

- Resource recovery technologies in the urban water cycle
- Stormwater treatment and management
- Digital solutions for carbon footprinting and environmental / economic assessment
- Advanced water and wastewater treatment
- Organic waste treatment and valorisation

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Lab. Ecotoxicology and Environmental Chemistry

Dipartimento
di Scienze
della Vita
e dell'Ambiente
DISVA


Prof. Francesco Regoli


Prof. Stefania Gorbi


Dr. Marica Mezzelani


Dr. Alessandro Nardi


Dr. Giuseppe d'Errico


Prof. Maura Benedetti


Dr. Lucia Pittura


Dr. Carola Mazzoli


Dr. Veronica Vivani


Dr. Marta Di Carlo


Dr. Giulia Lucia


Dr. Michela Panni


Dr. Melissa Orsini


Dr. Daniele Fattorini

Blue Lakes
No microplastics, just waves.

20 April	09.00 – 10.45	- Official Welcome - Global Nature Fund Presentation - Bluelakes Project - Microplastics in urban water cycle: Origins – Pathways – Fate - Microplastic determinations: Literature and state of the art, critical aspects and challenges
	10.45 – 11.00	Coffee break
	11.00 – 13.00	- Sampling methodologies - Analytical characterization methodologies
	13.00 – 14.00	Light lunch
	14.00 – 16.00	- Risk considerations associated with Microplastics in water and in environment - Examples and case studies
	16.00 – 16.20	Coffee break
	16.20 – 18.00	- Results and protocol from Blue Lakes project - Benchmark assesment
	19.30	- Welcome dinner in Giardino Restaurant https://ristorantegiardinoancona.it/
21 April	9.00-13.00	- Technical visit to wastewater treatment plant/potabilization plant - Experimental demonstrations using different sampling methods - Sample pre-processing and preparation
	13.00-14.00	Light Lunch
	14.00 – 16.00	- Description of the Lab equipment / instrumentation - Lab activity for sample sorting
	16.00 – 16.20	- Coffee break
	16.20 – 18.00	- Lab activity for sample characterization

Special Thanks to

Special Thanks to

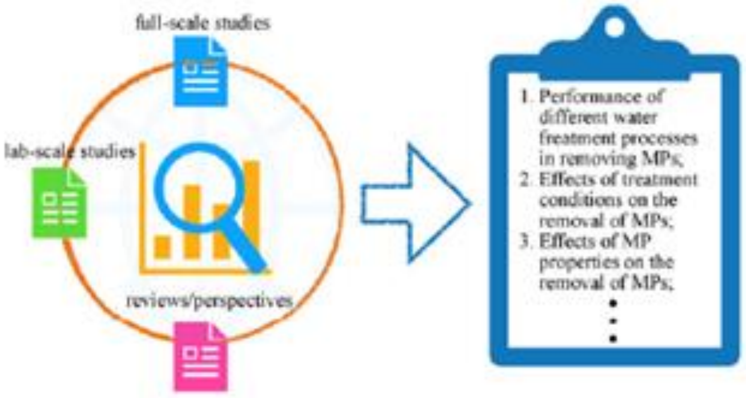
Microplastics in the Integrated Water Service

In the **European Green Deal** and in the new **Action Plan for Circular Economy**, the European Commission announced an initiative to face the unintentional release of microplastics in the environment.
The initiatives aim to develop measures for labelling, standardisation, certification and regulation on the unintentional release of microplastics in the environment, including:

- Measures to increase microplastics removal in all the phases of the life cycle of the products.

- Development and harmonisation of methods to detect the unintentional release of microplastics, especially from tires and tissues, and provide harmonised data on microplastics concentration in marine water.

- Fill the gap on scientific knowledge on risk about the presence of microplastics in the environment, in drinking water and in food.



Life Blue Lakes - LIFE18 GIE/IT/000813

Life Blue Lakes aims to face **the issue of microplastics in lakes** through actions of *governance*, training, scientific research, information e sensibilization.

Main actions are being deployed in **Garda, Bracciano, Trasimeno** and **Castreccioni lakes,** in Italy and in **Costanza** and **Chiemsee lakes** in Germany.

COUNTRIES INVOVLED:

Italy and Germany

START OF THE PROJECT:

1 October 2019

END OF THE PROJECT:

30 September 2023

BENEFICIARIO COORDINATORE

LEGAMBIENTE

BENEFICIARI ASSOCIATI

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Global Nature Fund

Bodensee Stiftung Lake Constance Foundation

UNIVERSITÀ POLITECNICA DELLE MARCHE

Blue Lakes No microplastics, just waves.

Legambiente ONLUS
ABDAC - Autorità di Bacino Distrettuale dell'Appennino Centrale
ARPA Umbria
ENEA – Agenzia Nazionale per le nuove tecnologie, l'energia e lo sviluppo economico sostenibile
UNIVP - Università Politecnica delle Marche
Global Nature Fund
Lake Constance Foundation

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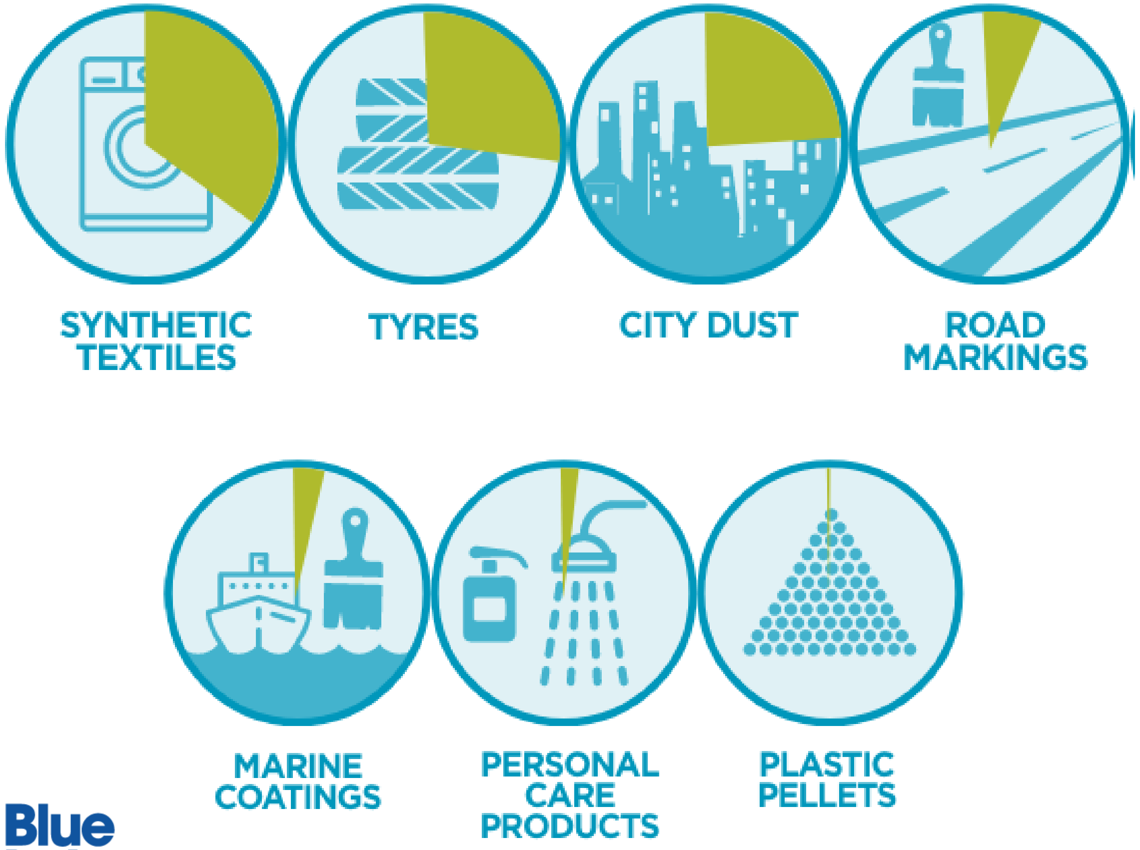
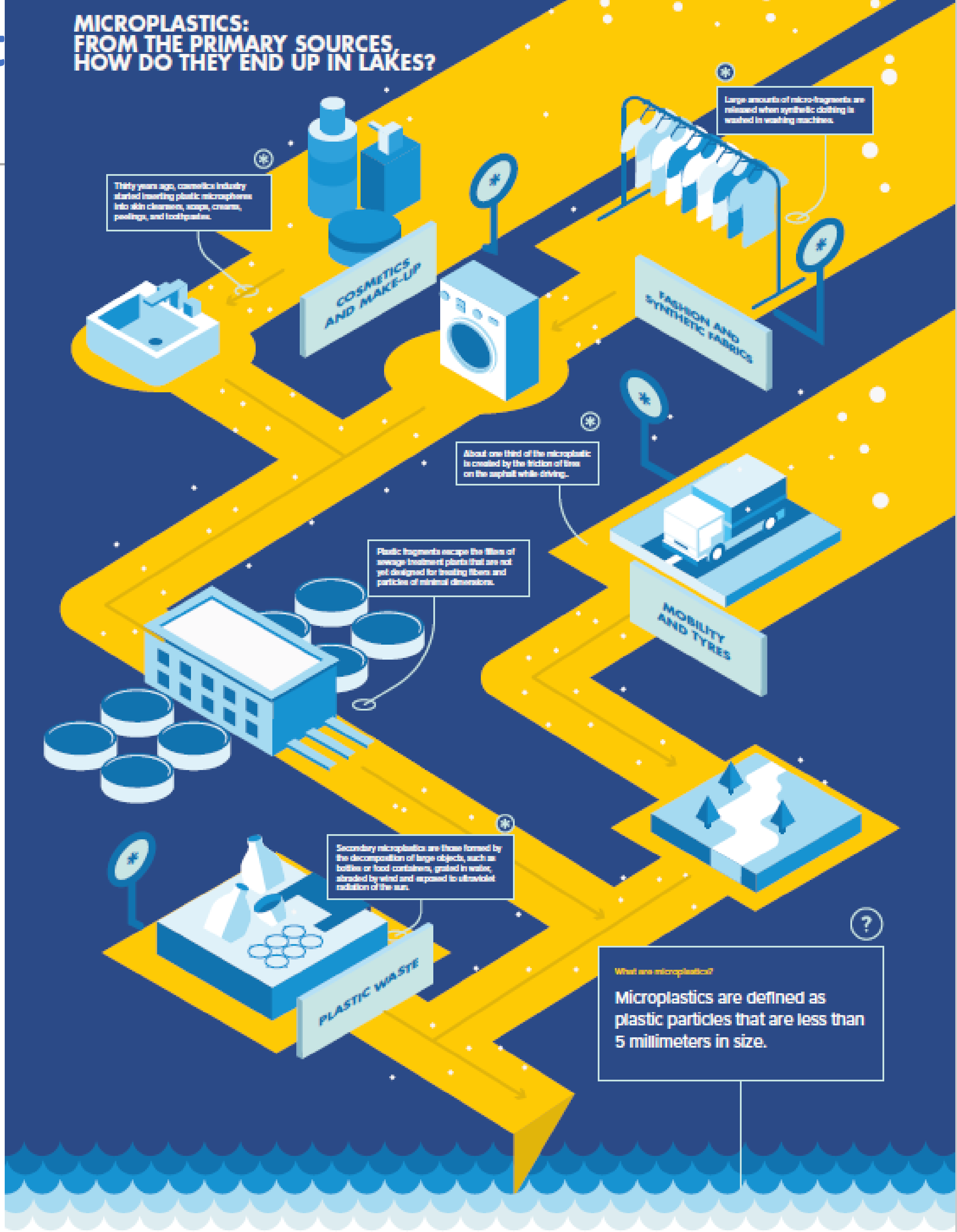
Origin of Microplastics in the Integrated Water Service

Microplastics are defined as all plastic fragments whose dimensions are < 5 millimeters.





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WHAT ARE MICROPLASTICS?

Microplastics: plastic fragments or particles smaller than 5 millimetres.

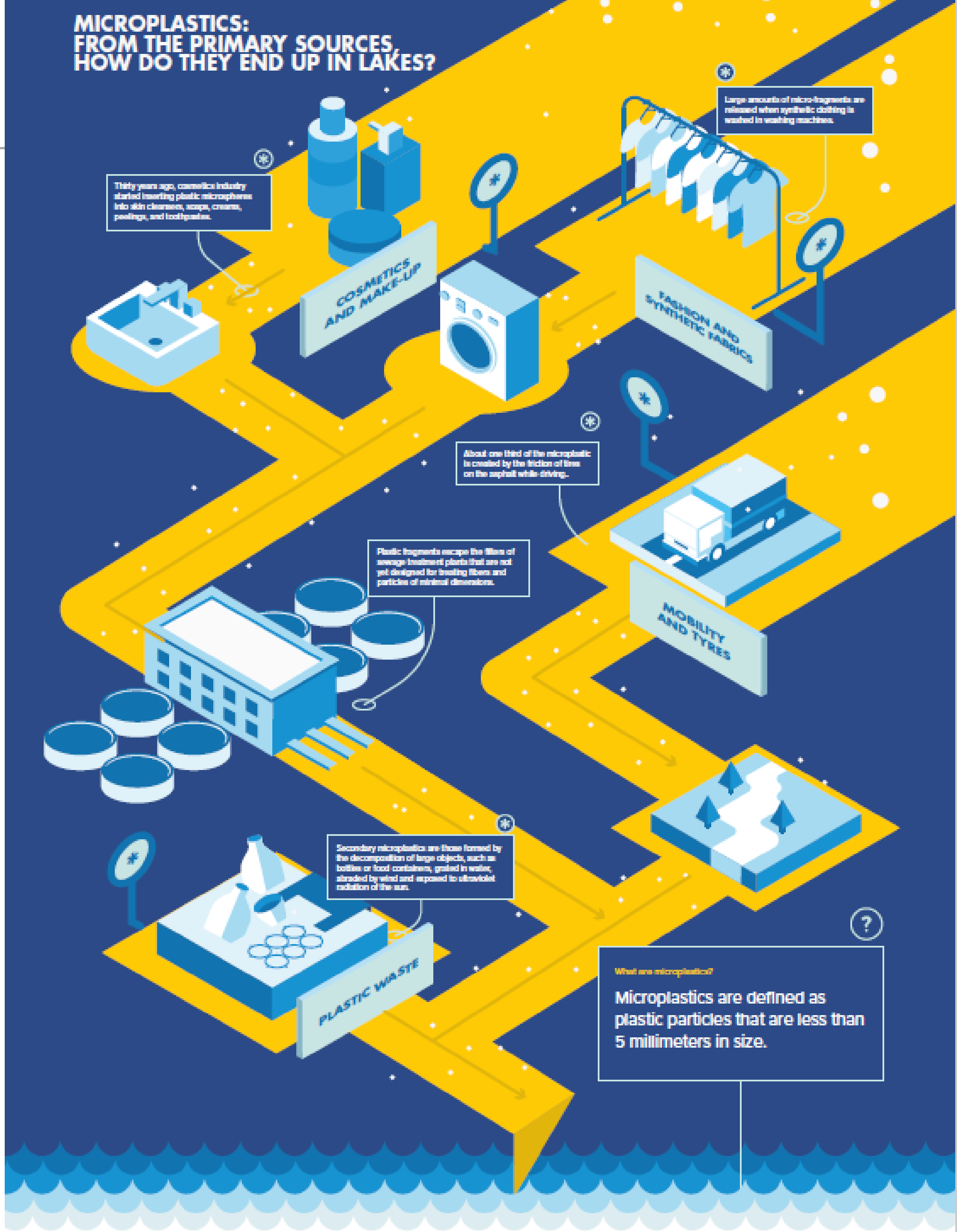
Primary microplastics: microbeads, fillers on artificial turf sports pitches or additives for cleaning, cosmetic products, exfoliation…

Secondary microplastics: result of chemical and physical ageing and degradation processes

→ IMPACTS ON ECOSYSTEMS AND

- Can easilly enter in contact with aquatic organisms
- May be vectors for toxical compounds, which may act as potentially endocrines distructors, once entered in the organsim, interfering with the hormonal functions.
- Have elevated adsorbance capacity and can transport pollutant substances present in water
- Can be occupied by microorgansism and pathogens.

Blue Lakes
No microplastics, just waves.



Microplastics in the Integrated Water Service

1970s
Research of microplastics in marine environment

2000s
Microplastics among emerging contaminants

2008 Marine Strategy Framework Directive (MSFD 2008/56/CE): microplastics included as descriptors to be monitored

2008
Water Framework Directive: Concepts of “waste hierarchy” and “producer responsibility”

2015
European Green Deal and circular economy action plan

2018
Research of microplastics in drinking water (peer-reviewed publications)

2018
EU ban on some single-use products

2019
ECHA (European Chemical Agency)
Proposal of restrictions on microplastics in products of UE/SEE market to avoid or reduce the release in the environment.

Microplastics introduced in the “Additional requirements” of the water reuse Regulation 741/2020

Microplastics in the control list of the new Drinking Water Directive 2020/2184

Life Blue Lakes - Project areas in Italy and in Germany

- **Lake Garda**

  370 km², located between three regions (Trentino Alto Adige, Veneto and Lombardia). Tourism

- **Lake Trasimeno**

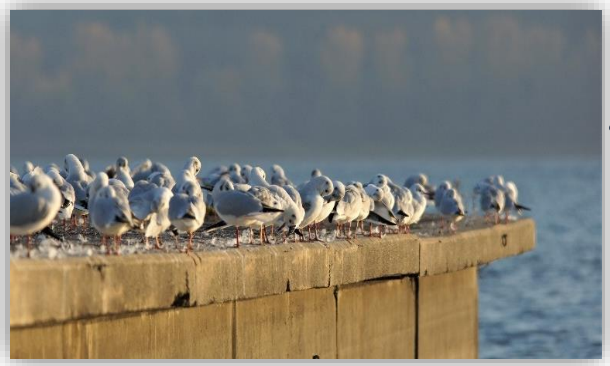
  128 km², Umbria. Nature conservation area, tourism

- **Lake Bracciano**

  56.5 km², Lazio. Drinking water reservoir, nature conservation area, tourism

- **Lake Castrreccioni**

  128 km², Marche. Drinking water reservoir, tourism



- **Lake Constance**

  536 km², international border between Germany, Switzerland, and Austria

  Drinking water reservoir, high standards for water treatment

  Nature conservation area, tourism

- **Lake Chiemsee**

  79.9 km², Bavaria nature conservation area, tourism

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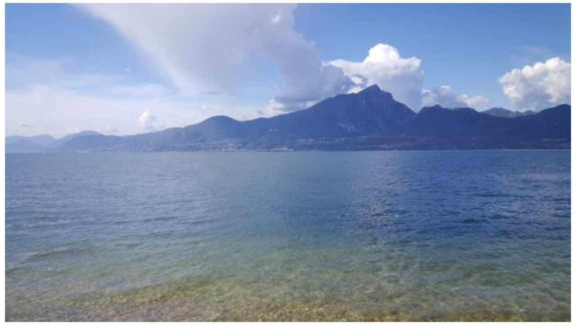
Microplastics in Italian lakes



[Plastic waste threatens lakes as well as oceans - BBC News](https://www.bbc.com/news/science-environment-24434378)
07 Ottobre 2013 - BBC

https://www.bbc.com/news/science-environment-24434378

Plastic waste threatens lakes as well as oceans

By Matt McGrath
Environment correspondent, BBC News

7 October 2013

Researchers found levels of plastics in Lake Garda similar to those in marine environments

Pollution with plastic waste is not confined to the oceans but poses a growing threat to lakes as well.

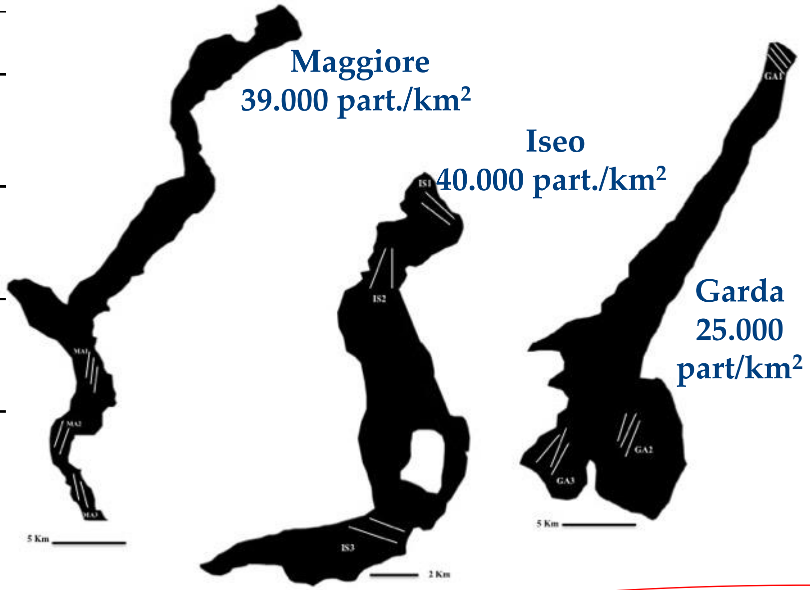
- Strategic basin for drinking water supply
- Presence of combined sewerage overflows
- Sewer network undergoing renovation
- Integrated Water Service managed by various companies
- Strong variability and relevance of anthropic and natural pressures

Microplastics in Italian lakes

Legambiente measurement campaigns in the Italian lakes

Lake (Sampling date)	Sample Location	Wind direction	Trawling direction	Transect	particles/km^2
IS (28/06/2016)	Lovere-Pisogne	SW	NW-SE	IS1	57000±36000
	Riva di Solto-Castro	SW	N-S	IS2	15000±11000
	Predore-Pilzone	S	E-W	IS3	50000±14000
MA (06/07/2016)	Ispra-Monvalle	Absent	SW-NE	MA1	45000±13000
	Arona-Angera	NE	SW-NE	MA2	41000±32000
	Lisanza-Dormelletto	S	NW-SE	MA3	29000±17000
GA (11-12/07/2016)	Riva-Torbole	N	SW-NE	GA1	55000±29000
	Sirmione	Absent	SW-NE	GA2	4000±2700
	Desenzano	N	SW-NE	GA3	16000±13000

43.000 part./km^2 Laurentian Great Lakes
11.000-36.000 part./km^2 Swiss lake



Environmental Pollution 236 (2018) 645–651

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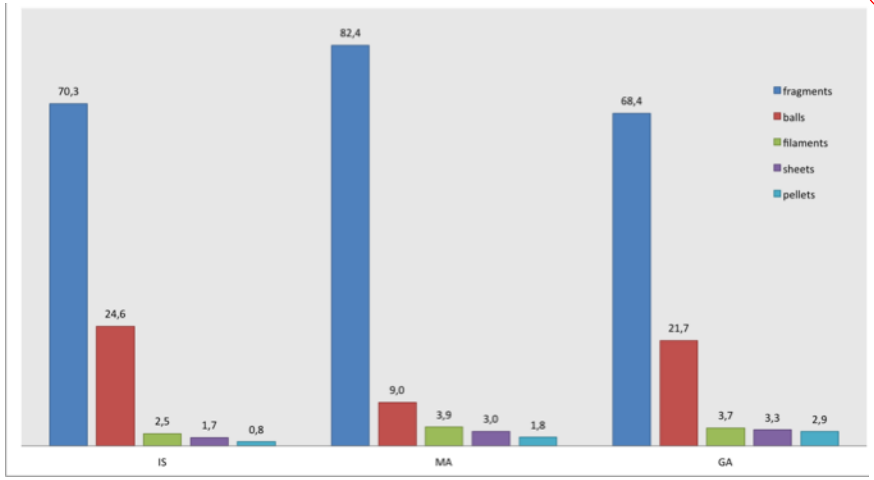
Microplastic pollution in the surface waters of Italian Subalpine Lakes☆

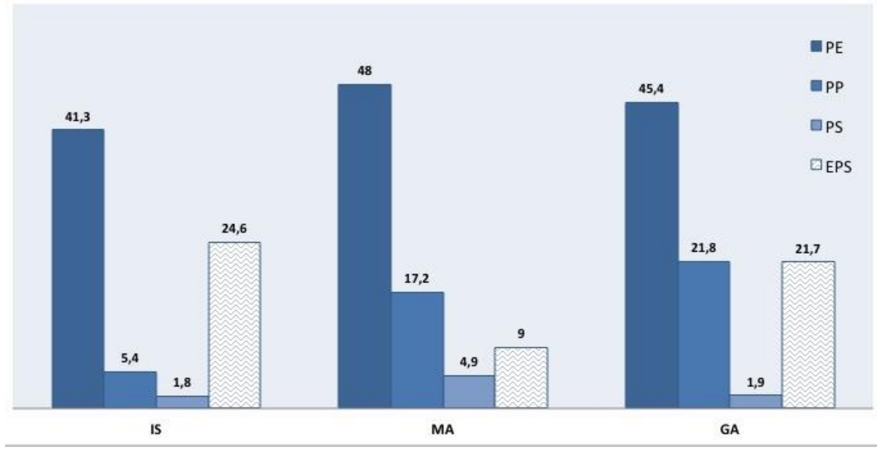
Maria Sighicelli [a, *], Loris Pietrelli [a], Francesca Lecce [a], Valentina Iannilli [a], Mauro Falconieri [a], Lucia Coscia [b], Stefania Di Vito [b], Simone Nuglio [b], Giorgio Zampetti [b]

[a] Italian National Agency for New Technologies, Energy and Sustainable Economic Development (ENEA) CR Casaccia, Rome, Italy
[b] LEGAMBIENTE, Onlus, Rome, Italy

- ✓ 22 TRANSECTS
- ✓ 843 PARTICLES
- ✓ 390 FTIR SPECTRES

Transects near river inputs and narrowings are by far the richest in plastics.





Blue Lakes
No microplastics, just waves.

PROJECT, OBJECTIVESAND ACTIONS

The **LIFE Blue Lakes project** contributes to reducing the **contamination of lakes with microplastics**.

Exemplary project areas are the **lakes Garda**, **Bracciano** and **Trasimeno** in **Italy** and **Lake Constance** and **Lake Chiemsee** in **Germany**. Further Italian and European lake communities will be involved in the promotion and dissemination of good practices.

The LIFE programme is the EU's largest funding instrument for the environment and climate action created in 1992 for supporting a wide range of measures and projects to safeguard biodiversity and nature, for enhancing the environmental policy and awareness raising on environmental issues.

LIFE BLUE LAKES SPECIFIC AIMS AND ACTIONS:

Supporting local administrations and enhancing the engagement of local economic entities located close to lakes by a Participatory Process to draft a Lake Paper. This document may suggest to local communities a set of solutions tailored to their specific territorial context, proposing monitoring programmes or techniques to improve wastewater treatment processes, discharge limits, provisions for reducing the impact resulting from companies and families as well as awareness raising initiatives for residents.

Design and test a **standard microplastic monitoring protocol** in the two pilot areas of the Trasimeno and Bracciano lakes in order to assess microplastics levels in these basins.

A **technical protocol** to reduce the release of microplastics from wastewater treatment plants based on the experiences of a pilot plant at Lake Garda. **Wastewater treatment plant operators** in Italy and Germany are closely involved and trained to ensure a comprehensive transfer of knowledge.

Cooperating with relevant companies (plastics, tyre, outdoor and cosmetics industries) and carrying out **an advocacy campaign** with the aim of reducing and preventing further contamination of lakes with microplastics.

Raising public awareness in Italy and Germany and promoting behaviours to prevent plastic waste.

Enhancing existing regulatory framework to face local microplastic pollution and influencing national and European political agenda in Italy and Germany through the development of a **Lake White Paper** which will be presented to the relevant authorities (Ministries of Environment, Agriculture, Health, Economic Development, Regions, Basin Authorities, etc.) to promote a legislative initiative to protect lakes from microplastics at national and European level.

www.lifebluelakes.eu

Blue Lakes

Specific objectives of LIFE Blue Lakes project

- ✓ **Support local authorities** and stakeholders through a partecipative process for the development of LAKE PAPER: a volountary proposal for management good practices and the diffusion of circular economy models.
- ✓ **Reduce microplastics presence connected to wastewater treatment plants, through the development of a Technical Protocol and training of water professionists.**
- ✓ Cooperate with local industries (plastic, tires producers, cosmetics) to develop solutions to reduce and prevent further primary loads of microplastics in lakes.
- ✓ **Raise awareness**, to prevent the spread of plastic waste in the environment;
- ✓ **Improve the existing regulatory framework** to address microplastic pollution in lake basins, influencing the policy agenda at Italian, German and European level.

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Specific objectives of LIFE Blue Lakes project

- Promote a participatory process to develop the Lake Paper: a voluntary commitment by local stakeholders for the implementation of good management practices and the dissemination of circular economy models aimed at protecting lakes and reducing the impact of economic activities.
- Monitor the release of microplastics from treatment plants by developing a technical protocol and training operators.
- Cooperate with stakeholders (plastics, pneumatics and cosmetics) to find and develop solutions to reduce and prevent further primary loads of microplastics;
- Raise public awareness and promote behaviors to prevent plastic waste;
- Improve the existing regulatory framework to address local microplastic pollution and influence the national and European policy agenda in Italy and Germany.

The measures are addressed to local authorities, businesses, industries and communities in the lake regions. Additional Italian and European lake communities will be involved in the promotion and dissemination of good practices.

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No microplastics, just waves.

Products of the project

- **3 Lake Papers in Italy and 2 Lake Papers in Germany** drafted through a participatory process involving three main types of stakeholders (local administrators, cultural associations/school sector, economic/tourist sector);

- ***Manifesto del Lago****, a tool that allows lake communities to undertake a participatory process aimed at protecting the lakes by reducing and mitigating the effects associated with the presence of microplastics in the waters;*
- **2 summer awareness campaigns** implemented for the promotion of the Lake Papers and the Manifesto del Lago;
- **Monitoring protocol** that provides methodological procedures for sampling and analyzing microplastic content in lakes, to support freshwater MP monitoring and assessment programmes.
- **Training courses** for ARPA technicians for the use/application of this Protocol (40 participants)

Products of the project

- **Monitoring protocol and operating manual** to optimize the sampling and analysis procedures for microplastics detection in treatment plants
- **Report on the results obtained from sampling campaigns** in drinking water and wastewater treatment plants
- **Training courses for Integrated Water Service professionals**

- **Contest** for students
- **Awareness/information campaign for stakeholders** (plastics, pneumatics and cosmetics). More than 250 companies reached.

UNIVPM activities in LIFE Blue Lakes project: MPs sampling campaign

- ✓ LAKE GARDA
- ✓ LAKE CASTRECCIONI

- WASTEWATER TREATMENT PLANTS
- DRINKING WATER TREATMENT PLANTS

- Strategic catchments
- Presence of overflows, WWTPs and DWTPs
- Ongoing upgrading of the sewer system
- Water service managed by various water utilities
- Variations in natural and anthropic pressures

PROMOTION OF GOOD PRACTICES EXPERIMENTED ON THE PILOT LAKES

Sampling in real environment

- ✓ evaluation of sampling systems and protocols
- ✓ ensure the transferability and replicability of the project results

MPs sample preparation and characterization

Optimization guidelines for the treatment stages

- ✓ critical audit of treatment technologies to improve the removal of microplastics

TECHNICAL PROTOCOLS FOR TREATMENT PLANTS

www.lifebluelakes.eu / info@lifebluelakes.eu

Thank you for the attention!

No microplastics, just waves.

Water and Waste Environmental Engineering

BENEFICIARIO COORDINATORE

BENEFICIARI ASSOCIATI

PROGETTO COFINANZIATO DA

Blue Lakes
No microplastics, just waves.

Microplastics: general overview

Università Politecnica delle Marche

BENEFICIARIO COORDINATORE

LEGAMBIENTE

BENEFICIARI ASSOCIATI

Autorità di Bacino Distrettuale dell'Appennino Centrale

arpa UMBRIA Agenzia Regionale per la Protezione Ambientale dell'Umbria

ENEA AGENZIA NAZIONALE PER LE NUOVE TECNOLOGIE, L'ENERGIA E LO SVILUPPO ECONOMICO SOSTENIBILE

Global Nature Fund

Bodensee Stiftung Lake Constance Foundation

UNIVERSITÀ POLITECNICA DELLE MARCHE

PROGETTO COFINANZIATO DA

PlasticsEurope Association of Plastics Manufacturers

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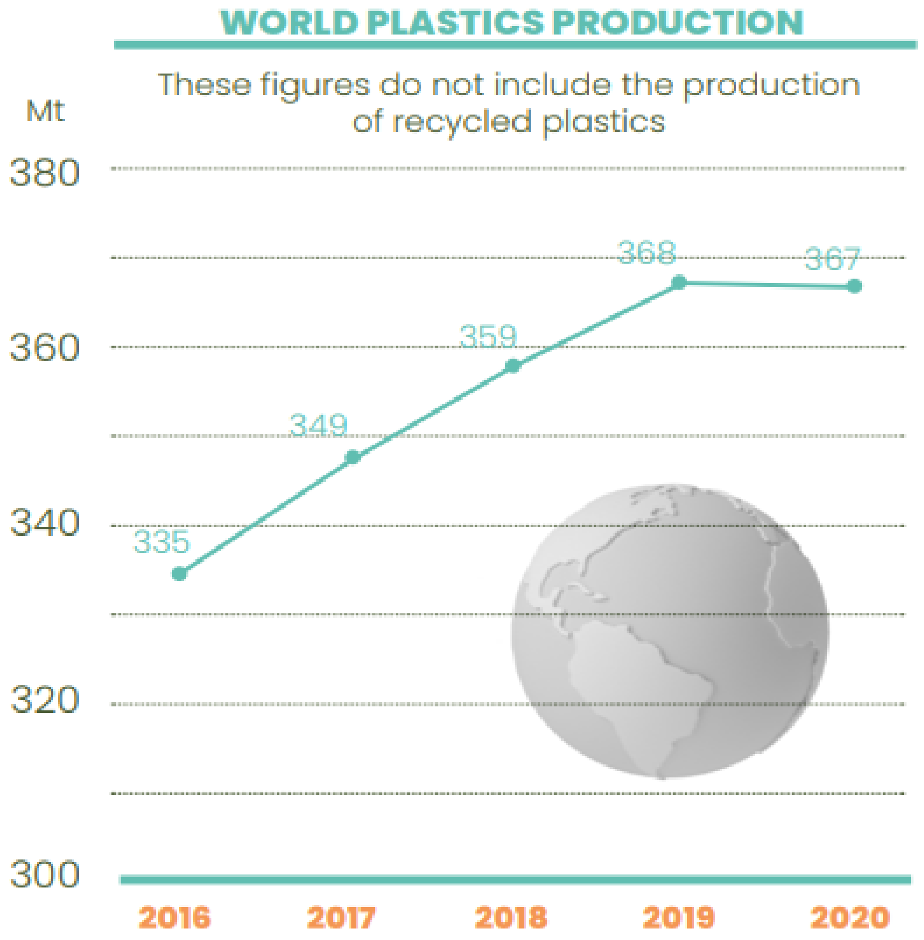
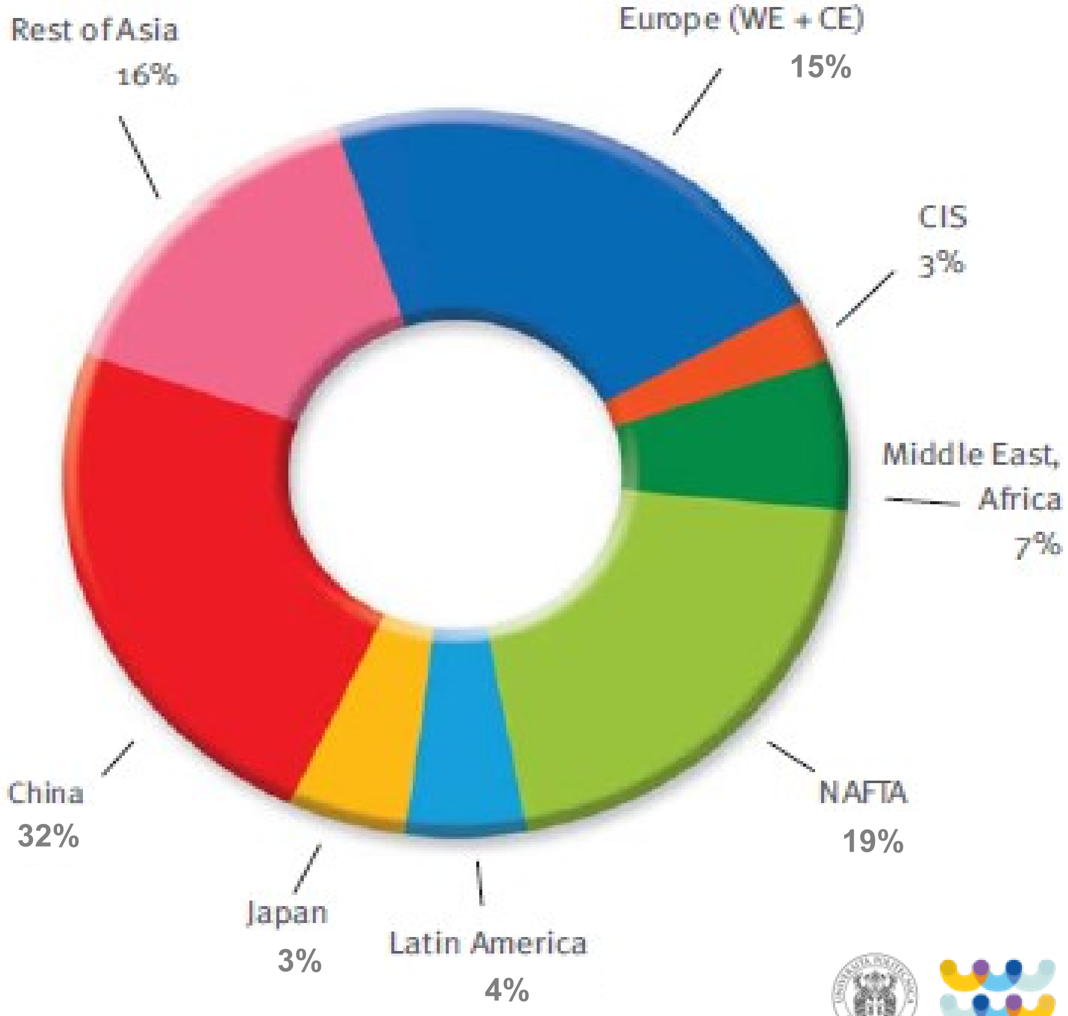
THE AGE OF PLASTIC

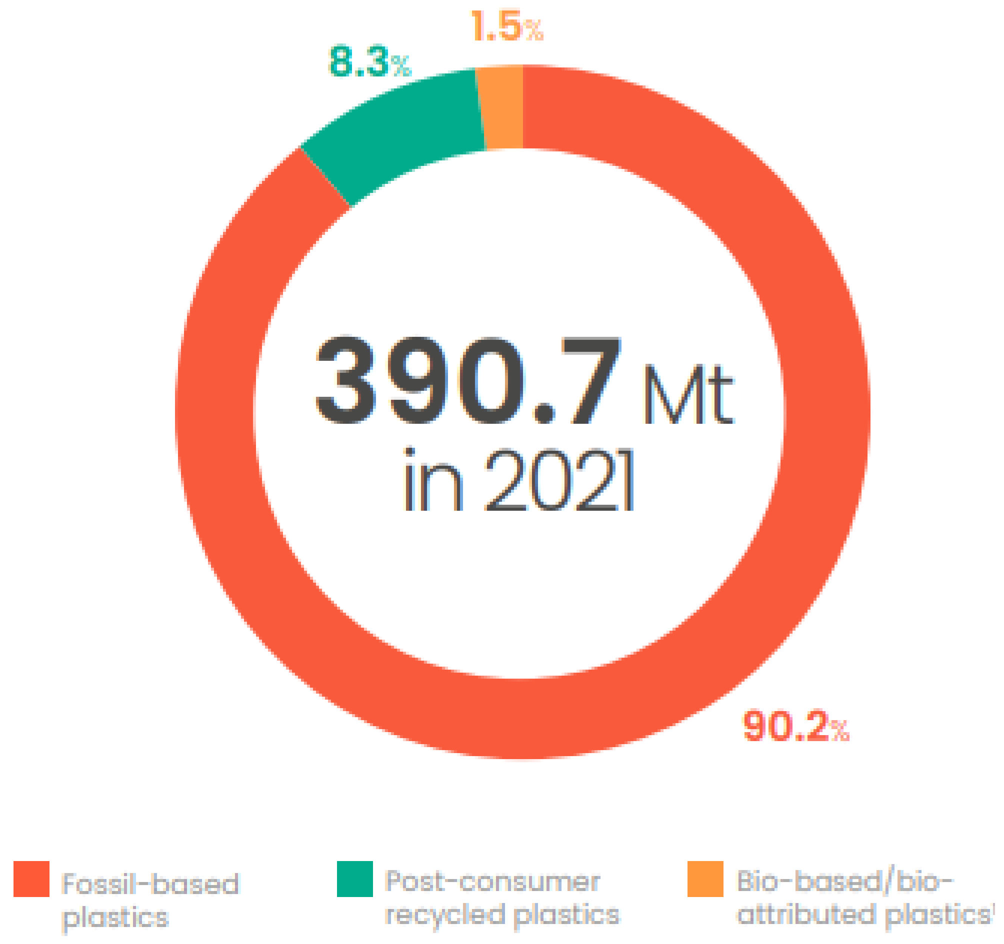
Plastic production increased worldwide over the last 60 years, from 0.5 million tons y-1 in 1960, to 390 million tons in 2021

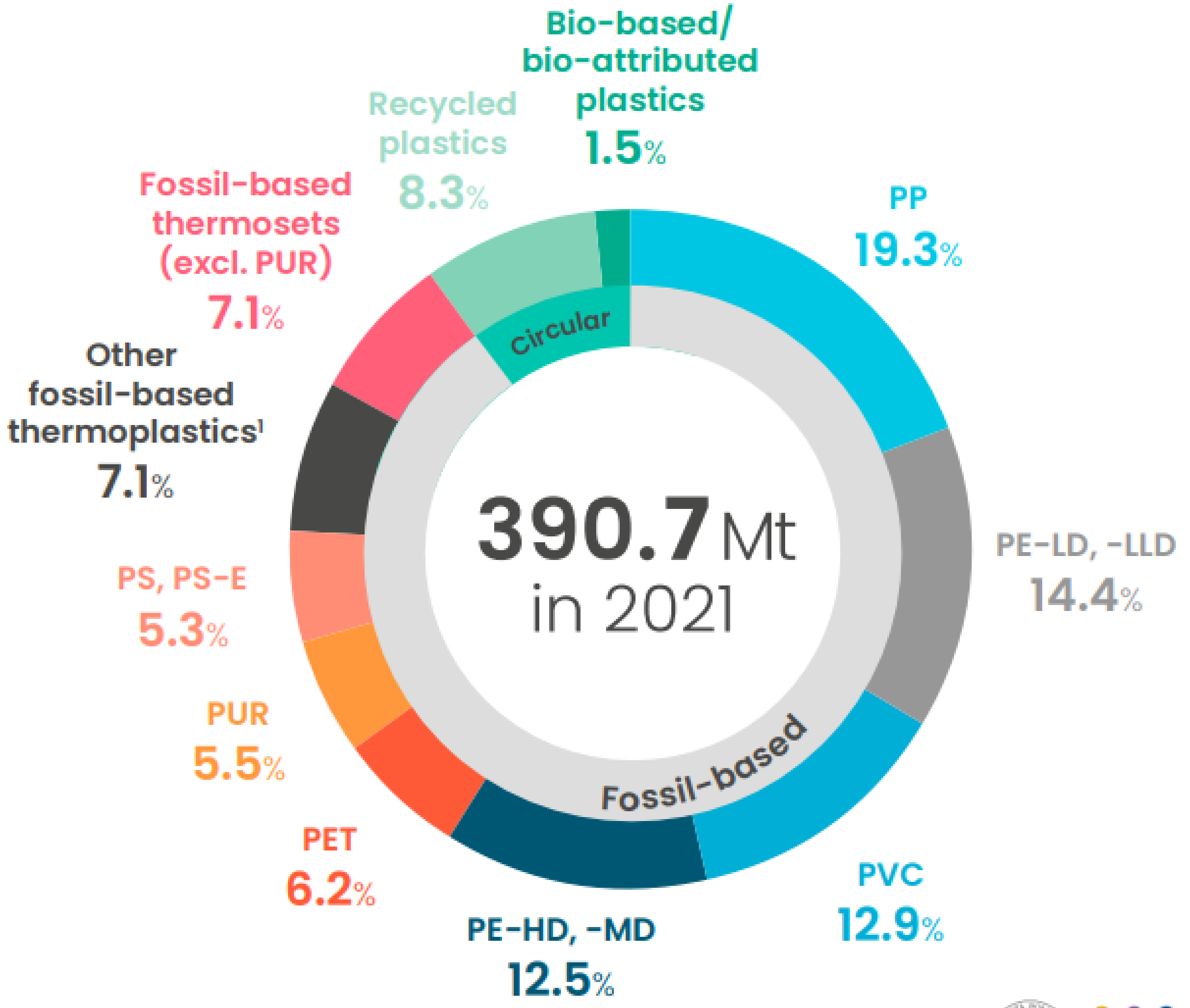




Plastic-the Facts 2022_PlasticEurope

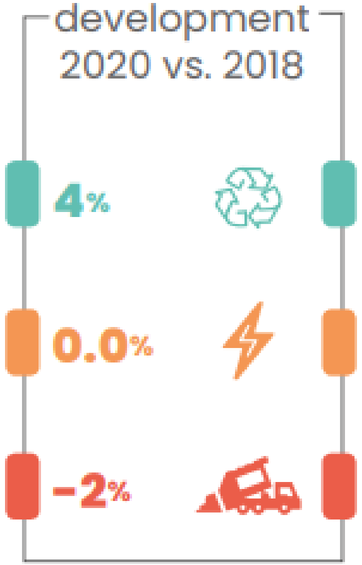
Global plastic production in relation to different polymers typologies



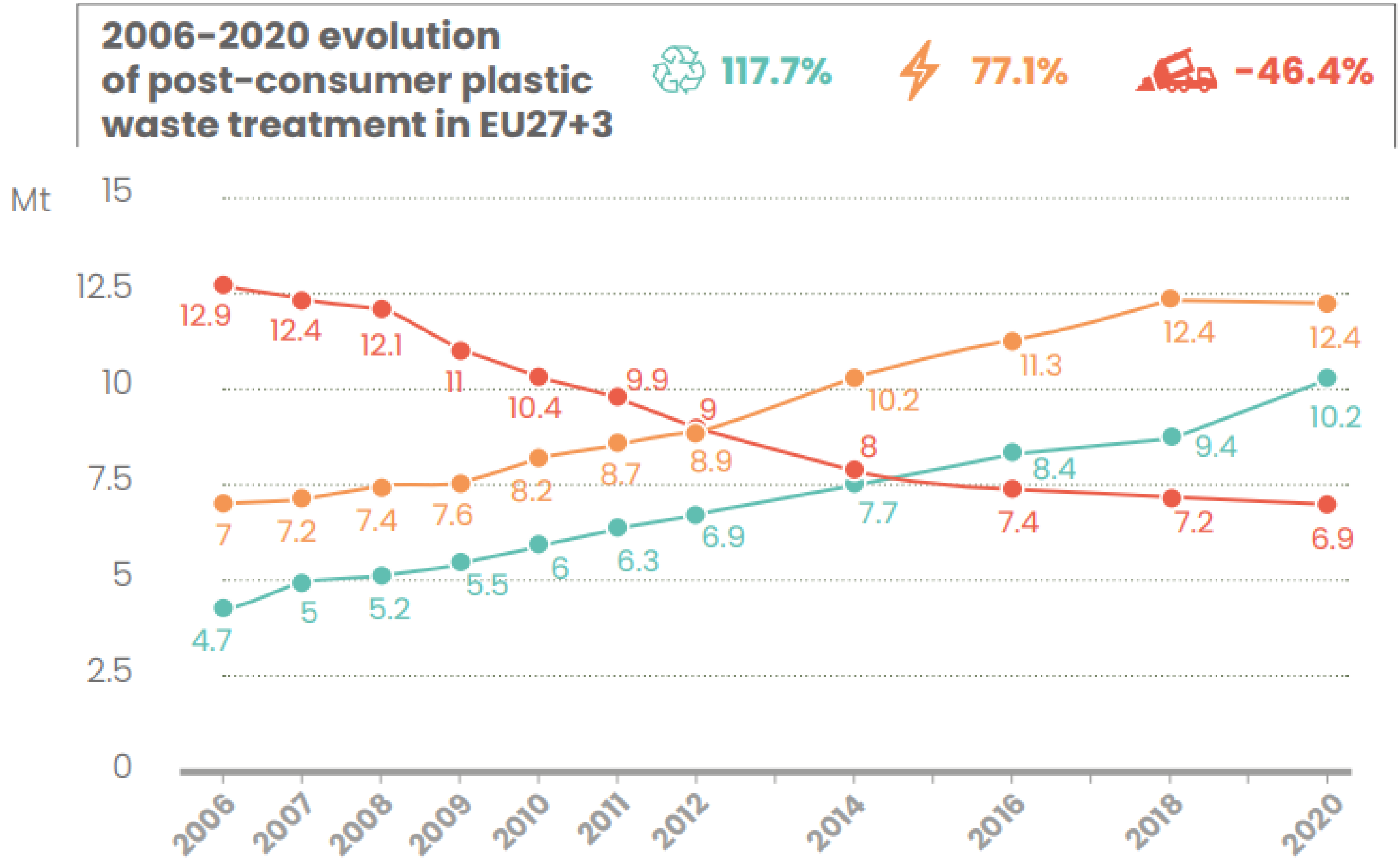


Plastic-the Facts 2022_PlasticEurope

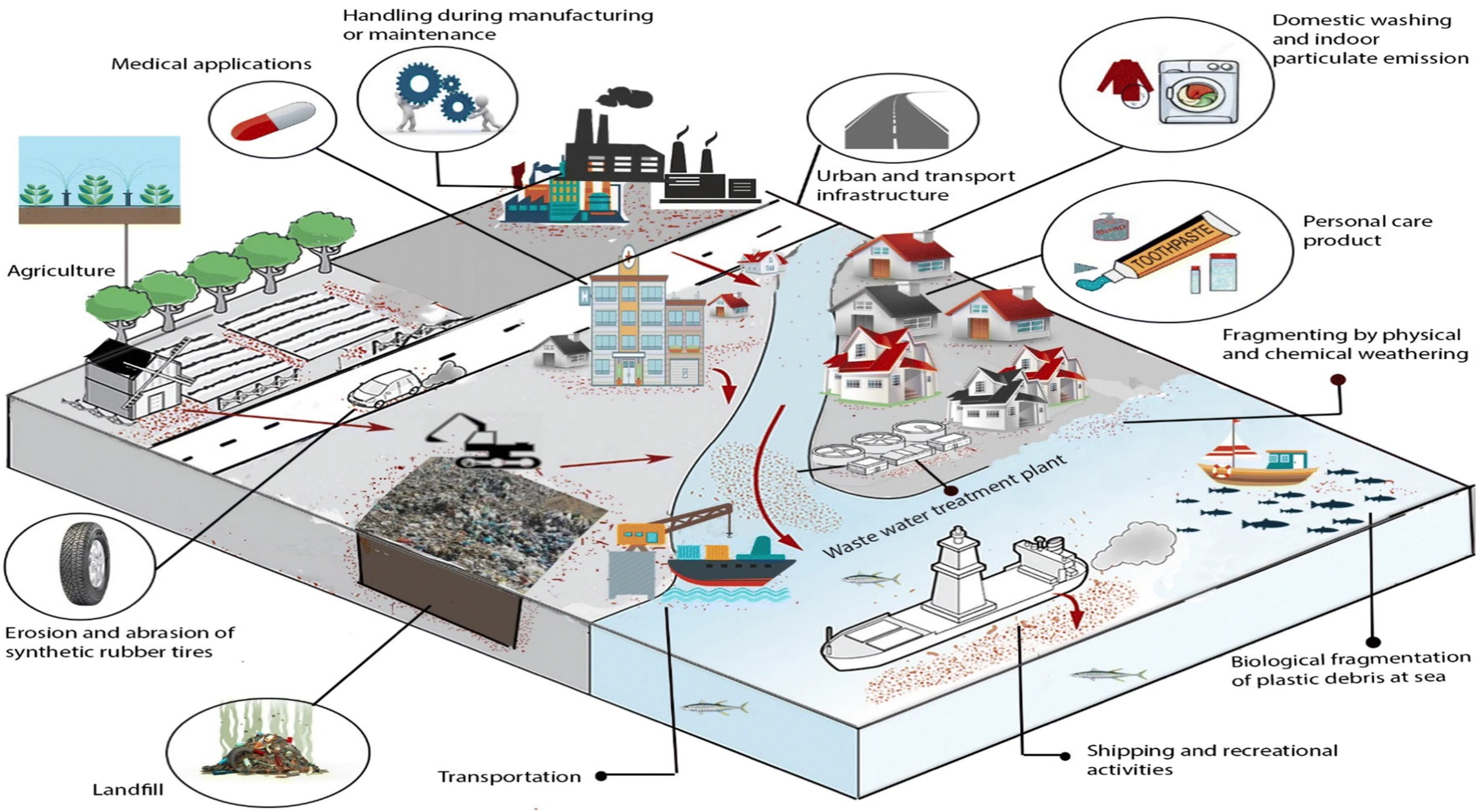
PLASTIC POST-CONSUMER WASTE
treatment in 2020 (preliminary data)



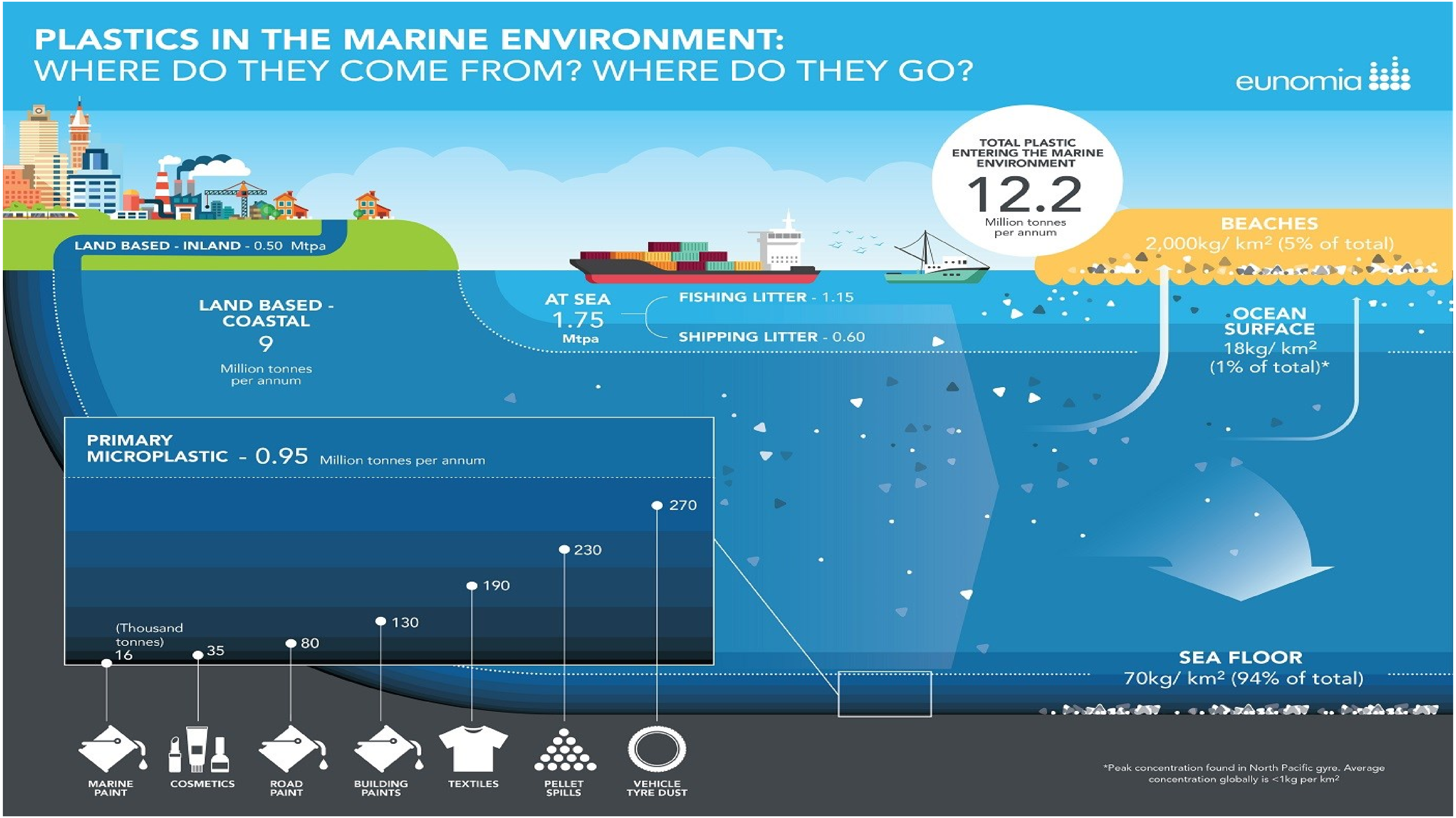
2006—2020
Total waste collected
(Mt)



The plastic journey… fom the land to the sea



Karbalaei et al., 2018. Env. Sci. Pollut. Res. Int.


PLASTICS IN THE MARINE ENVIRONMENT:
WHERE DO THEY COME FROM? WHERE DO THEY GO?
eunomia
TOTAL PLASTIC ENTERING THE MARINE ENVIRONMENT
12.2
Million tonnes per annum
LAND BASED - INLAND - 0.50 Mtpa
LAND BASED - COASTAL
9
Million tonnes per annum
AT SEA
1.75
Mtpa
FISHING LITTER - 1.15
SHIPPING LITTER - 0.60
BEACHES
2,000kg/ km² (5% of total)
OCEAN SURFACE
18kg/ km²
(1% of total)*
PRIMARY MICROPLASTIC - 0.95 Million tonnes per annum
(Thousand tonnes)
16
35
80
130
190
230
270
MARINE PAINT
COSMETICS
ROAD PAINT
BUILDING PAINTS
TEXTILES
PELLET SPILLS
VEHICLE TYRE DUST
SEA FLOOR
70kg/ km² (94% of total)
*Peak concentration found in North Pacific gyre. Average concentration globally is <1kg per km²

PLASTICS AND MICROPLASTICS…THE TIP OF THE ICEBERG

Microplastics: plastic particles < 5 mm

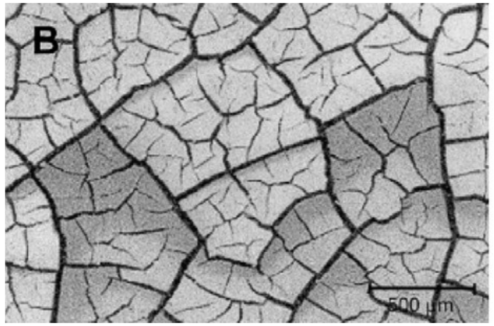
ORIGIN OF MICROPLASTICS

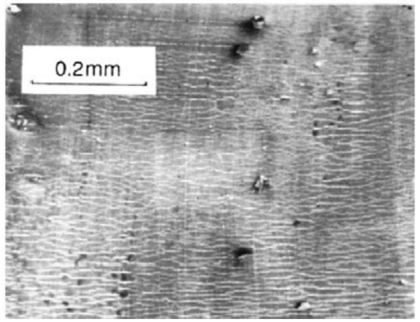
Primary MPs - Direct introduction:

- the micron-sized plastic particles used as exfoliants in cosmetic formulations
- industrial abrasives in synthetic ‘sandblasting’ media (beads of acrylic plastics and polyester)
- "nurdle" pre-production plastic pellets




Secondary MPs - Weathering breakdown of meso- and macroplastics

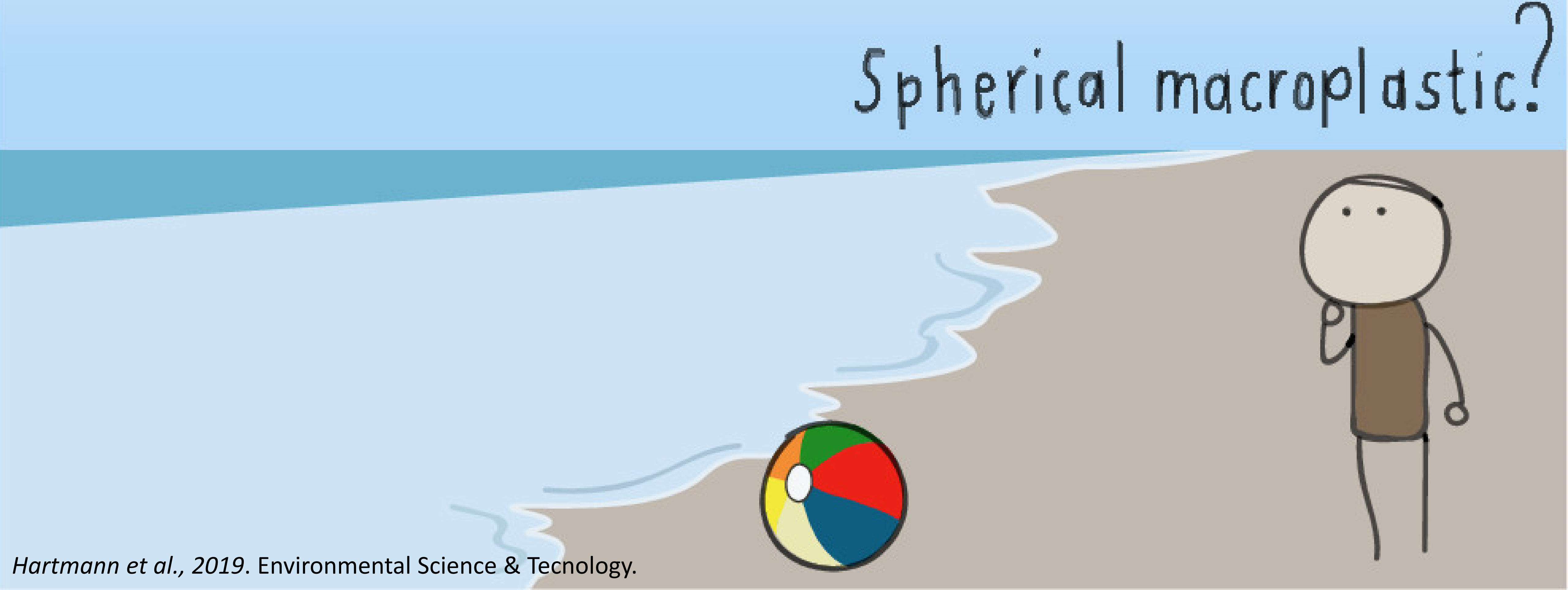






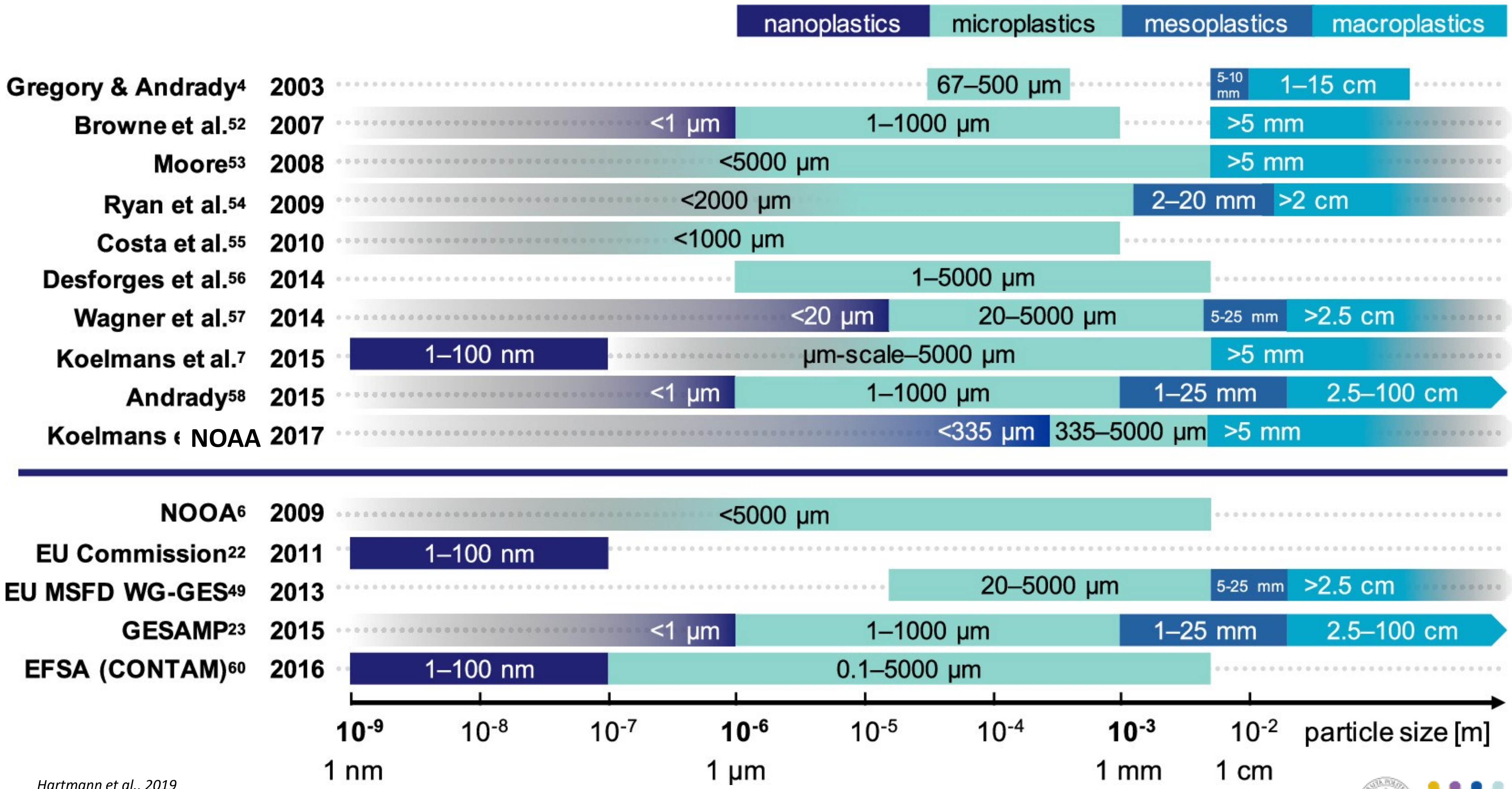
Textile fibers

Are we speaking the same language? Recommendations for a definition and categorization framework for plastic debris



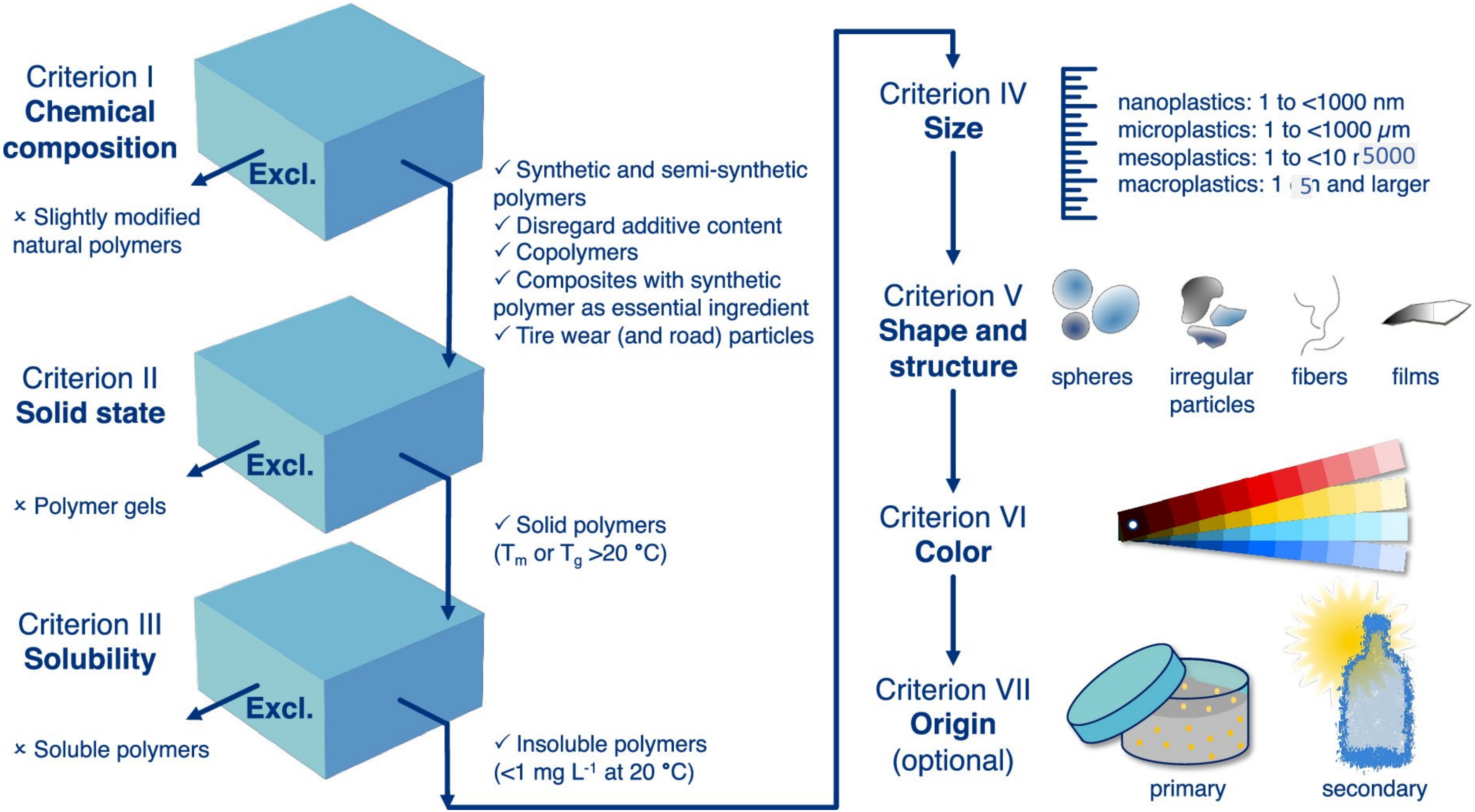
Hartmann et al., 2019. Environmental Science & Tecnology.

Microplastic definitions from scientific literature and international agencies



Hartmann et al., 2019

CRITERIA FOR MACROPLASTIC CATEGORIZATION



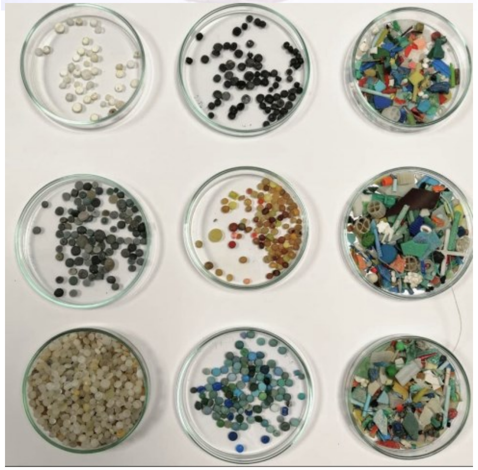
Hartmann et al., 2019

PLASTIC E MICROPLASTIC… IT'S A SIZE MATTER

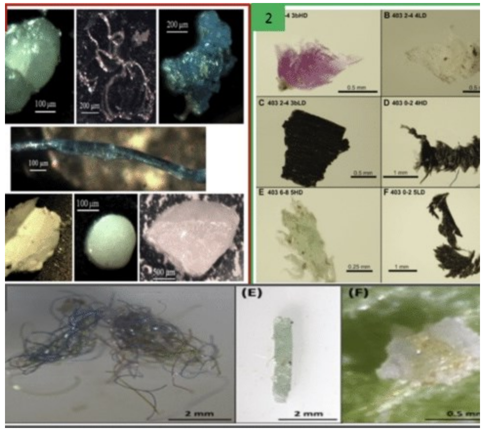
MACROPLASTIC > 5 cm

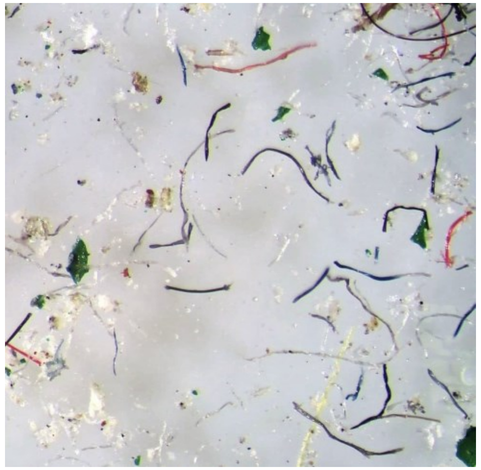
MESO PLASTIC
Small macroplastic
5mm - 5 cm

Large microplastic
1- 5 mm



MICROPLASTIC
1- 1000 µm (1mm)





<1µm (0,001mm) nano-plasticS

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Considering shape MPs can be defined as

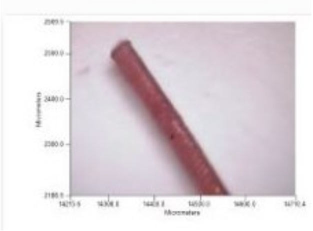
Fragment

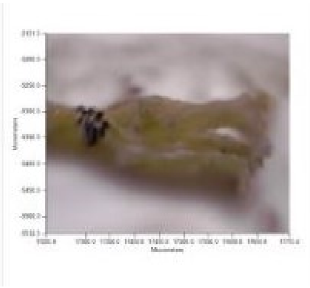
Film

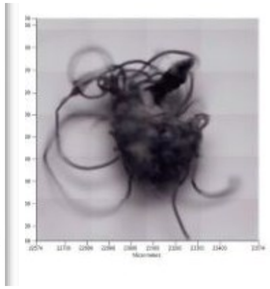
Pellet

Line

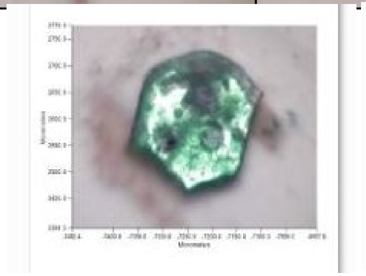
Fiber

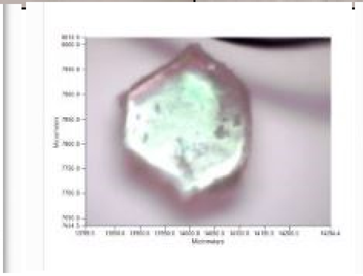


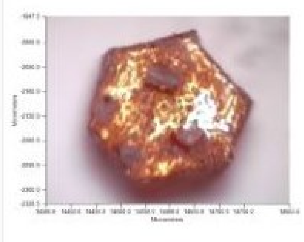




Fragment/Glitter







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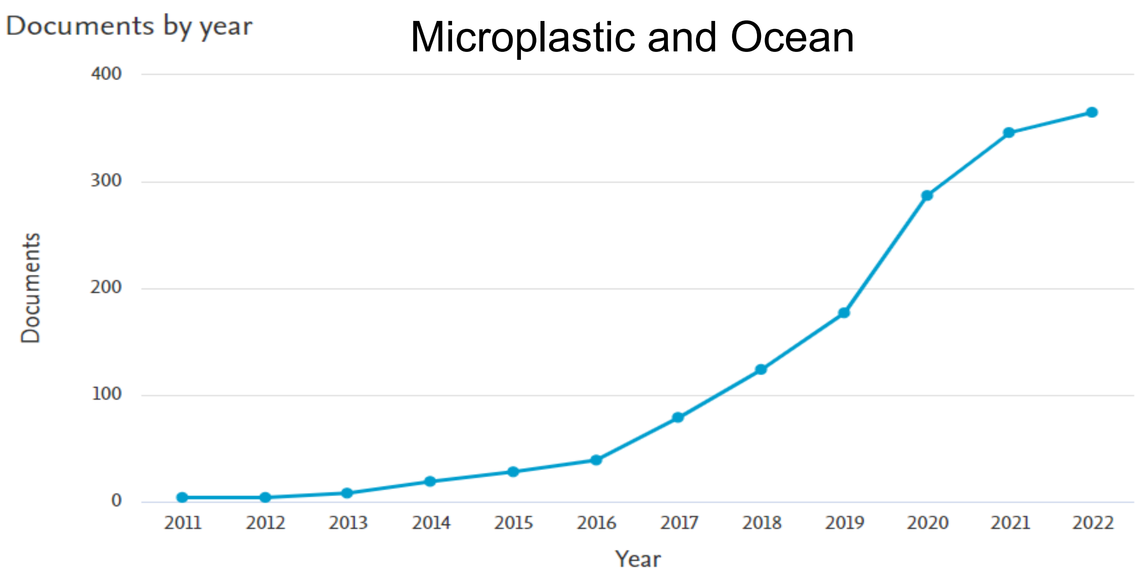

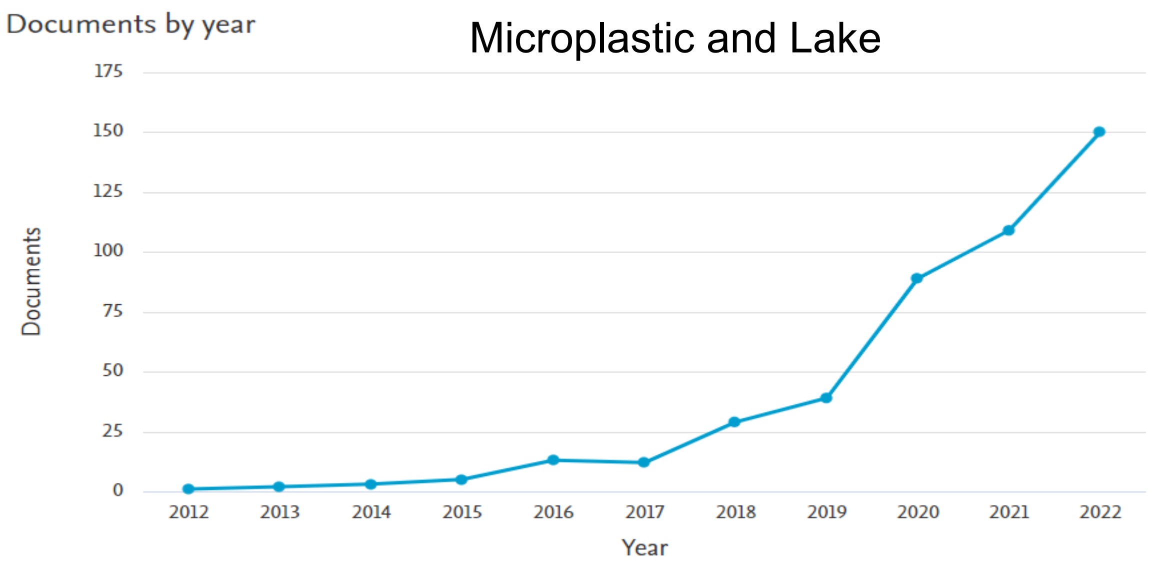

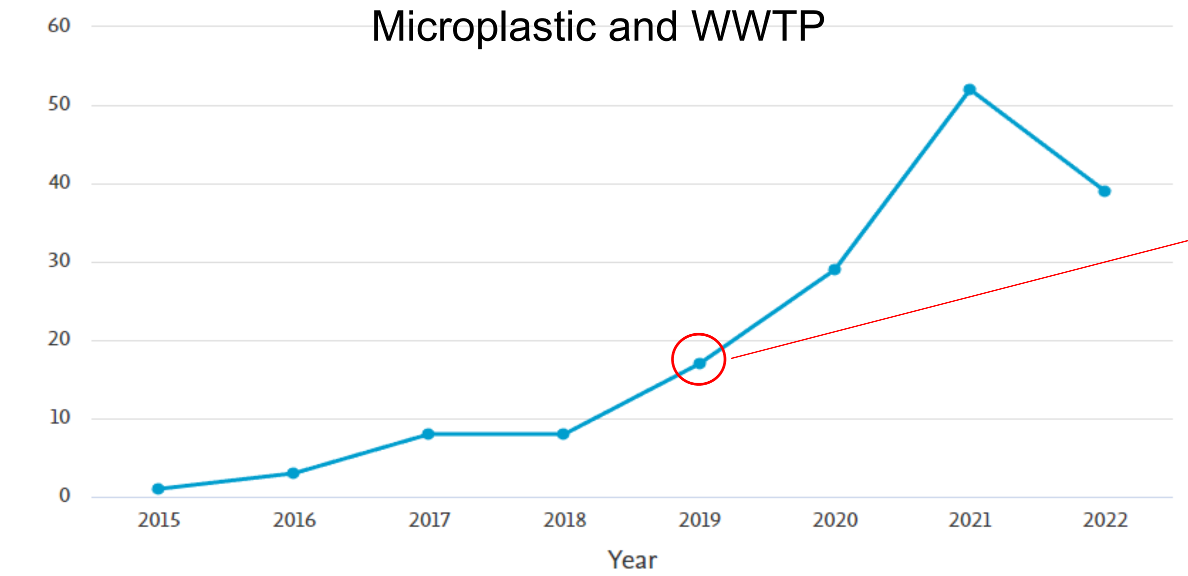

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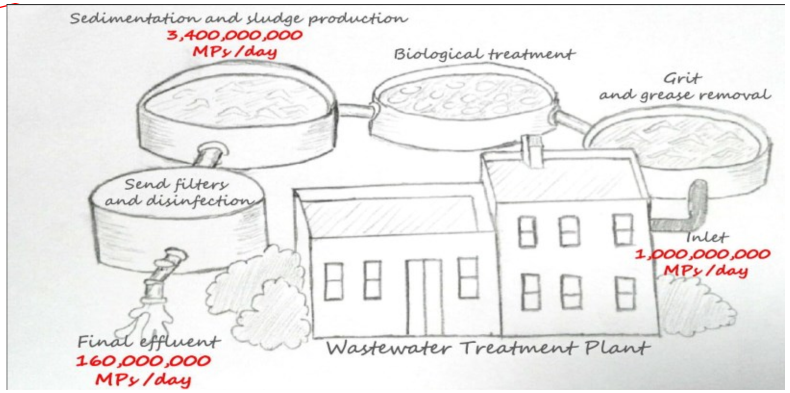
The fate of microplastics in an Italian Wastewater Treatment Plant

Stefano Magni [a,*], Andrea Binelli [a,*], Lucia Pittura [b], Carlo Giacomo Avio [b], Camilla Della Torre [a], Camilla Carla Parenti [a], Stefania Gorbi [b,c], Francesco Regoli [b,c]



Blue Lakes

Our Consortium

EPHEMARE

ECOTOXICOLOGICAL EFFECTS OF MICROPLASTICS IN MARINE ECOSYSTEMS

PRIN
Ministero dell'Istruzione dell'Università e della Ricerca

SORGENTI-PRESENZA-DINAMICA-DESTINO

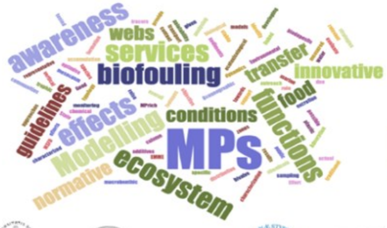
EFFETTI

EMME

Exploring the fate of Mediterranean microplastics: from distribution pathways to biological effects

Ecophysiology

Oceanography



Ecotoxicology

Experimental ecology

Durata
2018 – 2021

UNIVERSITÀ POLITECNICA DELLE MARCHE
UNIVERSITÀ DI SIENA
UNIVERSITÀ DI BOLOGNA
UNIVERSITÀ DEGLI STUDI DI PALERMO

LEGAMBIENTE
Global Nature Fund
Bodensee Stiftung
UNIVERSITÀ POLITECNICA DELLE MARCHE
PlasticsEurope

Blue Lakes

IL NOSTRO IMPEGNO A TUTELA DEI LAGHI. NO MICROPLASTICS, JUST WAVES.

FONDAZIONE Cariverona

SOLVING

Technologies and circular economy to counteract the impact of plastic in the Conero Riviera (Italy)

Ministero della Salute *Direzione generale della ricerca e dell'innovazione in sanità* ***BANDO RICERCA FINALIZZATA 2019 fondi esercizio finanziario 2018-2019***	***Titolo progetto:*** MicroPLASTICs in edible aquatic organisms: ecotoxicological effects, transfer of chemical and biological CONtaminants and susceptibility to bacteria biodegradation (PLASTICON)
Codice progetto: RF-2019-12370587	***Destinatario Istituzionale:*** Istituto Zooprofilattico Sperimentale dell'Umbria e delle Marche


JPI OCEANS

DELIVERABLE D4.2

Standardised protocol for monitoring microplastics in sediments

BASEMAN MICROPLASTICS ANALYSES IN EUROPEAN WATERS

JPI OCEANS

DELIVERABLE D4.1

Standardised protocol for monitoring microplastics in seawater

2019

BASEMAN MICROPLASTICS ANALYSES IN EUROPEAN WATERS

JPI OCEANS

DELIVERABLE D4.3

Harmonized protocol for monitoring microplastics in biota

2019

BASEMAN MICROPLASTICS ANALYSES IN EUROPEAN WATERS

EPHEMARE

ISO/DIS 24187

ISO/TC 61/SC 14 Secretariat: DIN

Voting begins on: 2021-12-08

Voting terminates on: 2022-03-02

Principles for the analysis of plastics and microplastics present in the environment


Blue Lakes

No microplastics, just waves.

NO MICROPLASTICS, JUST WAVES.

Deliverable ACTION B3

TECHNICAL REPORT AND OPERATING MANUAL ON THE IMPROVEMENT OF THE TREATMENT PROCESS

Manuale tecnico-operativo per l'analisi delle microplastiche negli impianti di trattamento acque

A cura di:

Dr. Lucia Pittura (DiSVA, UNIVPM)

Dr. Veronica Vivani (DiSVA, UNIVPM)

Dr. Serena Radini (SIMAU, UNIVPM)

Dr. Alessia Foglia (SIMAU, UNIVPM)

Prof. Stefania Gorbi (DiSVA, UNIVPM)

Prof. Anna Laura Eusebi (SIMAU, UNIVPM)

Prof. Francesco Fatone (SIMAU, UNIVPM)

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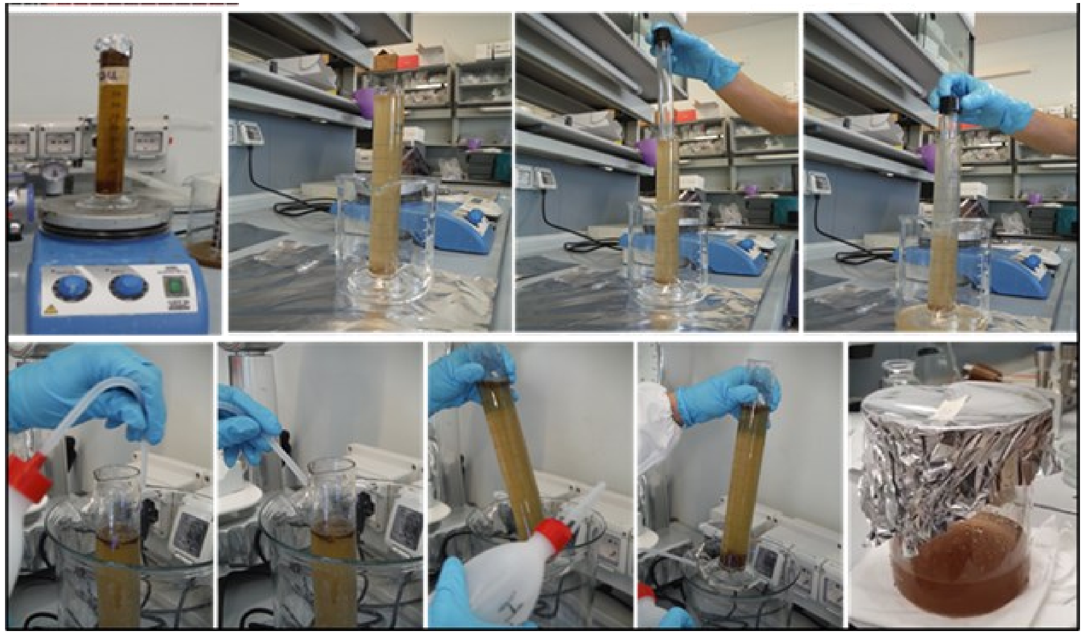
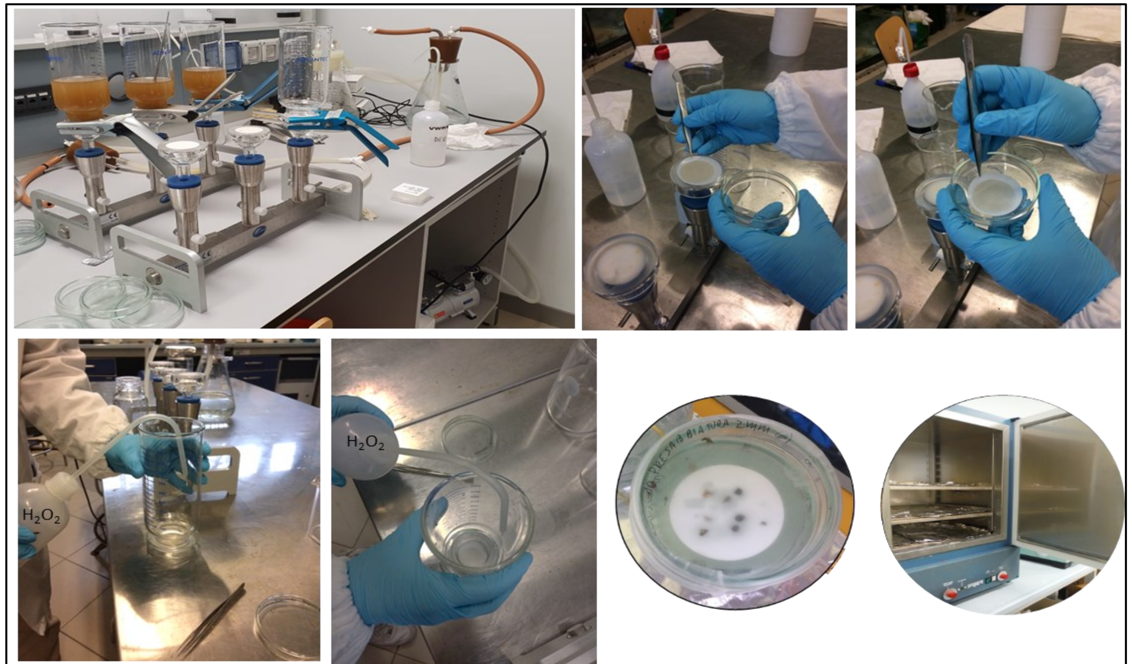
Global Nature Fund

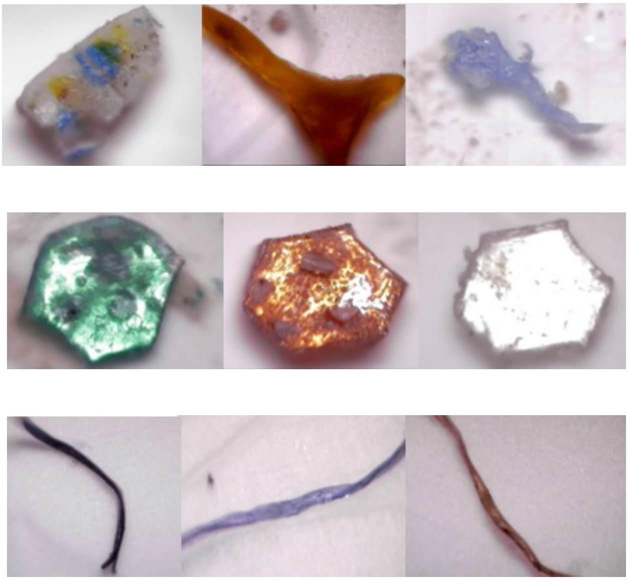
PlasticsEurope

1

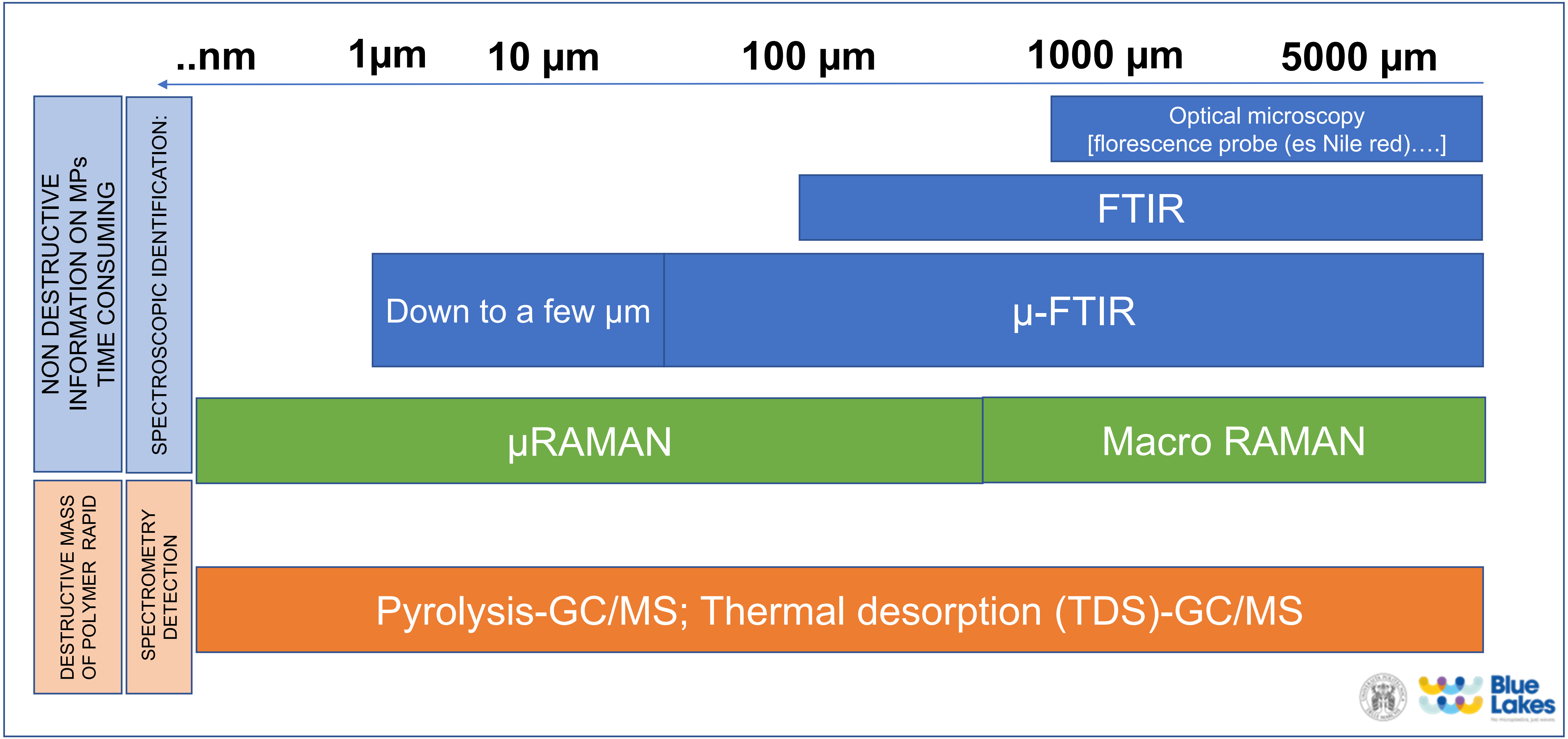
MPs extraction from environmental matrices: from sample collection to visual sorting





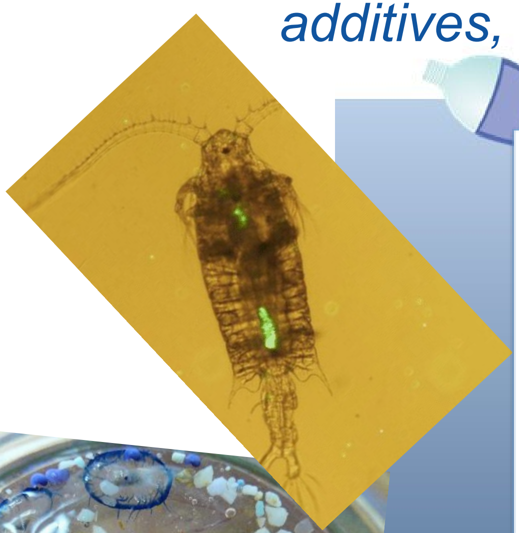


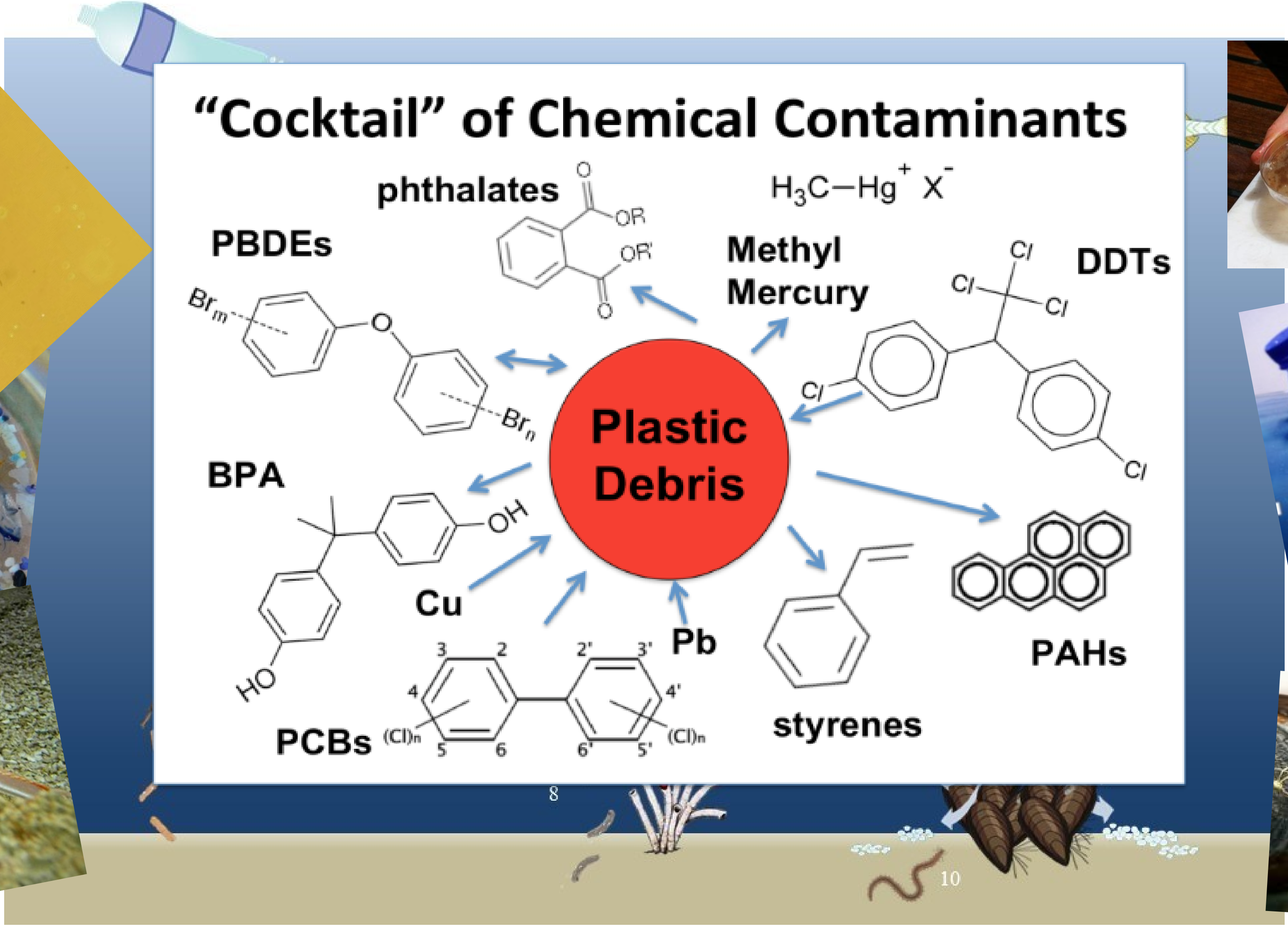
Quantification of MP in biotic and abiotic matrices
Different approach → Different results

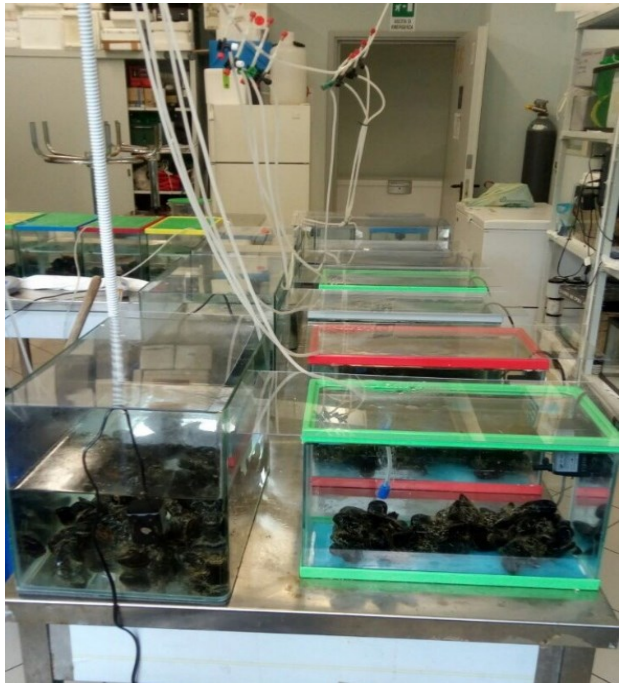


GENERAL CONCERN FOR MICROPLASTICS IN BIOTA

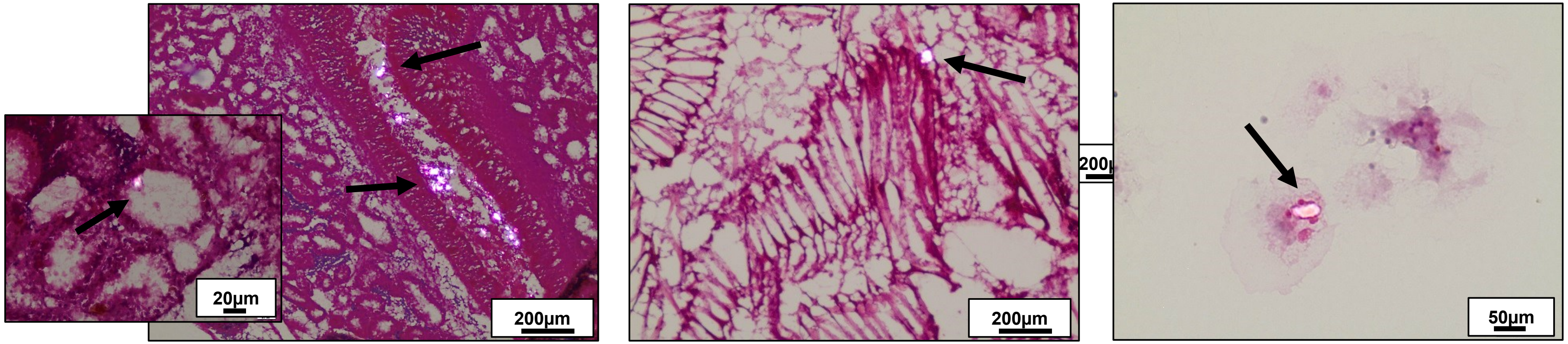
Accumulated in biota, they induce pseudo-satiety, physical damages, mechanical blockage of gastro-intestinal system, respiratory and locomotory appendages…but they can also release chemical additives, adsorb pollutants from seawater and transfer to trophic webs…



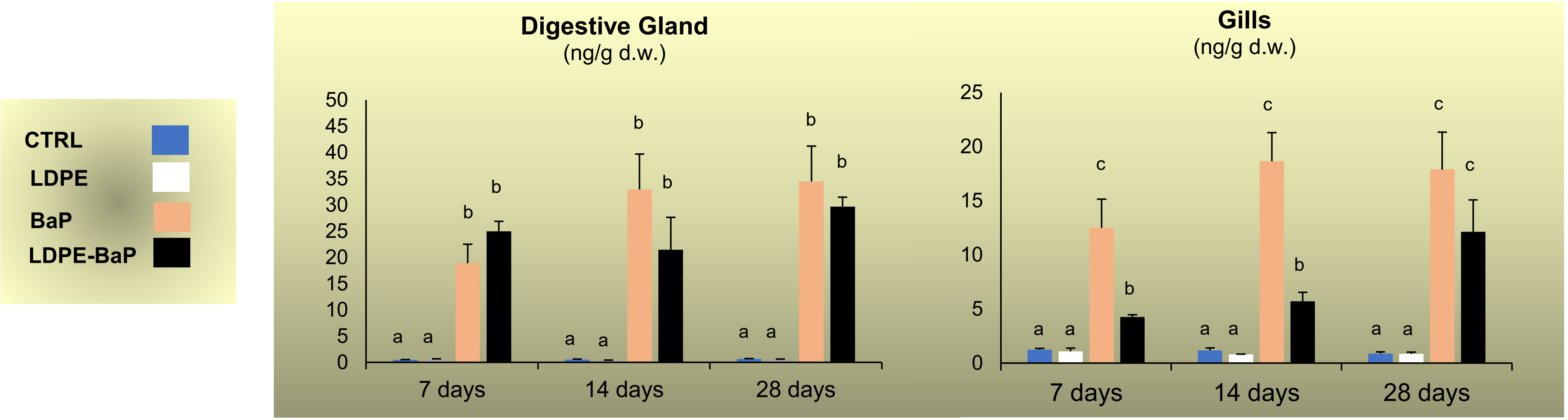




INGESTION, INFLAMMATION AND…



…BIOACCUMULATION: MICROPLASTICS AS PAH VECTOR

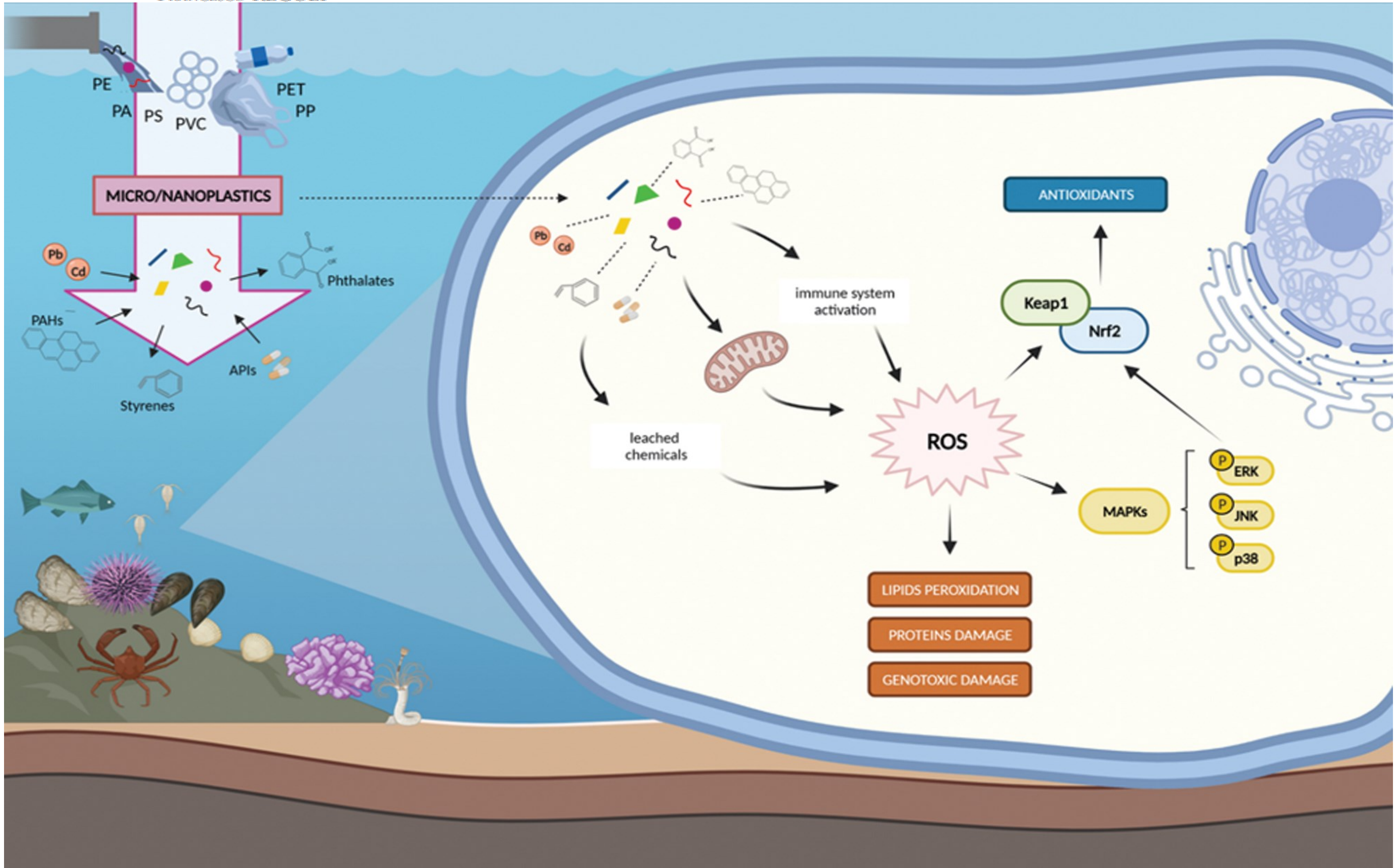


BIOCELL
2022 46(1): 37-49

Tech Science Press

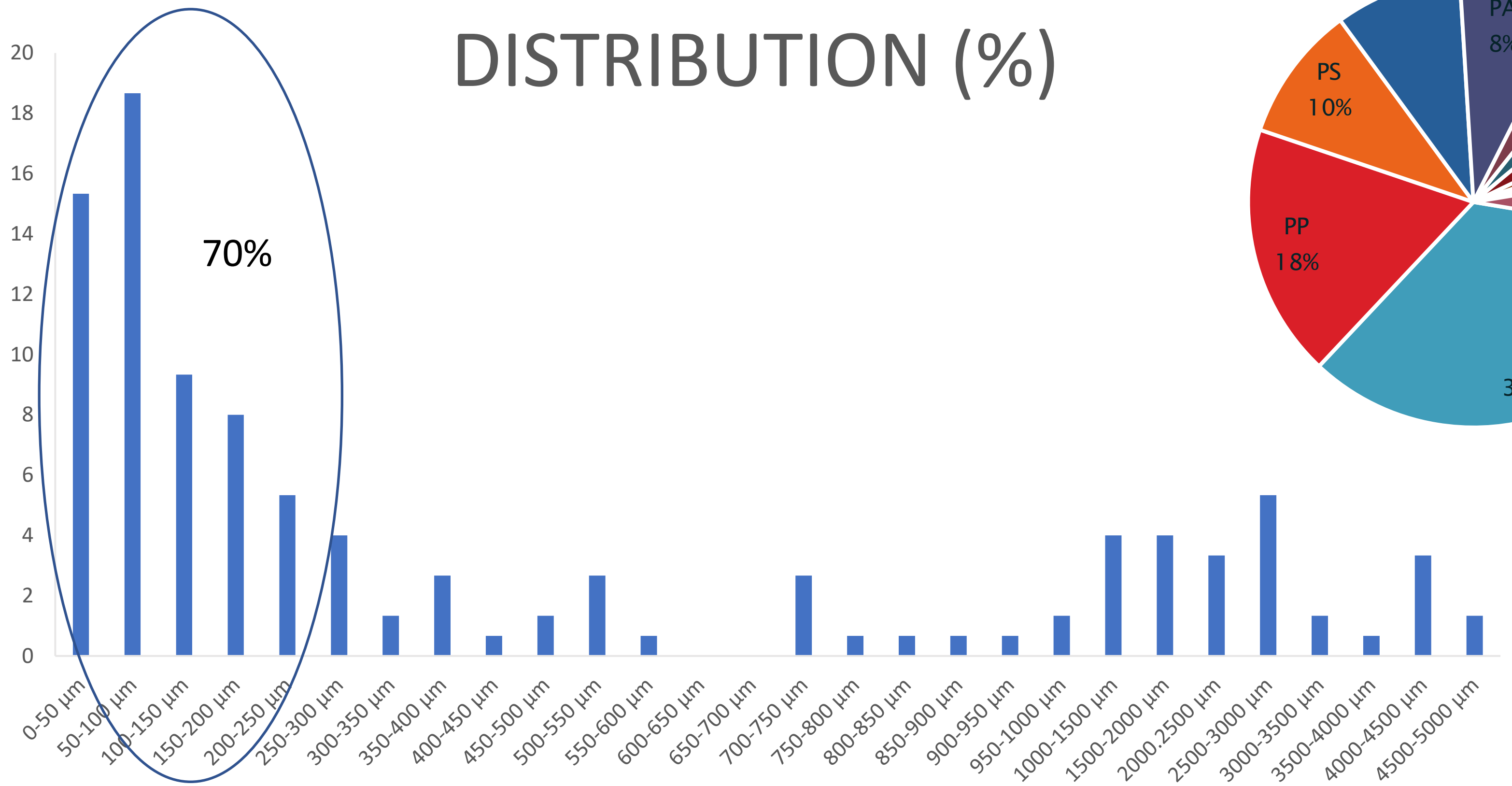
Emerging environmental stressors and oxidative pathways in marine organisms: Current knowledge on regulation mechanisms and functional effects

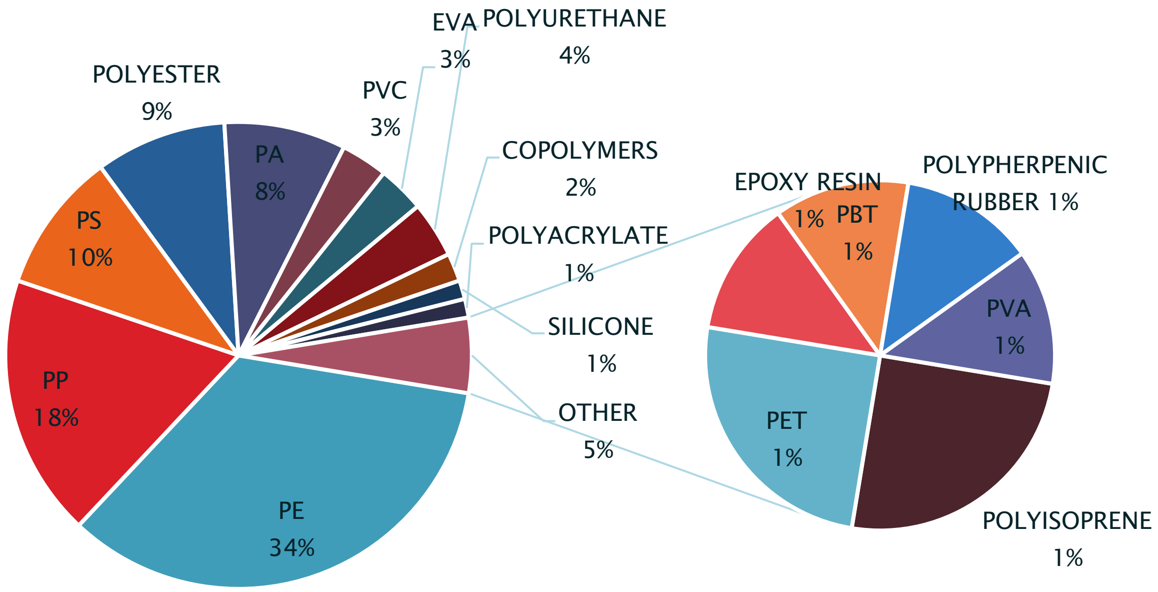
Maura BENEDETTI*; Maria Elisa GIULIANI; Marica MEZZELANI; Alessandro NARDI; Lucia PITTURA; Stefania GORBI; Francesco REGOLI



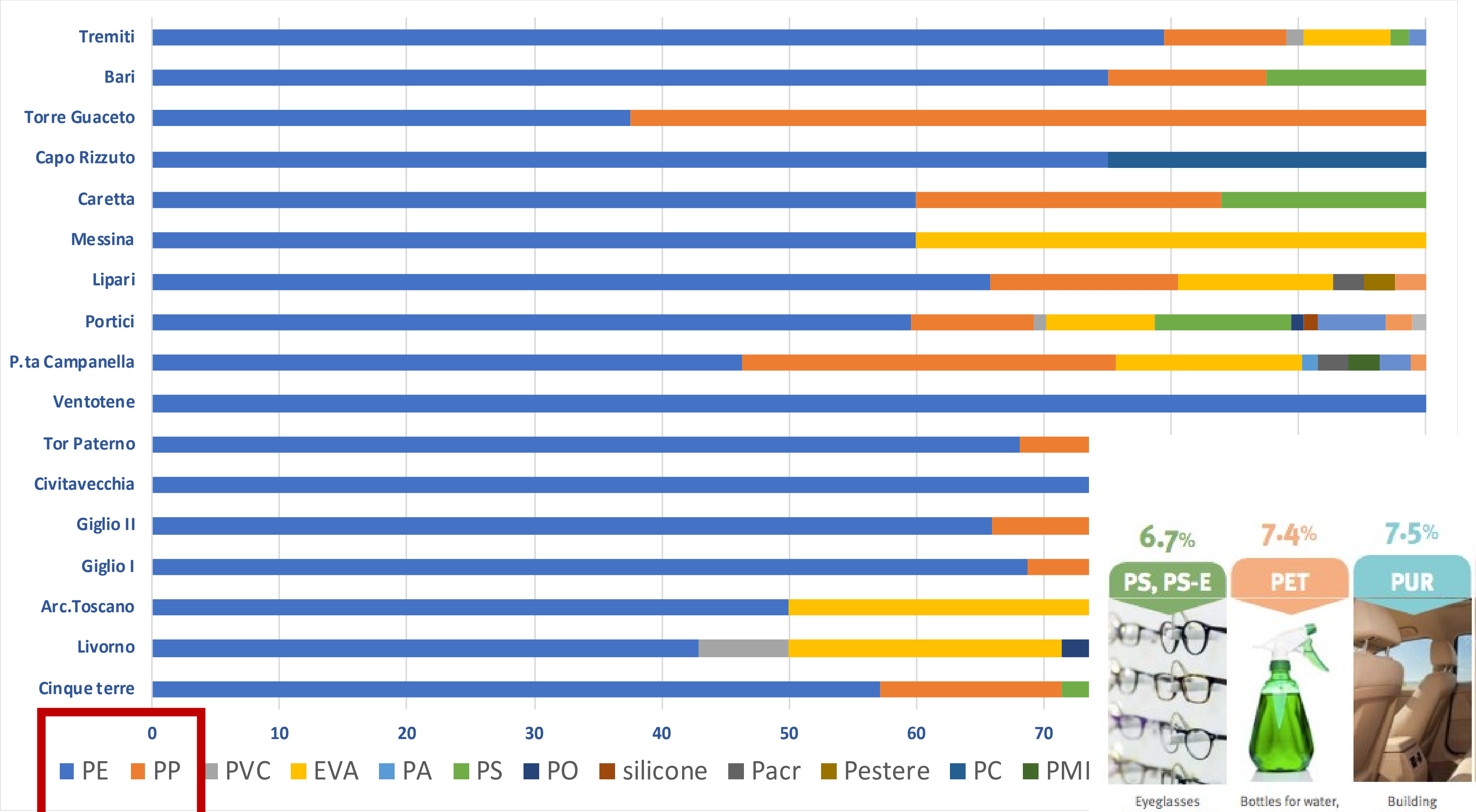
Blue Lakes

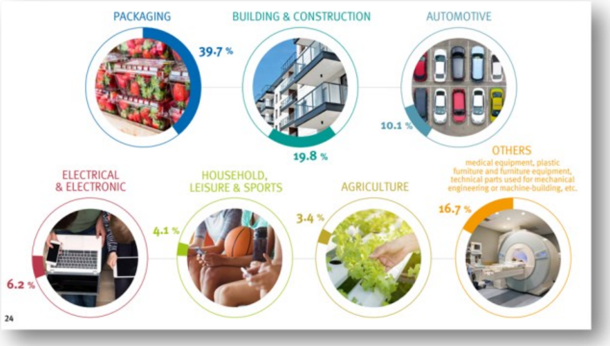
Morphological and polymeric characterization of MPs ingested by marine organisms



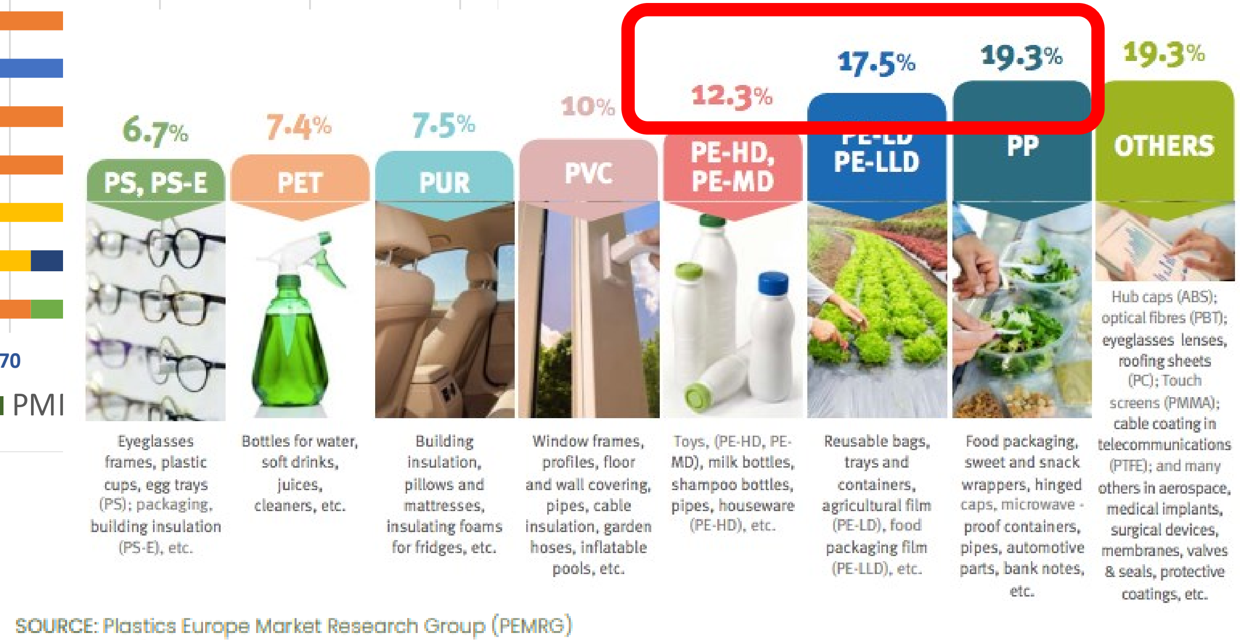


Microplastics in superficial sea water : polymeric characterization





Richiesta europea di plastica-polimeri (2020)



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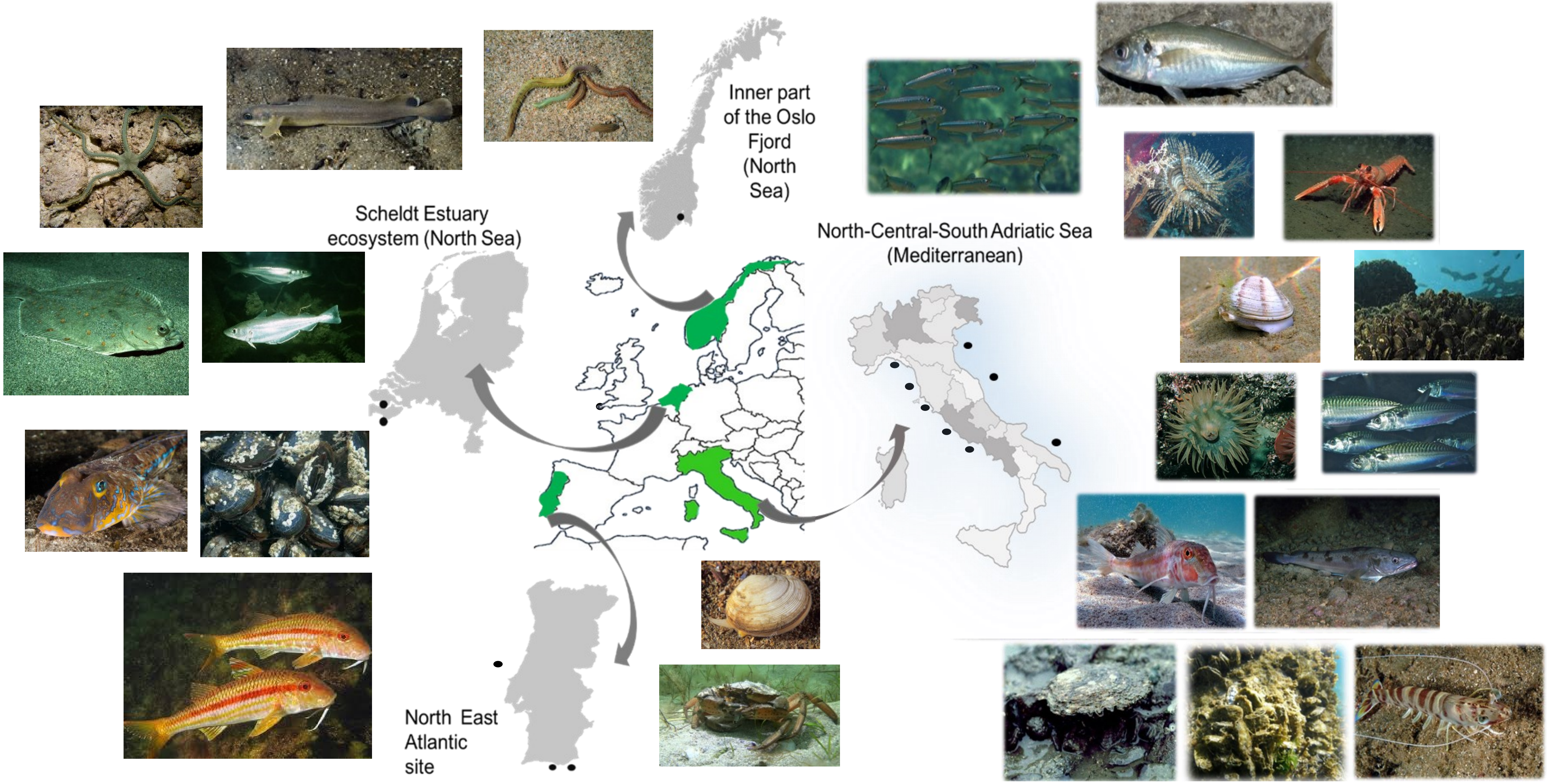
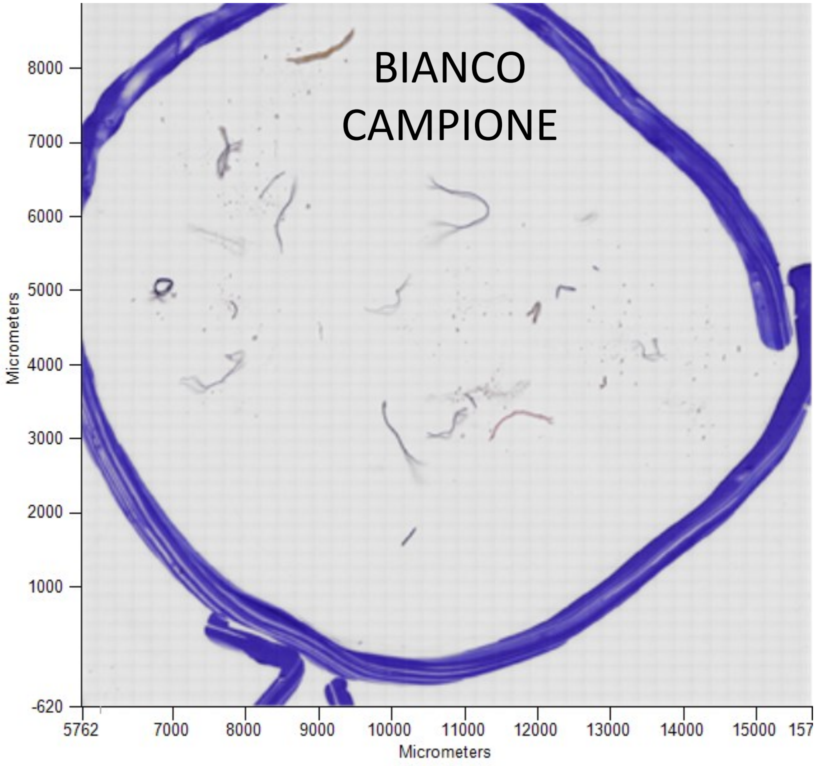
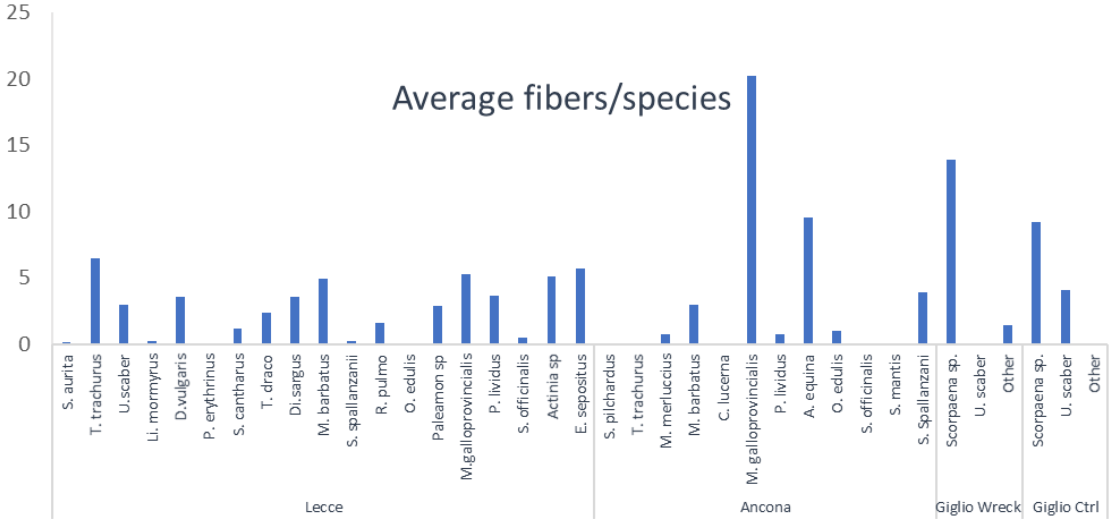
Field studies… biota investigations

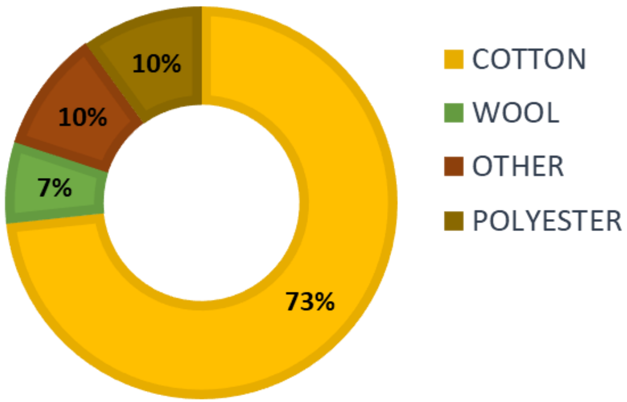
Thousands of analyzed organisms, more than 50 species, high ingestion frequency (about 20-30% reaching 90% in some cases), low number of MPs, independent from biological and ecological characteristics



…particular attention to micofibers due to airborne contamination…







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No microplastics, just waves.

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NO MICROPLASTICS, JUST WAVES.

Deliverable ACTION B3

TECHNICAL REPORT AND OPERATING MANUAL ON THE IMPROVEMENT OF THE TREATMENT PROCESS

Manuale tecnico-operativo per l'analisi delle microplastiche negli impianti di trattamento acque

A cura di:

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Microplastics in urban water cycle: Origins – Pathways – Fate

Università Politecnica delle Marche

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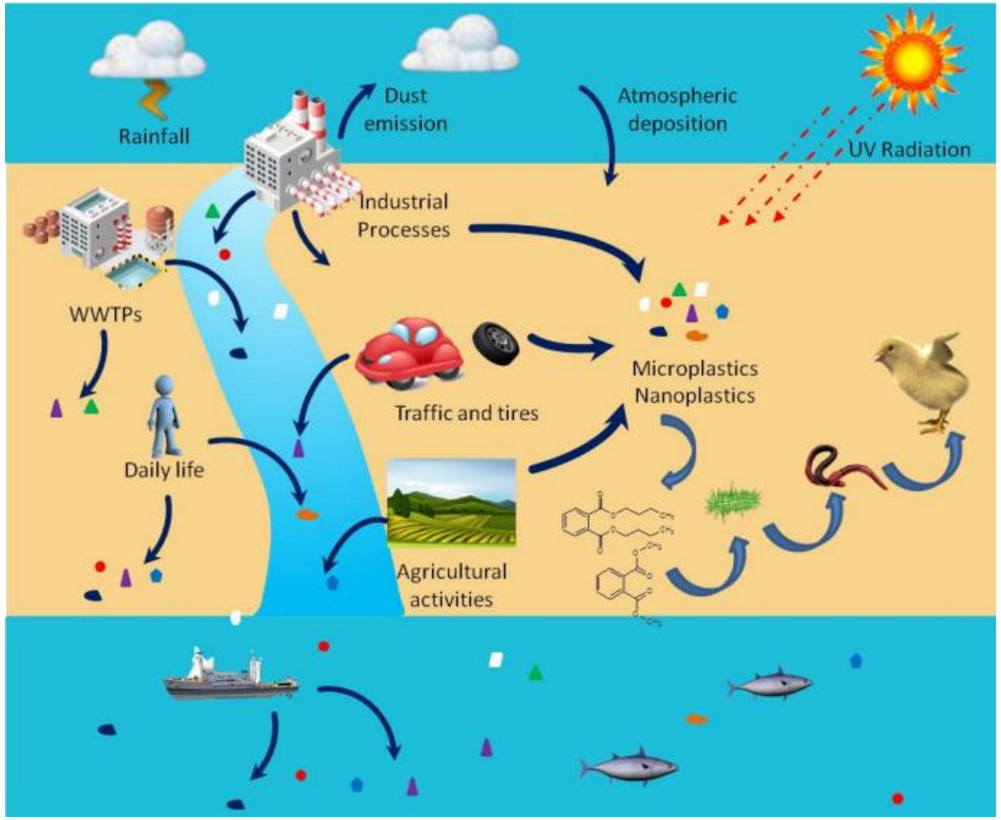
The origin of microplastics in the environment and in water



2016 — world production of plastics (packaging) > 320 million tons

60-80% of global waste is plastic (Derraik, 2002)

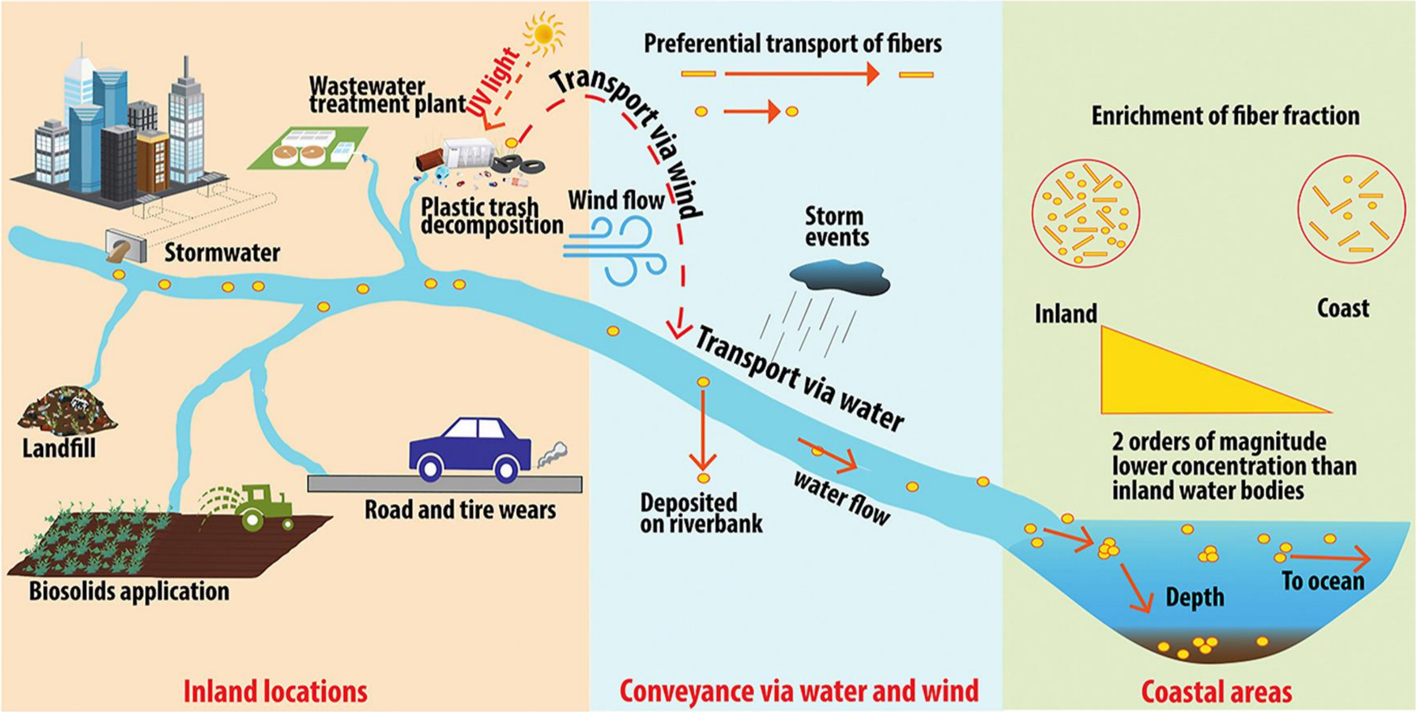
5-13 million tons of plastic waste enter the oceans each year (World Economic Forum, 2016).

Decomposition through chemical-physical mechanisms, such as photo-oxidative processes and mechanical forces

These processes break down larger plastic residues into smaller particles, forming microplastics (smaller than 5 mm in size) and nanoplastics (between 1 and 100 nm in size).

Microplastics in the Integrated Water Service

The origin of microplastics in the environment and in water



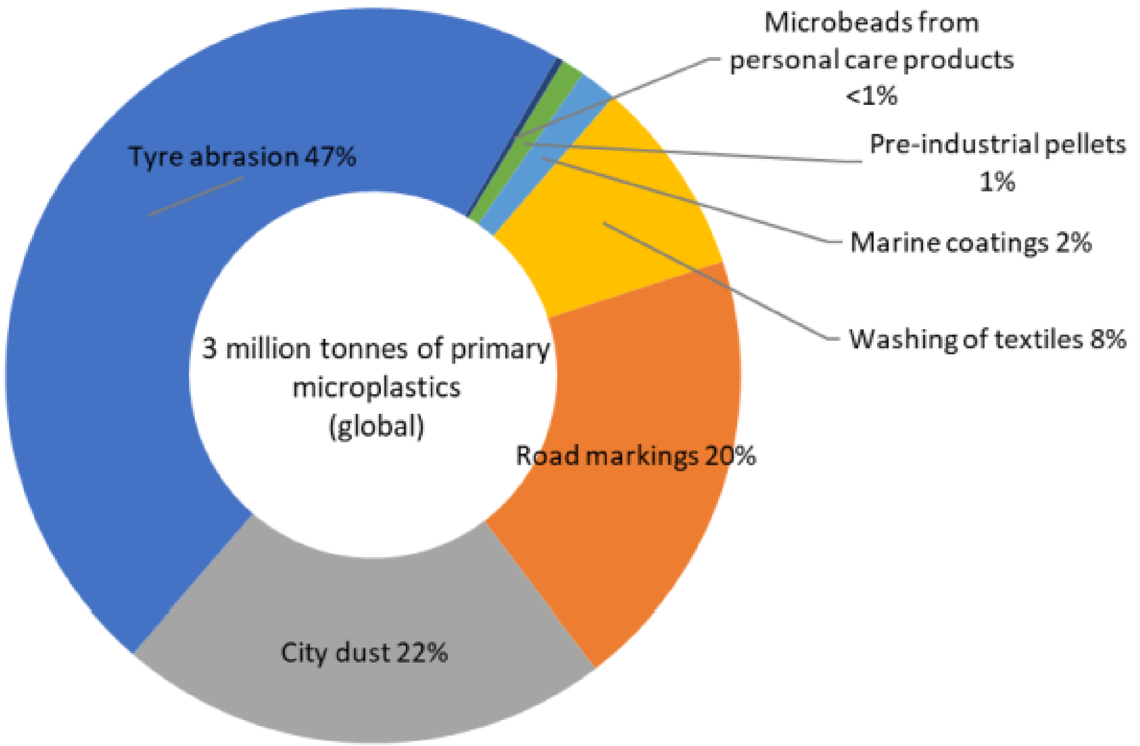
Approximately 42,000 tonnes of microplastics end up in the environment every year, when products containing them are used. Furthermore, **the release of accidentally formed microplastics** (when larger pieces of plastic wear out) into European surface waters is estimated to be around **176 000 tonnes per year**.

Source: https://echa.europa.eu/it/hot-topics/microplastics

Microplastics in the Integrated Water Service

The origin of microplastics in the environment and in water

Figure 2.3 Sources of primary microplastic release to the environment, global, estimated yearly releases, per cent



Source: UNEP (2018)

Vehicle tire abrasion is the predominant source of microplastic release into the environment, followed by **road markings** and the so-called "**city dust**", linked to built areas.

In addition to this: the abrasion of shoe soles; peeling and flaking paints and coatings; textile microfibres released through washing; road and sewage run-off; cosmetics

Microplastics in the Integrated Water Service

Microplastics transport

ATMOSPHERIC TRANSPORT

Atmospheric deposition: transport mechanisms and tendency of the smallest particles to be transported due to the effect of the wind. This would explain the discovery of microplastics even in places where human activity is reduced or absent.

LAND TRANSPORT

- road marking paints
- tire wearing
- city dust: result of the abrasion of various plastic objects common in urban areas (e.g. shoe soles, synthetic turf, ...)

WATER TRANSPORT

- civil waste water
- industrial waste water
- urban runoff water
- agricultural runoff water

domestic microplastics: synthetic textile fibers lost during washing, wear products of plastic materials, seals, paints and microbeads

industrial microplastics: cement pastes, drilling fluids, rust removers and paints

Pipes subjected to wearing

Sewer overflows (mixed sewage systems in the presence of intense atmospheric precipitation)

Microplastics in the internal waters

Inland waters certainly represent one of the ideal means for their diffusion, as they are able to collect and transport contaminants from numerous environmental sources, even over long distances. From here, microplastics can reach marine environments (often the final receptors of plastic pollution), fragment into smaller particles (even nanoplastics, which require different analytical techniques and toxicological assessments to be detected) or reach drinking water plants.

Microplastics originating from industrial and urban activities can be conveyed into the sewage system, arriving at wastewater treatment plants. Even though these facilities can remove even more than 90% of MPs from wastewater, due to the large volumes treated, millions of microplastics are discharged into the environment every day.

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Microplastic determinations: Literature and state of the art, critical aspects and challenges

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Microplastics in the Integrated Water Service

Many studies have been conducted on the presence and dispersion of microplastics in the marine environment (since the 1970s) but even freshwater is not immune to this problem.

To date, for inland waters and especially for lake waters, there are gaps in:

- quantity and distribution of microplastics in rivers and lakes
- characterization of the phenomenon
- time trends
- standards and protocols for monitoring, sample processing and analysis
- effects on aquatic organisms and ecosystems
- Information and awareness of the local population

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The legislation that establishes indicators and limits to monitor the quality of inland waters (Water Framework Directive 2000/60) does not consider the presence and effects of microplastics on their condition.

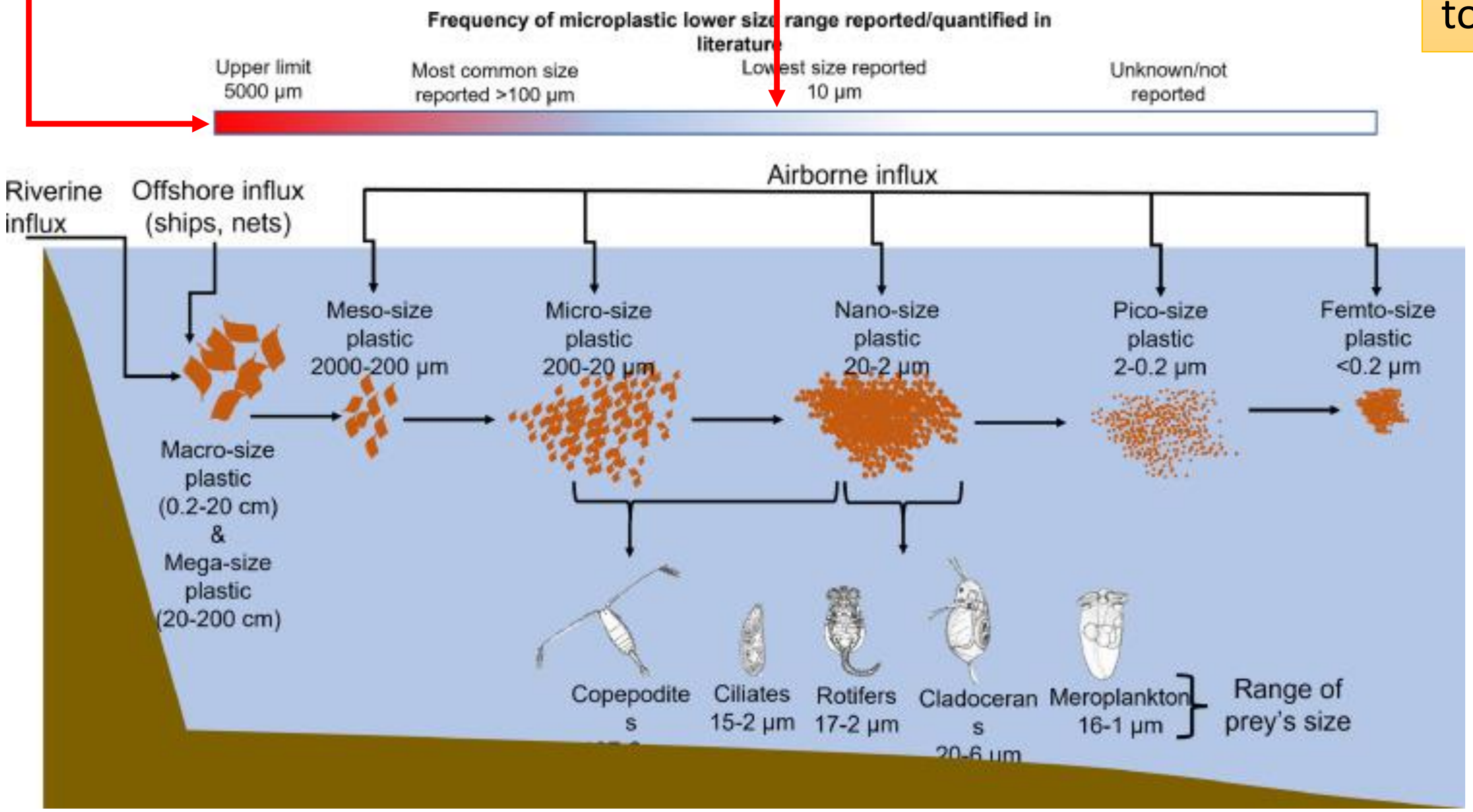
Dimensions

SUPERIOR LIMIT: 5 mm

IR CHARACTERISATION LIMIT: 20 µm

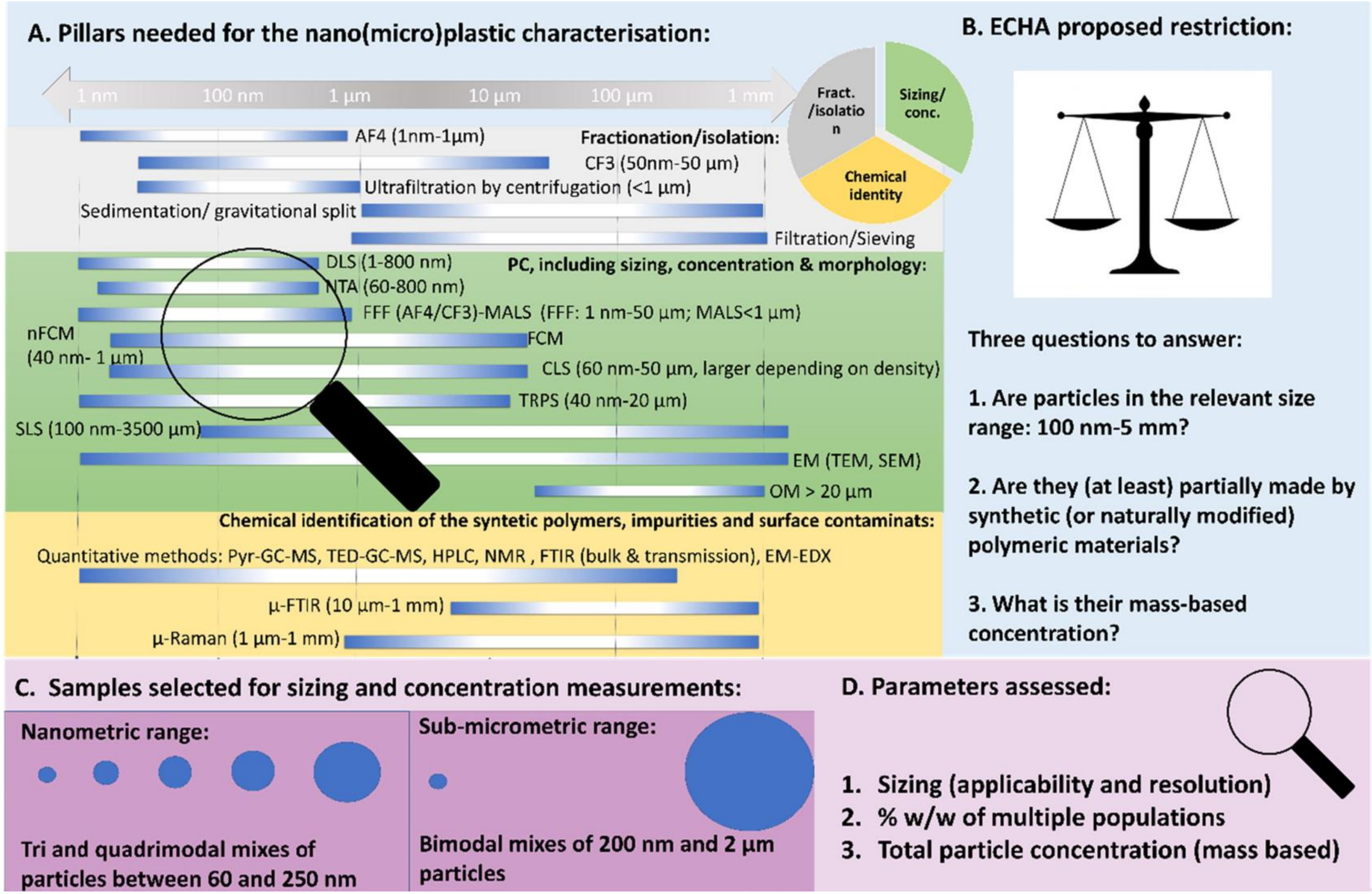
LITERATURE:
Inferior limits from 300 µm to < 3 µm

EVALUATE SIGNIFICANCE AND EFFECTIVENESS



Microplastics in the Integrated Water Service

Dimensions



F.Caputo et al., 2021

DIFFERENT METHODS WITH DIFFERENT LIMITS

IR CHARACTERISATION LIMIT: 20 µm

RELEVANCE OF MICROPLASTICS IN THE LOWER RANGES

FREQUENCY

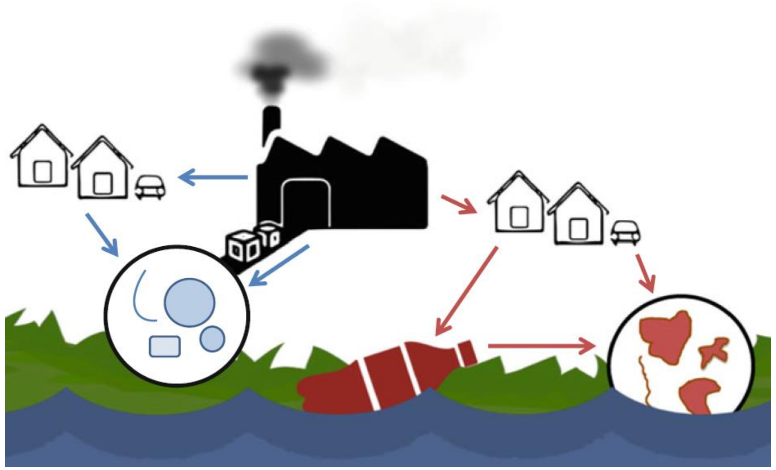
MASS

YIELDS OF THE SAMPLING METHODS FOR THE DIFFERENT MATRICES

MATRIX	RANGE
DRINKING WATER	20 µm – 5 mm
WASTEWATER - INFLUENT	50 µm – 5 mm
WASTEWATER - EFFLUENT	25 µm – 5 mm
SLUDGE	50 µm – 5 mm

Microplastics as Emerging Contaminants in the Integrated Water Service

- Microplastics include a wide class of contaminants
- They are characterized by strong heterogeneity
- They do not have the same behavior as other contaminants, such as dissolved or uniformly suspended chemicals
- The heterogeneities are amplified by the wide range of matrix types and samples that are analysed
- There are still many persistent knowledge gaps related to microplastics in water and sludge.
- Challenges in evaluating the full spectrum of characterization of microplastics in complex samples.
- Many microplastics characterization parameters are defined analytically, such as size limits due to sample processing or analytical techniques
- Furthermore, there is no instrument that can quickly measure microplastic content across the full spectrum of types and sizes.
- This introduces challenges associated with effectively defining "microplastics"



Microplastics in the Integrated Water Service

PRODUCTION

PRODUCTION

TRANSPORT

TREATMENT

RELEASE IN ENVIRONMENT

SAMPLING

FILTRATION

PRE-PROCESSING

QUANTIFICATION AND CHARACTERISATION

SAMPLING AND ANALYSIS

Microplastics in the Integrated Water Service

Measure

- Not homogenously distributed
- Variable dimensions
- Variable densities
- Different types with different chemical-physical characteristics (e.g. adhesion)

DRINKING WATER – TREATED WATER:

→ Low concentrations
→ Less input variability
→ Count of MPs: n. MPs/m3

WASTEWATER:

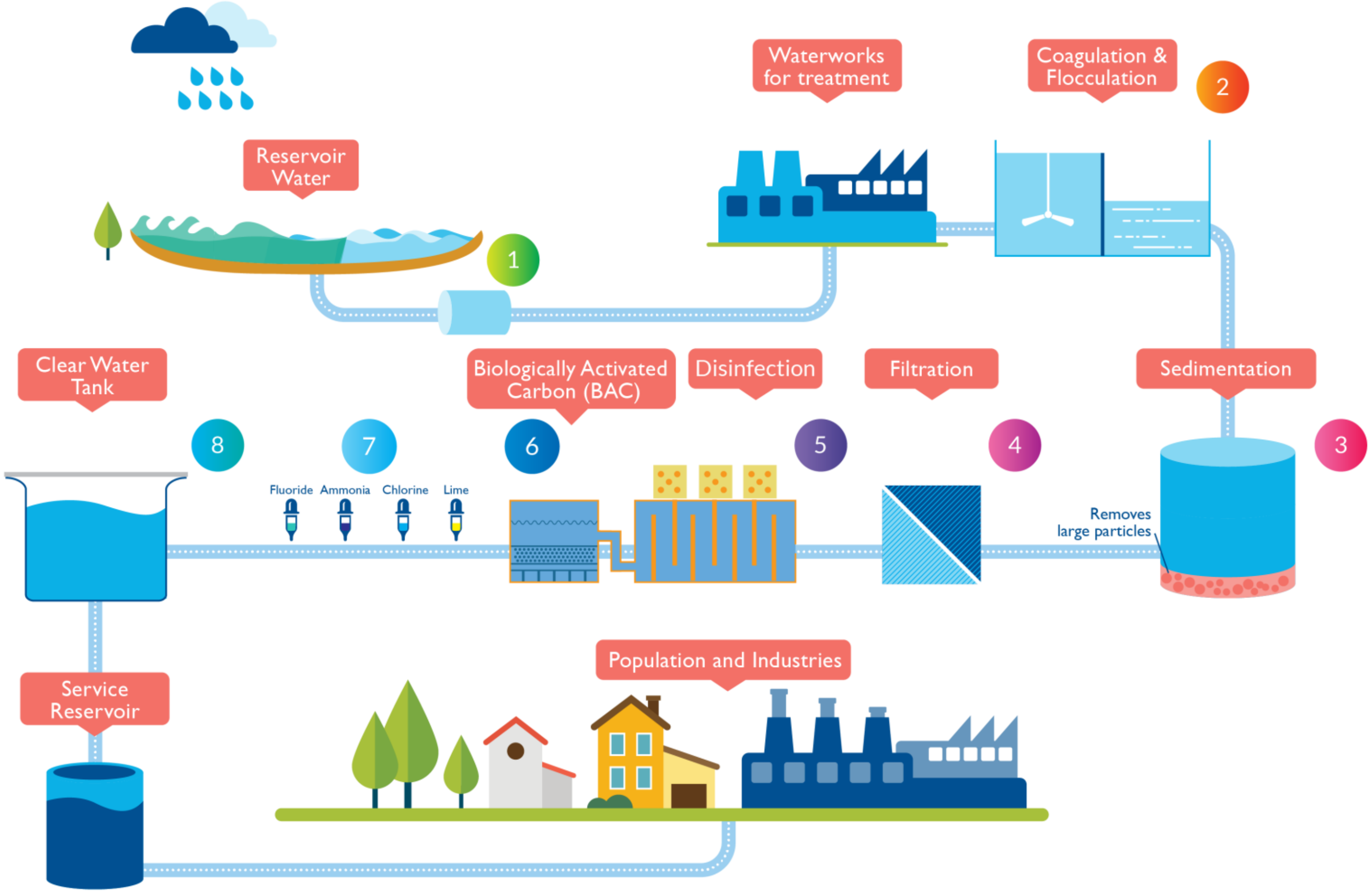
→ Higher concentrations
→ Greater input variability
→ Count of MPs: n. MPs/l or no. MPs/m3

SLUDGE:

→ Higher concentrations
→ Discontinuity (longer storage/retention times)
→ Count of MPs: n. MPs/d or no. MPs/m3 (some ref also in weight e.g. mg/g)

Microplastics in the Integrated Water Service

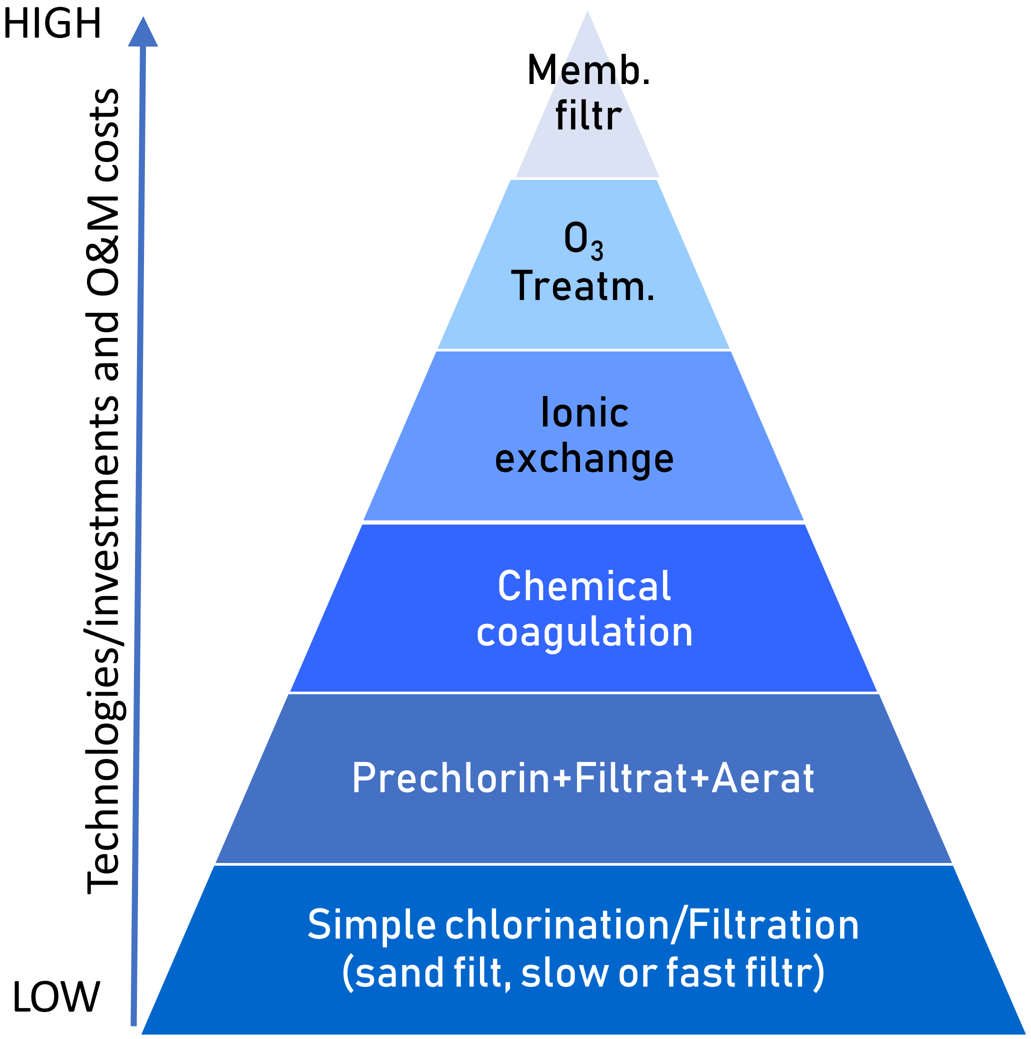
DWTPs



- INFLUENTIAL CHARACTERIZATION:
  - Uptake
  - Plant influent
- CHEMICAL-PHYSICAL TREATMENTS
  - Clari-flocculation and sedimentation
  - sludge
- OXIDATIVE TREATMENTS
  - Ozonation
- PHYSICAL TREATMENTS
  - Sand filtration
  - Carbon Filtration (GAC or BAC)
  - Backwash water
- DISINFECTION TREATMENTS
  - Chlorination
  - UV disinfection
- EFFLUENT CHARACTERIZATION:
  - System output
  - Distribution

Processes in DWTPs

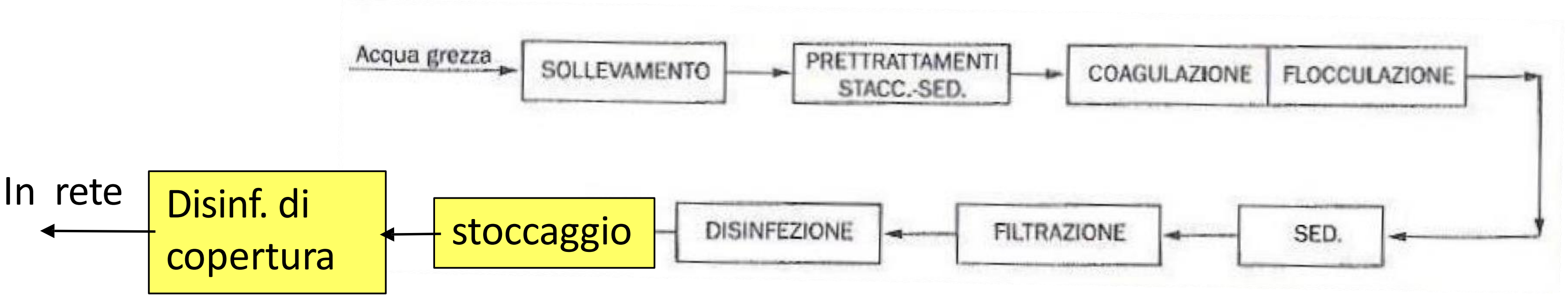
DWTPs

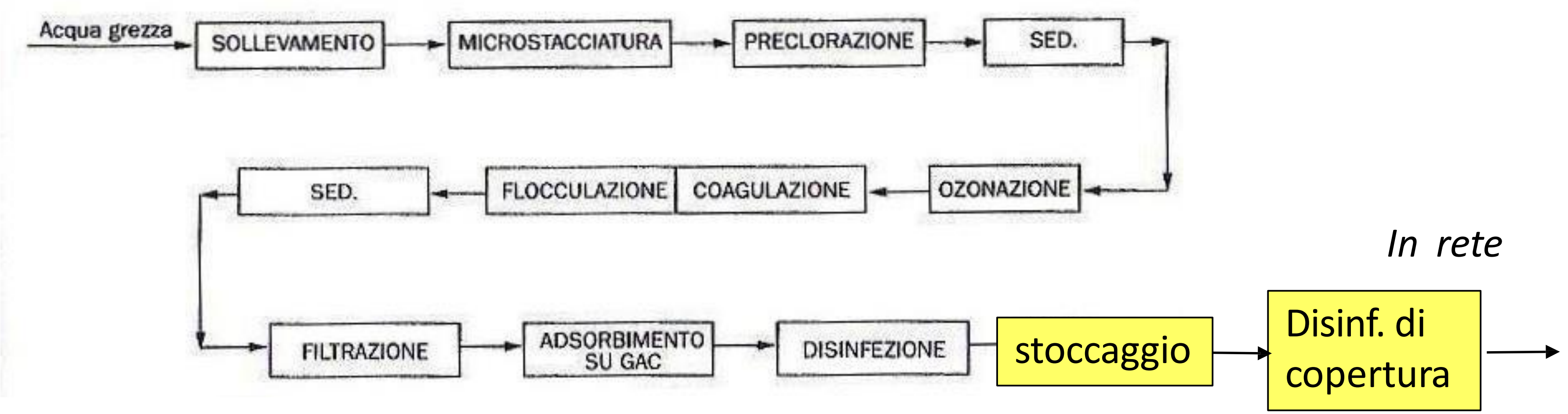


Be careful to chemical treatments

Processes in DWTPs

DWTPs – surface water





DWTPs –groundwater

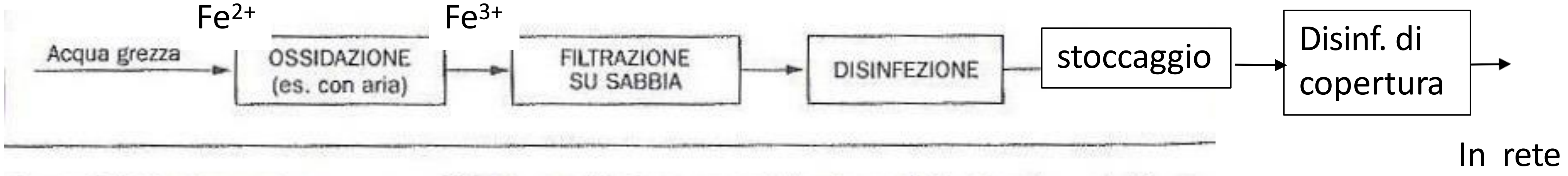


Figura 2.5 Trattamento per acque di falda non idonee per problemi specifici: rimozione del ferro.

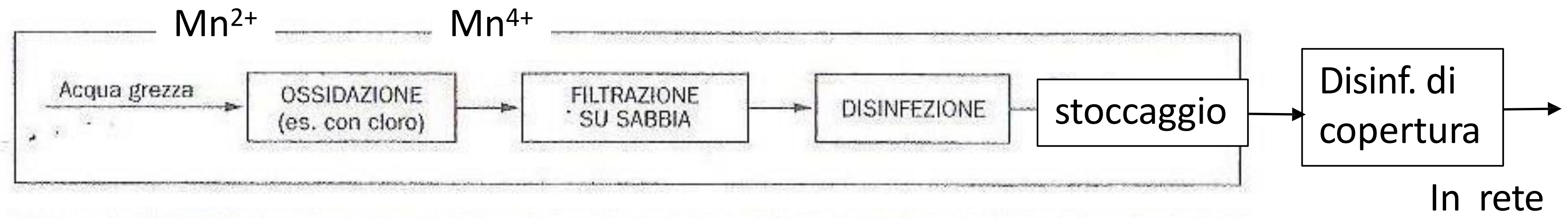


Figura 2.6 Trattamento per acque di falda non idonee per problemi specifici: rimozione del ferro e del manganese.

Processes in DWTPs

DWTPs – treatment units

INFLUENT	UdM
SAMPLING POINT	
Flowrate	l/s
CHEMICAL AND PHYSICAL CHARACTERISATION	
pH	-
Turbidity	NTU
Temperature	°C
Dissolved Oxygen	mg/L
Conductivity	microS/cm
Others available	………

GROSS FILTER	UdM
N° units	N°
N° working units	N°
Pores	mm

CLARI-FLOCCULATION	UdM
N° units	N°
N° working units	N°
Volume	m3
Surface	m2
Dosage PAC	gPAC/h
Contact time	minuti

ULTRAFILTRATION	UdM
N° units	N°
N° working units	N°
Porosità	micron
Materiale membrane	-
Surface	m2
Flow J	l/m2/h
Operating pressure	bar
Contact time	minuti
Flux of backwash water	l/s
Backwash frequency	
Frequency of chemical backwash	

SAND FILTERS	UdM
N° units	N°
N° working units	N°
Specific surface	m2
Volume	m3
Contact time	minuti
Velocity	l/m2/h
Flux of backwash air	l/s
Flux of backwash water	l/s
Backwash frequency	

CARBON FILTERS	UdM
N° units	N°
N° working units	N°
Carbon typology	
Volume	m3
Specific surface	m2
Carbon density	kg/m3
Contact time	minuti
Velocity	l/m2/h

Processes in DWTPs

DWTPs – treatment units

OZONATION	UdM
N° units	N°
N° working units	N°
Volume	m3
Dosage	Nm3/h air
	yield gO3/m3 air
	gO3/h
Contact time	sec
Residual Ozone	mgO3/L

CHLORINATION	UdM
Contact time	minuti
Dosage	g Cl/h
Cl residual	mg/l

CHEMICAL DISINFECTION	UdM
Reagent	-
Purity	%
Contact time	Min
Dosage	g/h

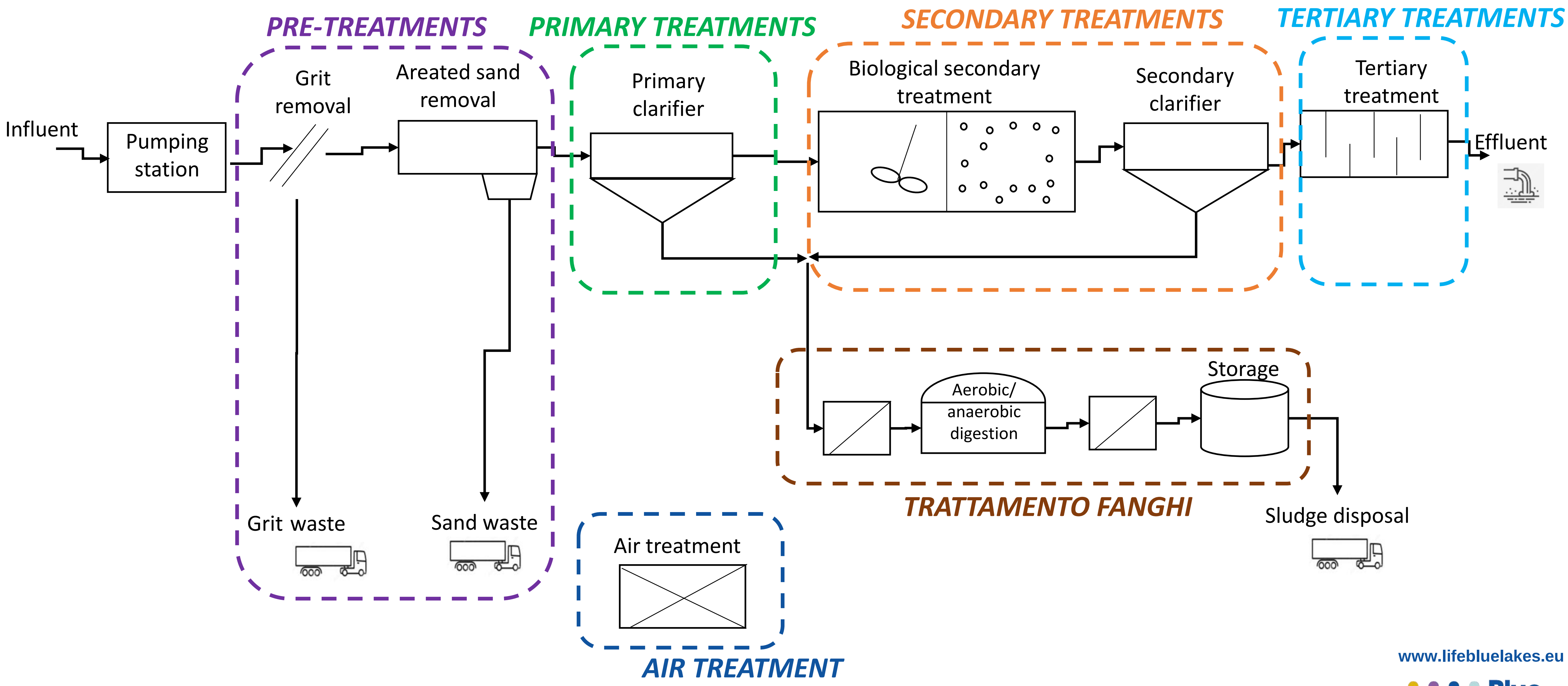
STORAGE	UdM
N° units	N°
N° working units	N°
Volume	M3
Storage time	h

EFFLUENT	UdM
pH	-
Conductivity	microS/cm
Cl residual	mg/L
Turbidity	mg/L
Others	…………

Processes in WWTPs

Water and Waste Environmental Engineering LAB

WWTPs



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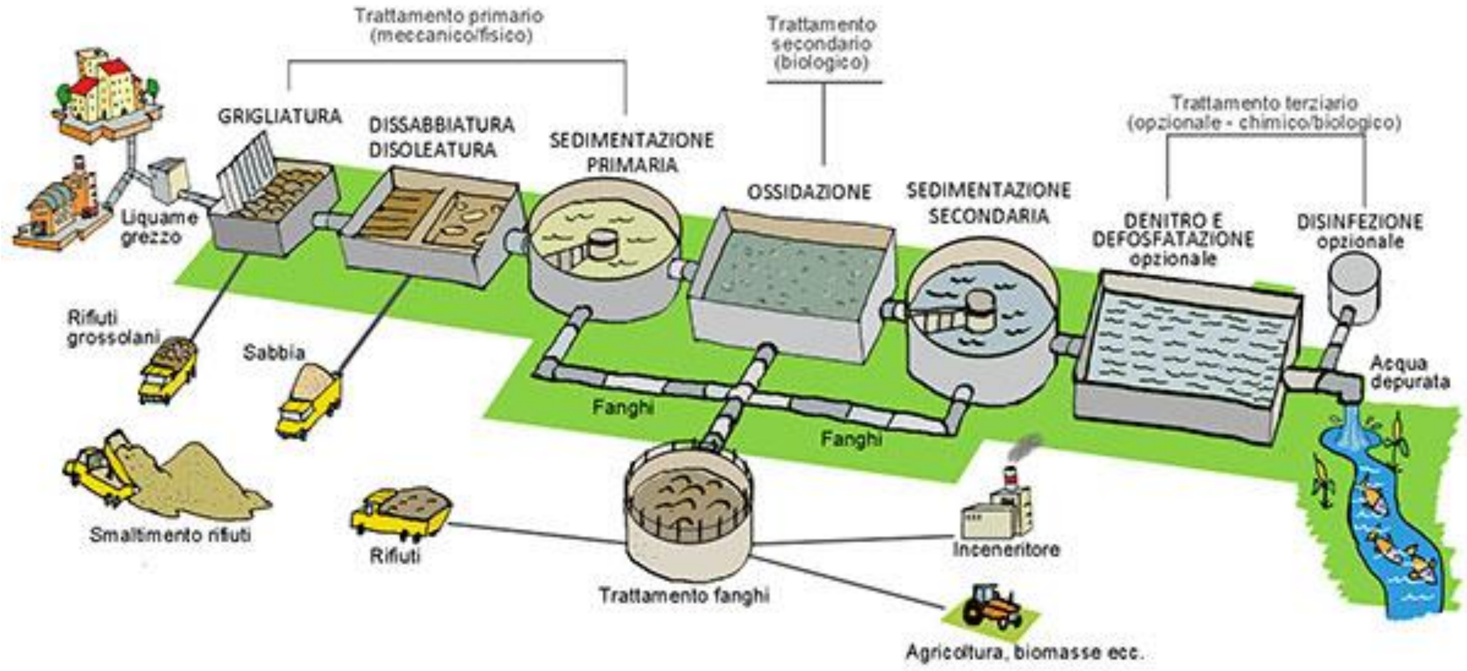
Microplastics in the Integrated Water Service

Sampling points – WWTPs



- INFLUENTIAL CHARACTERIZATION
- PRE-TREATMENTS
  - Screening
  - Sand and oil removal
- PRIMARY TREATMENTS
  - Primary sedimentation
  - Primary sludge
  - Chemical sludge
- SECONDARY TREATMENTS
  - Biological treatment
  - secondary sedimentation
  - Phosphorus removal
  - Organic sludge
  - Chemical sludge
- TERTIARY TREATMENTS
  - Filtration
  - UV disinfection
  - Chemical disinfection
- EFFLUENT CHARACTERIZATION

BE CAREFUL TO THE EVENTUAL POINTS OF INTERNAL PRODUCTION

Processes in WWTPs

WWTPs – treatment units

INFLUENT	UdM
Flowrate	m3/d
pH	-
Temperature	°C
Conductivity	microS/cm
TSS	mg/l
COD	mg/l
BOD_5	mg/l
Ntot	mg/l
NH4	mg/l
TKN	mg/l
Ptot	mg/l
$P\text{-}PO_4$	mg/l

SCREENING	UdM
N° units	N°
N° working units	N°
Area	m2
Mesh size	mm
Produced waste	ton/anno

SAND REMOVAL	UdM
N° units	N°
N° working units	N°
Area	m2
Volume	m3
HRT	min
Produced sand	ton/anno

PRIMARY SEDIMENTATION	UdM
N° units	N°
N° working units	N°
Area	m2
Volume	m3
Produced sludge	kg/d
Sludge characterisation	TS% TVS/TS N%TS P%TS
Characterisation of the effluent from primary sedimentation	mgTSS/l mgCOD/l mgBOD/l mgNtot/l mgNH4/l mgPtot/l ….

Processes in WWTPs

WWTPs – treatment units

BIOLOGIC TREATMENT	UdM
Type of process	
N° units	N°
N° working units	N°
Recycle flowrate	m3/d
Aerated mix flowrate	m3/d
Oxidation volume	**m3**
Denitrification volume	**m3**
MLSS	**g/l**
MLVSS	**g/l**
Air flowrate	m3/h

SECONDARY SEDIMENTATION	UdM
N° units	N°
N° working units	N°
Area	m2
Volume	m3
Extracted secondary sludge (supero)	kg/d
Sludge characterisation	TS% TVS/TS N%TS P%TS
Characterisation of the effluent from secondary treatment	mgTSS/l mgCOD/l mgBOD/l mgNtot/l mgNH4/l mgPtot/l ….
SRT	d

WWTPs – treatment units

PHYSICAL TERTIARY TREATMENTS	UdM
Type of treatment (e.g. granular, cloth, membrane filtration, etc.)	
N° units	N°
N° working units	**N°**
Filtration media (sand/carbon)	-
Porosity	mm
Area	m2
Backwash	m3/h

CHEMICAL OR UV DISINFECTION	UdM
Reagent	-
Purity	%
Dose	
Contact time	min

EFFLUENT	UdM
pH	-
TSS	mg/l
COD	mg/l
BOD_5	mg/l
Ntot	mg/l
NH4	mg/l
N-NOx	mg/l
TKN	mg/l
Ptot	mg/l
$P\text{-}PO_4$	mg/l
Others	………

Microplastics in the Integrated Water Service

Tracing the sources and transport of microplastics in the environment is a complex task. Little is known about the processes governing the transport of microplastics through freshwater environments and their distribution. However, key factors influencing their transport and distribution include the intrinsic properties of microplastics, i.e. their density, size and shape.

To date, there are insufficient methods to trace the sources and transport of microplastics in the environment and there are no standard sampling methodologies.

The presence of microplastics in freshwater has been investigated in the literature, with studies reporting particle counts ranging from approximately 0 to 10^3 particles/L (Koelmans et al., 2019). The results are notably influenced not only by the environmental and site-specific conditions, but also by the sampling technique and the method of analysis.

Location	Results reported (particles/L)	Sieve size (μm)	Study
Groundwater, Germany	Average:[b] 0.7×10^{-3} Range:[b] $0 - 7 \times 10^{-3}$	3	Mintenig et al., 2019
Three Gorges Reservoir, China	Average: 4.7 Range: 1.6–12.6	48	Di and Wang, 2018
Dongting Lake and Hong Lake, China	Averages: 1.2 and 2.3 Ranges: 0.9–2.8 and 1.3–4.7	50	Wang et al., 2018
Wuhan, China	Range: 1.6–8.9	50	Wang et al., 2017
Rhine river, Switzerland, France, Germany, Netherlands	Average: 0.0056	300	Mani et al., 2015
Western Lake Superior, USA	Average: 0.00026	333	Hendrickson, Minor, and Schreiner, 2018

PLEASE NOTE: The interpretation and comparison of the results of the literature studies must be carried out with great care, since the studies often use **different methods**, sampling different volumes, using filters of different sizes and using different enumeration techniques. This means that some studies do not detect the smallest particle sizes or even include some non-plastic materials such as plastics.

Sampling methodologies for wastewater

Literature research

SOURCE	PROCESS	VOLUME	METHOD	REFERENCE
Municipal wastewater	Grit-grease Primary clarifier Activated sludge Secondary clarifier effluent	60.1 L 59.3 L 103.4 L 143 L	• **Grabbed** in glass bottles, both in the morning and in the afternoon • Filter through diameter 110 mm, pore size 0.45 mm	(Bayo, Olmos, & López-Castellanos, 2020)
Municipal wastewater	Influent (after 6mm screen) After the primary clarification After the disinfection	4-30 L	Collected with a 10-L stainless steel bucket attached to a metal wire and poured to a cascade of two test sieves with mesh sizes of **250 µm** and 5.0 mm	(Lares, Ncibi, Sillanpää, & Sillanpää, 2018)
Municipal wastewater	Influent After the settler Effluent	30 L	• In the morning (9-11 am) • Filtered in loco with a suite of steel sieves with a mesh of 5 mm, 2 mm and 63 µm.	(Magni et al., 2019)
Municipal wastewater	Effluent	**500-21000 L**	• Filtered through a set of Tyler sieves at a flow rate of 12-18 L per minute for a period of 2-24 h • A **355 µm-mesh sieve** was stacked atop a **125 µm mesh sieve** for the shorter (2 h) sampling times, while the 0.355 mm-mesh sieve was used in isolation for the longer sampling periods	(Mason et al., 2016)
Municipal wastewater	Influent Pretreated influent Primary effluent Secondary effluent Final effluent	**1-2 L** 1-6 L 10-20 L 10-20 L 34-38 L	• **Grab samples** were collected in plastic containers	(Michielssen, Michielssen, Ni, &
Municipal (+industrial) wastewater	Effluent from different configurations of WWTPs	**390-1000 L**	• Custom made mobile pumping device with a filter housing containing a 10 mm stainless ste	Primpke,
Municipal wastewater	Influent Grit&grease effluent Primary effluent Final effluent	30-50 L	• n=303 • First passed through steel sieves (65 µm), then vacuum filtered through Whatman No. 1 qualit filter paper, with a pore size of **11 µm**.	, &
Municipal wastewater	Disc filter Rapid sand filter Dissolved ait floatation MBR CAS	Different volumes for different filter size and unit (2-1,000L)	• Custom made filtering device with in-situ fractionation • The mesh-sizes of the filters were 300, 100 and 20 µm, giving particle size fractions of >300 µn 20-100 µm • Additional composite samples for 24 h	& Setälä,
Municipal wastewater	Post primary treatment Post primary and secondary treatment Post primary, tertiary and RO treatment	200 l	• Each sampling event took approximately 1 h with a maximum flow rate of 10 L/min • The sampling device consists of four removable stainless-steel mesh screens (plain Dutch weave) with sizes of 500, 190, 100 and 25 µm with a diameter of 12 cm.	(Ziajahromi, Neale, Rintoul, & Leusch, 2017)

- **Grab samples**
- **Variable volumes from 1-2 L to > 1000 L**
- **Variable filtration mesh from 11 µm to 350 µm**

Sampling methodologies for wastewater

Literature research

SOURCE	PROCESS	VOLUME	METHOD	REFERENCE
Raw wastewater		**1 L**	Retsch AS 200 **vibratory sieve shaker** through 2 mm, 1mm and **500 µm sieve meshes**. Sodium dodecyl sulfate (SDS) as a surfactant added to a final concentration of 0.15 g/L before sieving to detach adhered MP particles from the larger solids. 200mL of the pre-sieved wastewater was incubated with cellulase enzyme (Aspergillus sp., Sigma-Aldrich, CAS no. 9012-54-8) for 48 h at 40 °C to degrade cellulose fibers deriving mainly from toilet paper. Organic material was oxidized with hydrogen peroxide where iron (II) was added to catalyze the reaction (Fenton reaction). Peroxide was added to a final concentration of 250 g/L and iron (II) sulfate to 2.5 g/L. The pH of the mixture was adjusted to approximately 3 with sodium hydroxide. The oxidized sample was wet-sieved (demineralized water with 0.15 g/L SDS) into two size fractions through an 80 µm sieve mesh. The effluent containing particles <80 µm was collected into a glass beaker. Particles >80 µm were removed from the sieve mesh into filtered demineralized water containing 0.15 g/L SDS by treatment in an Elma S50R ultrasonic bath. Particles from this liquid and the collected effluent were gathered on separate 10 µm steel meshes. Particles were removed from the filters into 25mL HPLC grade ethanol by ultrasonic treatment. The resulting particle-ethanol suspensions of the two size fractions were transferred into glass vials where their final volume was set to 5mL by evaporation with nitrogen gas. The chemical composition of the extracted particles was determined with an FPA-based FT-IR imaging technique.	(Simon, van Alst, & Vollertsen, 2018)
Treated wastewater			10 µm steel filters, ultrasonic treatment, collection in filtered demineralized water containing 0.15 g/L SDS. Incubation in a serum flask for 48 h at 40 °C with cellulase enzyme. Samples oxidized in 180 g/L hydrogen peroxide catalyzed by 1.8 g/L iron (II) sulfate and pH adjusted to 3 by sodium hydroxide. Size fractionation by wet-sieving and transferring the particle-ethanol suspension into glass vials.	
Municipal wastewater effluent	Screening Grit and grease removal Settling tank Aeration basin Clarifier	30-50 L	Steel buckets and sieve	(Murphy et al., 2016)
Municipal wastewater effluent			Fractionated filtering	
Municipal wastewater effluent			Sieving and filtering method	
Municipal wastewater effluent			Custom made pump +stainless steel cartridge filter	
Municipal wastewater effluent		2 L	Effluent: grab samples	
Wastewater, 24-hour composite samples	Influent wastewater, after mechanical purification and after the process from discharged wastewater.	From 100 ml (incoming wastewater) to 8 litres (purified wastewater**). 50 liters of purified wastewater were filtered through 300 and 100 µm filters** and **1 liter through the 20 µm filter**.	**Filter device** consists of three transparent plastic tubes (diameter 60 mm) and screw-on plastic connectors attaching the tubes to one another. Round (diameter 80 mm) filters are placed into the filter device between the connectors and tubes are screwed tightly together with rubber o-rings. Round filters are cut from different mesh size plankton nets. The largest mesh size filter 300 µm is placed on the top of the device, 100 µm filter in the middle and 20 µm filter at the bottom. All equipment has to be rinsed thoroughly prior to sampling.	(Talvitie et al., 2017)

- **Grab samples**
- **Variable volumes from 1-2 L to > 1000 L**
- **Variable filtration mesh from 11 µm to 350 µm**
- **Methodologies of sample pre-processing "customised"**
- **Examples of in-situ filtration with ad-hoc instrumentation**

Sampling methodologies for sludge

Literature research

SOURCE	PROCESS	VOLUME	METHOD	REFERENCE
Sewage sludge	Anaerobic digestion	**2 kg**	• Composite over one day in each month • Suspended, pre-washed and then filtered through 5 mm stainless steel	(Xu et al., 2020)
Sewage sludge	Activated sludge MBR sludge Anaerobic digestion	150-200 mL	Poured in glass flasks with metal funnel, kept in dark	(Lares et al., 2018)
Sewage sludge	Drained	500 g	Taken by shovel, stored in dark	(Mintenig et al., 2017)
Sewage sludge	Anaerobic digestion Thermal drying Lime stabilization	**30 g**	• Three replicates • Pellets of TD sludge were placed in water for 1 week to induce softening, transferred to a water bath (30 °C) for 24 h, and placed in an shaker for 12 h.	(Mahon et al., 2017)

- **Instantaneous samples**
- **Variable quantities from 30 g to 2 kg**
- **Discontinuous information on filtering mode and pre-processing**

Literature analysis for drinking water

Sampling Volumes

Author	Treatment unit	Volume sampled	n°MPs/L
(Wang et al., 2020)	Influent	1L x 3 samples	6614 ± 1132
	Effluent	1L x 3 samples	930 ± 71
(Pivokonský et al., 2020)	Influent	2L x 3 times/day	23±2
	Effluent	2L x 3 times/day	14±1
	Influent	2L x 3 times/day	1296±35
	Effluent	2L x 3 times/day	151 ± 4
(Pivokonsky et al., 2018)	Influent	1L x 3 samples/day x 3 times x 3 days	1473 ± 34
	Effluent	1L x 3 samples/ day x 3 times x 3 days	443 ± 10
	Influent	1L x 3 samples/ day x 3 times x 3 days	1812 ± 35
	Effluent	1L x 3 samples/ day x 3 times x 3 days	338 ± 76
	Influent	1L x 3 samples/day x 3 times x 3 days	3605 ± 497
	Effluent	1L x 3 samples/day x 3 times x 3 days	628 ± 28
(Mintenig et al., 2019)	Influent	300-1000 L	0.003
	Distribution	1200-2500 L	<0.001
	Influent	300-1000 L	0.007
	Effluent	1200-2500 L	<0.001
	Distribution	1200-2500 L	0.003
	Influent	300-1000 L	0.001
	Effluent	1200-2500 L	0.002
	Influent	300-1000 L	0.001
(Cherniak et al., 2022)	Influent	10 L *2 duplicates	42 ± 18 particles/L
	Effluent	10 L *2 duplicates	20 ± 8 particles/L
	Distribution	10 L *2 duplicates	20.5 ± 7.6 particles/L
(Jung et al., 2022)	Influent	10-100 L *12 monthly samples	2.2 ± 1.3
	Effluent		0.02 ± 0.02
Shi et al., 2021	Influent	n.d.	6614 ± 1132
	Effluent		930 ± 71
(Yuan et al., 2022)	Influent	n.d.	17.88
	Effluent		2.75
(Johnson et al., 2020)	Influent	n.d.	21.09 ± 20.49
	Effluent		0.001-0.024
(Leslie et al., 2017)	Influent	n.d.	1385 (dry season); 1796.6 (wet season)
	Effluent	n.d.	448.7 (dry season); 769.4 (wet season)

- Information not homogeneous and not always available on the volumes actually sampled
- Extreme variability from 1L to 2500L

Water and Waste Environmental Engineering LAB

Blue Lakes
No microplastics, just waves.

Literature analysis for drinking water

Dimension of seaving mesh

Comparison of MPs numbers in the drinking water treatment process in this study and previous studies.
(Unit: particle/L)

Research		Raw water	Pre-ozonation	Sedimentation		Sand filtration		Treated water (Samples)	Methodology (Samples)	Limit of size detection
This study		2.2 ± 1.3	2.3 ± 0.8	1.4 ± 0.15		0.2 ± 0.15		0.02 ± 0.02	Automated via micro-FTIR imaging, (Hyperion 3000, Bruker)	> 10 µm
Wang, 2020		Raw water	Coagulation/ sedimentation	Deep bed filtration		Ozonation + *GAC filtration		Treated water	Quantification: SEM Qualification: Raman (ThermoFisher)	>1 µm
	Downstream	1296	497	243		149		151		
	Upstream	23						14		
Leslie et al., 2017		Raw water	Screen-outlet	Clarifier-outlet		Filtration		Treated water	>300 µm: ATR-FTIR hand picking < 300 µm: Confocal Raman + Nile red	6.5–500 µm
	Dry season	1385	1298.5	823.2		536.7		448.7		
	Rainy season	1796.6	1669.2	122.9		844.6		769.4		
Shi et al., 2021		Raw water	Sedimentation	Sand filtration		Ozonation	GAC filtration	Treated water	Quantification: 25% of filter area via SEM Qualification: micro-Raman (ThermoFisher)	1–100 µm
		6614 ± 1132	~3000	~2000		~2000	<1000	930 ± 71		
Yuan et al., 2022		Raw water	Pre-disinfection	Flocculation	Pulse clarification	Sand filtration		Treated water	Quantification: Fluorescence microscope + Nile red staining (Zeiss AXIO) Qualification: ATR-FTIR	1–100 µm
		17.88	17.53	17.11	6.99	11.17		2.75		
Johnson et al., 2020		21.09 ± 20.49	-	-	-	-		0.001-0.024	Automated via micro-FTIR imaging	>25 µm

*Granular activated carbon. J.-W. Jung et al. 2022

- Different sizes

Literature analysis for drinking water

Dimension of seaving mesh and separation method

Reference	Sampling method	Downstream sample treatment
Z. Wang, 2019	Water samples were collected in **1L** brown glass bottles (pre-cleaned) from the raw water and effluents from each treatment process.	Filtration through a series of **5 µm** membrane filters (PTFE) followed by a pore size of 0.22 µm.
M. Pivokonský; 2020	**Two liters** of water was filled into borosilicate glass bottles (pre-cleaned). The samples were then stored in the dark at 4 ° C. Any contact of the samples with plastic materials was avoided during sampling campaign.	
M. Pivokonsky, 2018	A raw water sample and a treated water sample (**1L of both**) were taken in autoclavable (pre-cleaned) borosilicate glass bottles. The samples were stored at 4 ° C before analysis. Any contact of the samples with plastic materials was avoided during sampling campaign.	The pretreated samples were passed through a series of **5 µm** polytetrafluoroethylene (PTFE) membrane filters and subsequently **0.2 µm** pore size.
Mintenig S.M., 2018		**3µm** cartridge filters were used. The residual raw water and drinking water were removed from the filter units using filtered compressed air (0.2 µm). The retentate was collected on 3 µm (47 mm diameter) stainless steel filters

- Expensive and complex separation and characterization methods (even functionally at the minimum level of size detectability)

Literature analysis for drinking water

Characterisation methods

Comparison of MPs numbers in the drinking water treatment process in this study and previous studies.
(Unit: particle/L)

Research		Raw water	Pre-ozonation	Sedimentation		Sand filtration		Treated water	Samples Methodology	Limit of size detection
This study		2.2 ± 1.3	2.3 ± 0.8	1.4 ± 0.15		0.2 ± 0.15		0.02 ± 0.02	Automated via micro-FTIR imaging, (Hyperion 3000, Bruker)	> 10 μm
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		17.88	17.53	17.11	6.99	11.17		2.75		
Johnson et al., 2020		21.09 ± 20.49	-	-	-	-		0.001-0.024	Automated via micro-FTIR imaging	>25 μm

*Granular activated carbon. J.-W. Jung et al. 2022

- Different characterisation methods

Sampling methodologies for drinking water
Literature research

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SAMPLING POINTS	VOLUME	TYPE of SAMPLE	METHODS OF SAMPLING AND PROCESSING	FREQUENCY or n° of samples	Ref.
Raw and treated drinking water (after each process)	1L	Grab samples	Pre-processing: Digestion with 30% hydrogen peroxide (H_2O2) for 24 h. Filtration through a series of 5 µm (PTFE) membrane filters followed by a 0.22 µm pore sizes. The purpose of this two-filtration was to descend mesh size to pass the entire sample through the filter without clogging. These filters were used for scanning electron microscope (SEM) analysis of retained particles. For each sample, a volume of 250 ml was separately filtered for quantitative and qualitative analysis of particles. The filters after drying in an oven at 30°C for 30 min were stored in covered glass petri dishes for subsequent analysis. DXR2 micro-Raman imaging microscope system (Thermo Fisher Scientific, USA) was employed (532 nm laser, laser spot size around 0.5 µm, Raman shift 50–3550 cm_1, spectral resolution of 5 cm^{-1}) for qualitative analysis of particles.	3 times /winter	(Wang, Lin, & Chen, 2020)
Raw and treated drinking water	27L each sample	Average daily samples	Pre-processing: Wet peroxide oxidation was conducted to remove organic material, Filtration through a series of 5 µm (PTFE) membrane filters followed by a 0.22 µm pore sizes. The purpose of this two-filtration was to descend mesh size to pass the entire sample through the filter without clogging. These filters were used for scanning electron microscope (SEM) analysis of retained particles. For each sample, a volume of 250 ml was separately filtered for quantitative and qualitative analysis of particles. The filters after drying in an oven at 30°C for 30 min were stored in covered glass petri dishes for subsequent analysis	3 times within a 24-hour period (every 8 h) and repeated three times in winter period	(Pivokonsky et al., 2018)
Raw and treated drinking water	9-27 L		Scanning electron microscopy analysis for particle counts; both micro-Raman spectroscopy and µ-FT-IR were used for identification of particles with size of 1e10mm and>10mm		(Eerkes-Medrano, Leslie, & Quinn, 2019)
Raw and treated drinking water	1000 L	Grab samples	Samples directly sieved, tap water require no digestion.		(Koelmans et al., 2019)
Raw and treated drinking water	300-2500 L	Grab samples	Sampling: 3µm stainless steel cartridge filters 4 7/8", Wolftechnik, Germany Pre-processing: Residual raw water and drinking water was removed from t e filter units by using filtered (0.2 µm) compressed air. Then, the units were filled again with diluted hydrochloric acid (Carl Roth GmbH & Co. KG, Germany, 0.2 µm filtered, pH=2) to dissolve calcium carbonate and iron precipitates. After 24 h the filter units were emptied, the cartridge filters removed from the units and rinsed with Milli-Q and ethanol (30%, Carl Roth GmbH & Co. KG, Germany, filtered over 0.2 µm). The retentate was collected on 3 µm stainless steel filters (47mm in diameter) that were subsequently transferred into glass bottles and covered with 30 mL hydrogen peroxide (35%, Carl Roth GmbH & Co. KG, Germany). The bottles were closed using aluminium foil and incubated for 24 h at 40 °C. Finally, each sample was enriched onto a 0.2 µm aluminium oxide filter (Anodisc 25 mm, Whatman, U.K.) by using an in-house fabricated filter-funnel with an inner diameter of 11 mm. The filters were dried at 40 °C in half closed glass petri dishes for subsequent analysis.	24 samples	(Mintenig et al., 2017)

- **Grab samples**
- **Variables volumes from 1 L to 2500 L**
- **Lower filtration mesh (3µm)**
- **Different sampling and pre-processing methods**

Sampling methodologies for combined sewer overflows

Literature research

SAMPLING POINTS	VOLUME	TYPE OF SAMPLE	METHODS OF SAMPLING AND DETENTION	FREQUENCY or num° of samples	Ref.
stormwater runoff	1L per each sample	Grab sample	Iron bucket that was rinsed three times with the runoff before taking the samples. The samples were a combination of sediment and water due to the strength of the runoff streams in the streets or storm drains. These samples were collected at the beginning of the rain event and at approx 10 min and 30 min after the first samples were collected.	94 samples	(Piñon-Colin, Rodriguez-Jimenez, Rogel-Hernandez, Alvarez-Andrade, & Wakida, 2020)
Stormwater pond	up to several thousand liters for the bigger mesh size, 10-70 liters with a mesh size of 20 µm.	Grab sample	Sampling method consisted of a gasoline pump, hoses, filter holder and filter. Two types of filters were tested; plankton net (mesh size 300 µm) manually cut into circles and prefabricated polycarbonate filters (mesh size 10 µm). A mechanical volumeter was attached to the outlet hose in order to measure the volume of water filtered. The filter holder consisted of stainless-steel pipes, gaskets, and a clamp. The inner diameter of the stainless-steel pipes was in this case 2 inches. The inlet and outlet hoses chosen had inner diameters of 1,5 and 1 inch. The inlet hose was of sturdier material, not to deflate due to the suction pressure of the pump. Polyester plankton nets (Sefar Petex), where cut into circles to fit the filter holder. Two mesh sizes were used. The mesh size of 300 µm was used to allow for comparison of results with the majority of studies conducted thus far. Quantification performed manually by counting MPs using a microscope. Some of the detected MPs were analyzed with FTIR spectroscopy.		Coalition Clean Baltic, 2017

- **Existing literature reports the microplastics determined in rainwater.**
- **The presence and fate of microplastics in CSOs have not been fully investigated to date.**
- **Samples were taken discontinuously, in variable volumes (1-70 L).**

Related projects

The topic of microplastics in water is of great interest at European level and a wide range of projects are developing innovative solutions for their management. The first step is often to choose a simple, inexpensive and exploitable sampling method, which allows comparison and sharing of results. Some activities foresee the development of a sampling method: projects, such as CLAIM, TextileMission, EMISTOP, ENSURE and RUSEKU; studies, such as those for the HELCOM BASE Project and the Norwegian Institute for Water Research; and guidelines, such as those of CCB.

Project-Activity Title	Description	Links	Interest for Microplastics
CLAIM - Cleaning Litter by developing and Applying Innovative Methods in european seas	Development of innovative cleaning technologies and approaches, targeting the prevention and in situ management of micro and macroplastics in the Mediterranean and Baltic Sea.	https://www.claim-h2020project.eu/	Pre-filtering system to retain larger plastics, while simultaneously taking two samplers; Photocatalytic nanocoating device for cleaning microplastics in wastewater treatment plants to obtain the degradation of low-density polyethylene (LDPE) microplastic, by visible light-induced heterogeneous photocatalysis activated by Zinc oxide nanorods.
EmiStop - Identification of Industrial Plastic Emissions by Means of Innovative Detection Methods and Technology Development to Prevent the Input into the Environment via the Wastewater Pathway	Detect emissions of plastics into wastewater from relevant industries. Select wastewater treatment technologies that will optimise reduction of emissions of plastics for the respective value chain. The project will evaluate existing technologies for separating particles, investigate deposition rates, and develop approaches for technical optimisation. Optimisation also includes technological developments such as flocculants. Researchers will conduct tests in both laboratory and pilot project settings – selected large scale technical wastewater treatment plants will be investigated at industrial facilities.	http://www.emistop.de/page8.html https://bmbf-plastik.de/en/joint-project/emistop	Standardisation of sampling and sample preparation for industrial wastewater (in alignment with Plastik-Net and other joint research projects). Quantitative and qualitative measurement of plastic concentrations in industrial wastewater using Raman spectroscopy and dynamic differential calorimetry. Extended data collection at the sampled industrial wastewater treatment plants for the derivation of the plastic loads and testing of a correlation between the measurement results and routine water chemical analyses. Development of magnetic plastic particles in the micrometre range with the physical properties of relevant types of plastic. Development of a tracer test with magnetic plastic particles. Assessment of technologies for particle separation with regard to the retention of (micro-) plastic particles. Optimisation of particle separation technologies. Development of flocculants for the targeted improvement of the retention of individual types of plastics and their mixtures
TextileMission – Microplastics of Textile Origin - A Holistic View: Optimized Processes and Materials, Material Flows and Environmental Behavior.	Synthetic fiber particles with a diameter of less than 5 millimetres are only partially filtered out by modern wastewater treatment plants. The partners of the joint resreach project TextileMission have taken on the task of reducing this environmental impact.	https://textilemission.bsi-sport.de/en/	WP 4 Polyester fibres: At the TU Dresden, analysis and sample preparation method is established to quantify microparticles from wastewater streams and fractionate them according to size. Investigation of the retention capacity of textile (fluorescence-labelled) microparticles in the different stages of a laboratory wastewater treatment plant and identification of efficient retention possibilities. Material flows are analysed including a first estimate of the Germany-wide textile microplastic emission from wastewater into water bodies /soils. WP 5: Consideration of other environmental issues related to the project, stakeholder involvement and communication at the end of the project. Focus on the retention of textile microfibre particles through various purification stages in wastewater treatment plants.
ENSURE Development of New Plastics for a Clean Environment by Determining of Relevant Entry Points.	Holistic approach to reduce plastic in the environment as well as the related negative consequences, including improving methods of analyzing the environmental impact of plastics.	https://www.ensure-project.de https://bmbf-plastik.de/en/joint-project/ensure	In the "Traceability" module, undesirable plastic inputs in prioritised sectors (soils, wastewater treatment plants, composting plants and biogas plants) are detected and identified. In a first step, sampling strategies are developed so that in a second step representative investigations can be carried out to determine the current states of plastics in fermentation, compost and wastewater treatment plants.
RUSEKU – Precise Detection of Microplastics in Water	Plastics in the Environment: Sources - Sinks – Solutions. Development of representative test methods that can accurately and quickly determine the microplastic content over various parts of the water cycle. The focus is on sampling methods in urban wastewater systems and watercourses.	https://netzwerke.bam.de/ruseku https://bmbf-plastik.de/en/joint-project/ruseku	WP 2 Development of sampling methods; WP 3 Simulations software that simulates geometrically complex, application-oriented cases will be used to derive sampling strategy; WP 4 Sampling of real environmental compartment. quantification of the microplastic volume and transport in the real, urban wastewater system for the wastewater and precipitation water, domestic wastewater (partial flows grey and black water), industrial wastewater, and mixed wastewater. Further work will focus on sample preparation and preservation to evaluate the comparability of different sampling strategies. The investigations focus on the quantities and the importance of microplastic volumes in the individual entry points of the urban wastewater system into the water bodies.
Mapping microplastics in sludge - Research Report	Characterization of microplastics in sewage sludge from Norwegian domestic wastewater treatment plants applying different wastewater and sludge treatment technologies.	https://niva.brage.unit.no/niva-xmlui/handle/11250/2493527	Fenton's reagent was used to remove organic matter and density separations were employed to extract microplastics from sludge samples. Plastics were found in all ten sludge samples investigated from eight WWTPs. The overall average plastic abundance was 6077 particles kg-1 (d.w.) (1701 – 19 837) or 1 176 889 particles m-3 (470 270 – 3 394 274).
HELCOM BASE Project - Implementation of the Baltic Sea Action Plan in Russia	Preliminary study on synthetic microfibers and particles at a municipal wastewater treatment plant	https://helcom.fi/helcom-at-work/projects/base/	Study the amount of microplastic litter arriving at the Central Wastewater Treatment Plant (WWTP) of St. Petersburg and the effect of the purification process. Helsinki Region Environmental Services Authority HSY developed a microplastic sampling method targeted at wastewaters.

Related projects

Projects such as RUSEKU and SubµTrack and the HELCOM BASE study are focusing on MP detection in sewage treatment plants, and the REPLAWA, PLASTRAT, TextileMission and ENSURE projects are analyzing the treatment efficiency of different processes.

Project-Activity Title	Description	Links	Interest for Microplastics
RUSEKU – Precise Detection of Microplastics in Water	Plastics in the Environment: Sources - Sinks – Solutions. Development of representative test methods that can accurately and quickly determine the microplastic content over various parts of the water cycle. The focus is on sampling methods in urban wastewater systems and watercourses.	https://netzwerke.bam.de/ruseku https://bmbf-plastik.de/en/joint-project/ruseku	WP 2 Development of sampling methods; WP 3 Simulations software that simulates geometrically complex, application-oriented cases will be used to derive sampling strategy; WP 4 Sampling of real environmental compartment. quantification of the microplastic volume and transport in the real, urban wastewater system for the wastewater and precipitation water, domestic wastewater (partial flows grey and black water), industrial wastewater, and mixed wastewater. Further work will focus on sample preparation and preservation to evaluate the comparability of different sampling strategies. The investigations focus on the quantities and the importance of microplastic volumes in the individual entry points of the urban wastewater system into the water bodies.
SubµTrack	Tracking of (Sub)Microplastics of Different Identities - Innovative Analysis Tools for Toxicological and Process-engineering Evaluation. Development of new methods of analysis and evaluation, which will allow for assessment and toxicological investigations of plastic particles of different sizes.	https://www.wasser.tum.de/en/submuetrack/startseite/ https://bmbf-plastik.de/en/joint-project/submtrack	WP 4 Investigations on entry points and process-related evaluation. Real scenarios are first simulated with reference particles in laboratory wastewater treatment plants at the partner LfU to analyse the fate of the particles within the system. Parallel to this, investigations will be carried out at various measuring points in real wastewater treatment plants.
HELCOM BASE Project - Implementation of the Baltic Sea Action Plan in Russia	Preliminary study on synthetic microfibers and particles at a municipal wastewater treatment plant	https://helcom.fi/helcom-at-work/projects/base/	Study the amount of microplastic litter arriving at the Central Wastewater Treatment Plant (WWTP) of St. Petersburg and the effect of the purification process. Helsinki Region Environmental Services Authority HSY developed a microplastic sampling method targeted at wastewaters.
ENSURE Development of New Plastics for a Clean Environment by Determining of Relevant Entry Points.	Holistic approach to reduce plastic in the environment as well as the related negative consequences, including improving methods of analyzing the environmental impact of plastics.	https://www.ensure-project.de https://bmbf-plastik.de/en/joint-project/ensure	In the "Traceability" module, undesirable plastic inputs in prioritised sectors (soils, wastewater treatment plants, composting plants and biogas plants) are detected and identified. In a first step, sampling strategies are developed so that in a second step representative investigations can be carried out to determine the current states of plastics in fermentation, compost and wastewater treatment plants.
PLASTRAT - Strategies for Reducing the Entry of Urban Plastics into Limnic Systems	Development of solution strategies for the sustainable limitation of plastic residues propagation in the aquatic environment. Emphasis will be put on the analysis and evaluation of degradation levels of various types of plastic as well as leaching, adsorption, and desorption in different wastewater treatment stages.The focus will also be on the quantification and technical reduction potential (e.g. use of membrane technology) of plastic emissions in the field of urban water management including sewage sludge treatment under consideration of sampling, sampling preparation, and analysis methods.	http://www.plastrat.de/project/ https://bmbf-plastik.de/en/joint-project/plastrat	WP 2: Degradation and material dynamics. The release of pollutants (oligomers, additives and their transformation products) is analysed depending on the type of polymer and the degree of degradation. Furthermore, differences in the adsorption/desorption of environmental chemicals are investigated for different types of polymers and the role of wastewater treatment plants regarding the pollutant load of microplastics (enrichment or depletion). WP 3: Entry points and elimination. Different entry points of microplastics into limnic systems are assessed, focusing on the analysis and evaluation of the wastewater management system including measures for microplastic retention (e.g. membrane technology) that already exist or have been modified or developed in the course of the project. Core areas comprise rain and mixed water discharge, the assessment and evaluation of the entire wastewater treatment plant system, and an analysis of sewage sludge, digestate and compost as possible microplastic sinks. Emphasis is also put on the development and selection of suitable processing and analytical methods.
REPLAWA Reduction of the Input of Plastics via Wastewater into the Aquatic Environment.	The project will investigate and quantitatively assess entry points into water bodies through treatment plants, storm water drainage, and combined sewer overflows as well as swales at treatment facilities and in sewage sludge.	www.replawa.de	The project will test and rate various practical methods of reducing and eliminating plastic emissions into waterways during wastewater treatment. Based on the results of these investigations and of assessments regarding international regulatory approaches in this field, the project will derive strategies for reducing plastic release from wastewater treatment into waterways.
TextileMission – Microplastics of Textile Origin - A Holistic View: Optimized Processes and Materials, Material Flows and Environmental Behavior.	Synthetic fiber particles with a diameter of less than 5 millimetres are only partially filtered out by modern wastewater treatment plants. The partners of the joint resreach project TextileMission have taken on the task of reducing this environmental impact.	https://textilemission.bsi-sport.de/en/	WP 4 Polyester fibres: At the TU Dresden, analysis and sample preparation method is established to quantify microparticles from wastewater streams and fractionate them according to size. Investigation of the retention capacity of textile (fluorescence-labelled) microparticles in the different stages of a laboratory wastewater treatment plant and identification of efficient retention possibilities. Material flows are analysed including a first estimate of the Germany-wide textile microplastic emission from wastewater into water bodies /soils. WP 5: Consideration of other environmental issues related to the project, stakeholder involvement and communication at the end of the project. Focus on the retention of textile microfibre particles through various purification stages in wastewater treatment plants.

Related projects

Water and Waste Environmental Engineering LAB

Concerning the management of civil society organizations, projects such as INTCHATCH and InRePlast and CCB Guidelines provide useful information on the removal of PM in wetlands, rainwater ponds and drainage systems.

Project-Activity Title	Description	Links	Interest for Microplastics
INTCATHC	Monitoring and management of surface water quality; developing efficient, user-friendly water monitoring strategies and systems based on innovative technologies that will provide real time data for important parameters, moving towards SMART Rivers.	https://www.intcatch.eu/	Manage water pollution in surface runoffs and CSO: Expert Team provides customers with the most effective and low-cost solutions of Combined Sewer Outflow (CSO) and surface runoff treatment systems A wide range of completely automatic and fully adaptive treatment systems are offered depending on customer's needs including combination of coarse screening system, rotating dynamic filter, quartzite filter, GAC adsorption system and UV disinfection
InRePlast – Environmental Policy Instruments to Reduce Plastic Pollution of Inland Waters through Drainage Systems	How and which plastics end up in wastewater and how these inputs can be reduced with the help of environmental legislation is the focus of the joint research project InRePlast. Based on an analysis of sources, entry points and polluters, the researchers are developing and testing measures for behavioural changes.	www.inreplast.de https://bmbf-plastik.de/en/joint-project/inreplast	WP 1: Inventory of the entry points of plastics into the drainage systems. Determine the status quo of plastic discharges into the drainage systems in four selected model municipalities, which represent different settlement structures. For this purpose, the type and quantity of plastic products as well as their sources from households, industry, traffic and other activities related to wastewater collection and drainage of paved areas will be determined. WP 4: Material flow models of plastic inputs into canalisation systems and wastewater treatment plants. Material flow models for plastic discharges of macro- and microplastics from the identified sources into the drainage systems will be developed for the four model communities. Based on the model results, the sources and product types are analysed and evaluated with regard to their relevance for the plastic inputs. The data from the municipalities is then extrapolated to the federal level in a general model.
Guidance on concrete ways to reduce microplastic inputs from municipal stormwater and wastewater discharges	concrete ways to reduce micropalstics from stormwater and wastewater and simple methodology to monitor riverine inputs of micropalstics.	https://www.ccb.se/documents/Postkod2017/CCB%20-%20Guidance%20on%20concrete%20ways%20to%20reduce%20microplastics%20in%20stormwater%20and%20sewage.pdf	Constructed free water surface wetlands can be efficient in reducing microplastics from effluents of WWTPs to the water bodies. High MP concentrations found in urban stormwater. Stormwater ponds used as end of pipe solutions show good removal efficiency for microplastics. Methods for sampling and analyzing microplastic contents in water. Abundance of microplastics smaller than 300 µm in stormwater and sewage water.

Related projects

New treatment technologies are being developed in the SMART-Plant, CLAIM, Plastfri Roskilde Fjord and SimConDrill projects. New commercial products are also under development, such as Wasser 3.0 PE-X® technology.

Project-Activity Title	Description	Links	Interest for Microplastics
SMARTPLANT **Scale-up of low-carbon footprint MAterial Recovery Techniques in existing wastewater treatment PLANTs**	SMART-Plant will scale-up in real environment eco-innovative and energy-efficient solutions to renovate existing wastewater treatment plants and close the circular value chain by applying low-carbon techniques to recover materials that are otherwise lost.	https://www.smart-plant.eu/	Salsnes Filter AS is a technology provider and a partner of SMART-Plant. Salsness filters have been tested for the treatment of different water fluxes, including the effluent from WWTPs. Salsnes has developed a unique fine mesh sieve system for treatment of municipal and industrial wastewater, a mechanical wastewater treatment system, with integrated thickening and sludge dewatering. The patented filter technology is a very compact unit for mechanical separation of suspended solids from wastewater. With the integrated sludge dewatering unit, Salsnes Filter wastewater treatment processing plants meet the highest standards and the specifications of the European Commission for reduction of waste effluents (primary treatment). Salsnes Filter has significant experience from extensive national and international R&D activities, including FP6 and FP7 projects.
Plastfri Roskilde Fjord project	Investigating, mapping and identifying plastic pollution effects and sources, and finding concrete solutions and actions to prevent plastic pollution	https://plasticchange.dk/videnscenter/plastfri-roskilde-fjord-plastikforurening-i-danmark/	Alfa Laval supplied a pilot membrane filtration system that was used to determine the amount and type of microplastics in the main wastewater treatment plant, which releases treated water into Roskilde Fjord.
CLAIM - Cleaning Litter by developing and Applying Innovative Methods in european seas	Development of innovative cleaning technologies and approaches, targeting the prevention and in situ management of micro and macroplastics in the Mediterranean and Baltic Sea.	https://www.claim-h2020project.eu/	• Pre-filtering system to retain larger plastics, while simultaneously taking two samplers; • Photocatalytic nanocoating device for cleaning microplastics in wastewater treatment plants to obtain the degradation of low-density polyethylene (LDPE) microplastic, by visible light-induced heterogeneous photocatalysis activated by Zinc oxide nanorods.
SimConDrill - Innovative filter modules for the separation of microplastics from wastewater	Development of a filter that is ready for serial production, which enables the filtration of particles down to 0.01mm (this equals the thickness of household aluminium foil) based on the patented cyclone filter.	https://www.simcondrill.com/	New water filter removes microplastics with laser-drilled tiny holes. A group of five partners from industry and research now wants to develop a new filter that uses laser-drilled holes to efficiently filter out particles as small as 10 micrometres even in large amounts of water.
Wasser 3.0 PE-X®	Simple, reproducible and cost-efficient processes with no negative environmental effects for the elimination of microplastics from sewage water	https://wasserdreinull.com/	With Wasser 3.0 PE X it has been developed the first method to remove microplastics from the water without any additional complicated filter technology. By applying a non-toxic hybrid silica gel, table tennis ball sized balls float on the water surface and are easily removed from there.

www.lifebluelakes.eu / info@lifebluelakes.eu

Thank you for the attention!

Blue Lakes
No microplastics, just waves.

Water and Waste Environmental Engineering LAB

BENEFICIARIO COORDINATORE

LEGAMBIENTE

BENEFICIARI ASSOCIATI

Autorità di Bacino Distrettuale dell'Appennino Centrale

arpa UMBRIA Agenzia Regionale per la Protezione Ambientale dell'Umbria

ENEA AGENZIA NAZIONALE PER LE NUOVE TECNOLOGIE, L'ENERGIA E LO SVILUPPO ECONOMICO SOSTENIBILE

Global Nature Fund

Bodensee Stiftung Lake Constance Foundation

UNIVERSITÀ POLITECNICA DELLE MARCHE

PROGETTO COFINANZIATO DA

PlasticsEurope Association of Plastics Manufacturers

Sampling methodologies

Università Politecnica delle Marche

BENEFICIARIO COORDINATORE

BENEFICIARI ASSOCIATI

PROGETTO COFINANZIATO DA

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Sampling methods

Most of the research on microplastics in water has been focused on seas and oceans. As a result, sampling techniques and protocols have been developed primarily for marine systems.

To date, there is no standardized methodology for sampling microplastics in inland waters or treatment plants. The development of a uniform protocol is necessary for the correct interpretation and comparison of the results. The main variables to consider are:

- SAMPLING POINTS
- SAMPLING VOLUMES
- FILTRATION MESH
- TYPE OF SAMPLE AGGREGATION (e.g. weighted average)
- SAMPLING PERIODS
- SAMPLING FREQUENCIES

Sampling in surface waters: Monitoring Protocol developed by ENEA

RETINO MANTA

RETINO BONGO

WATER

BEACH

ENEA – LEGAMBIENTE – ARPA

Blue Lakes
No microplastics, just waves.

Sampling in surface waters: Monitoring Protocol developed by ENEA

SEASONAL MONITORING
20/21 e 21/22

SPRING SAMPLING
COVID lock-down

☑ SUMMER SAMPLING
1° Bracciano 01-02/07/2020
2° Bracciano 22-23/07/2021
1° Trasimeno 21-22/07/2020
2° Trasimeno 15-16/-07/2021

☑ AUTUMN SAMPLING
1°Bracciano 24-25/11/2021
2°Bracciano 14-15/12/2021
1° Trasimeno 02-03/12/2020
2°Trasimeno 01-02-12/2021

☑WINTER SAMPLING
1°Bracciano 24-02-2021
2°Bracciano 17-03-2022
1°Trasimeno 11-03-2021
2°Trasimeno 02-03 -2022

☑SPRING SAMPLING
1°Bracciano 03-05-2021
2°Bracciano 03-05-2022
1°Trasimeno 26-05-2021
2° Trasimeno 18-05-2021

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ENEA

ARPA umbria
agenzia regionale per la protezione ambientale

Sampling in surface waters: Monitoring Protocol developed by ENEA

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CORSO DI FORMAZIONE

MONITORAGGIO DELLE MICROPLASTICHE: IL PROTOCOLLO BLUE LAKES

ARPA UMBRIA, in collaborazione con ENEA organizza un corso di formazione di tre giorni sul monitoraggio delle microplastiche lacustri finalizzato alla condivisione del Protocollo Standard Blue Lakes. Il corso è rivolto ai tecnici e personale ARPA/APPA. La durata è di tre giorni, le lezioni frontali e le attività di laboratorio si svolgono presso i Laboratori ARPA di Terni, mentre le attività di campionamento sono effettuate sul lago Piediluco, area pilota del progetto Blue Lakes.

PROGRAMMA PROVVISORIO DEL CORSO

26-09-2022 ore 15:00-19:00 (In sede)
03-10-2022 ore 15:00-19:00 (In sede)

- Registrazione
- Introduzione al corso
- Il progetto Blue Lakes: il monitoraggio delle microplastiche

Sede del Corso
ARPA Umbria
Via Carlo Alberto Dalla Chiesa, 32, 05100 Terni TR

Contatti
Responsabili scientifici e organizzativi
Maria Sighicelli: tel. 06 30486348 cell 340 2936190 maria.sighicelli@enea.it
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Paolo Stranieri: 075 51596218; p.stranieri@arpa.umbria.it
Valentina Stufara: tel. 075 51596649 mail: v.stufara@arpa.umbria.it

Come raggiungere la sede del Corso
Dalla stazione ferroviaria di Terni:
Bus 3, 9, E616, E618,
In auto:
Raccordo Terni – Orte (SS675): Uscita Terni Nord

Informazioni albergo convenzionato

Classic Hotel Tulipano
Via Carlo Alberto Dalla Chiesa, 24 Loc. Borgo Rivo Terni 05100
tel: +39 (0) 744 306024 fax: +39 (0) 744 306628 e-mail: info@classichotelterni.com

27-09-2022 ore 9:00 – 18:00 (Piediluco)
04-10-2022 ore 9:00 – 18:00 (Piediluco)

Attività di campionamento:

- uscita in barca per prelievo di campioni di acqua superficiale e colonna
- lungo le spiagge per prelievo sabbie

28-09-2022 ore 9:00 -16:00 (In sede)
05-10-2022 ore 9:00 -16:00 (In sede)

Attività di laboratorio:

- Analisi dei campioni prelevati (sorting e caratterizzazione)
- Discussione risultati

Sampling methodologies

ISO/DIS 24187
Principles for the analysis of microplastics present in the environment

Status : Under development

Key principles for the investigation of microplastics in the environment and for the subsequent development of specific procedures for sampling, processing and analysis.

Minimum requirements for particle size classification, the use of certain sampling equipment, sample preparation and the determination of representative sample quantities.

→ The particle size to be considered is strictly related to the detection method.

→ This standard does not include requirements for monitoring actions

Sampling methodologies

ISO/DIS 24187
Principles for the analysis of microplastics present in the environment

DRAFT INTERNATIONAL STANDARD

ISO/DIS 24187

ISO/TC **61**/SC **14** Secretariat: **DIN**

Voting begins on: **2021-12-08**

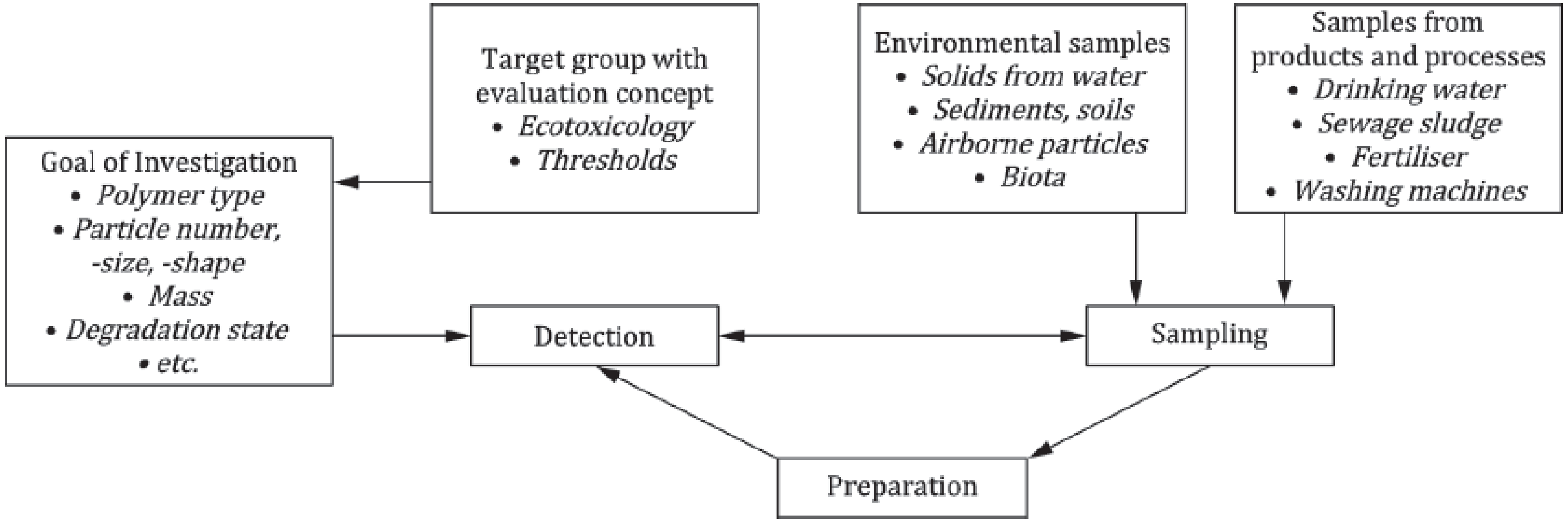
Voting terminates on: **2022-03-02**

Principles for the analysis of plastics and microplastics present in the environment

To be considered:
different physical and chemical properties, such as shape, size (range), type of polymer(s), presence of additives, presence of fillers, state of degradation.

Sampling methodologies

ISO/DIS 24187
Principles for the analysis of microplastics present in the environment



- Avoid cross-contamination → blank
- Evaluate if sterilization step is necessary in the processing phase
- Record relevant information on measurement and analysis conditions

Sampling methodologies

ISO/DIS 24187
Principles for the analysis of microplastics present in the environment

- Subdivision into dimensional ranges

classification		large microplastics	microplastics					
particle size classes	µm	5 000 to 1 000	< 1 000 to 500	< 500 to 100	< 100 to 50	< 50 to 10	< 10 to 5	< 5 to 1
average particle size	µm	3 000	750	300	75	30	7,5	3
mass[a]	mg	14	0,22	0,014	$2,2 \times 10^{-4}$	$1,4 \times 10^{-5}$	$2,2 \times 10^{-7}$	$1,4 \times 10^{-8}$
number of particles in 14,13 mg	number	1	64	1 000	$6,4 \times 10^{4}$	$1,0 \times 10^{6}$	$6,4 \times 10^{7}$	$1,0 \times 10^{9}$

[a] Mass here is determined from the average particle size assuming spherical particle with a density of 1.

- Choice of the method of analysis

- Fourier Transform Infrared Spectroscopy (FTIR),
- Attenuated Total Reflection Fourier Transform Infrared Spectroscopy (ATR-FTIR),
- Focal Plan Array Detector Fourier Transform Infrared Spectroscopy (FPA-FTIR),
- Quantum cascade laser induced infrared spectroscopy (QCL-IR),
- Near or Short-Wave Infrared Spectroscopy (NIR, SWIR).

The analysis of very small particles (<5 µm) is complex and partly limited for real samples.

Sampling methodologies

ISO/DIS 24187
Principles for the analysis of microplastics present in the environment

SAMPLING VOLUME

The sampling volume depends on the size range of the microplastics under investigation and the expected number of particles or mass. It is assumed that the smaller the diameter of the particle is, the greater its presence is.

The smaller is the expected particle quantity, the more sample must be taken in order to examine a representative number of particles.

Very large representative sample volumes need to be taken in almost solid-free water bodies.

Sampling methodologies

ISO/DIS 24187
Principles for the analysis of microplastics present in the environment

FILTRATION MESH

Subdivision into dimensional classes based on the filtration ranges.

In case of high concentrations of solids in the water sample and large sample volumes, a fractional filtration helps to reduce the filter cake formation and the consequent blockage or partial blockage of the filters.

The volume of water sampled and the volume of water actually filtered must always be reported in the documentation of sampling methods.

→ To ensure the quality of the filtration process, recovery tests are recommended.

Sampling methodologies

ISO/DIS 24187
Principles for the analysis of microplastics present in the environment

FILTRATION MATERIALS

FILTRATION EQUIPMENT

References to filtration methods non-specifics for microplastics for the different environmental matrices (marine waters, surface waters, groundwater)

SLUDGE

In sewage sludge analysis, traditional sampling practices are not easily transferable to the field of MPs. The size and number of plastic particles, in particular, play an important role in representative sampling.

Sampling methodologies

There is a huge differentiation in the volume of water and sludge samples taken from influent and/or effluent as well as from different treatment plant processes.

Sampling can be done in several ways, mainly including:

- Collection in containers and subsequent filtration
- Collection with autosampler and subsequent filtration

PROS: easier from an operative point of view
CONTRA: limited volumes

- Pumping and filtration
- Composite filtration devices

PROS: higher volumes
CONTRA: not common, developed for specific projects

Due to the relatively low concentrations of microplastics and their non-uniform temporal and spatial distributions in waters, the representativeness of the sample should be considered when interpreting the data and defining the sampling methodology.

Research has highlighted the need to analyze microplastic pollution in treatment plants over a longer period of time to reveal the temporal variation of microplastic concentrations.

Definition of a sampling protocol

Minimum sampling volumes proposed in BLUE LAKES

Sector	Plant	Unit	Type of sample	Min. volume	Min. number of samples	Notes
Drinking water supply	Drinking water treatment Plant	Influent	Min 1-2 h average sampling	1000 l	3*	*Min. number of sampling campaigns defined to detect seasonal variability.
		Effluent from each operativeunit	Min 1-2 h average sampling	1000 l	3*	
		Final Effluent	Min 1-2 h average sampling	1000 l	3*	
		Sludge**	Grab	5 l	3*	**Sludge is considered as liquid at maximum TS% of about 5%TS.
	Distribution	Final Distribution***	Min 1-2 h average sampling	1000 l	3*	***Min. Number of Sampling points has to be set accordingto the distribution network complexity.
Sewage system	CombinedSewer Overflow	CSO	Grab or Average sampling	50 l****	3*	****Min volume could be very variable depending on the quantity overflowed.
Wastewater Treatment	Wastewater Treatment Plant	Influent	Average sampling	30-300 l*****	3*	*****Min. volume could be very variable depending on watercharacteristic.
	Wastewater Treatment Plant	Effluent from each operativeunit	Average sampling	30-300 l *****	3*	
	Wastewater Treatment Plant	Final Effluent	Average sampling	30-300 l *****	3*	
	Wastewater Treatment Plant	Sludge**	Grab	5 l	3*	

Definition of a sampling protocol

Scheme for sampling activity

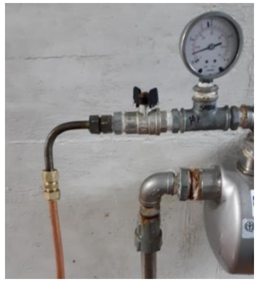
SAMPLING POINT	DATE	WEATHER	METHOD	START OF SAMPLING	DURATI ON	END OF SAMPLING	VOLUME	CHEMICAL AND PHYSICAL CHARACTERISATION (es. TSS)	NOTES

Write down any particular condition (e.g. unit malfunctions, events, anomalies during sampling, …)

Possibly match the sampling with the routine characterizations of the plant

Sampling methodologies for water treatment plants

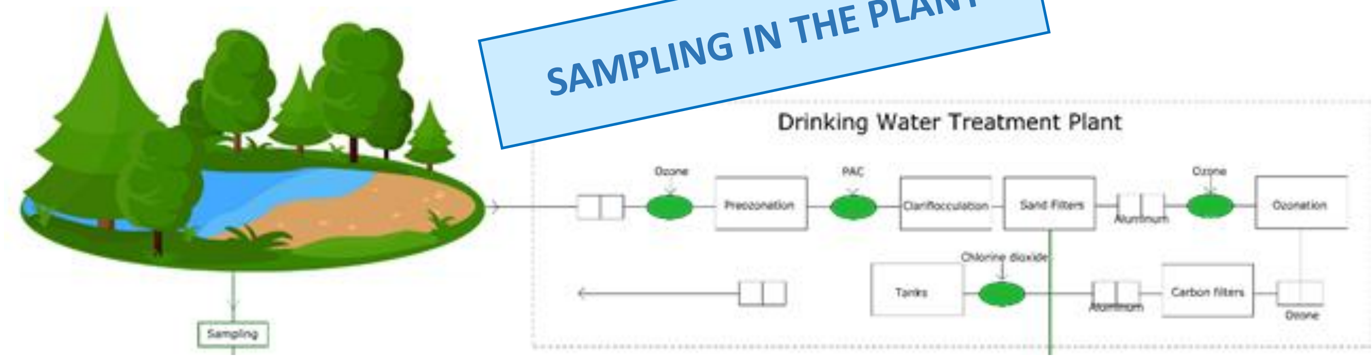
Sampling points




CARTRIDGE FILTER (50 micron)


PUMPING AND SIEVING
(up to 50 micron)

SAMPLING IN THE PLANT



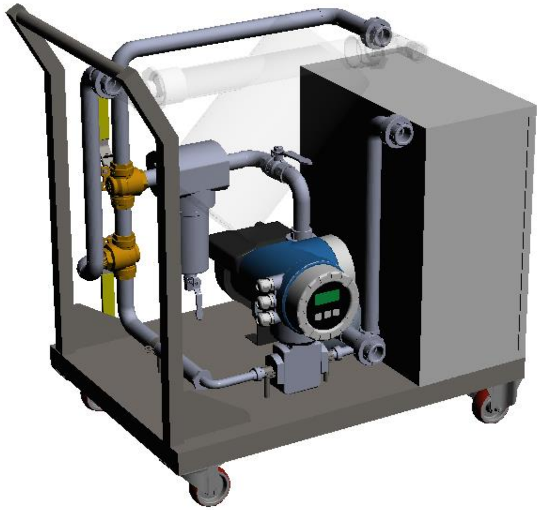

SAMPLING IN THE
DISTRIBUTION NETWORK

Sampling methodologies for water treatment plants

Optimisation of sampling methods

PUMPING AND SEIVING
(50 micron)

STEEL FILTERS (50 micron) About 1000 l sampled in drinking water



AUTOMATIC SAMPLER
(50 and 25 micron)
Tested in wastewater

Sampling methodologies for water treatment plants

Istantaneous sampling and subsequent filtration

Sample collection in tanks → Subsequent processing in lab

Used when it is not possible to connect filtering systems on site

Limited quantities of volumes (about 5-20 L)

For **sludge samples**, which are generally taken discontinuously, in situ collection and subsequent filtration in the laboratory on batteries of sieves are generally used.
Prior to filtration, sludge samples are stored at -20°C if not processed immediately.

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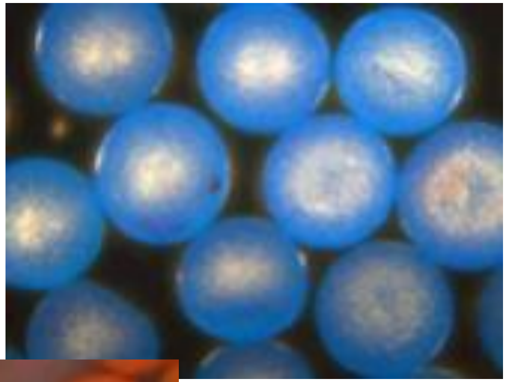
ATTENTION TO THE CONCEPT OF SAMPLING YIELD

Recovery capacity of standard MPs/ introduced MPs %

Also by Size Class



Sieving

The sieve batteries consist of steel sieves with mesh sizes of 5 mm, 2 mm and 50 µm (ISO 3310-1:2000). They are used in case of instantaneous sampling, as this procedure is feasible only for limited quantities of volume (e.g. 25 litres).

A pumping system may be required to convey the water flow to the sieve battery. The pumping system must be made with non-plastic components, to avoid contamination. In particular, the pump is generally made of steel and the connections are made of copper or brass.

Sampling methodologies for water treatment plants

Sieving

1. Adjust the water flow and record it manually.
2. Calculate the time required to filter the desired volume in situ
3. Filter the sample through the battery of steel sieves with 5 mm, 2 mm and 50 µm meshes (ISO 3310-1:2000)
4. BLANK: To control any external environmental contamination, place a jar filled with deionized water up to ¾ of the volume. Leave the can open during the entire filtration time through the sieves and during material recovery operations. Close the jar with the lid and then with the parafilm.
5. After filtration, remove the 5 mm mesh sieve: this sieve is used in sets to exclude any plastic particles larger than 5 mm that may be present. Material retained on the 5mm sieve should not be recovered.
6. Rinse the particles on 2 mm and 50 µm sieves in glass jars with water
7. Use spray bottles and/or hand pressure pump with deionized water to collect material retained on sieves. The recovered material must be stored in glass jars closed with lids and then with parafilm.
8. Identify the sample by writing directly on the can or on white tape/packet attached to the container. The stored sample will then be processed later in the laboratory.

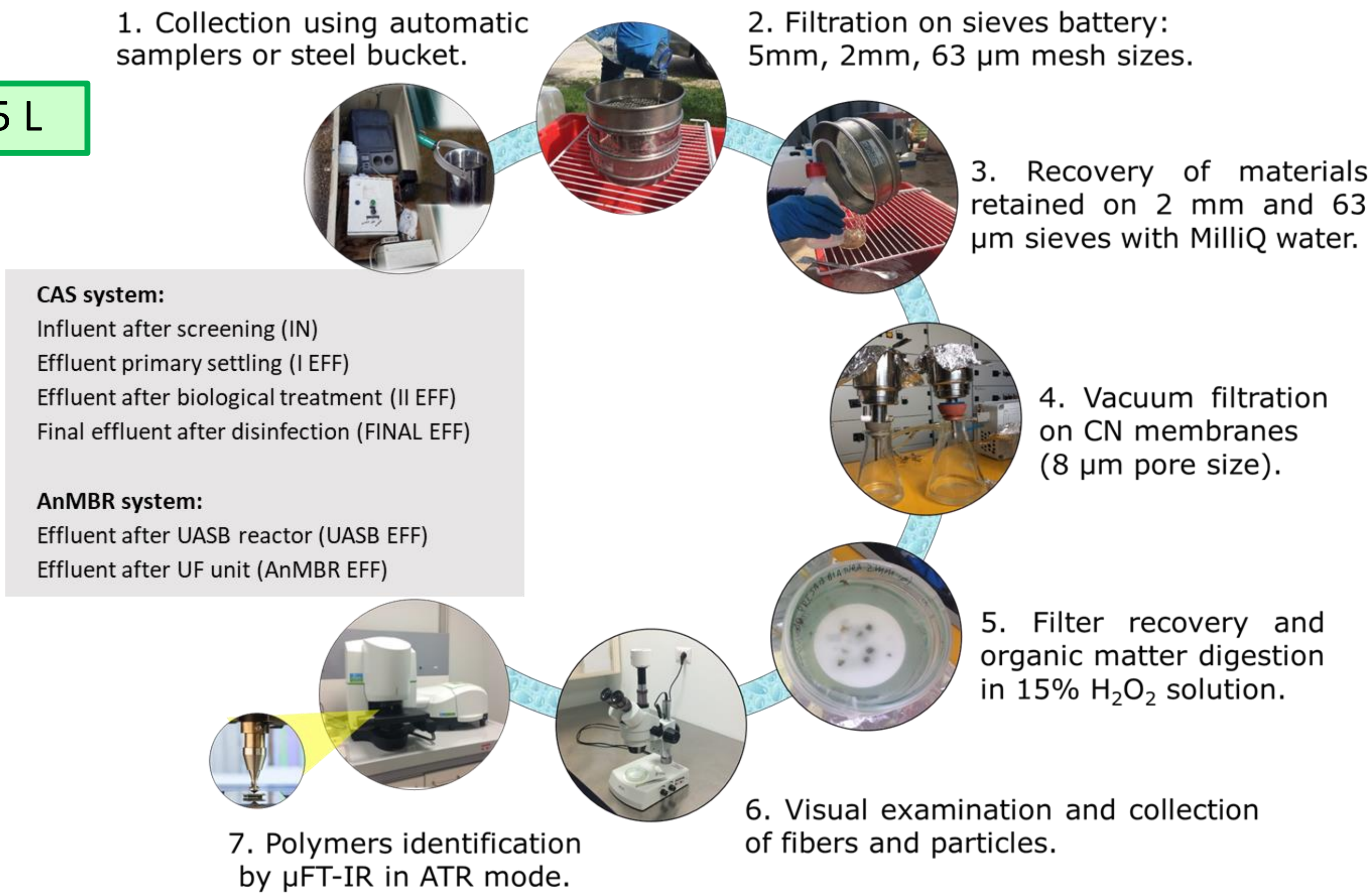
Sampling methodologies for water treatment plants

Sieving

Pittura et al., 2021 "Microplastics in real wastewater treatment schemes: Comparative assessment and relevant inhibition effects on anaerobic processes" Chemosphere, 262, 128415

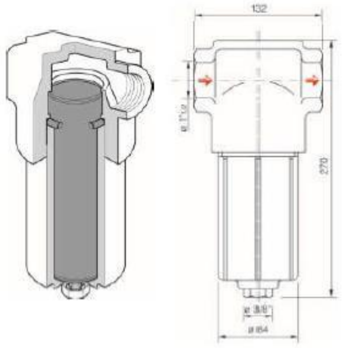
Wastewater processing for MPs analysis

VOLUMES ~25 L



Sampling methodologies for water treatment plants

Closed filtering systems



Closed filter systems are preferably used when there is the possibility of connecting the filter system directly to the system pipes.
Direct filtration allows to obtain composite samples during the filtration time and can process larger volumes (about 1000 L).

The filtering device consists of a metal container inside which a cylindrical filter with a 50 µm mesh is housed. The filter cartridge is made of micro-expanded stainless steel sheet.
The connections between the cartridge filter and the system piping are made with copper pipes to avoid any plastic contamination.

Operating pressure	**30 barg**
Filtration degrees	**From 50 µm onwards**
Design pressure	**45 barg**
Maximum operating temperature	**70 °C**
Inlet/Outlet flanges	**Ø 1” 1/2**
Discharge	**Ø 3/8**
Drain valve	**Manual ball**

Sampling methodologies for water treatment plants

Closed filtering systems

1. Connect the filter to the system sampling tap using suitable copper pipes and brass fittings.
2. Adjust the water flow and record it manually.
3. Calculate the time required to filter the desired volume in situ, through a 50 µm stainless steel filter.

Closed filtering systems

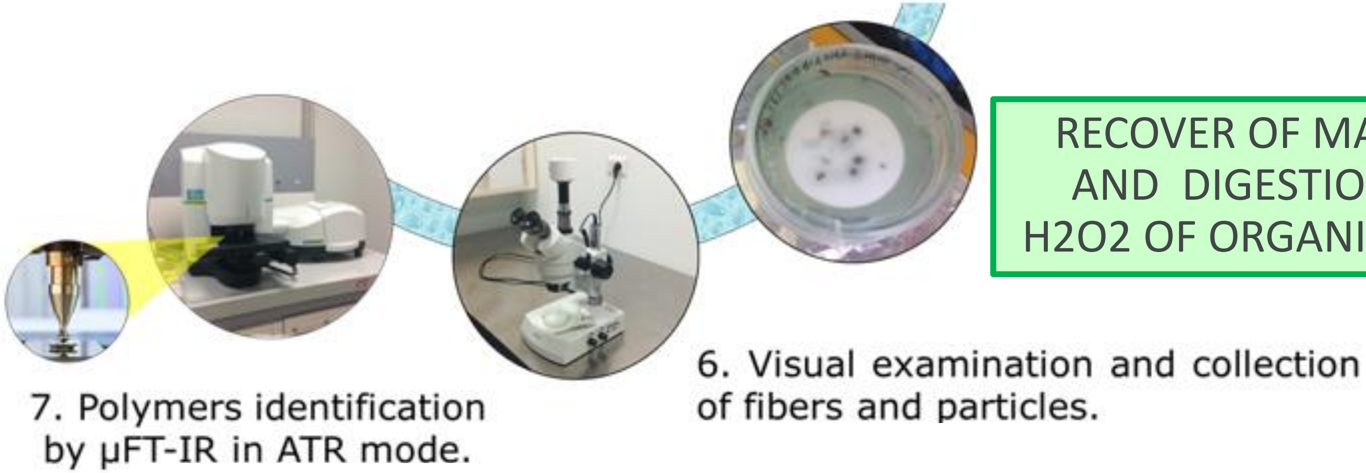
4. Once filtration is complete, place the filter in a steel pan or glass beaker and rinse the filter with deionized water to recover any particles retained on the filter. If necessary, use pressure washers and/or manual pressure pumps that can facilitate/optimize the operation.
5. Place an empty jar filled with deionized water and leave open during the wash step for each sample. This will be used as a control to account for any contamination from the air.
6. Once the filter is completely cleaned, pour the washed water into a glass jar and rinse the bowl in the jar to recover all particles. Close the jar with its lid and then using the parafilm.
7. Name the samples and each control jar, then take them to the laboratory for processing.

Sampling methodologies for water treatment plants

Closed filtering systems

Drinking water treatment plants

SAMPLING A VOLUME OF ~1000 L AND FILTERING WITH STEEL CARTRIDGE FILTER DEVICE (50 micron)



RECOVER OF MATERIALS AND DIGESTION WITH H2O2 OF ORGANIC MATTER

CHARACTERIZATION WITH IR

Closed filtering systems

González Camejo, J., Morales, A., Peña-Lamas, J., Lafita, C., Enguídanos, S., Seco, A., Martí, N., 2022. Feasibility of rapid gravity filtration and membrane ultrafiltration for the removal of microplastics and microlitter in sewage and wastewater from plastic industry. J. Water Process Eng. 03853. (submitted)

Be careful if they form layer a control necessary to stop filtration

- Sampling device for in situ filtration with a wide range of sizes simultaneously during sampling.
- Ability to continuously filter a large volume of wastewater.
- Divide the sample into several fractions, so that each of them contains solids of a certain size range.
- Filters and/or sieves of different pore sizes.
- Four removable stainless steel links with sizes of 500, 190, 100 and 25 µm.
- In this way it is possible to separate particles with diameters between >500, 190-500, 100-190 and 25-100 µm.
- The links have a diameter of 20 cm and are placed on bars stacked on top of each other.
- The stack of rods is placed inside a rigid polypropylene case with a base and lid that serve as the body of the sampling device.
- The cap and base are tight to the casing to prevent any leaks that could occur at the edges of the displays.
- Flow meter at the sampler head, to know the volume of the sampled wastewater at any time

Sampling methodologies for water treatment plants

Water and Waste Environmental Engineering LAB

QA/QC: Prevention and control of external contamination from plastic material and fibres

Main measures adopted during all phases: sampling, recovery, processing and characterization

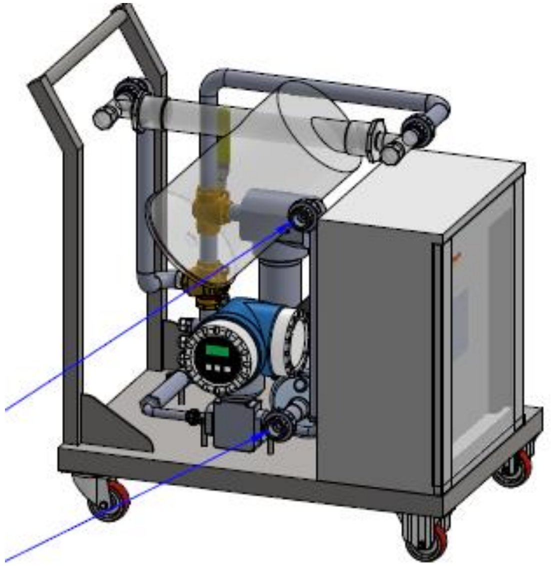
- use of non-plastic material (stainless steel, glass, aluminum, copper)
- if plastic materials are used (gaskets, washers…) the material must be characterized to eventually exclude it from the results.
- Closed sampling system vs system exposed to the atmosphere.

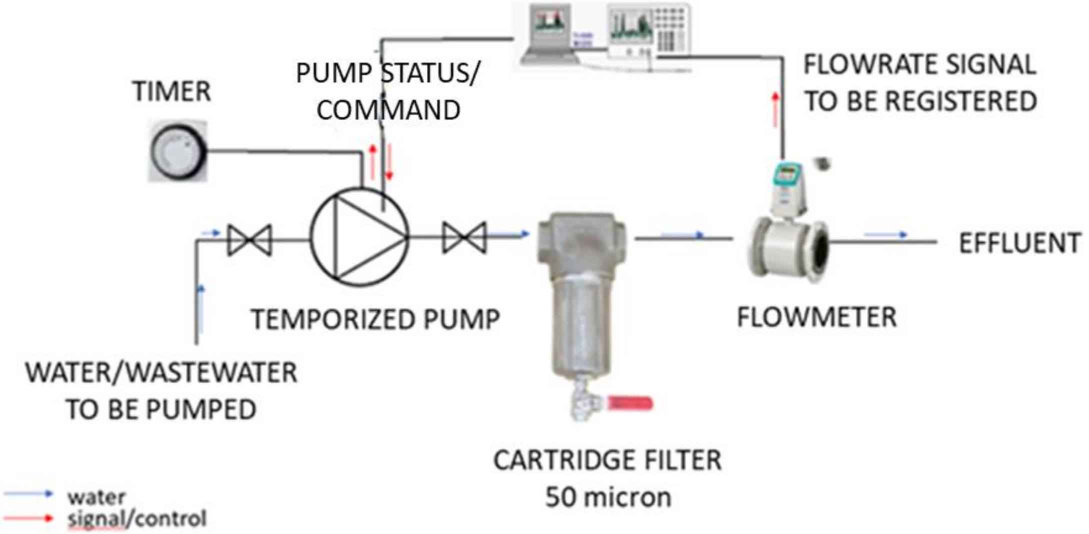
- Execution of blank samples for each sample collected: a beaker containing deionized water is left open on the workbench for the entire time necessary to recover the sample and subsequently processed according to the same procedures as the water or sludge sample.

Blue Lakes
No microplastics, just waves.

Automatic sampler

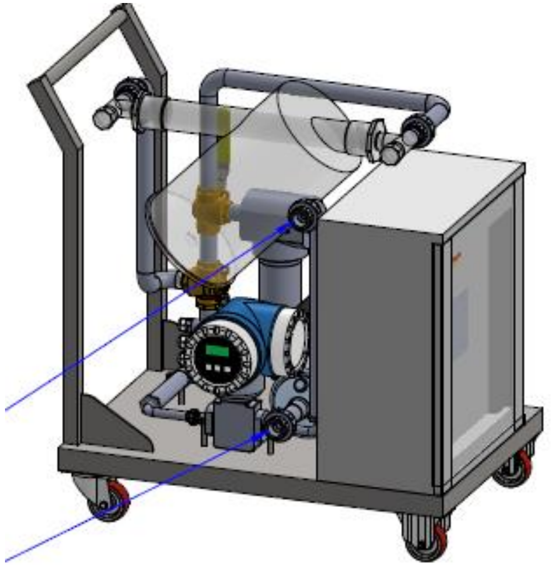
The automatic sampling system, currently under development by the WWEELab (Marche Polytechnic University), consists of a timed sampling pump, a cartridge filtration system (50 micron), an electromagnetic flow meter and PLC data logging and control. This allows you to acquire a composite sample (24 hours) and filter larger quantities of water (up to 300-1000 L for wastewater and up to 5000 L for potable water). Flow rate measurements will allow you to know exactly how much volume is being filtered and to stop the pump when the flow rate drops below a certain value due to clogging problems.

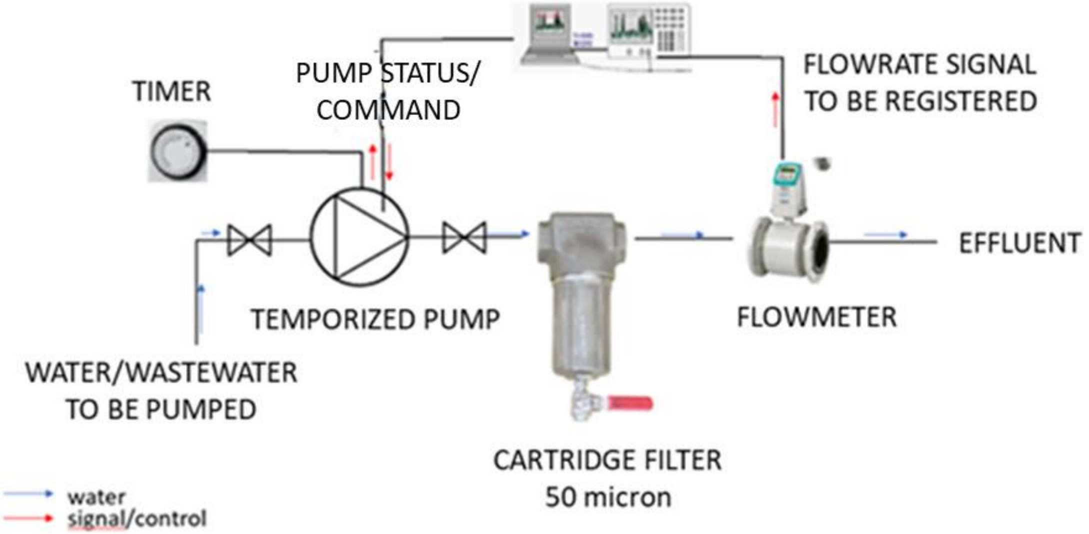




Automatic sampler

The device can be set to work with time control or combined time and flow rate.
When set in timed mode, the pump is activated only at certain time intervals, with filtering cycles and pause cycles. In this way it is possible to perform average samples.
When the device works in time and flow control, the pump automatically interrupts its filter/pause cycles when the flow reaches a predefined lower threshold, which means that the filter has reached a certain clogging level.





Sampling methodologies for water treatment plants

Automatic sampler

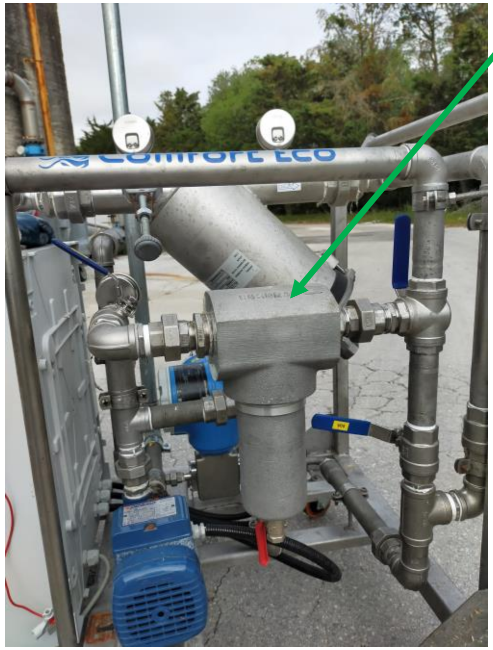
- Automatic recording of sampled volumes
- Possibility to modulate sampling intervals and periods
- Time-based and flow-based regulation
- Possibility of filtering large volumes (≈ a few m3)
- Representativeness of plant variations
- Ease of use by operators

Sampling methodologies for water treatment plants

Automatic sampler

NEW PROTOTYPE OF AUTOMATIC SAMPLER
TESTED IN A FULL-SCALE WWTP

- Flowrates meter with data recording
- Pressure meter
- Subsequent filters of 50 µm and 25 µm



50 µm filter

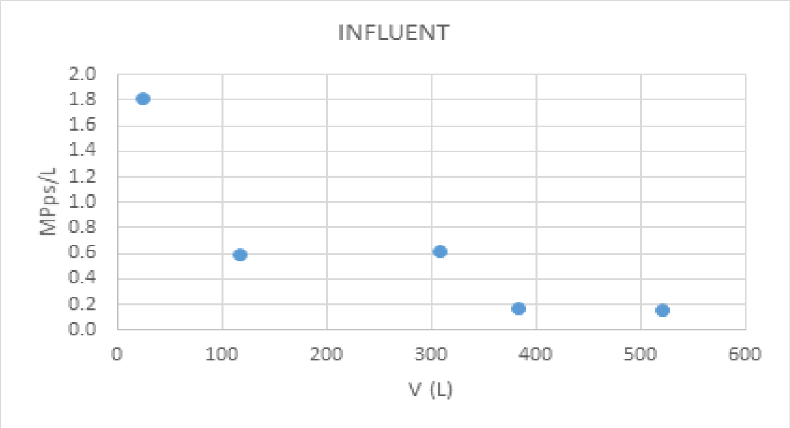
25 µm filter

Filtered volumes registration

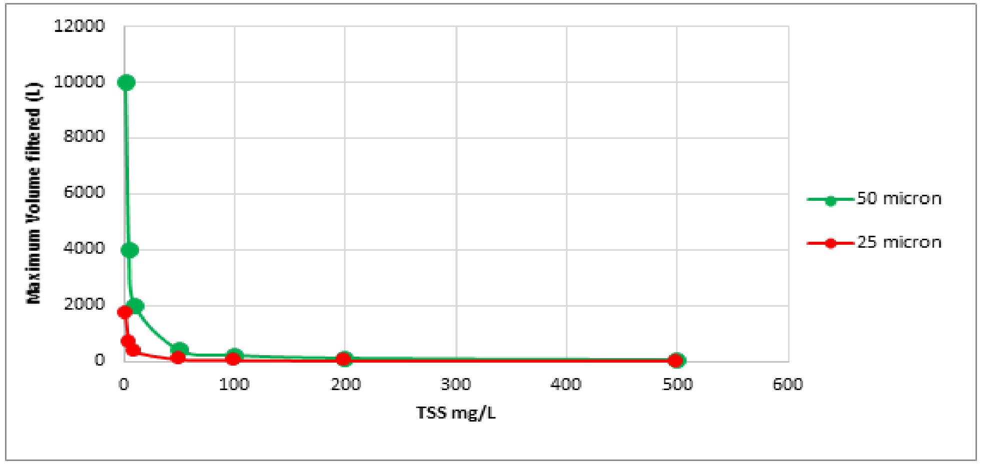
Sampling methodologies for water treatment plants

Tests to identify the minimum representative volume for the quantification of microplastics in purification plants

INFLUENTE		
Volume (L)	MPs/L	TSS mg/L
25	1.800	~200
119	0.580	
310	0.610	
385	0.160	
521	0.146	



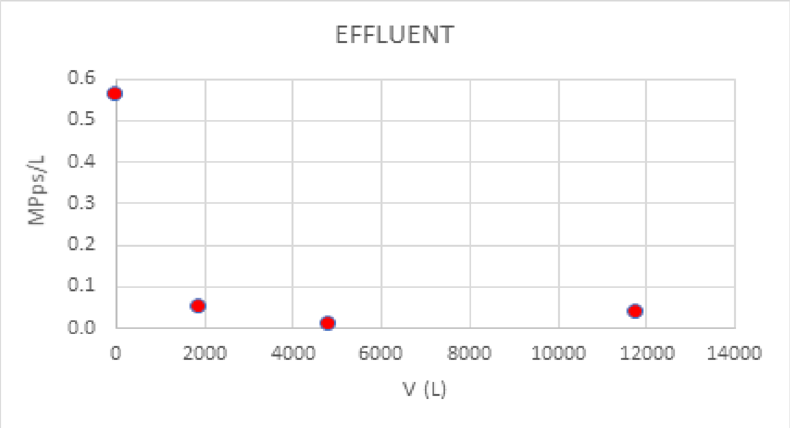
Maximum volume filtered at different solid concentrations



By increasing the sampling volume, the concentrations of microplastics decrease, until they reach a stable level:

- 100-400 L of filtered influent
- 1000-2000 L of filtered effluent

EFFLUENTE		
Volume (L)	MPps/L	TSS mg/L
25	0.560	<5
88	n.d.	3.6
1898	0.047	2
4828	0.009	3
11758	0.037	2.2



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Thank you for the attention!

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Extraction and characterization methodologies

Samples processing for microplastics analysis in Integrated Water Service matrices

Università Politecnica delle Marche

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Extraction and characterization of MPs from environmental matrices

UNIVERSITÀ POLITECNICA DELLE MARCHE

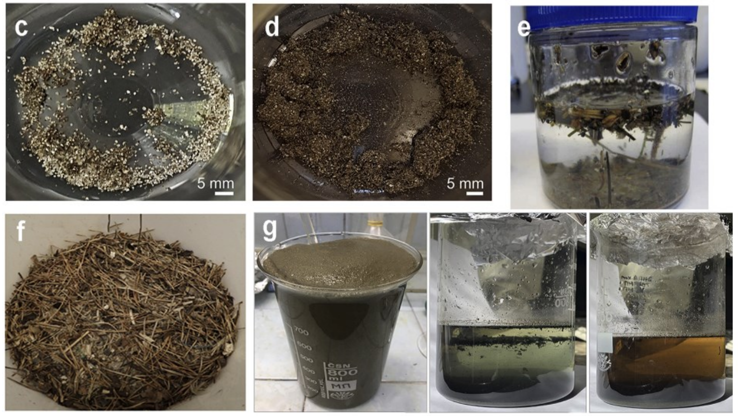
COMPLEX MATRICES

Inland water, wastewater, sludge, treated water : mix of organic matter and mineral components, often in aggregation.

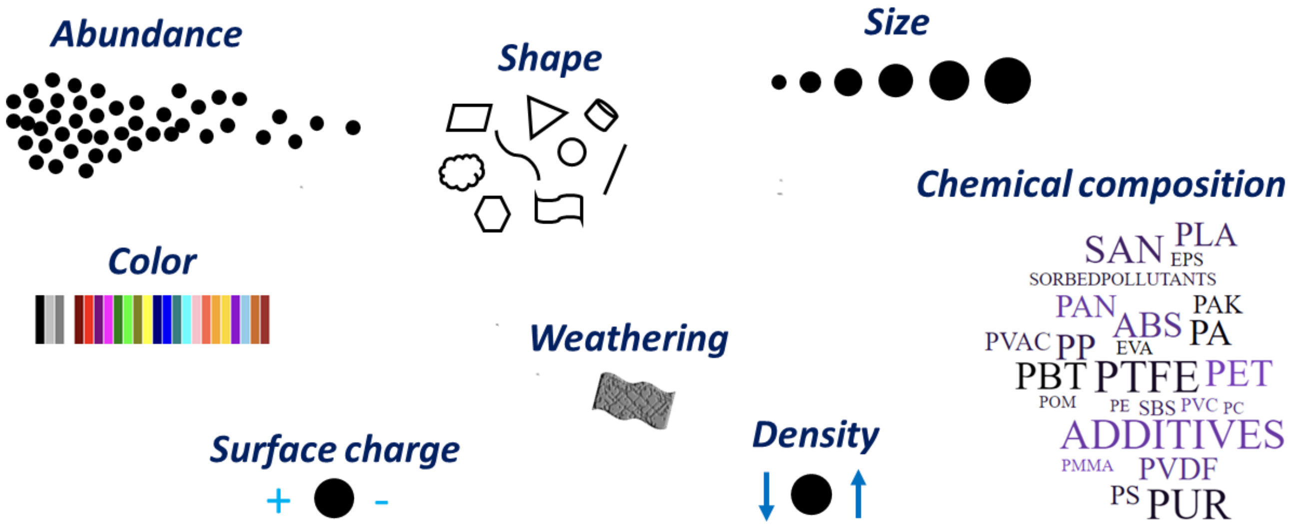
+

HETEROGENEOUS CLASS OF CONTAMINANTS

Microplastics (MPs) are a complex group of synthetic solid particles varying for sizes (5mm-1µm), shapes, colors, density, surface charge and chemical compositions.



From Monteiro & da Costa, 2021



SAMPLES ARE PROCESSED TO REDUCE MASS (OR VOLUME) AND ISOLATE MPs FROM OTHER ORGANIC AND INORGANIC PARTICLES.

PROPERLY ISOLATING MPs IS THE KEY TO OBTAIN HIGH EXTRACTION EFFICIENCIES, GUARANTEE PARTICLE PRESERVATION AND GENERATE ACCURATE DATA.

Methods for extraction of MPs

DIGESTION

DENSITY-BASED SEPARATION

SIEVING/FILTRATION

- The 3 procedures are usually applied in combination using different methods which vary in complexity, time and cost of materials.
- The choice of method often depends on the type of sample (water vs sludge/; organic matter and mineral content).
- The extraction efficiency is influenced by: type of matrix, MPs characteristics, applied method.
- In turn, MPs characteristics (shape, color, surface texture, chemical composition) can be altered by the extraction method applied.

Journal of Cleaner Production 337 (2022) 130458
Contents lists available at ScienceDirect
Journal of Cleaner Production
journal homepage: www.elsevier.com/locate/jclepro

A review on microplastics separation techniques from environmental media

Iqra Nabi [a,1], Aziz-Ur-Rahim Bacha [a,1], Liwu Zhang [a,b,*]

Environmental Science & Technology
pubs.acs.org/est Critical Review

A Critical Review of Extraction and Identification Methods of Microplastics in Wastewater and Drinking Water

Dounia Elkhatib and Vinka Oyanedel-Craver*

Cite This: Environ. Sci. Technol. 2020, 54, 7037−7049 Read Online

Science of the Total Environment 745 (2020) 140943
Contents lists available at ScienceDirect
Science of the Total Environment
journal homepage: www.elsevier.com/locate/scitotenv

Review

How can we trace microplastics in wastewater treatment plants: A review of the current knowledge on their analysis approaches

Peiying Kang [a,b,*], Bin Ji [a,b], Yaqian Zhao [a,b,*], Ting Wei [a,b,c]

Trends in Environmental Analytical Chemistry 33 (2022) e00151
Contents lists available at ScienceDirect
Trends in Environmental Analytical Chemistry
journal homepage: www.elsevier.com/locate/treac

Methods for the extraction of microplastics in complex solid, water and biota samples

Silvia S. Monteiro *, João Pinto da Costa

Trends in Environmental Analytical Chemistry 36 (2022) e00181
Contents lists available at ScienceDirect
Trends in Environmental Analytical Chemistry
journal homepage: www.elsevier.com/locate/treac

An insight on sampling, identification, quantification and characteristics of microplastics in solid wastes

Palas Samanta [a], Sukhendu Dey [b], Debajyoti Kundu [c], Deblina Dutta [c,d], Rohit Jambulkar [c], Rahul Mishra [c], Apurba Ratan Ghosh [b], Sunil Kumar [c,*]

Methods for extraction of MPs

DIGESTION

- Used to eliminate organic material and to remove biofilm from the surface of MPs.

- Applied to waste/treated water and sludge samples as first processing, due to the high concentration of organic matter in these matrices: pre-treatment to filtration and density-based separation procedures.

- There are several methods of digestion, used singly or in combination. The digestion efficiency and the effect on MPs depend on the type of agent used and the concentration, the incubation time and the working temperature.

- **Acid digestion (HNO3 or HCl):** the most effective but also the most destructive method, it causes the degradation of various plastic polymers especially at high acid concentrations and at high temperatures. Method not recommended as it may lead to underestimation of MPs.

- **Alkaline digestion (KOH):** valid alternative, it is a simple, inexpensive method, relatively low chemical risk and few effects on plastic polymers. However, it has low efficiency in degrading cellulose and chitin, which are common components of soil and sludge. Most commonly used method for processing samples of animal origin.

- **Oxidative digestion (H_2O_2):** most popular method. Little effect on the integrity of the MPs if used at less than 20%: at higher concentrations, changes in transparency and shrinkage of the dimensions of the MPs and interferences in the chemical characterization phase can be observed. Long digestion times at room temperature which can be reduced if carried out at room temperature (less than 40°C).
- H_2O_2 +Fe^{2+} (catalyst): faster reaction, low cost of reagents, high degradation efficiency of lignin, cellulose, EPS. However highly reactive (caution!) and can decompose MPs in an acidic environment.

- **Enzymatic Digestion (e.g. Proteinase-K):** simple, low-risk method with high recovery rates and no adverse effects on plastics. However, method onerous and often requires long incubation periods. Applicable to small volumes (or quantities) of samples.

Methods for extraction of MPs

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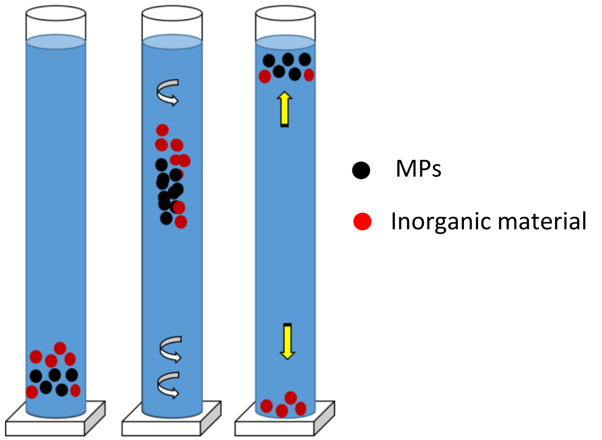
DENSITY-BASED SEPARATION

- Applied to separate MPs from non-organic material.
- The process is based on the buoyancy properties of MPs in a denser saline solution: the sample is mixed with the saline solution and left to decant to collect the supernatant while heavier non-plastic debris settles on the bottom. The extraction efficiency increases by repeating the procedure.
- Duration of mixing and settling time can vary considerably depending on the volume and type of sample, from minutes to several hours or days.
- There is a range of salts that varies in density, cost and toxicity.



Comparison of the main salts used for density-based separation (Frias et al., 2018)

Salt	Abbr.	Toxicity (Health hazard)	Price (€/500g, listino *Merck*)
Cloruro di sodio	NaCl*	Low	30
Sodio tungstato diidrato	STD	Low	303
Bromuro di sodio	NaBr	Low	80
Ioduro di sodio	NaI	Moderate	345
Cloruro di zinco	$ZnCl_2$	High	90
Bromuro di zinco	$ZnBr_2$	High	170
Sodio politungstato	SPT	Low	1300

***NaCl** the most common used, inexpensive, readily available and ecofriendly, recommended for monitoring plans with high number of samples. May have a low recovery rate for MPs with similar or slightly higher densities.

Buoyancy of plastic polymers in saline solutions based on their respective densities (g cm-3)

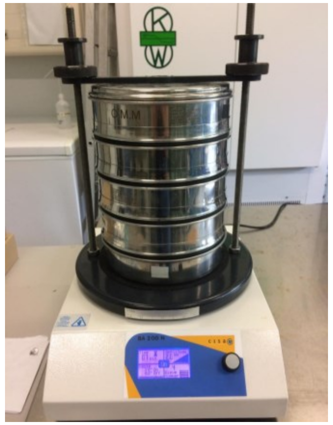
Polymer	Abbr.	Polymer density	NaCl* (1.2)	STD (1.4)	NaBr (1.4)	NaI (1.4-1.8)	$ZnCl_2$ (1.6-1.8)	$ZnBr_2$ (1.1.7)	SPT (2.94-3)
Polystyrene	PS	0.01 – 1.06	+	+	+	+	+	+	+
Polypropylene	PP	0.85 – 0.92	+	+	+	+	+	+	+
Low-density polyethylene	LDPE	0.89 – 0.93	+	+	+	+	+	+	+
Ethylene vinyl acetate	EVA	0.93 - 0.95	+	+	+	+	+	+	+
High-density polyethylene	HDPE	0.94 – 0.98	+	+	+	+	+	+	+
Polyamide	PA	1.12 – 1.15	+	+	+	+	+	+	+
Nylon 6,6	PA 66	1.13 – 1.15	+	+	+	+	+	+	+
Poly methyl methacrylate	PMMA	1.16 – 1.20	+-	+	+	+	+	+	+
Polycarbonate	PC	1.20 – 1.22	+-	+	+	+	+	+	+
Polyurethane	PU	1.20 – 1.26	+-	+	+	+	+	+	+
Polyethylene terephthalate	PET	1.38 – 1.41	-	+-	+	+	+	+	+
Polyvinyl chloride	PVC	1.38 – 1.41	-	+-	+-	+	+	+	+
Polytetrafluoroethylene	PTFE	2.10 – 2.30	-	-	-	-	-	-	+

Methods for extraction of MPs

SIEVING/FILTRATION

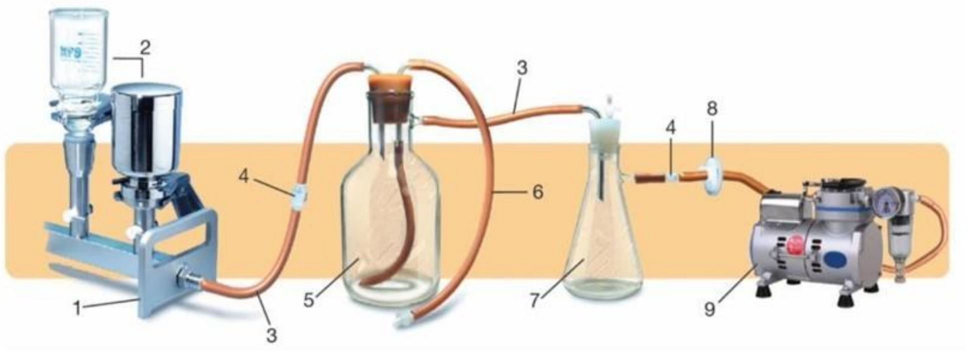
- **SIEVING** : applied as a first phase to remove coarse material (5mm mesh), reduce the volume (or mass) of the sample (if not done in the sampling phase), make a first selection of MPs on a dimensional basis.

  - Use of a battery of sieves with mesh in the 5mm-20µm range.
  - The material retained by the <5mm mesh sieves is recovered and subjected to processing for the extraction of the MPs.
  - The portion of sample that passes from the last sieve of the battery can be filtered under vacuum on membranes of lower porosity to recover MPs smaller than 20µm.



- **FILTRATION UNDER VACCUM**: direct filtration of the sample without a pre-treatment (digestion and/or density-based separation) is not recommended, it would require long times and a high workload in the characterization phase of MPs. Applied as the last stage of the extraction process.

  - Porosity of membrane filters varies between 0.1 and 20 µm.
  - Filters are available in different materials: polytetrafluoroethylene, polycarbonate, nylon, glass fibre, cellulose (nitrocellulose, cellulose acetate or mixed cellulose), stainless steel, aluminum oxide.
  - Type of filter is chosen on the basis of availability, porosity, structure and suitability for the analytical techniques used for the subsequent characterization of the retained particles.



Methods for extraction of MPs

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ALTERNATIVE METHODS

Physical separation of particles according to their lipophilic properties (oil extraction methods)…

A novel, density-independent and FTIR-compatible approach for the rapid extraction of microplastics from aquatic sediments†

Ellika M. Crichton,[a] Marie Noël,[a] Esther A. Gies[ab] and Peter S. Ross*[a]

Science of the Total Environment 733 (2020) 139338

Contents lists available at ScienceDirect

Science of the Total Environment

journal homepage: www.elsevier.com/locate/scitotenv

ELSEVIER

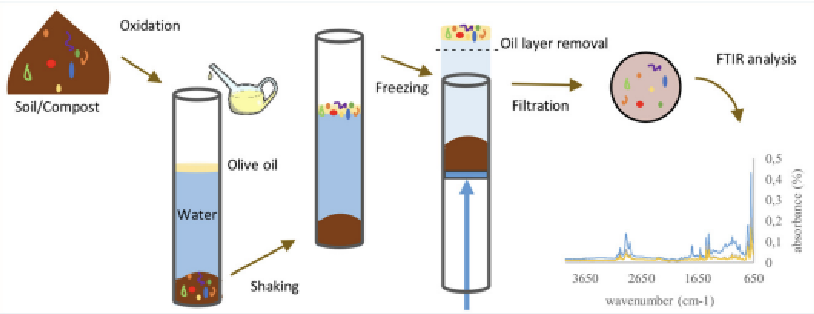
Olive oil-based method for the extraction, quantification and identification of microplastics in soil and compost samples

Costanza Scopetani[a,*], David Chelazzi[b], Juha Mikola[a], Ville Leiniö[c], Reijo Heikkinen[d], Alessandra Cincinelli[b,e], Jukka Pellinen[a]

HIGHLIGHTS

- A methodology for microplastic extraction from solid samples is suggested.
- Olive oil was selected to extract microplastics from soil and compost samples.
- The developed method is able to extract high density polymers.
- High recovery rate of 90% ±2% to 97% ± 5% were achieved.
- Olive oil seems to have high affinity for a wide set of polymers.

GRAPHICAL ABSTRACT



Marine Pollution Bulletin 133 (2018) 553–561

Contents lists available at ScienceDirect

Marine Pollution Bulletin

journal homepage: www.elsevier.com/locate/marpolbul

ELSEVIER

Retention of microplastics in a major secondary wastewater treatment plant in Vancouver, Canada

Esther A. Gies[a,b], Jessica L. LeNoble[a], Marie Noël[a], Anahita Etemadifar[a], Farida Bishay[c], Eric R. Hall[b], Peter S. Ross[a,*]

…or surface charge (electrostatic separation).

Environmental Pollution

Volume 234, March 2018, Pages 20-28

ELSEVIER

A new approach in separating microplastics from environmental samples based on their electrostatic behavior ☆

Stefanie Felsing, Christian Kochleus, Sebastian Buchinger, Nicole Brennholt, Friederike Stock, Georg Reifferscheid

Methods for extraction of MPs

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QUALITY ASSURANCE AND QUALITY CONTROL (QA/QC)

DURING THE PROCESSING (AND SAMPLING) OF ENVIRONMENTAL MATRICES IT IS ESSENTIAL TO DEVELOP AND APPLY PROCEDURES THAT ENSURE THE ACCURACY AND REPRODUCIBILITY OF DATA.

QA/QC procedures include:

1. implementation of contamination mitigation measures: particularly relevant for microfibres.
2. determination of the recovery rates of extraction methods: they are influenced by various variables, including the reagents used, the characteristics of MPs (polymer, size, shape) and the environmental matrix.
3. evaluation of effects of the extraction methods on the properties of MPs: alteration of size, shape, surface texture, color and characteristics of the polymer.

Special Issue: Microplastics

Applied Spectroscopy

Applied Spectroscopy
2020, Vol. 74(9) 1099–1125
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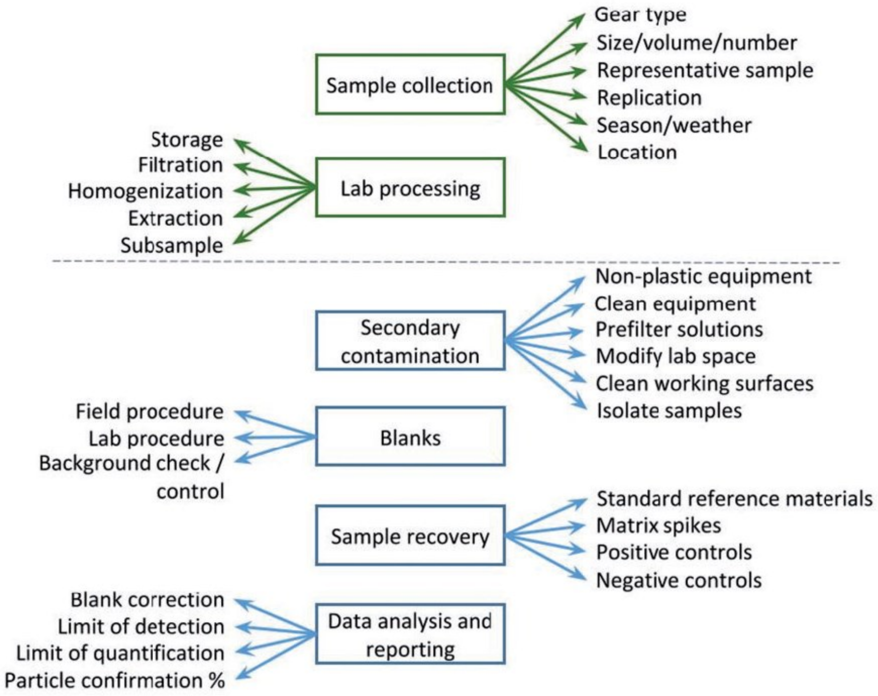
SAGE

Sampling and Quality Assurance and Quality Control: A Guide for Scientists Investigating the Occurrence of Microplastics Across Matrices

Susanne M. Brander[1], Violet C. Renick[2], Melissa M. Foley[3], Clare Steele[4], Mary Woo[4], Amy Lusher[5], Steve Carr[6], Paul Helm[7], Carolynn Box[8], Sam Cherniak[9], Robert C. Andrews[9], and Chelsea M. Rochman[10]



Methods for extraction of MPs

QA/QC (1): MITIGATION MEASURES ON CONTAMINATION by EXTERNAL MPs

- Avoid using plastic devices and materials, replacing them with glass or metal. If not possible, it is necessary to characterize these materials and compare them with MPs extracted from samples: if they correspond, remove from results.

- Clean materials and instruments with ultrapure/deionized water and/or ethanol, filter solutions, especially saline solutions, (0.22 or 0.45 µm pore size), keep samples covered as much as possible (petri dish lids, aluminum foil).

- The problem of fibers:

➢ the use of cotton lab coats may contain the release of synthetic textile fibers. However, even natural fabrics can release fibers: the use of lab-coats, gloves and brightly colored paper can help identify accidental contamination.

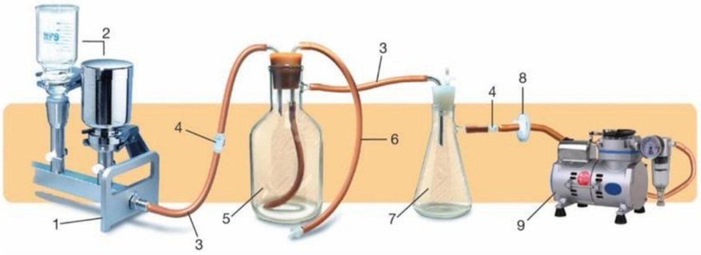
➢ it is suggested to process the samples under a laminar flow hood: chemical hoods are poorly efficient in controlling contamination as the unfiltered air from the laboratory is sucked into the hood and then expelled outside. The alternative is to work in rooms with controlled airflow and access (minimum circulation of personnel).

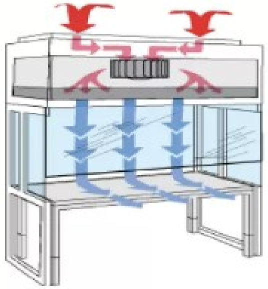
- To check background contamination :

➢ Airborne blanks: Beakers with water or wet filter in a Petri dish left open on the workbench during sample processing.

➢ Procedural blanks: pure reagents (or water) treated with the same procedures and for the same times as the environmental samples.

They can be performed separately or in a single solution (a single blank to control airborne deposition and procedures).





Methods for extraction of MPs

QA/QC (2 and 3): RECOVERY RATE OF EXTRACTION METHOD AND IMPACT ON PARTICLES

- The effectiveness of a procedure for extracting MPs from a matrix (recovery rate and impact on particles) can be tested using **recovery experiments** (spiking experiments): addition to the sample of a known number of MPs, of which size, shape, color are also known and polymer («positive control»).

- It is suggested to prepare a heterogeneous mixture of MPs, since the extraction efficiency depends on the method used but also on the characteristics of the particles: commercial MPs (primary origin) or hand-made MPs obtained from commonly used plastic objects can be used (secondary origin).

- **Extraction yield**: measured by calculating the percentage of added MPs recovered at the end of the sample processing, also verifying possible variations in the physical and chemical characteristics of the added MPs.

- Known organic and inorganic material could also be added to the samples to evaluate the incidence of false positives.

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Methods for extraction of MPs

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QA/QC: VALIDATION OF MPs EXTRACTION FROM SEWAGE SLUDGE

Digestion with 15% H_2O_2 solution + density-based separation with NaBr

- 4 types of sludge (primary, active, post-dehydration, granular) + 1 blank sample
- 12 MPs added to each kind of sludge (2 particles of 6 different typologies):

1. Polyisoprene (δ=0.93-0.98g/cm3). Size: 1-2mm. Hand-made particles from stationery elastics (secondary origin).
2. Nylon (PA) (δ=1.13-1.15g/cm3). Size: 1-0.5mm. Hand-made particles from fishing lines (secondary origin).
3. Polyethylene terephthalate (PET) (δ=1.31-1.43g/cm3). Size: 1.5-2mm. Hand-made particles from plastic bottles (secondary origin).
4. Polypropylene (PP) (δ=0.82-0.90g/cm3). Size: 1.5-0.8mm. Commercial particles (primary origin).
5. Polyethylene (PE) (δ=0.92-0.97g/cm3). Size: 1-0.5mm. Commercial particles (primary origin).
6. Polystyrene (PS) (δ=1.05-1.06g/cm3). Size: 1-0.5mm. Commercial particles (primary origin).

MPs were photographed, measured and characterized (FT-IR spectroscopy) before and after processing: no appreciable modifications on size, color, polymer IR spectra.

EXTRACTION YIELD:

Primary sludge: 95%

Activated sludge: 92%

Dewatered sludge: 96%

Granular sludge: 98%

Blank sample: 100%

Chemosphere 262 (2021) 128415

Contents lists available at ScienceDirect

Chemosphere

journal homepage: www.elsevier.com/locate/chemosphere

ELSEVIER

Microplastics in real wastewater treatment schemes: Comparative assessment and relevant inhibition effects on anaerobic processes

Check for updates

Lucia Pittura [a], Alessia Foglia [b, **], Çağrı Akyol [b, *], Giulia Cipolletta [b], Maura Benedetti [a], Francesco Regoli [a], Anna Laura Eusebi [b], Simona Sabbatini [b], Linda Y. Tseng [c], Evina Katsou [d], Stefania Gorbi [a], Francesco Fatone [b]

Analytical Techniques for MPs Characterization

- **PHYSICAL AND CHEMICAL CHARACTERIZATION:** once the extraction phase is complete, particles are characterized in terms of size, shape, surface texture, color and, above all, polymer to identify the actual number of items of synthetic nature (i.e. MPs).

- The various techniques available can be distinguished on the basis of their ability to determine some of the properties of microplastics.

- Several techniques can be used in sequence or in association to compensate for the analytical limitations of one or the other.

- The choice of techniques depends on the objective of the study and on the available instruments (often the dimension of microplastics to be analyzed is the driving factor).

- Depending on the objective of the analysis, it may be sufficient to apply a (pre)screening method with relatively simple and inexpensive techniques which may provide limited information but does not require sophisticated instrumentation: cost- and time- effective routine analysis.

Physical characterization: Microscopy techniques (OM and SEM)

- Physical characterization through microscopy techniques is primarily used to identify and classify microplastics preserved on a filter or in petri dishes or jars.

- **OPTICAL MICROSCOPY (OM)** is suitable to visually examine particles of submillimeter size retaining the 3D shape and color of suspected MPs but does not provide information on the chemical composition.

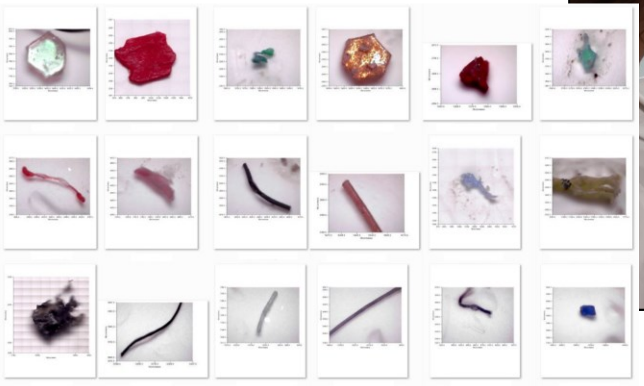
- Visual guidelines, physical and tactile guidelines can help the operator in the identification of suspected MPs:

  bright and unnaturally colored particles, fragments with sharp geometrical shapes, shiny surfaces, and featureless fibers with a consistent width, the particle holding its shape or stretched when poked and resistance to easy breakage (*Primpke et al., 2020*).

- **Advantage** of OM: relatively cheap and easy approach.

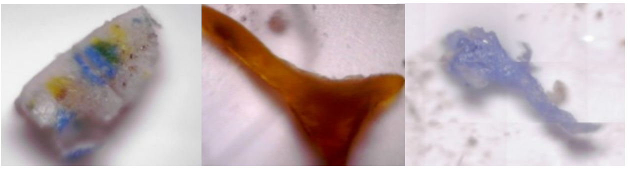
- **Disadvantage** of OM: it requires considerable time and resources in terms of researchers involved in counting hundreds of particles. It gets better with experience.

- Once particles were identified, they are measured using an image analysis software and categorized by shape, color, and size classes.

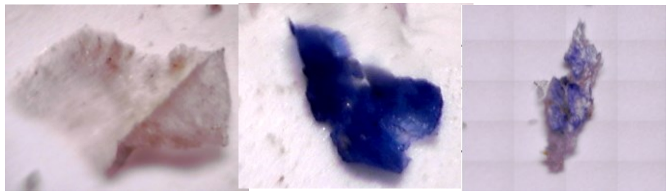


MPs classification by shape

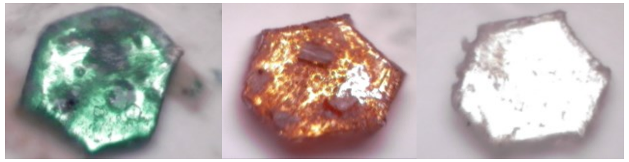
FRAGMENT: hard particle, thick, with sharp cutting edges and an irregular shape (*Lusher et al., 2017*) .



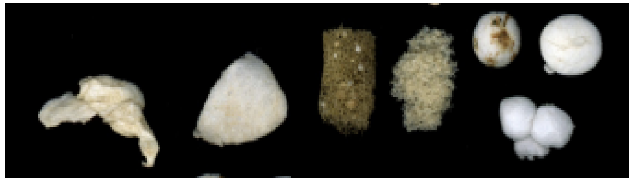
FILM: flat and flexible particle, with an irregular shape(Hartmannet al., 2019) .



GLITTER: iridescent disc with a hexagonal shape(*Yurtsever et al., 2019*).



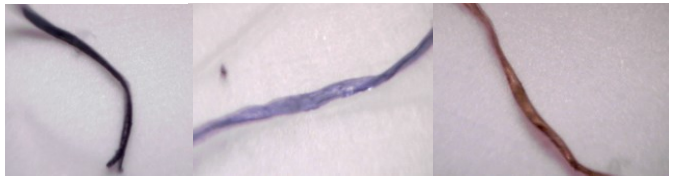
FOAM: flexible and elastic particle, it shapes and softens to the touch (spongy), of different thicknesses and with an irregular outline(*Rochman et al., 2019*).



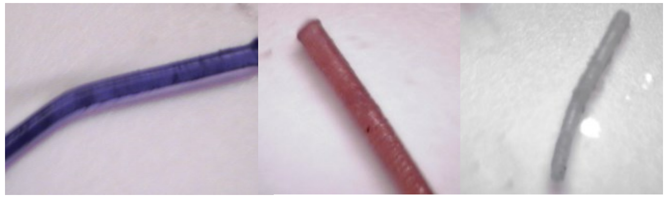
SPHERE: particle with every point on the surface having the same distance from the center. It can also be present as a hemisphere, probably due to breakage during production, use or presence in the environment (*Hartmann et al., 2019*) .

PELLET: similar to the sphere but tends to be larger and ovoid in shape, usually between 3 and 5 mm (*Rochman et al., 2019*).

FIBER: filiform structure with irregular diameter and frayed ends which can take trilobate, ribbon or L-shaped shapes (*Cesa et al., 2017*).



LINE: particle with regular diameter along its entire length and without frayed ends relative to the fibers (*Magni et al., 2019*).



MPs classification by color

1. Black
2. Blue
3. White
4. Transparent
5. Red
6. Green
7. Multicolour
8. Others

MPs classification by size class

- Recording of the maximum particle length.
- Identification of size ranges within which to categorize MPs: the upper limit is set at 5 mm (maximum size of MPs by definition), the lower limit is dictated by sampling methodologies and analytical techniques for characterization.
- Development of increasingly performing analytical techniques in the identification of the smallest MPs: the sizes reported in the literature are becoming more diversified incorporating a wider range of size classes.
- There is a lack of harmonization in the definition of size classes: a major obstacle to comparing studies.

Table 1 — Particle size classification

classification		large microplastics	microplastics					
particle size classes	µm	5 000 to 1 000	< 1 000 to 500	< 500 to 100	< 100 to 50	< 50 to 10	< 10 to 5	< 5 to 1

Classificazione proposta da:

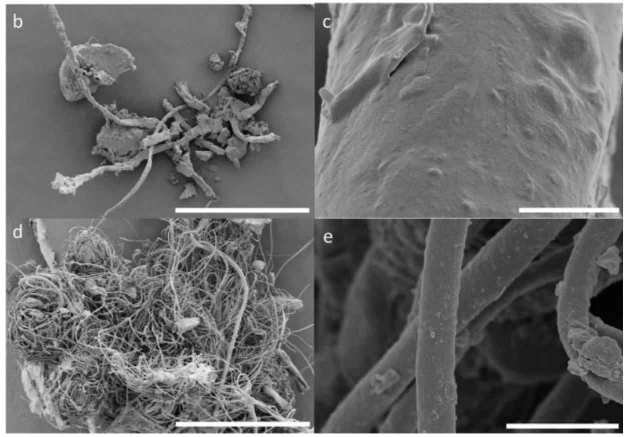
ISO/DIS 24187
Principles for the analysis of microplastics present in the environment

Physical characterization: Microscopy techniques (OM and SEM)

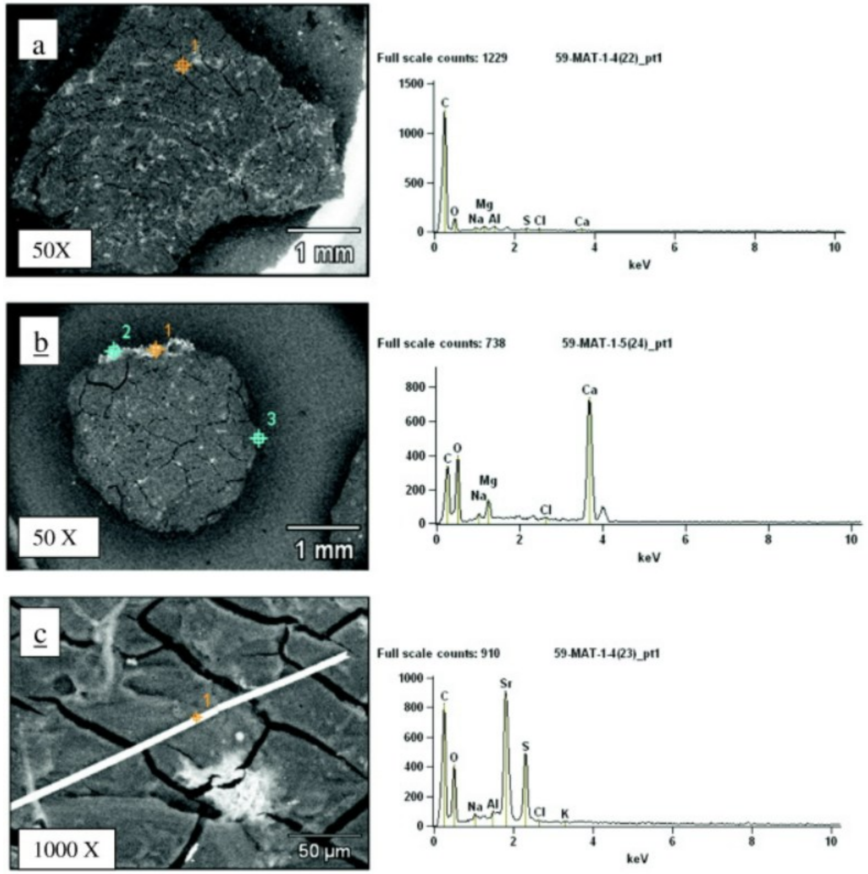
- **Scanning electron microscopy (SEM)** evaluation of the surface characteristics of the particles (texture), especially the smallest ones (even nanometric)

- **SEM-EDX**: Discrimination of surface structures of plastics and other materials can be integrated with an energy-dispersive X-ray probe to provide further information on the elemental composition of organic and inorganic species, particularly useful for environmental samples

- **Disadvantage** of SEM-EDX: expensive and requires substantial time and effort for sample preparation and examination, which limits the number of samples that can be handled in routinary analyses.



From Prajapati et al., 2021. et al., 2017. ESPR



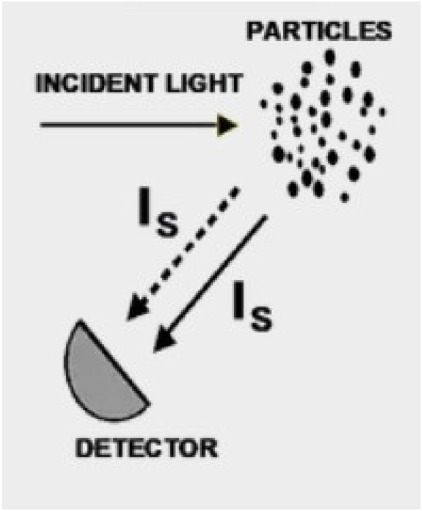
From Wang et al., 2017. STOTEN

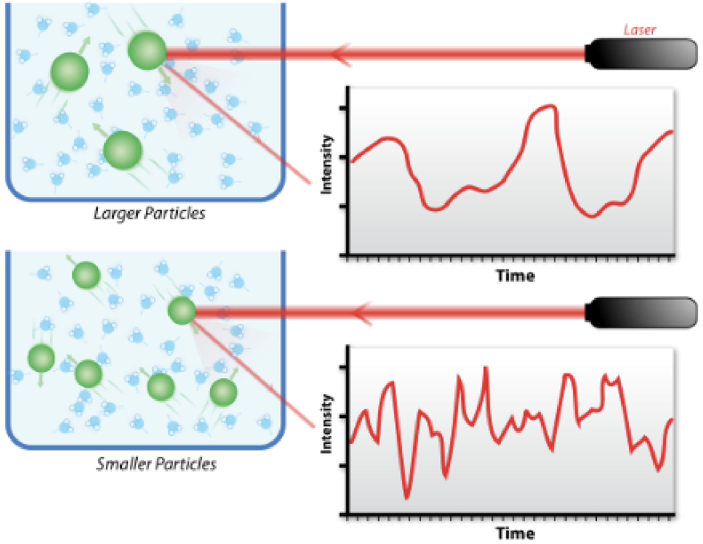
Physical characterization: Light-Scattering Technique (DLS)

- Multiple methods apply the scattering of laser light on particles to obtain information on physical properties like particle size and particle-size distribution in suspensions and emulsions.

- **Dynamic light scattering (DLS),** the most widely used, measures particle sizes in the range from 1 nm to 3 mm based on the fluctuation of intensity of a laser beam that passes the suspension:
  the particles are illuminated with a monochromatic and coherent light source (laser) and the intensity variations of the scattered light are measured as a function of time: at the same temperature and viscosity, the 'small' particles move rapidly – creating variations scattering intensity – while 'large' particles move more slowly – creating slow intensity variations.

- **Disadavantage**: does NOT allow to distinguish MPs from other particles: MPs can be measured only if previously isolated in a rigorous manner from all other organic/inorganic particles.





Chemical characterization: Spectroscopy Methods (FTIR e Raman)

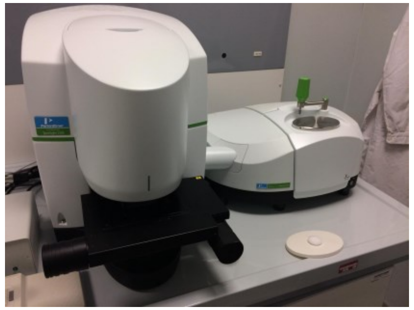
- They are the most common approaches in the chemical identification of microplastics: based on the energy absorption by characteristic functional groups of polymer particles, resulting in a vibrational spectrum which is unique for every polymer type.

- Nondestructive techniques: they allow multiple analyses on the same sample and can be coupled with other methodologies to obtain additional and complementary information on the composition of plastic polymers.

- In coupling the spectrometer (FTIR or Raman) to a microscope, small microplastics are measurable through the "micro"-spectroscopy (μ-FTIR and μ-Raman): μ-Raman spectroscopy can characterize microplastic samples higher than 1 μm, while μ-FTIR spectroscopy could identify microparticles higher than 10–20 μm

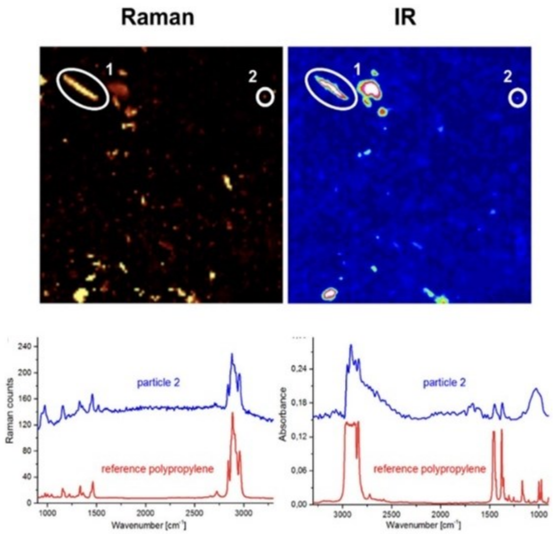
- Point-wise measurements: Require manual isolation of selected potential MPs by visual examination. Time-consuming.

- Focal plane array (**FPA**)-based FTIR **imaging**: allows for detailed and unbiased high-throughput analysis of total MPs on a sample filter. This technique enables the simultaneous recording of several thousand spectra within an area with a single measurement and thus the generation of chemical images. **Disadvantages:** extended processing time to map an entire filter (9 h) to scan one filter paper, refractive errors during measurement of irregularly shaped MPs, lack of information on associated organic additives to MPs and overlap of polymer bands given by organic and inorganic contaminations that can disturb identification of particles.



macroFT-IR e μFTIR

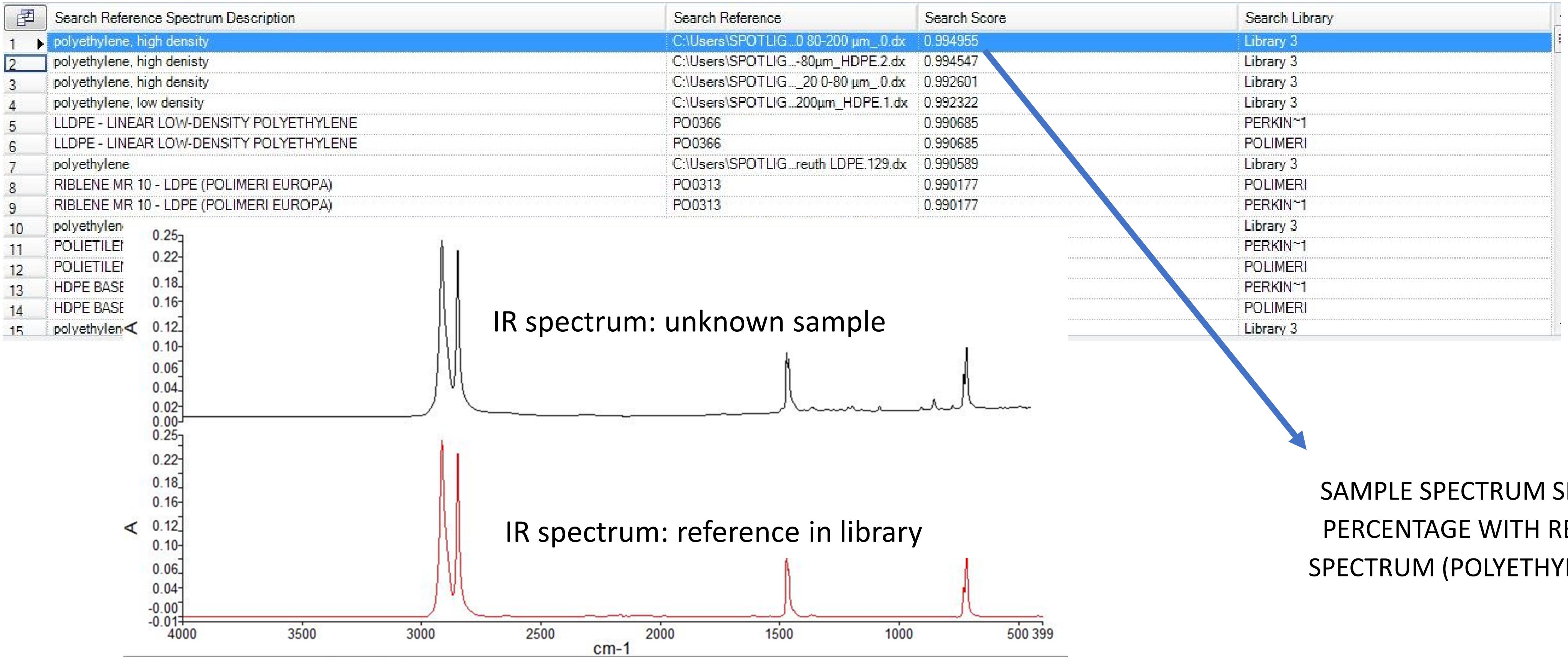
μRaman



Chemical characterization: Spectroscopy Methods (FTIR e Raman)

- Interpretation of data is facilitated by the existence of dedicated software which significantly reduces the execution times of the analyses.

- Chemical identification of the particles is achieved by comparing the spectrum of the sample under investigation with spectra of known polymers by matching them to spectral libraries using database comparison algorithms.



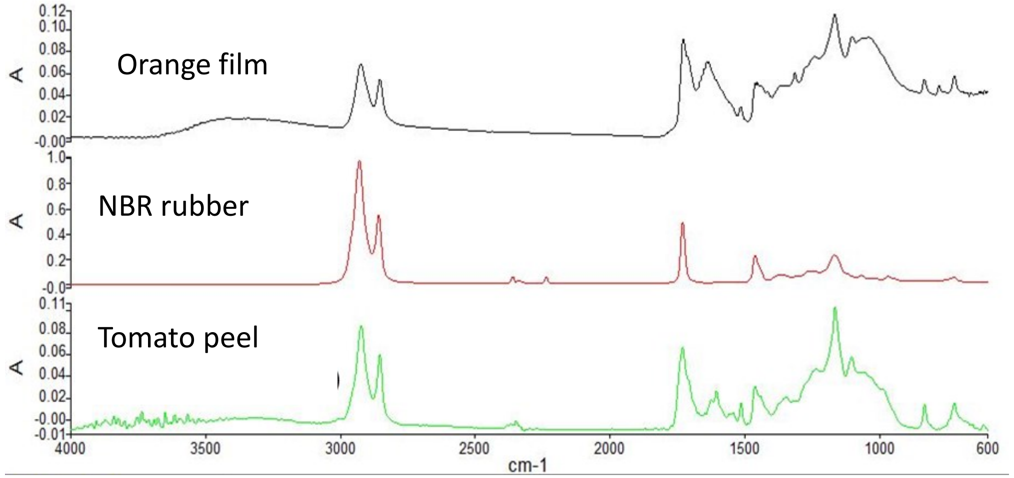
	Search Reference Spectrum Description	Search Reference	Search Score	Search Library
1	polyethylene, high density	C:\Users\SPOTLIG...0 80-200 µm_.0.dx	0.994955	Library 3
2	polyethylene, high denisty	C:\Users\SPOTLIG...-80µm_HDPE.2.dx	0.994547	Library 3
3	polyethylene, high density	C:\Users\SPOTLIG..._20 0-80 µm_.0.dx	0.992601	Library 3
4	polyethylene, low density	C:\Users\SPOTLIG...200µm_HDPE.1.dx	0.992322	Library 3
5	LLDPE - LINEAR LOW-DENSITY POLYETHYLENE	PO0366	0.990685	PERKIN~1
6	LLDPE - LINEAR LOW-DENSITY POLYETHYLENE	PO0366	0.990685	POLIMERI
7	polyethylene	C:\Users\SPOTLIG...reuth LDPE.129.dx	0.990589	Library 3
8	RIBLENE MR 10 - LDPE (POLIMERI EUROPA)	PO0313	0.990177	POLIMERI
9	RIBLENE MR 10 - LDPE (POLIMERI EUROPA)	PO0313	0.990177	PERKIN~1
10	polyethylen			Library 3
11	POLIETILEI			PERKIN~1
12	POLIETILEI			POLIMERI
13	HDPE BASE			PERKIN~1
14	HDPE BASE			POLIMERI
15	polyethylen			Library 3

SAMPLE SPECTRUM SIMILARITY PERCENTAGE WITH REFERENCE SPECTRUM (POLYETHYLENE): 99%

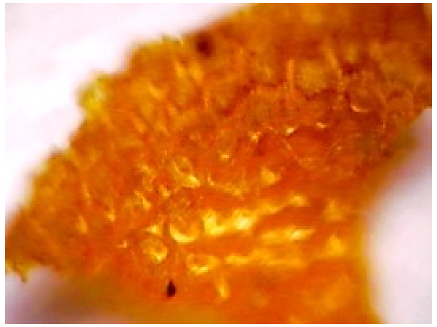
Chemical characterization: Spectroscopy Methods (FTIR e Raman)

UNIVERSITÀ POLITECNICA DELLE MARCHE

BEWARE OF FALSE POSITIVES...never trust reference libraries completely...



IR spectrum: unknown sample



IR spectrum of the first 15 results from the match with library (70-80% similarity)

IR spectrum of the control material: TOMATO PEEL (correct result, 88-95% similarity)

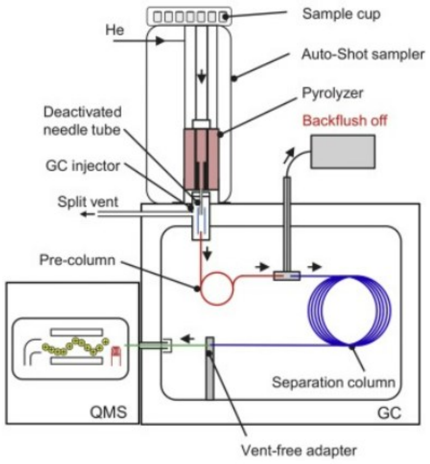
It is important to implement commercial libraries that often derive from the characterization of pure polymers, with spectra acquired from environmental sample and of non-synthetic materials….

Chemical characterization: Thermoanalytical Methods (Py-GC-MS)

- **Pyrolytic gas chromatography in combination with mass spectrometry** (Py-GC-MS) can be used to assess the chemical composition of potential microplastic particles by analyzing their thermal degradation products.

- In following a pyrolytic process, decomposition products characteristic of each polymer are trapped on a solidphase adsorbent and thermally desorbed. Volatile compounds are then separated by gas chromatography and identified by mass spectrometry

- The pyrolysis of plastic polymers results in characteristic pyrograms, which facilitate the polymer identification by comparing combustion products with reference pyrograms of known virgin-polymer samples.



From Matsui et al., 2020. JAAP

- **Advantages**:

➢ individual sorting of particles is not needed

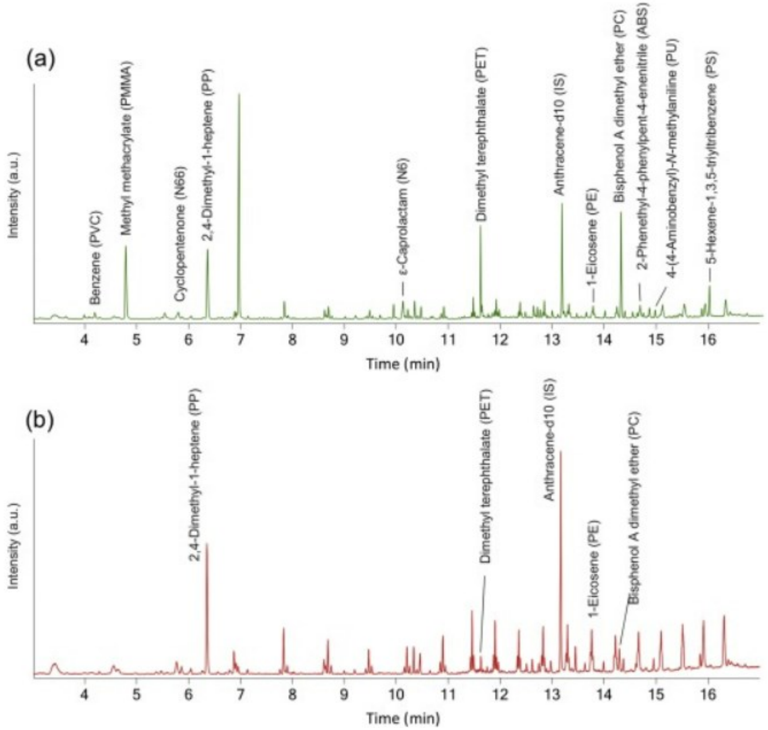
➢ contrarily to Raman or FTIR technique, which only investigates the surface of a particle, Py-GC-MS allows the analysis of the whole particle, enabling to simultaneously identify polymer types and associated organic plastic additives.

- **Disadvantages**:

➢ It allows to chemically identify particles but not to quantify or classify them according to shape.

➢ Destructive analysis: it does not allow the sample to be reused to submit it to other types of analysis.

➢ The amount of sample that can be analyzed (e.g., 0.35–7 mg).



Blue Lakes

No microplastics, just waves.

Risk considerations associated with Microplastics in water and in environment

Università Politecnica delle Marche

BENEFICIARIO COORDINATORE

LEGAMBIENTE

BENEFICIARI ASSOCIATI

Autorità di Bacino Distrettuale dell'Appennino Centrale

arpa UMBRIA Agenzia Regionale per la Protezione Ambientale dell'Umbria

ENEA AGENZIA NAZIONALE PER LE NUOVE TECNOLOGIE, L'ENERGIA E LO SVILUPPO ECONOMICO SOSTENIBILE

Global Nature Fund

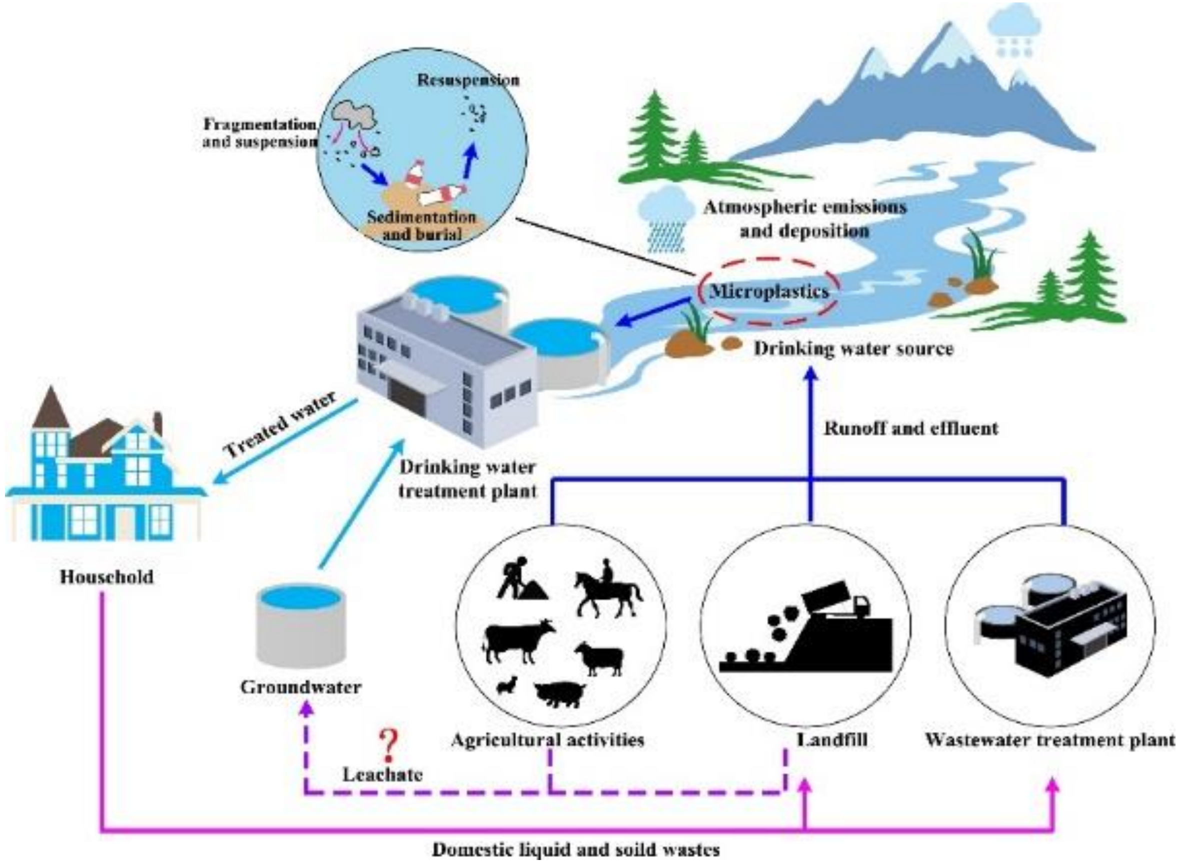
Bodensee Stiftung Lake Constance Foundation

UNIVERSITÀ POLITECNICA DELLE MARCHE

PROGETTO COFINANZIATO DA

PlasticsEurope Association of Plastics Manufacturers

Microplastics in the Integrated Water Service

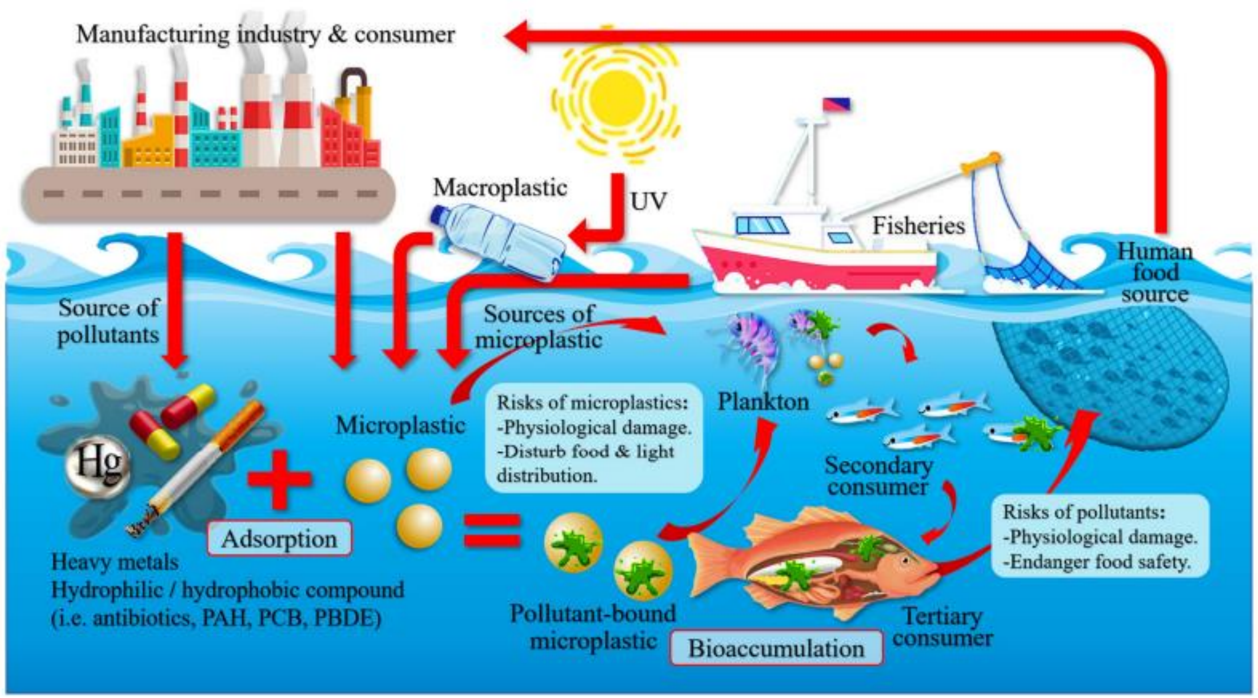


Microplastics are present in the environment and in water

Humans could be exposed to microplastics through ingestion of contaminated food and water, inhalation of air, and skin contact.

The potential toxicological effects of microplastics are still unknown → **Microplastics are classified as emerging contaminants (CECs)**

Microplastics in the Integrated Water Service

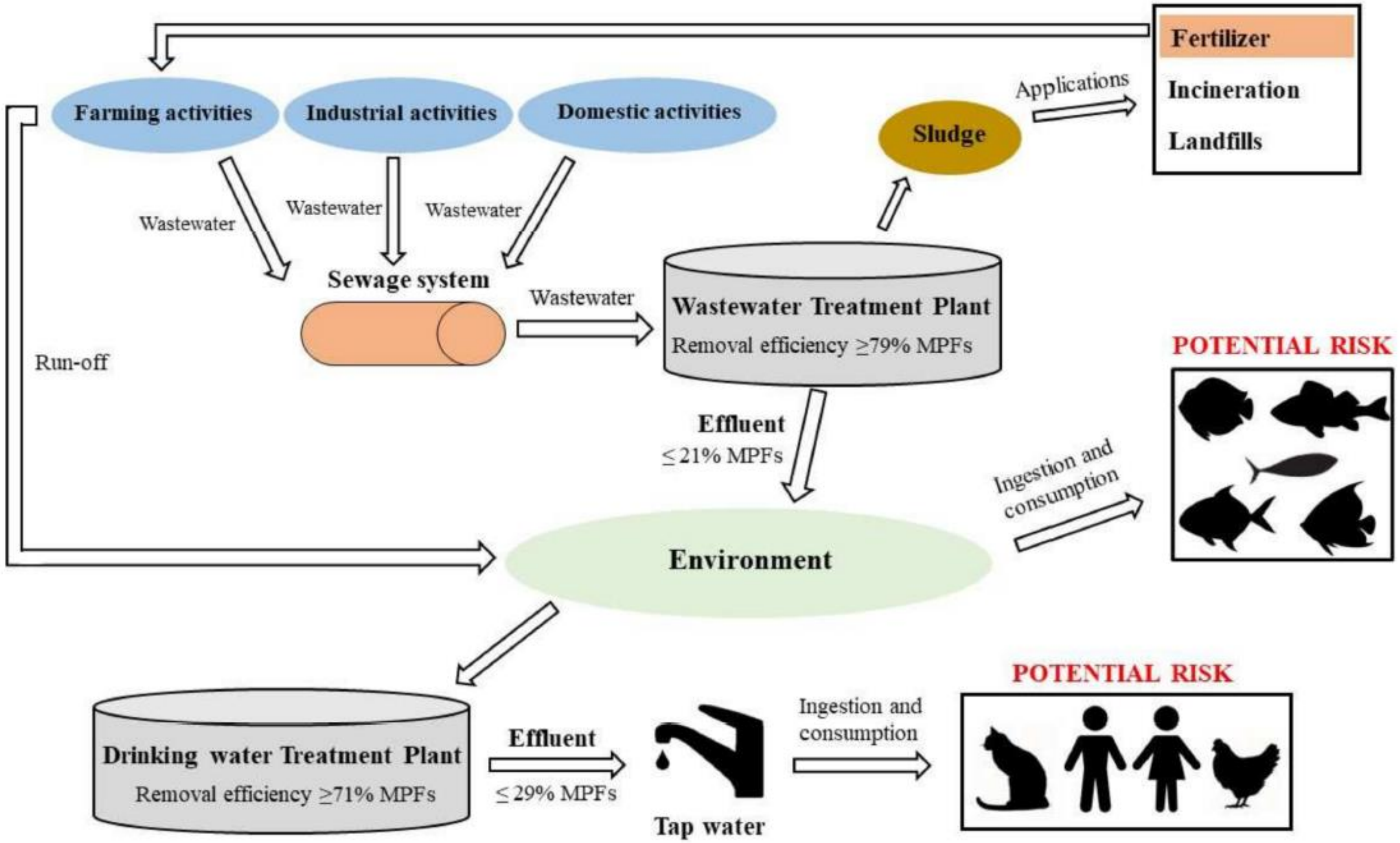


- ACCUMULATION THROUGH THE FOOD CHAIN

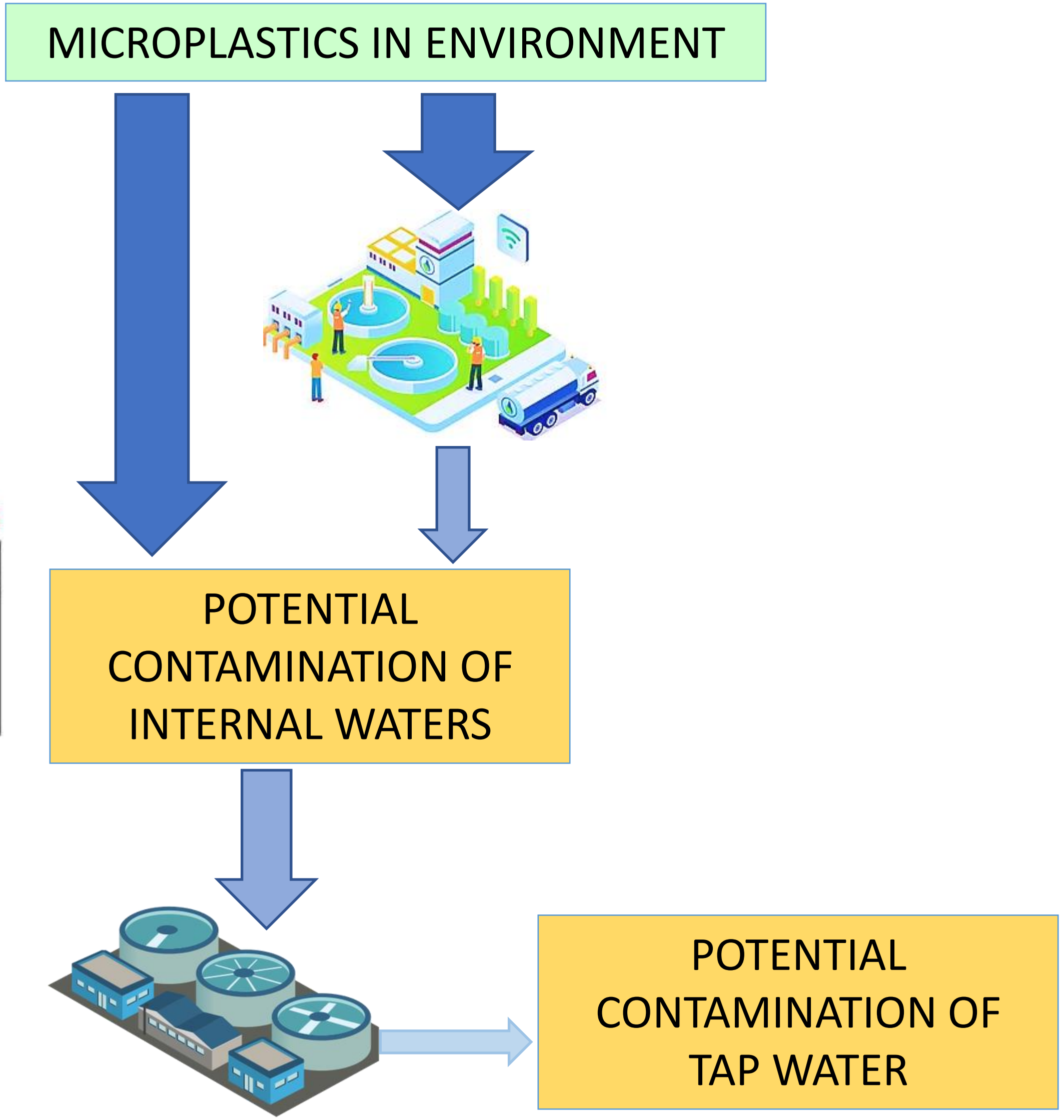
The effect on human health is still unknown, but plastics often contain additives, such as stabilizers or flame retardants, and other potentially toxic chemicals that can be harmful to the animal or human who ingests them.

https://www.europarl.europa.eu/news/en/headlines/society/20181116STO19217/microplastics-sources-effects-and-solutions

Microplastics in the Integrated Water Service



Sol et al., 2021



IMPACT ON THE ENVIRONMENT DUE TO THE PRODUCTION

The 2016 Ellen MacArthur Foundation report finds that 390 million tons of carbon were emitted as part of plastic production (and consumption) in 2012, or about 1% of the carbon balance, and that this share should grow up to 15% by 2050 as a result of the expected increase in demand.

IMPACT ON THE HEALTH DUE TO THE RELEASE

There are concerns that some additives used in plastics, such as bisphenol A (BPA) or some phthalates used in polyvinyl chloride (PVC), may have adverse effects on human health and the environment, mainly due to the release of these substances from wastes into the environment and subsequently transmitted to wildlife, with uncertainties about long-term exposure and cumulative effects. Additionally, persistent organic pollutants can attach to plastics in water and enter the food chain via marine life.

Plastics in a circular economy - Opportunities and challenges. Briefing European Parliamentary Research Service, 2017

Conventional, non-conventional and emerging pollutants

Conventional pollutants: *organic matter, nutrients, suspended solids, pathogenic microorganisms*	***Known sanitation effects,*** *known environmental problems (i.e. eutrophication)*	*Processing technologies established, but not optimized!*
Non-conventional pollutants: *heavy metals and persistent organic compounds (dioxins and furans, PAHs, etc)*	***Known toxic and ecotoxic effects*** *even at very low concentrations*	*Unconsolidated treatment technologies, for concentrations in the urban water cycle*
Emerging pollutants: *medicines for human and veterinary use, compounds for body care*	*Chronic toxic and ecotoxic effects,* ***to be ascertained,*** *because they are linked to long-term exposure*	*Treatment technologies under study, ongoing debate on target compounds, action according to the precautionary principle*

Microplastics in national and European legislation

- **European Directive 2008/105/CE**

Defines environmental quality standards (EQS) of priority list substances

EQS: the concentration of a particular pollutant or group of pollutants in water, sediment and biota which must not be exceeded, in order to protect human and environmental health.

- **European Directive 2009/90/CE**

Defines the monitoring and analysis technical specifications (measurement uncertainty, limits of quantification, ISO17025 obligation)

- **New European Directive 2013/39/CE**

Microplastics in national and European legislation

- **News Directive 2013/39/EC**
    - EQS for 12 new priority substances (Bifenox, Terbutrin, Cybutrin, Cypermethrin, Dichlorvos, Aclonifen, Hexabromo-cyclodecane, Quinoxifen, Dicofol, PFOS, Heptachlor/Eptachlor epoxide, “Dioxins”)
    - EQS modified for some existing substances
    - EQS biota new priority substances and existing substances
    - Inland water EQS based on the bioavailable fraction for nickel and lead (Annex II)
    - Specific provisions for UBPT (ubiquitous, persistent, bioaccumulation and toxicity) - (art 8 bis) - Reduction of monitoring and Separate Classification
    - New priority hazardous substances (Annex I)
- **Provisions for drugs (strategy and monitoring - art. 8)**

www.lifebluelakes.eu

Emerging contaminants

– Substances that are not regulated

…… are not monitored

…… there is no data available

……there are no data to propose prioritization

..so there is no data to assess the risk

– CHECKLIST for substances for which monitoring data needs to be collected

New Drinking Water Directive

DIRECTIVE (EU) 2020/2184 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 16 December 2020 concerning the quality of water intended for human consumption

Parlamento Europeo

23.12.2020 | IT | Gazzetta ufficiale dell'Unione europea | L 435/1

I

(Atti legislativi)

DIRETTIVE

DIRETTIVA (UE) 2020/2184 DEL PARLAMENTO EUROPEO E DEL CONSIGLIO

del 16 dicembre 2020

concernente la qualità delle acque destinate al consumo umano

(rifusione)

(Testo rilevante ai fini del SEE)

To respond to growing public concern about the human health effects of emerging compounds, such as endocrine disruptors, pharmaceuticals and microplastics, present in water intended for human consumption and to address the issue of new emerging compounds in the supply chain, a checklist mechanism should be introduced in this Directive. The checklist mechanism will make it possible to respond dynamically and flexibly to growing concerns. It will also make it possible to follow up on new knowledge on the importance of these emerging compounds to human health and on the most appropriate monitoring methods and approaches.

New Drinking Water Directive

DIRECTIVE (EU) 2020/2184 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 16 December 2020 concerning the quality of water intended for human consumption

2020 — A type of approach was introduced in the Directive, based on the drawing up a “checklist" of substances (for which limits or threshold values have not been defined) with the aim of approaching the problem in a flexible and dynamic way.

2024 — The Directive subordinates the inclusion of the parameter into the checklist to the definition of a methodology for measuring microplastics that the European Commission must issue by 12 January 2024.

2029 — The transmission of a report (and subsequent possible updates) by the Commission to the European Parliament and the Council (by 12 January 2029) on the potential threats due to microplastics for sources of water intended for human consumption, as well as on the related potential health risks.

New Drinking Water Directive

DIRECTIVE (EU) 2020/2184 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 16 December 2020 concerning the quality of water intended for human consumption

In order to adapt this Directive to technical and scientific progress, the power should be delegated to the Commission to […] adopt a methodology for measuring microplastics.

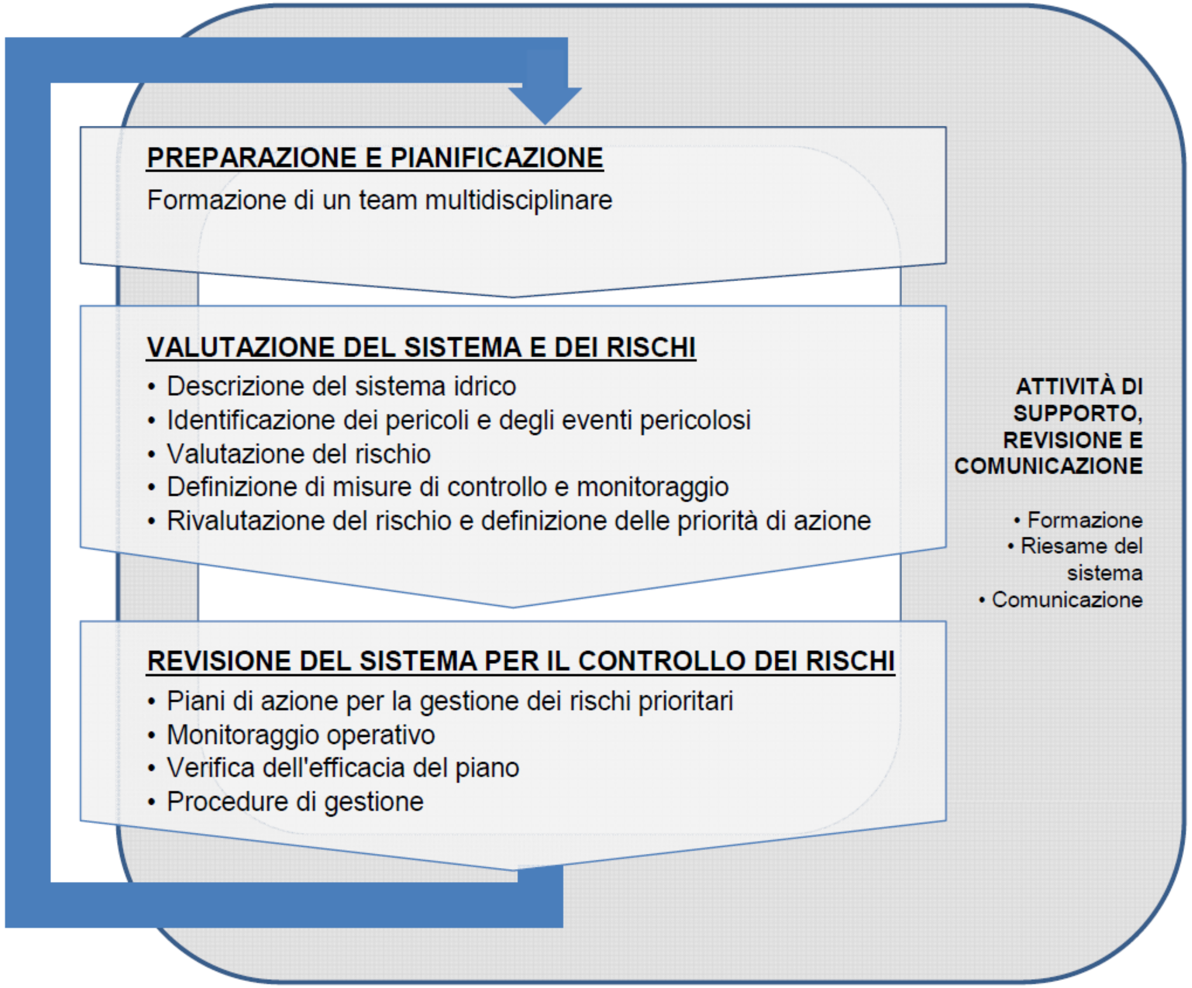
By 12 January 2024, the Commission adopt delegated acts in accordance with Article 21 to supplement this Directive by adopting a methodology for measuring microplastics to include them into the checklist referred to in paragraph 8 of this Article once the conditions referred to in this paragraph are met.

The Commission submit to the European Parliament and the Council by 12 January 2029 and subsequently, if appropriate, a report on the potential threats to sources of water intended for human consumption due to microplastics, pharmaceuticals and, if necessary, other pollutants causing new concern, as well as its potential health risks.

New Drinking Water Directive

DIRECTIVE (EU) 2020/2184 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 16 December 2020 concerning the quality of water intended for human consumption

In the case surface waters are used as water intended for human consumption, Member States should be pay particular attention to ***microplastics*** *and endocrine distrupting compounds in their* ***risk assessment****, and, where relevant, they should also require water suppliers to* ***monitor and, if necessary, treat*** *these and other parameters included in the checklist* ***if they are considered to be a potential danger to human health****.*
Based on basin risk assessment for abstraction points, management measure should be adopted to prevent or control the identified risks in order to safeguard the quality of water intended for human consumption.



New Drinking Water Directive

DIRECTIVE (EU) 2020/2184 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 16 December 2020 concerning the quality of water intended for human consumption

Better knowledge of relevant information and increased ***transparency*** *should aim at strengthening* ***citizens' trust*** *in water supply and water services and should lead to an* ***increase in the use of tap water*** *as water intended for human consumption, which could contribute to the* ***reduction of plastic waste and use and greenhouse gas emissions*** *and have* ***a positive impact on climate change mitigation and the environment*** *as a whole.*

The Commission adopts implementing acts to ***establish and update a checklist for substances or compounds of public or scientific health concern ("checklist")****, such as pharmaceuticals, interfering compounds endocrines and microplastics.*

Water safety plan – general scheme

PREPARATION AND PLANNING

- Formation of a multidisciplinary team

ASSESSMENT OF THE SYSTEM AND RISKS

- Description of the water system
- Identification of dangers and dangerous events
- Risk assessment
- Definition of control and monitoring measures
- Reassessment of risk and definition of priorities for action

AUDIT OF THE RISK CONTROL SYSTEM

- Priority risk management action plansi
- Operational monitoring
- Verification of the effectiveness of the plan
- Management procedure

SUPPORT, AUDIT AND COMMUNICATION ACTIVITIES

- Training
- Review of the system
- Communication

- ✓ global critical evaluation of the system and its reliability over time
- ✓ monitoring planning and implementation
- ✓ systematic implementation of management procedures
- ✓ programs to improve water quality, including with adequate investment planning
- ✓ role and training of operators
- ✓ definition of incident response protocols
- ✓ information for the public

Water safety plan – risk analysis

*Risk = Probability * Severity*

Severity of the consequences

severity or intensity of the impact that the danger occurrence may have, primarily for human health, but also for the quality of the service in terms of sanitation quality of the water supplied, organoleptic characteristics, quantity supplied, continuity of supply , etc..

Probability

'how often' or 'how likely' a hazard or dangerous event can conceivably occur, particularly considering hazards that have occurred in the past and their probability of recurrence over time; it must also predict the probability of risks and events that did not occur.

Tabella 4. Matrice per la classificazione del rischio per la filiera idropotabile secondo l'OMS

Grado di probabilità	Gravità delle conseguenze: Insignificante (senza impatto o con impatto insignificante)	Minore (impatto poco significativo)	Moderata (es. non conformità di tipo organolettico)	Grave (non conformità a valori di legge o di riferimento)	Molto grave (effetti gravi /catastrofici sulla salute)
Raro (es. 1 volta ogni 5 anni)	1	2	3	4	5
Improbabile (es. 1 volta all'anno)	2	4	6	8	10
Moderatamente probabile (es. 1 volta al mese)	3	6	9	12	15
Probabile (es. 1 volta a settimana)	4	8	12	16	20
Quasi certo (es. 1 volta al giorno)	5	10	15	20	25

Legenda del rischio

Grado	<6	6-9	10-15	>15
Classificazione	*basso*	*medio*	*alto (significativo)*	*molto alto*

Microplastics in national and European legislation

From drinking water to reuse water

DIFFERENT WATER RESOURCES

DIFFERENT USE DESTINATIONS

HETEROGENEITY AND COMPLEXITY

↓

MULTIDISCIPLINARY APPROACH

↓

COMPLEX MONITORING PROGRAMS

- Origin and nature of waters
- Sources of contamination
- Seasonality
- Events
- Climate changes
- Indirect risk from biofilm
- Indirect risk from contaminants adhering to the particles

Wastewater reuse

Guidelines to support the application of Regulation (EU) 2020/741 laying down minimum requirements for water reuse

5.8.2022 | IT | Gazzetta ufficiale dell'Unione europea | C 298/1

II

(Comunicazioni)

COMUNICAZIONI PROVENIENTI DALLE ISTITUZIONI, DAGLI ORGANI E DAGLI ORGANISMI DELL'UNIONE EUROPEA

COMMISSIONE EUROPEA

COMUNICAZIONE DELLA COMMISSIONE

Orientamenti a sostegno dell'applicazione del regolamento (UE) 2020/741 recante prescrizioni minime per il riutilizzo dell'acqua

(2022/C 298/01)

Some pollutants which are not yet regulated and cannot be found in the directives and regulations (e.g. ***microplastics*** *or some* ***compounds of emerging interest****) could be* ***added to the hazard list, if the risk to human and animal health or environment is supported by scientific evidence and it is demonstrated that these contaminants come from the water reuse system*** *and not from other sources. Risk assessment could also* ***identify the source*** *of these contaminants, e.g. for the presence of particular industries, and plan any preventive measures.*

Wastewater reuse

ANNEX II to REGULATION (EU) 2020/741 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 25 May 2020 laying down minimum requirements for water reuse

MAIN ELEMENTS OF RISK MANAGEMENT

- Description of the **whole water reuse system**
- Identification of the **bodies involved**, roles and responsibilities
- List of possible **hazards and hazardous events**
- Identification of **populations** at risk and **routes of exposure**
- **Risk assessment** for the environment and for human and animal health

ADDITIONAL REQUIREMENTS

→ **Heavy metals**
→ Pesticides
→ Disinfection **by-products**
→ Drug
→ Other substances of **growing concern** (micropollutants, microplastics, …)
→ Resistance to antimicrobial agents

PREVENTION MEASURES

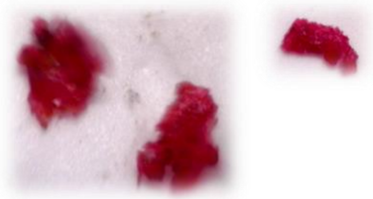
→ Access control
→ Additional measures of **disinfection** or **elimination of pollutants**
→ **Irrigation technologies**
→ **Specific requirements** for sprinkler irrigation Specific requirements for agricultural fields
→ Suppression of pathogens before **harvesting**
→ Minimum safety **distances**
→ **Signage**
→ **Quality control systems** and procedures, water **monitoring, maintenance** programs
→ Environmental **monitoring systems**
→ Management of **incidents** and **emergency situations**
→ **Coordination** between the different actors

→ RISK ANALYSIS

→ RISK MANAGEMENT PLANS

Microplastics in the Integrated Water Service

	OPERATIONAL ASPECTS	*REGULATORY ASPECTS*
STATE OF ART	Microplastics present in the environment and in water.	Microplastics included in the "checklists" and their presence must be evaluated in the risk analysis
MATERIALS AND METHODS	Microplastics sampling campaign in drinking water treatment plant.	The EU must propose a standardized methodology for monitoring microplastics in water
RESULTS	Results of the sampling surveys. Monitoring protocol.	Analysis and report of the European Commission

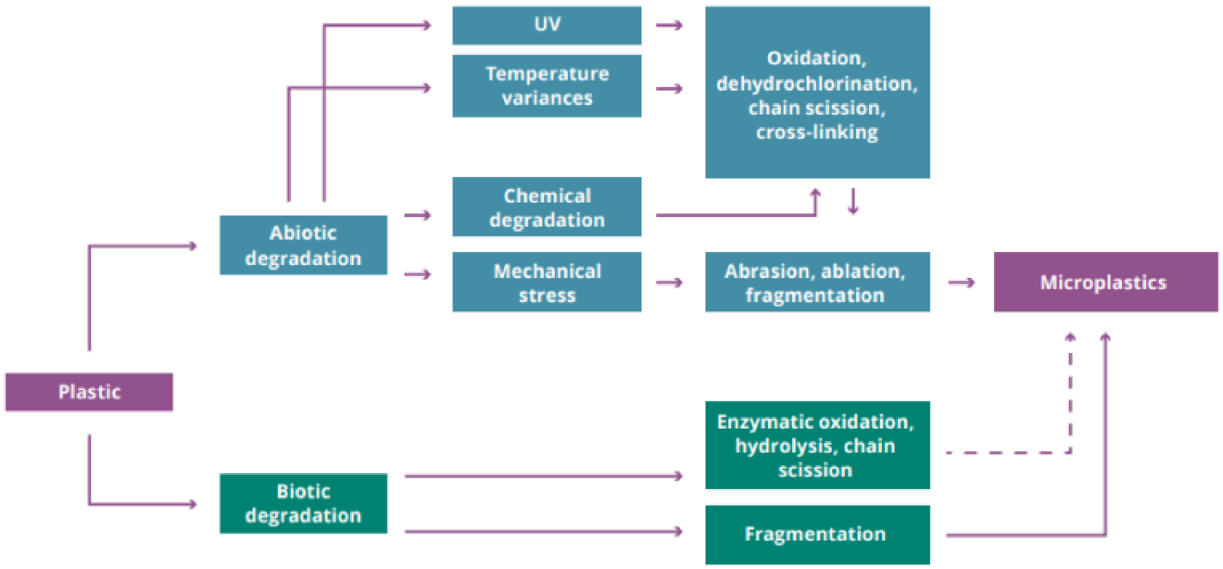


Monitoring of microplastics in purification plants and drinking water.
Analysis of the possible risks caused by the presence of microplastics in water.

Microplastics as emerging contaminants

The report of the European Environment Agency, published in mid-March 2022, highlights the environmental impacts due to the dispersion of microfibres from textile products.

ETC/CE Report 1/2022: Microplastic pollution from textile consumption in Europe



Source: Modified from Zhang, et al. (2021)

Every year 6-15 million tons of plastic, which represent 2-4% of world production**,** enter the **environment**

- **Primary microplastics**
- **Secondary microplastics**

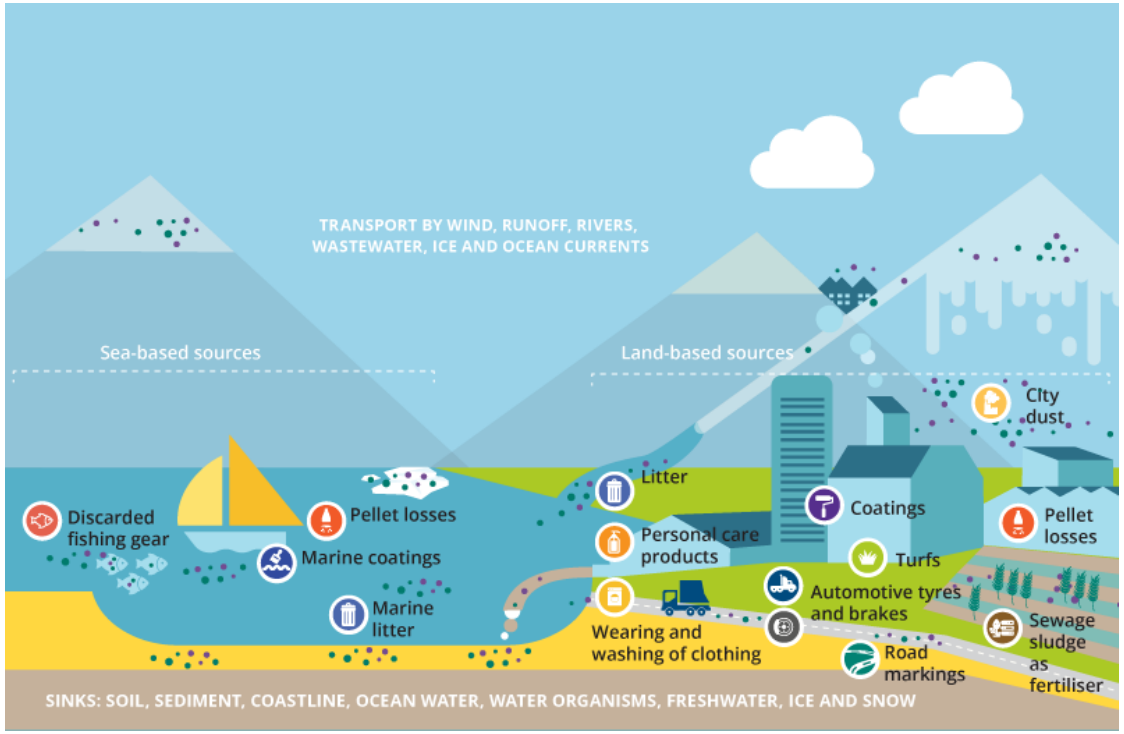
Microplastics as emerging contaminants

ETC/CE Report 1/2022: Microplastic pollution from textile consumption in Europe

European Environment Agency

environmental and health impacts associated with microplastics pollution

- INGESTED BY LIVING ORGANISMS (from plankton to fish to mammals)
- INHALED IN THE INTERNAL ENVIRONMENT
- INHALED IN THE EXTERNAL ENVIRONMENT
- INGEST IN FOOD
- ACCUMULATION THROUGH THE FOOD CHAIN



- Potentially toxic effects of the substances contained (additives, monomers, catalysts and production reaction by-products)
- High levels of exposure to microplastics induce inflammatory reactions and toxicity, and microplastics can be vectors for the spread of pathogens and microbes

Microplastics and risk analysis

MICROPLASTICS IN THE ENVIRONMENT

WATER CONTAMINATION

AIR CONTAMINATION

CONTAMINATION OF BIOTA

INTERACTION WITH THE ORGANISM

- significant uncertainties about the quality and extent of data on human exposure to microplastics in drinking water
- difficulty in estimating a cause-effect relationship for microplastics

current knowledge on toxicological effects requires the acquisition of more solid scientific evidence

Martellone et al., “Microplastiche nelle acque potabile, ISS.

Microplastics and risk analysis

INTERACTION OF MICROPLASTICS WITH THE ORGANISM

EXTREME HETEROGENEITY
DIFFERENT WAYS TO CREATE HEALTH DAMAGE

DIRECT TOXICITY	INDIRECT TOXICITY
possibility that microplastics may cause harm due to their particle-like properties	possibility that microplastics may act as carriers of other toxic products
Particle shape and size	Particle surface

Martellone et al., “Microplastiche nelle acque potabile, ISS.

Microplastics and risk analysis

DIRECT TOXICITY

PARTICLES < 150 µm

They can be absorbed by human tissues and produce systemic effects

Potential to be absorbed in the intestinal cellular epithelium (0.1-10 µm) and distributed throughout the body

However, the real contribution of these absorption mechanisms in microplastic toxicity remains to be clarified.

PARTICLES > 150 µm

Predominantly local effects in the respiratory and gastrointestinal systems.

Main route of entry into the body of particles > 150 µm

More subject to the toxic action of larger microplastics, which pass through them without being absorbed.

Oral exposure to large microplastics has been associated (even following high levels of intake), with mild intestinal irritation and inflammation.

Martellone et al., "Microplastiche nelle acque potabile, ISS.

Microplastics and risk analysis

INDIRECT TOXICITY

Surface of microplastics suitable for the **absorption of persistent organic contaminants** such as polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs) or pesticides and **to favor the growth of bacterial biofilms**, which could also contribute to the phenomenon of antibiotic resistance.

Additives, such as phthalates and colorants (e.g. titanium dioxide - TiO_2, cadmium pigments - Cd) to improve the properties of plastic materials.

Release into waters following degradation of plastics.

The toxicological profile of absorbable substances, additives and pathogens linked to the development of biofilms is quite well known, but **at the moment the WHO suggests a low risk of toxicity from these contaminants linked to microplastics.**

Martellone et al., "Microplastiche nelle acque potabile, ISS.

Microplastics and risk analysis

European Food Safety Authority

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

https://www.efsa.europa.eu/it/efsajournal/pub/4501

- Microplastics found in fish mostly in the stomach and intestines

Consumers less exposed if eliminated

Greater exposure for crustaceans and bivalve molluscs, (oysters and mussels) for which the digestive tract is consumed

- Microplastics also found in other foods (honey, beer, table salt)

POTENTIAL HAZARD: Concentrations of polychlorinated biphenyls (PCBs) and polycyclic aromatic hydrocarbons (PAHs) and residues of compounds used in packaging such as bisphenol A (BPA), which can accumulate in microplastics.

Some studies indicate that microplastics, after consumption in food, can transfer to tissues. → EVALUATE THE AVERAGE INTAKE

EFSA has estimated that one portion of mussels (225g) could contain seven micrograms of microplastic. Even if that amount of material contained the highest ever measured concentrations of PCBs or BPA, for example, it would contribute little to overall exposure to these substances: it would increase PCB exposure by less than 0.01% or exposure to BPA of less than 2%.

WHO 2019: Microplastics in drinking water

Microplastics are not individual chemicals or well-characterized substances but are particles that vary in **shape, size and composition**

↓

Challenges to traditional human health risk assessment approaches

Potential dangers associated with microplastics in drinking water

- PARTICLES → physical danger
- CHEMICAL SUBSTANCES
  - monomers
  - additives
  - absorbed substances
- BIOFILM

- No human or epidemiological studies on ingested microplastics were identified.
- Data from laboratory animal studies are scarce and inadequate to inform human health risk assessment of ingestion of microplastics.
- The current database of information on the toxicity (and absorption) of plastic particles is limited to a few studies using PET, PS or PE, and there are questions about the reliability of some of these studies.

WHO 2019: Microplastics in drinking water

Potential hazards associated with particles

Absorption studies of microplastics and nanoplastics FAO 2017 and EFSA 2016

↓

Absorption kinetics in the gastrointestinal tract of microplastics

- Most ingested microplastics (>90%) are probably not absorbed
- Microplastics >150 µm are probably not absorbed
- Limited absorption of smaller microplastics (≤0.3%).
- It is possible that uptake and distribution may be more significant for nanoplastics than microplastics (up to 7% for nanoplastics <0.1 µm
- Limited data → further studies are needed

WHO 2019: Microplastics in drinking water

Potential hazards associated with particles

MONOMERS
ADDITIVES
SUBSTANCES ABSORBED

PARAMETER	INTAKE	RATIONAL
Shape	Spherical	Greater specific surface area and volume
Dimensions	150 µm	More frequent (Mintening et al., 2019)
Density	2.3 g/cm3	Highest Density Detected (Polyester)
Number of particles in water	10.4 particles/L	Conservative estimate from literature data

CONSERVATIVE SCENARIO: Estimated daily intakes 0.1 - 2 µg/day

Chemical[a]	Upper bound concentration in microplastic (µg/g)	Maximum daily intake (ng/kg bw/day)[b]	Point of departure (µg/kg bw/day)	Margin of exposure (MOE)	Adequacy of MOE	Conclusion
Bisphenol A	0.7297	0.001	609	5.9×10^8	MOE of at least 100	No safety concern
Cadmium	3390	5.0	0.8	1.7×10^2	MOE of at least 10[c]	No safety concern
Chlordane	0.0144	0.00002	50	2.5×10^9	MOE of at least 100	No safety concern
Di(2-ethylhexyl)phthalate	0.0699	0.0001	2500	2.5×10^{10}	MOE of at least 100	No safety concern
Dichlorodiphenyltrichloroethane	7.1	0.0001	1000	1.0×10^8	MOE of at least 100	No safety concern
Hexachlorobenzene	0.0587	0.00002	50	6.0×10^8	MOE of at least 100	No safety concern
Polyaromatic hydrocarbons	119	0.06	100	6.0×10^5	MOE of at least 10 000	No safety concern
PBDEs	9.9	0.01	100	7.2×10^6	MOE of at least 100	No safety concern
PCBs	18.7	0.03	5	1.9×10^5	MOE of at least 1000[d]	No safety concern

From the available data, no significant risks are identified → To be investigated on a case-by-case basis based on the individual active compounds

WHO 2019: Microplastics in drinking water

Potential hazards associated with particles

World Health Organization

limited data on the distribution of biofilms (both in suspension and in pipes
→ Different effects to be explored) associated with microplastics in drinking water

no evidence suggesting a risk to human health from biofilms associated with microplastics in drinking water.

DRINKING PLANTS → clarification / membrane filtration / disinfection

effective methods to remove particles with attached microorganisms and inactivate biofilms.

Some microplastics can detach from **materials within water treatment and distribution systems** → very small fraction of the surface area and biofilms generated on the starting materials.
Additionally, in many countries, plastics and materials used in drinking water systems are subject to standards, including **testing to demonstrate that they do not support microbial growth** (WHO, 2014).

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Thank you for the attention!

Blue Lakes
No microplastics, just waves.

Water and Waste Environmental Engineering LAB

BENEFICIARIO COORDINATORE

LEGAMBIENTE

BENEFICIARI ASSOCIATI

Autorità di Bacino Distrettuale dell'Appennino Centrale

arpa UMBRIA Agenzia Regionale per la Protezione Ambientale dell'Umbria

ENEA AGENZIA NAZIONALE PER LE NUOVE TECNOLOGIE, L'ENERGIA E LO SVILUPPO ECONOMICO SOSTENIBILE

Global Nature Fund

Bodensee Stiftung Lake Constance Foundation

UNIVERSITÀ POLITECNICA DELLE MARCHE

PROGETTO COFINANZIATO DA

PlasticsEurope Association of Plastics Manufacturers

Examples and case studies

Università Politecnica delle Marche

BENEFICIARIO COORDINATORE

BENEFICIARI ASSOCIATI

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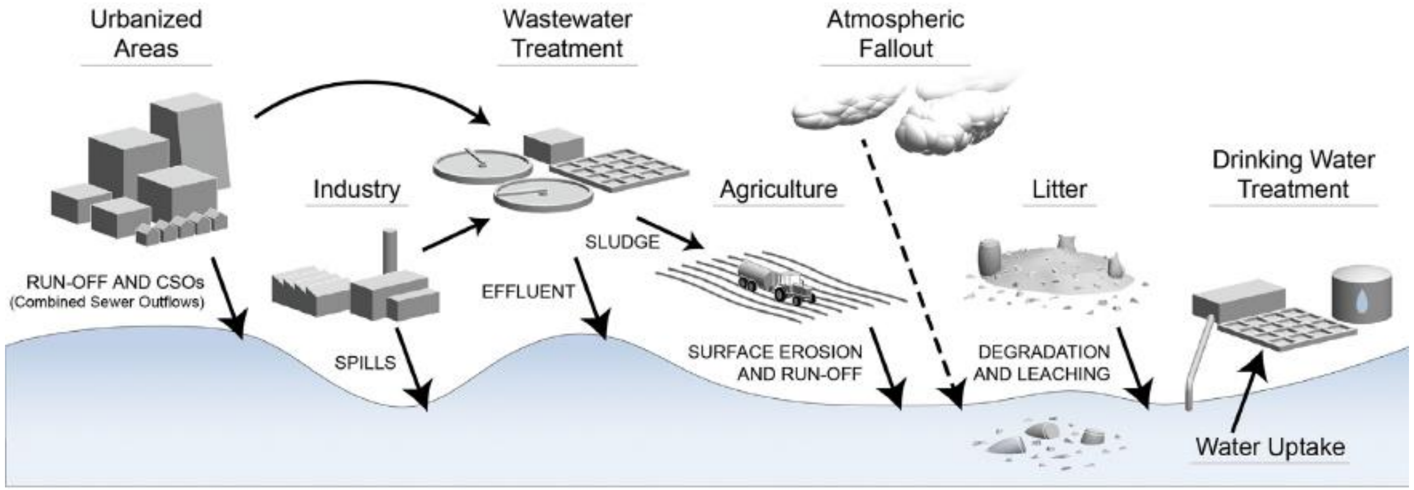
Microplastics in the Integrated Water Service

Plants receive the microplastics contained in the influent from a wide variety of potential sources:

- Textile laundry fibres
- Plastics in personal care products
- Fragmentation of larger plastic objects
- Plastics in industrial waste
- Tire and road wear particles
- Runoff waters

Wastewater treatment plants are often regarded as a ***source of microplastics*** for the environment.
However, most of the microplastics released do not originate from internal plant processes. For this reason, the most appropriate definition is a ***release path***



Routes of entry for microplastics leading to drinking water sources. Eerkes-Medrano 2019

The reduction of microplastics in the effluent depends to some extent on the treatment processes employed.
Removal efficiencies of up to 99% have been reported in the literature.

Despite the low concentrations of microplastics in the effluent, the large volumes treated by the plants result in substantial **cumulative releases over time.**

$$Mass\ load = Concentration * Volume$$

During the treatment processes, the microplastics are transferred to the sludge which, based on the type of final delivery, could give rise to release phenomena based on the final delivery point.

MPs in water treatment plants

From measures to mass balances

Sampling point	Flowrate (l/s)	start	end	time (min)	Volume (l)
Influent	0.18	13:30	15:00	90	972
Out ozone	0.18	13:33	15:09	96	1037
Out filters	0.15	14:02	15:53	111	1000
Effluent	0.11	13:59	16:30	147	970
Distribution	0.29	14:27	15:25	58	1000

Measured in the field before the start of the test

- Meters
- Verified on site

$$Flowrate\left(\frac{l}{s}\right) = Volume\ (l)\ /\ \ time\ (s)$$

$$Time\ (min) = Volume\ (\sim 1000\ l)\ /\ Flowrate\left(\frac{l}{s}\right)\ /\ 60\ (\frac{sec}{min})$$

$$Volume\ (l) = Flowrate\left(\frac{l}{s}\right) * (\ start\ time - end\ time) * \ 60\ (\frac{sec}{min})$$

N.B. Transform hours into minutes!

MPs in water treatment plants

From measures to mass balances

Sampling point	Volume (l)	n. Microplastic Particles (MPPs) in the sample	~~n. Natural Microfibres (MNFs)~~	n. Plastic Microfibres (MPFs)	n. Microplastics (MPs)	MPS concentration [MPs/m3]
Influent	972	10	~~2~~	4	14	**14.4**
Out ozone	1037	6	~~3~~	2	8	**7.7**
Out filters	1000	3	~~2~~	0	3	**3.0**
Effluent	970	1	~~2~~	1	2	**2.1**
Distribution	1000	3	~~1~~	0	3	**3.0**

$$Count\ Microplastics\ (MPs) = Plastic\ Microparticles(MPPs) + Plastic\ Microfibres\ (MPFs)$$

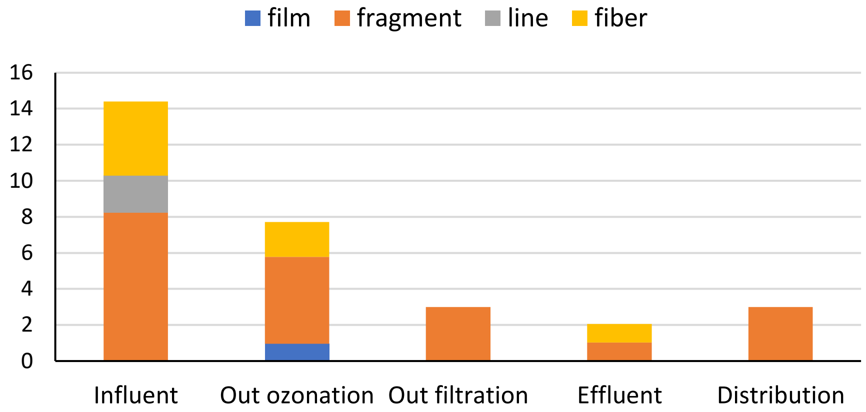
$$Concentration\ MPs\ \left(\frac{MPs}{m3}\right) = n.MPs\ counted / \ Volume\ (l)/1000\ \left(\frac{l}{m3}\right)$$

MPs in water treatment plants

From measures to mass balances

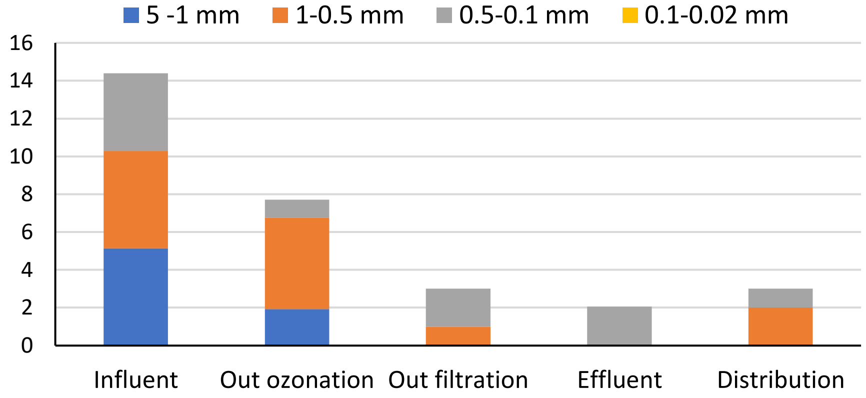
SHAPE

Sampling point	n. MPs	film	fragment	line	fiber
Influent	14		8	2	4
Out ozone	8	1	5		2
Out filters	3		3		
Effluent	2		1		1
Distribution	3		3		



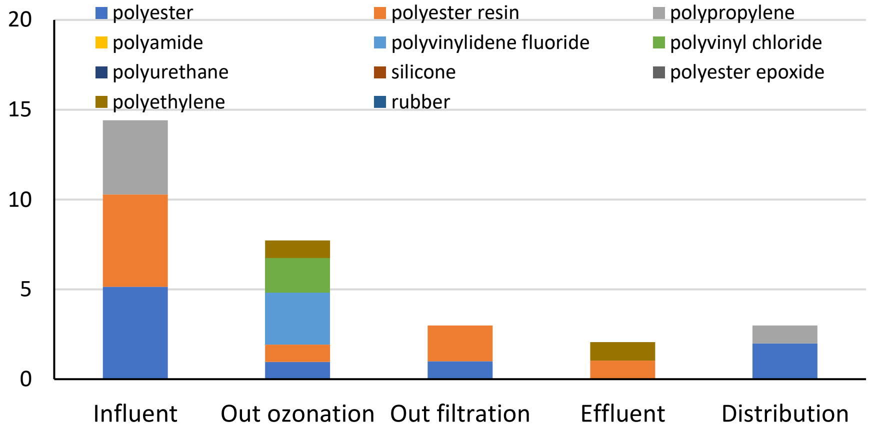
DIMENSION

Sampling point	nn. MPs	5 -1 mm	1-0.5 mm	0.5-0.1 mm	0.1-0.02 mm
Influent	14	5	5	4	
Out ozone	8	2	5	1	
Out filters	3		1	2	
Effluent	2			2	
Distribution	3		2	1	



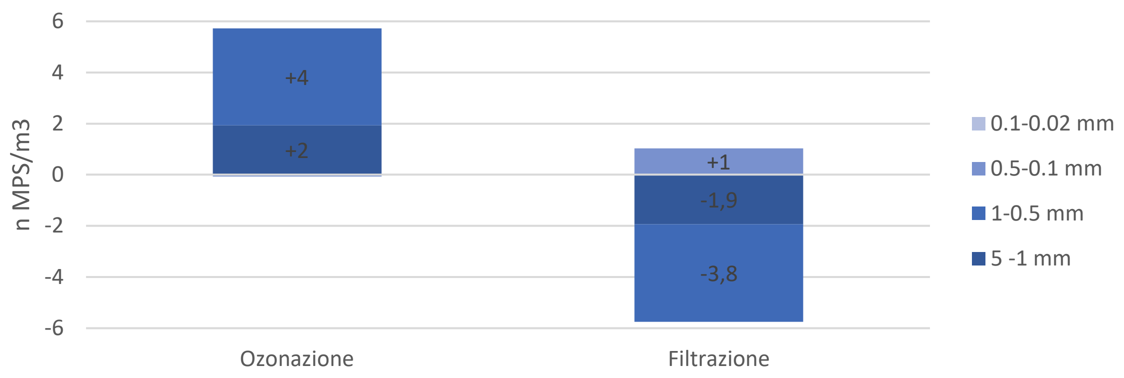
TYPOLOGY

Sampling point	n. MPs	polyester	polyester resin	polypropylene	polyvinylidene fluoride	polyvinyl chloride	polyethylene
Influent	14	5	5		4		
Out ozone	8	1	1		3	2	1
Out filters	3	1	2				
Effluent	2		1				1
Distribution	3	2		1			



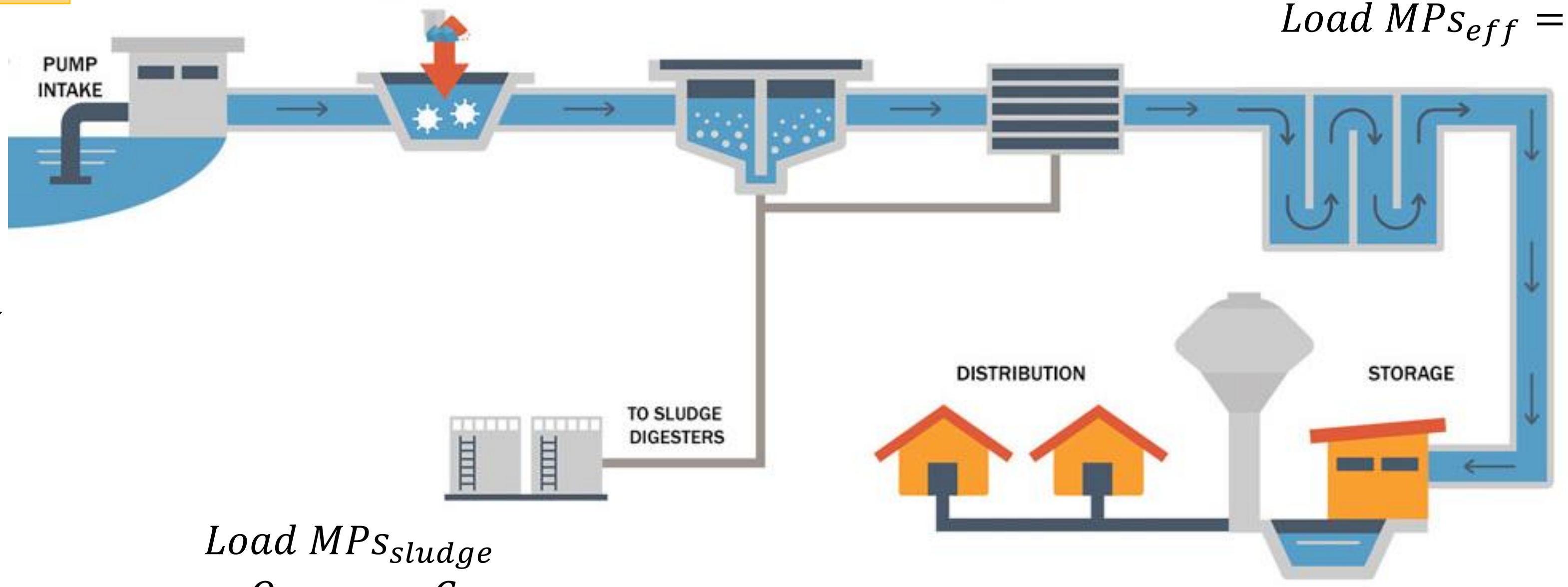
MPs in water treatment plants

From measures to mass balances



EVALUATE THE CONCENTRATION VARIATIONS IN THE DIFFERENT TREATMENT UNITS

EVALUATE THE QUANTITIES



$Load\ MPs_{eff} = Q * Conc_{eff}$

lOAD $MPs_{in} = Q_{in} * Conc_{in}$

$Load\ MPs_{sludge} = Q_{sludge} * Conc_{sludge}$

$Load\ MPs_{distrib} = Q * Conc_{distrib}$

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MPs in water treatment plants

From measures to mass balances

Es: Drinking water treatment plant with Qin = 100 l/sec

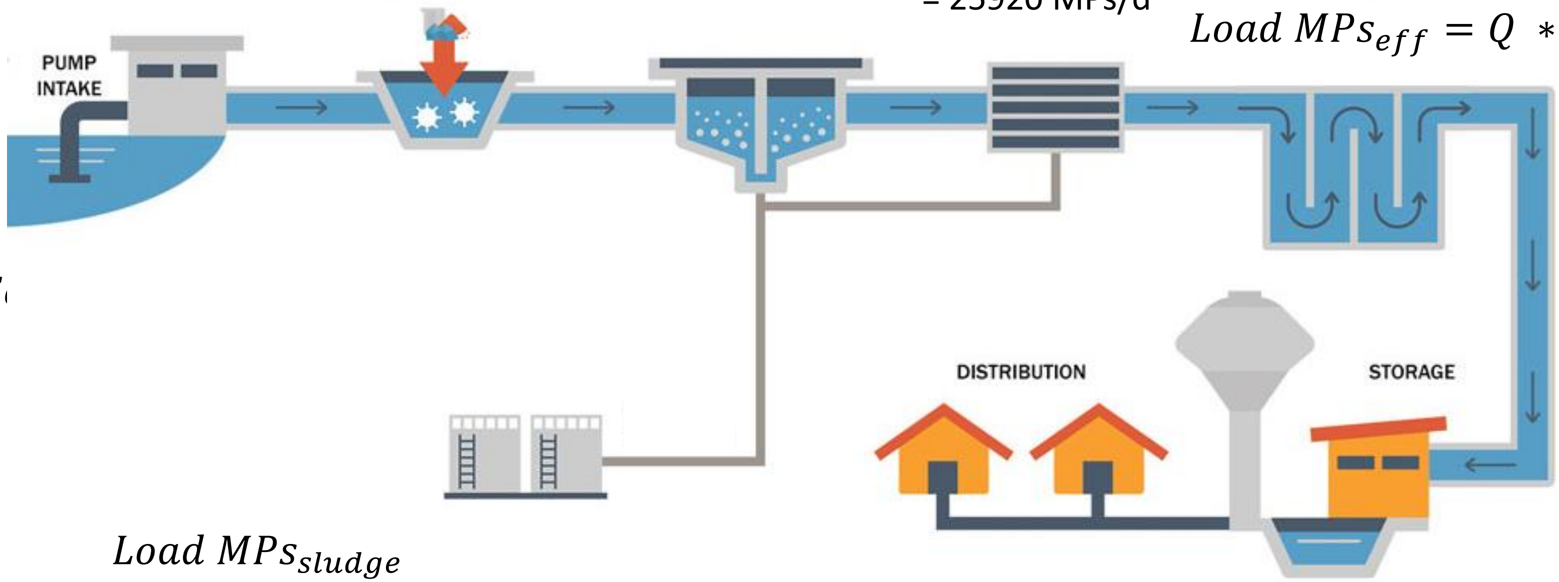
$$Flowrate\ (m3/d) = Flowrate\ \left(\frac{l}{s}\right) * \frac{1m3}{1000\ l} * \frac{60\ sec}{1\ min} * \frac{60\ min}{1\ h} * \frac{24\ h}{1\ d}$$

Sampling point	Concentration MPs/m3	Load MPs/d
Influent	14.4	124416
Out ozone	7.7	66528
Out filters	3.0	25920
Effluent	2.1	18144
Distribution	3.0	25920

= 66528 MPs/giorno

= 25920 MPs/d

$$Load\ MPs_{eff} = Q\ * Conc_{eff}$$



$$Load\ MPs_{in} = Q_{in}\ * C$$

= 124416 MPs/d

= 18144 MPs/d

$$Load\ MPs_{sludge} = Q_{sludge}\ * Conc_{sludge}$$

$$Load\ MPs_{distrib} = Q\ * Conc_{distrib}$$

= 25920 MPs/giorno

Experiences on the analysis of microplastics in wastewater treatment plants

Pittura et al., 2021 "Microplastics in real wastewater treatment schemes: Comparative assessment and relevant inhibition effects on anaerobic processes" Chemosphere, 262, 128415

Chemosphere 262 (2021) 128415

Contents lists available at ScienceDirect

Chemosphere

journal homepage: www.elsevier.com/locate/chemosphere

ELSEVIER

Microplastics in real wastewater treatment schemes: Comparative assessment and relevant inhibition effects on anaerobic processes

Check for updates

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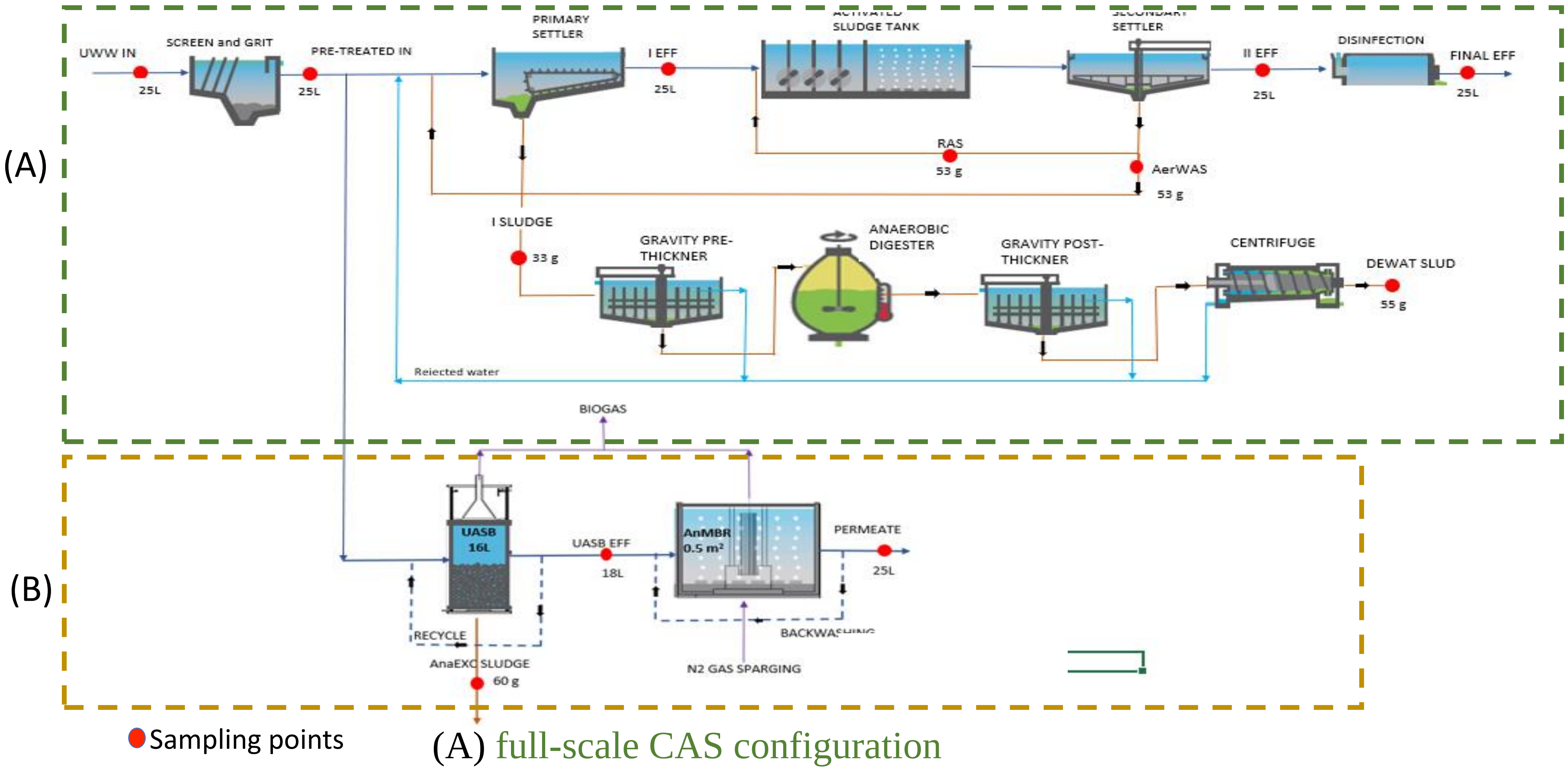
IMPIANTO DI TRATTAMENTO IN PIENA SCALA

Experiences on the analysis of microplastics in wastewater treatment plants

Presence and removal of microplastics in conventional large-scale and innovative pilot-scale treatment schemes of a municipal wastewater treatment plant



(A) full-scale CAS configuration

(B) pilot-scale UASB+AnMBR configuration

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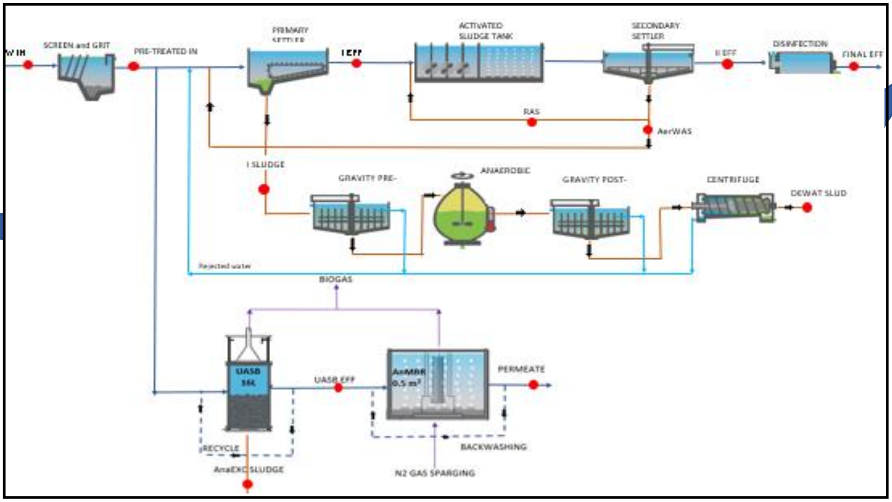
Experiences on the analysis of microplastics in wastewater treatment plants

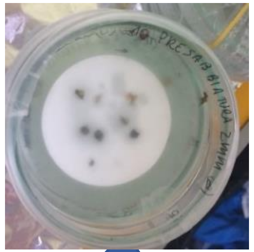
Water and Waste Environmental Engineering LAB

Conventional Full-scale WWTP and pilot scale AnMBR



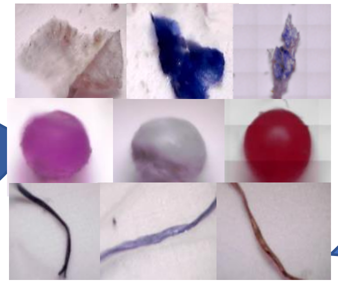
MPs sampling

MPs processing

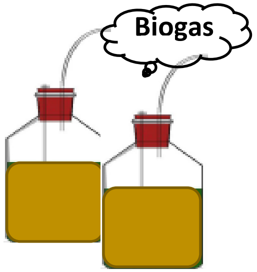


Visual sorting

MPs characterization



MPs Effect on the processes



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Blue Lakes

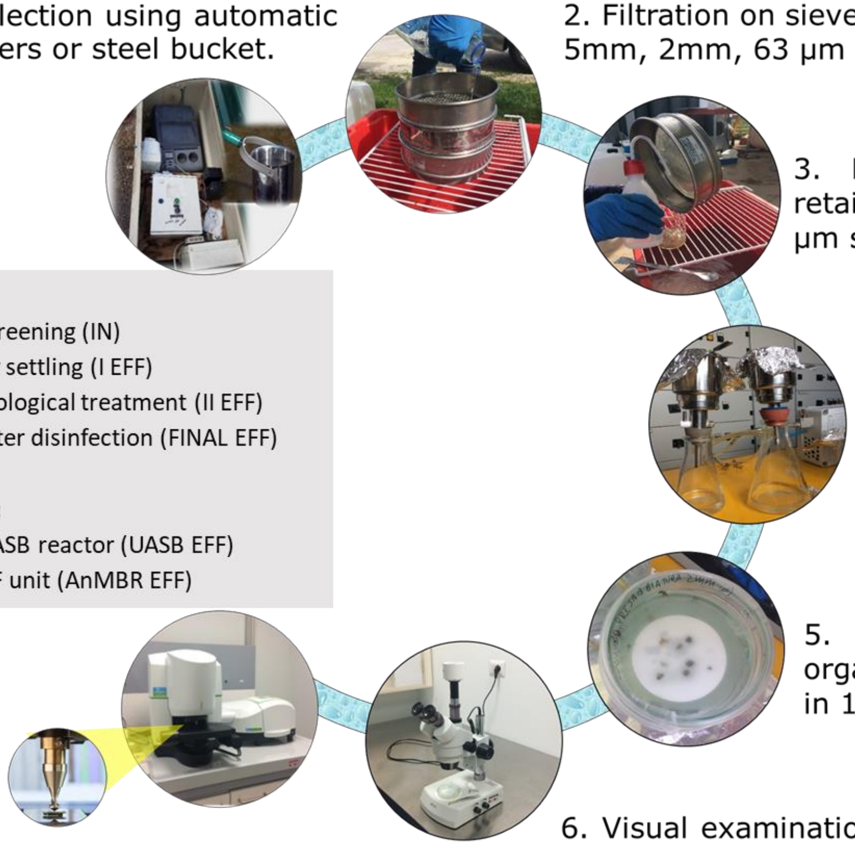
No microplastics, just waves.

Experiences on the analysis of microplastics in wastewater treatment plants

Wastewater processing for MPs analysis

SAMPLING A VOLUME OF ~25 L

SAMPLING WITH SIEVES UP TO 63 MICROMETERS



1. Collection using automatic samplers or steel bucket.

2. Filtration on sieves battery: 5mm, 2mm, 63 µm mesh sizes.

3. Recovery of materials retained on 2 mm and 63 µm sieves with MilliQ water.

4. Vacuum filtration on CN membranes (8 µm pore size).

5. Filter recovery and organic matter digestion in 15% H_2O_2 solution.

6. Visual examination and collection of fibers and particles.

7. Polymers identification by µFT-IR in ATR mode.

CAS system:
Influent after screening (IN)
Effluent primary settling (I EFF)
Effluent after biological treatment (II EFF)
Final effluent after disinfection (FINAL EFF)

AnMBR system:
Effluent after UASB reactor (UASB EFF)
Effluent after UF unit (AnMBR EFF)

DIGESTION OF ORGANIC SUBSTANCE

CHARACTERIZATION WITH IR

Experiences on the analysis of microplastics in wastewater treatment plants

Presence and removal of microplastics in conventional large-scale and innovative pilot-scale treatment schemes of a municipal wastewater treatment plant

	Analyzed samples	MPs concentration
Full scale WWTP based on conventional active sludge process (CAS)	Influent wastewater	3.1 MPs/L
	Wastewater after primary settling	1.9 MPs/L
	Wastewater after biological treatment (aerobic condition)	0.8 MPs/L
	Wastewater in the final effluent	0.5 MPs/L
	Secondary sewage sludge	5.3 MPs/g (79% particles and 21% fibers)
Innovative AnMBR system in the Pilot Hall	Wastewater after UASB reactor	1.7 MPs/L
	Wastewater after ultrafiltration unit	0.2 MPs/L
	UASB sludge	1 MPs/L (10% particles and 90% fibers)

ALONG THE TREATMENT LINE, MPs DECREASE AND ARE RETAINED IN SLUDGE >> ATTENTION TO SLUDGE DISPOSAL/ VALORIZATION!

***86%** REMOVAL FROM COVENTIONAL WATER LINE*

<

***94%** REMOVAL FROM INNOVATIVE WATER LINE*

Experiences on the analysis of microplastics in wastewater treatment plants

Efficiency in restraining microplastics: conventional vs innovative system

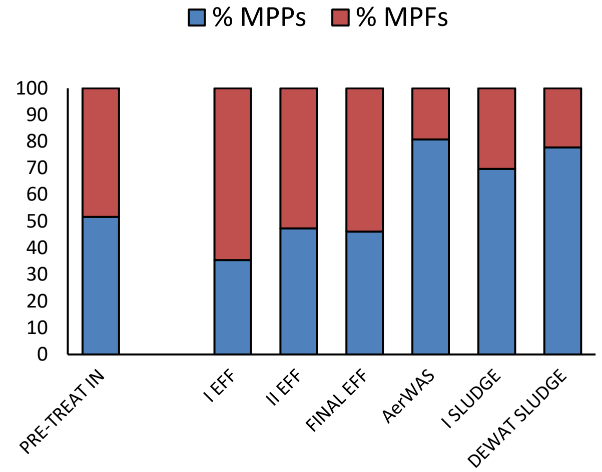
Treatment Steps	n°MPs/day	MPs removal (%)		
INFLUENT	**7.73E+07**			
EFFLUENT AFTER PRIMARY SETTLING	4.14E+07	45		82
EFFLUENT AFTER BIOLOGICAL TREATMENT	1.56E+07	62	79	
EFFLUENT AFTER CHEMICAL DISINFECTION	**1.33E+07**	15		

Treatment Steps	n°MPs/day	MPs removal (%)	
INFLUENT	**7.73E+07**		
EFFLUENT AFTER UASB	3.47E+07	55	95
EFFLUENT AFTER AnMBR	**3.91E+06**	40	

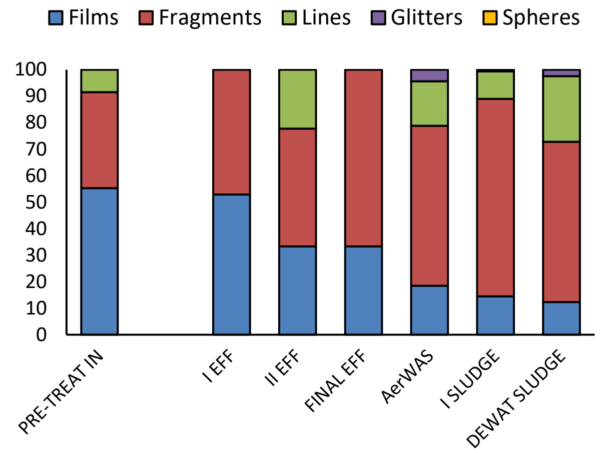
SYSTEM REMOVAL EFFICIENCY UASB ANMBR: 94% > SYSTEM REMOVAL EFFICIENCY CAS: 86%

Experiences on the analysis of microplastics in wastewater treatment plants

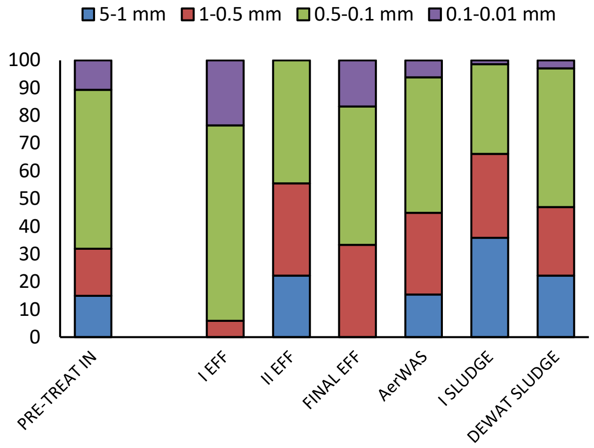
Microplastics characterisation



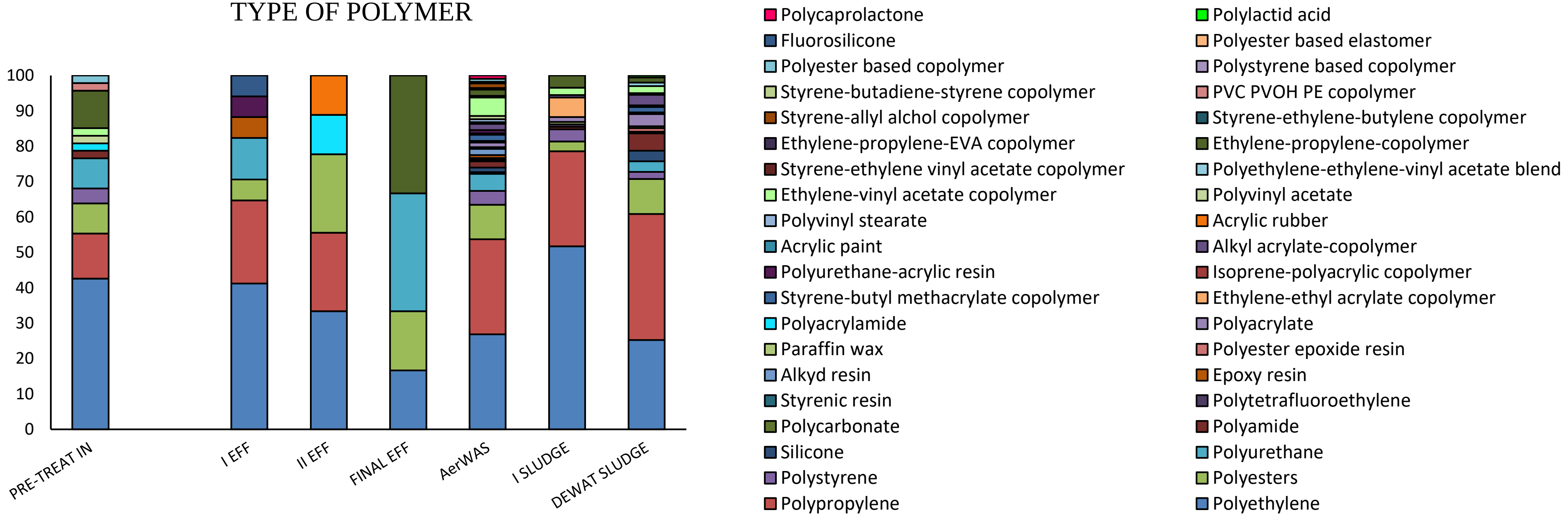
SHAPE



DIMENSIONS



TYPE OF POLYMER



THE MOST FREQUENT MPS ARE POLYETHYLENE AND POLYPROPYLENE

ALONG THE SUPPLY CHAIN THE CONCENTRATIONS DECREASE AND THEY ARE FOUND IN THE SLUDGE >> ATTENTION TO SLUDGE DISPOSAL / VALORIZATION!

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Legends: PRE-TREAT IN (pre-treated effluent), I EFF (primary effluent), II EFF (secondary effluent), FINAL EFF (final effluent), AerEXC SLUD (excess sludge), WAS (waste activated sludge), DEWAT SLUD (dewatered sludge).

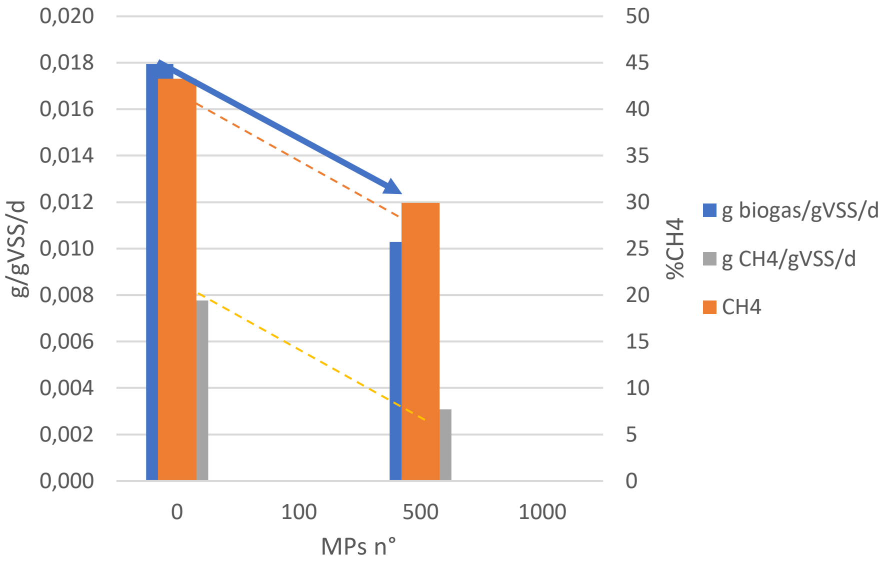
Experiences on the analysis of microplastics in wastewater treatment plants

Analysis of inhibitory effects of MPs on anaerobic biomass

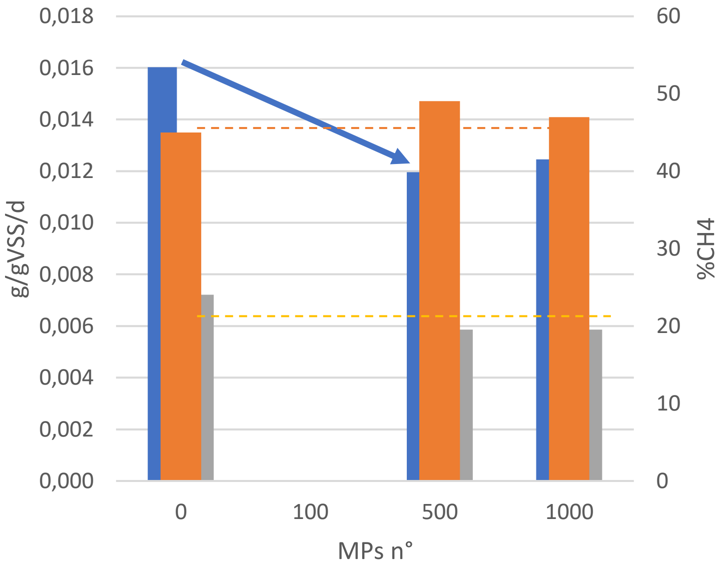
LAB TESTS

	BIOMASSS	BIOLOGICAL PROCESS	BATCH TESTS	MONITORING PARAMETER	
AEROBIC ACTIVATED SLUDGE	suspended	aerobic	F/M=0.4-0.7	SOUR	mg/gVSS/h
ANAEROBIC GRANULAR SLUDGE	suspended	anaerobic	COD/VSS=0.25	SGP	g biogas/gVSS/d
ANAEROBIC SLUDGE	suspended	anaerobic	COD/VSS=0.25	SGP	g biogas/gVSS/d

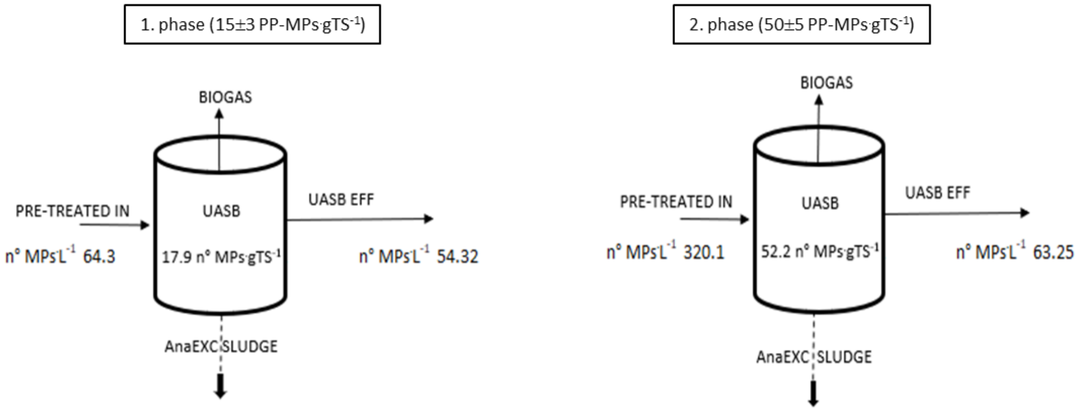
Anaerobic granular sludge



Anaerobic flocculant sludge

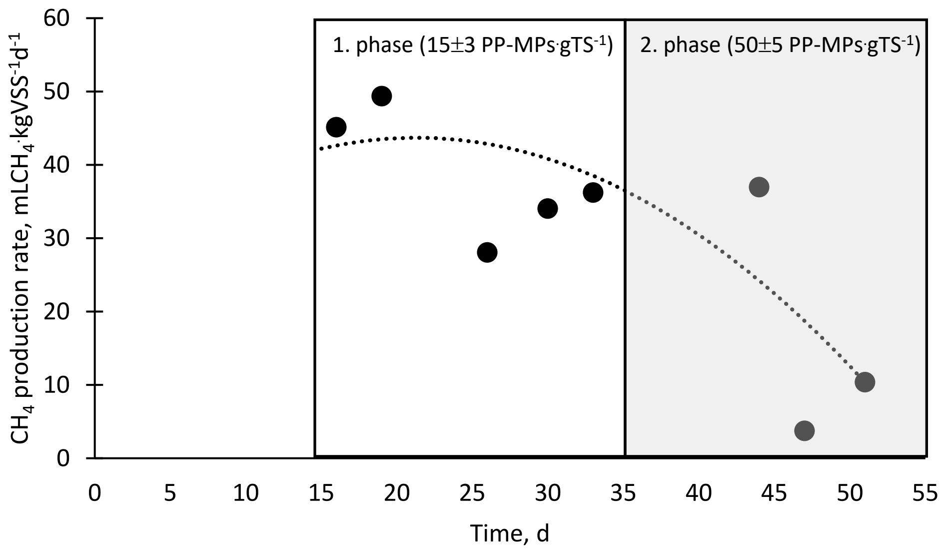


Experiences on the analysis of microplastics in wastewater treatment plants



Analysis of inhibitory effects of MPs on anaerobic biomass

(A) Schematic diagram of the mass balance of the spiked PP-MPs in the pilot-scale UASB reactor



DECREASE OF BIOGAS PRODUCTION AS MICROPLASTICS INCREASE IN THE UASB SYSTEM

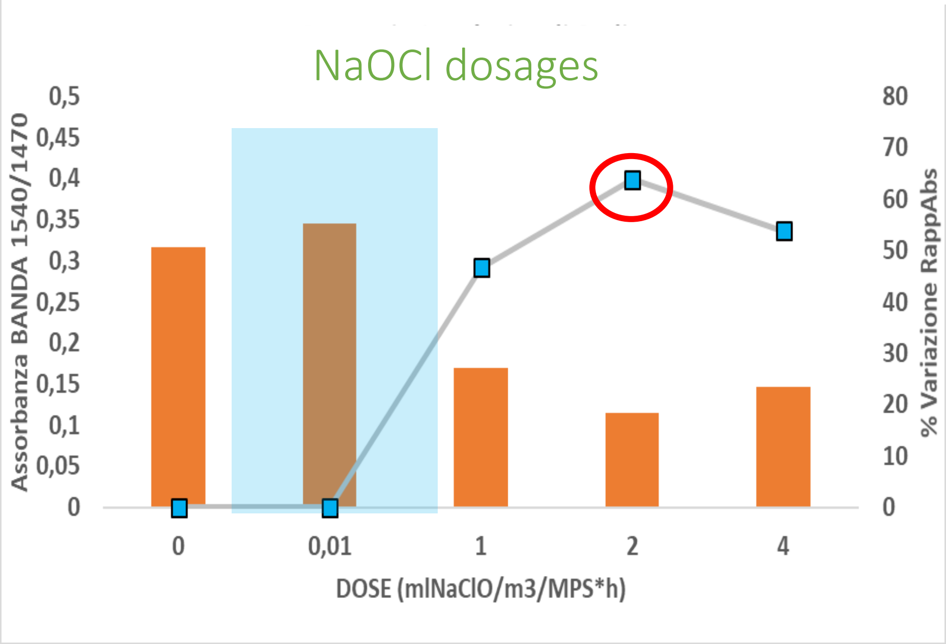
THE METHANOGENIC ACTIVITY IN THE ANAEROBIC REACTOR IS INHIBITED BY 58% WHEN THE CONCENTRATION OF MPs IS 50 PP-MPs/gTS

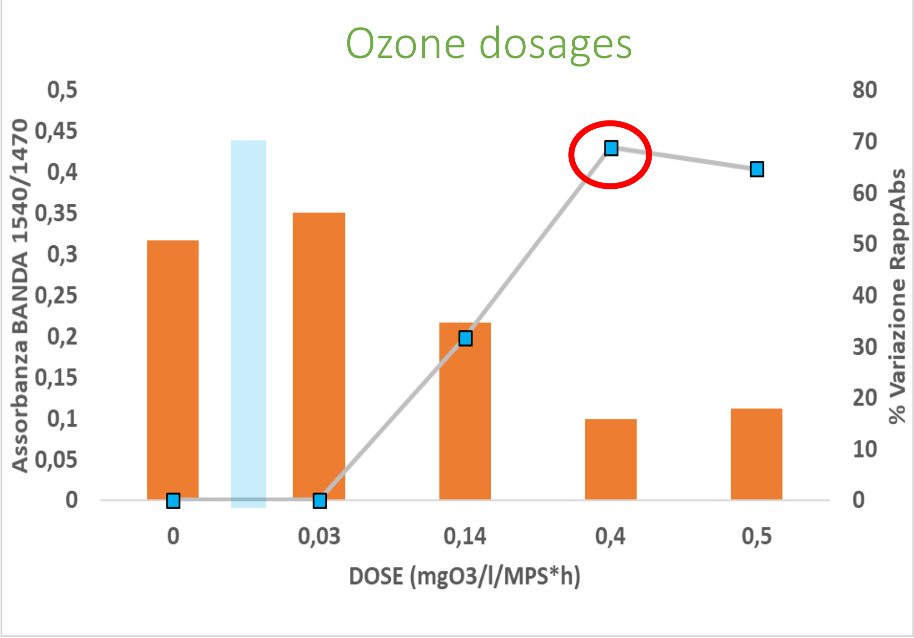
(B) Variation in CH_4 production rate of the pilot-scale UASB reactor upon the PP-MPs spiking. 1. and 2. phases refer to the spiking of 15±3 PP-MPs·gTS^{-1} and 50±5 PP-MPs·gTS^{-1}, respectively.

Experiences on the analysis of microplastics in wastewater treatment plants

Water and Waste Environmental Engineering LAB

Effect of tertiary disinfection treatments on PE microplastics: dose-dependent effects of oxidants





- Changes in absorbance at 1470 and 1540 cm-1 related to the NO_3 group.
- Treatments with doses of 0.4 mgO3*h/L/MPs and 2 mLNaOCl*h/m3/MPs reduce the absorbance ratio by 68% and 64%, respectively.
- The toxicity before and after the oxidative actions is still being evaluated with specific targeted experimental activities.

Experiences on the analysis of microplastics in wastewater treatment plants

- Preparatory studies for the definition of the MPs sampling method and of the extraction protocol for the detection and characterization of MPs in drinking water, wastewater and sludge;

- The presence and removal of MPs in WWTPs were evaluated, both for conventional and innovative treatment processes, resulting in a crucial role of ultrafiltration units (94%);

- The effect of MPs on biological processes has been studied, demonstrating an inhibition of methanogenic activity (58%) at a high concentration of MPs.

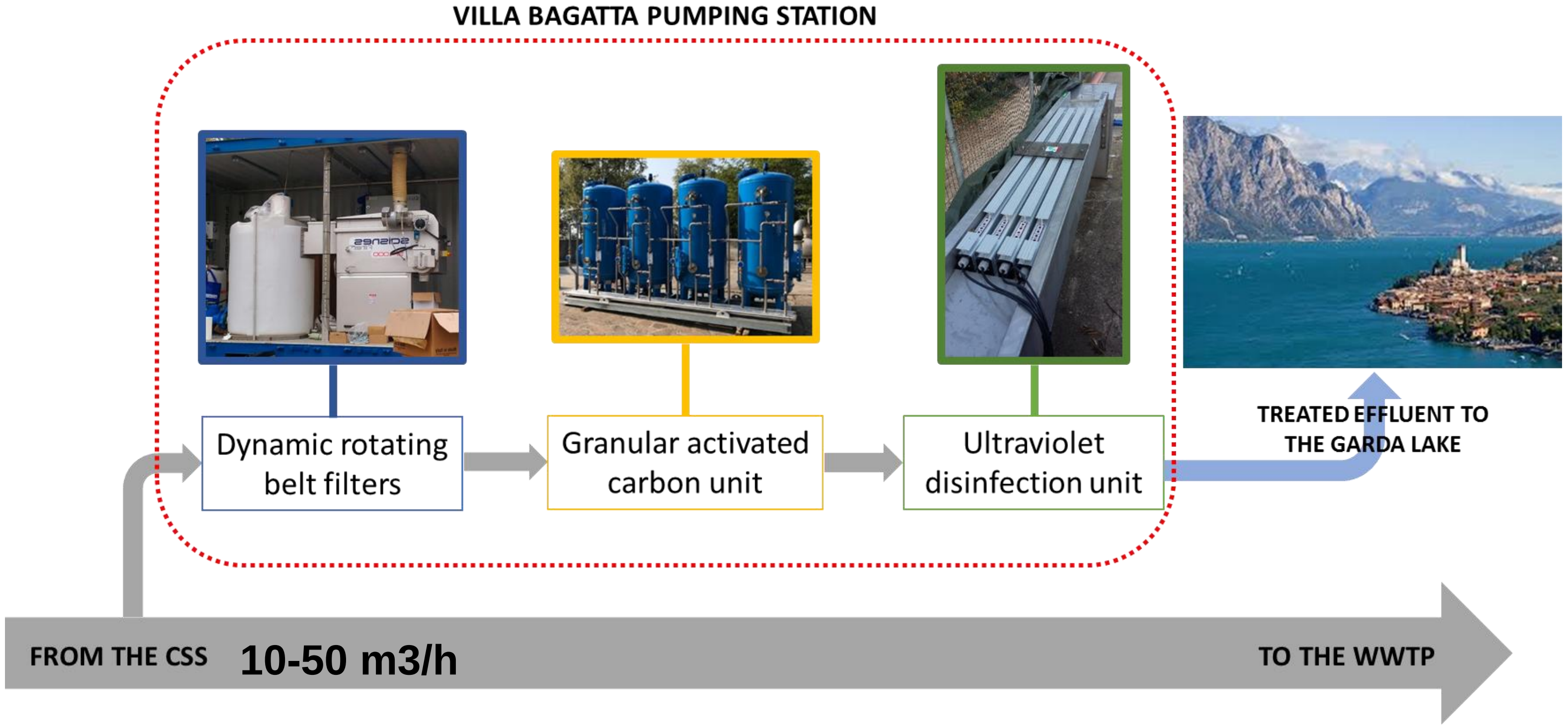
- The effect of high-dose tertiary treatments on MPs was studied resulting in a dependent effect between dosages and MPs composition by changing the chemical structure of the NO_3 group.

Innovation activities for water infrastructures in the Lake Garda basin (Combined sewer overflows)

INTCATCH 2020

HORIZON 2020 INTCATCH (http://www.intcatch.eu/)
Integration of Compact Solutions for the treatment of flood overflows

Compact Solutions in the plants: (*Lazise - Lago di Garda*)
Solids Removal, Rapid Adsorption, UV Disinfection (*Lazise - Lago di Garda, IT*)



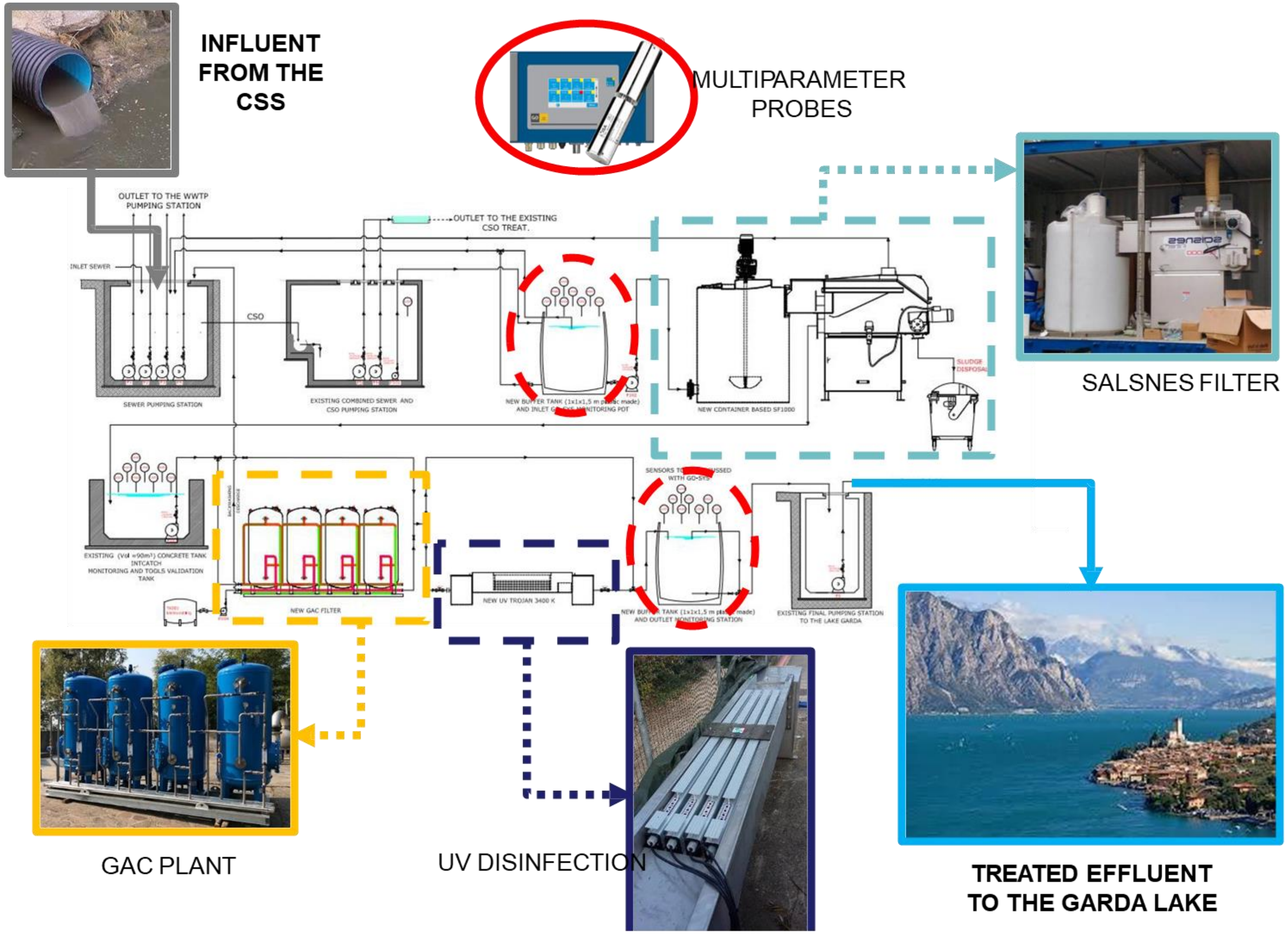
EXPERIENCES ON THE MONITORING OF TERRITORY CSOs

+

COLLABORATION WITH LOCAL MANAGERS AND STAKEHOLDERS

AZIENDA GARDESANA SERVIZI AGS

Innovation activities for water infrastructures in the Lake Garda basin (Combined sewer overflows)



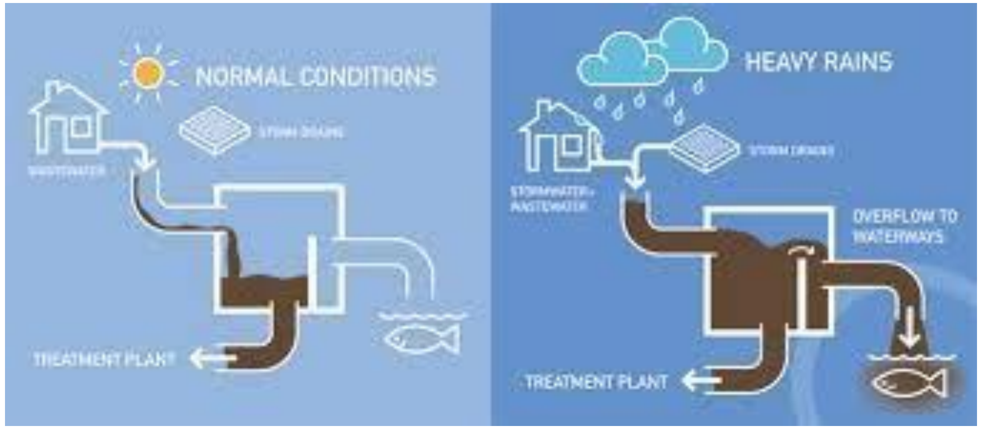
Villa Bagatta lifting station

- The station pumps approximately 22,000 m3/day
- Solutions for CSO treatment
- The treated CSO is discharged far from the shore, from a sub-lake pipe
- In 2016-2017 only 36 CSO events with an average discharged volume of 1,800 m3 and a duration of 3.35 hours

Parameter analysed: COD, TSS, TP, TN, E. coli and coliforms, PPCPs and emerging contaminants, such as microplastics

Combined sewer overflows

- They contain untreated waste from human and industrial activities, toxic materials and debris, as well as rainwater
- One of the main problems of the countries that have the Combined Sewage System
- Numbers:
- 650,000 CSOs in Europe (EurEau)
- 20% of surface waters are at serious risk of pollution (EU Water Framework Directive)
- 11 CSOs on the eastern shore of Lake Garda



Innovation activities for water infrastructures in the Lake Garda basin

Critical analysis with evaluation of peak and minimum scenarios, both long and short term (e.g. high vs low tourist season, weekend vs working days) for system performance optimization

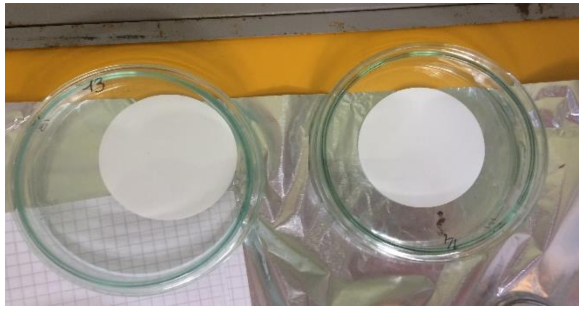
SAMPLING OF EMERGING CONTAMINANTS IN THE PLANT: MPs

Sampling points

→Pre screening: 25 L – grab sample

→Post degritting: 25 L - grab sample

→Out (post disinfection): 25 L - grab sample



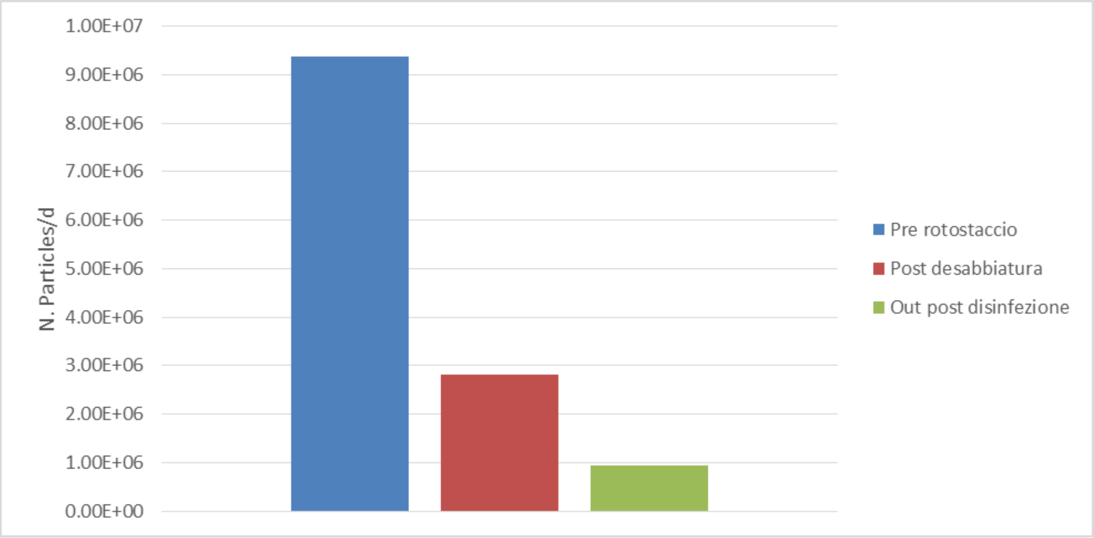
Sampling dates : 1/08/2018, 24/08/2018, 28/09/2018

Critical analysis with evaluation of peak and minimum scenarios, both long and short term (e.g. high vs low tourist season, weekend vs working days) for system performance optimization

SAMPLING OF EMERGING CONTAMINANTS IN THE PLANT: MPs: 01/08/2018

WATER STREAM	N. MPs/m3*	N. MPs/h	N. MPs/d	% rimozione relativa	% rimozione assoluta
PRE SCREENING	400	390933	9.38E+06		
POST DEGRITTING	120	117280	2.81E+06	70	
OUT POST DISINFECTION	40	39093	9.38E+05	67	90

*Mainly Polyethylene

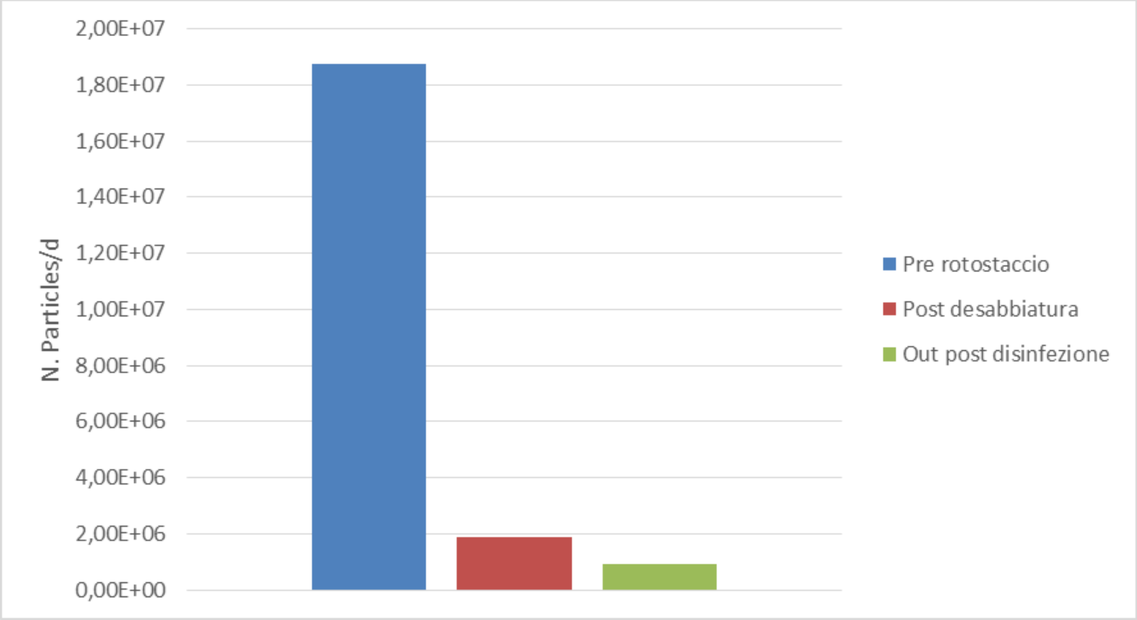


Critical analysis with evaluation of peak and minimum scenarios, both long and short term (e.g. high vs low tourist season, weekend vs working days) for system performance optimization

SAMPLING OF EMERGING CONTAMINANTS IN THE PLANT: MPs: 24/08/2018

WATER STREAM	N. MPs/m3*	N. MPs/h	N. MPs/d	% RELATIVE REMOVAL	% ABSOLUTE REMOVAL
PRE SCREENING	800	781866	1.88E+07		
POST DEGRITTING	80	78186	1.88E+06	90	
OUT POST DISINFECTION	40	39093	9.38E+05	50	95

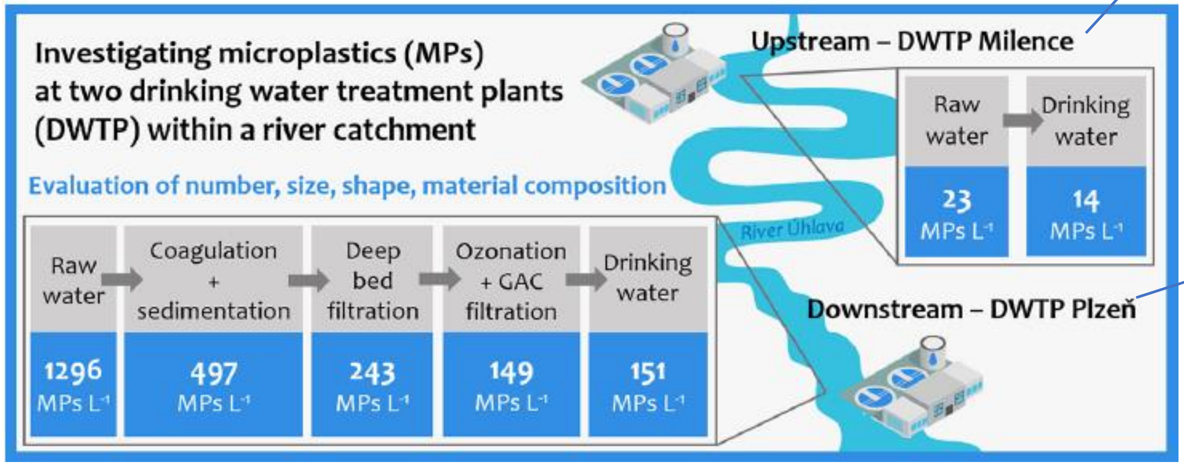
*Mainly polyvinyl stearate and polymer rubber → from tyres, pipes, shoe soles and gaskets



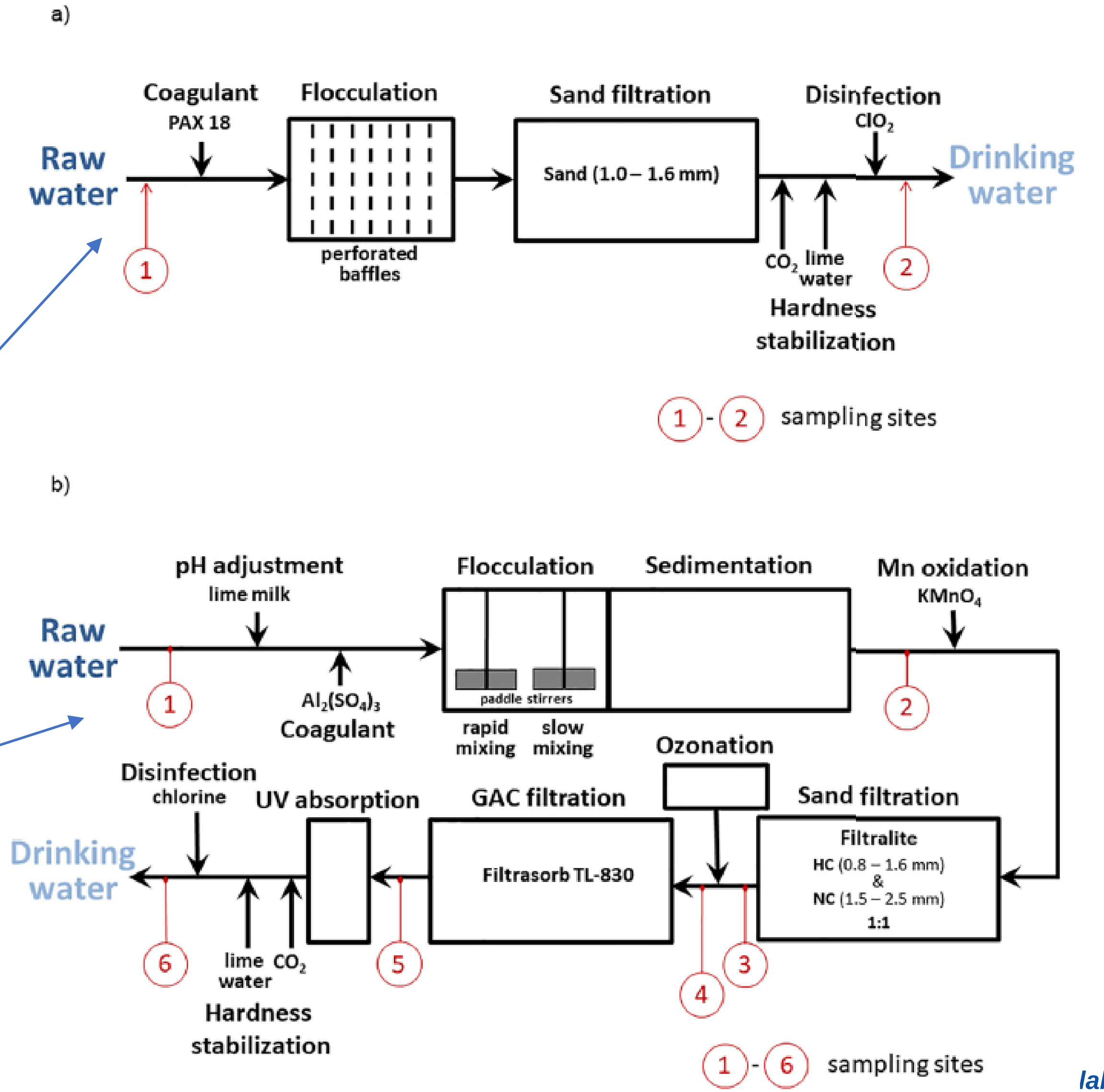
Literature research

Microplastics in drinking water treatment plants – case study 1

Analysis of MPs ≥ 1 µm in raw and treated water from two treatment plants which are both located on the same river, but where the local water quality and applied treatment technology differ. Sampling was conducted three times in one day, taking 2 L of water on each occasion.



M. Pivokonský et al. (2020)



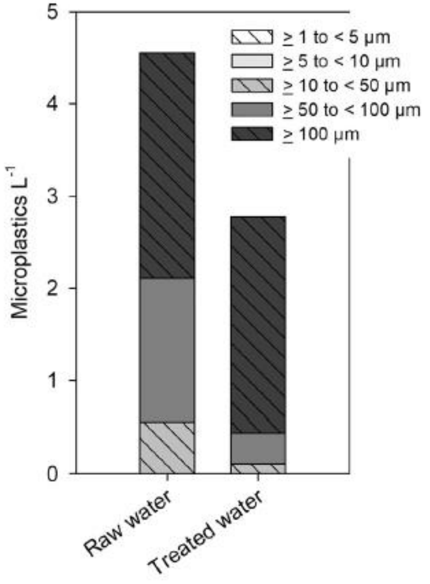
lakes.eu

Literature research

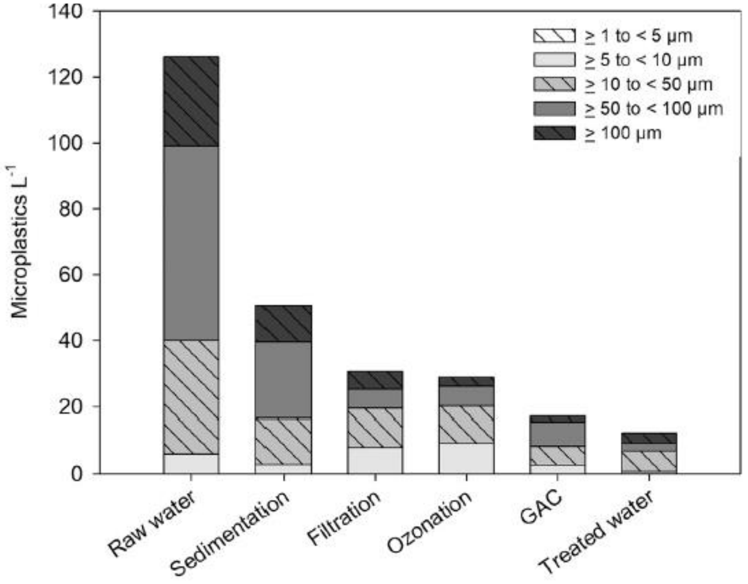
Microplastics in drinking water treatment plants – case study 1

FIBRES

DWTP A

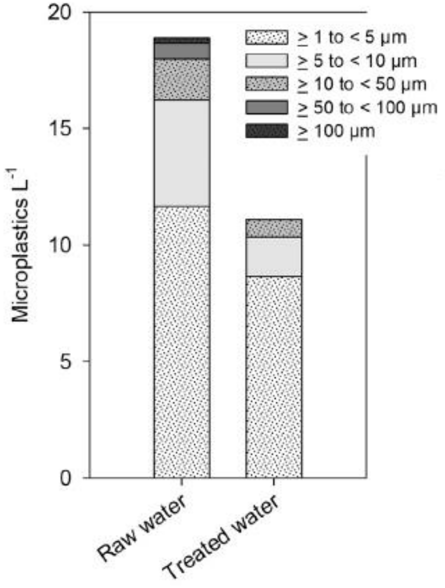


DWTP B

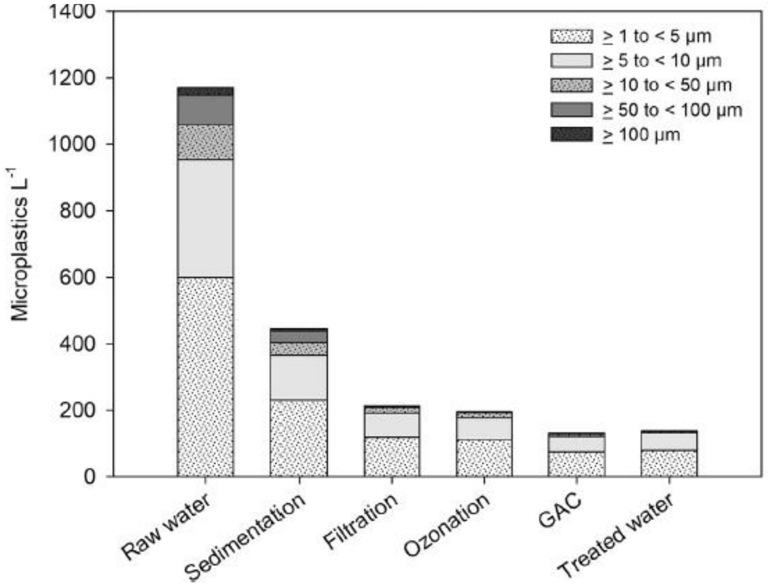


FRAGMENTS

DWTP A



DWTP B



M. Pivokonský et al. / Science of the Total Environment 741 (2020)

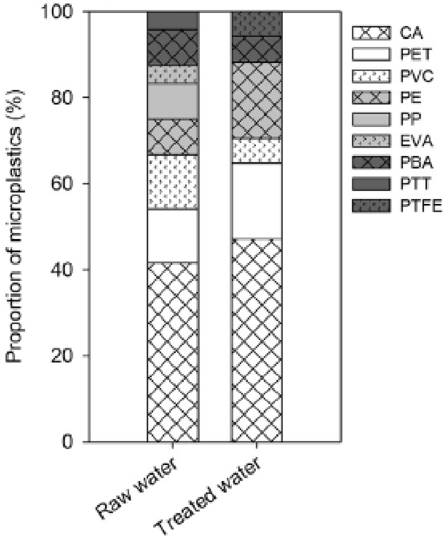
High concentrations found, mainly due to:
- Mesh (1 µm)
- Representativeness of the sample (2-6 L)

Literature research

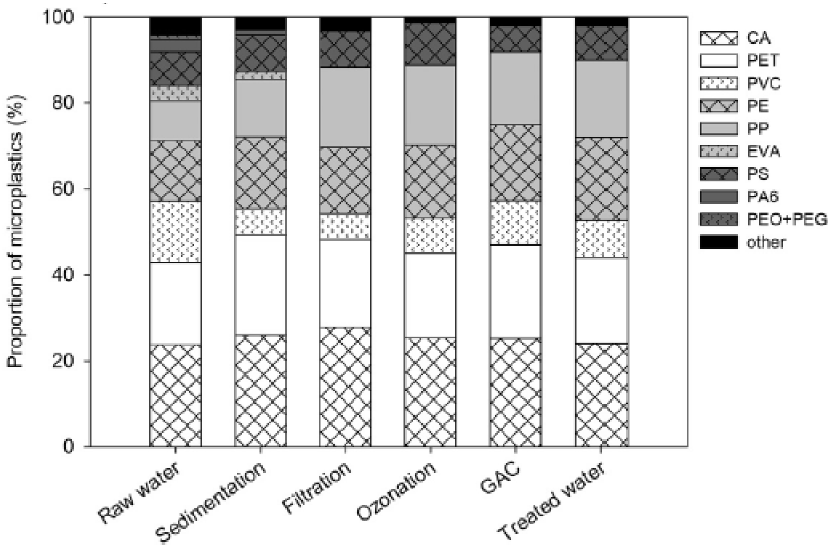
Microplastics in drinking water treatment plants – case study 1

PLASTIC TYPES

DWTP A

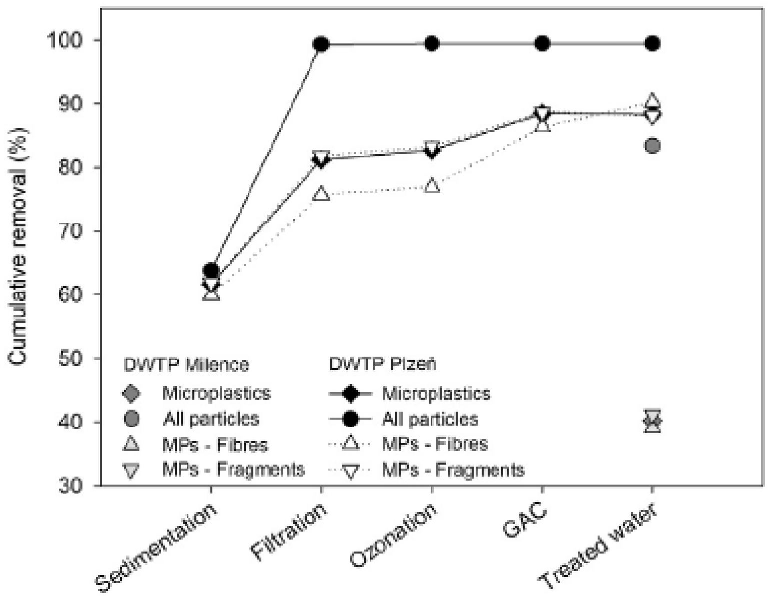


DWTP B



M. Pivokonský et al. / Science of the Total Environment 741 (2020)

CUMULATIVE REMOVAL EFFICIENCY

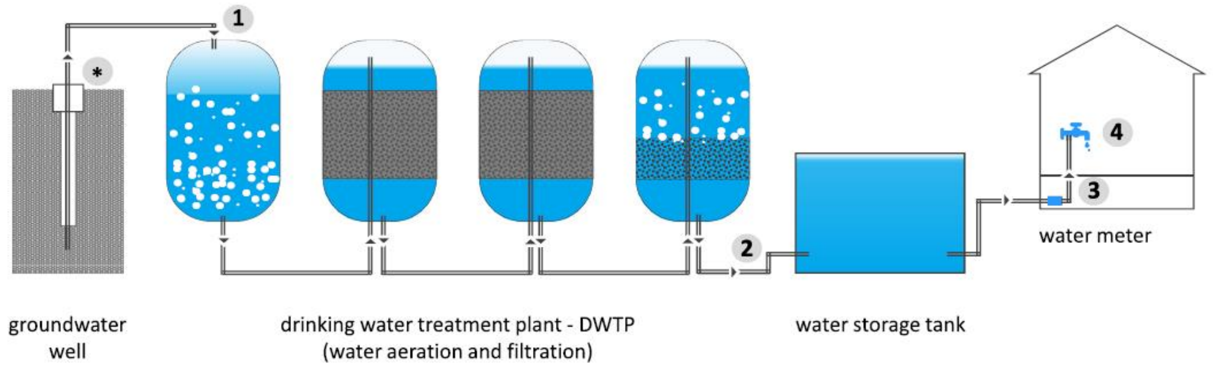


Treatment	Removal efficiency [%]
coagulation-flocculation-sedimentation	62%
Deep bed filtration	20%
Granular active carbon filtration	6%

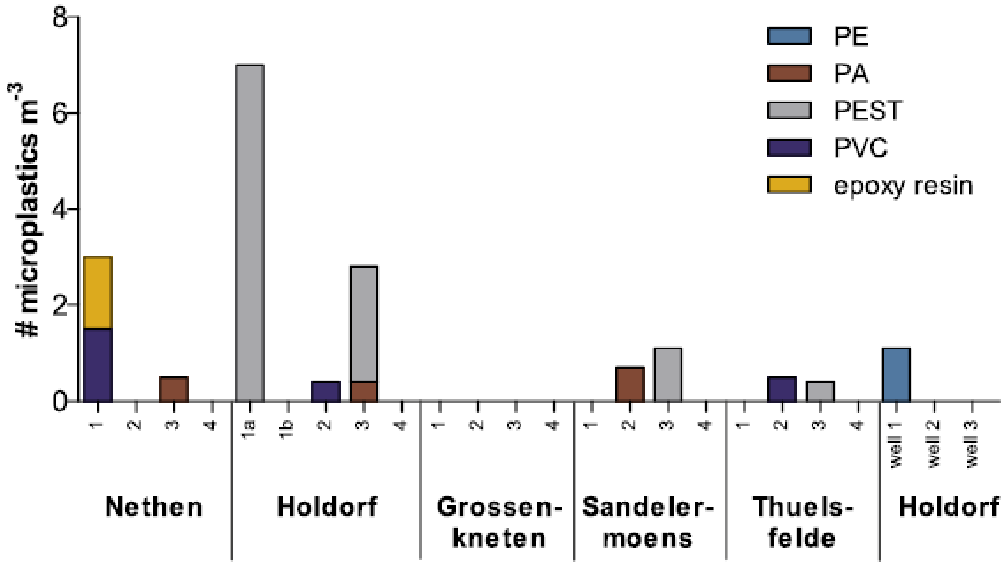
Removal efficiencies range from 40% for the first plant (basic configuration) up to 88% for the complex plant

Literature research

Microplastics in drinking water treatment plants – case study 2



S.M. Mintenig et al. 2019



Drinking water treatment plants linked to **groundwater** (Germany)

- Sampling Volumes:
  - between 300 and 1000 L of raw water
  - from 1200 to 2500 L of drinking water
- Mesh: 3-20 µm

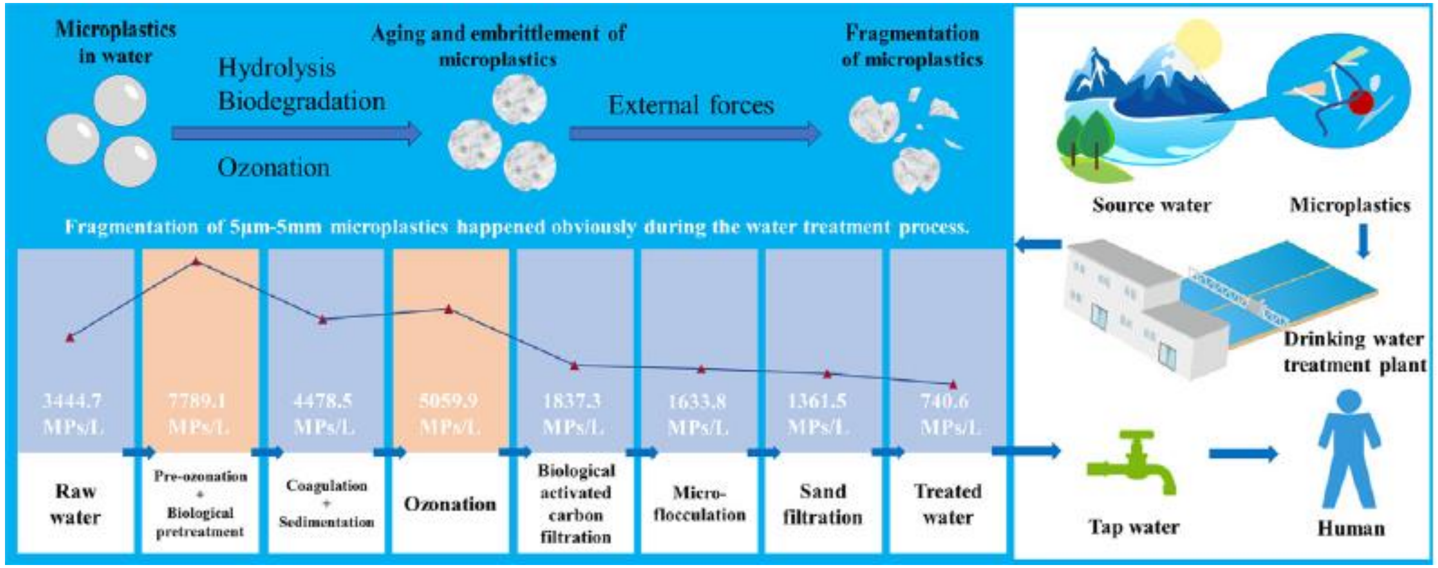
EVALUATE SIGNIFICANCE AND EFFECTIVENESS

RESULTS

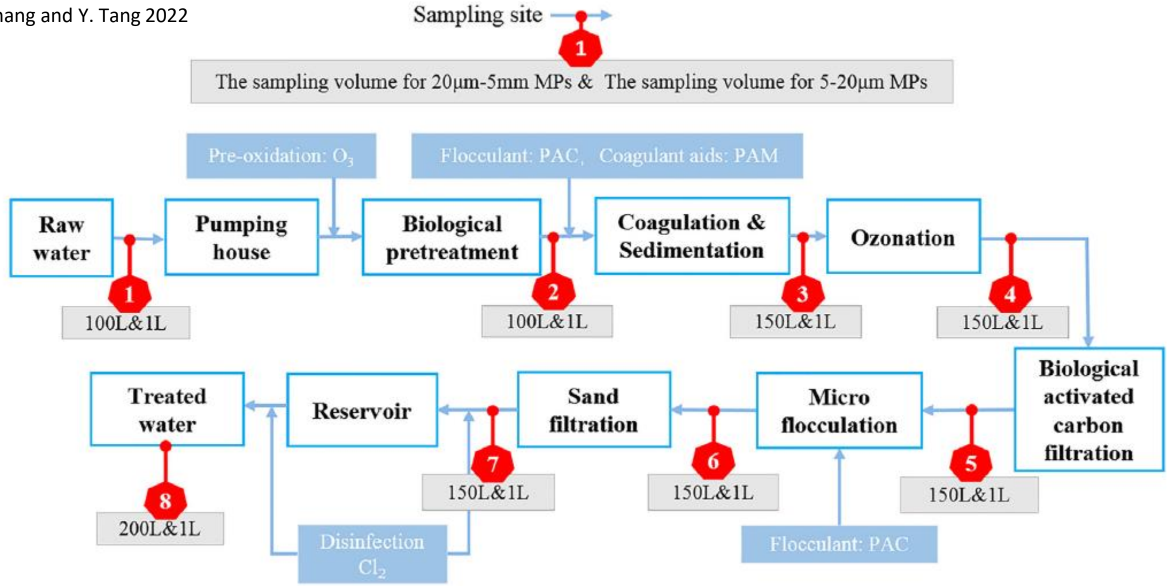
- **Concentrations**: from 0 to 7 MPs/m3.
- **Main categories**: polyethylene, polyamide, polyester, polyvinyl chloride or epoxy resin
- **Dimensions**: 50 - 150 µm

Literature research

Microplastics in drinking water treatment plants – case study 3



J.Wu, Y. Zhang and Y. Tang 2022

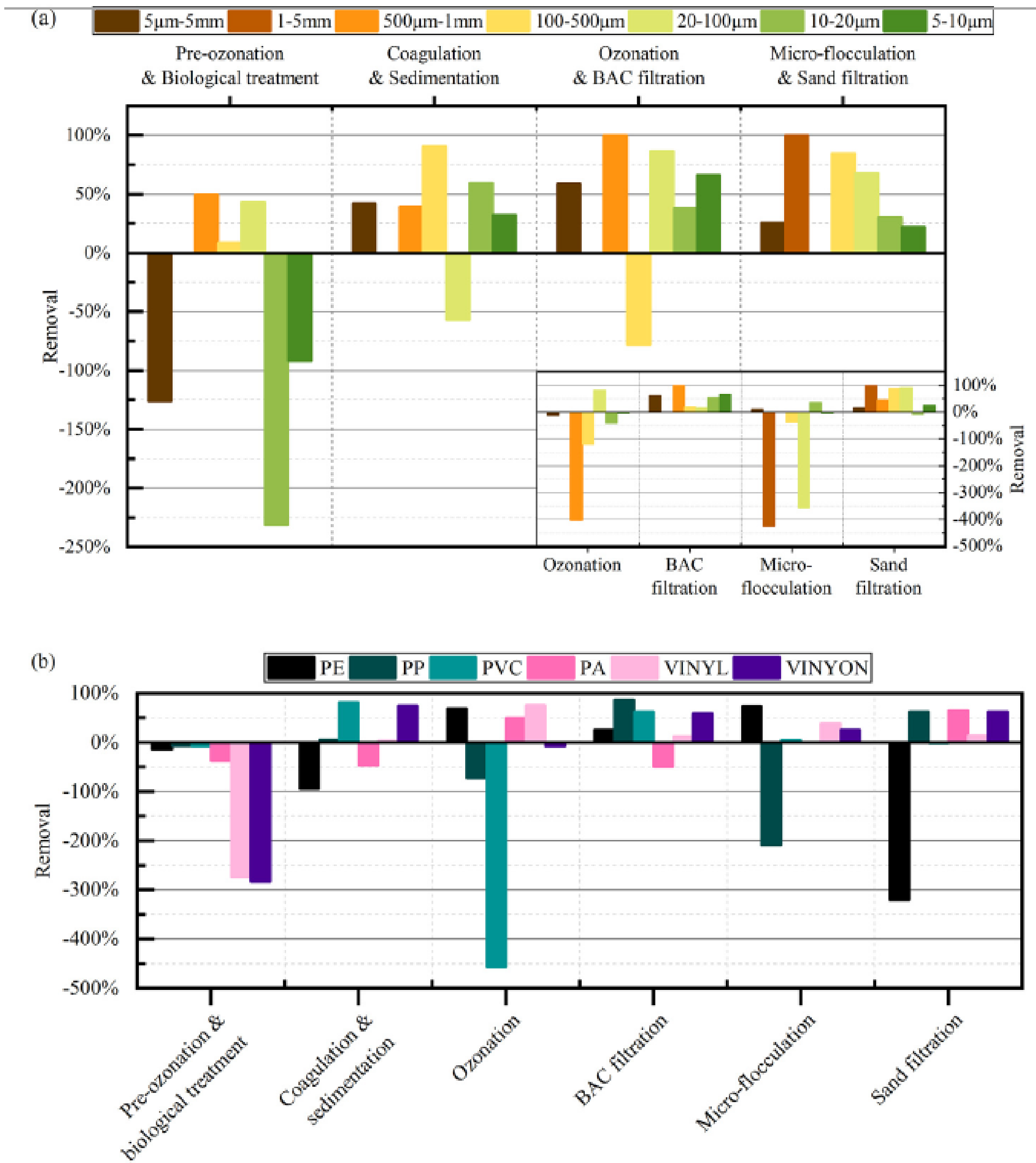


DWTP
Flowrate: 150000 m3/d
Captation from surface waters
Volumes: from 1L (5–20 μm) to 100−200L (20 μm-5 mm)

Abundance of granular MPs (n/L) in raw water and treated water of the DWTP.

Category	Characters of MPs	Raw water Average(n/L)	Treated water Average(n/L)	Removal %
Size	1–5 mm	0.10 ± 0.09	0	100.00
	500 μm-1 mm	0.13 ± 0.05	0.02 ± 0.01	88.10
	100–500 μm	2.88 ± 1.04	0.07 ± 0.06	97.74
	20–100 μm	41.80 ± 6.6	0.31 ± 0.1	99.21
	10–20 μm	933.34 ± 49.01	316.03 ± 82.84	65.82
	5–10 μm	2760.14 ± 408.27	379.24 ± 51.25	86.24
Major material composition	PP[a]	917.27 ± 67.4	208.73 ± 50.49	77.12
	PE[b]	500.58 ± 32.33	176.33 ± 10.46	64.70
	PVC[c]	479.57 ± 54.22	69.85 ± 32.29	85.15
	PA[d]	243.39 ± 64.22	93.36 ± 50.53	59.25
	VINYL[e]	362.24 ± 70.28	20.77 ± 31.49	95.05
	VINYON[f]	566.80 ± 57.89	40.61 ± 35.27	92.39
Total		3738.36 ± 461.29	695.66 ± 39.32	81.18

Literature research



Oxidation Treatment

- Negative removal efficiencies
- Better removal effect on smaller sizes (5-10 µm) than 10-20 µm. the smallest MPs could remain attached to the biofilm or adhere to the microorganisms

Physical treatments:

higher removal efficiencies

- BAC (Biological Activated Carbon)
- Sand filtration

Literature research

Microplastics in wastewater treatment plant

- 4 WWTPs with different technologies
- Customized in situ filtration device with mesh sizes of 300, 100 and 20 µm.
- No information on sampled volumes

Talvitie et al., 2017

Treatment method	Influent	Effluent	Removal %
Primary treatment	686.7 ± 155.0	10.9 ± 2.9	98
CAS	10.9 ± 2.9	1.3 ± 0.9	88
RSF	0.7 ± 0.1	0.02 ± 0.007	97.1
MBR	6.9 ± 1.0	0.005 ± 0.004	99.9

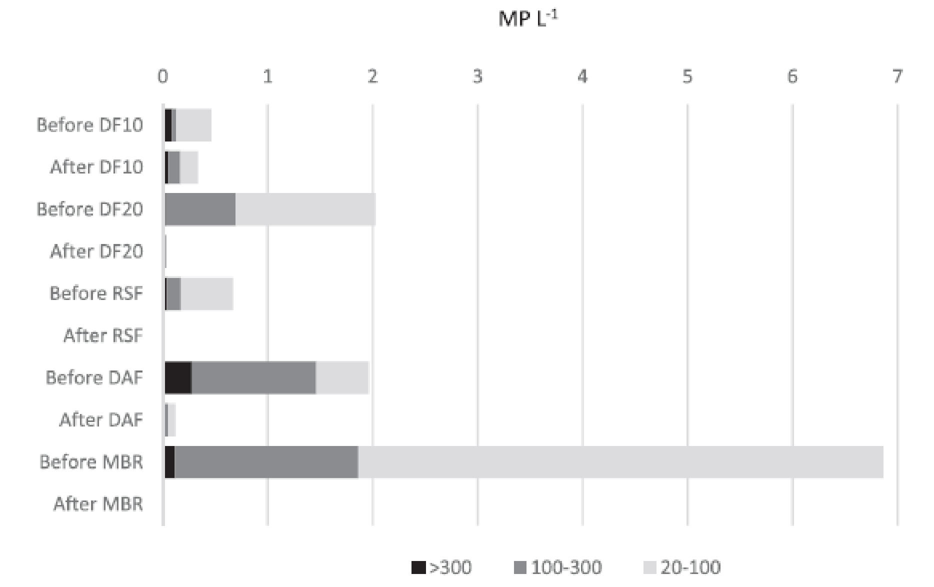


Fig. 1. Concentration of MPs in each size fraction (20–100 µm, 100–300 µm, >300 µm) before and after the treatments. DF10 = discfilter with pore size 10 µm, DF20 = discfilter with pore size 20 µm, RSF = rapid sand filters, DAF = dissolved air flotation and MBR = membrane bioreactor.

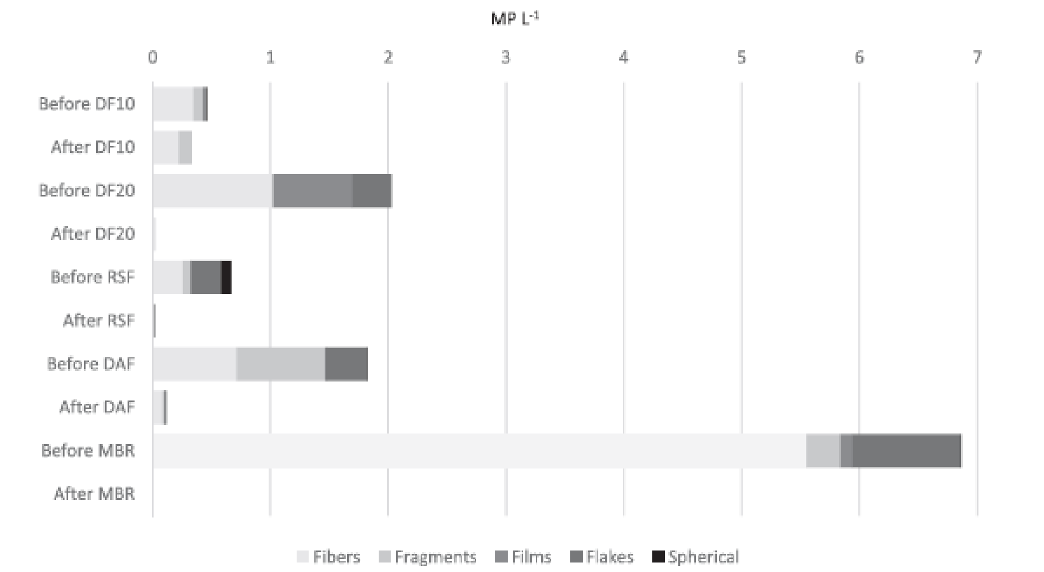


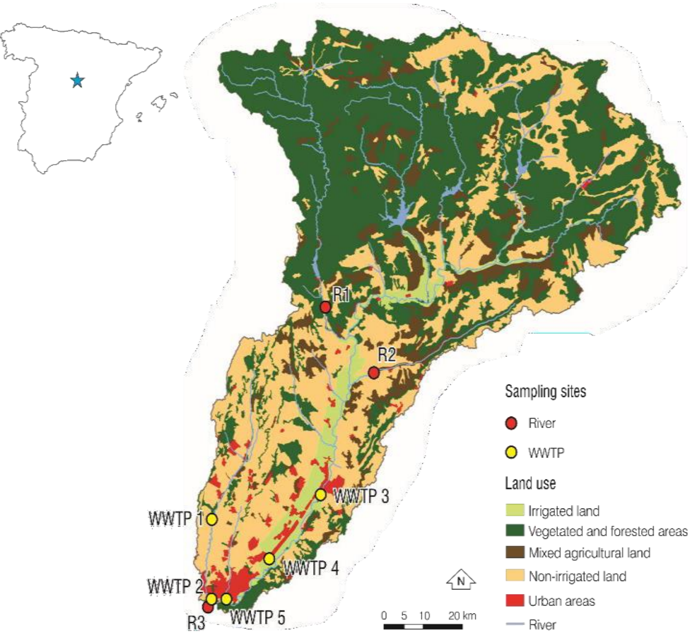
Fig. 2. Concentration of MPs in the different MP shape categories before and after the treatments. DF10 = discfilter with pore size 10 µm, DF20 = discfilter with pore size 20 µm, RSF = rapid sand filters, DAF = dissolved air flotation and MBR = membrane bioreactor.

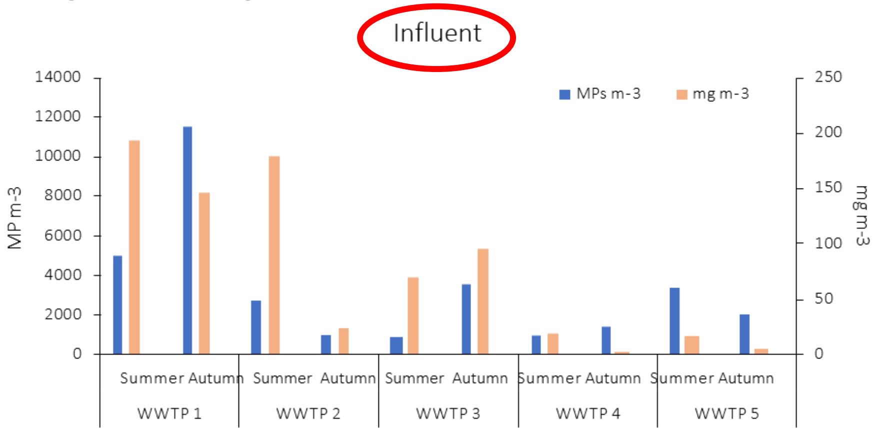
Literature research

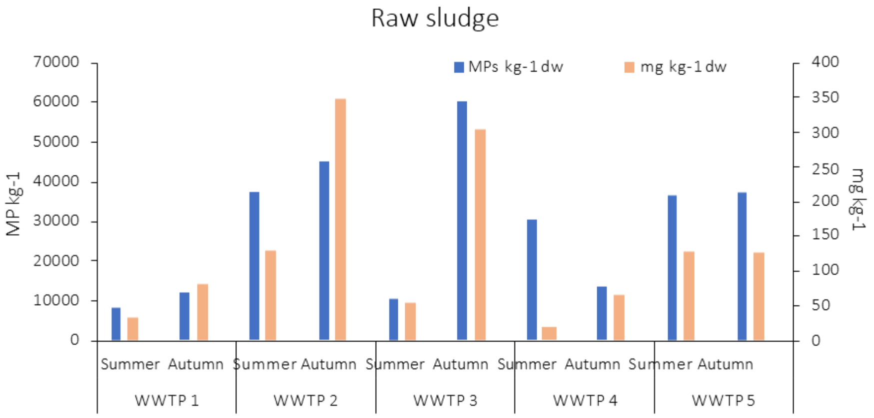
Microplastics in wastewater treatment plant

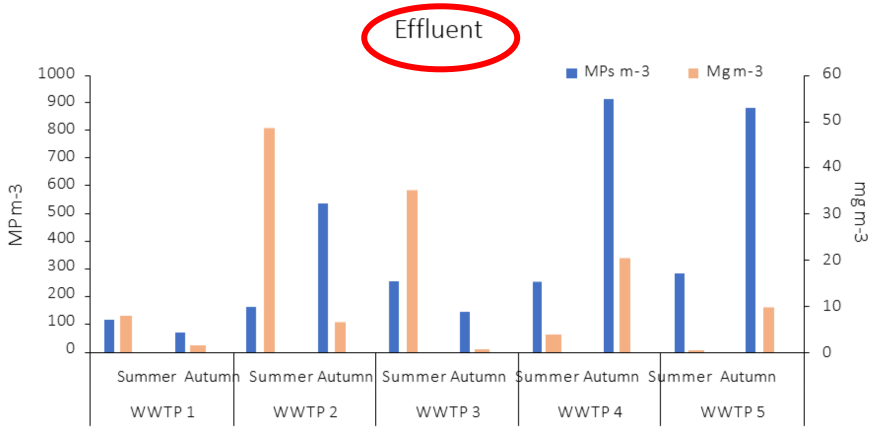
Impact of MicroPlastics in AgroSystems and Stream Environments (IMPASSE)

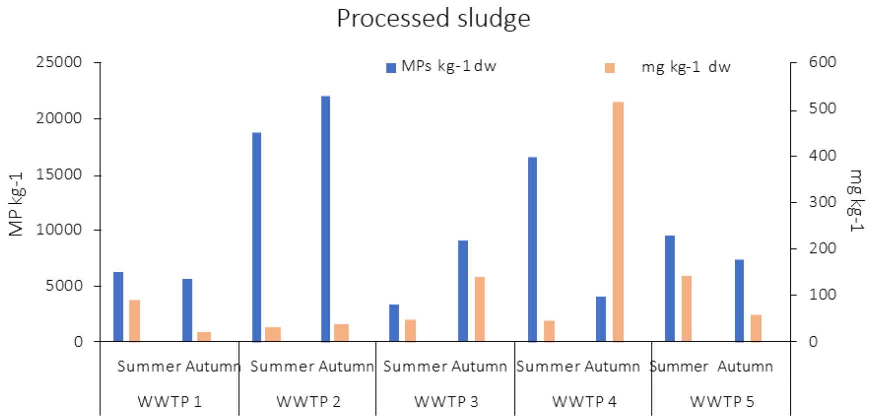
Funded by Water and FACCE Joint Programming Initiative (JPI)











VARIABILITY>> DO NOT ALLOW TO ESTABLISH TREND WITH A SINGLE SAMPLING EVEN CONSIDERING PLANT HRT!!

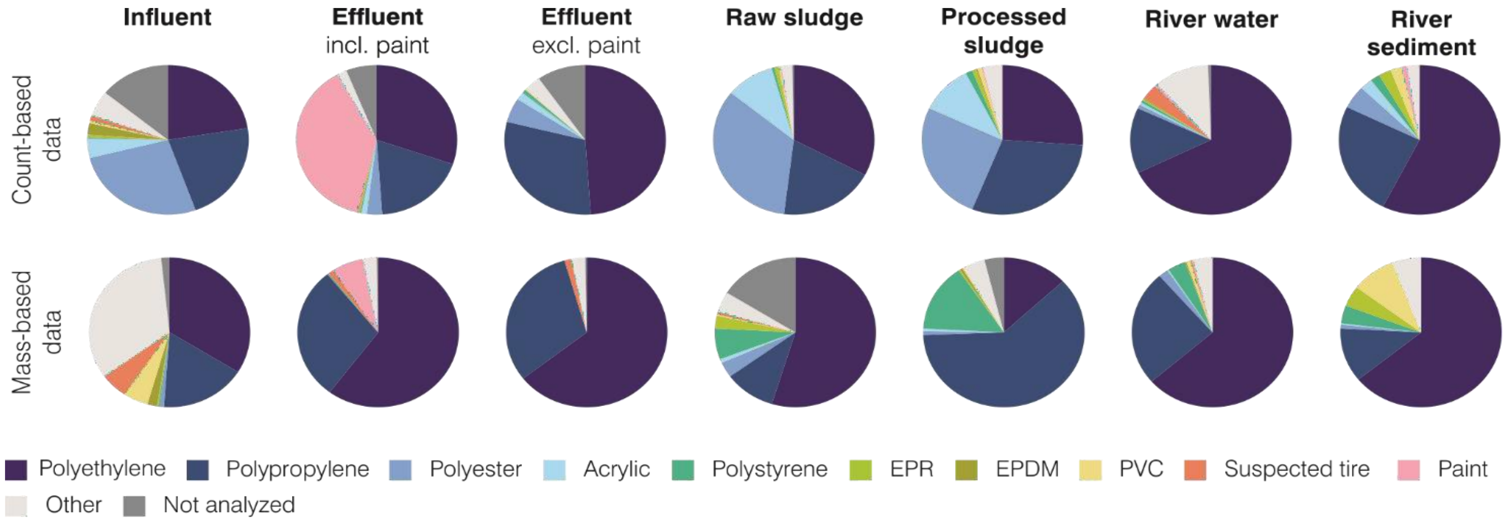
Beware of internal plant productions

Literature research

Microplastics in wastewater treatment plant

WWTP	Influent type	Treatment	Season	MP retention %	Effluent discharge $m^3\ day^{-1}$	MPs emitted on sampling day
1	Urban/industrial	Secondary	Summer	97.8	24675	202,070
			Autumn	99.4	19989	148,470
2	Urban	Secondary	Summer	93.8	520	327,030
			Autumn	46.5	370	1,075,885
3	Urban/industrial	Tertiary	Summer	70.0	1837	8,179,635
			Autumn	96.2	2121	5,071,545
4	Urban	Secondary	Summer	80.5	1982	101,400
			Autumn	67.9	2011	166,500
5	Urban/industrial	Tertiary	Summer	98.7	32077	1,110,375
			Autumn	86.0	37567	5,596,920

	Amount of wastewater produced in the catchment in 2017 in m^3	Concentration of MPs in wastewater	
		$mg\ m^{-3}$	$MPs\ m^{-3}$
Treated urban and industrial wastewater	49,225,286	6.47	161
Untreated urban wastewater	789,574	76	2439
Industrial effluents unknown treatment	2,276,415	5.5	123
Total amount	52,161,976		



- The capture efficiency of the wastewater treatment plant varies between 46.5% and 99.4%
- Polyethylene, polypropylene and polyester are the predominant polymer types
- Paint chips in effluent not detected in influent
- Preferential retention of some polymer/particle types

Literature research

Microplastics in wastewater treatment plant

Project funded by the Norwegian Environment Agency in 2017

Main objective: to characterise microplastics in sewage sludge from Norwegian domestic wastewater treatment plants which apply different wastewater and sludge treatment technologies.

8 Norwegian sewage plants monitored (35% of population and annual sludge production).

Analysed sludge samples ≈ 100 g for MPs < 50 µm


Mapping microplastics in sludge

Lusher, Amy L.; Hurley, Rachel; Vogelsang, Christian; Nizzetto, Luca; Olsen, Marianne

Research report

Published version

View/Open
7215-2017.pdf (8.920Mb)

URI
http://hdl.handle.net/11250/2493527

Abstract
The main objective of this project was to characterize microplastics in sewage sludge from Norwegian domestic wastewater treatment plants applying different wastewater and sludge treatment technologies. WWTPs were selected to cover the threemain domestic WWTP categories in Norway and the main applied sludge treatment processes. Fenton's reagent was used to remove organic matter and density separations were employed to extract microplastics from sludge samples. Plastics were found in all ten sludge samples investigated from eight WWTPs. The overall average plastic abundance was 6 077 particles kg-1 (d.w.) (1701 – 19 837) or 1 176 889 particles m-3 (470 270 – 3 394 274). Based on the average microplastic abundance and the present application of sewage sludge in Norway, it was estimated that over 500 billion microplastics are released into the environment via sewage sludge application each year, to agricultural soils, green areas and soil producers. This likely represents a significant source of microplastics to terrestrial and marine systems.

Description
Project manager Marianne Olsen

Publisher
Norsk institutt for vannforskning

Series
NIVA-rapport;7215
Miljødirektoratet-rapport;907

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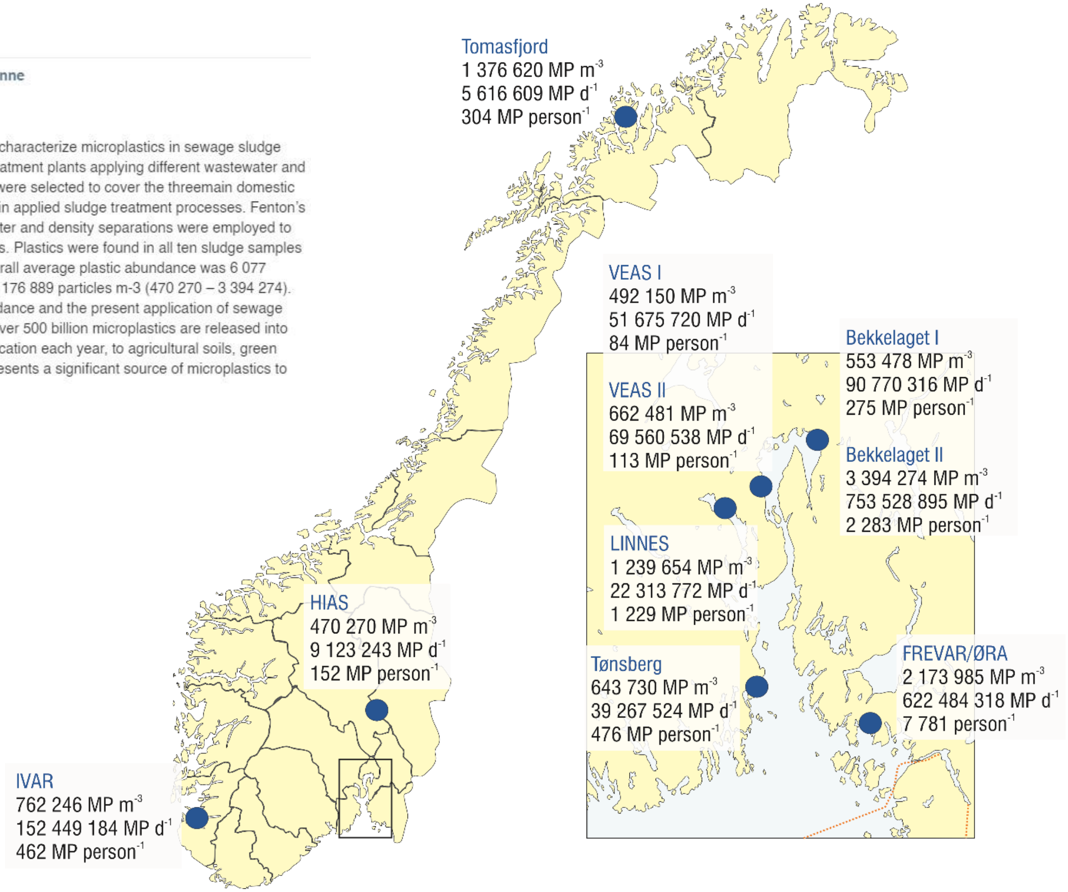
Norwegian Institute for Water Research



On average, 181 679 012 microplastic particles transferred to the sludge phase each day, corresponding to 1316 MPs/AE/d (median: 383).

→ Corresponding to 6.8 billion MPs/d, if compared to the Norwegian population

Literature research

Microplastics in wastewater treatment plant - sludge

446 billion MPs spread on agricultural soils

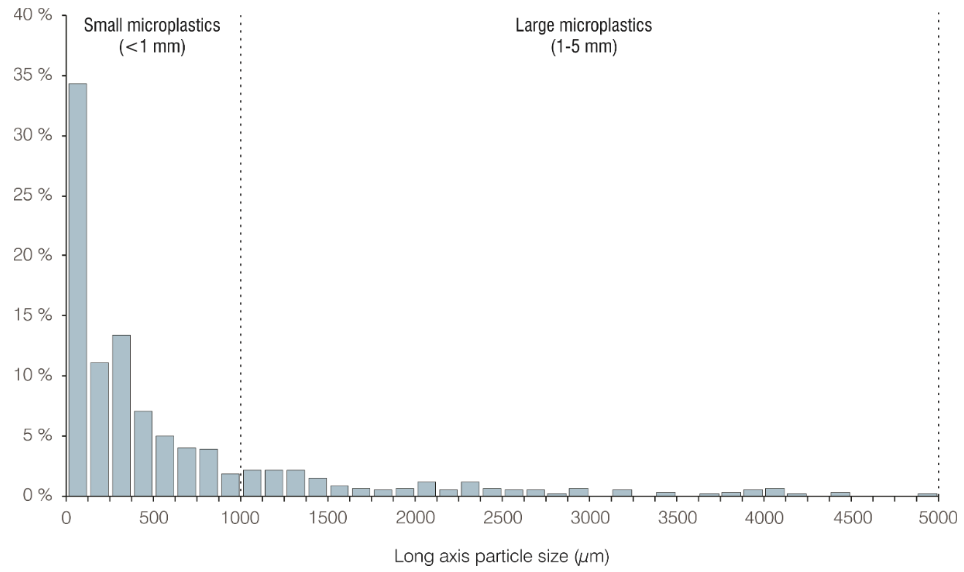
27 billion MPs added to green areas

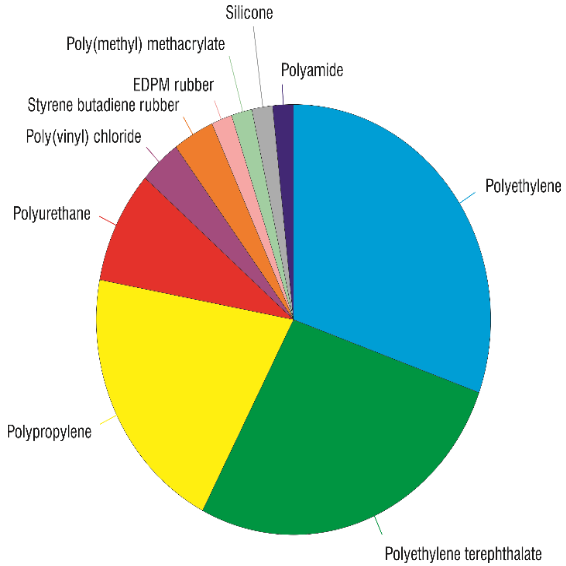
112 bn MPs sent to soil producers

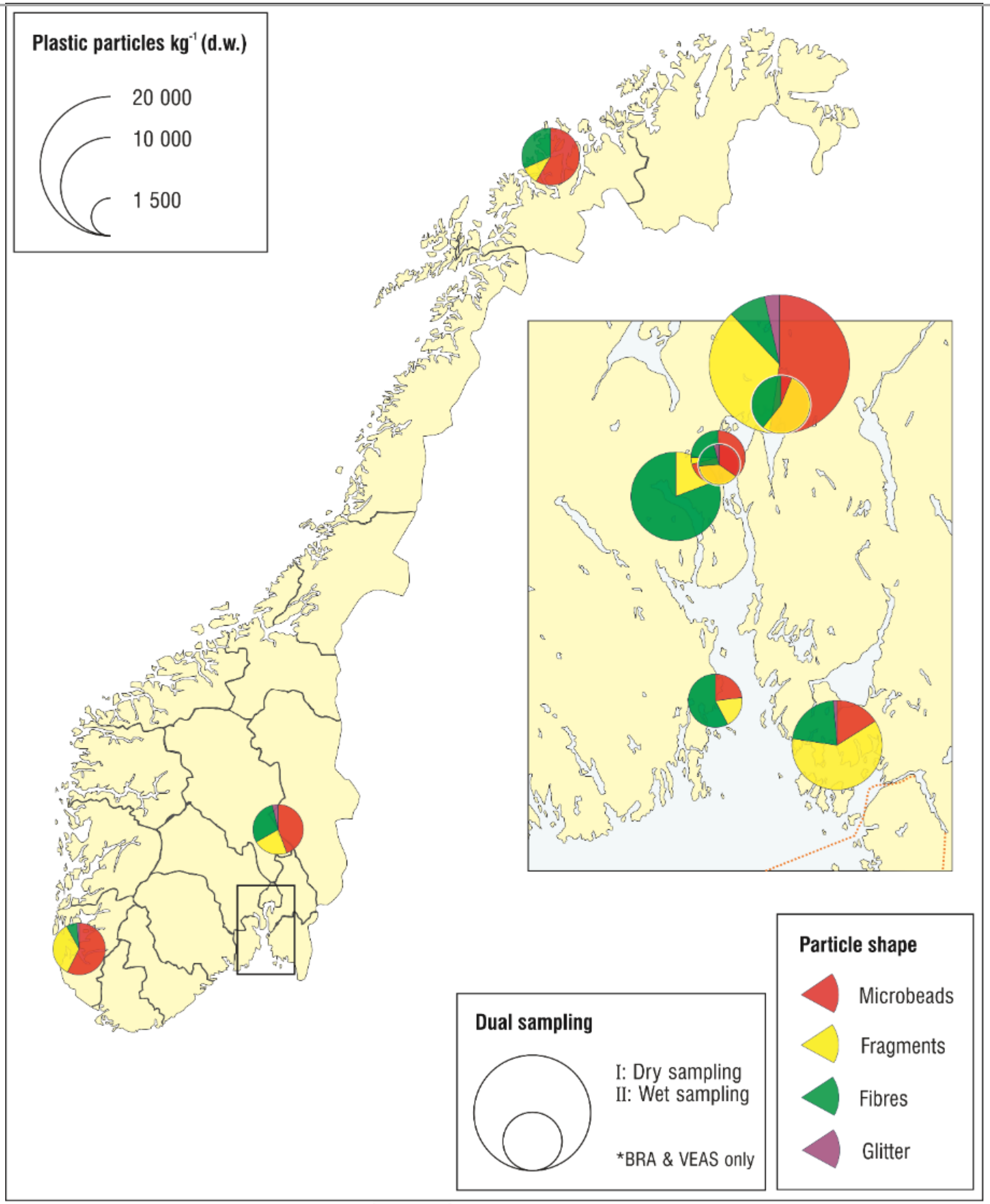
Reproportioning on production in Norway,
584 bn MPs released into the environment through sludge each year

Literature research

Microplastics in wastewater treatment plant







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Thank you for the attention!

Blue Lakes
No microplastics, just waves.

Water and Waste Environmental Engineering LAB

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PROGETTO COFINANZIATO DA

Results and protocol from Blue Lakes project

Università Politecnica delle Marche

BENEFICIARIO COORDINATORE

BENEFICIARI ASSOCIATI

PROGETTO COFINANZIATO DA

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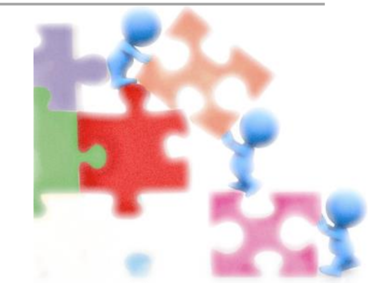
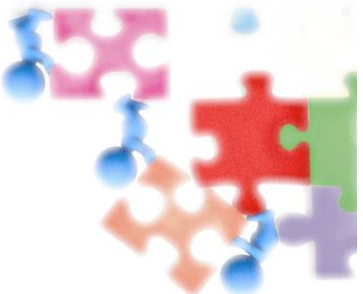
Development of the Standard Monitoring Protocol

1. EXPERIENCES OF SAMPLING IN MARINE WATER
2. EXPERIENCES OF SAMPLING IN WASTEWATER TREATMENT PLANTS
3. CRITICAL ANALYSIS OF THE TECHNICAL-SCIENTIFIC LITERATURE
4. SAMPLING CAMPAIGNS IN DRINKING WATER AND WASTEWATER TREATMENT PLANTS
5. OPTIMIZATION OF SAMPLING METHODS
6. DEVELOPMENT OF A PROTOCOL FOR THE MONITORING OF MICROPLASTICS IN PLANTS
7. PROTOCOL SHARING





Definition of a sampling protocol


REPORT BEST PRACTICES

Treatment plants typology and efficiency

NO MICROPLASTICS, JUST WAVES.

SEPARATE CHAPTER PROJECT IMPACT EX ANTE REPORT

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Deliverable ACTION B3

TECHNICAL REPORT AND OPERATIVE MANUAL REGARDING THE IMPROVEMENT OF THE TREATMENT PROCESS

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ANALYTICAL PROTOCOL FOR PROCESS CONTROL

MPs IN DRINKING AND WASTEWATER TREATMENT PLANTS

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- Report Best Practices - Treatment plants typology and efficiency
- Ex-ante report
- Technical report and operative manual regarding the improvement of the treatment process
- Analytical protocol for process control - mps in drinking and wastewater treatment plants

Definition of a sampling protocol

Blue Lakes
No microplastics, just waves.

NO MICROPLASTICS, JUST WAVES.

Deliverable ACTION B3

TECHNICAL REPORT AND OPERATING MANUAL ON THE IMPROVEMENT OF THE TREATMENT PROCESS

Manuale tecnico-operativo per l'analisi delle microplastiche negli impianti di trattamento acque

A cura di:

Dr. Lucia Pittura (DiSVA, UNIVPM)
Dr. Veronica Vivani (DiSVA, UNIVPM)
Dr. Serena Radini (SIMAU, UNIVPM)
Dr. Alessia Foglia (SIMAU, UNIVPM)
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TECHNICAL PROTOCOL FOR TREATMENT PLANT

PROMOTION OF GOOD PRACTICES EXPERIMENTED ON THE PILOT LAKES DURING THE PROJECT ACTIVITIES

Definition of a sampling protocol

Literature analysis

Literature

SAMPLING POINTS	VOLUME	TYPE of SAMPLE	METHODS OF SAMPLING AND DETENCTION	FREQUENCY or num° of samples	Ref.
Raw and treated drinking water	1000 L	*Grab samples*	Samples directly sieved, tap water require no digestion.		(Koelmans et al., 2019)
Raw and treated drinking water	300-2500 L	*3µm stainless steel cartridge filters* 4 7/8", Wolftechnik, Germany	Residual raw water and drinking water was removed from t e filter units by using filtered (0.2 µm) compressed air. Then, the units were filled again with diluted hydrochloric acid (Carl Roth GmbH & Co. KG, Germany, 0.2 µm filtered, pH=2) to dissolve calcium carbonate and iron precipitates. After 24 h the filter units were emptied, the cartridge filters removed from the units and rinsed with Milli-Q and ethanol (30%, Carl Roth GmbH & Co. KG, Germany), filtered over 0.2 µm). The retentate was collected on 3 µm stainless steel filters (47mm in diameter) that were subsequently transferred into glass bottles and covered with 30 mL hydrogen peroxide (35%, Carl Roth GmbH & Co. KG, Germany). The bottles were closed using aluminium foil and incubated for 24 h at 40 °C. Finally, each sample was enriched onto a 0.2 µm aluminium oxide filter (Anodisc 25 mm, Whatman, U.K.) by using an in-house fabricated filter-funnel with an inner diameter of 11 mm. The filters were dried at 40 °C in half closed glass petri dishes for subsequent analysis.	24 samples	(Mintenig et al., 2017)

1. NECESSARY INSPECTION BEFORE SAMPLING CAMPAIGN

2. DETAILS ON THE IDENTIFIED SAMPLING POINTS (presence of taps, pressure, flow rate, possibility of pumping..etc)

3. DURATION OF SAMPLING FOR EACH PLANT OF ABOUT 1 DAY, TO POSSIBLY COINCIDE WITH ROUTINE COMPANY CHECKS

Definition of a sampling protocol

Minimum sampling volumes proposed in BLUE LAKES

Sector	Plant	Unit	Type of sample	Min. volume	Min. number of samples	Notes
Drinking water supply	Drinking water treatment Plant	Influent	Min 1-2 h average sampling	1000 l	3*	*Min. number of sampling campaigns defined to detect seasonal variability.
		Effluent from each operative unit	Min 1-2 h average sampling	1000 l	3*	
		Final Effluent	Min 1-2 h average sampling	1000 l	3*	
		Sludge**	Grab	5 l	3*	**Sludge is considered as liquid at maximum TS% of about 5%TS.
	Distribution	Final Distribution***	Min 1-2 h average sampling	1000 l	3*	***Min. Number of Sampling points has to be set according to the distribution network complexity.
Sewage system	Combined Sewer Overflow	CSO	Grab or Average sampling	50 l****	3*	****Min volume could be very variable depending on the quantity overflowed.
Wastewater Treatment	Wastewater Treatment Plant	Influent	Average sampling	30-300 l*****	3*	*****Min. volume could be very variable depending on water characteristic.
	Wastewater Treatment Plant	Effluent from each operative unit	Average sampling	30-300 l *****	3*	
	Wastewater Treatment Plant	Final Effluent	Average sampling	30-300 l *****	3*	
	Wastewater Treatment Plant	Sludge**	Grab	5 l	3*	

Definition of a sampling protocol

PROTOCOLS FOR SAMPLING AND MONITORING OF MPS

- ✓ SAMPLING VOLUMES
- ✓ METHODOLOGIES

REPORT BEST PRACTICES

Treatment plants typology and efficiency

TECHNICAL INSPECTION AT THE FACILITIES

- ✓ DETAIL OF SAMPLING POINTS
- ✓ POSSIBILITY OF INSTALLING FILTERS

DATA REQUEST FOR THE CHARACTERIZATION OF FLOWS AND OPERATING UNITS ALSO UNDER THE DIFFERENT OPERATING CONDITIONS AND DISTRIBUTION LINKED TO SEASONALITY

UNITÀ OPERATIVA	UdM	Medio estivo	Medio invernale
Portata	l/s		
pH	-		
Torbidità	NTU		
Temperatura	°C		
Ossigeno disciolto	mg/L		
Conducibilità	microS/cm		
N° unità	N°		
N° unità in funzione	N°		
Volume caduna	m3		
Dosaggio (ozono, reagenti, ...)	g/h		
Tempo di contatto	secondi		
Controlavaggi e frequenze	-		
...	-		

Definition of a sampling protocol

BEFORE THE BEGINNING OF THE SAMPLING CAMPAIGN, A DATA REQUEST QUESTIONNAIRE FOR THE CHARACTERIZATION OF THE FLOWS AND THE OPERATING UNITS, EVEN UNDER THE DIFFERENT OPERATING AND DISTRIBUTION CONDITIONS RELATED TO SEASONALITY WAS SENT

UNIT	UdM	Medio mese estivo	Medio mese invernale
Flowrate	l/s		
pH	-		
Turbidity	NTU		
Temperature	°C		
Dixolved Oxygen	mg/L		
Conductivity	microS/cm		
N° unità	N°		
N° operating units	N°		
Volume	m3		
Dose (ozone, chemicals, …)	g/h		
Contact time	sec		
Backwash	n, m3/h, freq.		
…	-		

Definition of a sampling protocol

Scheme for sampling activity

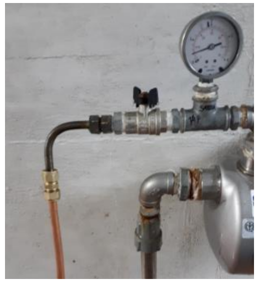
SAMPLING POINT	DATE	WEATHER	METHOD	START OF SAMPLING	DURATI ON	END OF SAMPLING	VOLUME	CHEMICAL AND PHYSICAL CHARACTERISATION (es. TSS)	NOTES

Write down any particular condition (e.g. unit malfunctions, events, anomalies during sampling, …)

Possibly match the sampling with the routine characterizations of the plant

Sampling methodologies for water treatment plants

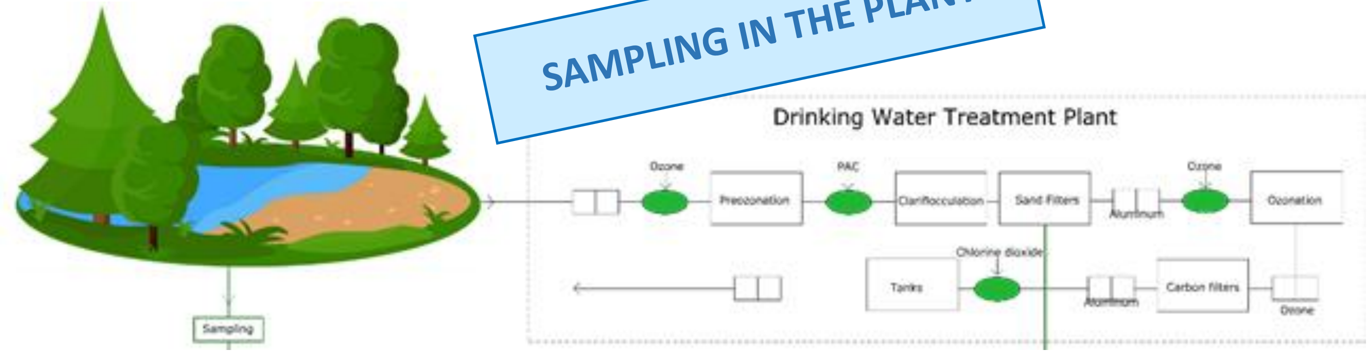
Sampling points




CARTRIDGE FILTER (50 micron)


PUMPING AND SIEVING
(up to 50 micron)

SAMPLING IN THE PLANT




SAMPLING IN THE DISTRIBUTION NETWORK

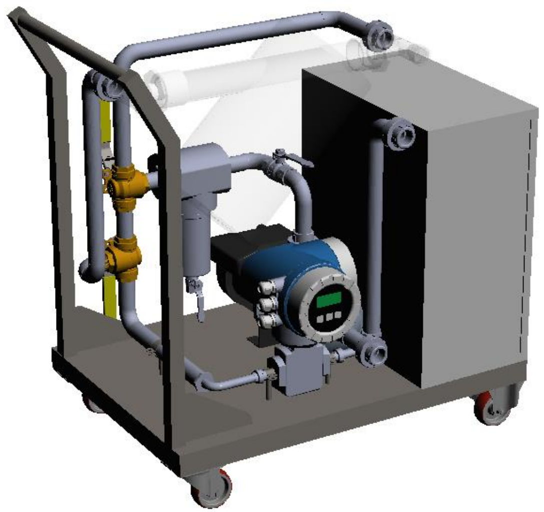
Blue Lakes
No microplastics, just waves.

Sampling methodologies for water treatment plants

Optimisation of sampling methods

PUMPING AND SEIVING
(50 micron)

STEEL FILTERS (50 micron) About 1000 l sampled in drinking water



AUTOMATIC SAMPLER
(50 and 25 micron)
Tested in wastewater

Sampling methodologies for water treatment plants

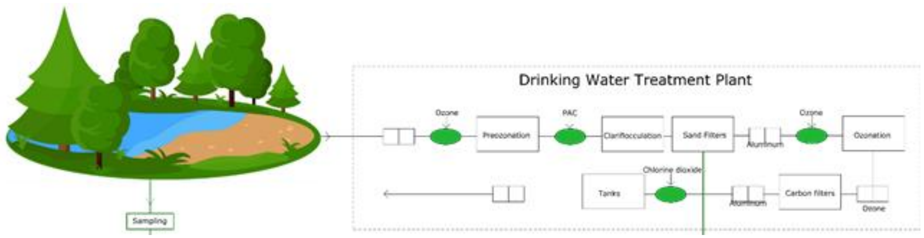
QA/QC: Prevention and control of external contamination from plastic material and fibres

Main measures adopted during all phases: sampling, recovery, processing and characterization

- use of non-plastic material (stainless steel, glass, aluminum, copper)
- if plastic materials are used (gaskets, washers…) the material must be characterized to eventually exclude it from the results.
- Closed sampling system vs system exposed to the atmosphere.

- Execution of blank samples for each sample collected: a beaker containing deionized water is left open on the workbench for the entire time necessary to recover the sample and subsequently processed according to the same procedures as the water or sludge sample.

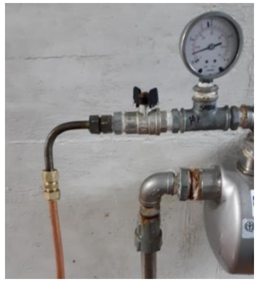
MPs in drinking water treatment plants



DWTP A
Influent – lower quote and upper quote
Out pre-ozonation
Out flocculation
Sludges from flocculation
Out filtration
Backwash
Out post-ozonation
Out GAC
Effluent
Distribution 1
Distribution 2

DWTP B
Influent
Out ozonation
Out filtration
Effluent
Distribution

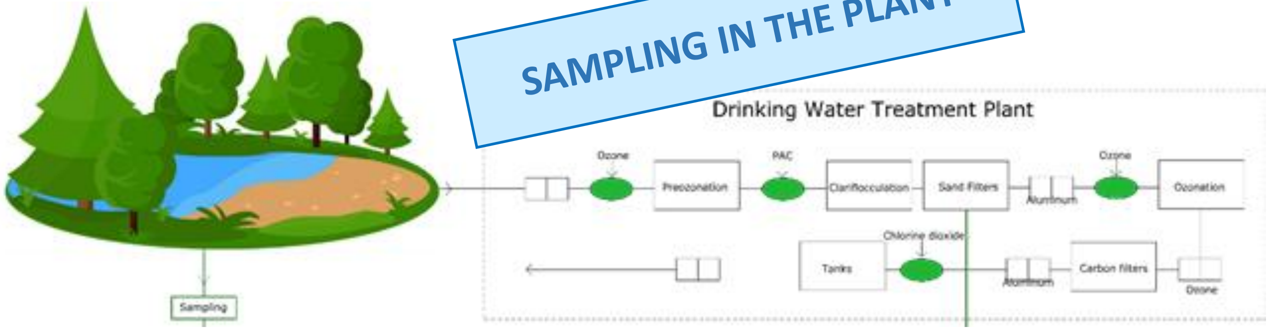
DWTP C
Influent
Backwash
Backwash Ultrafiltration
Effluent
Distribution



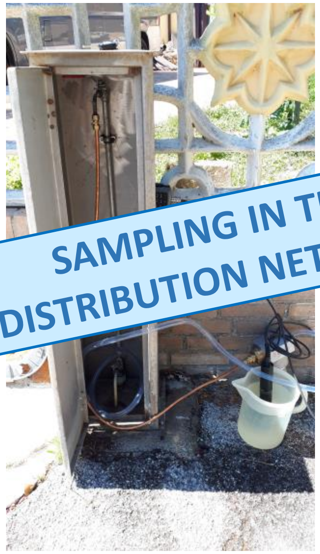

CARTRIDGE FILTER (50 micron)


PUMPING AND SIEVING
(up to 50 micron)

SAMPLING IN THE PLANT



SAMPLING IN THE DISTRIBUTION NETWORK




No microplastics, just waves.

MPs in wastewater treatment plants

WWTP D
Influent
Out flotation
Effluent
Sludge

WWTP E
Influent
Out sedimentation
Out lamellar settler
Effluent
Sludge

WATER:
AUTOMATIC SAMPLER
25 µm and 50 µm

ABOUT 1000 L FILTERED AT EACH SAMPLING POINT

SLUDGE:
GRAB SAMPLE 25 L

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Thank you for the attention!

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No microplastics, just waves.

Water and Waste Environmental Engineering LAB

BENEFICIARIO COORDINATORE

BENEFICIARI ASSOCIATI

PROGETTO COFINANZIATO DA

Results and Protocol from Blue Lake Project

Technical-operative manual for microplastics analysis in the Integrated Water Service matrices

Università Politecnica delle Marche

BENEFICIARIO COORDINATORE

BENEFICIARI ASSOCIATI

PROGETTO COFINANZIATO DA

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Technical-operative manual for sampling and processing of Integrated Water Service matrices for microplastics analysis, edited by UNIVPM.


Blue Lakes
No microplastics, just waves.

NO MICROPLASTICS, JUST WAVES.

Deliverable ACTION B3

TECHNICAL REPORT AND OPERATING MANUAL ON THE IMPROVEMENT OF THE TREATMENT PROCESS

Manuale tecnico-operativo per l'analisi delle microplastiche negli impianti di trattamento acque

The document was developed as "Action" of the Life *Blue Lakes* Project by integrating the skills and knowledge of the research groups of Water and Wastewater Environmental Engineering Lab and of Ecotoxicology and Environmental Chemistry Lab belonging, respectively, to the SIMAU and DiSVA Departments of the Polytechnic University of Marche.

It was developed based on the main methods described in the scientific literature and optimized and validated by the two research groups over the years of experience in sampling and processing environmental matrices from water treatment plants for MPs analysis.

The protocol aims to be an operational guide for those who work in the sector by proposing procedures, providing alternatives and suggestions. The intention is also to favor the harmonization of methods to facilitate the comparison of results.


Science of the Total Environment 652 (2019) 602–610

Contents lists available at ScienceDirect

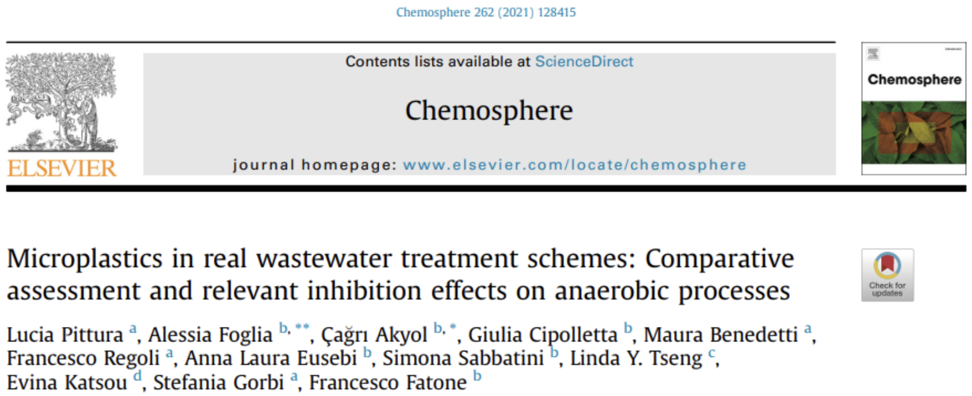
Science of the Total Environment

journal homepage: www.elsevier.com/locate/scitotenv

ELSEVIER

The fate of microplastics in an Italian Wastewater Treatment Plant

Stefano Magni [a,*], Andrea Binelli [a,*], Lucia Pittura [b], Carlo Giacomo Avio [b], Camilla Della Torre [a], Camilla Carla Parenti [a], Stefania Gorbi [b,c], Francesco Regoli [b,c]


Chemosphere 262 (2021) 128415

Contents lists available at ScienceDirect

Chemosphere

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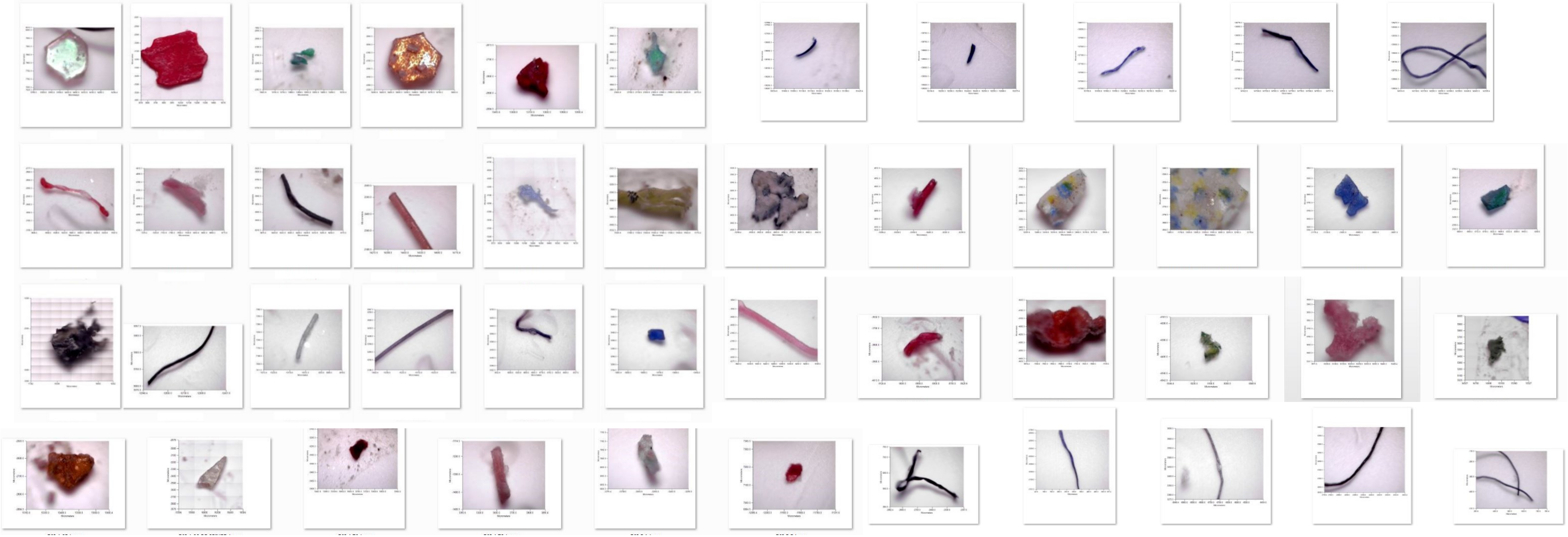
ELSEVIER

Microplastics in real wastewater treatment schemes: Comparative assessment and relevant inhibition effects on anaerobic processes

Lucia Pittura [a], Alessia Foglia [b,**], Çağrı Akyol [b,*], Giulia Cipolletta [b], Maura Benedetti [a], Francesco Regoli [a], Anna Laura Eusebi [b], Simona Sabbatini [b], Linda Y. Tseng [c], Evina Katsou [d], Stefania Gorbi [a], Francesco Fatone [b]

Definitions

Microplastics (MPs): any synthetic solid particle or polymeric matrix, with size ranging from 1 µm to 5 mm, consisting of either items that are manufactured to be of microscopic dimensions (primary origin) or that are formed from the weathering and fragmentation of larger plastic waste items (secondary origin) (*Bessa et al., 2019*).



Definitions


Blue Lakes

NO MICROPLASTICS, JUST WAVES.

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TECHNICAL REPORT AND OPERATING MANUAL ON THE IMPROVEMENT OF THE TREATMENT PROCESS

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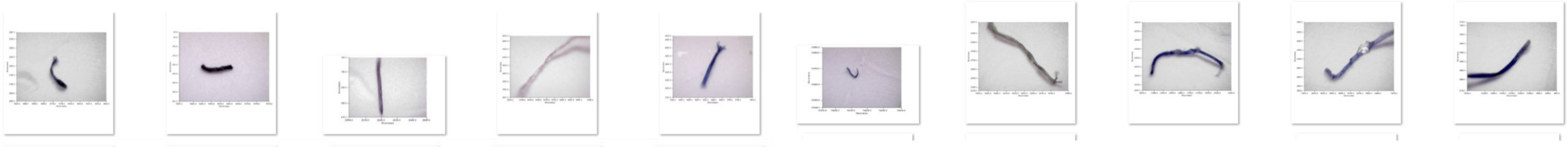
Microfibers (MFs): synthetic or natural materials of thread like structure with a diameter lower than 50 µm, length ranging from 1 µm to 5 mm, and length to diameter ratio greater than 100. Microfibers are released or shed from textiles or related fibre-based products such as clothes; agricultural, industrial, and home textiles; and some textile products, semi-manufactured goods, or accessories used in other fields, during production, use, and end-of-life disposal (Liu et al., 2019).



Synthetic textile fibers: created in the laboratory and derived from petroleum (e.g. polyester, polyamide, acrylic).

Natural textile fibers: obtained from materials of a vegetable (e.g. cotton, linen and hemp) or animal (wool, silk and leather) nature.

Artificial textile fibers: obtained from natural raw materials (such as cellulose or animal and vegetable proteins) but are processed in the laboratory using chemical substances (e.g. viscose or rayon).

NATURAL-BASED MICROFIBRES UBIQUITOUS IN THE ENVIRONMENT and MORE FREQUENTLY FOUND THAN SYNTHETICS: EMERGING FOCUS FOR THE SCIENTIFIC COMMUNITY

IF POSSIBLE, IT IS STRONGLY SUGGESTED TO ALSO INDICATE THE QUANTITATIVE DATA RELATING TO THE FRACTION OF MFs OF NATURAL ORIGIN COMPARED TO THOSE OF SYNTHETIC ONE, IN THE MATRICES UNDER STUDY.

Extraction of MPs and MFs: water samples

NO MICROPLASTICS, JUST WAVES.

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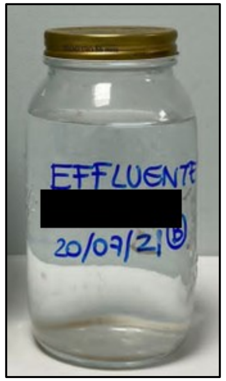
TECHNICAL REPORT AND OPERATING MANUAL ON THE IMPROVEMENT OF THE TREATMENT PROCESS

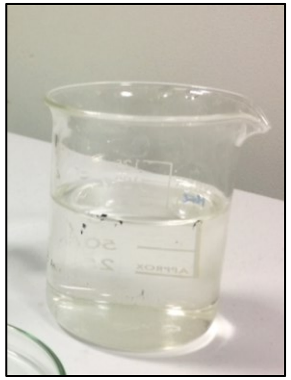
Manuale tecnico-operativo per l'analisi delle microplastiche negli impianti di trattamento acque

1. DIGESTION

Water sample



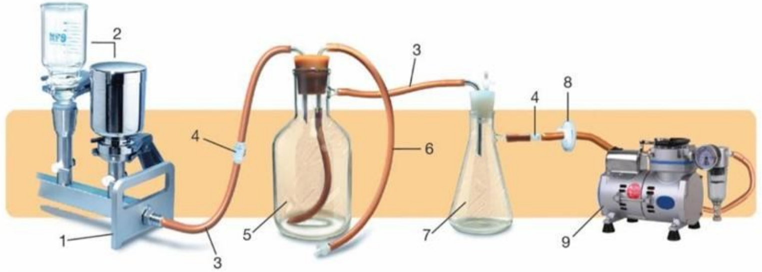
Blank sample

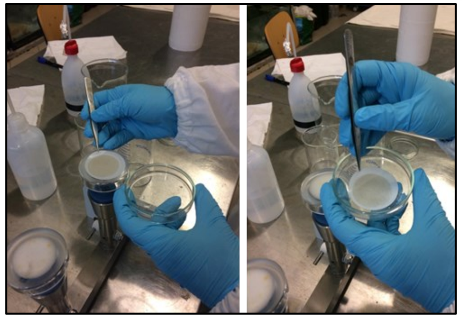


H_2O_2 15%

T: 40 °C

2. VACUUM FILTRATION





3. DIGESTION

4. DRYING OF FILTER MEMBRANE (40°C)

Extraction of MPs and MFs: sludge samples


Blue Lakes

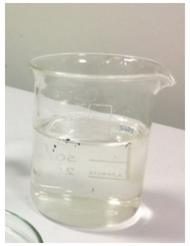
NO MICROPLASTICS, JUST WAVES.

Deliverable ACTION B3

TECHNICAL REPORT AND OPERATING MANUAL ON THE IMPROVEMENT OF THE TREATMENT PROCESS

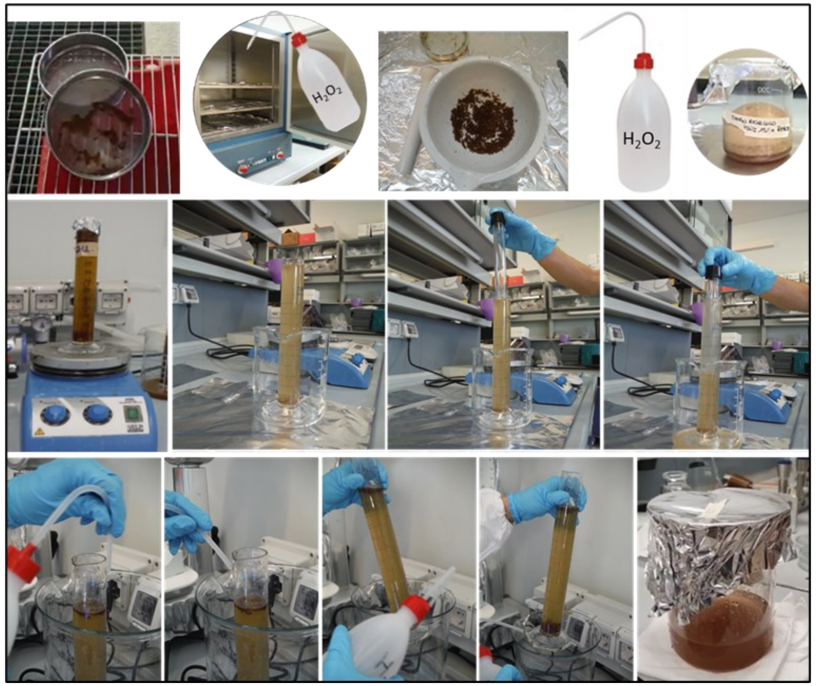
Manuale tecnico-operativo per l'analisi delle microplastiche negli impianti di trattamento acque


Sludge sample


Blank sample

Complex matrix: several pre-treatment steps are required compared to the procedure applied to water samples.

If the sample to be analyzed is a dewatered sludges, the processing starts directly from point 3.



NOTE

NaBr: the solution used is recovered and reused after filtration (0.45 µm cellulose membrane), the density is possibly adjusted by adding salt.

NaCl: recommended for monitoring plans with a large number of samples to contain costs.

1. SIEVING

Sieving through a 5 mm (to exclude macro-plastics) and 50 µm mesh steel sieve (comparison with water samples obtained from 50 µm mesh cartridge filters).
The sludge remaining on the 50 µm sieve is recovered with a steel spoon/spatula and placed in a preferably low glass container with a large surface area to facilitate phases 2 and 3 (Petri dishes or crystallizers are recommended).

2. DIGESTION (15% H_2O_2) | DRYING (40°C)

15% H2O2 solution is added in small quantities several times a day until the digestion reaction is no longer observed. At the end of the reaction, the sample is left to dry in an oven. This stage can last up to a few days.

3. GRINDING | DIGESTION (15% H_2O_2)

Once the sample is dried, it is gently ground in a mortar to obtain a powder which will be subjected to further digestion (it prevents the re-aggregation of the dried material).

4. DENSITY SEPARATION with NaBr

Polymer	Abbr.	Polymer density	NaCl	STD	NaBr	NaI	$ZnCl_2$	$ZnBr_2$	SPT
Polystyrene	PS	0.01 – 1.06	+	+	+	+	+	+	+
Polypropylene	PP	0.85 – 0.92	+	+	+	+	+	+	+
Low-density polyethylene	LDPE	0.89 – 0.93	+	+	+	+	+	+	+
Ethylene vinyl acetate	EVA	0.93 - 0.95	+	+	+	+	+	+	+
High-density polyethylene	HDPE	0.94 – 0.98	+	+	+	+	+	+	+
Polyamide	PA	1.12 – 1.15	+	+	+	+	+	+	+
Nylon 6,6	PA 66	1.13 – 1.15	+	+	+	+	+	+	+
Poly methyl methacrylate	PMMA	1.16 – 1.20	+	+	+	+	+	+	+
Polycarbonate	PC	1.20 – 1.22	+-	+	+	+	+	+	+
Polyurethane	PU	1.20 – 1.26	+-	+	+	+	+	+	+
Polyethylene terephthalate	PET	1.38 – 1.41	-	+-	+	+	+	+	+
Polyvinyl chloride	PVC	1.38 – 1.41	-	+-	+-	+	+	+	+
Polytetrafluoroethylene	PTFE	2.10 – 2.30	-	-	-	-	-	-	+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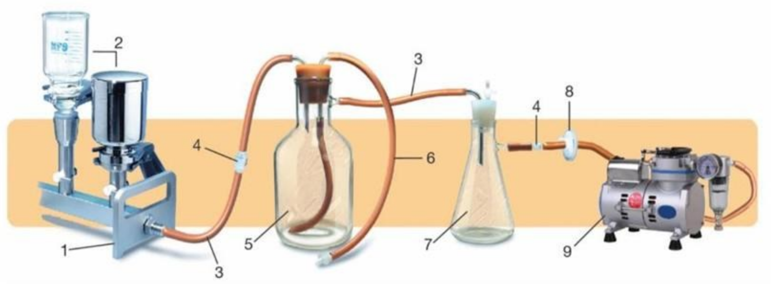
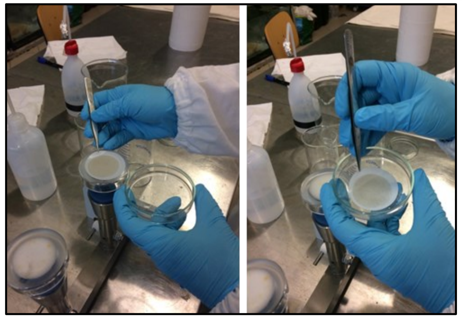
Extraction of MPs e MFs: sludge samples

After step 4, the same steps applied to water samples follow.

5. VACCUM FILTRATION





6. DIGESTION

7. DRYING OF FILTER MEMBRANE (40°C)

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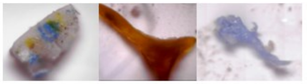
Manuale tecnico-operativo per l'analisi delle microplastiche negli impianti di trattamento acque

Identification of MPs and MFs extracted from water and sludge samples

Physical characterization: optical microscopy

Classification based on Shape

FRGMENT: hard particle, thick, with sharp cutting edges and an irregular shape (*Lusher et al., 2017*) .

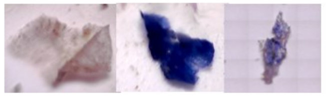


GLITTER: iridescent disc with a hexagonal shape (*Yurtsever et al., 2019*).

SPHERE: particle with every point on the surface having the same distance from the center. It can also be present as a hemisphere, probably due to breakage during production, use or presence in the environment (*Hartmann et al., 2019*) .

FIBER: filiform structure with irregular diameter and frayed ends which can take trilobate, ribbon or L-shaped shapes (*Cesa et al., 2017*).

FILM: flat and flexible particle, with an irregular shape (*Hartmannet al., 2019*) .

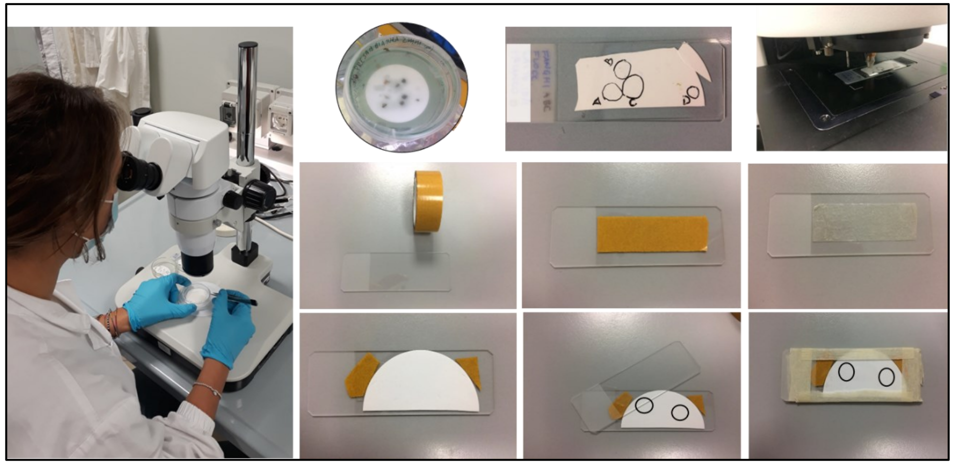


FOAM: flexible and elastic particle, it shapes and softens to the touch (spongy), of different thicknesses and with an irregular outline (*Rochman et al., 2019*).

PELLET: similar to the sphere but tends to be larger and ovoid in shape, usually between 3 and 5 mm (*Rochman et al., 2019*).

Classification based on Color

1. Black ■
2. Blue ■
3. White
4. Transparent
5. Red ■
6. Green ■
7. Multicolour ■
8. Others ■ ■ ■ ■ ■



Visual sorting: the particles are isolated and transferred onto a "homemade" support which will also be used for the chemical characterization in µATR-FT-IR spectroscopy. It is closed as a "sandwich" waiting to be characterized.

Classification based on Size

- 4 size classes: 5 -1 mm, 1-0.5 mm, 0.5-0.1 mm, 0.1-0.02 mm.
- Upper size limit fixed according to definition of MPs and MFs
- Lower limit defined by the detection limit of 20 µm of the µFT-IR instrument in use.
- The size classes identified are in line with the classification proposed by the ISO protocol under development.

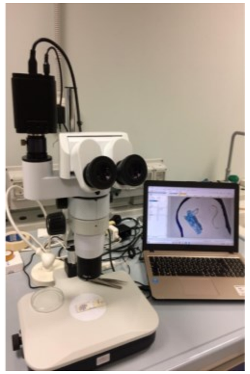


Table 1 — Particle size classification

classification		large microplastics	microplastics					
particle size classes	µm	5 000 to 1 000	< 1 000 to 500	< 500 to 100	< 100 to 50	< 50 to 10	< 10 to 5	< 5 to 1

ISO/DIS 24187
Principles for the analysis of microplastics present in the environment

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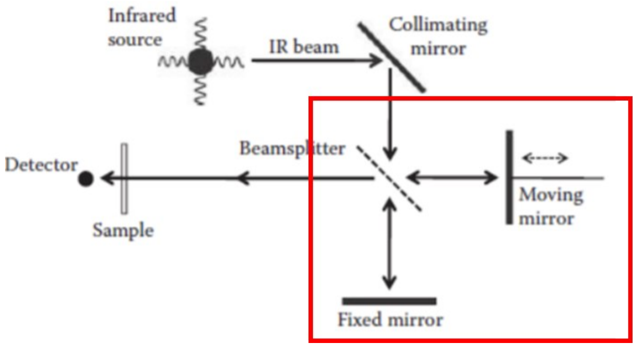
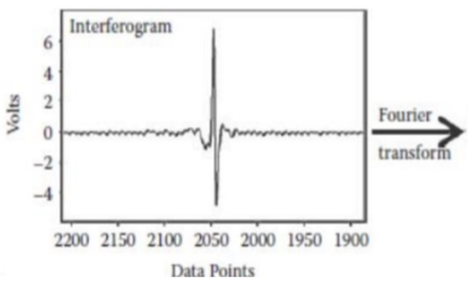
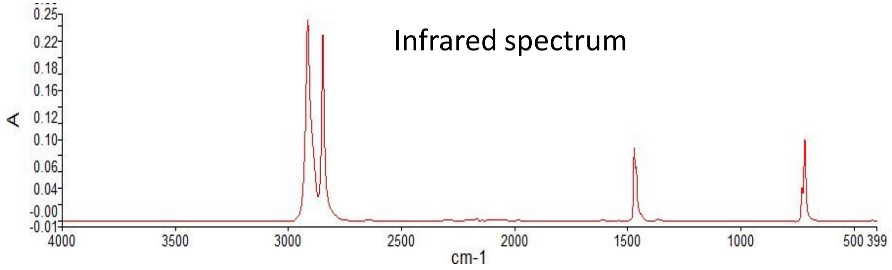
Identification of MPs and MFs extracted from water and sludge samples

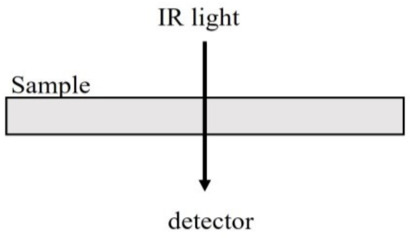
Chemical characterization: FT-IR spectroscopy (single-point measurements)



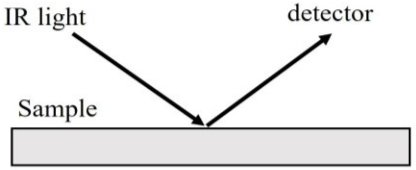




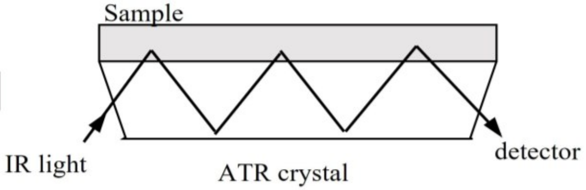
It is made using an **interferometer**, which allows the scanning of all the frequencies present in the IR radiation generated by the source. Scanning is possible thanks to a mobile mirror which, by moving, introduces a difference in the optical path, which gives rise to constructive or destructive interference with the ray reflected by a fixed mirror. This results in an **interferogram** showing the intensity representation in the time domain. By applying the **Fourier transform** we obtain the **infrared spectrum**, i.e. the representation of the intensity in the frequency domain expressed as a wave number.



TRANSMITTANCE



REFLECTANCE



ATTENUATED TOTAL REFLECTANCE (ATR)

All 3 acquisition modes are applicable for the analysis of MPs but in ATR the contact particle-crystal with a high refractive index, allows a more performing characterization.

Infrared (IR) spectrum: the fingerprint of materials

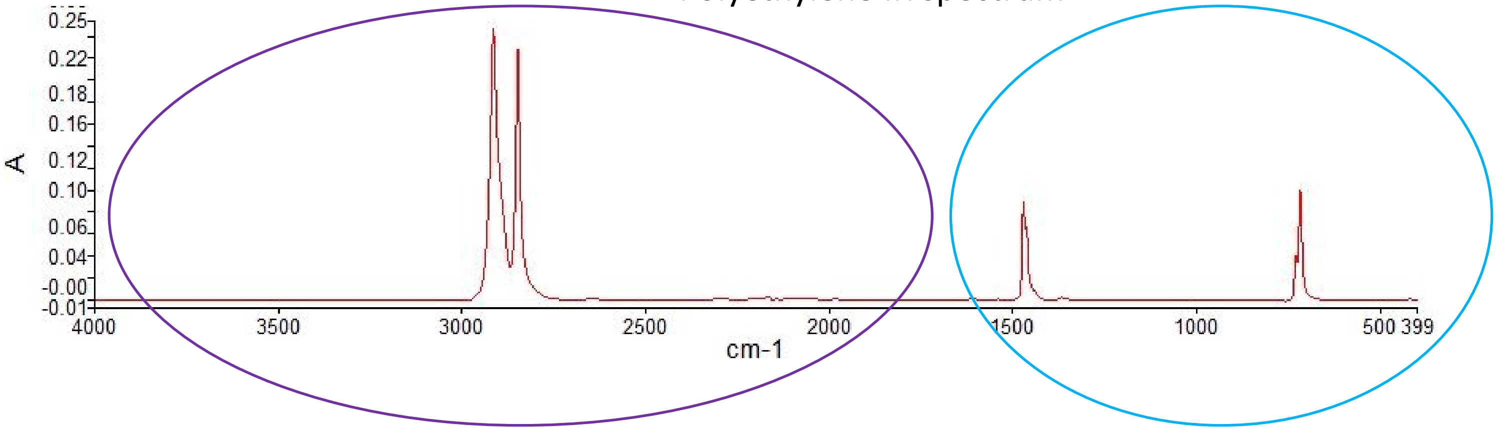
It appears as a series of absorption bands positioned according to the wave number (frequency expressed in cm-1).

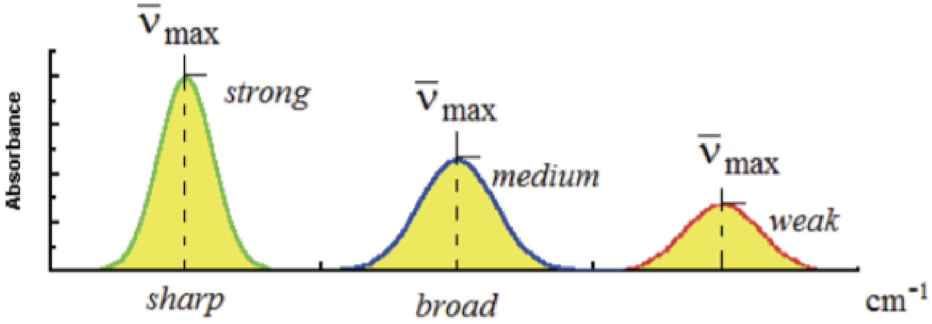
The location (frequency) and intensity of individual absorption bands contribute to the overall spectrum, creating the characteristic fingerprint of the molecule.

The parameters that characterize an IR absorption band are:

- the position
- the intensity that expresses the height of the absorption peak (*strong, medium, weak*)
- the shape (*sharp, broad*)

Polyethylene IR spectrum





Absorption band location:

- **Functional groups area**, from 3800 to 1300 cm-1 and includes bands due to both stretching and deformation of functional groups (e.g. N-H, O-H, C-H, C=C, C=O bonds, etc.).

- **Fingerprint area**, from 1300 to 650 cm-1. Peaks are the result of the combination of various vibrational modes which give rise to a series of absorption bands typical of each single molecule. They make it impossible for different molecules to have the same IR spectrum.

Chemical identification of MPs and MFs extracted from water and sludge sample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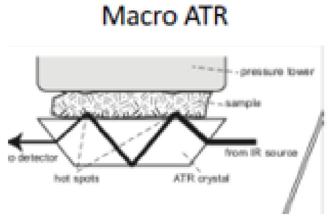
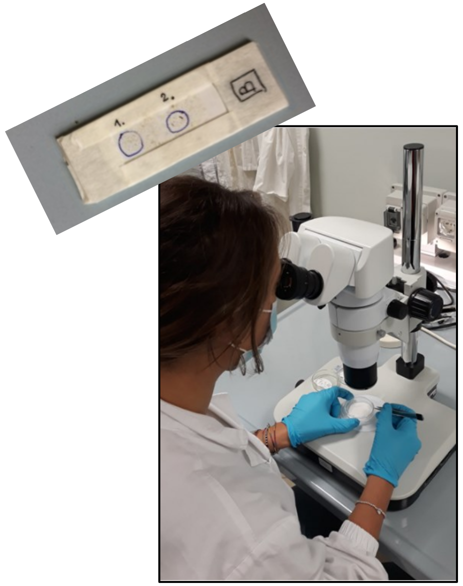
NO MICROPLASTICS, JUST WAVES.
Deliverable ACTION B3
TECHNICAL REPORT AND OPERATING MANUAL ON THE IMPROVEMENT OF THE TREATMENT PROCESS
Manuale tecnico-operativo per l'analisi delle microplastiche negli impianti di trattamento acque

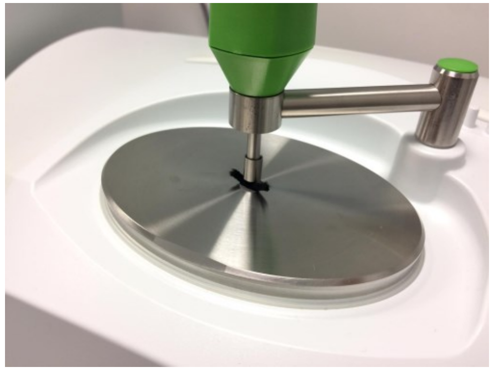
Instrument in use: FT-IR spectroscope with UATR

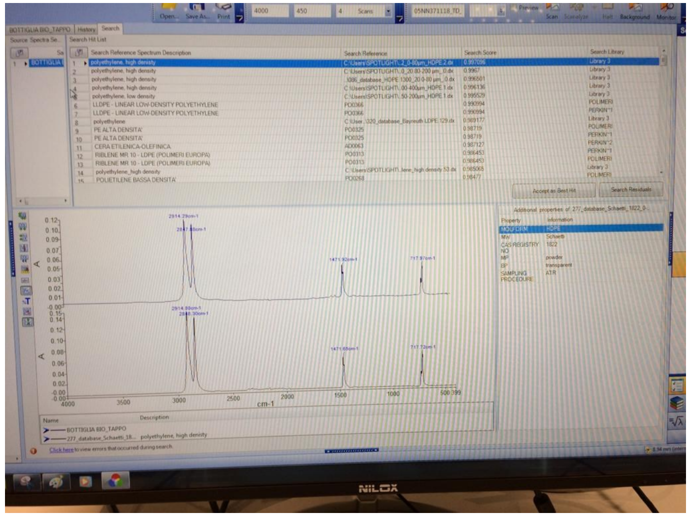


An FT-IR spectrophotometer equipped with a universal ATR accessory (UATR) is used to characterize all those extracted particles that are visible to the naked eye and that can be transferred to the instrument using tweezer or mounted needle.



Opening of the hand-made support and check to reposition the particles and fibers that may have moved from their original position or may have remained adhered to the internal surface of the slide used in the "sandwich".





Chemical identification of MPs and MFs extracted from water and sludge samples

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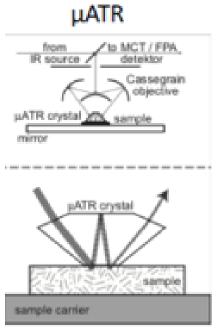
Deliverable ACTION B3

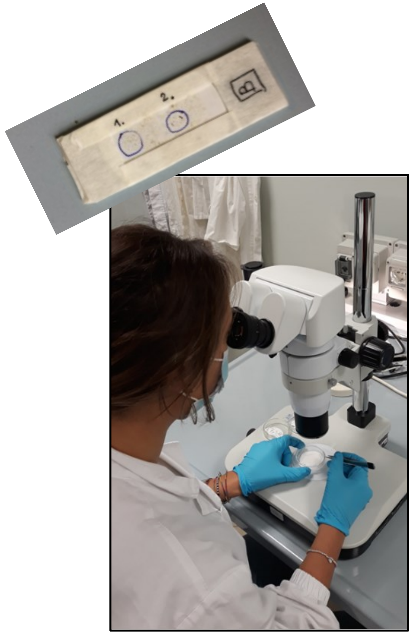
TECHNICAL REPORT AND OPERATING MANUAL ON THE IMPROVEMENT OF THE TREATMENT PROCESS

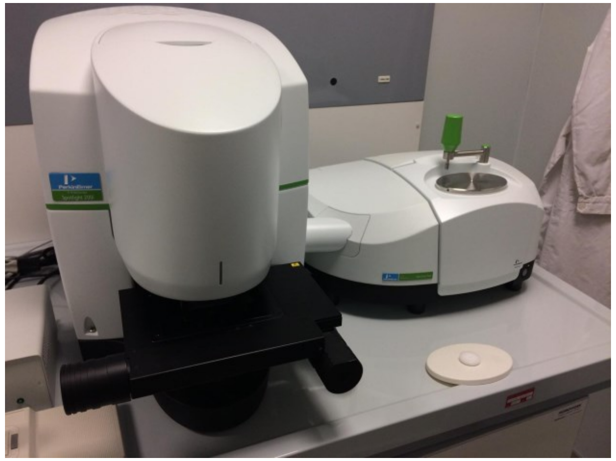
Manuale tecnico-operativo per l'analisi delle microplastiche negli impianti di trattamento acque

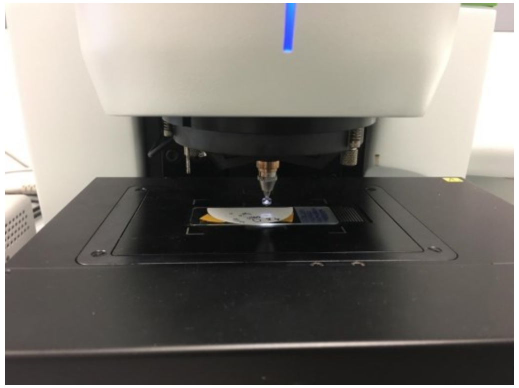
Instrument in use: FT-IR spectroscope + microscope with µATR

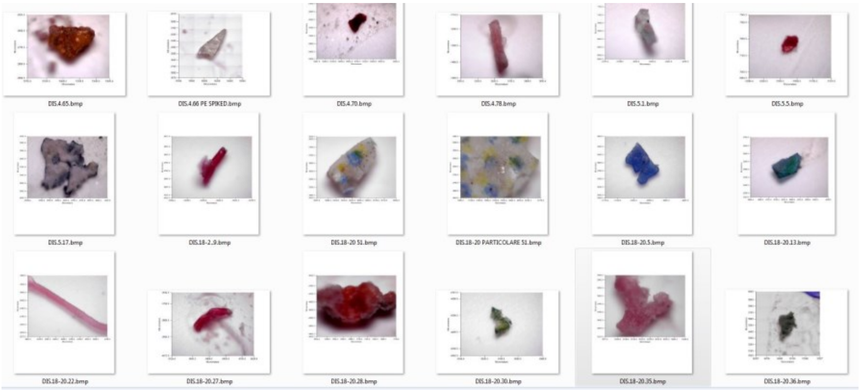
An FT-IR spectrophotometer coupled to a microscope equipped with the µATR accessory is used to characterize all those isolated particles that are not visible to the naked eye.

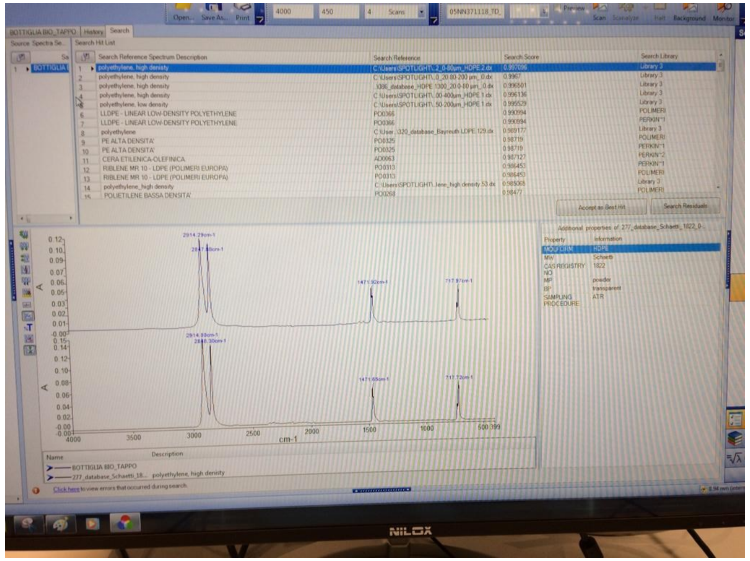












Opening of the hand-made support and check to reposition the particles and fibers that may have moved from their original position or may have remained adhered to the internal surface of the slide used in the "sandwich".

Data elaboration and expression: MPs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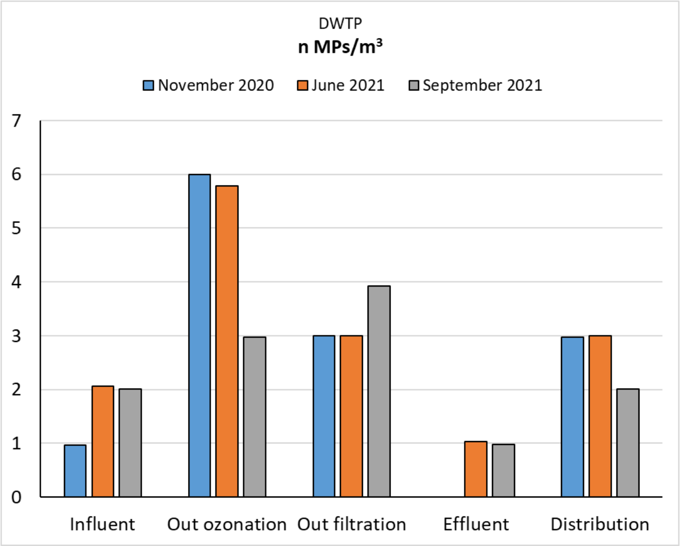
Manuale tecnico-operativo per l'analisi delle microplastiche negli impianti di trattamento acque

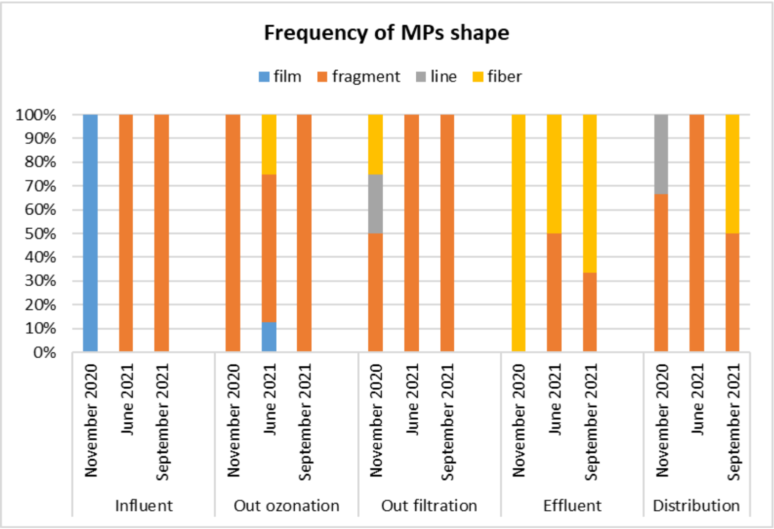
- Information resulted from analyses are recorded in a paper file and then reported in an Excel file for the elaboration of quantitative and qualitative results on MPs and MFs.
- Only items of synthetic nature and < 5 mm in size are considered as MPs.

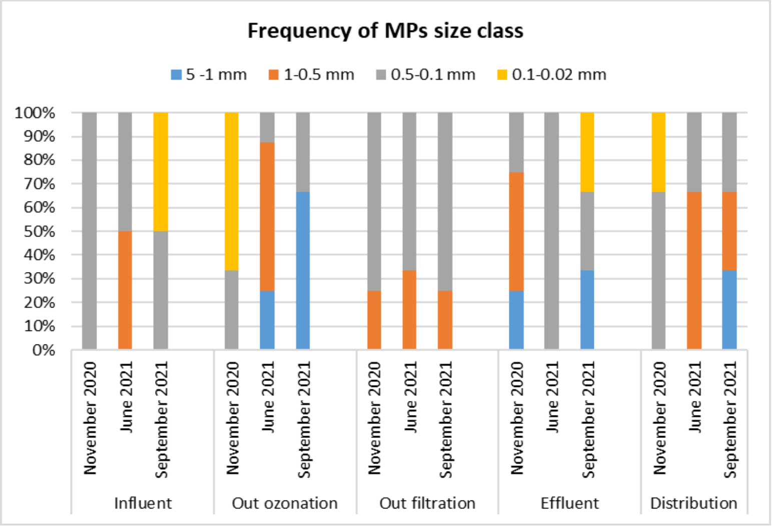
- Items extracted from field samples matching for shape, color and polymer with those found in blank samples, are eliminated from the count.

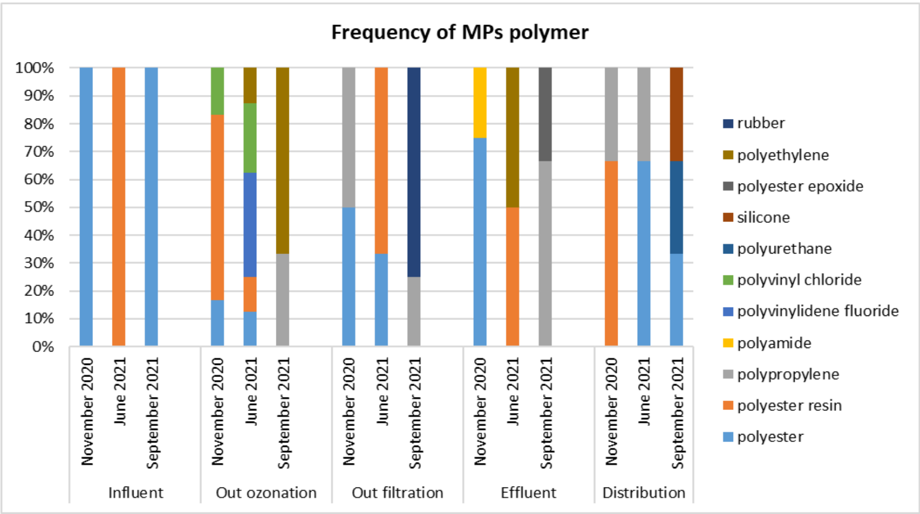
- **Data on quantification/concentration** of MPs are expressed as number of MPs extracted per liter/m^3 or per gram (g) of sample based on the type of analyzed matrix.

- **Data on physical and chemical characterization** of MPs are expressed as the percentage contribution (frequencies) of each shape, size class, color and polymer on the total extracted MPs.







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Manuale tecnico-operativo per l'analisi delle microplastiche negli impianti di trattamento acque

Data elaboration and expression: focus on MFs

- Besides data on synthetic microfibers (included in MPs elaboration) it is suggested to elaborate and show also data relating to microfibers of natural origin.

Results can be presented as follows:

• Number of total MFs extracted per liter (L) or per m^3 or per gram (g) (depending on the type of analyzed matrix), including both those of synthetic and natural origin.

• Percentage contribution of natural MFs vs synthetic MFs on the total of characterized MFs.

• Number of MFs of natural origin and, separately, of synthetic one extracted per liter (L) or per m^3 or per gram (g).

Sampling step	Sampling period	MFs/m^3	Synthetic MFs (plastic)	Natural MFs
Influent	November 2020	0.0	0	0
	June 2021	2.06	0	100%
	September 2021	5.02	0	100%
Out ozonation	November 2020	2.0	0	100%
	June 2021	4.82	40%	60%
	September 2021	0.99	0	100%
Out filtration	November 2020	3.0	33%	67%
	June 2021	2.00	0	100%
	September 2021	2.95	0	100%
Effluent	November 2020	3.9	100%	0%
	June 2021	3.09	33%	67%
	September 2021	8.86	22%	78%
Distribution	November 2020	3.0	0	100%
	June 2021	1.00	0	100%
	September 2021	6.01	17%	83%
Flocculated sludge	July 2020	26,500	40%	60%
	November 2020	23,250	23%	77%
	May 2021	2,000	60%	40%

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Thank you for the attention!

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Global Nature Fund
Bodensee Stiftung Lake Constance Foundation
UNIVERSITÀ POLITECNICA DELLE MARCHE

PROGETTO COFINANZIATO DA
PlasticsEurope Association of Plastics Manufacturers

Pratical activities at the DiSVA Educational Laboratories
(afternoon of April 21st)


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Deliverable ACTION B3

TECHNICAL REPORT AND OPERATING MANUAL ON THE IMPROVEMENT OF THE TREATMENT PROCESS

Manuale tecnico-operativo per l'analisi delle microplastiche negli impianti di trattamento acque

EXTRACTION OF MICROPLASTICS FROM WATER AND SLUDGE SAMPLES

Demonstration of the processing of a sludge sample: pre-treatments and density gradient separation, parallel run of the blank sample.

Vacuum filtration of pre-digested water samples and blank sample.

VISUAL SORTING E PHYSICAL CHARACTERIZATION of POTENTIAL MPs

Observation of membrane filters obtained from the filtration of water samples and classification of the isolated particles on the basis of shape and color.

CHEMICAL CHARACTERIZATION of EXTRACTED ITEMS

Polymeric identification of isolated particles by macro-ATR-FTIR spectroscopy.

VISIT TO THE DiSVA RESEARCH LABORATORIES

(Laboratory of Ecotoxicology and Environmental Chemistry)

Characterization of MPs by µATR-FTIR spectroscopy.

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Benchmark assessment
Università Politecnica delle Marche

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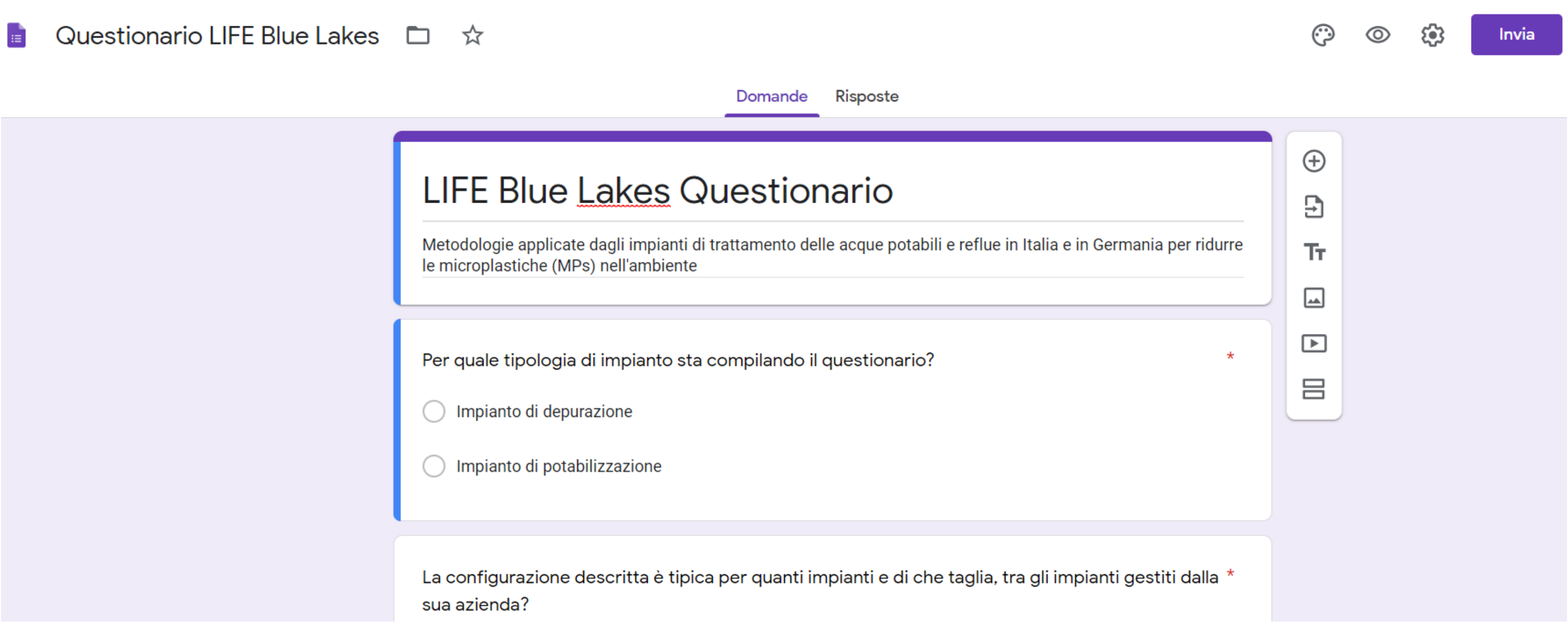
PlasticsEurope Association of Plastics Manufacturers

Current status analysis: Microplastics in the water sector

QUESTIONNAIRE ON THE METHODOLOGIES APPLIED BY DRINKING WATER AND WASTE WATER TREATMENT PLANTS IN ITALY AND GERMANY TO REDUCE MICROPLASTICS (MPs) IN THE ENVIRONMENT



MORE THAN 50 STAKEHOLDERS CONTACTED

Results in Project Impact Ex- ante Report

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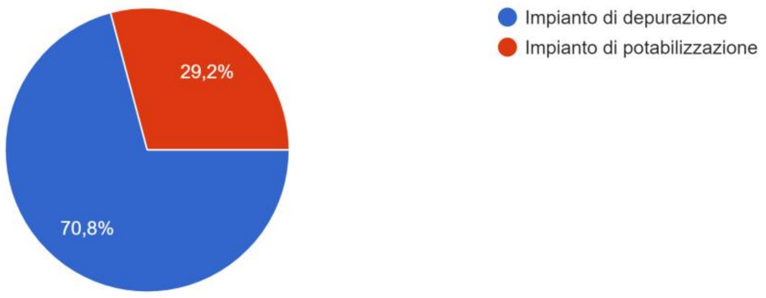
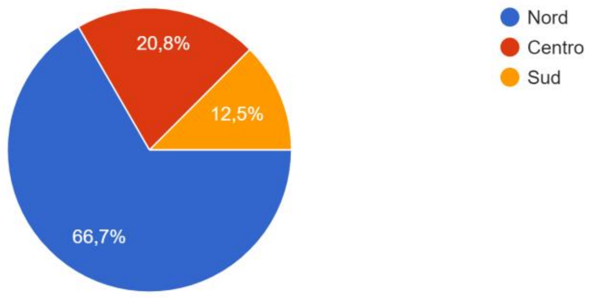
Current status analysis: Microplastics in the water sector

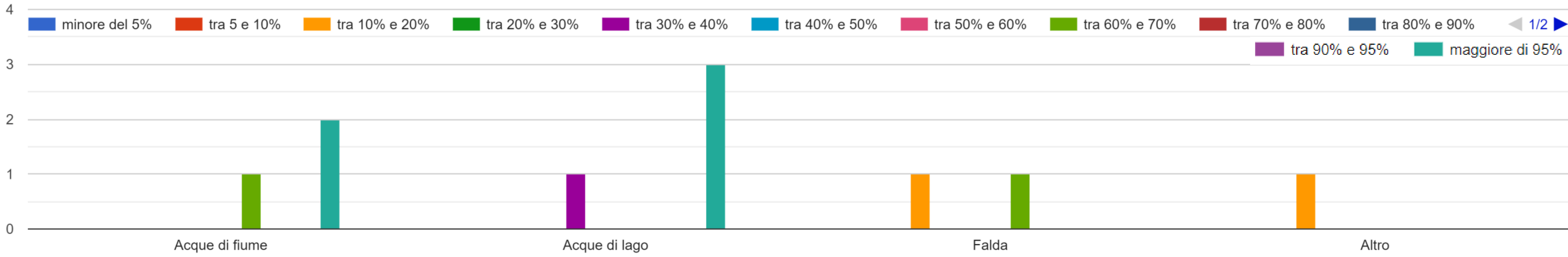
Per quale tipologia di impianto sta compilando il questionario?
24 risposte



L'impianto è collocato geograficamente
24 risposte



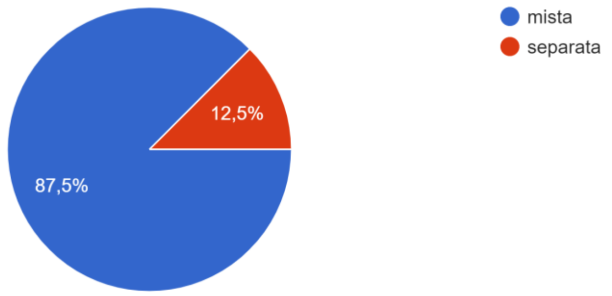
In caso di impianto di potabilizzazione, quali sono i diversi contributi dell'acqua influente? Indicare tipologie e percentuali dei diversi contributi



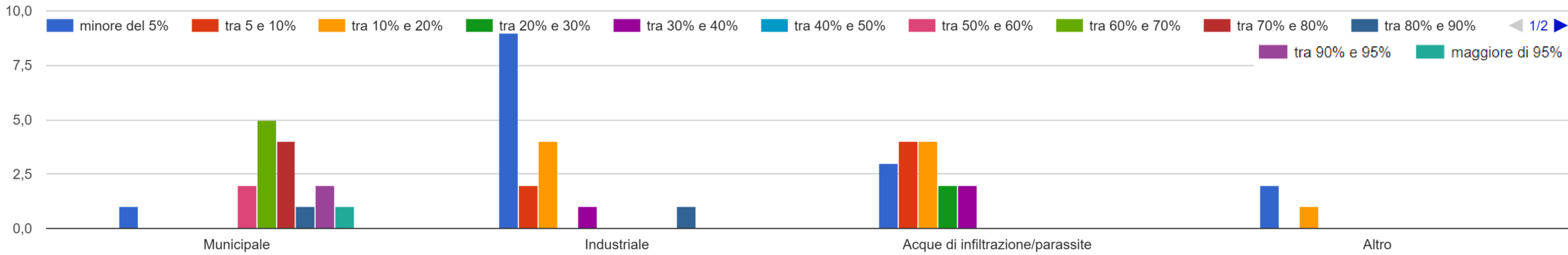
Current status analysis: Microplastics in the water sector

In caso di impianto di depurazione, la rete è mista o separata?

24 risposte

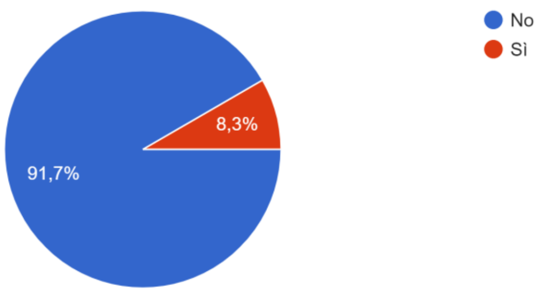


In caso di impianto di depurazione, quali sono i diversi contributi dell'acqua reflua influente (es: acque reflue municipali o industriali)? Indicare tipologie e percentuali dei diversi contributi

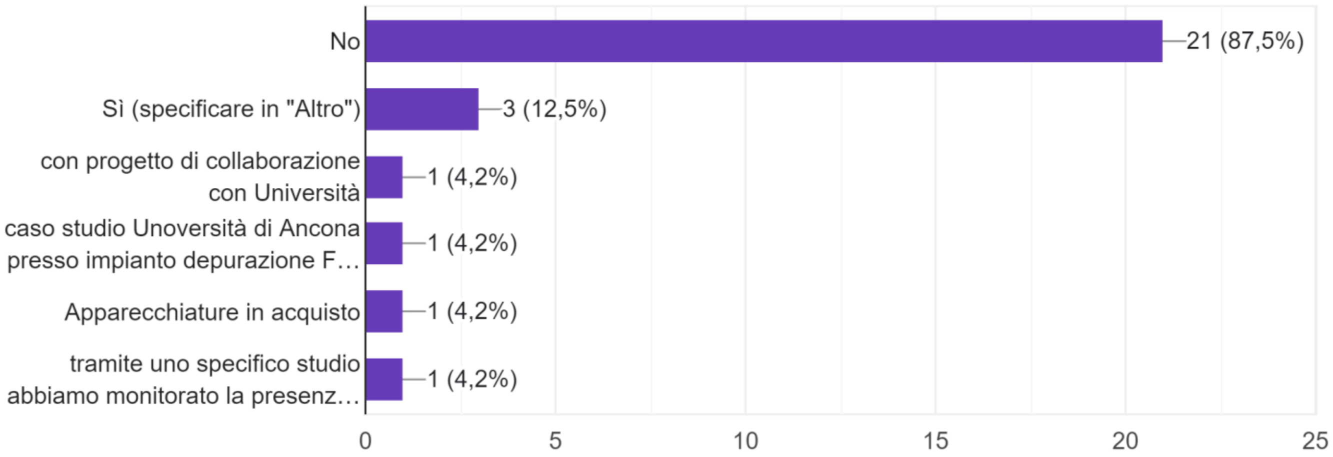


Current status analysis: Microplastics in the water sector

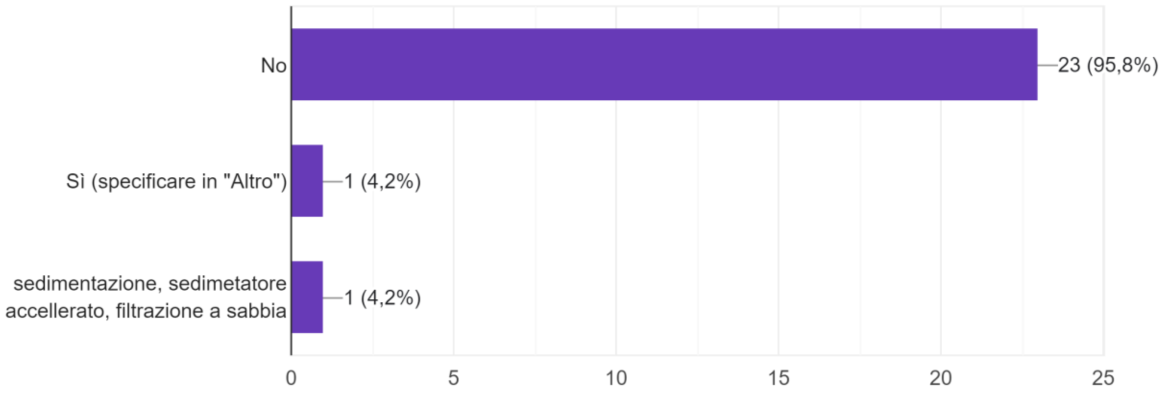
State attualmente considerando la presenza ed il destino delle microplastiche come tematica prioritaria nella vostra regione e nell'impianto?
24 risposte



Al momento state monitorando e/o misurando microplastiche? Nel caso, con che frequenza e con quali metodi? Potreste descrivere le procedure di campionamento e misurazione applicate?
24 risposte



Sono applicate al momento nell'impianto trattamenti/metodi specifici per ridurre le microplastiche? Nel caso, che tipo di metodi e/o trattamenti?
24 risposte



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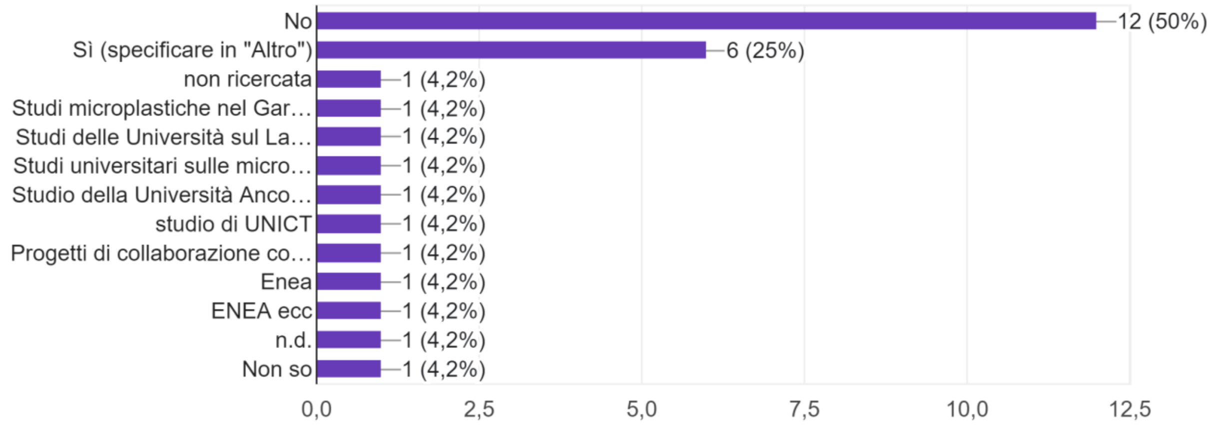
Current status analysis: Microplastics in the water sector

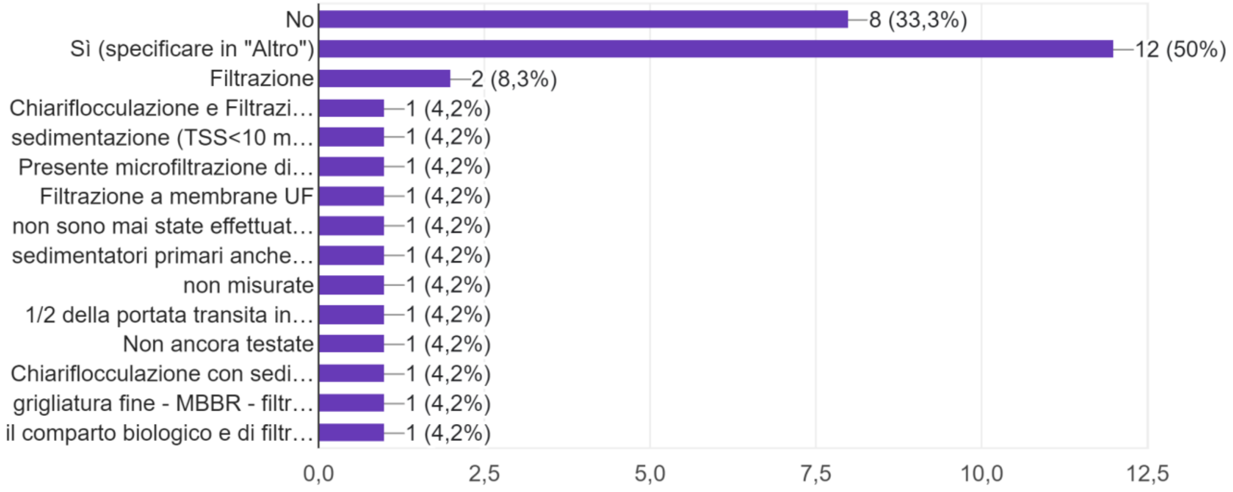
Ci sono evidenze (es: da altri progetti o attività svolti nella vostra regione) riguardo la presenza di microplastiche nell'acqua trattata?

24 risposte



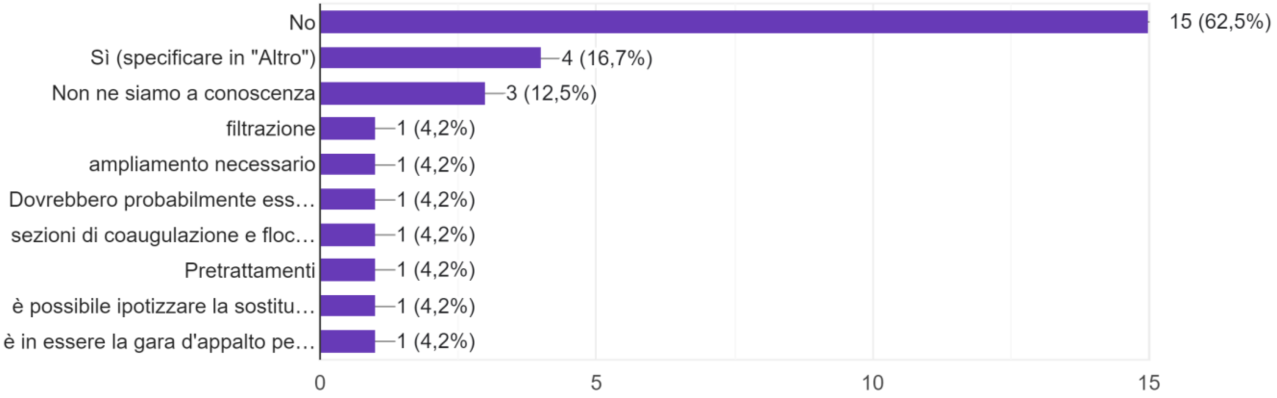
Sono presenti metodologie/trattamenti nell'impianto che, anche se non specificatamente mirati per le microplastiche, potrebbero rimuoverle dall'acqu...no le efficienze di rimozione supposte o misurate?

24 risposte



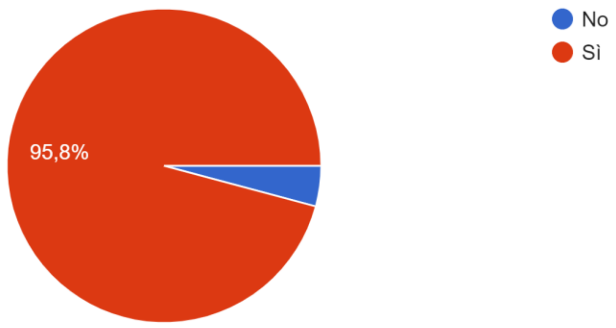
In caso di presenza di microplastiche, il vostro impianto è flessibile a miglioramenti per aumentare le efficienze di rimozione? Ci sono unità esistenti...entate o ne dovrebbero essere installate di nuove?

24 risposte



Siete disponibili/disposti a organizzare campagne di monitoraggio nel vostro impianto per individuare microplastiche?

24 risposte



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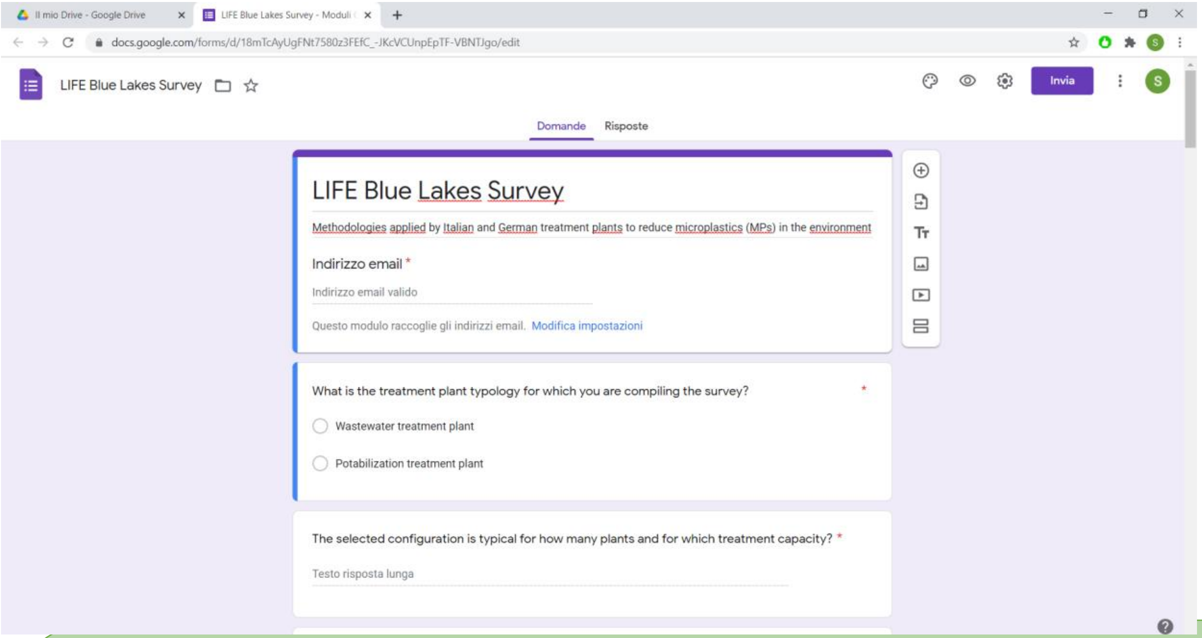
Current status analysis: Microplastics in the water sector



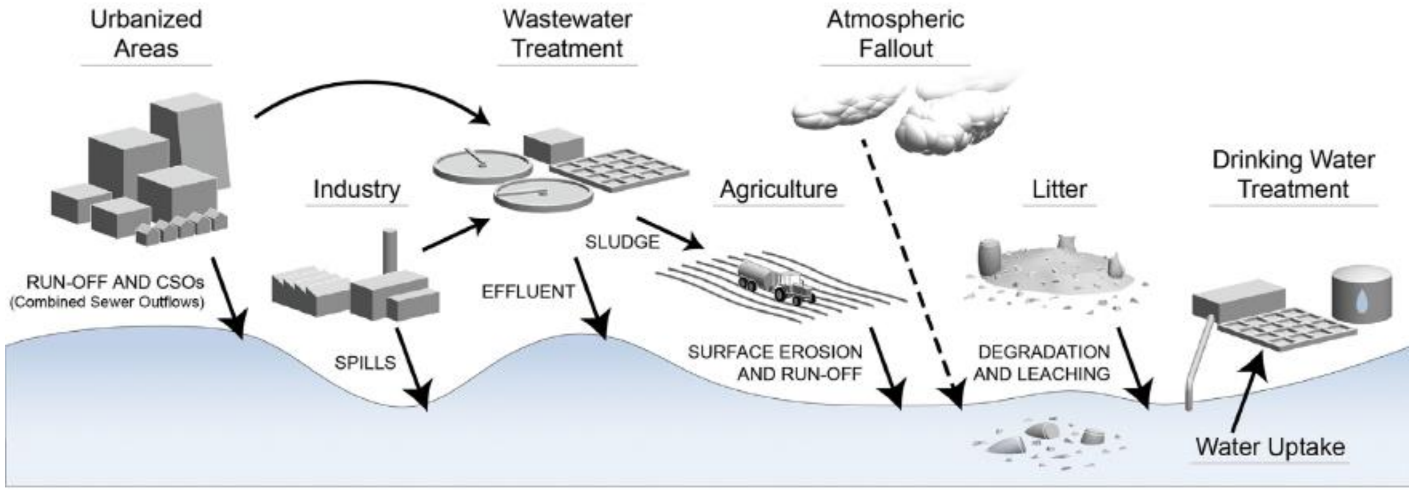
41 Italian water companies and 23 German utilities contacted

24 surveys collected from 17 Italian water utilities and 5 questionnaires from plants in Germany

- While the most common configurations of water and wastewater treatment plants are not specifically designed for the removal of microplastics, current units can impact their removal from water streams.
- Although most of the interviewees do not yet consider the removal of MPs as a priority, their presence in waters has already been investigated by some activities carried out in the area by research institutions or universities (VALUE CE-IN, ENEA, UNICT project).
- The companies interviewed showed their willingness to organize sampling campaigns to detect microplastics in the plants
- Companies have expressed their interest in having specific free training on the occurrence and removal of microplastics in treatment plants.

Microplastics in the Integrated Water Service

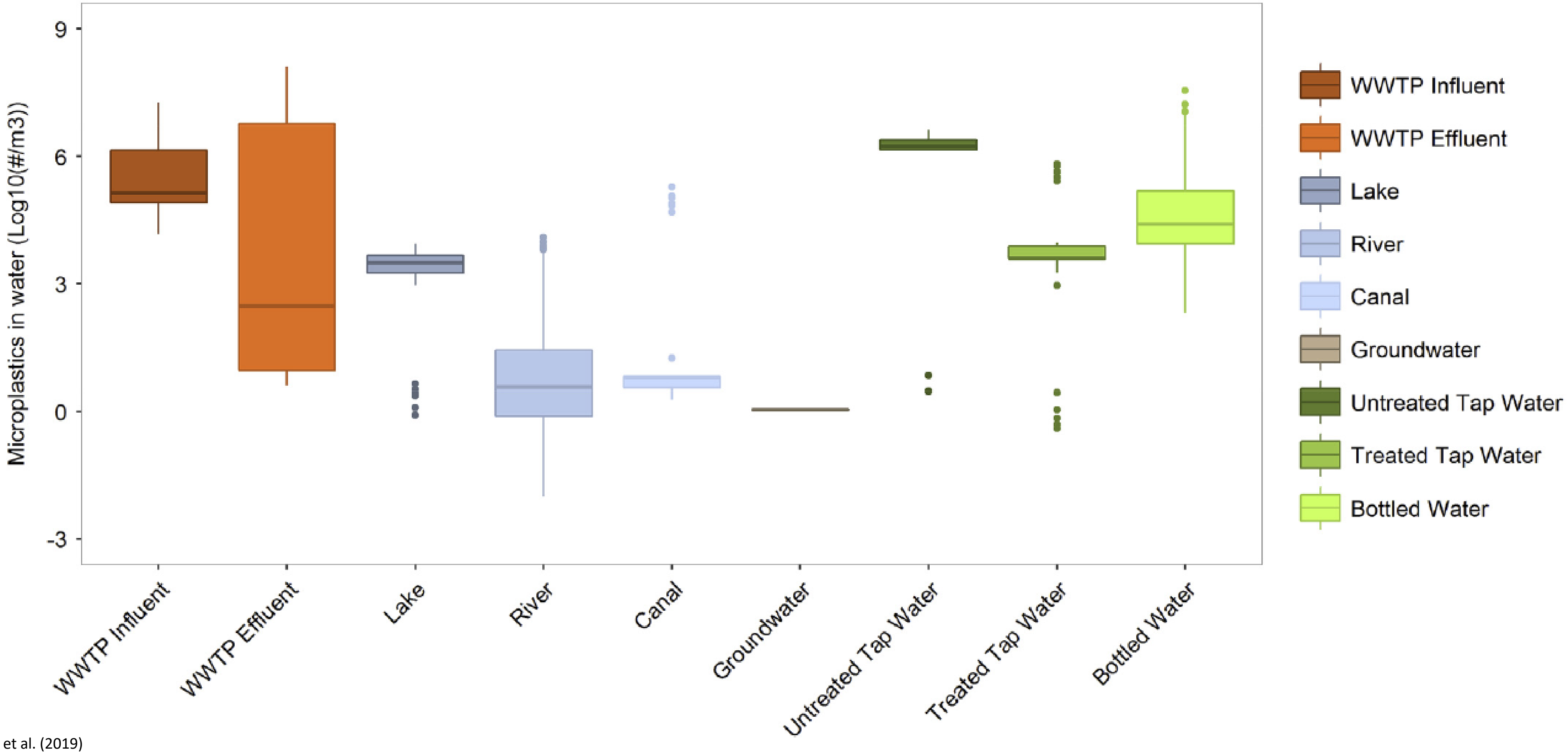
Several aspects require more scientific attention to better understand the presence and fate of microplastics in these systems



Routes of entry for microplastics leading to drinking water sources. Eerkes-Medrano 2019

- Study focused on the fate of microplastics in different plants
- Study focused on the fate of microplastics in different processes and treatment units
- Role of sewage flood events in the release of microplastics
- The fate and implications of microplastic release into receiving water bodies and soil environments.

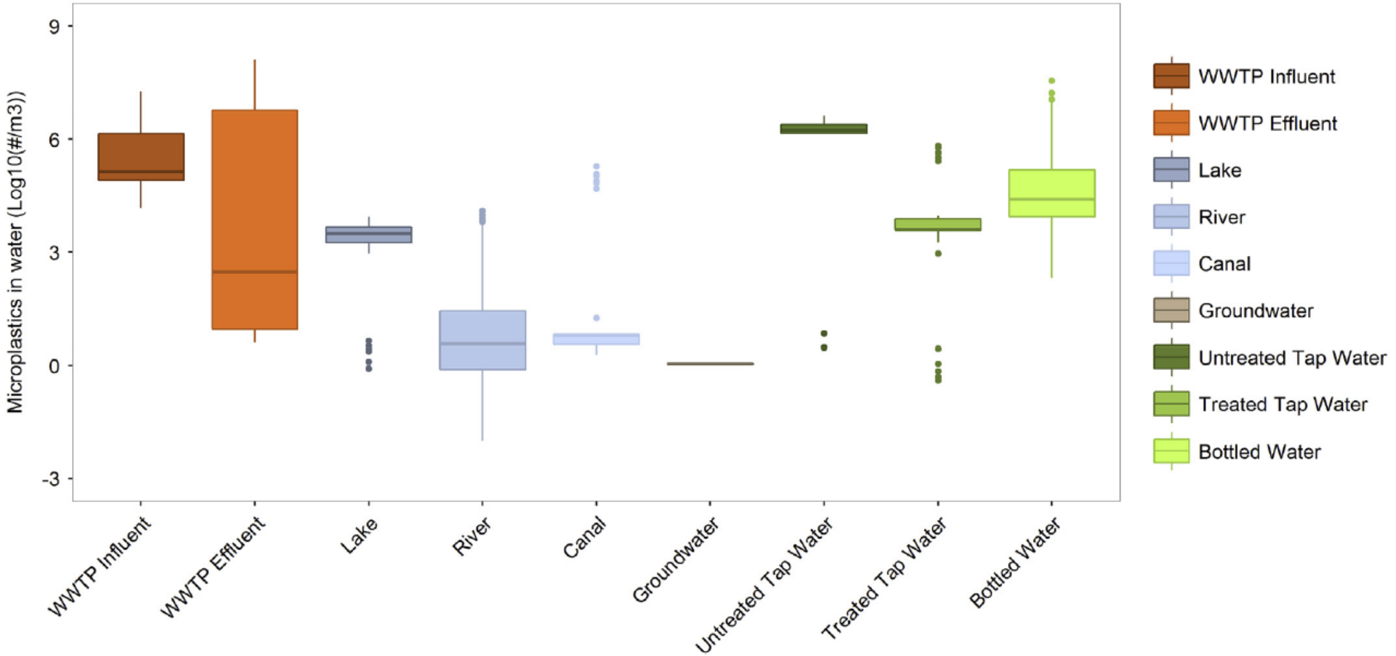
Microplastics in the Integrated Water Service



A.A. Koelmans et al. (2019)

Box and whisker plot showing median and variation in microplastic number concentrations in individual samples taken from different water types. Data relate to individual samples unless only means were reported, in which case the mean value was taken into account n times, with n being the number of samples which the mean was based on. References included: (Estahbanati and Fahrenfeld, 2016; Faure et al., 2015; Fischer et al., 2016; Hoellein et al., 2017; Kosuth et al., 2018; Leslie et al., 2017; Magnusson and Noren, 2014; Mason et al. 2016a, 2018; McCormick et al. 2014, 2016; Michielssen et al., 2016; Mintenig et al., 2019b; Obmann et al., 2018; Pivokonsky et al., 2018; Rodrigues et al., 2018; Schymanski et al., 2018; Simon et al., 2018; Talvitie et al. 2015, 2017a, 2017b; Vollertsen and Hansen, 2017;Wang et al. 2017, 2018; Ziajahromi et al., 2017), with n ¼ 27.

Microplastics in the Integrated Water Service



NB: Pay attention to the number of quantifications available (number of case studies) and the protocols used (both for sampling and for analyses)

Currently, the legislation does not indicate a concentration limit for the presence of microplastics in water, nor sampling and analysis methods.

- Considerable heterogeneity of the concentrations found in the literature (logarithmic scale) between the different categories
- Considerable variability even within the same category (e.g. purification effluent)
- Groundwater is characterized by low concentrations (and low variability)
- Effluents from treatment plants are on average about 3 orders of magnitude lower than influents
- Bottled water has higher average concentrations than tap water

Literature analysis for drinking water

Author	Treatment unit	Volume sampled	n°MPs/L
(Wang et al., 2020)	Influent	1L x 3 samples	6614 ± 1132
	Effluent	1L x 3 samples	930 ± 71
(Pivokonský et al., 2020)	Influent	2L x 3 times/day	23±2
	Effluent	2L x 3 times/day	14±1
	Influent	2L x 3 times/day	1296±35
	Effluent	2L x 3 times/day	151 ± 4
(Pivokonsky et al., 2018)	Influent	1L x 3 samples/day x 3 times x 3 days	1473 ± 34
	Effluent	1L x 3 samples/ day x 3 times x 3 days	443 ± 10
	Influent	1L x 3 samples/ day x 3 times x 3 days	1812 ± 35
	Effluent	1L x 3 samples/ day x 3 times x 3 days	338 ± 76
	Influent	1L x 3 samples/day x 3 times x 3 days	3605 ± 497
	Effluent	1L x 3 samples/day x 3 times x 3 days	628 ± 28
(Mintenig et al., 2019)	Influent	300-1000 L	0.003
	Distribution	1200-2500 L	<0.001
	Influent	300-1000 L	0.007
	Effluent	1200-2500 L	<0.001
	Distribution	1200-2500 L	0.003
	Influent	300-1000 L	0.001
	Effluent	1200-2500 L	0.002
	Influent	300-1000 L	0.001
(Cherniak et al., 2022)	Influent	10 L *2 duplicates	42 ± 18 particles/L
	Effluent	10 L *2 duplicates	20 ± 8 particles/L
	Distribution	10 L *2 duplicates	20.5 ± 7.6 particles/L
(Jung et al., 2022)	Influent	10-100 L *12 monthly samples	2.2 ± 1.3
	Effluent		0.02 ± 0.02
Shi et al., 2021	Influent	n.d.	6614 ± 1132
	Effluent		930 ± 71
(Yuan et al., 2022)	Influent	n.d.	17.88
	Effluent		2.75
(Johnson et al., 2020)	Influent	n.d.	21.09 ± 20.49
	Effluent		0.001-0.024
(Leslie et al., 2017)	Influent	n.d.	1385 (dry season); 1796.6 (wet season)
	Effluent	n.d.	448.7 (dry season); 769.4 (wet season)

The analysis of the literature reveals considerable heterogeneity, also due to the different sampling methods and the representativeness of the volumes analyzed.

As the sampling volumes increase, the concentrations are considerably reduced >> greater representativeness of the results, also in consideration of the actual volumes treated in the plant

Literature analysis for tab water and bottled water

Author	Water type	Lower size bound (μm)	Particles/L in sample (average)	Particles/L in blanks (average)	Particle size (μm)	Particle shape	Predominant polymer type
(Oßmann et al., 2018)	Bottled (mineral water) • Glass • Single use PET • Reusable PET	1	3074–6292 2649 4889	384	Most particles smaller than 5 (>75% in glass and >95% in plastic bottles),	No discussion of shapes	PET in plastic bottles, PE, and styrene butadiene copolymer in glass
Schymanski et al. (2018)	Bottled • Single use • Returnable • Glass • Beverage carton	5–20	14 118 50 11	14 ± 13	40–50% in 5–10 range; over 80% <20	No discussion on shape; described as fragments	PET but also PP, PE
(Mason et al., 2016)	Bottled	6.5–100 lower bound based on microscope and software	315	23.5	Not specified	Not specified	No characterization
		>100	10.4	4.15	Not specified	Fragments (66%), fibres (13%), films (12%)	PP (54%)
Strand et al. (2018)	Tap from ground- water sources	10–100	0.2, 0.8 and 0.0 (LoD = 0.3) **	Unknown	Mainly 20–100.	Fragments	PET, PP, PS, acrylonitrile butadiene styrene, PUR
		>100 (10 μm sieve size)	0.312 (LoD = 0.58) **	0.26	Not specified	Fibres (82%), fragments (14%), films (4%)	PET, PP, PS
(Mintenig et al., 2019)	Tap from ground- water sources	20	0.0007	0.67 particles/L 0.3 fibres/L	In the range 50–150. Fragments	Fragments	Polyester, PVC, PE, PA, epoxy resin
Uhl, Eftekhardadkhah, and Svendsen (2018)	Tap from 24 sources	60	Average not reported since only a single result above LoQ (that result was 5.5)	0.5 (LoQ = 4.1 LoD** = 0.9)	Not specified	Not specified	No characterization
Kosuth, Mason and Wattenberg (2018)	Tap from unspecified sources	100 lowest reported	5.45	0.33 (based on 5 particles in 30 blanks (ea. 500 mL)	Fibre lengths 100–5000	Mainly fibres (98.3%).	No characterization

Adattato da WHO, 2019. Microplastics in drinking-water

- Few studies
- Variability of values
- The size is not always defined
- Not clear if values include microfibers of different origins
- Predominant type of PET polymer for bottled water, variable for tap water

Literature analysis for wastewater

Reference	Treatment	n°MPs/L
Browne et al. 2011	Effluent	1
Carr et al. 2016	Effluent	0
	Effluent	1.36626E-06
Dris et al. 2015	Influent	293
	Effluent	35
Dyachenko et al. 2017	Effluent	0.02
	Effluent	0.17
Lares et al. 2018	Influent	57.6
	Effluent	1
Leslie et al. 2017	Influent	489
	Effluent	52
Magnusson and Noren 2014	Influent	15.1
	Effluent	8.25
Mason et al. 2016	Effluent	0.05
Michielssen et al. 2016	Influent	133
	Effluent	2.6
	Effluent	2.6
	Effluent	0.5
Mintenig et al. 2017	Effluent	4.505
Murphy et al. 2016	Influent	15.7
	Effluent	0.25
Simon et al. 2018	Influent	7216
	Effluent	54
Talvitie et al. 2015	Influent	430
	Effluent	8.6
Talvitie et al. 2017	Influent	645
	Effluent	1.4
Talvitie et al. 2017b	Influent	6.9
	Effluent	0.3
The Danish Environmental Protection Agency, 2017	Influent	5.9
	Effluent	0.016
Vermaire et al. 2017	Effluent	0.07
Ziajahromi et al. 2017	Effluent	1.5
	Effluent	0.48
	Effluent	0.28
Magni et al., 2018	Influent	2.5
	Effluent	0.4
Gündoğdu et al., 2018	Influent	24
	Effluent	5.5

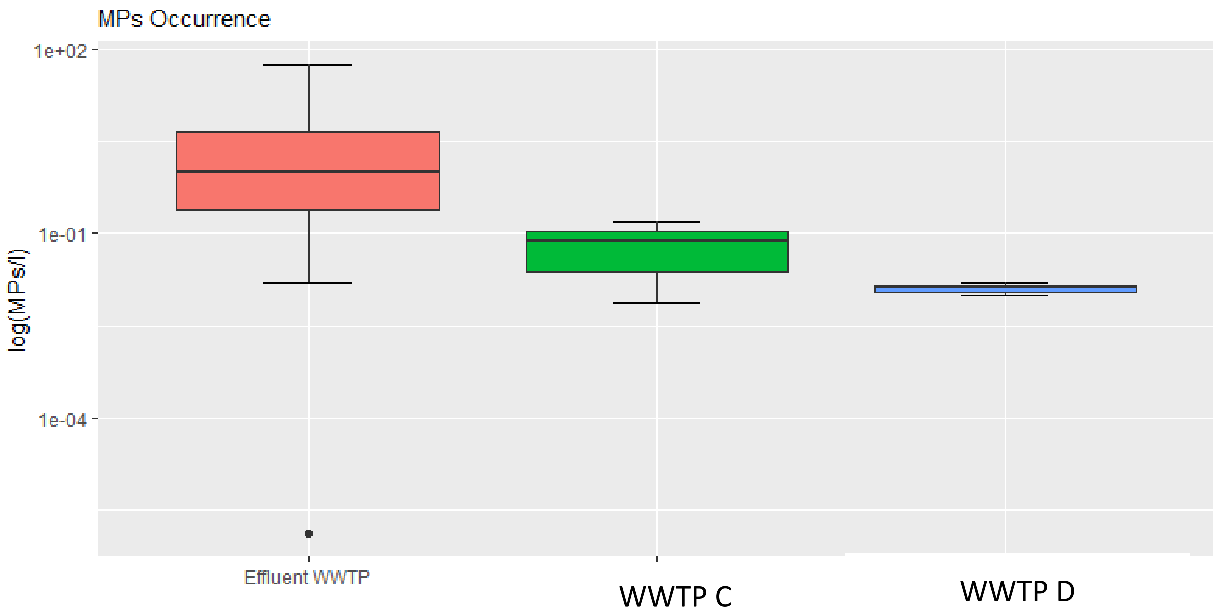
Also for wastewater treatment plants there is considerable variability in sampling and analysis methods

Although large data variability was reported, MPs concentration ranged between 6 and 7*10^3 particles/L in influent and 0 and 35 particles/L in effluent.

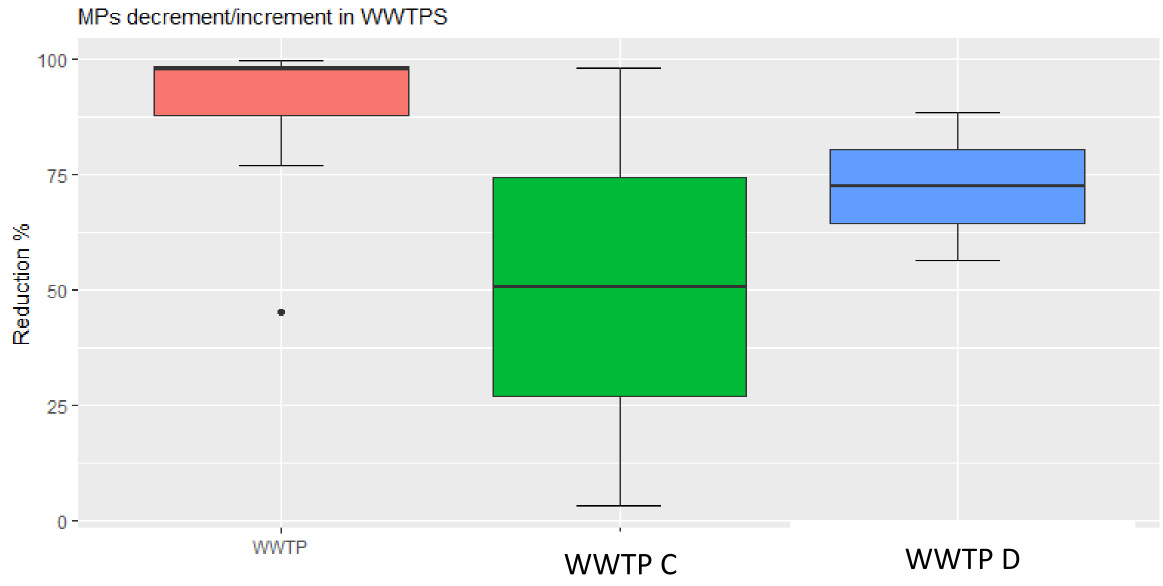
The concentrations of removed MPs found vary in conventional case studies by 4 orders of magnitude

MPs in wastewater treatment plants

Comparison with literature



Comparison between the concentrations measured with the technical-scientific literature

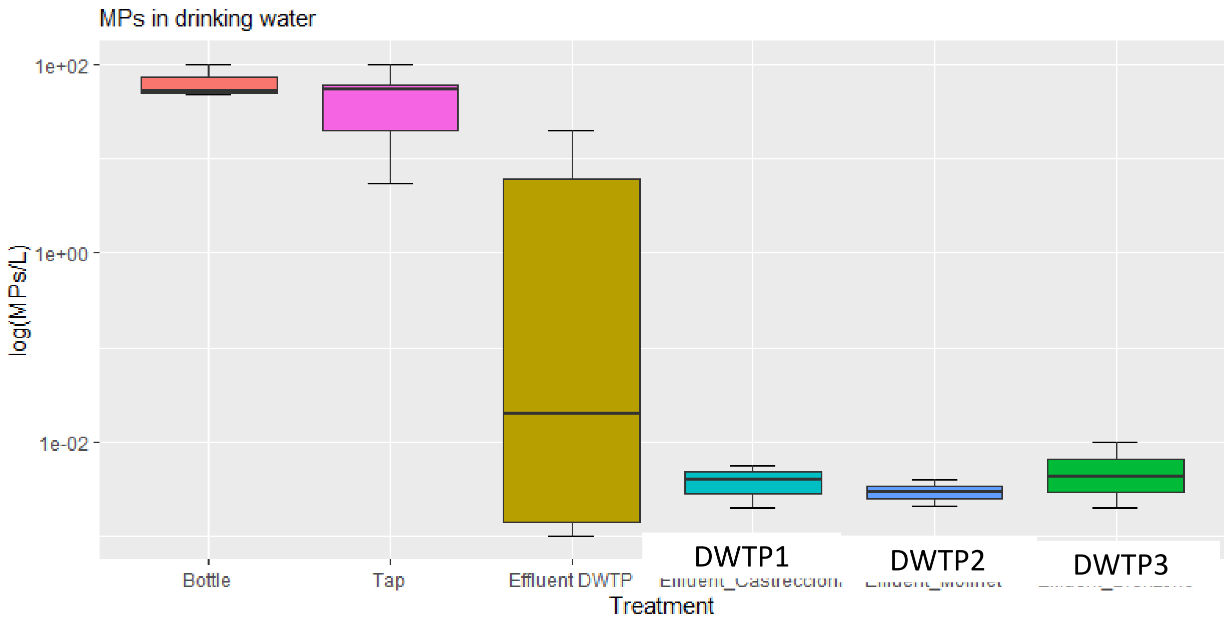


Comparison between the measured reductions and the technical-scientific literature

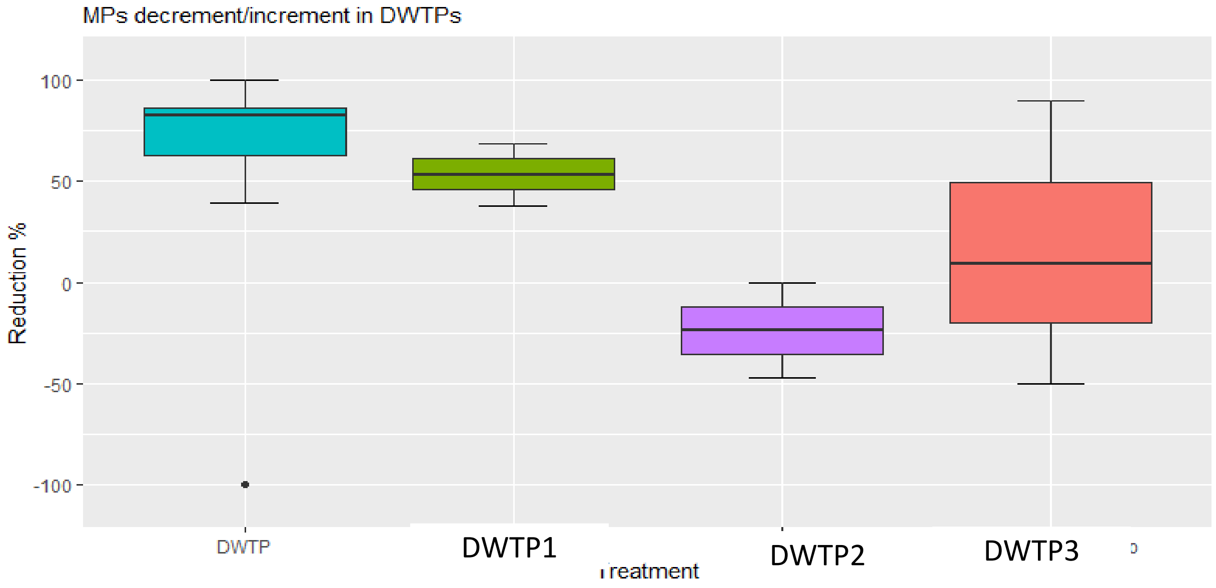
- The measured values are below those of the literature
- The literature results are extremely variable and influenced by the different sampling, analysis and characterization methods, as well as by site-specific conditions
- Despite the already low concentrations entering the plant, further reductions are found at the end of the treatment chain.

MPs in drinking water treatment plants

Comparison with literature



Comparison between the concentrations measured with the technical-scientific literature



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Thank you for the attention!

No microplastics, just waves.

Water and Waste Environmental Engineering

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