CONGRESSO NAZIONALE
Divisione di Didattica Chimica SCI 2025
Bertinoro, 7/8 Dicembre 2025

Società Chimica Italiana
Divisione di Didattica Chimica

Analisi Green delle Microplastiche nella sabbia dei litorali italiani

Una proposta di Citizen Science

Teresa Cecchi
cecchi.teresa@istitutomontani.edu.it

ITT "G. e M. Montani" Fermo, FM

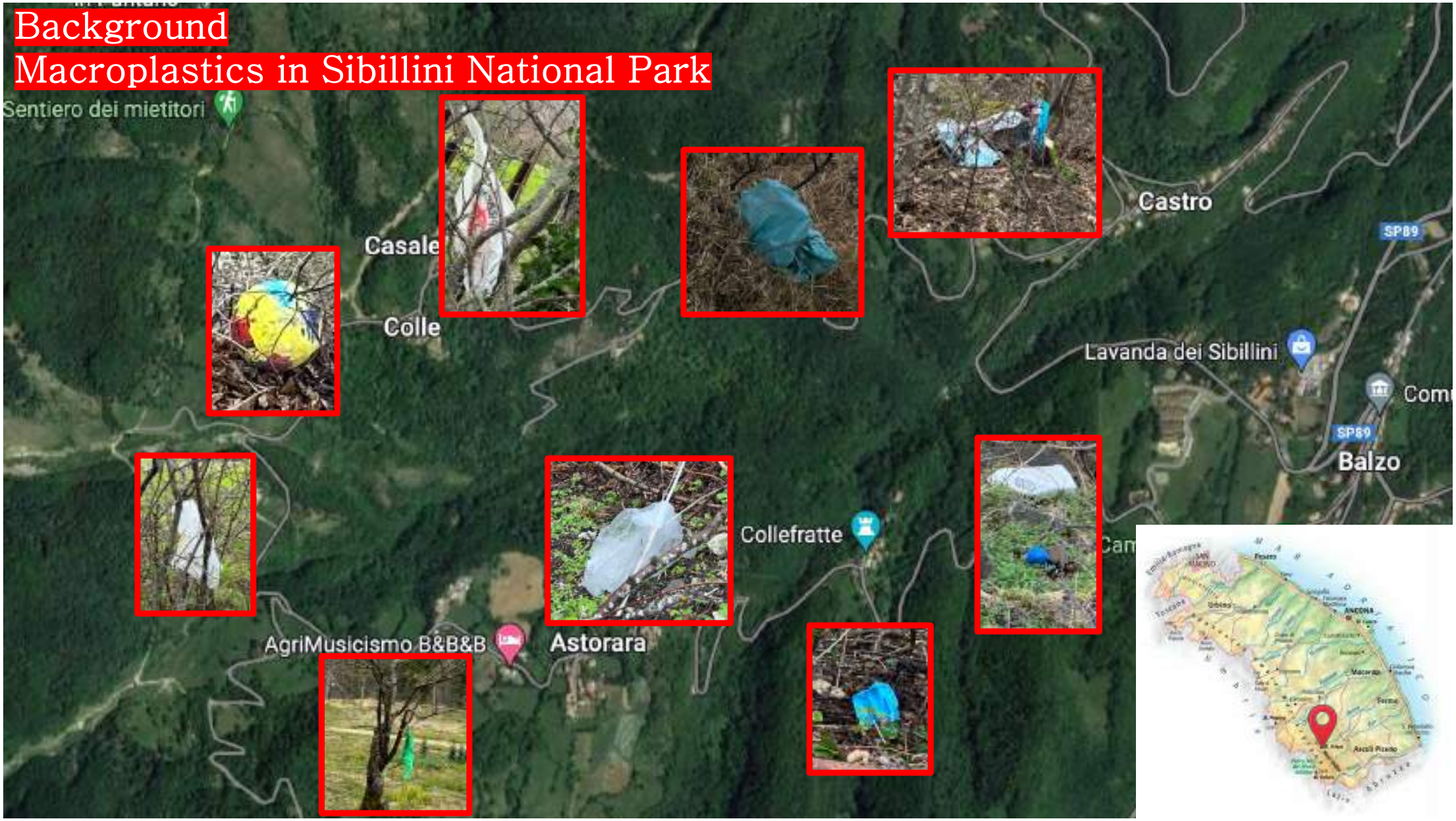
#Expert Citizen Science
#Green Chemistry&Outreach
#Outdoorlearning
#Servicelearning

MPs research and monitoring is needed

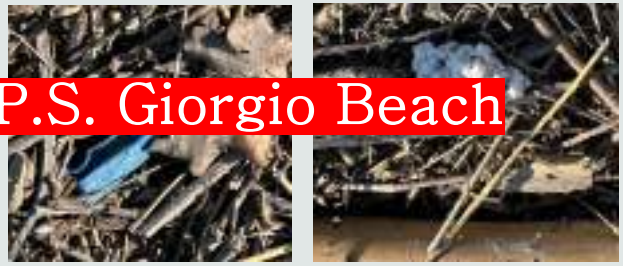
- Project-based learning develops students' talent and engagement with sustainability
- Students are crucial for Expert Citizen Science to expand research capabilities, generate vast datasets over large geographic areas for environmental monitoring
- Research-oriented Green Chemistry teaching must be inspired by the analytical greenness metrics (AGREE)
- **Learning of founding concepts (density) and intertwined advanced competence (representativeness, preanalytical steps, GC, FTIR, Microscopy, polymers, accuracy e precision):**

Citizen Science helps, but it must go GREEN

Background
Macroplastics in Sibillini National Park



From Macro to MPs – P.S. Giorgio Beach



What is the best matrix for citizen science? SAND

Sampling Site 1.

Alberoni WWF Oasis

Sampling within one h

in ebb tide conditions,

dry and calm conditions

outside of the tourist

season

Venice, 15th Nov 2024


Venezia
Lido di Venezia
Santa Maria del Mare
Laguna Veneta
Google
Sampling Site 1
Alberoni Öffentlicher Strand
100 m
10 m
strandline
shoreline
Google
Area:100 m x10 m
15 sampling points
Representativeness

Sampling

3 sampling point spaced 5 m along 5 orthogonal foreshore transepts spaced 25 m
At each sampling point, sand collected to a depth of 5 cm within a 50 x50 cm quadrat at its center and vertices

Composite sample of sand (500 g each)

IBL construction of the Lab Experiment Expert citizen science (GREEN)

Dry the sample

Eliminate the moisture content of sand to give MPs on a dry matter basis
40°C for 1 week
(to avoid the glassy transition of Nylon)

Weight 500 g dry sand in triplicate

Saturated solutions	D (g/ml)	Pictogram
Sodiumm Chloride	1.2	
Sodium hexametaphosphate	1.3	
Calcium Chloride	1.4	
Sucrose	1.45	
Iron (III) Chloride	1.5	
Calcium Nitrate (1€/kg)	**1.50**	
Xylitol	1.50	
Potassium Formate (90€/kg)	1.57	
Sodium Silicate	1.6	
Zinc Chloride	1.6-1.7	
Sodium Iodide	1.6	
Potassium Iodide	1.7	
Calcium/Strontium Bromide (320€/kg)	1.8	
Cesium Chloride	1.90	
Zinc Bromide	1.99	
Cesium Iodide	2.4	
Cesium Formate	2.4	
Potassium Carbonate	2.43	
Sodium/Cesium tungstate (800€/kg)	2.8	

What is the best Green Density Separation approach for expert citizen science?

- No health hazard
- No damage to aquatic environment
- No reaction with H2O2
- No low pH (Polyamides at risk)
- No high pH (Polyesters at risk)
- No high viscosity
- Not expensive

Regulation (EC) No 1272/2008

Polymer	Density (g/ml)
Rubber	0.92
*LDPE	0.91-0.97
*HDPE	0.94-0.97
*PP	0.85-0.94
*PS	0.96-1.05
*PA	1.12-1.14
*PU	1.20
*PMMA	1.20
*PC	1.20
PLA	1.21-1.25
CA	1.28
*PVC	1.38
*PET	1.34-1.39
*PTFE	2.2

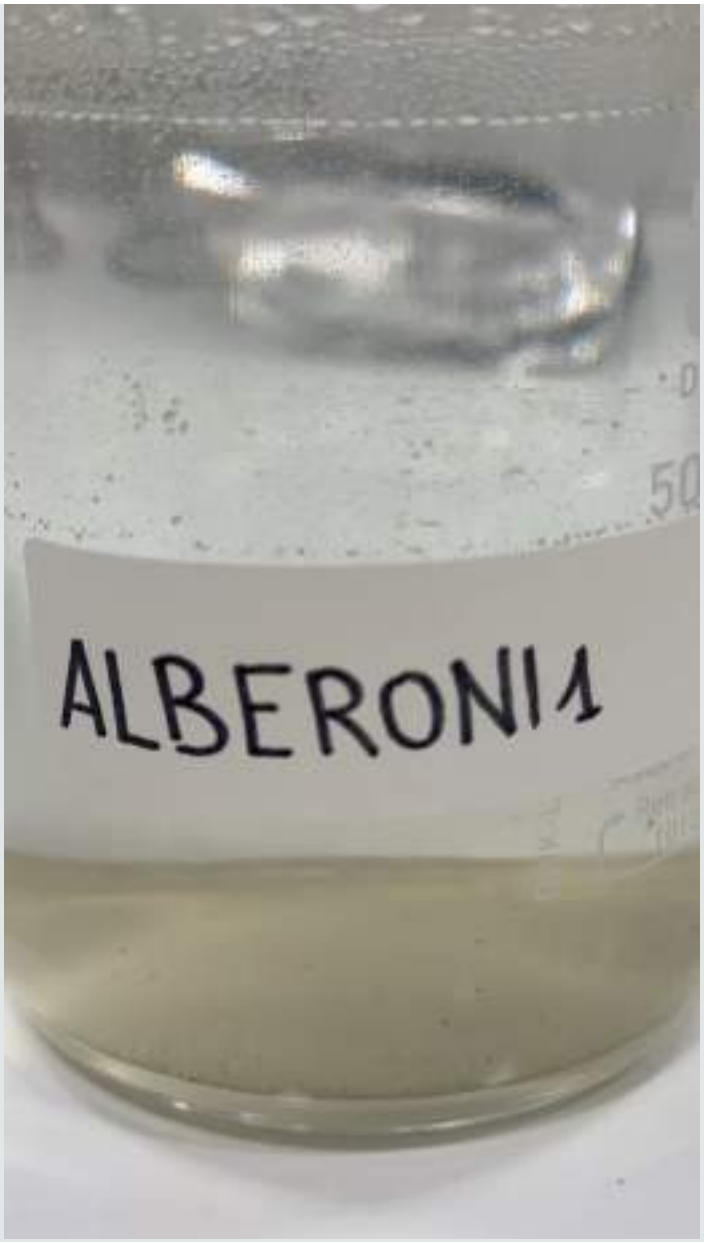
Theoretical EFFECTIVENESS of a $Ca(NO_3)_2$ saturated solution (d 1.5 g/ml) floating

Float MPs

- Add 1000 ml density separation medium
- Stir 20 mins to let MPs float
- Let sand settle overnight
- Transfer the supernatant in a bottle

Destroy the organic matter to avoid interference

- H2O2 treatment avoids false positives
- Room temperature –reaction ended after 3 days
- H2O2/floating mixture ratio below 1 to prevent discolouring MPs
- No Fenton reaction



Cascade Sieving

R 5000, discarded

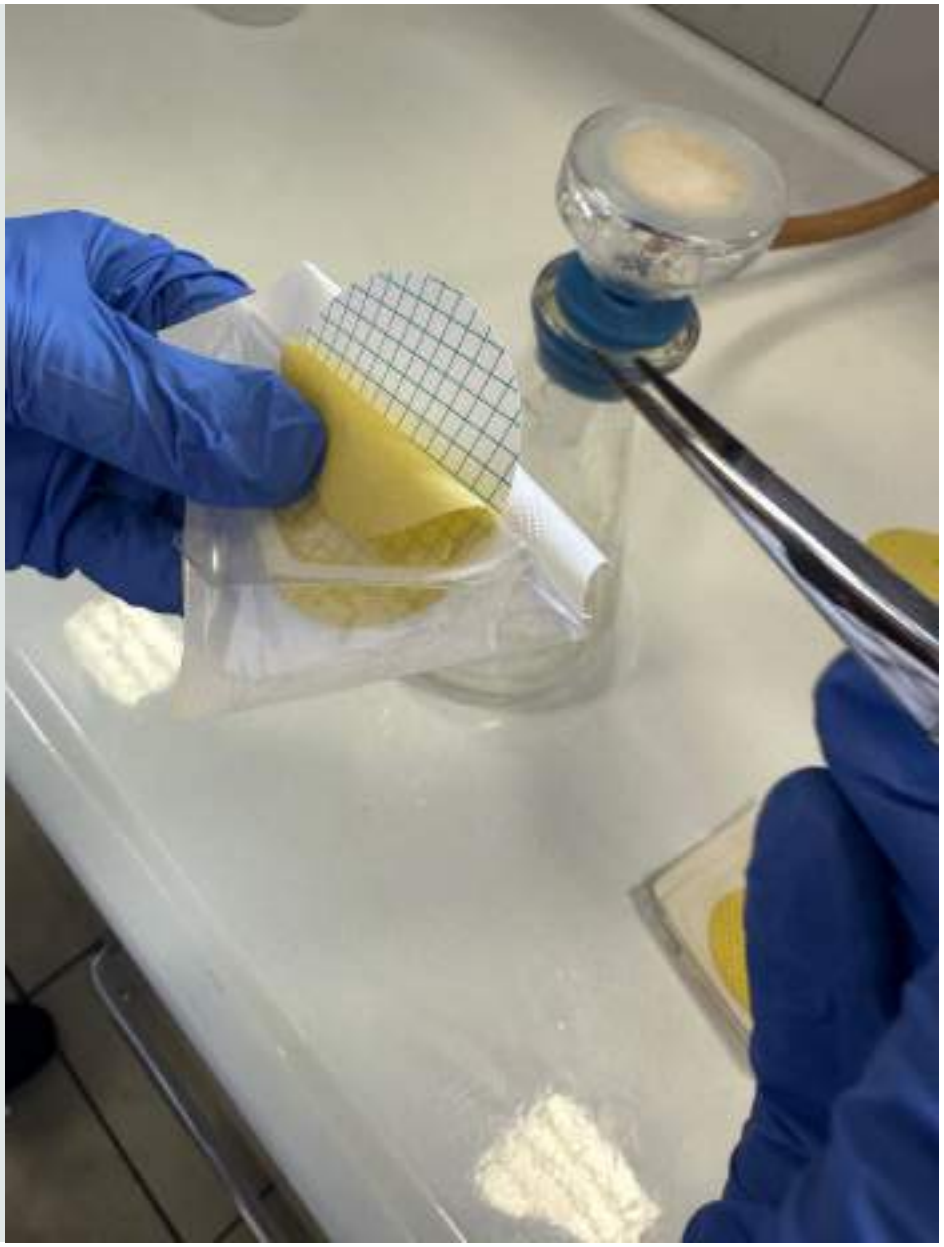
R 1000

R 300

R 100

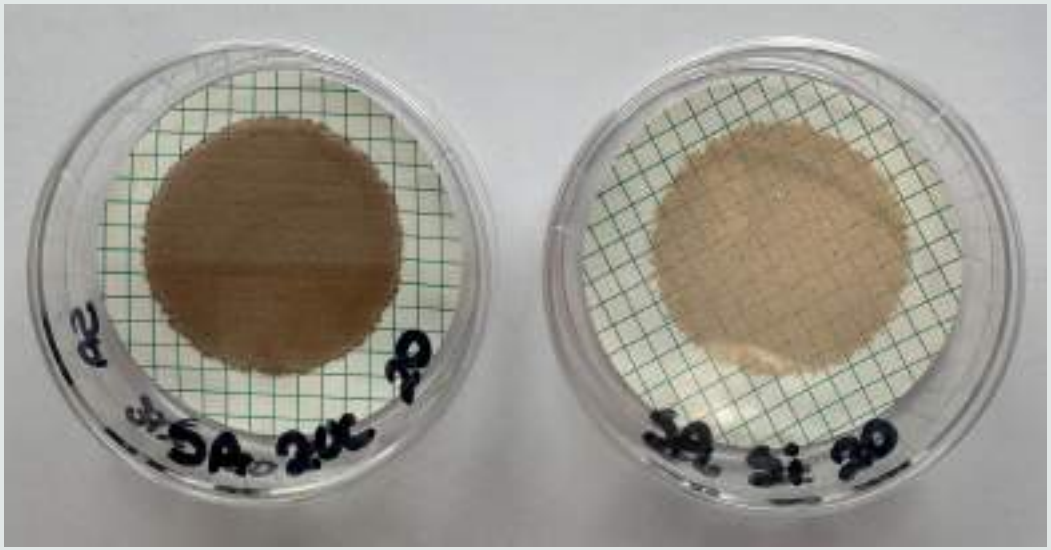
R 20

Rinse each sieve with DW to transfer each retentate to the vacuum filtration (0.45 µm)

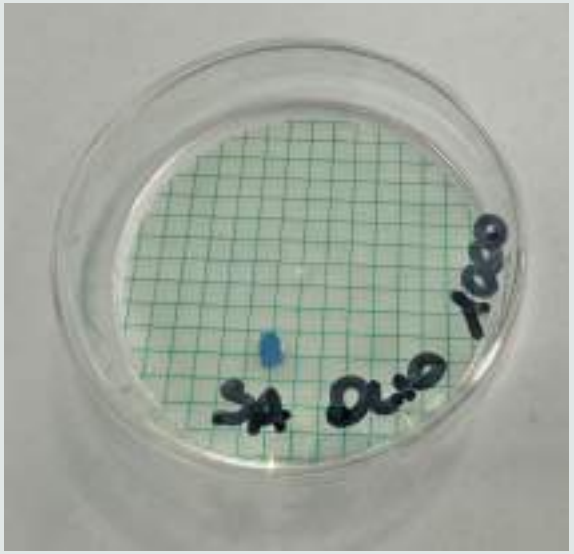


Storage of each filter with its retentate in a Petri Dish for subsequent microscopy

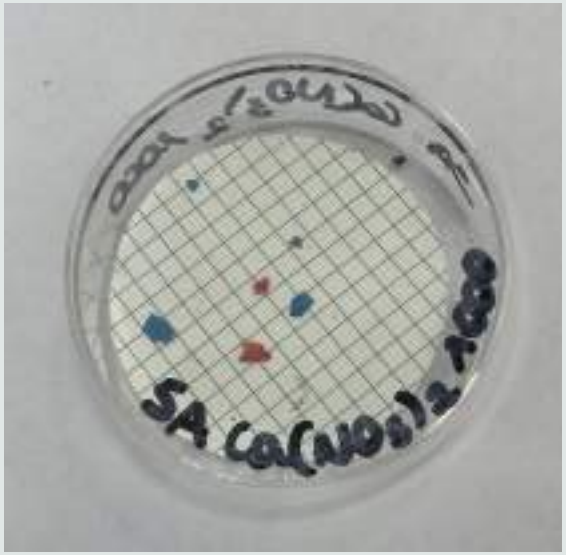
Comparison
Green Density Separation Media and vegetable oil
Negative results count!



Sucrose, xylitol, and Silicate sat solutions prevent settlement of the finest inorganic particles making the detection of the 20 µm MPs fraction impossible

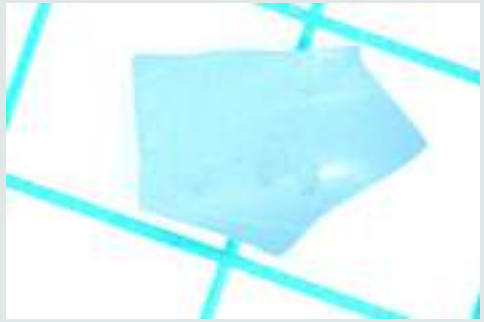


Edible oil conflicts with the organic matter oxidation by H_2O_2 increased viscosity due to epoxidation

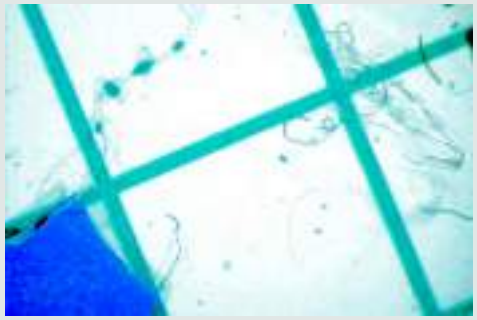


$Ca(NO_3)_2$ sat solution

Red fragment, 1000 µm 20x



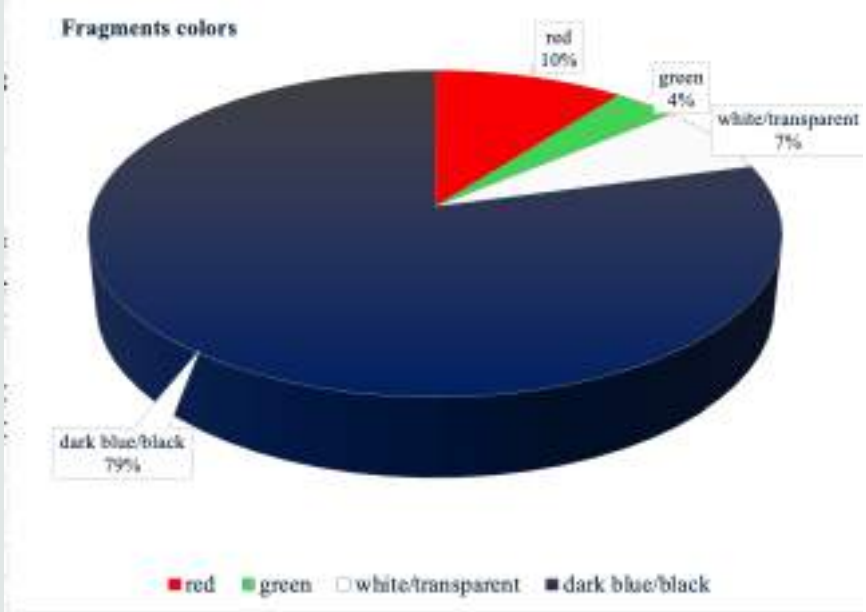
Blue Fragment, 1000 µm 20x

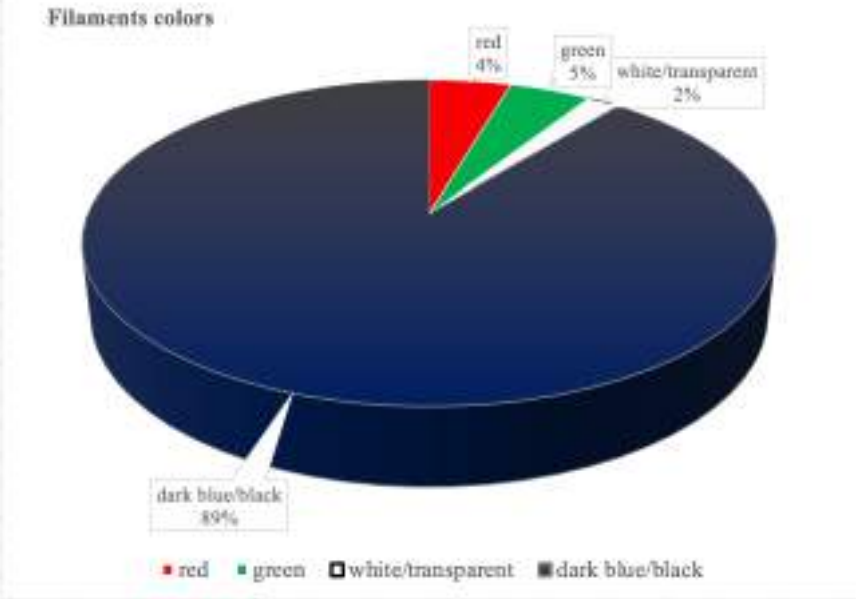


Fibers, 1000 µm 20x

Fragments, 20 µm 20x

Fragments, 20 µm 350x

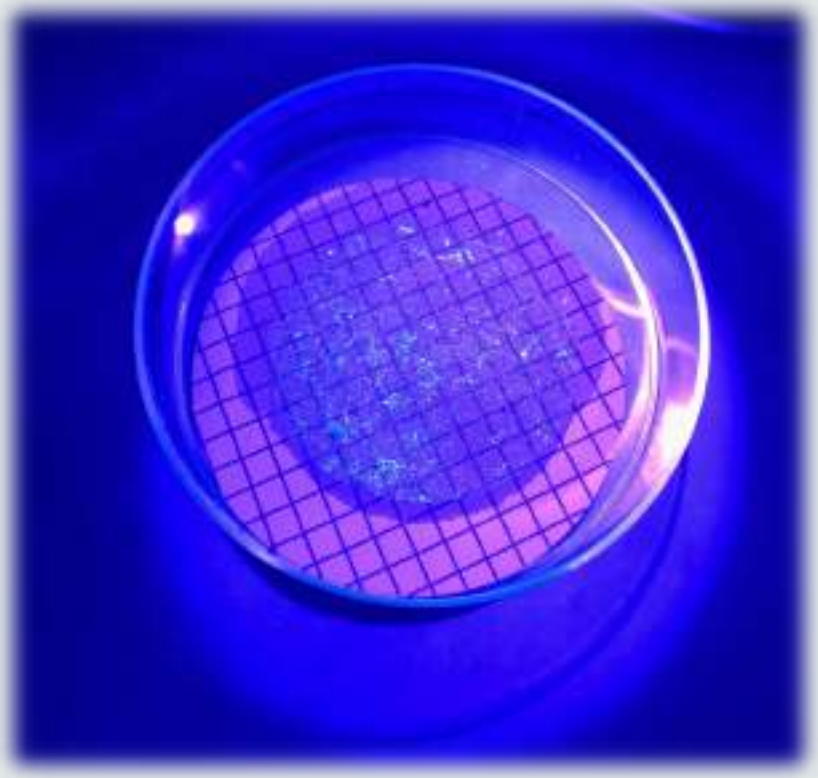




Alberoni Oasis Results MPs/Kg d.m.

Size Class	Filament/Fiber	Fragment	Film	Beads/Pellet	Sponge	Total
1000-5000 µm	29 ± 8	29 ± 9	0	0	0	59
300-1000 µm	39 ± 10	26 ± 8	1 ± 1	6 ± 2	0	72
100-300 µm	42 ± 11	31 ± 9	4 ± 1	11 ± 4	0	88
Total	110	87	5	17	0	

- Fibers confirm to be the most abundant MPs kind
- Dark color is predominant
- Compared to the most recent results featuring thousands MPs/kg in Malaysia (Khalid et al. 2025) or Galapagos (Basurto Alcívar et al. 2024) present results are encouraging
- They are slightly higher than those found in the UNESCO Biosphere Reserve in Vietnam (31.99 to 92.56 MPs/kg) even if in that case the density separation salt was NaCl hence not all MPs could have been estimated (Khuyen et al. 2021).



Microscope observation of the retentate on each filters (with/without Wood lamp) Consider negative controls

AGREE – Analytical GREEnness metric approach and software

DOI 10.1021/acs.analchem.0c01887

$ZnCl_2$ off-line
Standard procedure
Should go GREEN!

$Ca(NO_3)_2$ off-line
Expert Citizen Science

Sugar (or NaCl), in line
- Citizen Science
- Primary school

1. Sample treatment
2. Sample amount
3. Device positioning
4. Sample prep. stages
5. Automation, miniaturization
6. Derivatization
7. Waste
8. Analysis throughput
9. Energy consumption
10. Source of reagents
11. Toxicity
12. Operator's safety

HS-SPME-GC-MS
adsorbates and leachates

FTIR/μFTIR
polymer identification

Bioplastics
at ITT Montani

Green
Chemistry

Green Analysis
of MPs
at ITT Montani

Analysis of pyrolysis
products at ITT Montani
(Chemical Recycling)

Joinable

Take home messages

- Full coverage of MPs monitoring along the Italian Coasts through ITTs engagement
- Progressive IBL didactic path (Curricolo Verticale) and levels
- Outreach events to foster public awareness, engagement and responsible consumption bridging the gap between scientists and the community

NUOVO CICLO TEMATICO A.S. 25-26
dedicato a chimica e sostenibilità

- Microplastiche: un confronto tra industria e NGO (con Legambiente)

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Microplastics in Sand: Green Protocol for Expert Citizen Science over Large Geographical Areas

by Teresa Cecchi

https://doi.org/10.3390/app152413007

μMED INTERNATIONAL CONFERENCE ON MICROPLASTIC POLLUTION IN THE MEDITERRANEAN SEA

Special Thanks to

- **ITT Montani: Dr.ssa Stefania Scatasta, Prof.ssa Nadia Fraticelli, Prof. Roberto Barbieri and Students Armanu Dragos, Bianconi Lorenzo, Bordoni Riccardo, Callarà Sofia, CAnnavò Michele, Patrizi Cecilia, Plosko Patrizia, Prebibaj Daniel, Scrascia Giuseppe, Tschauschev Eros, Zhang Cristina**
- **VLPF: Dr. Davide Poletto and Dr.Gherardo Toso**