Analisi Green delle Microplastiche nella Sabbia

Un laboratorio fra Citizen Science e Letteratura

Teresa Cecchi

ITT Montani, Fermo

XI Scuola Nazionale di Didattica della Chimica "Giuseppe del Re"

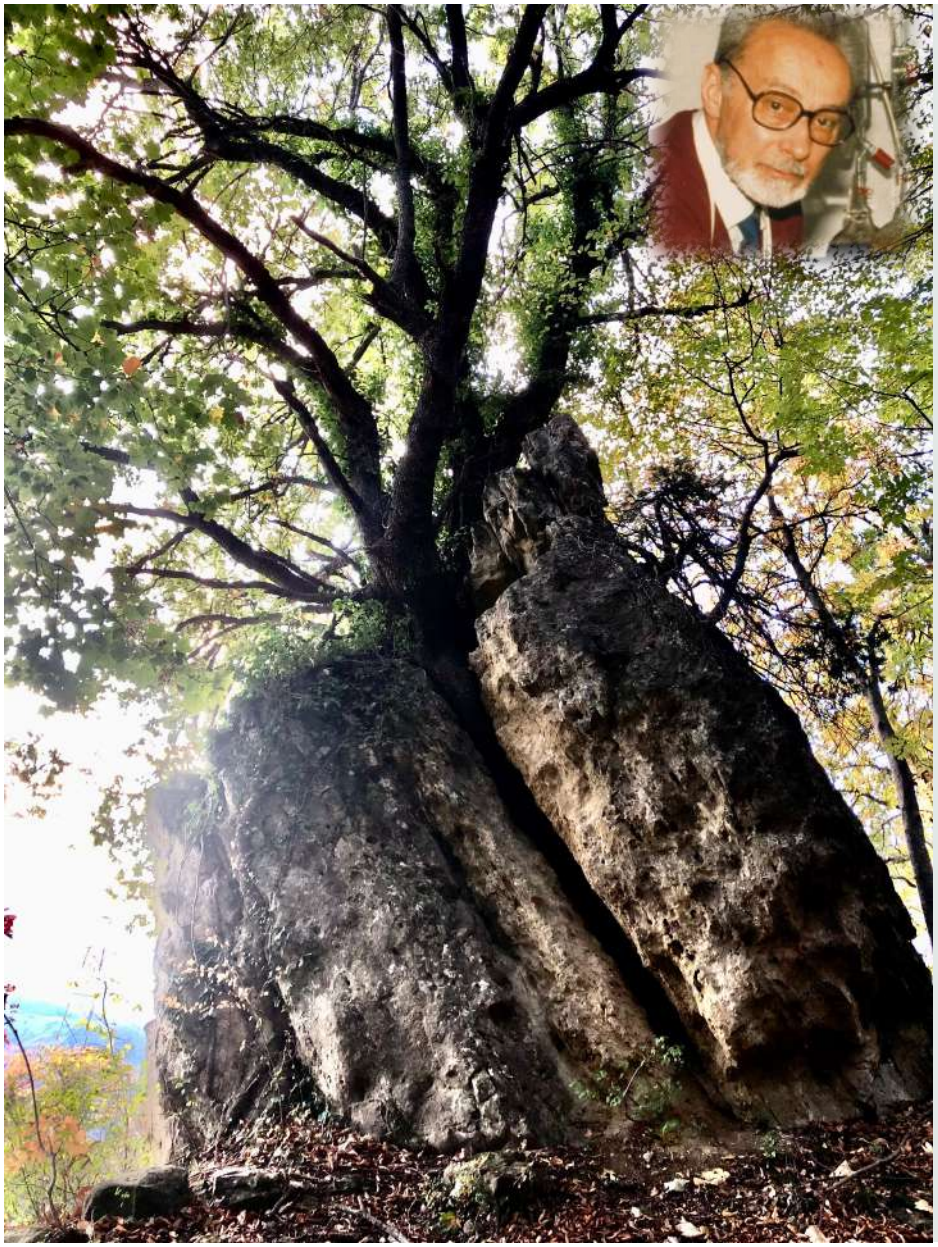
Chimica e Contaminazioni

cecchi.teresa@istitutomontani.edu.it

Società Chimica Italiana
Divisione di Didattica Chimica

Piano Nazionale Lauree Scientifiche

VIRTUS ET LABOR
1854
MONTANI FERMO



Primo Levi
Il sistema periodico - Carbonio

L’anidride carbonica che “costituisce la materia prima della vita, la scorta permanente a cui tutto ciò che cresce attinge, e il destino ultimo di ogni carne, non è uno dei componenti principali dell’aria, bensì un rimasuglio ridicolo, un’impurezza”

Il Carbonio dell’anidride carbonica
ogni 200 anni entra nel ciclo della vita
“dalla stretta porta della fotosintesi”

Il Carbonio nella plastica deriva da organismi vissuti 10 - 100 milioni di anni fa
Ogni pezzo di plastica è un “reperto fossile”

Background
Macroplastics in Sibillini National Park



From Macro to Mps P.S. Giorgio Beach



















What is the best matrix for citizen science? SAND



Plastics have become a vital asset for humanity

1856 — *A. Parkes* **Parkesine** (Nitrocellulose derivative)



1865 — *J.W. Hyatt* **Celluloid** (Nitrocellulose Derivative with camphor) Kodak (1889), film industry



1891 — *L. M. H. Berniguat* **Rayon** (Cellulose derivative)



1898 — *H. von Pechmann* (1898) **PE** *(Polyethylene)*



1907 — *F. Kipping* (1907) **Silicone**

1907 — *Leo Baekeland* (1907) **Bakelite** (phenol formaldehyde resin)



1912 — *J. E. Brandenberger* (1912) **Cellophane** (Cellulose derivative)



1912 — *H.V. Regnault (1835 stiff PVC;) W. Semon (1926 flexible PVC)* (Polyvinyl Chloride)



1930s — *O. K. J. Röhm* (1933) **Plexiglas**

1930s — *W Carothers* (1935) **Nylon** (polyamide)



1938 — *R. Plunkett* (1938) ***PTFE*** *(Polytetrafluoroethylene)*



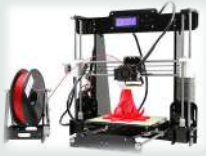
after 1950 — ***ABS*** *(Acrylonitrile Butadiene Styrene)*



after 1950 — *G. Natta (1954)* **PP** *(Polypropylene)*



After 2000 — ***PLA PHA PBS PBAT PCL*** *(bioplastics)*





After 2000 — **PET** *(Polyester)*



Composites

Educazione Civica

- 2023 → REACH 2023/2055 –
  Restrizione su MPs intenzionalmente aggiunte
  (ambito sportivo, cosmetico, fertilizzanti...)
- 2024 → Urban Wastewater Treatment Directive -MPs nelle acque reflue.
- 2024 → Decisione 2024/1441/Ue si affianca al Dlgs 23/2/2023 –MPs acque potabili
- 2025 → Plastic pellets regulation – prevenzione della perdita dei pellet plastici
- 2026 → Regulation 2026/1168 Aggiornamento della restrizione REACH sulle microplastiche intenzionalmente aggiunte.
- 2026 → Modifica Water Framework Directive, Environmental Quality Standards Directive e Groundwater Directive - Per la prima volta, introduce esplicitamente il monitoraggio delle MPs fra inquinanti delle acque. Gli Stati membri dovranno recepire le modifiche entro il 22/12/2027

Dimensional definition of MP

< 5 mm. REACH

20 µm - 5 mm EU (2024)

MPs research and monitoring is needed

- Project-based learning develops students' talent and engagement with sustainability
- Absence of standardized protocols
- Expert Citizen Science expands 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):

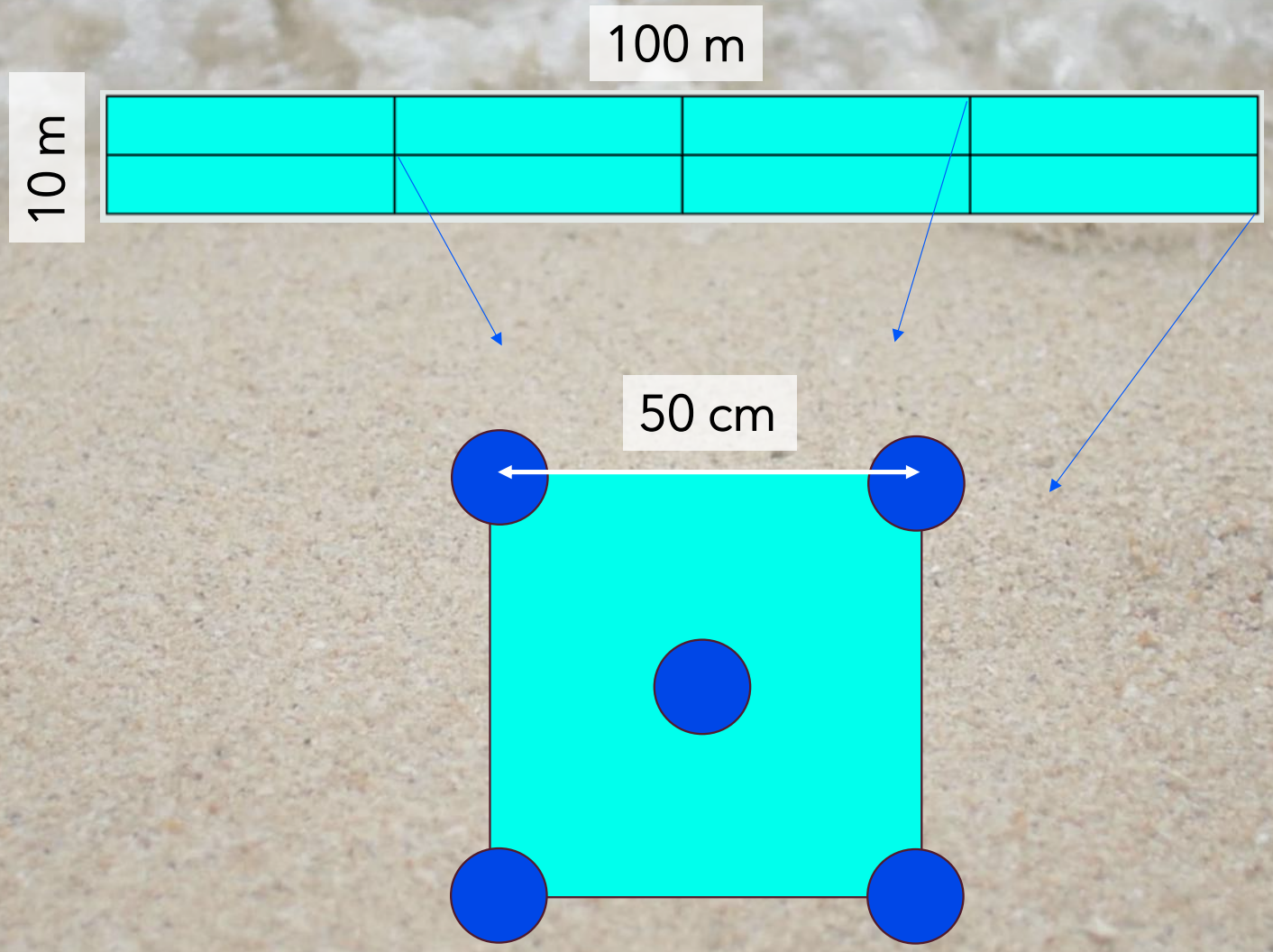
Citizen Science helps, but it must go GREEN

Green Chemistry and Outreach –IBL and CLIL

Domande stimolo

1. Come svolgere un campionamento efficiente e rappresentativo?
2. Quali precauzioni evitano che il campione si contamini con MP dal laboratorio?
3. A quale temperatura è bene essiccare la sabbia?
4. Come isolare le MP dalla sabbia con un metodo efficiente ma green?
5. Come evitare che materiale biotico potenzialmente galleggiante possa essere confuso con le MP?
6. Come quantificare correttamente le MP dividendole per classi dimensionali/forma/colore?
7. Come quantificare l'aderenza ai 12 Principi della Chimica Verde di questo protocollo innovativo?
8. Come massimizzare l'impatto educativo di questa attività a livello scolastico e sulla società?
9. Come valutare gli apprendimenti?

Representative Sampling




In Lab Experiment
Expert citizen science (GREEN)



Avoid contaminations in the lab

Sample Dry Sieve Weigh Float Oxidise Sieve Rinse Filter Observe















Discard retentate
> 5000 µm

Return settled
sand to the beach

Results in
triplicate for
each size class

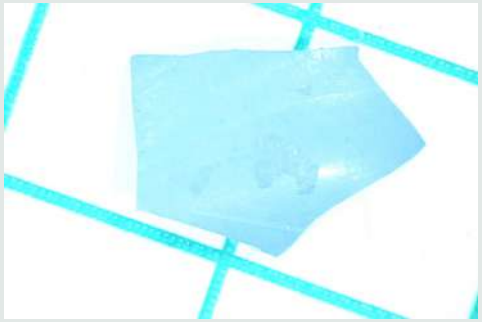
Workflow
blank: sand in muffle furnace for 4 h 450°C



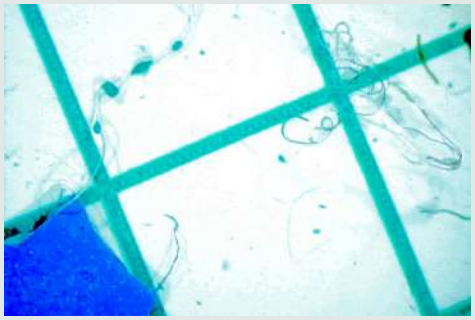
1000-5000 µm 20x



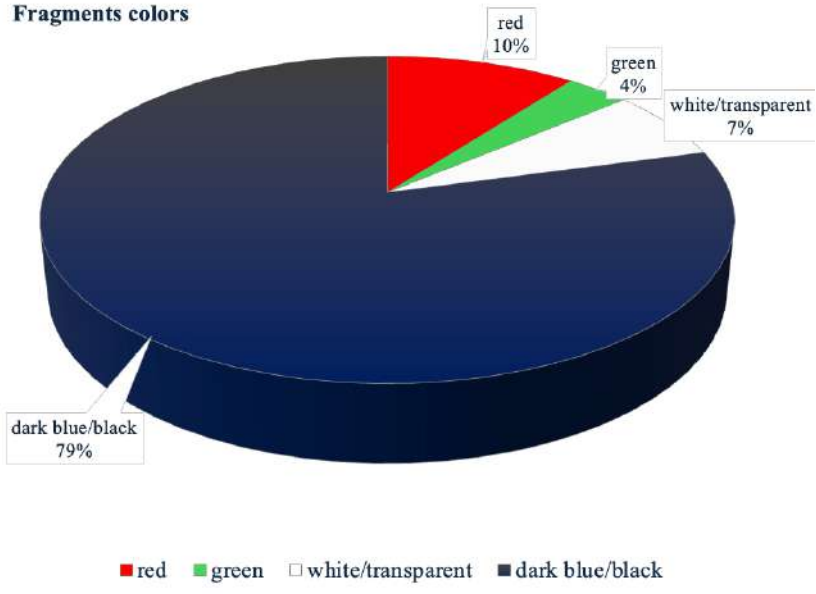
Red fragment

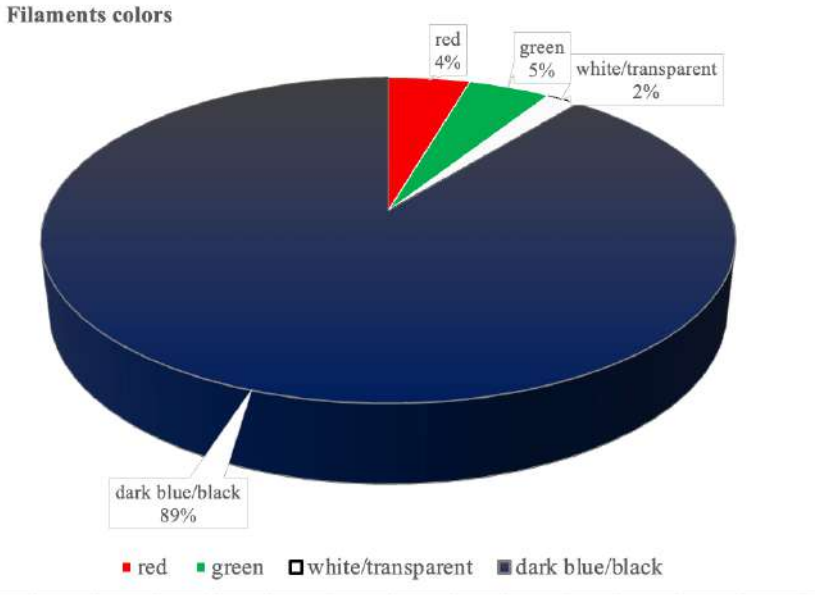


Blue Fragment

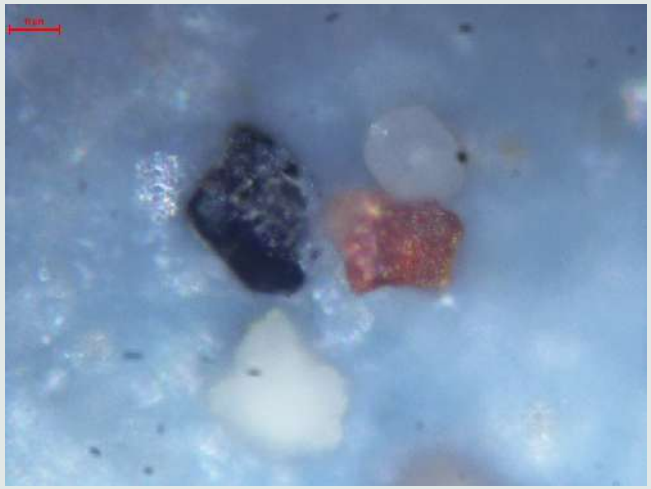


Fibers

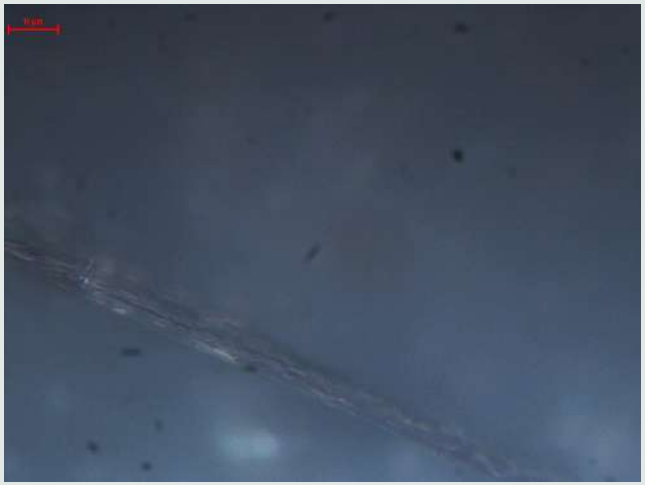


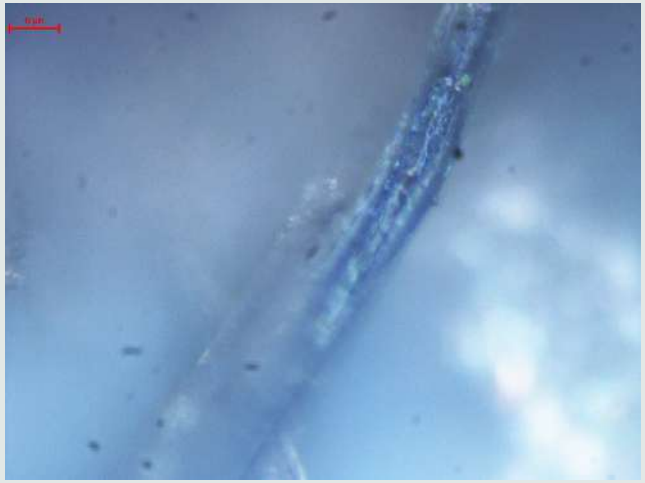


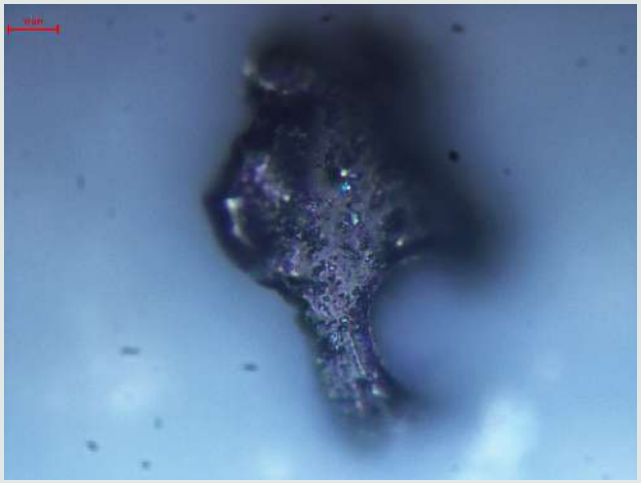
20-75 µm 500x

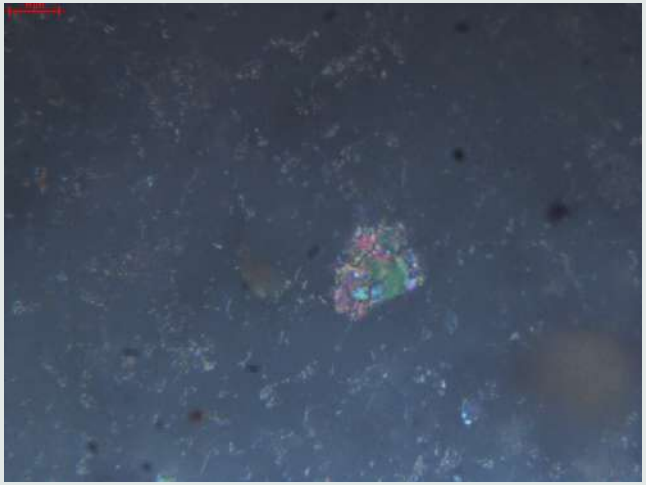


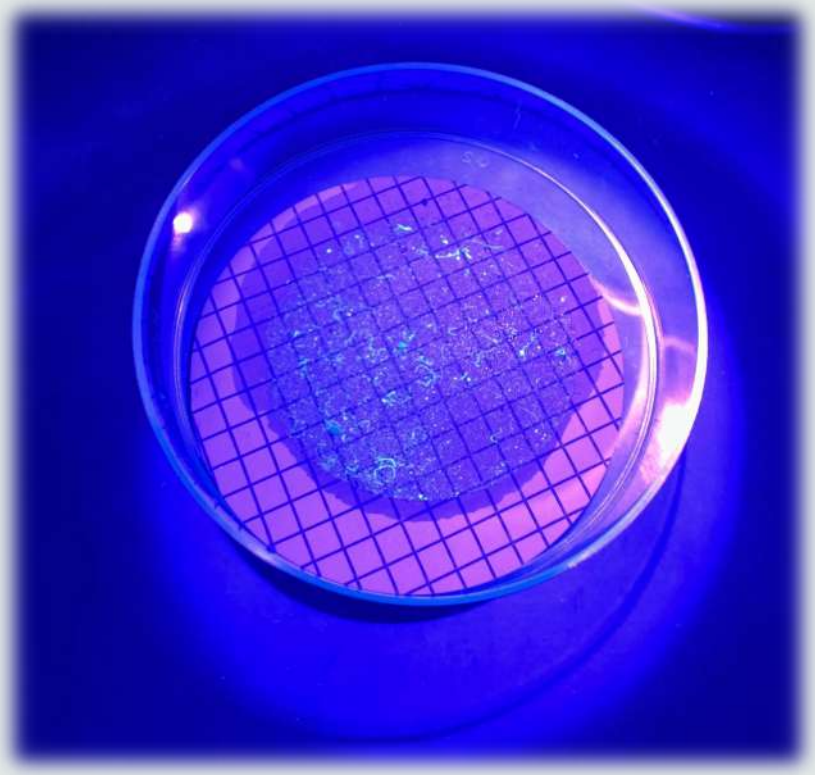








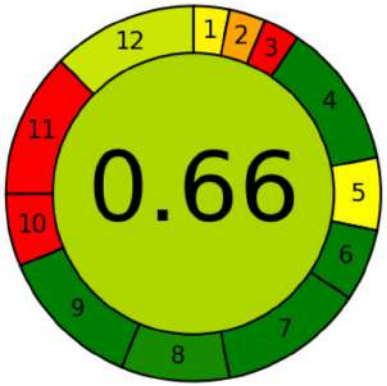




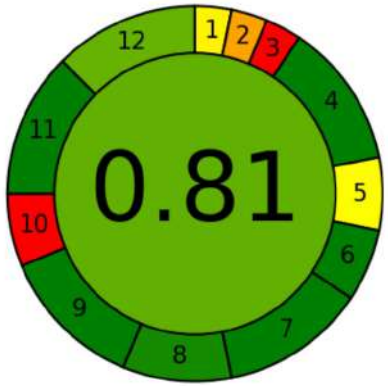
Microscope observation of the retentate on each filters (with/without Wood lamp) Consider Blank controls

AGREE – Analytical GREEnness metric approach and software

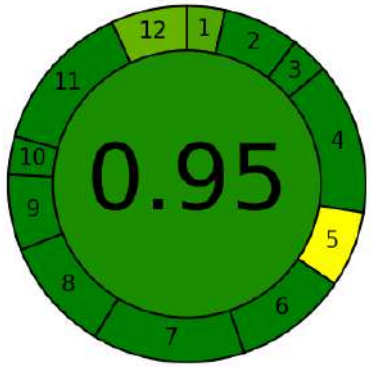
DOI 10.1021/acs.analchem.0c01887



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



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

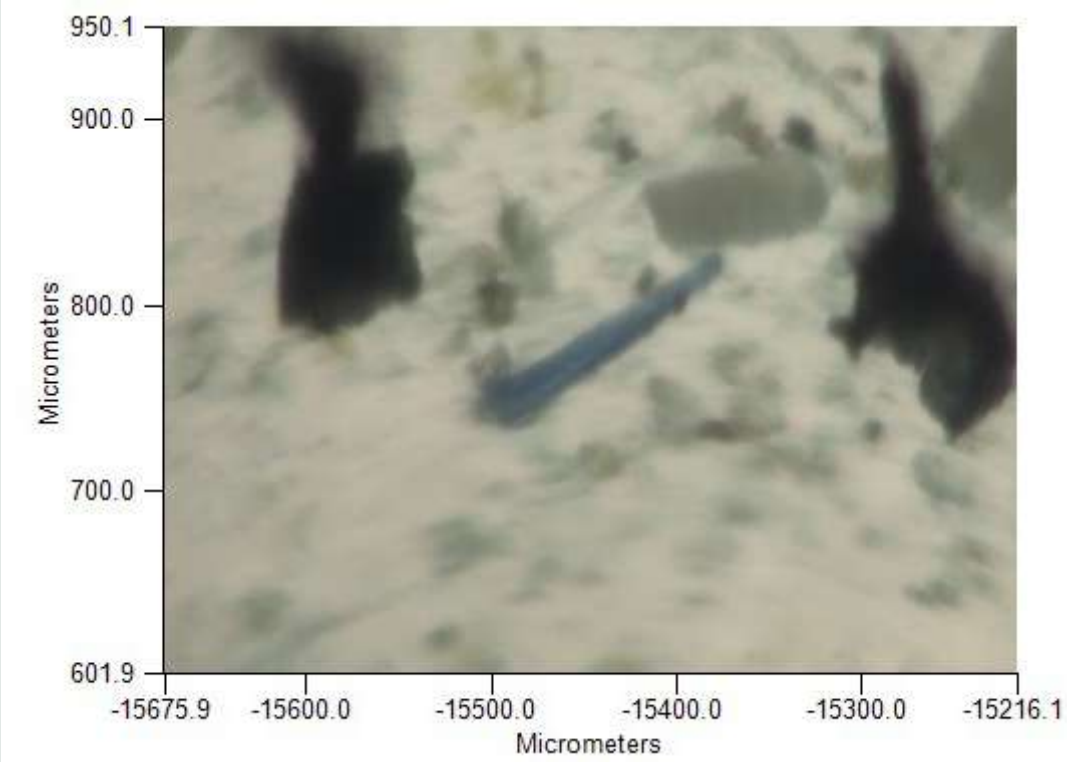


Sugar (or NaCl), in line

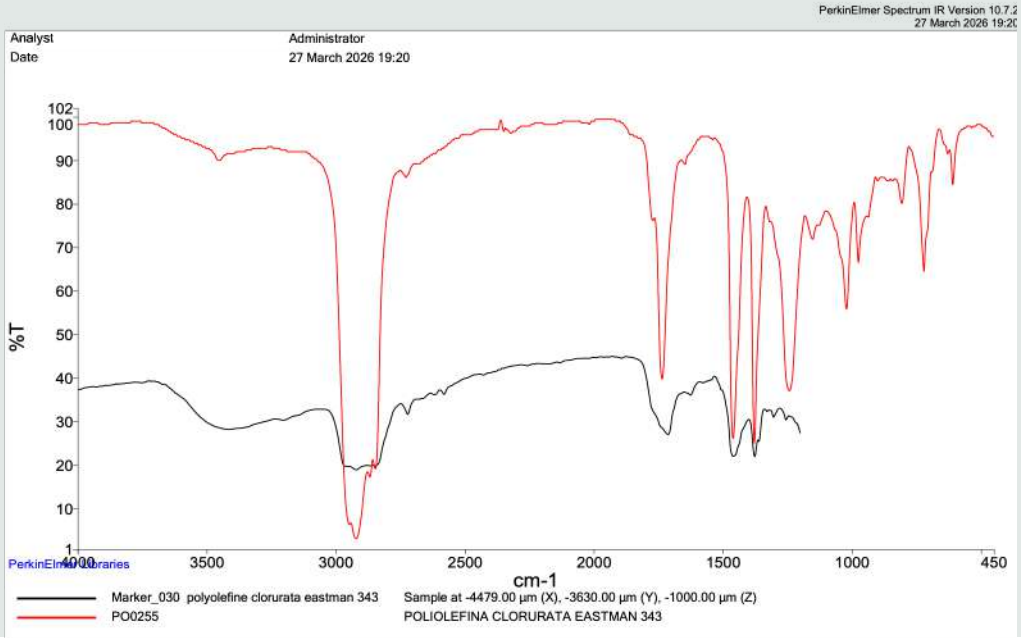
- Citizen Science
- Primary school

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

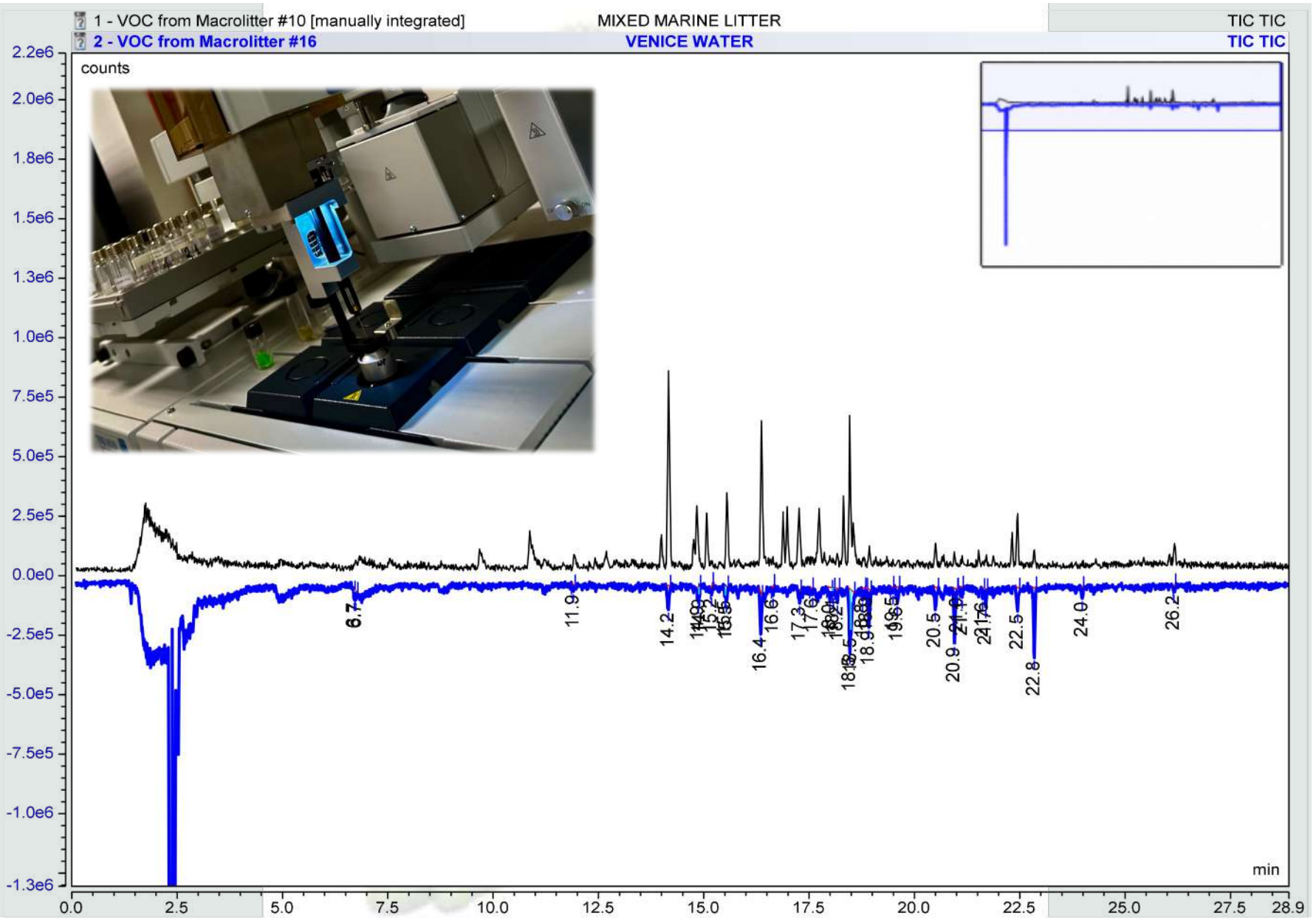
PVC fragment µFTIR
Polymer identification







HS-SPME-GC-MS adsorbates and leachates



Bioplastics



Green Chemistry

Green Analysis of MPs

Chemical Recycling



Scientific aspects https://www.mdpi.com/2076-3417/15/24/13007



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

by Teresa Cecchi

Istituto Tecnico Tecnologico (ITT) "G. e M. Montani", Via Montani 7, 63900 Fermo, Italy

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Didactic aspects https://chimicanellascuola.it/index.php/cns/article/download/311/560



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Convegno 2025 della Divisione di Didattica
Contributi brevi

Analisi Green delle Microplastiche nella sabbia dei litorali italiani: una proposta di *Citizen Science*

Teresa Cecchi[1] e Davide Poletto[2]

Outreach

- 2° Prize Giffoni Film Festival https://vimeo.com/1207424985/0e209d81bd?fl=ip&fe=ec&share=copy
- FermHamente Fermo 23-25/10/26 https://fermhamente.it/attivita/plastisfera-e-citizen-science/
- Maker Faire Eu Edition Rome 23-25/10/26



PLASTISFERA

ROME Maker Faire® THE EUROPEAN EDITION

GIFFONI

FERMHAMENTE Festival della SCIENZA di Fermo

Take home messages

- Full coverage of MPs monitoring along the Italian Coasts through ITTs engagement
- Outreach events to foster public awareness, engagement and responsible consumption bridging the gap between scientists and the community
- DDSCI involvement to shape societal changes and inspire policy makers

