Multifaceted effects of plastic pollution: features of micro-sized particles making them challenging pollutants to be addressed by regulatory actions

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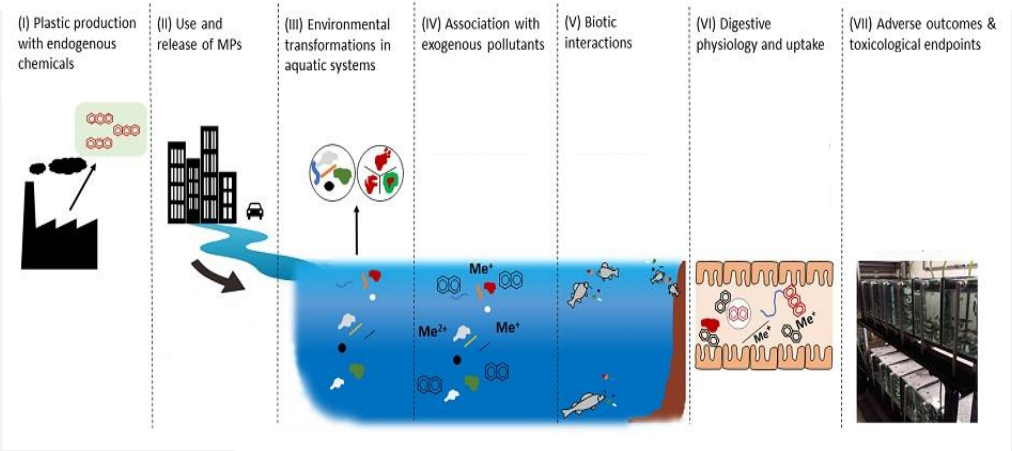
Plastic pollution: an issue of global concern

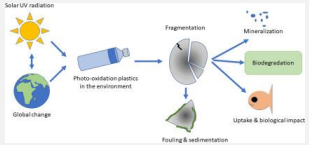
The increasing applications of polymers in everyday products inevitably results in the widespread presence of plastic waste in the natural environment

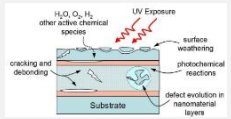
Plastics in the last decade represent 50-60% of municipal solid waste, 30-40% of industrial waste and between 15-25% of all hospital waste in developed countries

Plastic litter toxicity: why so variable?

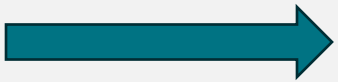


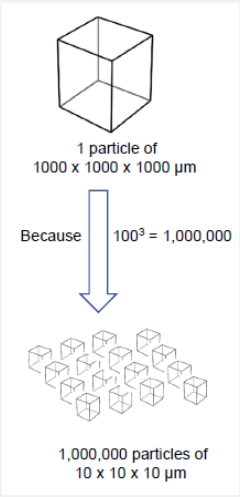
Khan, F. R., Catarino, A. I., Clark, N. J. (2022). Emerg. Top. Life Sci.

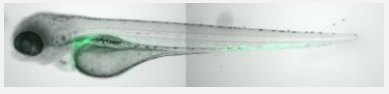




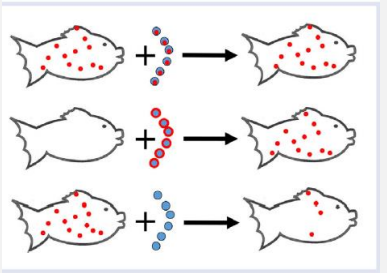
Plastic litter: size matters ….

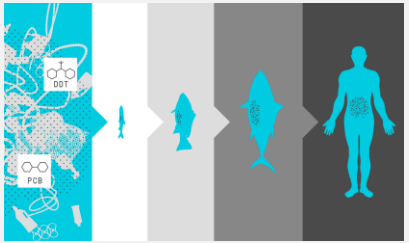






Credit: Neel Aluru, WHOI





Environmental risk assessment & pollution management

Define and monitor **adverse effects** of plastic litter → Identify toxicity thresholds

Lessons learned from past experiences tackling other type of pollutants?

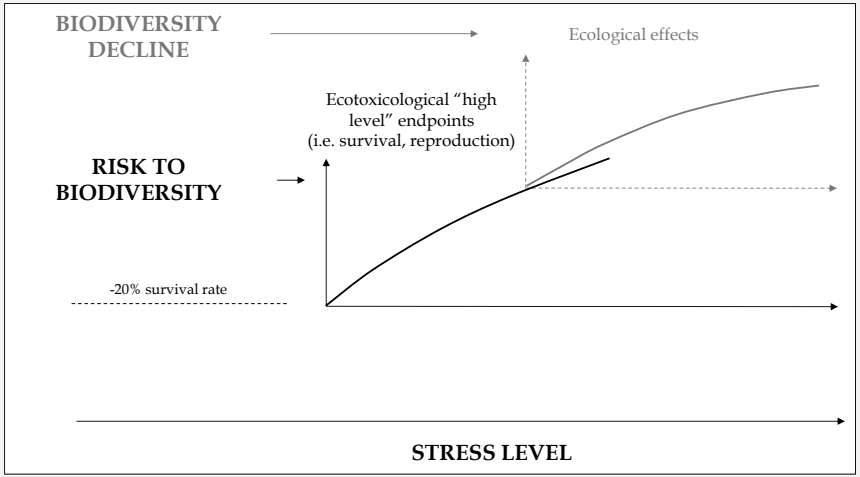
Toxicity trigger: **plastic particles vs adsorbed chemicals vs plastic additives leached out**

Scientific tools applied to shape the policy initiatives

Risk assessment, impact assessment and life cycle assessment

Call for a reliable **environmental risk assessment procedure**

Correctly identify the **health status of the environment** and enable actions **if** needed



Plastic litter toxicity: some dilemmas from a regulatory perspective

Key policy initiatives targeting plastic pollution are based on scientific evidence…

Thresholds definitions for actions → Environmental management

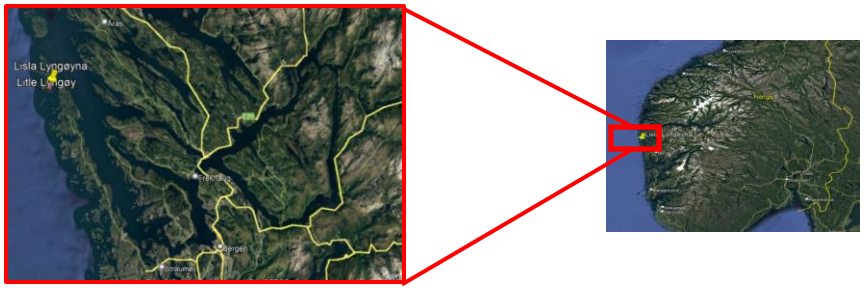
Mandatory action requested!

Action suggested

No action needed

Background

Plastic polluted Lisle Lyngøyna island, Hordaland- Norway



The area has been previously characterized for long term plastic pollution and as such represents a unique field “open lab” where a large amount of stranded marine litter has been buried in time and several ecological processes can be followed and studied including plastic fragmentation, release of plastic adsorbed chemicals and plastic’s interaction with flora and fauna.

Handelens Miljøfond

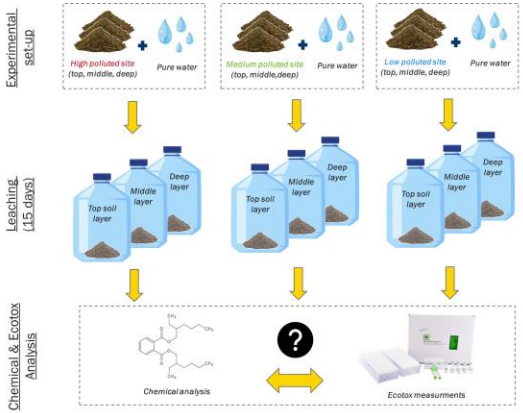
Characterization and profiling in soil layers

Top (0-5 cm), median (25-35 cm) and bottom (75-85 cm) soil layers were collected for analysis

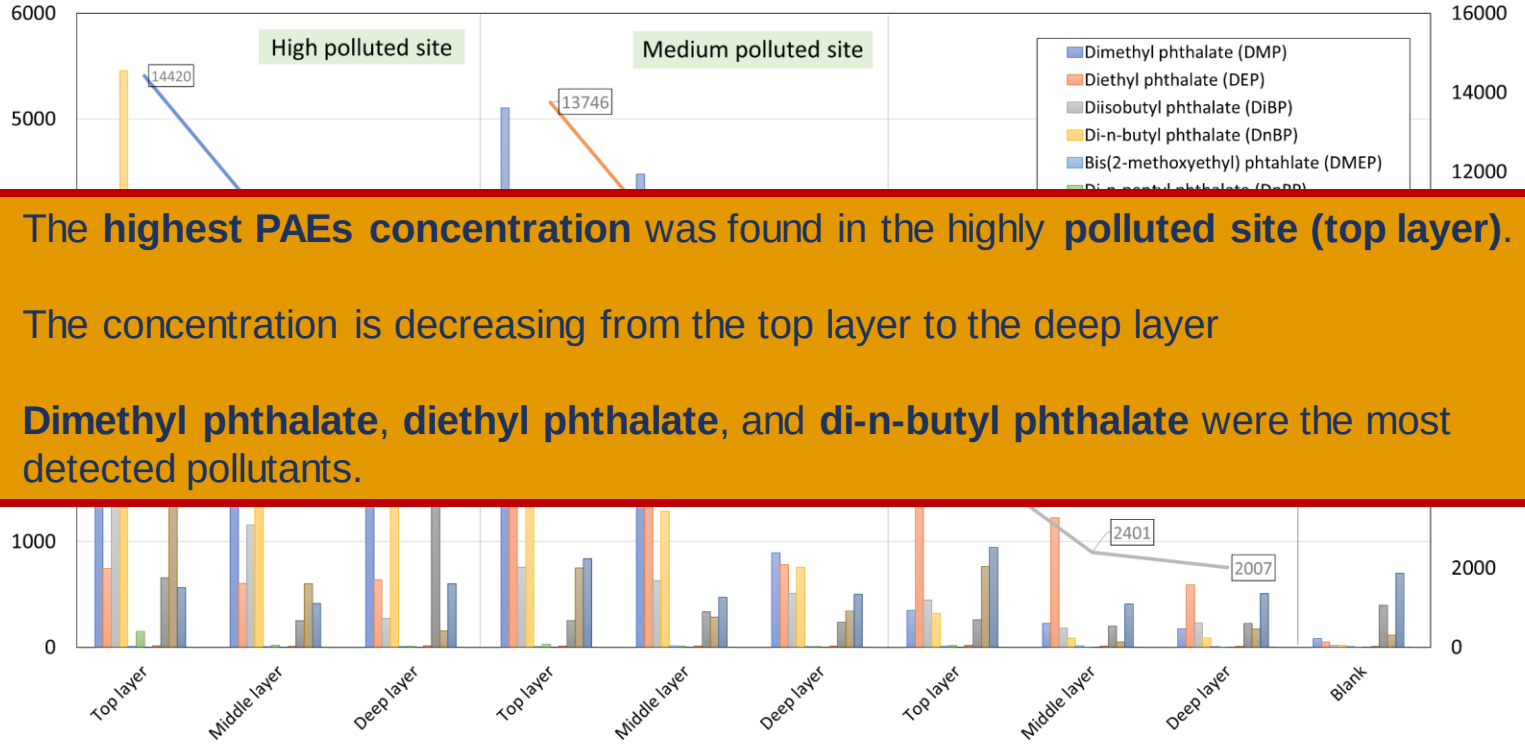
Task 1 - Leachates extracted from soil using a freshwater model medium to evaluate the tendencies of chemicals to “easily” leach from the degraded plastics or contaminated soil

Task 2 – Chemical characterization of the leachates

Task 3 – Test the ecotoxicity of obtained leachates

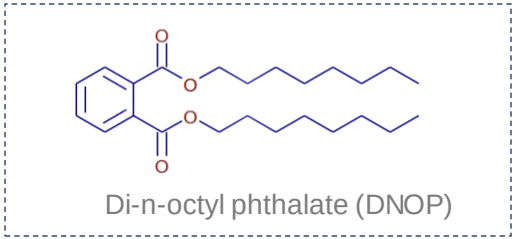


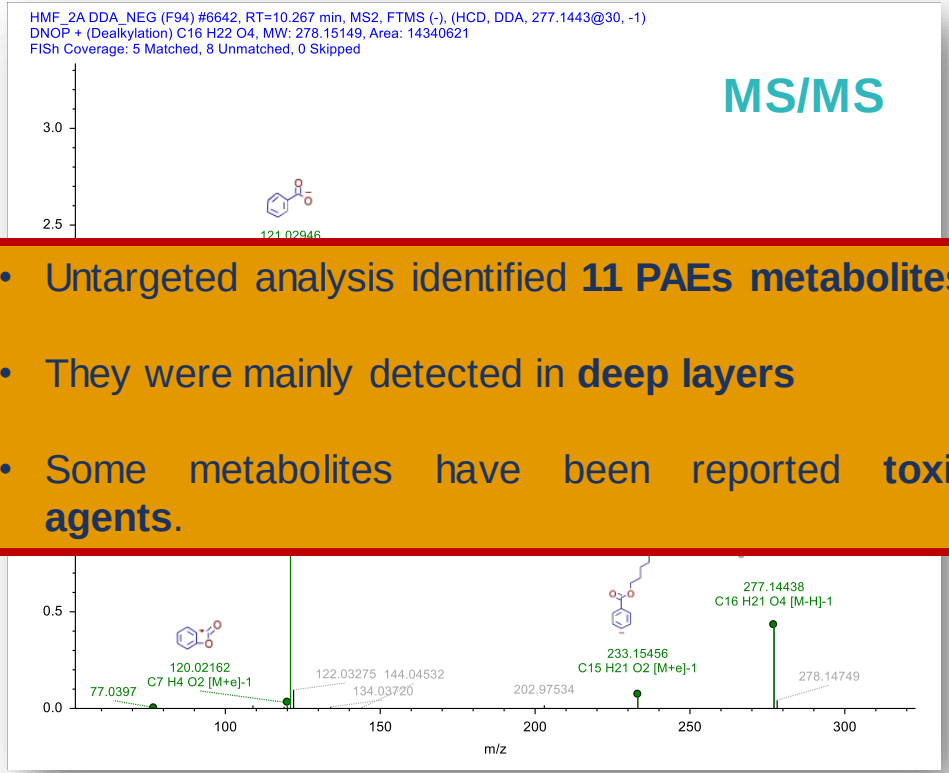
Results chemistry



- The **highest PAEs concentration** was found in the highly **polluted site (top layer)**.
- The concentration is decreasing from the top layer to the deep layer
- **Dimethyl phthalate**, **diethyl phthalate**, and **di-n-butyl phthalate** were the most detected pollutants.

Results chemistry





- Untargeted analysis identified **11 PAEs metabolites**
- They were mainly detected in **deep layers**
- Some metabolites have been reported **toxic agents**.

Take home message

•The levels of buried plastic items correlates well with the levels of chemicals contamination

•The scored higher toxicity in the deeper layers points out that most of the chemicals and their metabolites are percolating to deeper layers

•An effective environmental risk assessment procedure need to be developed enabling both a correct evaluation of the environmental quality of plastic contaminated as well as the identification of the correct restoration and ri-qualification actions considering the plastic litter but also their associated leached chemicals and additives

Characterization of car tire rubber particles toxicity using a multiple endpoints approach in a combination of marine, freshwater and terrestrial biological models

Hypothesis 1: *the composition of chemicals leaching from car tire rubber (CTR) particles is constant in time.*

Hypothesis 2: *Under natural like conditions the leaching is more effective in marine environments (from a purely chemical perspective) resulting on different -toxicity in relation to marine, freshwater and terrestrial organisms.*

Hypothesis 3: *the cocktail of chemicals leached from tyre wear particles elicit different toxic effects (with different magnitude) in marine, freshwater and terrestrial environments*.

Ecotoxicity assessment of leachates

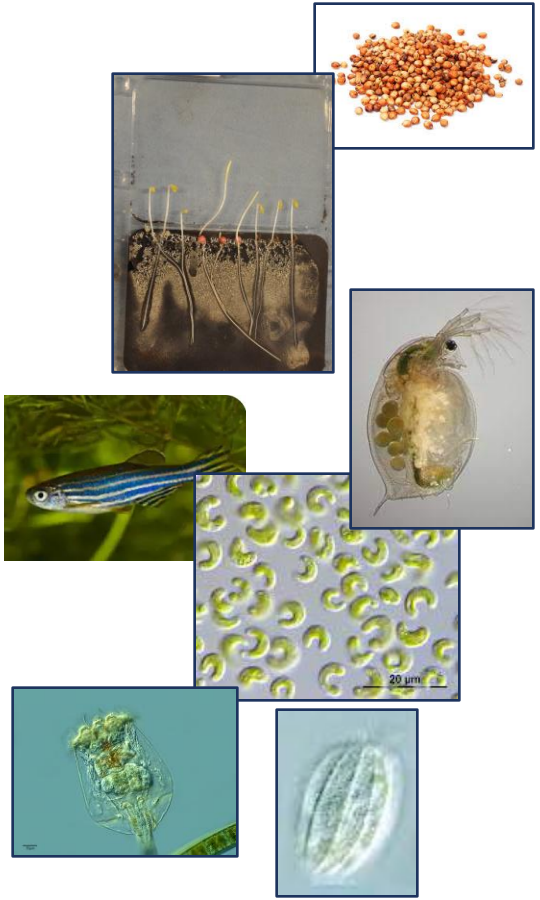
Multiple species assessment

- Terrestrial plants physiology assessment: germination and roots elongation tests. Genotoxic effects on native plants applying the micronucleus formation test.

- Application of a robust freshwater and marine environments biological model: the crustacean D. magna using a combination standard toxicity testing like mortality with a suite or sub lethal stress addressing oxidative stress, genotoxicity, cell functioning impairment and the zebrafish embryo survival rate & gene expression rate

- Assessing the effects in biological models playing a key role in the ecosystems as primary producer autotroph organism in freshwater and marine environment: *R. subcapitata and P. tricornutum*

- Testing promising biological models: freshwater protozoans (*Euplotes spp*) and rotifers (*Brachionus spp*)



Knowledge needed to facilitate regulatory actions

Studies addressing **toxicity in tandem with toxic chemical** is very important to understanding MPs dynamics and developing a mitigation strategy

Humans are probably the most exposed organism because they are at the top of the food chain and are exposed to high levels of urban microplastics

There is **still a lot of uncertainty related to determining the harms of plastic pollution**

It is therefore important that **policy initiatives allow for flexibility and continuing adjustment to the on-going knowledge generation** and that it is made possible to provide **continue relevant research and the science-informed policy development**

THANK YOU

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