FROM POLLUTANTS TO PROPAGATORS:

Unveiling microplastics as vectors for trace elements

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SCAN ME

Aim of the SANO 3D group

Understanding the combined effects of microorganisms and toxic trace elements on microplastics (MP) in the marine environment.

Objective

To perform a literature study on the effects of microplastics as vectors for toxic trace elements in the marine environment.

Two questions were rised prior to the study:

1. Which polymer is a better adsorbent of which toxic metals?
2. How does environmental parameters affect the interaction between MP and toxic trace elements (temperature & pH)?

Background

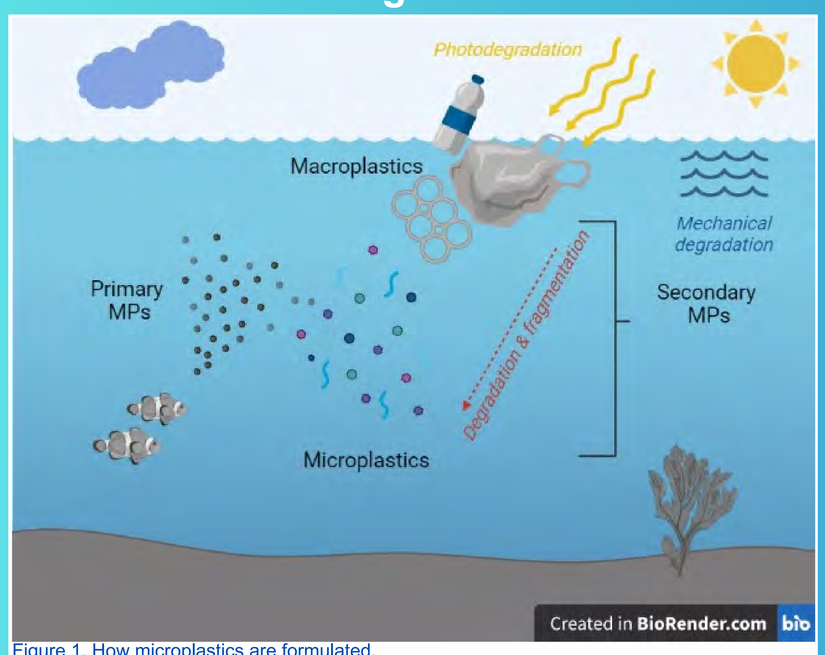
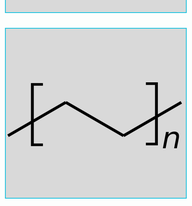
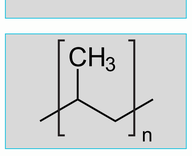
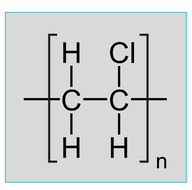
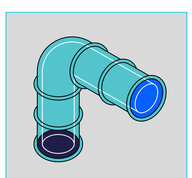
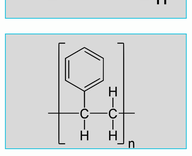
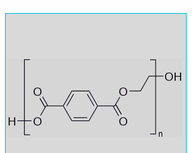


Figure 1. How microplastics are formulated.

- Microplastics are classified as small semi-synthetic plastic polymers with a size smaller than 5 mm [14].
- Plastic is cheap, durable, lightweight, and versatile therefore there are unlimited possible applications for it.
- When plastics are exposed to sunlight, UV radiation breaks down the polymer chains which is known as photodegradation.
- Photodegradation weakens the plastic's structure, making it more prone to physical degradation and fragmentation, and are seen as the starting point of plastic degradation[19].

Polymer	Structure	Material	Properties
Polyethylene (PE)			Most resistance to light degradation. But once aged its easily degraded by miroorganisms
Polypropyle-ne (PP)			Less degradable by microorganisms than PE.
Polyvinyl-chloride (PVC)			Susceptible to light degradation, especially after one Cl groups is removed.
Polystyrene (PS)			Susceptible to light degradation, due to the ring stucture.
Polyethylene teraphthalat-e (PET)			Degradation occur very slowly.

How do environmental parameters affect the interaction between microplastics & trace elements?

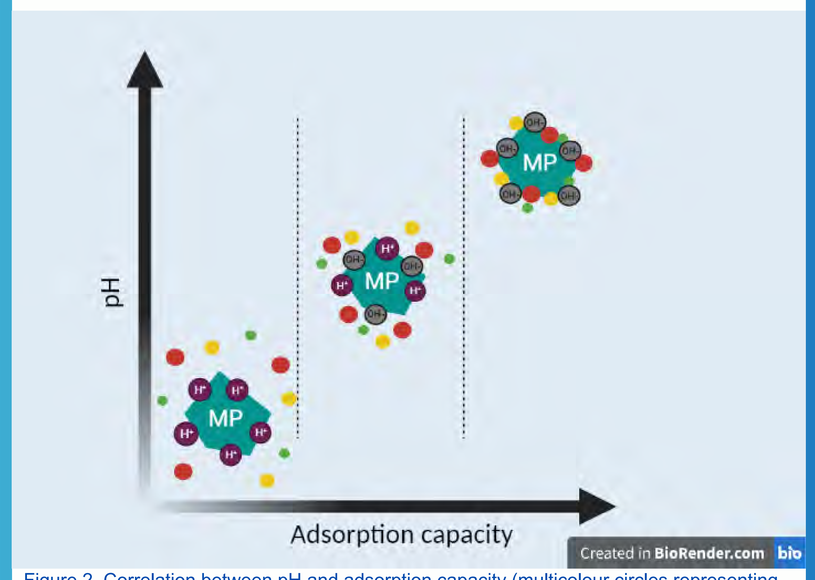


Figure 2. Correlation between pH and adsorption capacity (multicolour circles representing metals).

- The pH of the environment is seen as the most important factor [20] which alter the charge characteristics of microplastics and toxic metal ions.
- Adsorption is defined as the physical interaction between a surface and a metal ion [29].
- Decreased adsorption of positively charged elements at lower pH could be explained by the competition with H+ in the water. Examples are Cu, Cd, Pb, and Hg [30].
- Conversely, lower pH tends to increase the adsorption of negatively charged elements such as As and Cr [30].
- Low pH can release trace elements because their chemical properties changes [31].

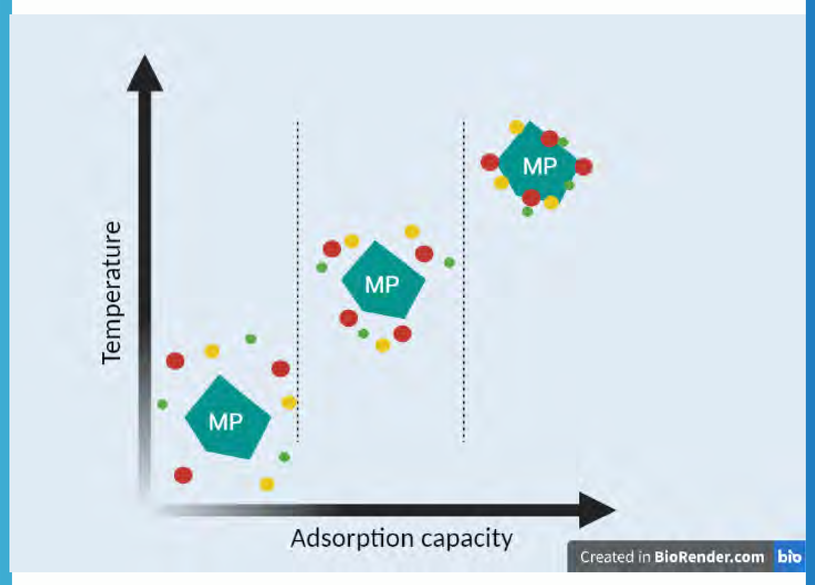


Figure 3. Correlation between temperature and adsorption capacity (multicolour circles representing metals).

- Temperature can impact the kinetics of adsorption and desorption processes.
- Higher temperatures generally increase the rate of chemical reactions, including the adsorption of trace elements onto microplastics [10].
- Temperature can also affect the solubility and mobility of trace elements, potentially influencing their interactions with microplastics.

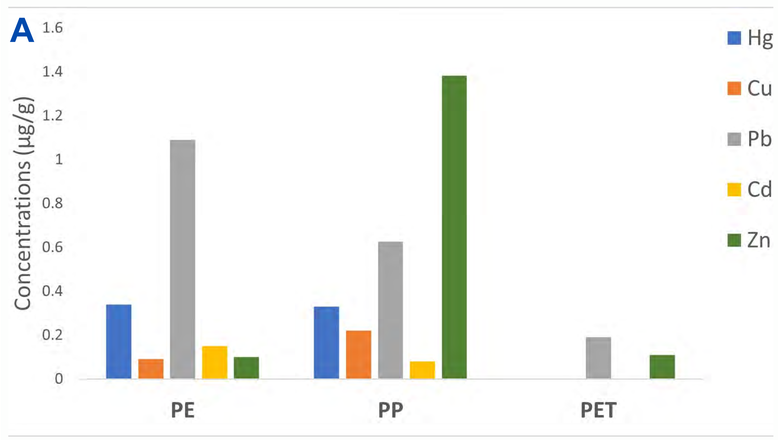
Why is microplastics good adsorbents

Microplastics have a high affinity for toxic and essential elements due to:

- Increased surface area with fragmentation
- Increased surface roughness with aging
- Changes in chemical composition at the surface
- Their negative charge in seawater.

Which polymer is a better adsorbent for which trace elements?

- Literature study of toxic and essential elements adsorption onto microplastic.
- The average concentration of elements adsorbed onto five microplastic polymer was examined.



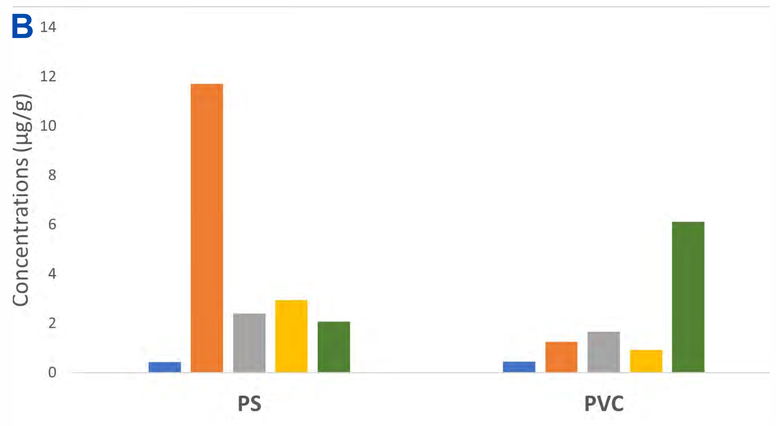


Figure 4. Plastic (polyethylene, polypropylene & polyadsorption rate to different toxic trace elements.

- Overall absoprtion PS > PVC > PP > PE > PET.
- Different polymers have different affinities for various toxic and essential elements.
- The age of the plastic in the enviornment may also determine the efficiency of adsorption.

Conclusion

- This literature study has provided evidence that MP is a good adsorbent due to its durable nature and abundance present in the environment.
- Temperature and pH levels are important environmental factors to take into consideration when studying MP.
- Certain toxic elements have higher adsorption capacity for specific MPs.
- Further research in the degradation of plastics is needed in different environmental conditions and biogeographical locations to confirm the adsorption and export of toxic and essential elements in marine environments.

Acknowledgement

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