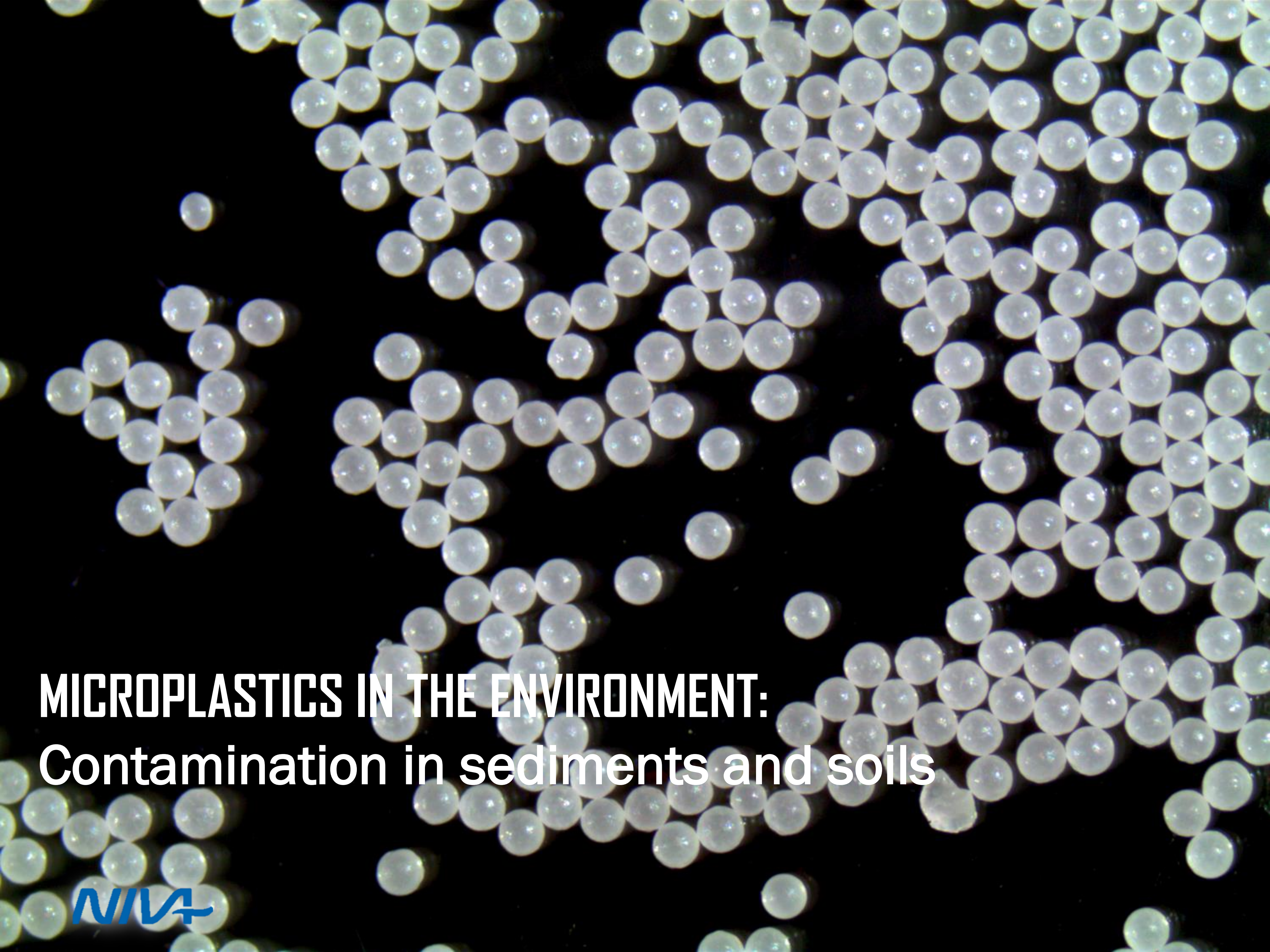


MICROPLASTICS IN THE ENVIRONMENT:
Contamination in sediments and soils

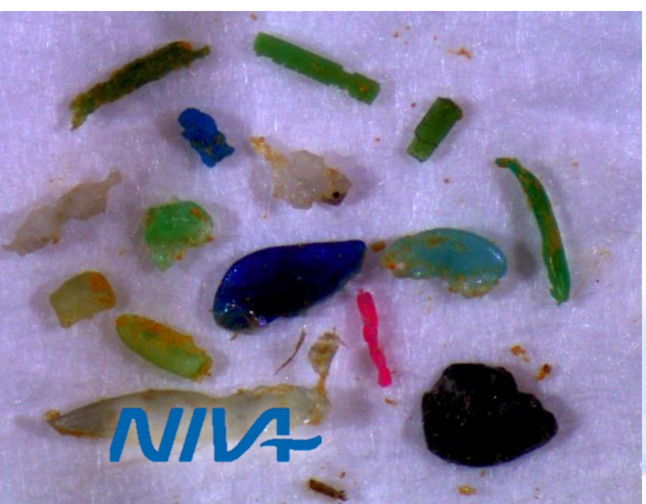
Microplastics

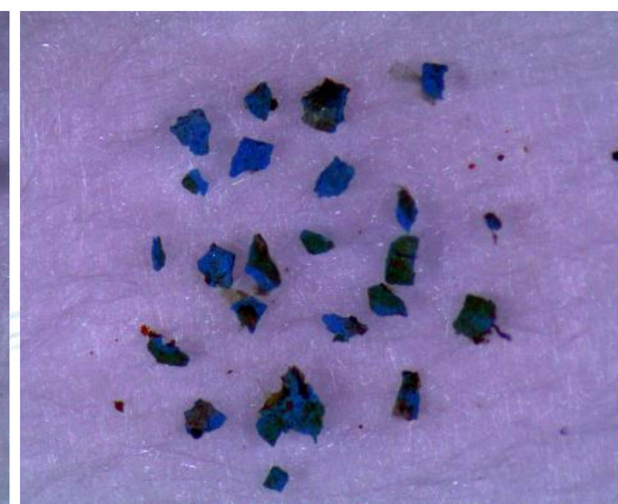
- Microplastics are defined as small plastic particles smaller than 5 mm (in some cases, <1 mm).

- They may be specifically designed (e.g. microbeads) or they may be produced when larger plastic items fragment

- Microplastic contamination is very heterogeneous, including a range of different shapes (microbeads, fibres, fragments etc.), sizes, and colours.

- Microplastics are also composed of a very wide range of polymer types and each of these have different characteristics (e.g. density, additives etc.).





Microplastics in sediments

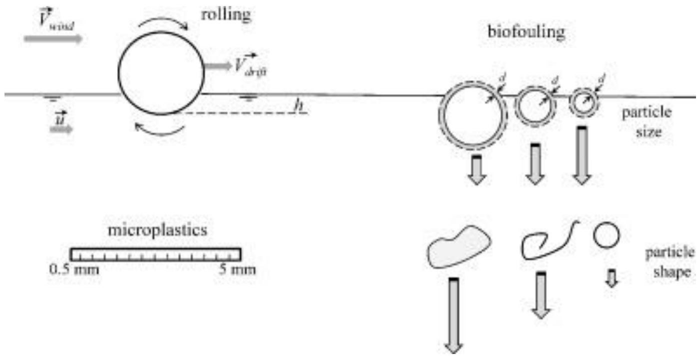
- Microplastics composed of different polymer types have different densities.

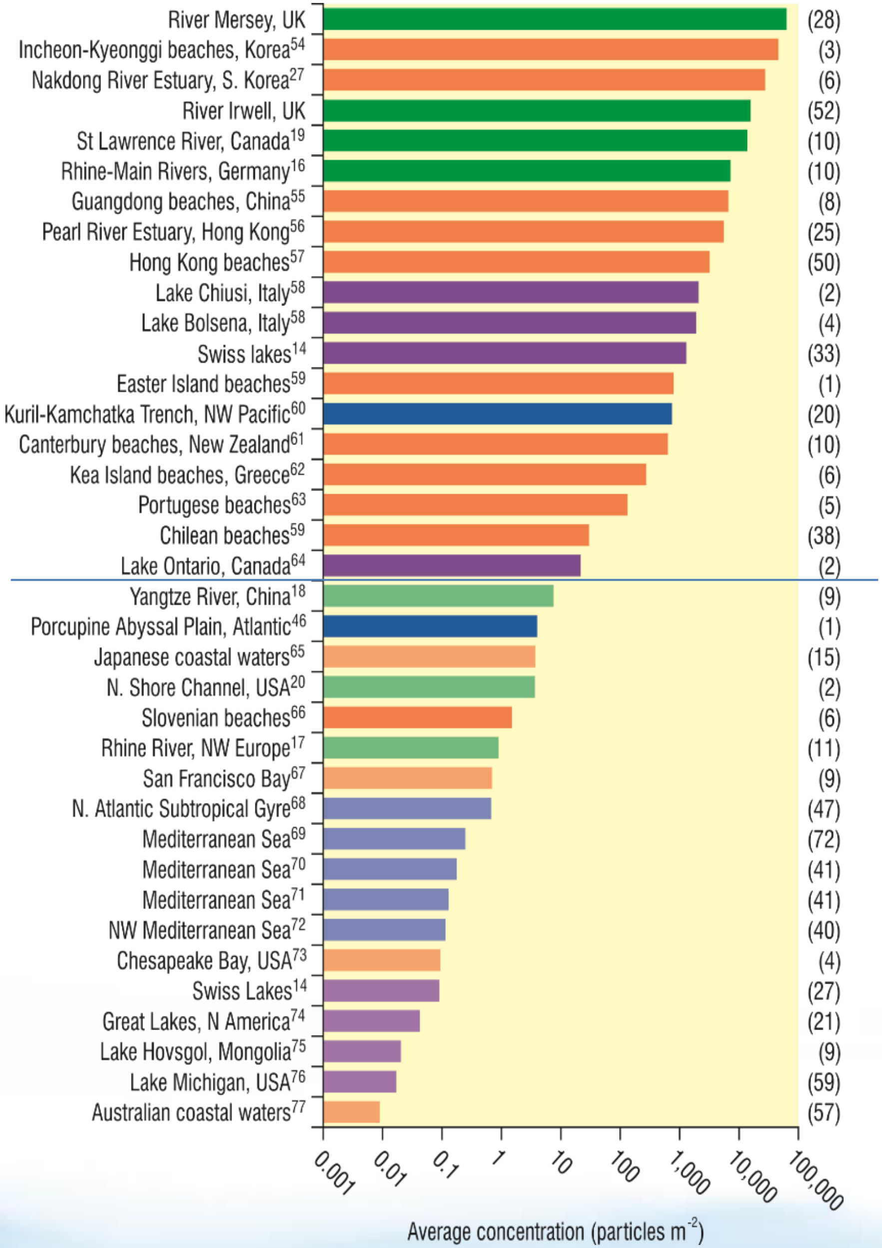
- Some polymers are buoyant in fresh/saline waters (e.g. PE, PP, EPS), while others will sink (e.g. PVC, PET).

- Even the buoyant polymers may eventually sink due to biofouling or through processes such as marine snow.

- This is may be a dynamic process of buoyancy change, which is also influenced by particle shape.

- However, it is likely that most microplastics eventually accumulate in sediments, where marine sediments likely represent the ultimate fate for most microplastic particles.



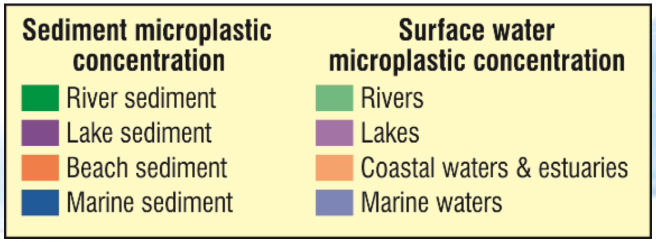


Microplastics in sediments

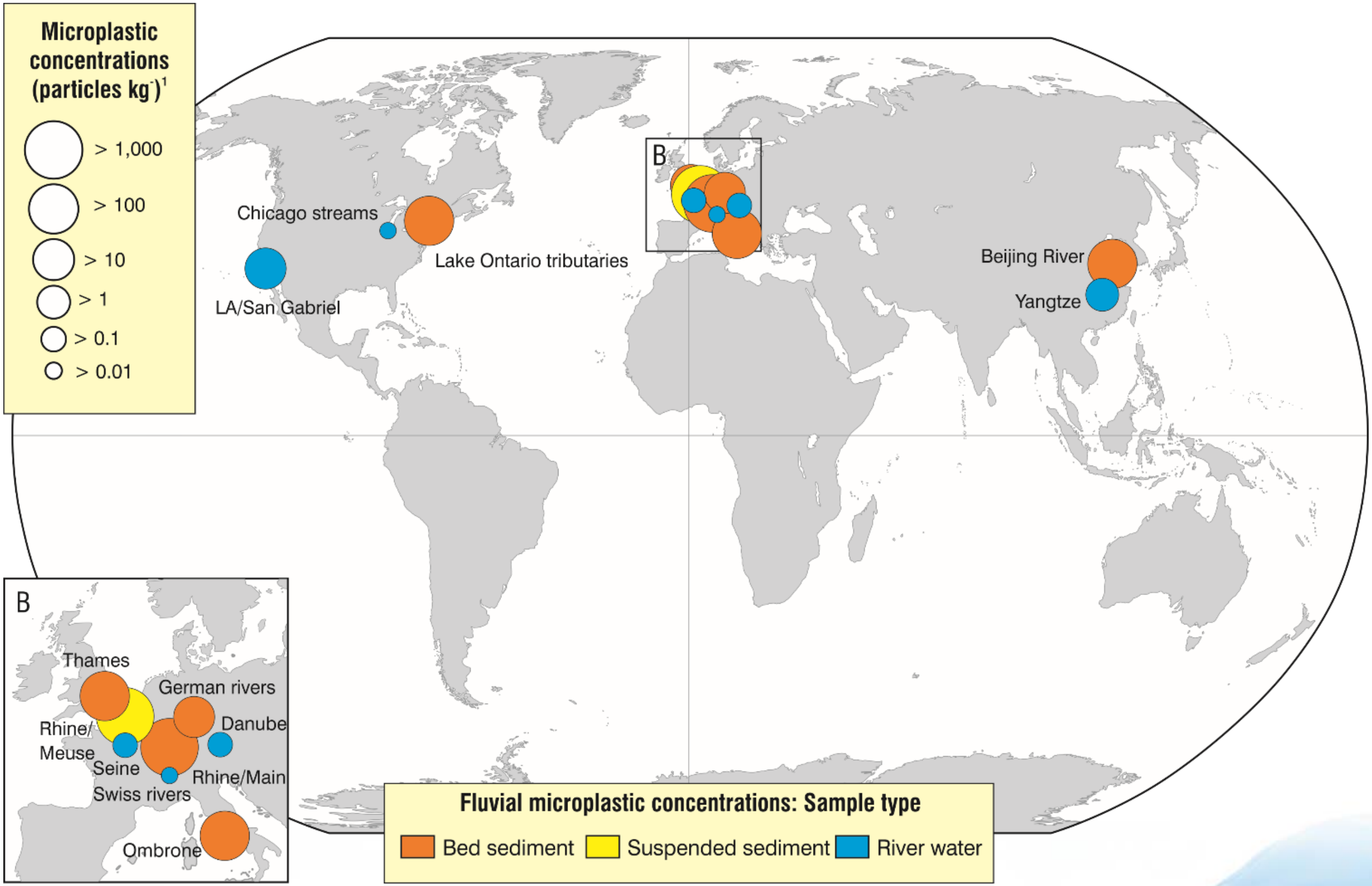
- Microplastic concentrations are generally several orders of magnitude higher in sediments than in the water phase in aquatic systems.

- River and beach sediments have been shown to have the highest concentrations of microplastic globally.

- We are still filling in some of the gaps regarding sediment microplastic monitoring, for example in deep sediments that are difficult/expensive to sample.



Hurley et al., 2018



Published studies of microplastics <5 mm, reported as particles kg^{-1} or particles m^{-3} (converted to particles kg^{-1}), produced Feb 2017

- Sources of microplastics include: Wastewater systems, road and urban runoff, industrial effluents, agricultural runoff, release from shipping, and the degradation of macroplastic litter.

- Sources are likely to be numerous, episodic, and spatially complex across
  - This makes microplastic contamination difficult to track.

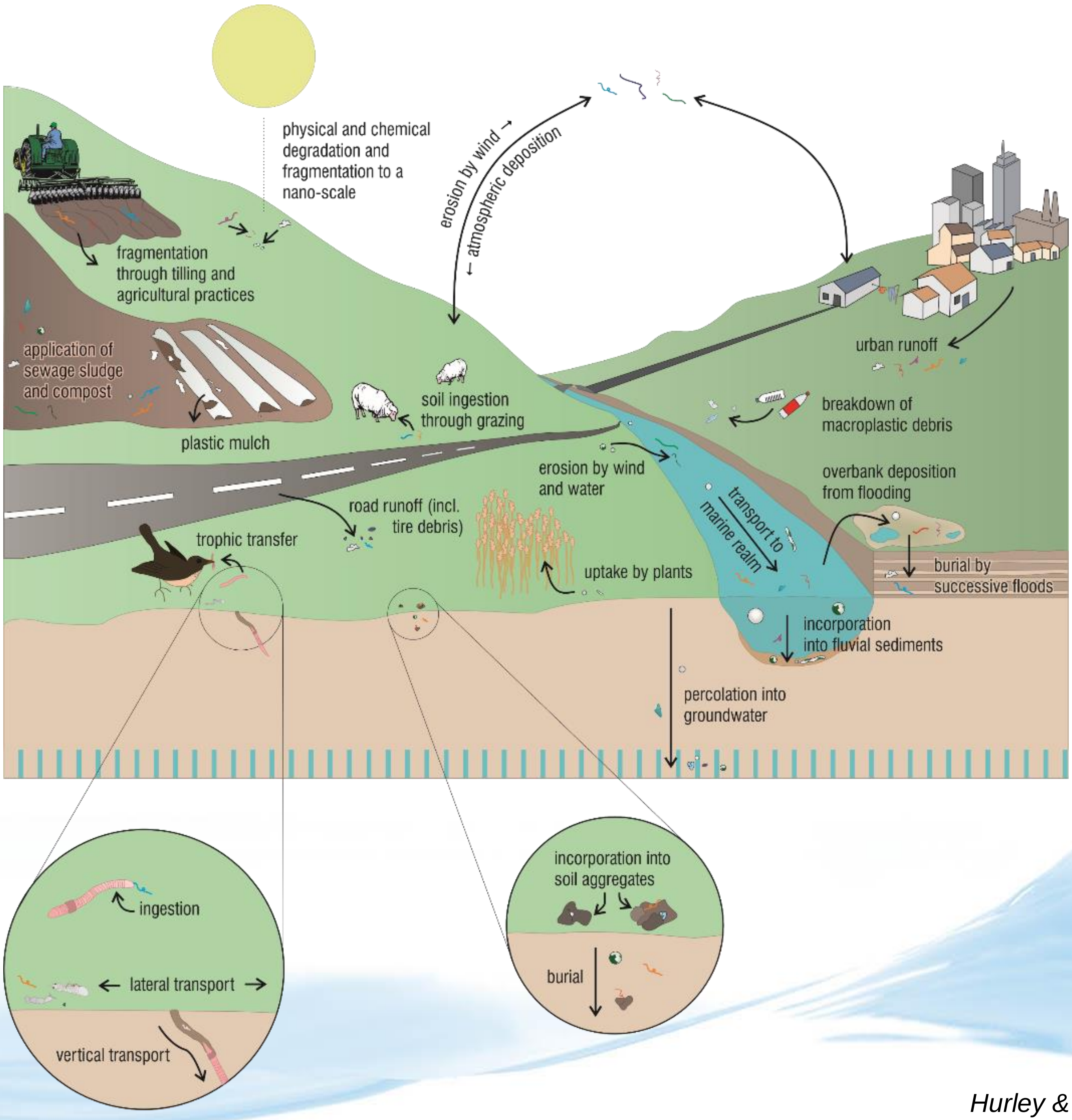
- There is a link between microplastics and urban environments, where there are high densities of potential sources.

- Land-based sources (typically via rivers) contribute approx. 64-90% of marine microplastic pollution.

Missing gaps in sediment microplastic research

- Some sedimentary environments present sampling difficulties and so monitoring of these locations is currently sparse.
    - For example, deep sea or lake sediments have not been widely sampled across the globe.

- We need to fill in missing gaps in our understanding of processes relating to microplastic contamination of sediments.
    - For example, research points to the role of flood events as major pulse of microplastic contamination to the oceans, of which only a proportion is likely to be buoyant in saline waters.
    - Floods can flush microplastic contamination from river beds but we do not yet know what proportion is transferred downstream and what proportion is delivered to floodplain environments.
    - We also do not yet fully understand processes of accumulation and entrainment of microplastics within sedimentary environments.



Hurley & Nizzetto., 2018

Microplastics in sewage sludge

- Sewage sludge or ‘biosolids’ application to agricultural soils may be one of the largest sources of microplastics to terrestrial environments.

- Up to 99% of microplastics are captured by WwTPs in the sludge phase. Large volumes of sludge are produced daily and the most economical solution is to repurpose for use in agriculture as fertiliser.
    - Approximately 50% of sewage sludge in Europe and N. America is used in this way.

- The microplastic content of these soils have not yet been demonstrated experimentally.
    - However current estimates suggest 63,000-430,000 tons of microplastics are added to European farmlands each year, (Nizzetto et al., 2016).

Missing gaps in soil microplastic research

- There are very few published studies that analyse microplastic concentrations in soils.
  - Further research is needed to establish a global picture of microplastic concentrations and spatial dynamics.

- We don’t yet know what proportion is eroded into aquatic systems and what proportion accumulates in soil profiles.
  - Soils may act as a source of microplastics to other environments, or a large environmental reservoir of microplastic particles.

- The influence of microplastics on soil quality is not fully understood.
  - This includes interactions with soil biota, as well as aggregation processes or soil nutrient dynamics.

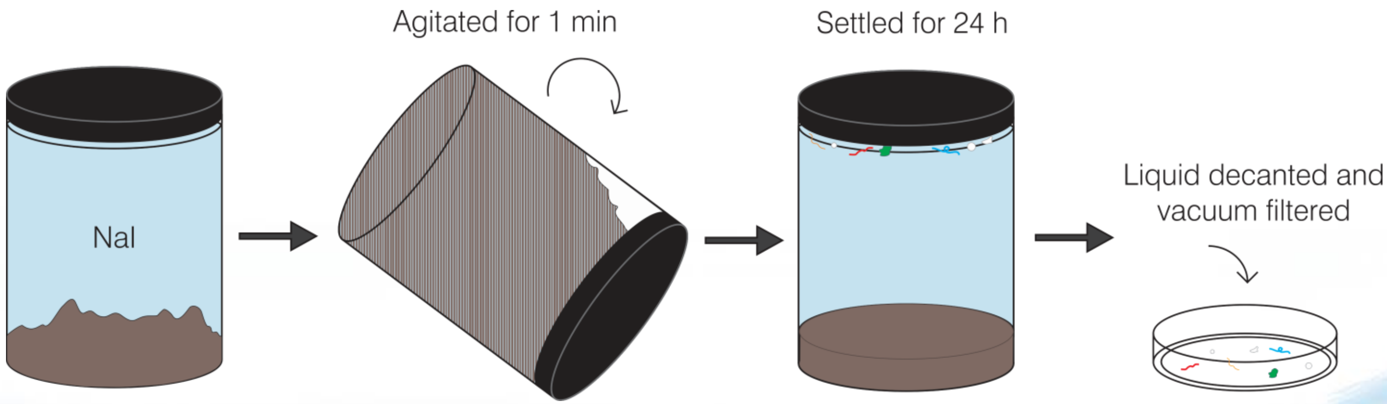
- The scale of sources of microplastic to soils are currently poorly constrained.

Extracting microplastics from sediments

- Microplastics are most commonly extracted from sediment matrices based upon their density.
  - This includes the use of salt solutions as well as elutriation-based methods.

- Organic matter removal protocols may need to be considered based upon the amount and type of organic material in the sample.

- Extraction efficiencies are generally higher for sediment extractions, although particle shape does have an influence on recovery.



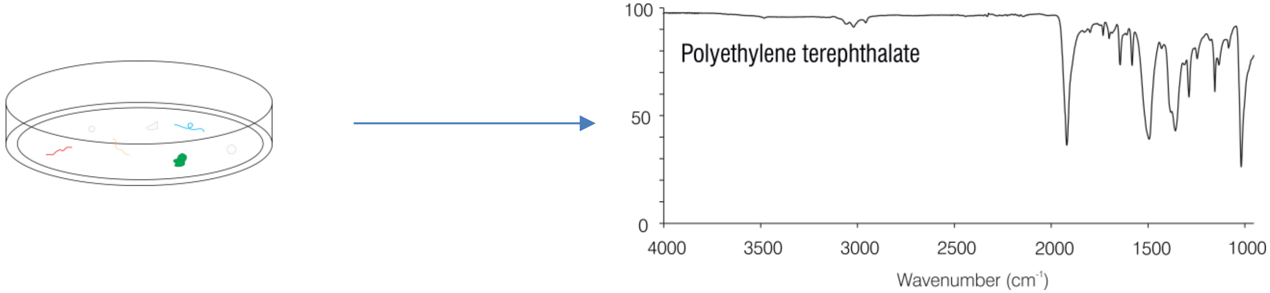
Extracting microplastics from soils

- Some forms of organic matter e.g. SOM in soils may exhibit similar properties (e.g. density) to MPs and so may also be extracted during typical physical isolation methodologies

- If organic material is extracted with microplastic particles it can hinder visual analysis (obscuration) and chemical characterisation (particle coatings).

- Hence, the organic component must be removed prior to density-based separations. Work performed at NIVA highlights Fenton's reagent as the optimum protocol for reducing organic content whilst preserving microplastic particles (Hurley et al., *forthcoming*).

- Direct extraction techniques have been developed for use with soils that negate sample pretreatment (e.g. organic matter removal, density separation)
  - These include PLE and TED-GC-MS.
  - However, they destroy particle information (particle number, shapes, sizes etc.) which are important for identifying potential sources or understanding particle behavior in the environment.



Chemical characterisation of MPs is most commonly achieved through IR spectroscopy: FT-IR and Raman.

Standard FT-IR and Raman can analyse larger microplastic particles, typically with a lower size limit of detection at around 200-300 µm. However, these techniques can be coupled with microscopy to analyse particles down to approx. 10-20 µm (µFT-IR) and approx. 2 µm (µRaman).

FT-IR is most commonly used in microplastic analyses – related to very quick measurement times. The techniques have been further optimised to include µFT-IR imaging which scans entire samples and detect microplastic particles.

Key analytical difficulties

- Reducing the time required to process samples prior to analysis – e.g. optimising sample pretreatments.

- Reducing the time required to perform a thorough characterisation of particles e.g. particle size distributions, particle shapes, polymer type.

- Improving the establishment of mass-based concentrations for environmental monitoring
    - Establishing mass-based contamination levels for different polymer types
    - Linking mass-based concentrations to targeted size categories.

- Reducing contamination of samples during analysis – microplastics are everywhere!

Summary

- Microplastic contamination of soils and sediments has the potential to be high and we don’t yet fully understand interactions with biota or other processes that may be affected.

- We still have limited understanding of the processes governing microplastic release, transport, and accumulation – although new studies come out each week!

- Method development is a key area to optimise microplastic analysis in soils and sediments.