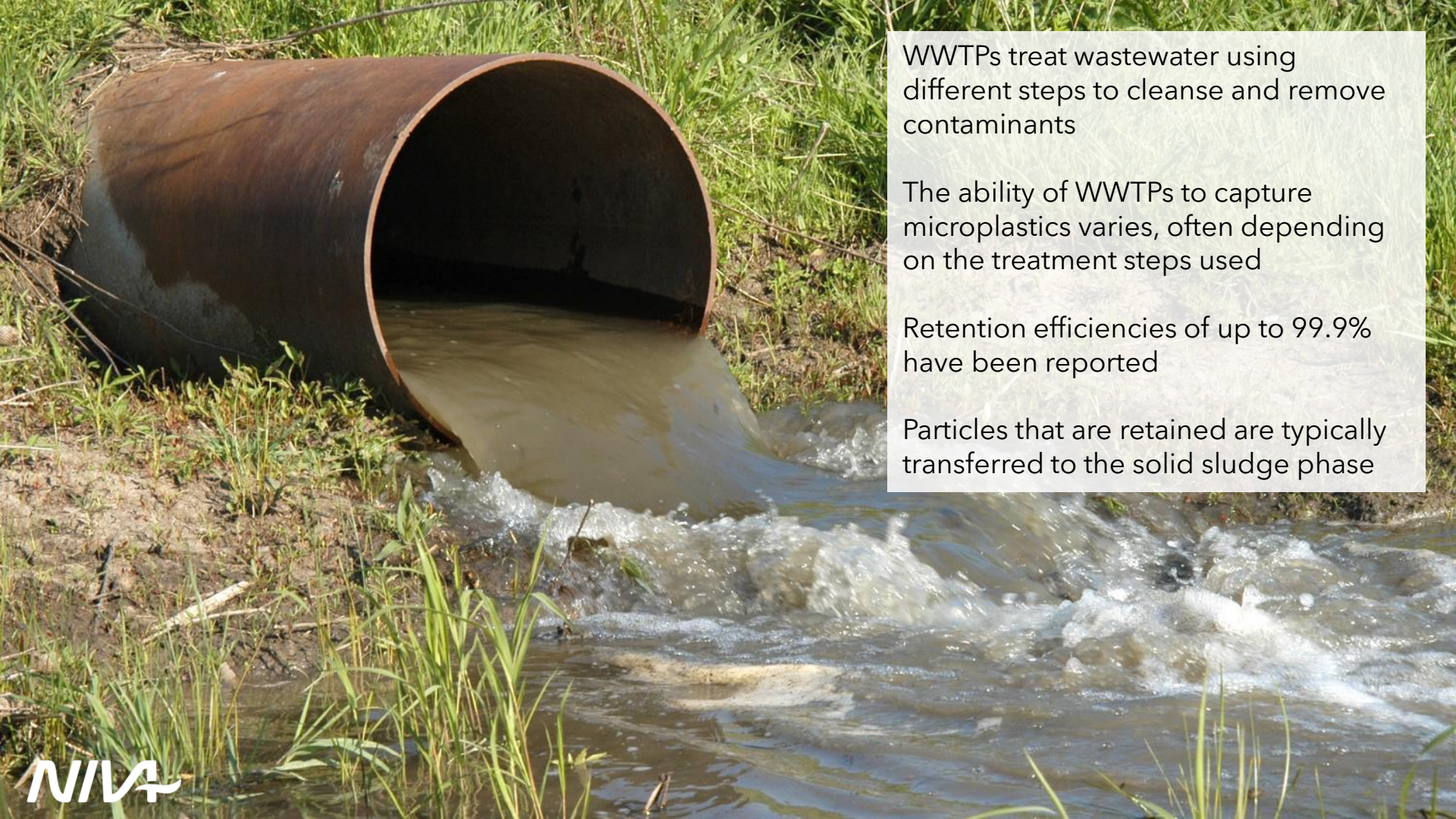
Transfer of microplastics from agricultural soils to aquatic systems

Wastewater treatment plants (WWTPs) are receive microplastics from several sources:

For example:

- Synthetic textile fibres from laundry
- Plastics in personal care products, detergents, or paints
- Fragments from larger plastic items
- Depending on connectivity: industrial effluents or tyre and road wear particles



WWTPs treat wastewater using different steps to cleanse and remove contaminants

The ability of WWTPs to capture microplastics varies, often depending on the treatment steps used

Retention efficiencies of up to 99.9% have been reported

Particles that are retained are typically transferred to the solid sludge phase

Sewage sludge is often applied to land as a soil conditioner or fertiliser

Large quantities of sludge are produced daily and are difficult to handle

This represents a cheap solution for farmers and WWTP operators

However, it also represents a release of microplastics to soils

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446 billion microplastics spread on agricultural soils

112 billion microplastics sent to soil producers

27 billion microplastics added to green areas

584 billion microplastics released into the environment via sewage sludge each year in Norway

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Another important source of microplastic to soil are agricultural plastics

3-4 million tonnes of agricultural plastics are currently in use in Europe

One third is used for protected cultivation systems in the form of thin films:

- Mulching films
- Low tunnel systems
- Greenhouse systems

Other uses include: irrigation systems, silage wraps, and polymeric encapsulation of seeds or plant protection products

1 million tonnes plastic waste is generated each year

Agricultural plastics can degrade during their use, removal, and waste handling

Polymeric encapsulations of seeds and plant protection products represent an intentional release

Biodegradable plastics may be used as an alternative to conventional plastics, but may represent sources of high levels of transient microplastic

There is a need to understand the importance of agricultural plastics as a source of microplastic to soils

We need to establish practices for the use of these products that balance the needs of today against the long-term sustainability of our agricultural systems

Image: CK Gurney, CC BY-SA 3.0

There are likely to be several other sources of microplastic to soils, some of which we don't yet know much about

For example, atmospheric deposition is expected to occur in agricultural settings

Compost produced from different waste streams also has the potential to be contaminated by microplastic.

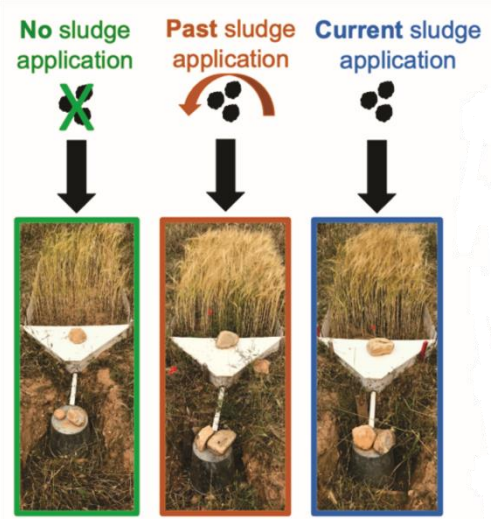
This is likely to vary country-by-country or even by region depending on how waste streams are organised and handled

There is a need to better understand the magnitude and variability of these sources of plastics to soils

What happens to microplastics added to agricultural soils?

Study 1: Spain

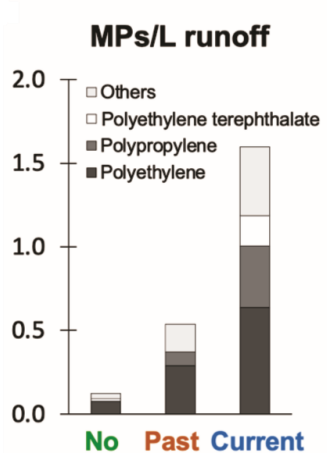
- Experimental farm, Alcala de Henares
- Runoff plots constructed to collect surface runoff from 2m^2 area
- Three treatments:
  - Control (no sludge added)
  - Past sludge application (soils treated with sludge 4 years ago)
  - Current sludge application (plots directly treated with sludge)



- More microplastics in runoff from recently treated soils

- Microplastics dominated by low density polymer types and fragments

- Compared to the microplastics in the soil in the plots:
  - Preferential mobilisation of low density particles
  - Preferential retention of fibres in the soils



Study 2: Canada

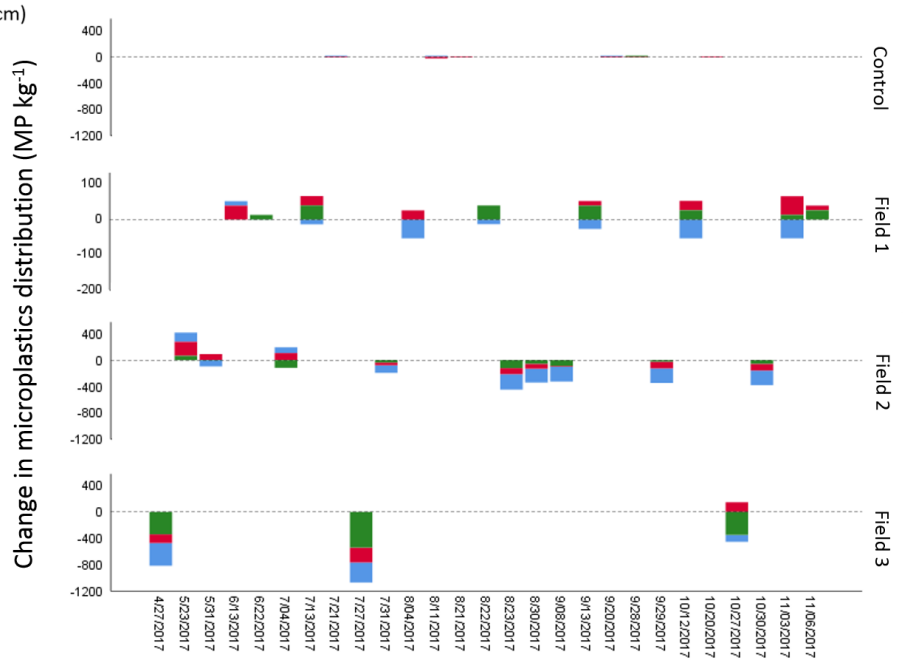
- Real farms, Ontario
- Soil samples were taken before sludge treatment and several times after using a corer to sample three depths
- Three fields treated with sludge & one control

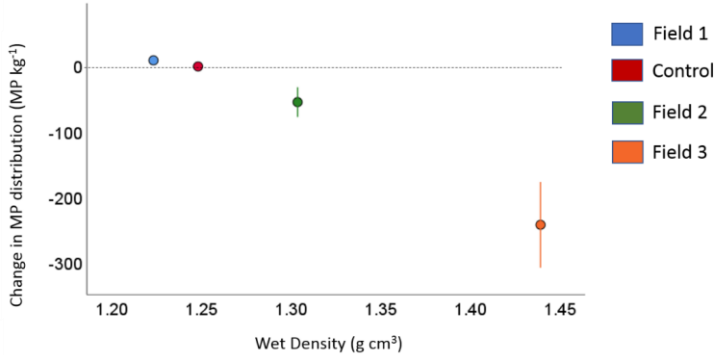
- Field 1: vertical transport of microplastics

- Field 2: Net loss of microplastic and limited microplastics infiltration

- Field 3: Net loss of microplastic

- Net losses potential associated with soil density





Spain

95-99% of microplastics added were **retained** by the soils after 1 year

Canada

>99% of microplastics added were **exported** from soils after 1 year

This demonstrates the potential variability in the capacity of soils to retain microplastic particles

There are many variables likely to influence retention that need to be explored

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Implications for the environment

If microplastics stay in soils, then successive inputs will lead to high concentrations over time

If microplastics are exported from soils, then soil environments will act as a pathway for microplastic pollution to other environments

Image: Floydian, CC BY-SA 3.0

Implications for the environment

High concentrations in soils could lead to:

- Effects on soil properties
- Effects on soil organisms
- Effects on plants

This could ultimately result in a decline in soil health and fertility and impacts on food security

Implications for the environment

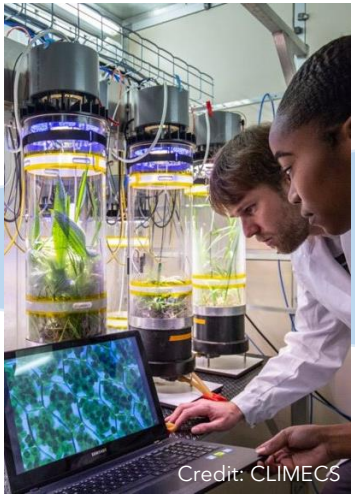
Export of plastics from soils to other environments will contribute to wider environmental plastic pollution

For biodegradable plastics used in agriculture, this means that particles may end up in an environment in which they do not biodegrade

Next steps: Understanding microplastic fate across multiple scales

Lab scale → Field scale


Credit: IMDEA


Credit: CLIMECS


Credit: IMDEA


Credit: LSMF


Credit: IMDEA

High environmental control → High environmental realism

Thank you

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DIMISOR: Defining the Impact of MIcroplastics on SOil Resilience