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Hydro Nation Scholars Programme

Micro- and nanoplastics in wastewater treatment systems and receiving waters

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Background

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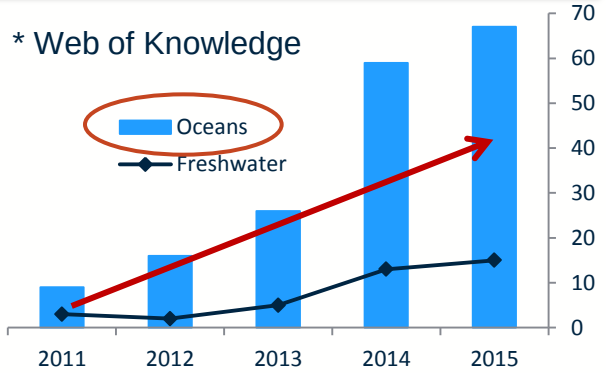
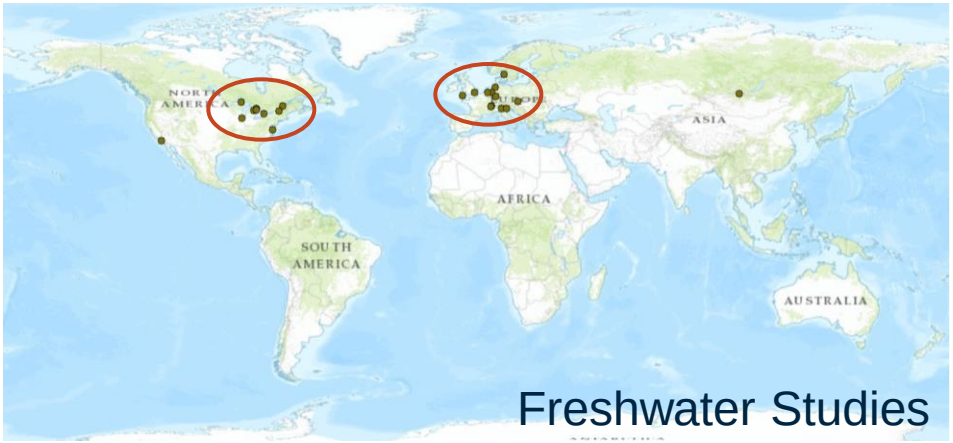
- Environmental problem worldwide; of greater concern recently are smaller fractions:
  - Microplastics (< 5 mm)
  - Nanoplastics (< 100 nm)

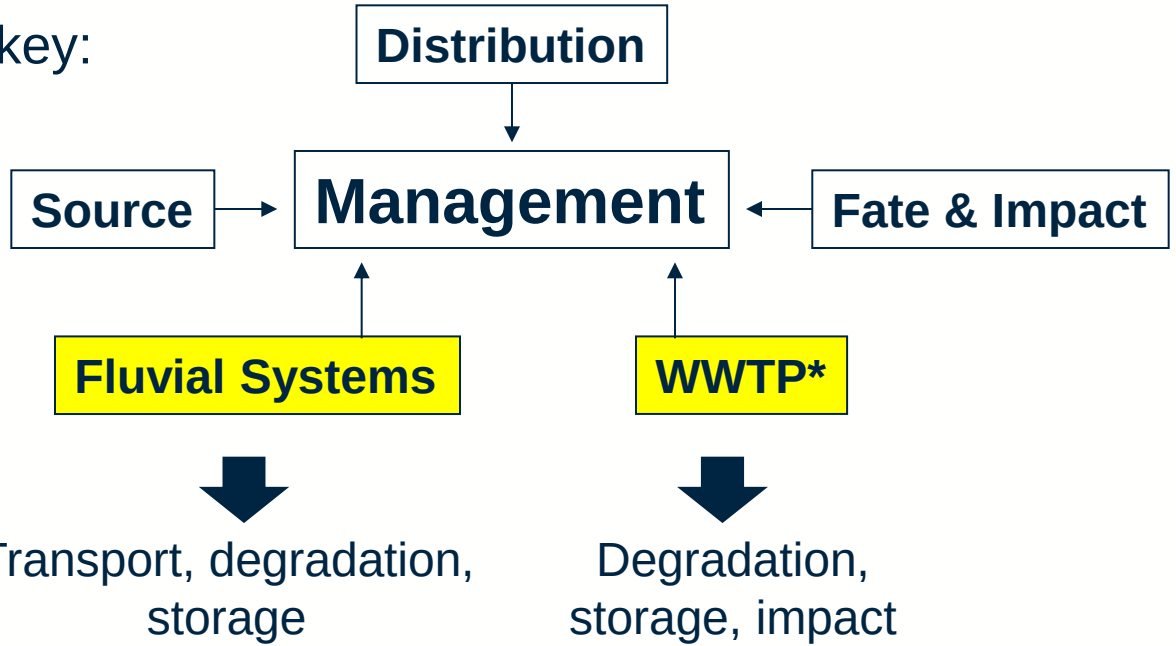
  } "MNP"
  - Research more advanced in oceans
  - Spatial coverage in freshwaters still limited





Justification

- Lack of adequate data for reliable risk assessment
- MNP are emerging contaminants
- Management of inputs is key:



- **MISSING**

* **WWTP**, wastewater treatment plant

Objectives

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AIM: Describe and model the behaviour of MNP in WWT* and fluvial systems

Distribution:

1) Detect and quantify MNP WWT and recipient water in an urban catchment

Sources:

2) Identify the main sources and categories of MNP

Impact:

3) Evaluate the impact of MNP on WWTP efficacy at different treatment stages

Fate:

4) Assess the ability of WWTP to process MNP, and predict loading

5) Model transport and distribution of MNP in receiving waters

Sinks or sources??

* **WWT**, wastewater treatment

- METHODS -

Study Site

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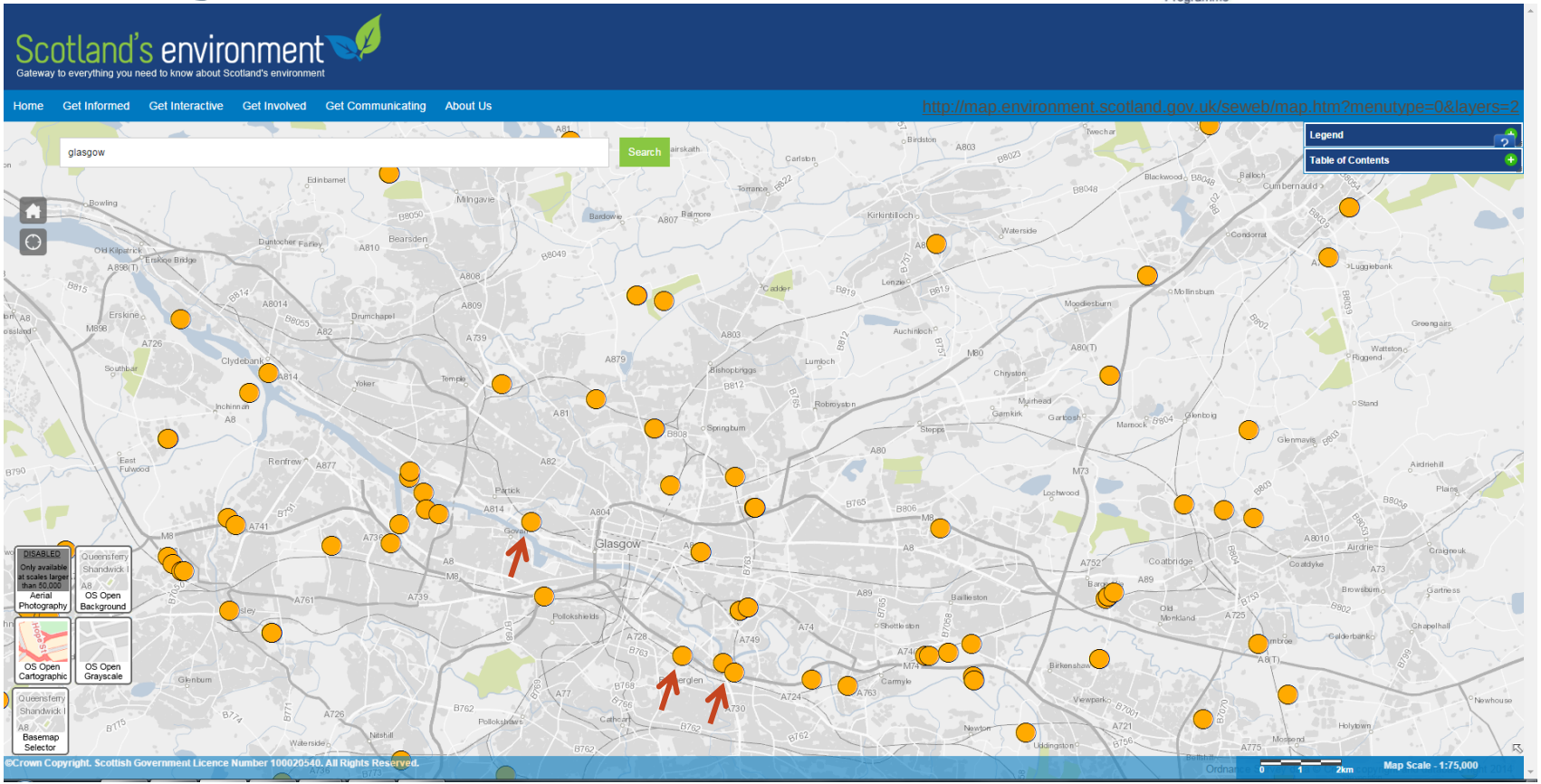

Detect and Quantify

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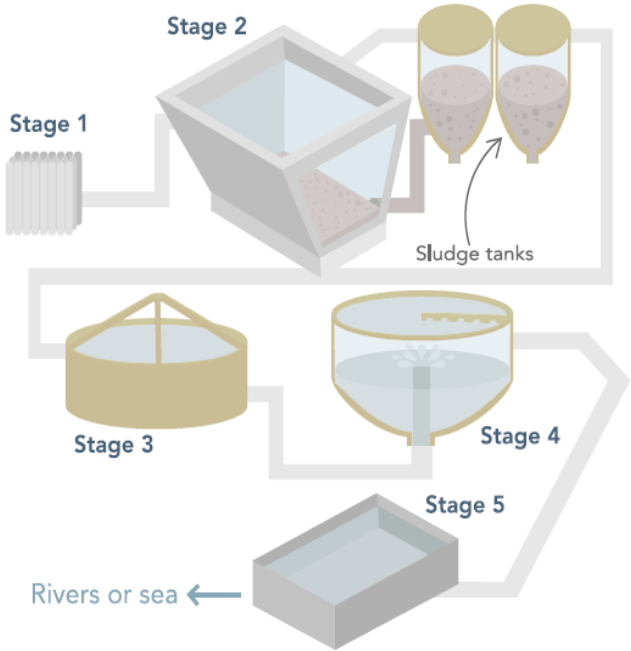
Sampling

- Water sample collection
  - WWTP inflow & effluent
  - Recipient water + Reference site
- Sediment samples
- Sewage sludge sample collection



Stages of Waste Water Treatment. Source: http://www.scottishwater.co.uk/

Detect and Quantify

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Sorting

- Size fraction sieving
- Density separation with NaCl solution (1.2 g cm^{-3})
- H_2O_2 digestion (wastewater)
- Filtration

Source: © Alice Stedman

Source: © Alice Stedman

Source Characterisation

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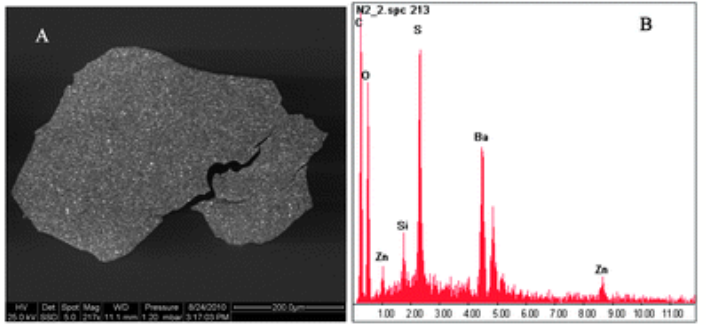
- Visual characterisation of categories
  - e.g. shape, colour
- Naked eye or light microscope
- Electron microscopy
  - Scanning electron microscopy (SEM)
  - Transmission electron microscopy (TEM)



Source: http://www.csir.co.za/ (top); Figure 6, Fries et al., 2013 (bottom)

Source Characterisation

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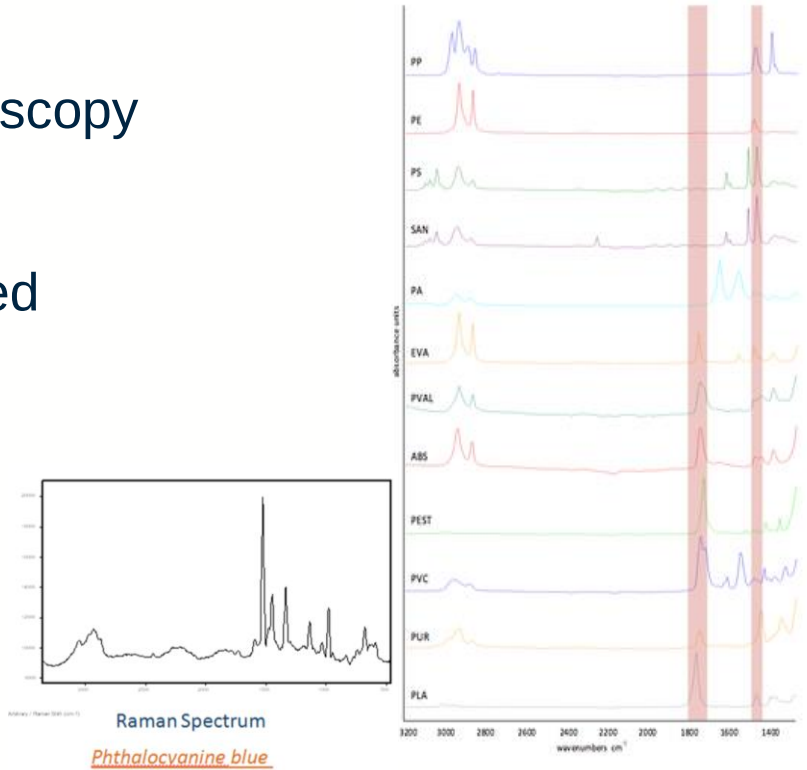
- Vibrational spectrometry
  - Fourier-Transform Infra-Red Spectroscopy (FT-IR) – light absorbed
  - Raman Spectroscopy – light scattered
- Molecular fingerprint
  - Polymer type
  - Crystalline structure (sorption behaviour)
  - Degradation



Source: http://www.gatewayanalytical.com (left); Alfred-Wegener-Institut / Svenja Mintenig, Gunnar Gerdts (right)

Impact & Fate

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- Response in WWTP
  - Bacterial growth
    - COD, direct counting
  - Blockages
    - Laboratory sand column experiments
- Loading to freshwater environment
  - Flow data
- Transport and deposition models
  - Delft3D Suite – particle tracking and sediment movement

Source: http://www.wri.org/ © Hugh Venables

Expected Outcomes

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- Generate incisive understanding of the distribution and behaviour of microplastics in freshwater environment
- Legislators, manufacturers, industry ➔ monitoring and regulation strategies
- Relevant to Hydro Nation goals:
  - Connecting research and policy
  - Developing the economic, environmental and social values of Scotland's water resources
  - Raising Scotland's international profile
  - International knowledge exchange