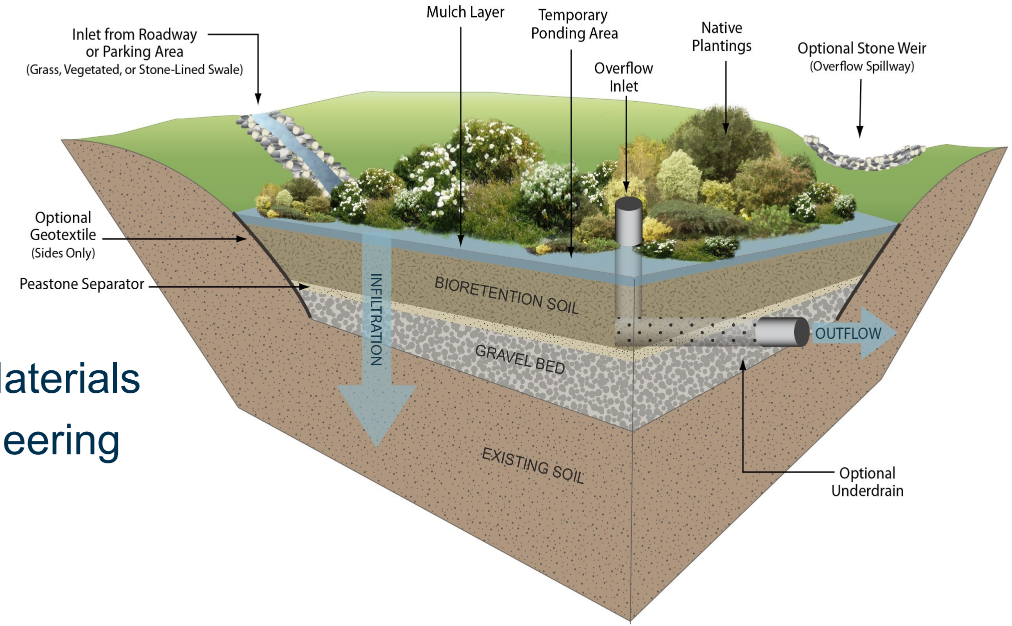
Development of innovative rain gardens to filter and degrade microplastics



Professor Ann-Margret Strömvall
Water Environment Technology
Theme: Urban Water and Contaminated Materials
Department of Architecture and Civil Engineering
2022-03-23

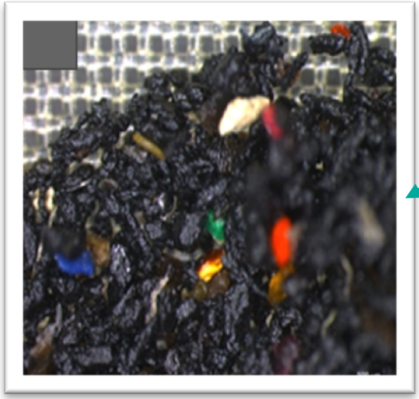
Development of innovative rain gardens to filter and degrade microplastics

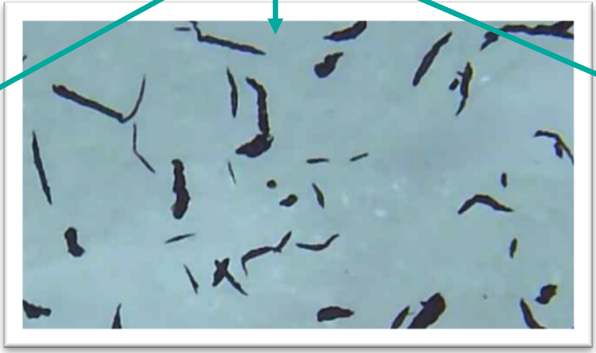
- design, construct and explore an innovative and sustainable rain garden where microplastics, metals, nutrients and organic pollutants from urban runoff are retained, degraded or recovered.
- investigate if a combination with different filter materials, selected plants with or without the addition of mycorrhiza, are applicable for remediation of water polluted with microplastics.
- significantly reduce the transport of urban pollution to receiving waters, and to contribute to a green infrastructure and to a circular economy in the society.

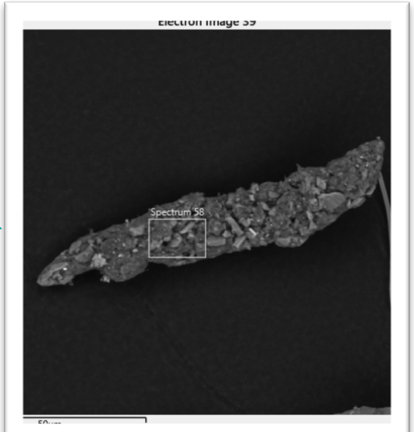
Microplastics

Microplastics are synthetic materials and consist of solid particles that are smaller than 5 mm. Additionally, microplastics are insoluble in water and not degradable (RIVM, 2015).

Tyre and Road Wear Particles = TRWP







Stormwater? – Urban runoff? – Road runoff?

parking lots

urban streets

roofs

Urban runoff = Surface runoff of rainwater created by urbanization. This runoff is a major source of water pollution and flooding in urban communities worldwide!

Järlskog I., Strömvall A-M., Magnusson K., Gustafsson M., Polukarova M., Galfi H., Aronsson M., Andersson-Sköld Y. (2020). Occurrence of tire and bitumen wear microplastics on urban streets and in sweepsand and washwater. Science of The Total Environment, Volume 729, 10 August 2020, 138950.

Streetsweeping – Stormwater Sahlgrenska – Microplastics - TRWP

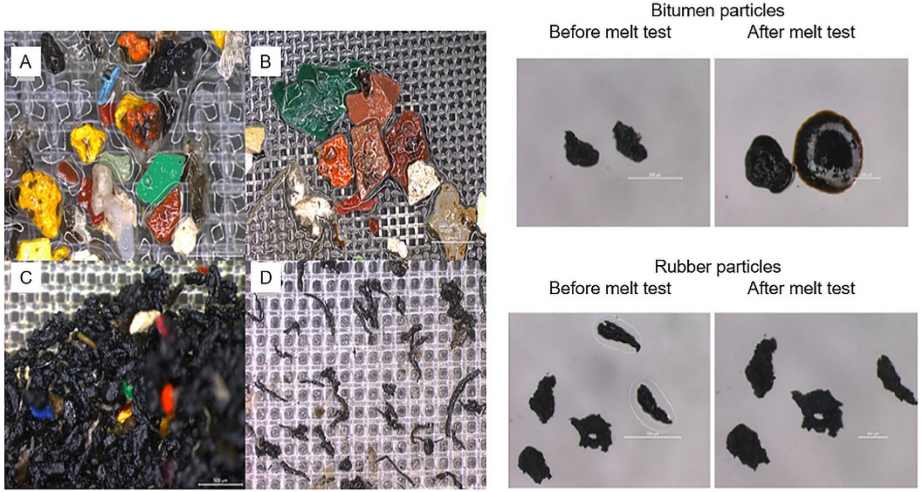


Fig. 4. to the left: Pictures A and B show paint particles from sweepsand. C shows rubber particles from sweepsand, and D shows rubber particles from washwater. Picture top right: bitumen particles before and after heating. Bottom picture: rubber particles before and after heating. Photos by Kerstin Magnusson, IVL Swedish Research Institute.

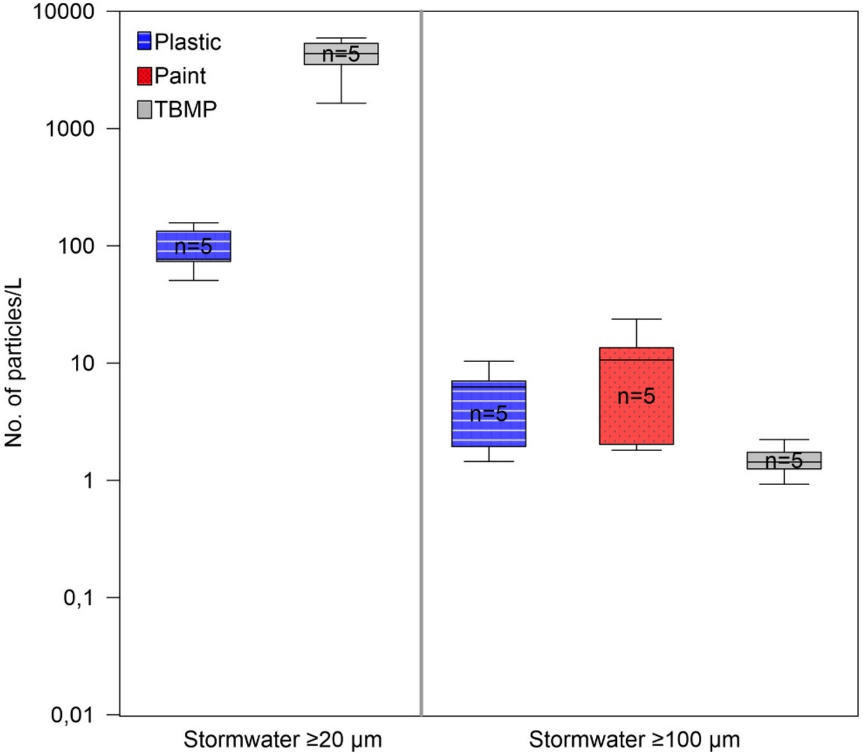
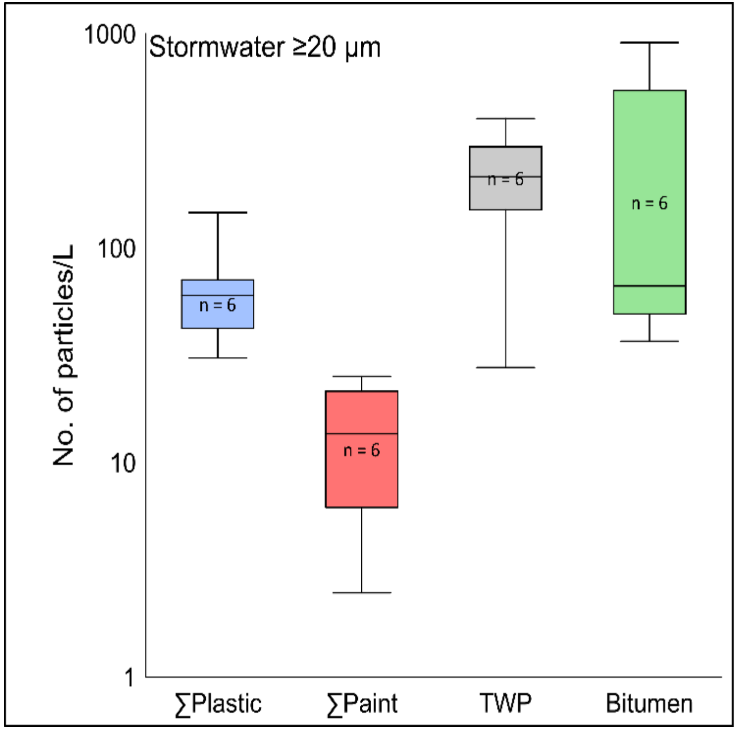


Fig. 11. Plastic, paint and TBMP in stormwater, measured as flow-weighted rain event mean concentration. Boxes to the left relate to particles ≥20 µm and boxes to the right show particles ≥100 µm. (No density separation of the samples).

Occurrence of TRWP in Stormwater at Gullbergsvass



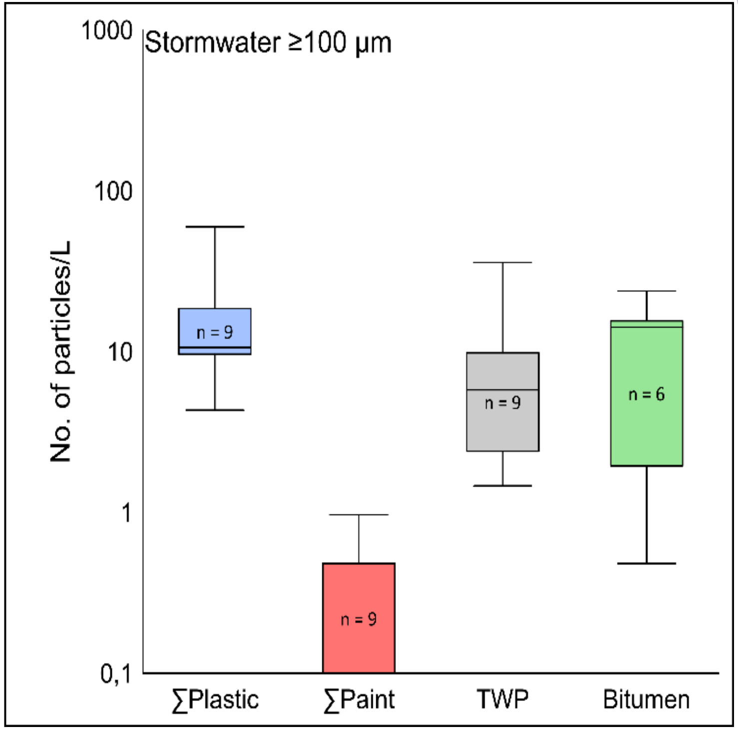


Figure 4. Event mean concentrations of different categories of microplastics (≥20 µm left and ≥100 µm right) identified in stormwater. n = number of samples. Nine stormwater samples were analyzed for particles ≥100 µm, six of which were also analyzed for particles ≥20 µm.

Järlskog I., Strömvall A-M., Magnusson K., Galfi H., Björklund K., Polukarova M., Garcao R., Markiewicz A., Aronsson M., Gustafsson M., Norin M, Blom L., Andersson- Sköld Y. (2021). Traffic-related microplastic particles, metals, and organic pollutants in an urban area under reconstruction. Science of The Total Environment, Volume 774, 20 June 2021, 145503.

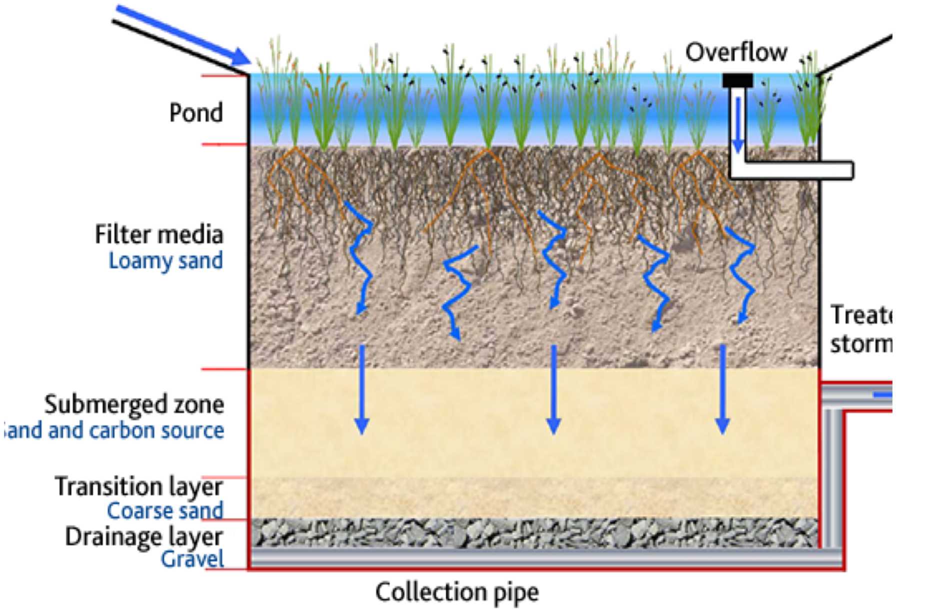
Objectives

Phase 1, 2021 – 2022. Design and construct innovative and sustainable **pilot-scale rain gardens** to study the removal processes of the microplastics and other pollutants and evaluate sorption materials such as peat, biochar and ash as bed material, with and without plants in plants in mycorrhiza symbiosis with fungi.

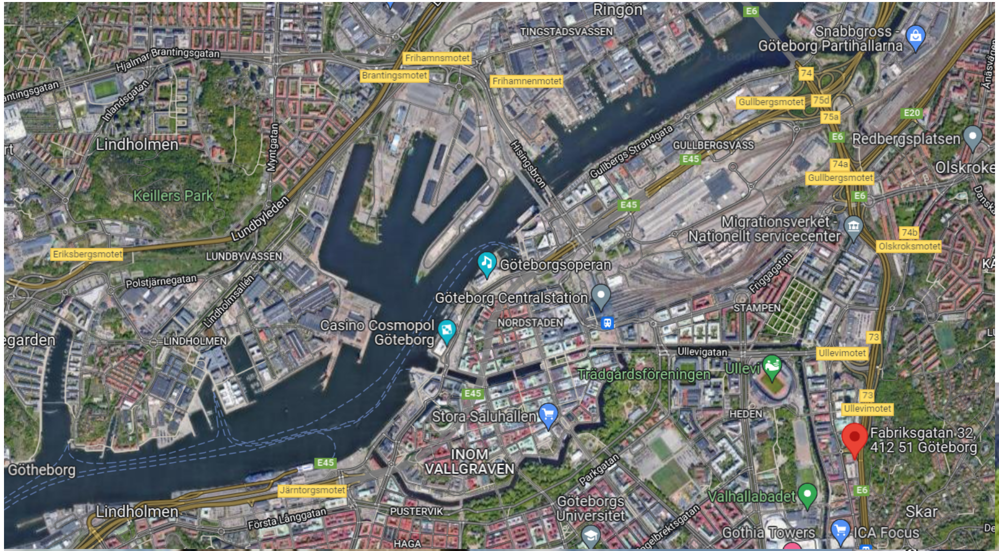
Phase 2, 2022 – 2023. In the pilot and in the laboratory, **in-depth study the initial processes** in the rain beds for removal, distribution, degradation, potential uptake in plants, possible leaching of **microplastics**, other pollutants and nutrients.

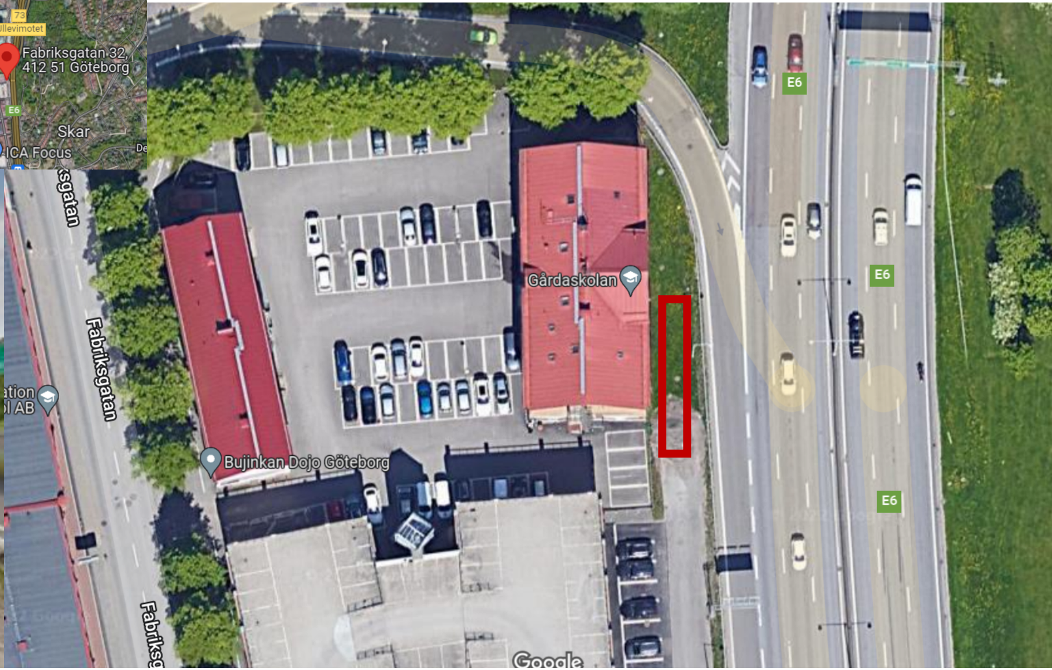
Scientific questions

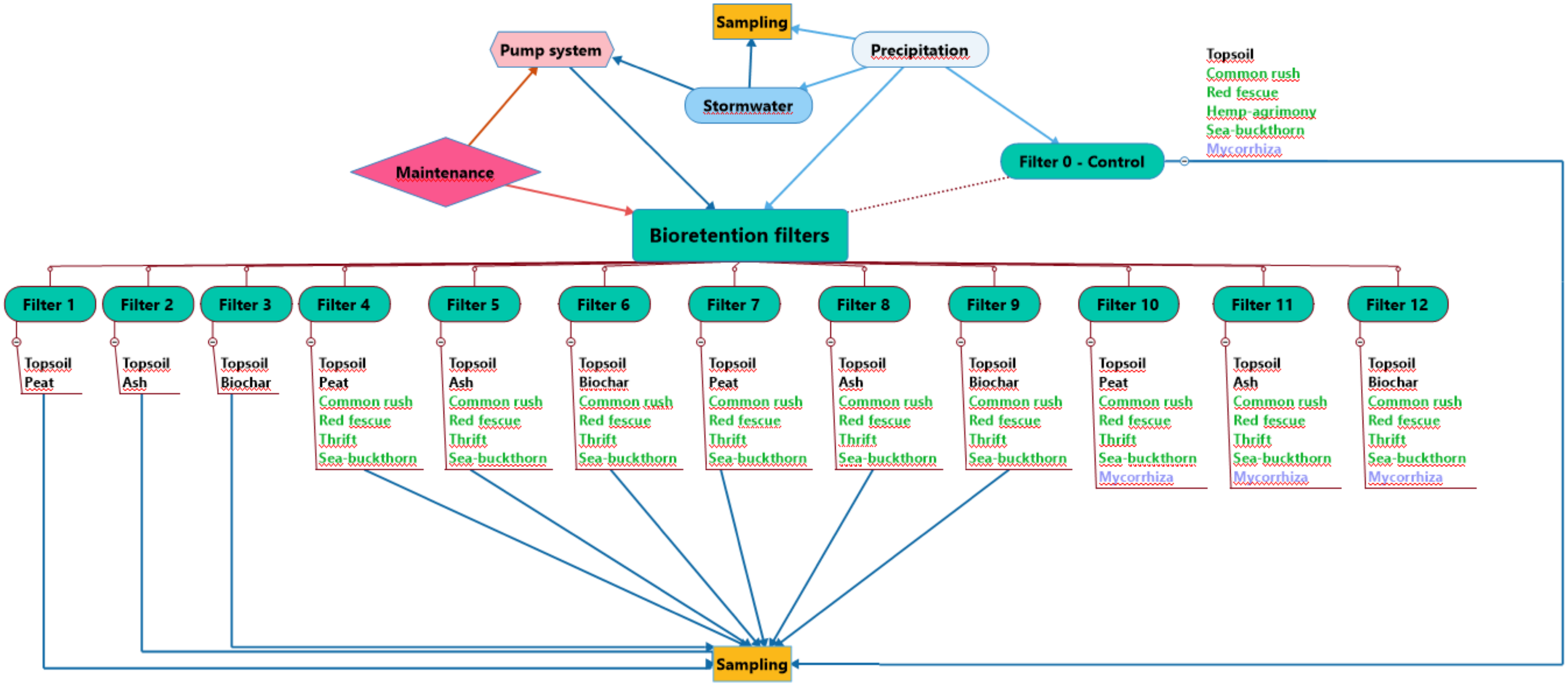
- What are the processes for transport and removal of the microplastics and other pollutants in the various soil beds? How are these processes affected by different environmental conditions?
- Can the processes in the root zones of the plants affect degradation of organic pollutants and microplastics? Can the mycorrhiza fungi even further degrade organic pollutants and microplastics?
- How can the remaining microplastics be effectively separated and recycled from the soil-sorption materials, plants and roots in the used biofilters?
- Is it possible to develop a method that effectively degrades microplastics and organic pollutants, and at the same time recycle valuable metals?



Pilot Rain garden in Gårda
Catcment area of Göta River

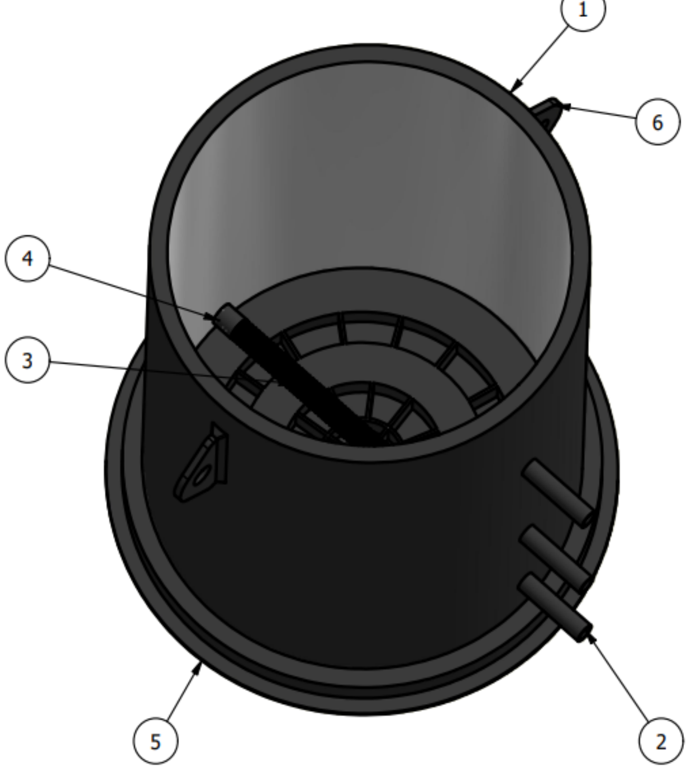





Sampling
Pump system
Precipitation
Stormwater
Topsoil
Common rush
Red fescue
Hemp-agrimony
Sea-buckthorn
Mycorrhiza
Maintenance
Filter 0 - Control
Bioretention filters
Filter 1
Topsoil
Peat
Filter 2
Topsoil
Ash
Filter 3
Topsoil
Biochar
Filter 4
Topsoil
Peat
Common rush
Red fescue
Thrift
Sea-buckthorn
Filter 5
Topsoil
Ash
Common rush
Red fescue
Thrift
Sea-buckthorn
Filter 6
Topsoil
Biochar
Common rush
Red fescue
Thrift
Sea-buckthorn
Filter 7
Topsoil
Peat
Common rush
Red fescue
Thrift
Sea-buckthorn
Filter 8
Topsoil
Ash
Common rush
Red fescue
Thrift
Sea-buckthorn
Filter 9
Topsoil
Biochar
Common rush
Red fescue
Thrift
Sea-buckthorn
Filter 10
Topsoil
Peat
Common rush
Red fescue
Thrift
Sea-buckthorn
Mycorrhiza
Filter 11
Topsoil
Ash
Common rush
Red fescue
Thrift
Sea-buckthorn
Mycorrhiza
Filter 12
Topsoil
Biochar
Common rush
Red fescue
Thrift
Sea-buckthorn
Mycorrhiza
Sampling

Design rain garden beds

- Height (h): 125 cm (100 cm will be filled with filter material and soil)
- Diameter (d): 100 cm
- Radius (r): 50 cm
- Surface area (A) for the beds ($A=\pi r^2$) = 0.785 m^2
- Volume (v) for the filter material (A*h material) = 0.785 m^3



Design rain garden beds

Control filter

0-15 cm: compost

15-80 cm: sandy loam mixed with 15% compost

80-90cm: coarse sand

90-110 cm: fine gravel

Peat filters

1st : compost

2nd : sandy loam mixed with peat

3rd: peat

4th: coarse sand

5th: fine gravel

Ash filters

1st : compost

2nd : sandy loam mixed with ash

3rd : peat

4th : biochar

5th : coarse sand

6th: fine gravel

Biochar filters

1st : compost

2nd : sandy loam mixed with biochar

3rd : biochar

4th : coarse sand

5th : fine gravel


Thrift
Sea-buckthorn
Common rush
Red fescue

Interreg
North Sea Region
IMMERSE
European Regional Development Fund
EUROPEAN UNION

Estuary:

Topic: Water Quality

Partner:

Pressure:

Pollution

M14
Quantify the potential to use biological agents to filter microplastics from the water column within the Humber

(UHull, Julie Hope)

Benefit:

Improving water quality

Preparation

[insert content to explain measure]

Interreg North Sea Region IMMERSE
European Regional Development Fund
EUROPEAN UNION

Does your estuary face similar pressures?

Could the presented solution(s) be applied in other estuaries?