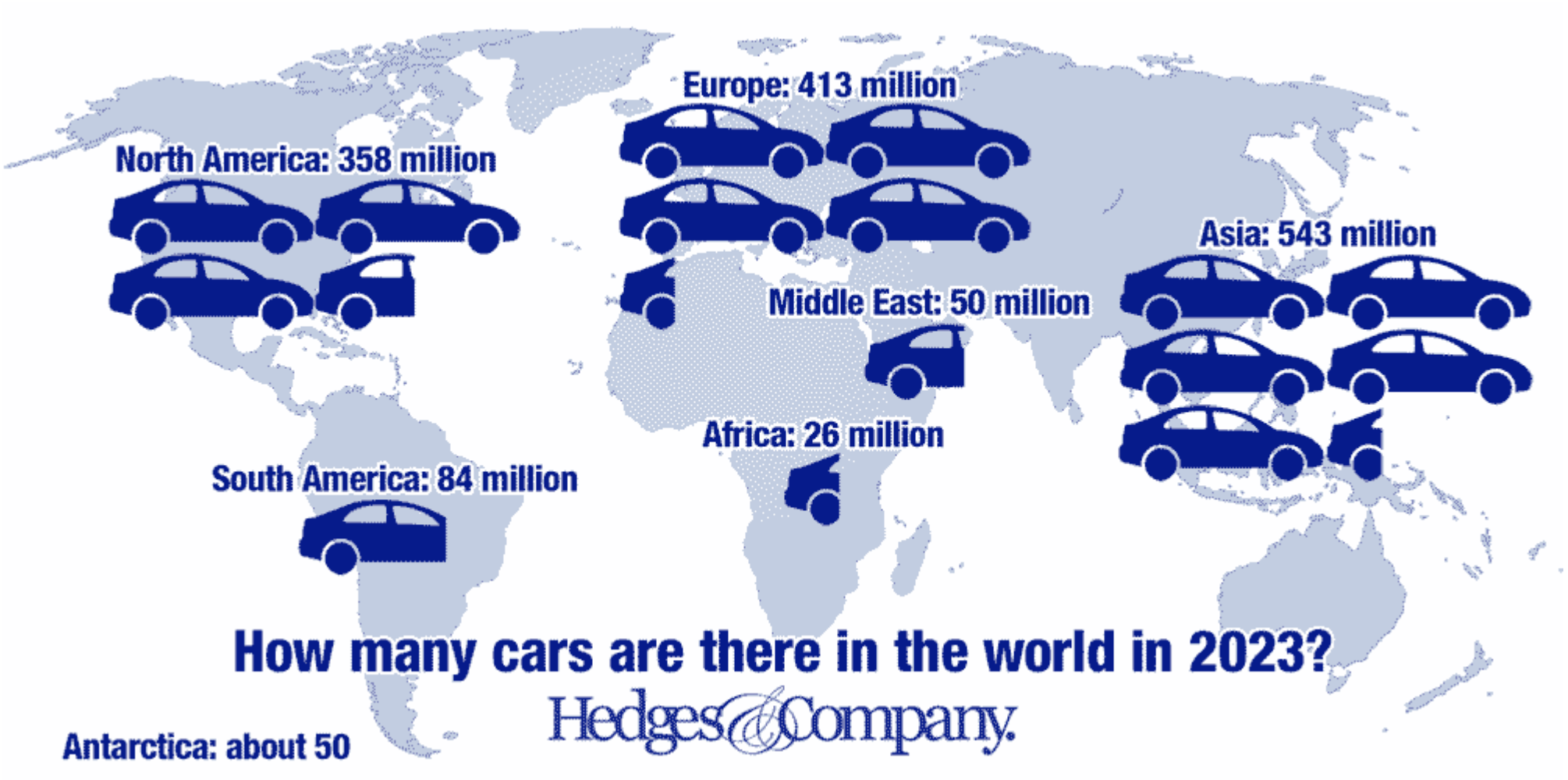
Compounds from tire wear particle in recipients.

Preliminary results from a Nordic study.

Linda Hanssen, Natascha Schmidt

The climate and environmental research institute NILU
A part of the research alliance NORIN

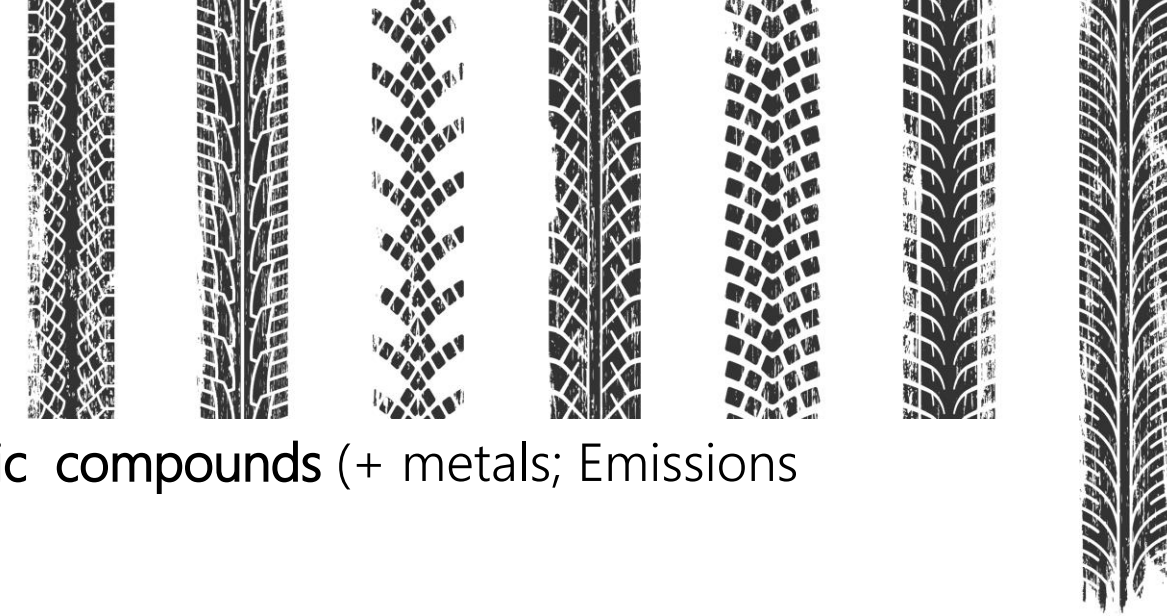
Background


Europe: 413 million
North America: 358 million
Asia: 543 million
Middle East: 50 million
Africa: 26 million
South America: 84 million
How many cars are there in the world in 2023?
Hedges & Company
Antarctica: about 50

Background

- During use, the friction between tires and roads creates **Tire and Road Wear Particles** (TRWP)
- Norway: estimated land-based release of microplastics = 19,000 t/year, 40% of which is estimated to be TRWP (Sundt et al., 2021)
- Factors which can **influence the release rate** of TRWP: speed limits, tire pressure, car weight, use of studded or non-studded tires

Background



- Tire particles contain on average **over 400 organic compounds** (+ metals; Emissions Analytics, 2023)
- Examples are **6PPD** (**antioxidant**; N-(1,3-dimethylbutyl)-N'-phenyl-p-phenylenediamine) or **HMMM** (**crosslinking agent**; Hexa(methoxymethyl)melamin)
- These compounds can be transformed e.g. *via* photooxidation, forming **transformation products**
- **6PPD quinone**, a transformation product of 6PPD, was found to induce acute toxicity in coho salmon (*Oncorhynchus kisutch*), but not in chum salmon (*Oncorhynchus keta*) or Atlantic salmon (*Salmo salar*)

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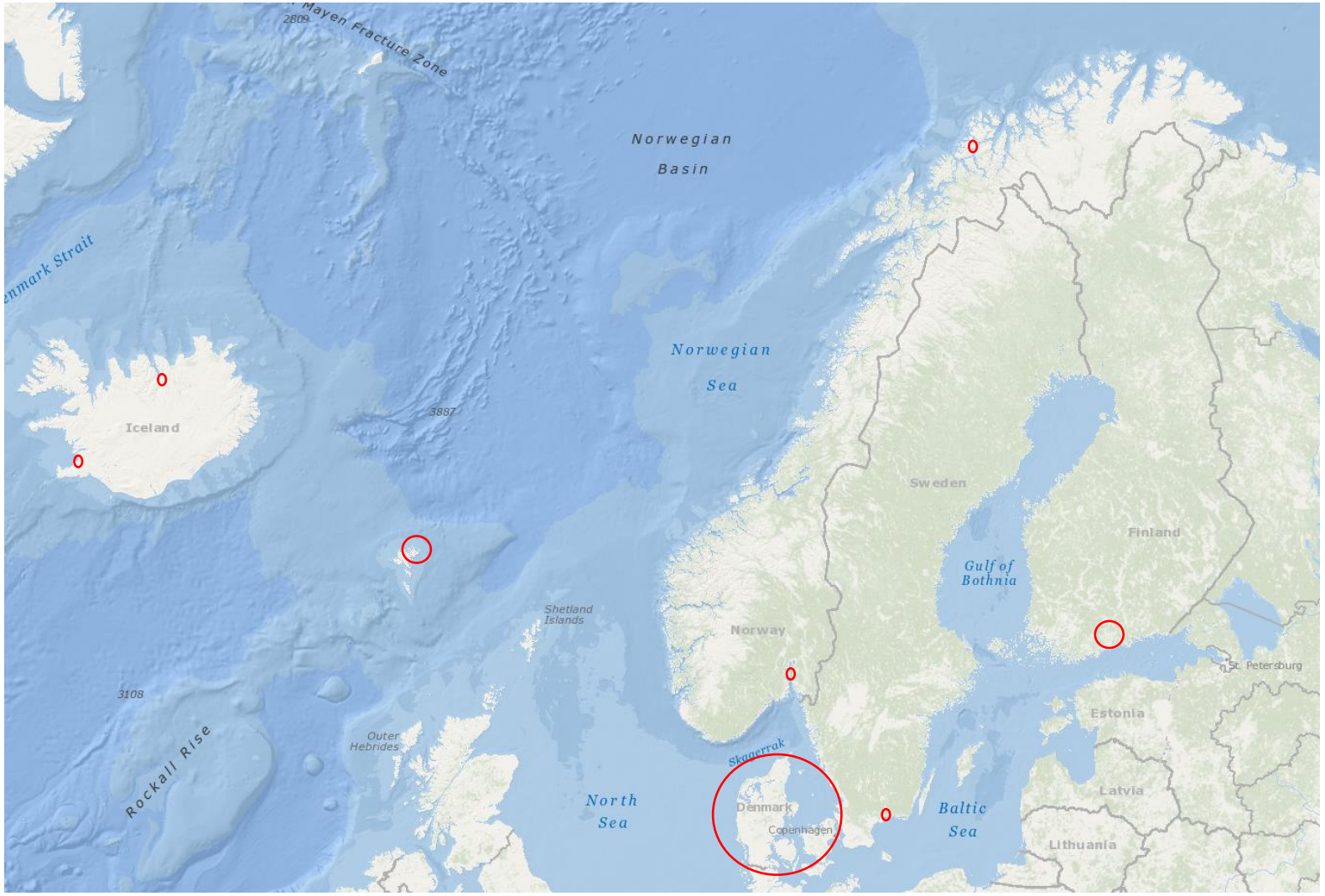
Research question

To which extend are Nordic countries subject to contamination by tire related additive chemicals?

What is the frequency of occurrence and how are these chemicals distributed among different environmental compartments?

Which factors might explain the occurrence and distribution of these chemicals?

Sampling strategy & Challenges



Map source: NOAA

Samples included:

Water: road runoff, road runoff recipient, urban stream, stormwater, stormwater after filtration ponds

Snow: residential area, snow dumping site, next to road

Sediments: snow dumping site (terrestrial & marine)

+ Blue mussels

+ Atmospheric deposition

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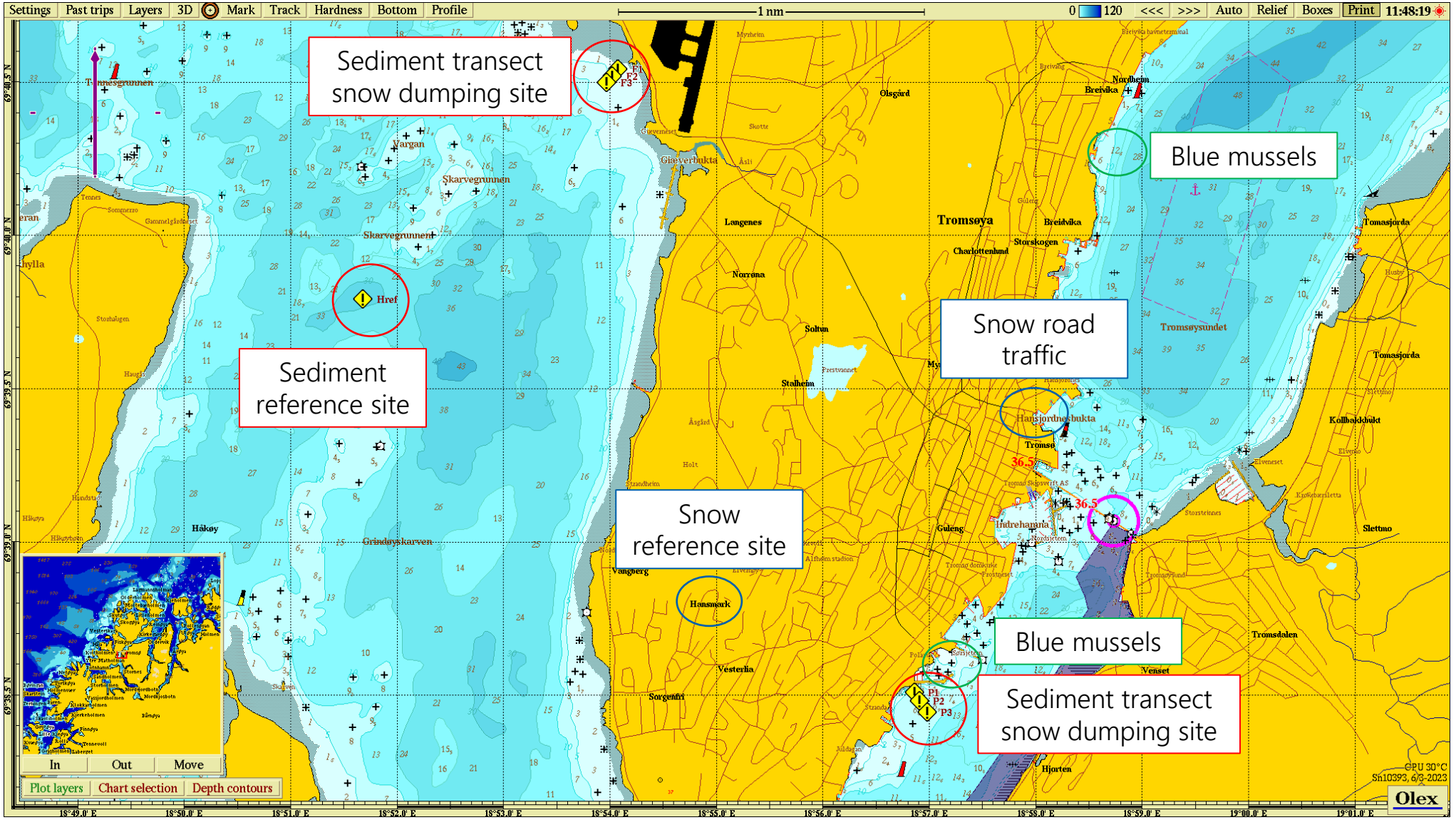
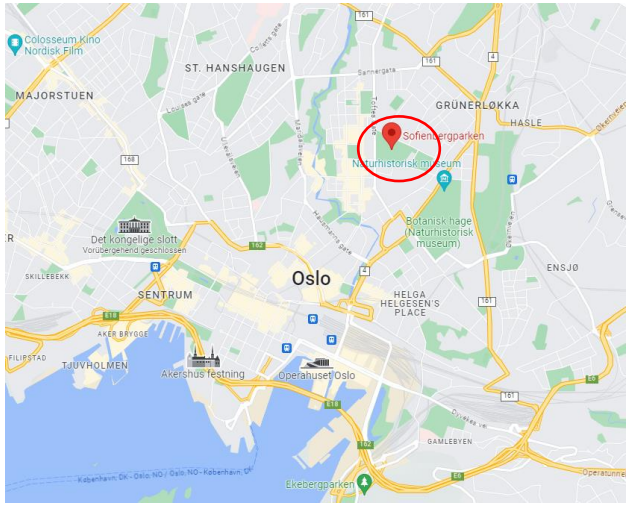
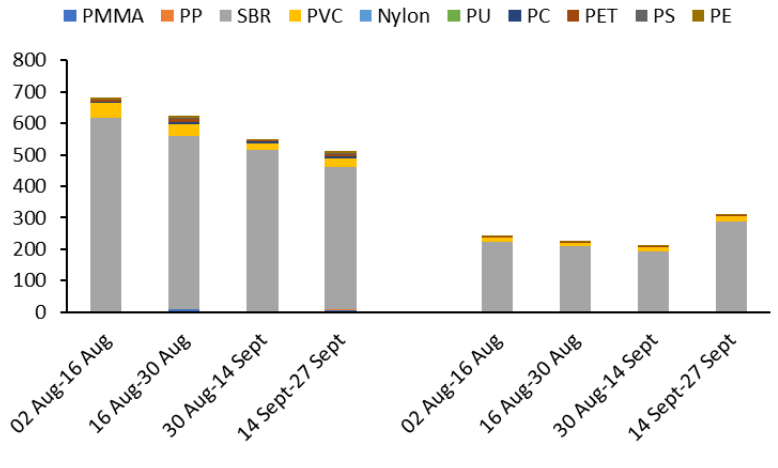
Sampling strategy (Norway)



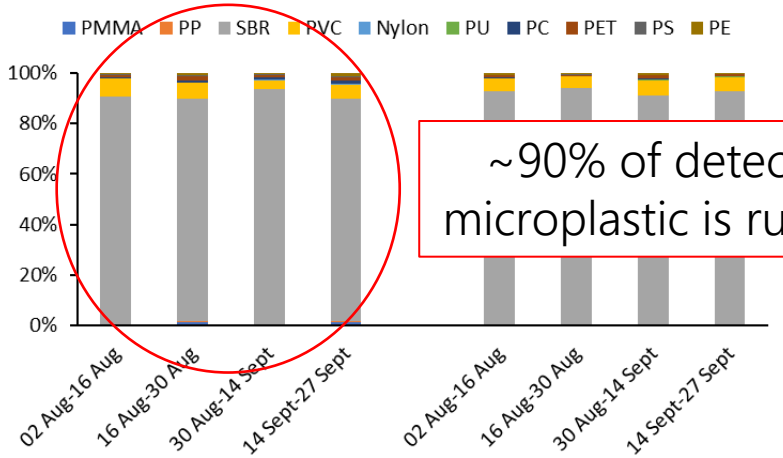
Sampling strategy (Norway)





Passive samples ng/m²/d

Active samples ng/m³



~90% of detected microplastic is rubber!

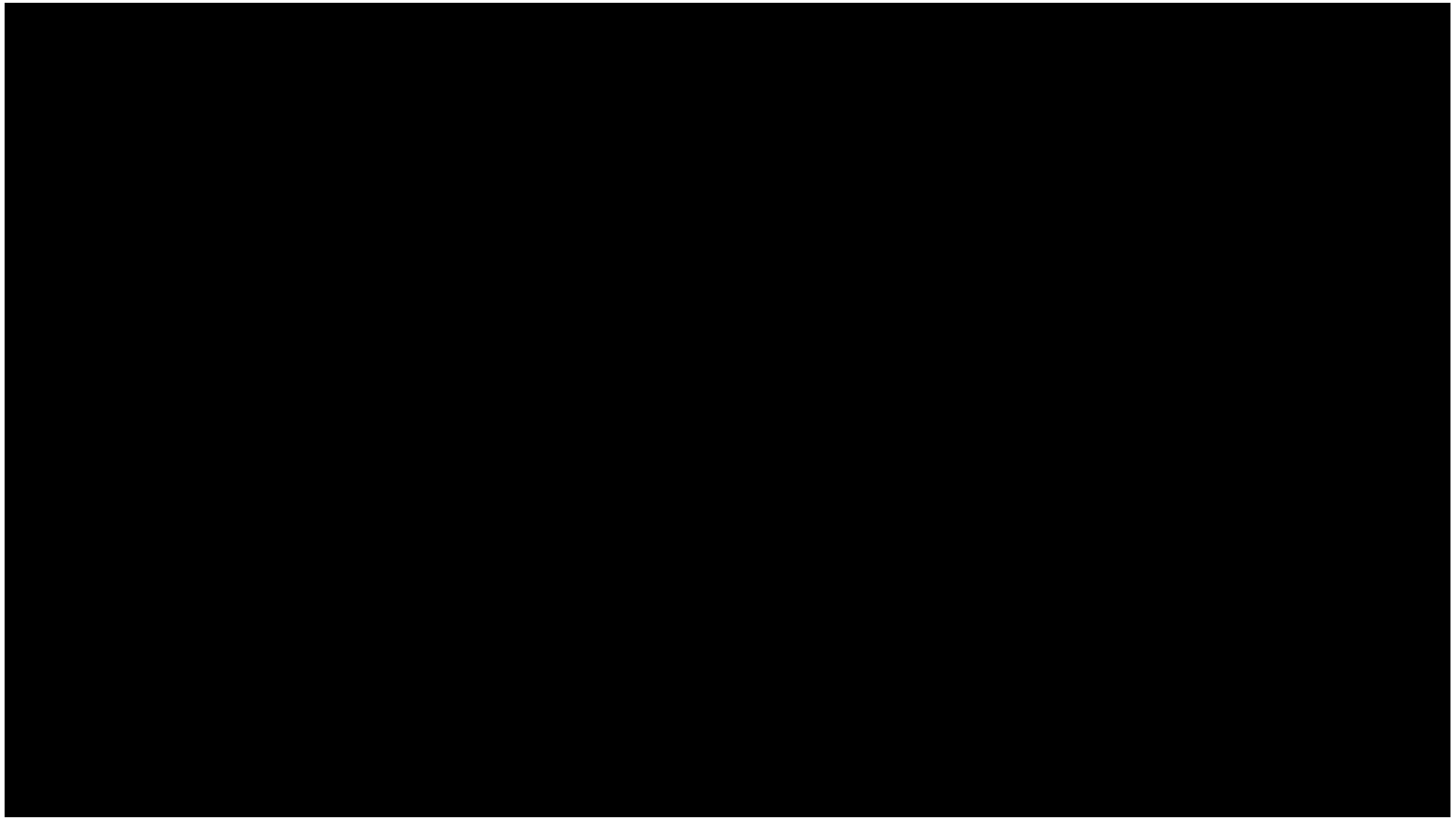
Sampling strategy (Norway)

First sedimentation basin for removal of large particles & gravel (water & sediment)

Last sedimentation basin before filtration step (water)

Outlet water from last basin (water)

Sludge from membrane filter (sediment)



Video source: NCC SnowClean - smelter og renser snøen (YouTube)

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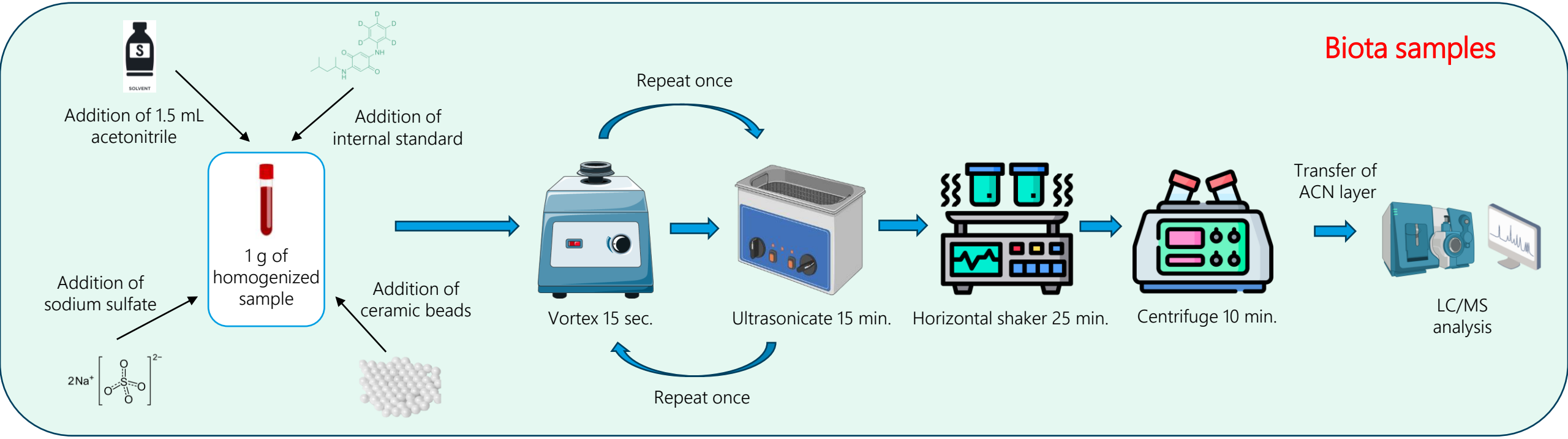
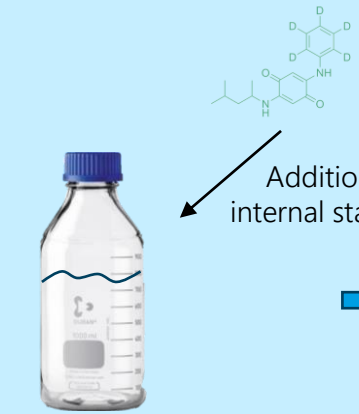
Extraction methods



Extraction methods

Water & snow samples



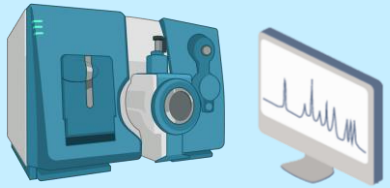
Filtered water

Addition of internal standard

Solid Phase Extraction

Elution using MeOH

Concentration using N_2



LC/MS analysis

Sediment samples

Drying at 50°C

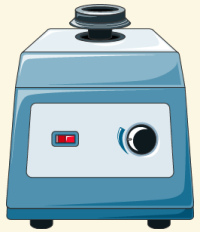
Sieving to remove stones

Sub-sample 200 mg

Addition of internal standard

Addition of 1.5 mL acetonitrile

Repeat once



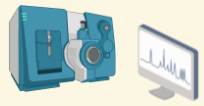
Vortex 15 sec.

Ultrasonicate 15 min.

Repeat once

Dry to dryness

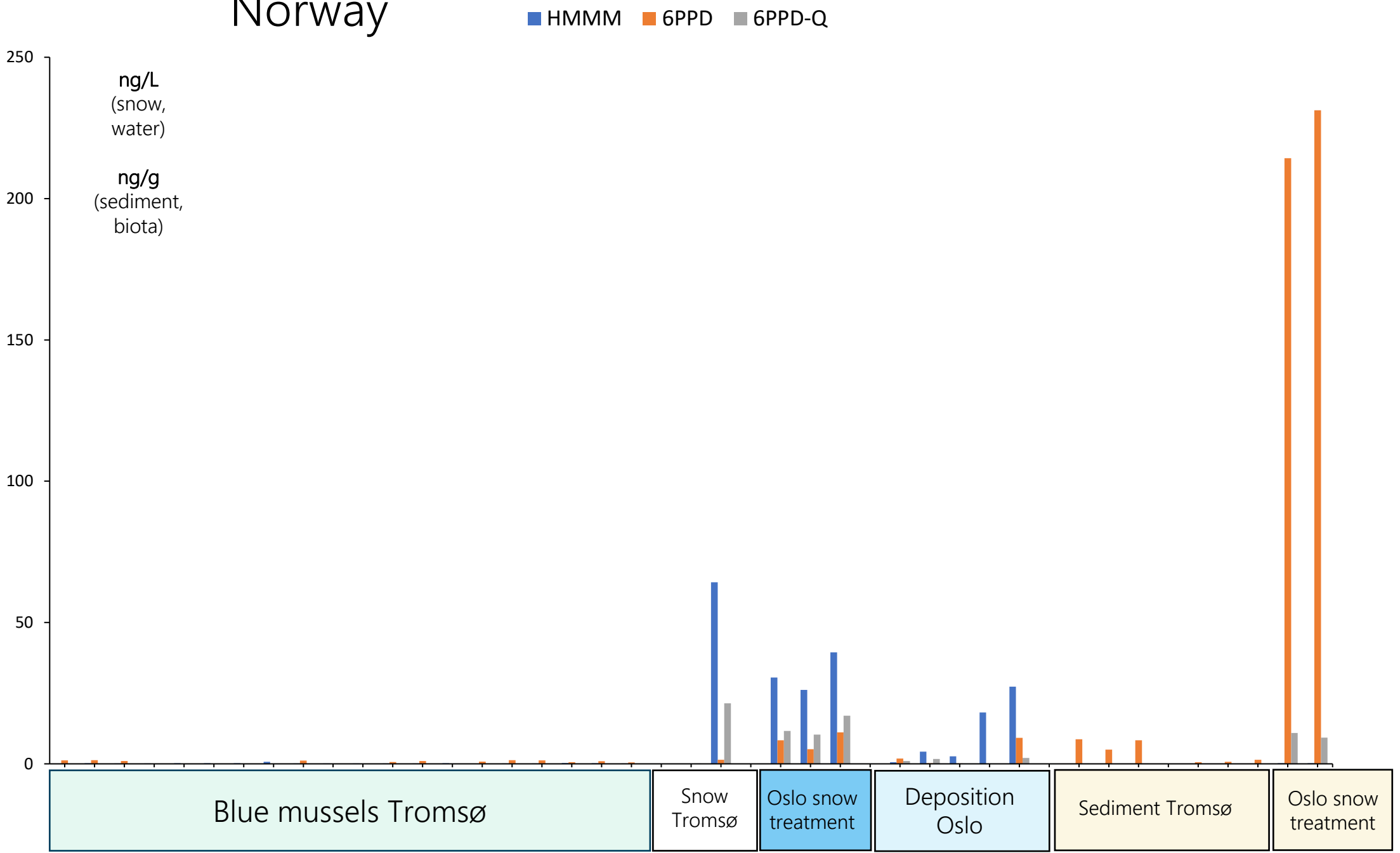
Redissolve in 100 µL ACN



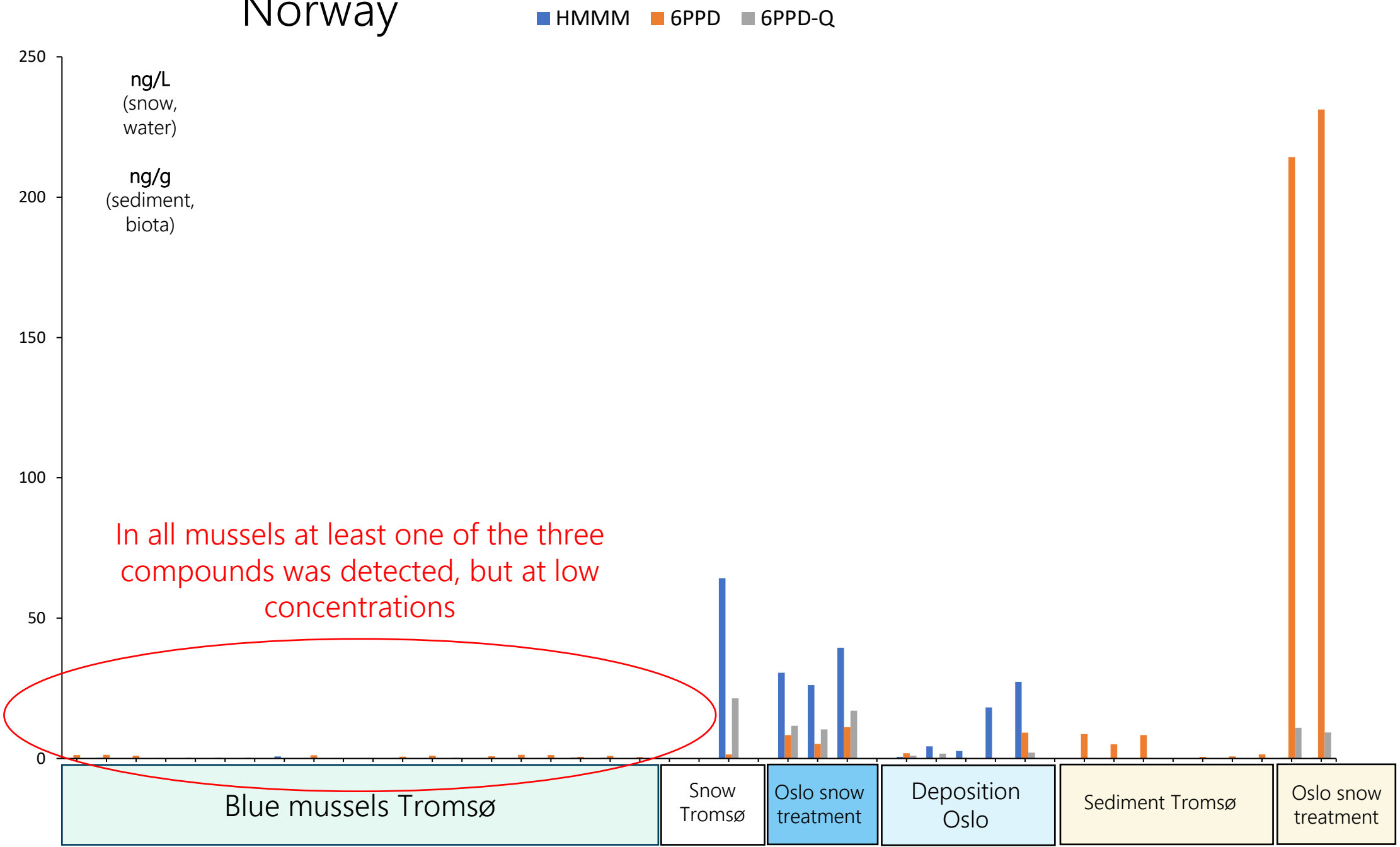
LC/MS analysis

Preliminary results
Norway

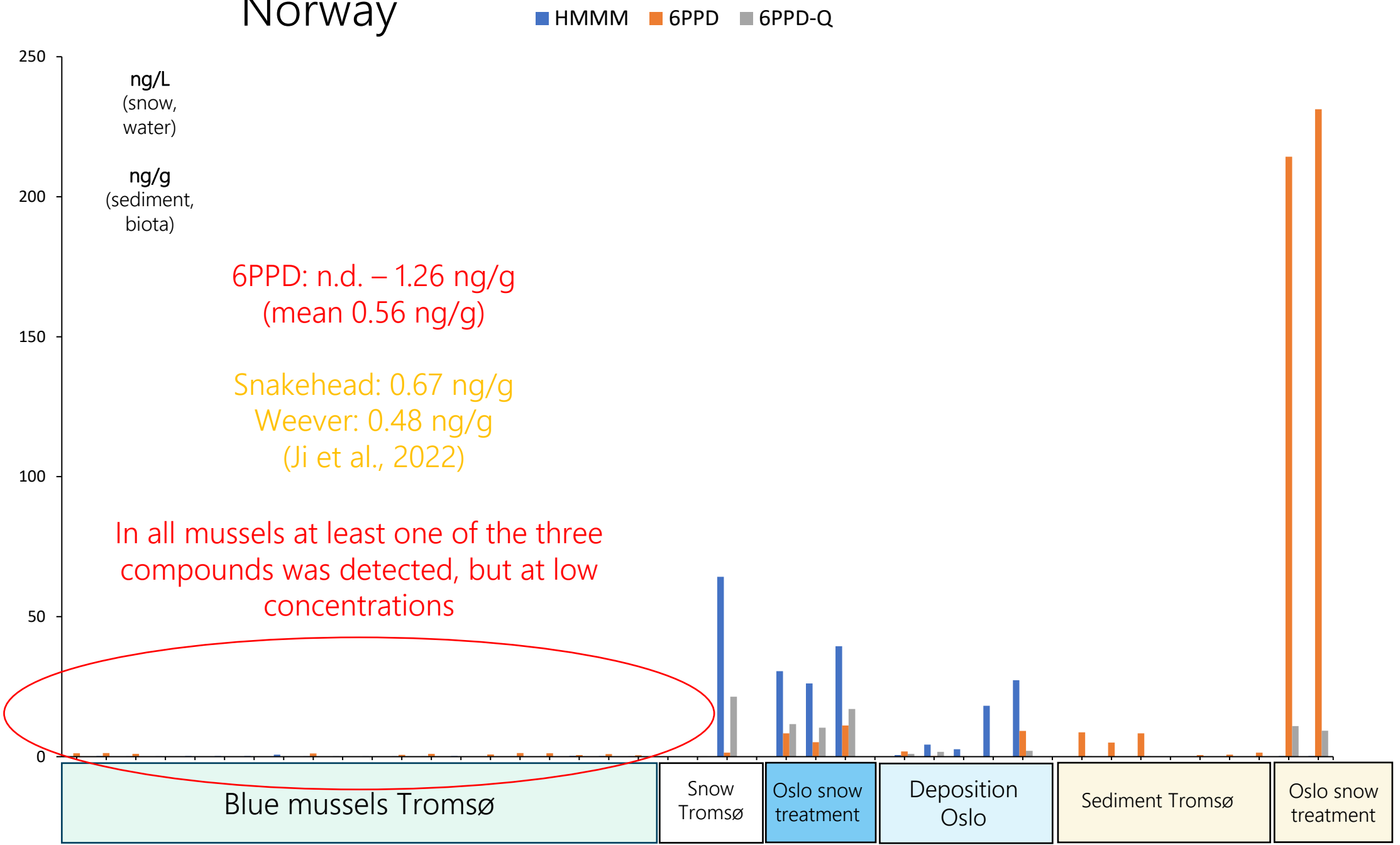
Norway


HMMM
6PPD
6PPD-Q
250
200
150
100
50
0
ng/L
(snow,
water)
ng/g
(sediment,
biota)
Blue mussels Tromsø
Snow
Tromsø
Oslo snow
treatment
Deposition
Oslo
Sediment Tromsø
Oslo snow
treatment

Norway


HMMM
6PPD
6PPD-Q
250
200
150
100
50
0
ng/L
(snow,
water)
ng/g
(sediment,
biota)
In all mussels at least one of the three compounds was detected, but at low concentrations
Blue mussels Tromsø
Snow Tromsø
Oslo snow treatment
Deposition Oslo
Sediment Tromsø
Oslo snow treatment

Norway


HMMM
6PPD
6PPD-Q
250
200
150
100
50
0
ng/L
(snow,
water)
ng/g
(sediment,
biota)
6PPD: n.d. – 1.26 ng/g
(mean 0.56 ng/g)
Snakehead: 0.67 ng/g
Weever: 0.48 ng/g
(Ji et al., 2022)
In all mussels at least one of the three compounds was detected, but at low concentrations
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Snow Tromsø
Oslo snow treatment
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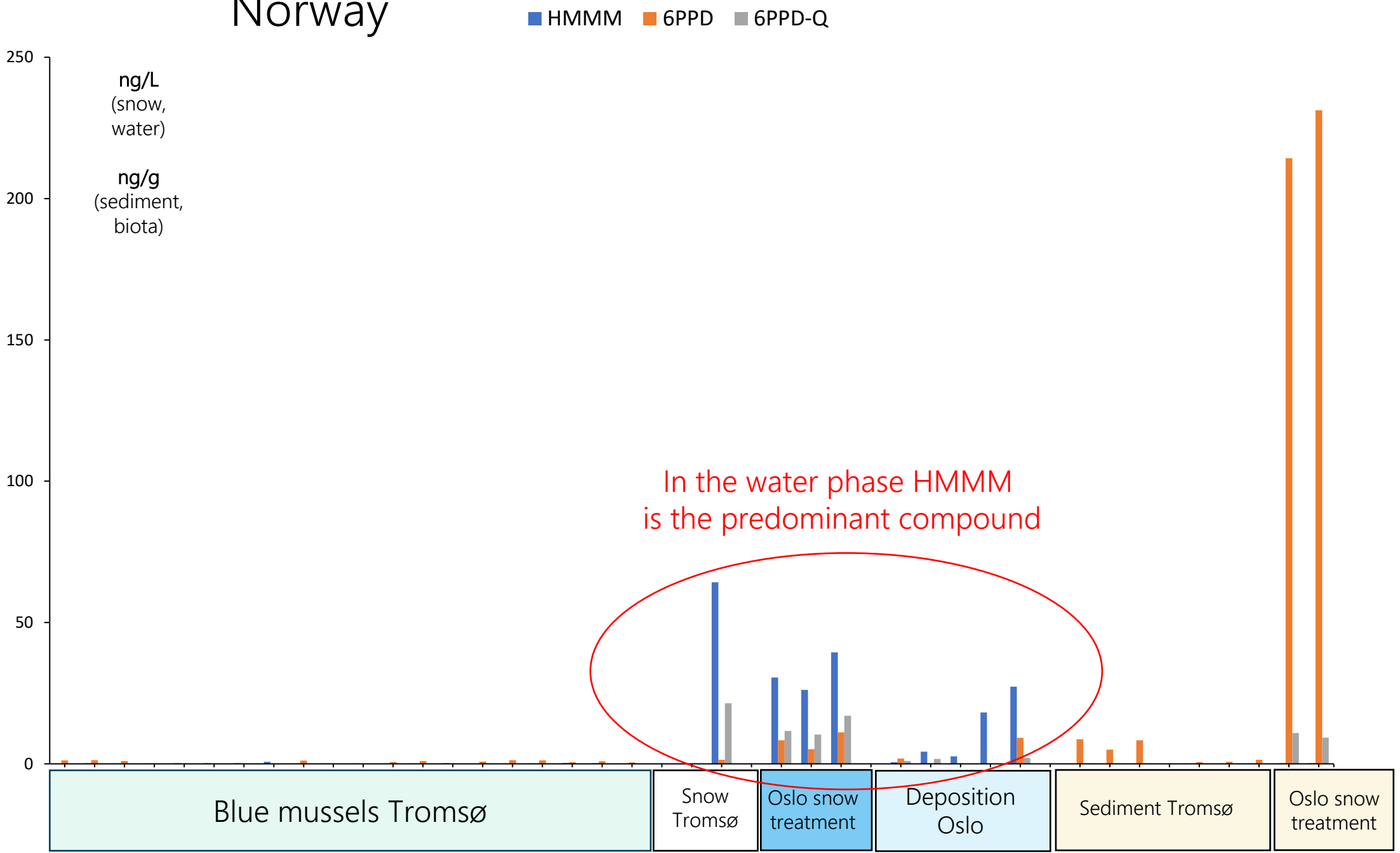
Norway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250
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ng/L
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ng/g
(sediment,
biota)
In the water phase HMMM
is the predominant compound
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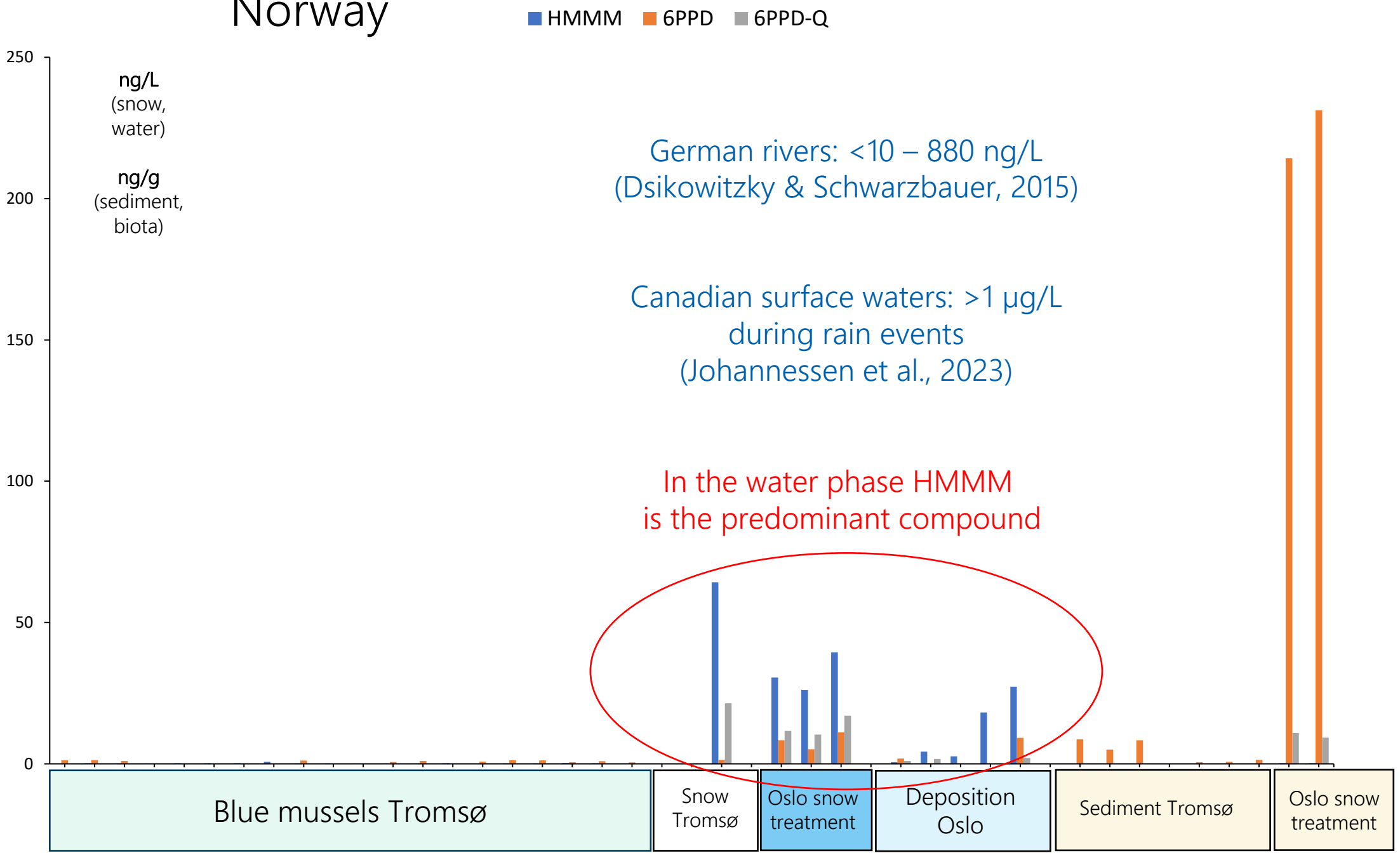
HMMM
6PPD
6PPD-Q
250
200
150
100
50
0
ng/L
(snow,
water)
ng/g
(sediment,
biota)
German rivers: <10 – 880 ng/L
(Dsikowitzky & Schwarzbauer, 2015)
Canadian surface waters: >1 µg/L
during rain events
(Johannessen et al., 2023)
In the water phase HMMM
is the predominant compound
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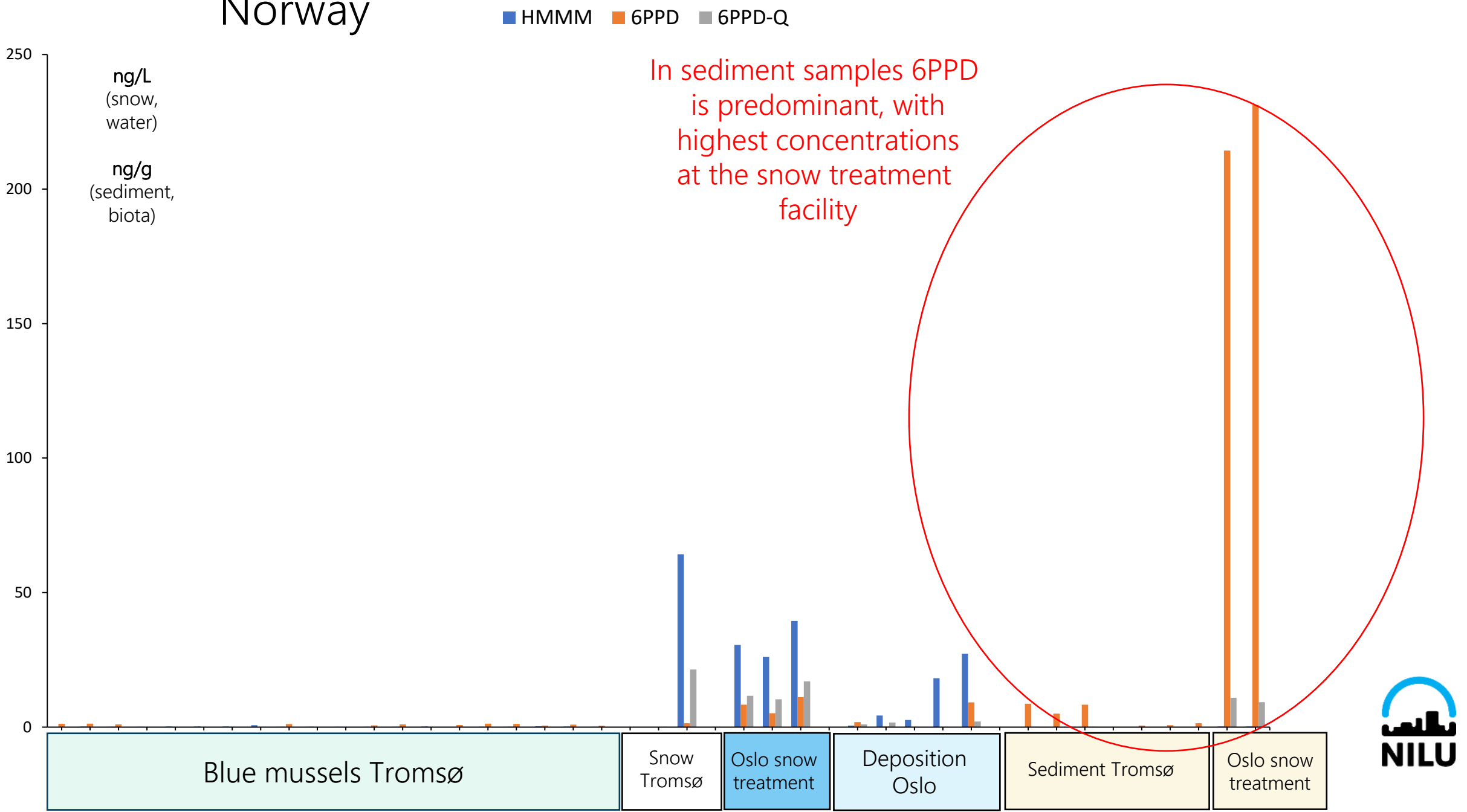
Norway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6PPD
6PPD-Q
250
200
150
100
50
0
ng/L
(snow,
water)
ng/g
(sediment,
biota)
In sediment samples 6PPD is predominant, with highest concentrations at the snow treatment facility
Blue mussels Tromsø
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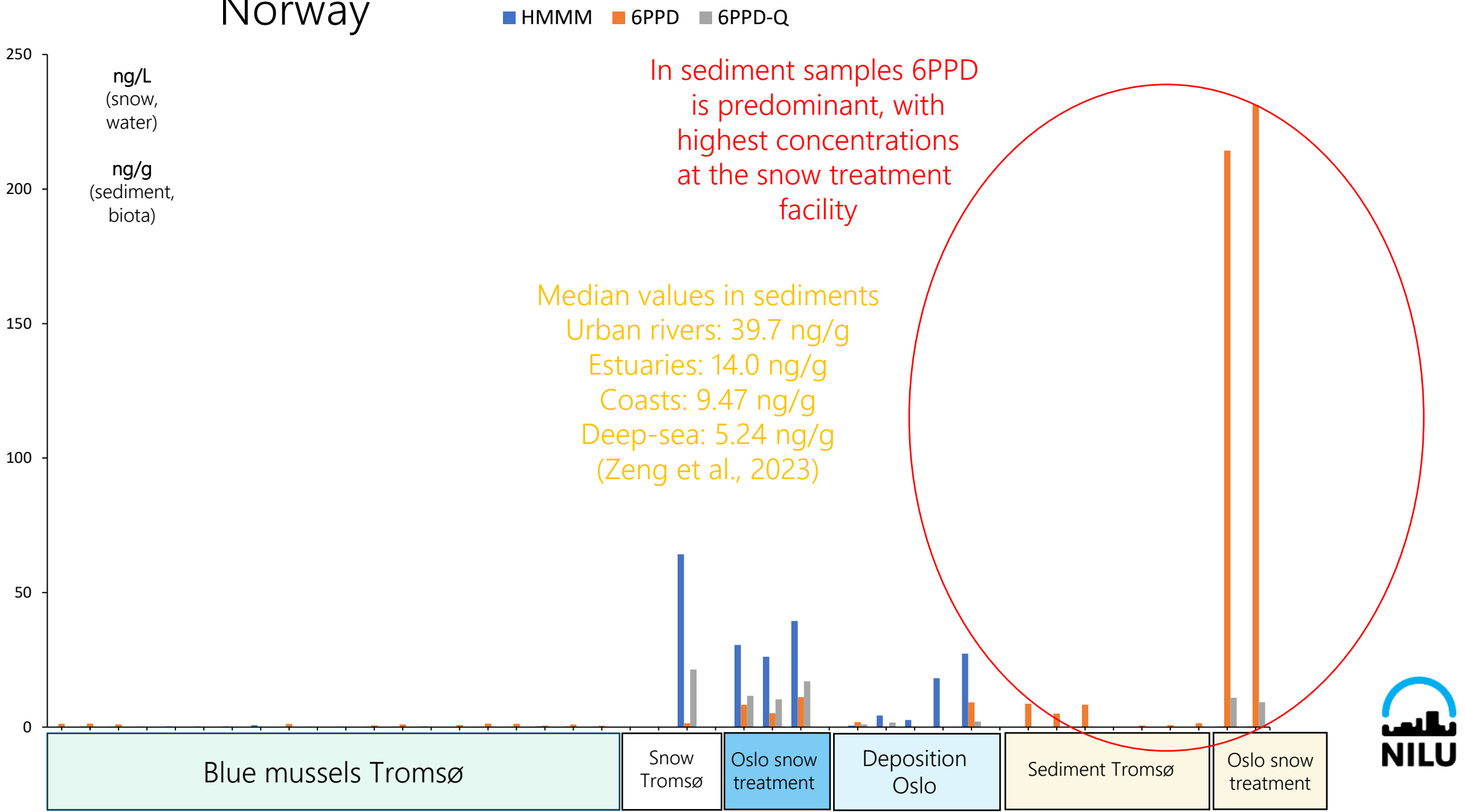
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6PPD
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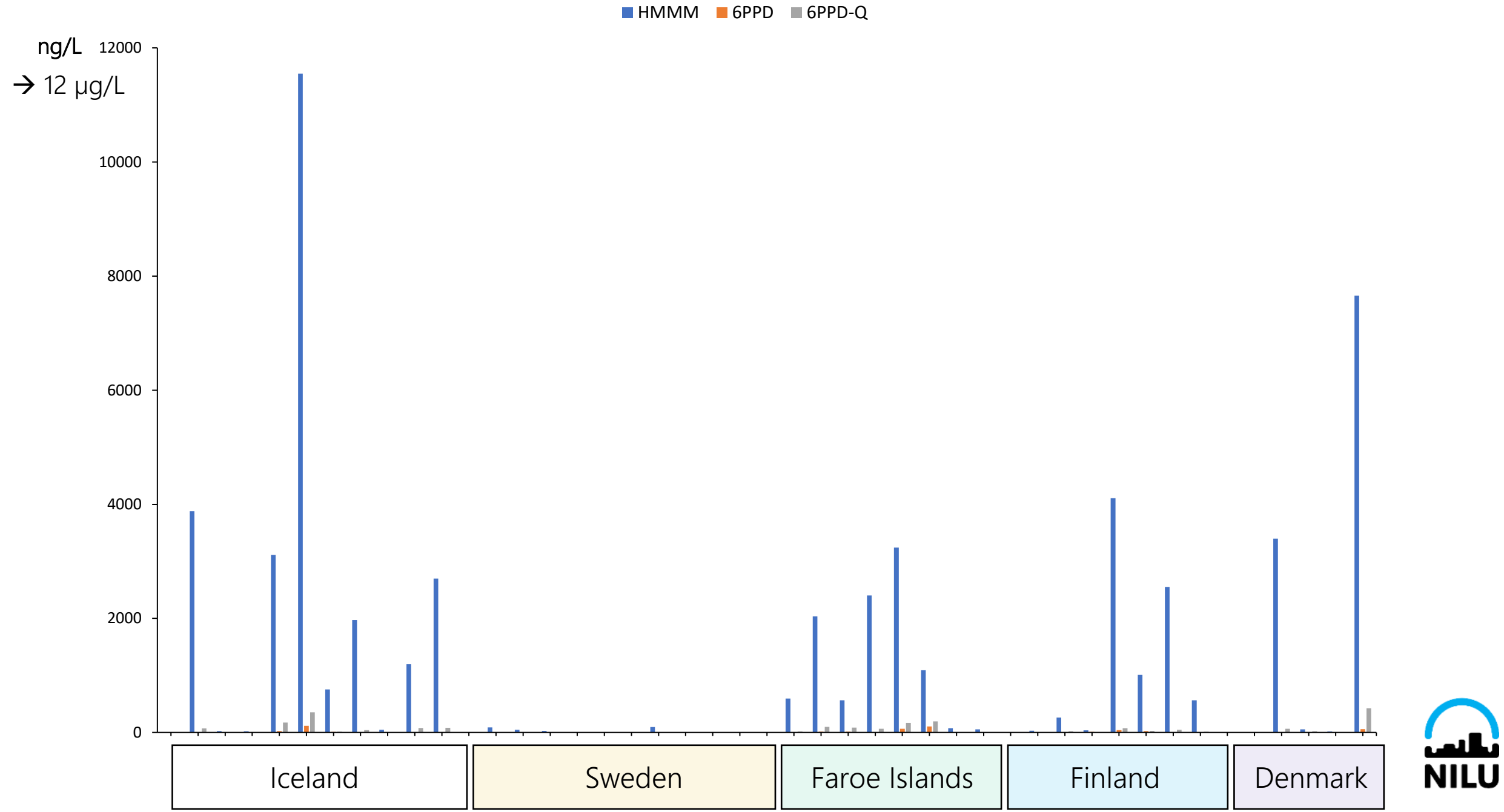
250
200
150
100
50
0
ng/L
(snow,
water)
ng/g
(sediment,
biota)
In sediment samples 6PPD is predominant, with highest concentrations at the snow treatment facility
Median values in sediments
Urban rivers: 39.7 ng/g
Estuaries: 14.0 ng/g
Coasts: 9.47 ng/g
Deep-sea: 5.24 ng/g
(Zeng et al., 2023)
Blue mussels Tromsø
Snow Tromsø
Oslo snow treatment
Deposition Oslo
Sediment Tromsø
Oslo snow treatment

Preliminary results Iceland, Sweden, Faroe Islands, Finland, Denmark


HMMM
6PPD
6PPD-Q
ng/L
→ 12 µg/L
12000
10000
8000
6000
4000
2000
0
Iceland
Sweden
Faroe Islands
Finland
Denmark
NILU

Contact:

Linda Hanssen lha@nilu.no
Natascha Schmidt nsch@nilu.no

Acknowledgments

Thanks to Gabriele Piattoli, Vladimir Nikiforov & Ådne Hotvedt for help in the lab.

Thanks to the Nordic Working Group on Chemicals, Environment and Health for funding.

Thanks to our Nordic partners: Fredrik Andreasson (SE), Iben Boutrup Kongsfelt (DK), Bergdís Björk Bæringsdóttir (IS), Katrin Hoydal (FO), Emmi Vähä (FI) & their colleagues that helped plan & carry out the project, organized sampling campaigns and performed fieldwork.

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