Pharmaceuticals and personal care products as environmental pollutants in Faroe Island, Iceland and Greenland

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Frame of the Study

- To investigate if there are **measurable** and eventually **potential harmful concentrations** of pharmaceuticals and additives of personal care products in the marine environment of Faroe Island, Iceland and Greenland
- To investigate if there is a **need for implementation of an action** concerning effectiveness of WWTP purification steps and/or legislation
- To **fill knowledge gaps** about the presence of PPCPs in the western Nordic Countries

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Selection of Compounds

- Based on a survey of the pharmaceuticals used in Faroe Island, Iceland and Greenland in 2010
- Statistics are based on number of **defined daily doses** of drugs

Decreasing volume of pharmaceutical

ATC	Greenland (Nuuk)	Faroe Islands	Iceland
C09AA02	Enalapril	Amlodipin	Acidum acetylsalicylicum
C08CA01	Amlodipin	Enalapril	Simvastatin
C10AA01	Simvastatin	Acetylsalicylic acid	Zopiclon
A02BC01	Omeprazol	Simvastatin	Omeprazol and esomeprazol
N02BE01	Paracetamol	Paracetamol	Ibuprofen
C03AB01	Bendroflumethiazid and kalium	Bendroflumethiazid and kalium	Citalopram/escitalopram
B01AC06	Acetylsalicylic acid	Furosemid	Amlodipin
G03AC08	Etonandestrel	Omeprazol	Losartan
G03AA09	Desandestrel and estranden	Metoprolol	Enalapril
A11DA01	Thiamin (vitamin b1)	Candesartan	Hydrochlorothiazid
M01AE01	Ibuprofen	Gliclazid	Amilorid
N06AB04	Citalopram	Atorvastatin	Progestogen
A11AA03	Multivitamines and other minerales, incl. comb.	Citalopram	Paracetamol
C07AB02	Metoprolol	Esomeprazol	Furosemid
G03AA07	Levonorgestrel and estranden	Zopiclon	Levothyroxinum natrium
D07AB02	Hydrocortisonbutyrat	Ibuprofen	Atenolol
R03BA02	Budesonid	Levothyroxinnatrium	Levonorgestrel and estrogen
R03AC03	Terbutalin	Sertralin	Sertralin
C09CA01	Losartan	Isosorbidmononitrat	Diclofenac
C03CA01	Furosemid	Felodipin	Nicotin

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Investigated Compounds

Total: 37 pharmaceuticals and 7 additives of personal care products

Non steroidal anti-inflammatory and antipyretic analgesics and local anesthetics (6):

Acetylsalicylic acid
Diclofenac
Ibuprofen
Lidocaine
Naproxen
Paracetamol

Antibiotics and antimicrobal agents (1):

Sulfamethizol

Antidepressants (5):

Citalopram
Fluoxetine
Paroxetine
Sertraline
Venlafaxine

Antidiabetics (2):

Glicazide
Metformin

Anti ulcer drugs (1):

Omeprazole

Hypnotics (1):

Zopiclone

Cardiovascular drugs (14 +2):

Amiloride
Amlodipine
Atenolol
Bendroflumethiazide
Candesartan
Dipyridamole
Enalapril + Enalaprilat
Furosemide
Hydrochlorothiazide
Lidocaine
Losartan
Metoprolol
Perindopril + Perindoprilat
Simvastatin
Warfarin

Hormones (5):

17-a-Etinylestradiol (EE2)
17-β-Estradiol (E2)
Estriol (E3)
Estrone (E1)
Levothyroxine

Additives in Personal Care Products (7):

Diethyl-phthalate (**DEP**)
Butylparaben (**BuP**)
Cocoamidopropyl betain (**CAPB**)
Sodiumdodecyl sulphate (**SDS**)
Sodiumlaureth sulphate (**SDSEO-1-4**)
Certrimonium Br-salt (**ATAC-C16**)
Ethylen diamine tetraacetic acid (**EDTA**)

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Sampling sites and sample selection

- Sites where **sewage water from urban areas** as well as **hospitals** are discharged to the recipient
- **In WWTPs:** sewage water on several sites in the treatment process: influent water, effluent water and sludge samples
- Areas **without WWTPs**: sewage lines with sampling or maintenance wells: water was classified as effluent water and sludge sample
- From the **recipient**: water and sediment samples

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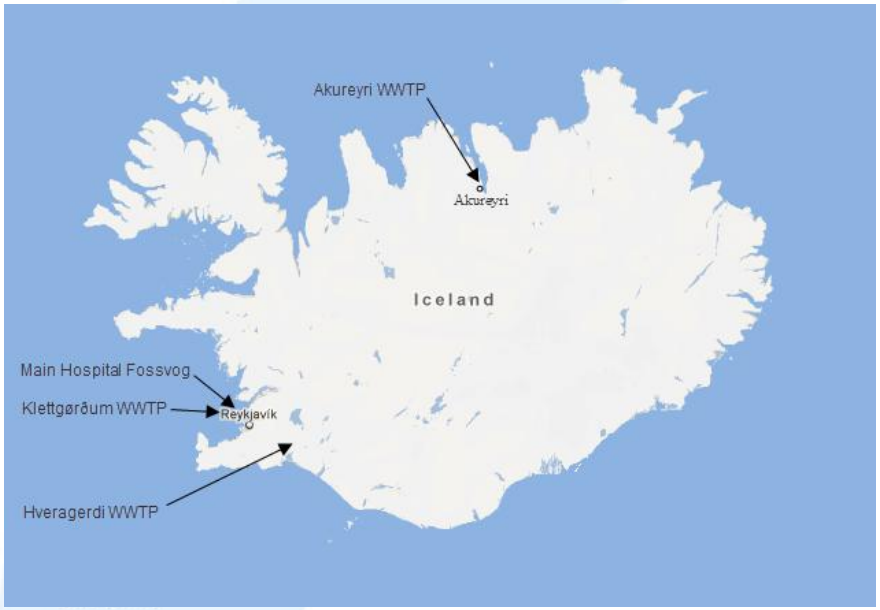
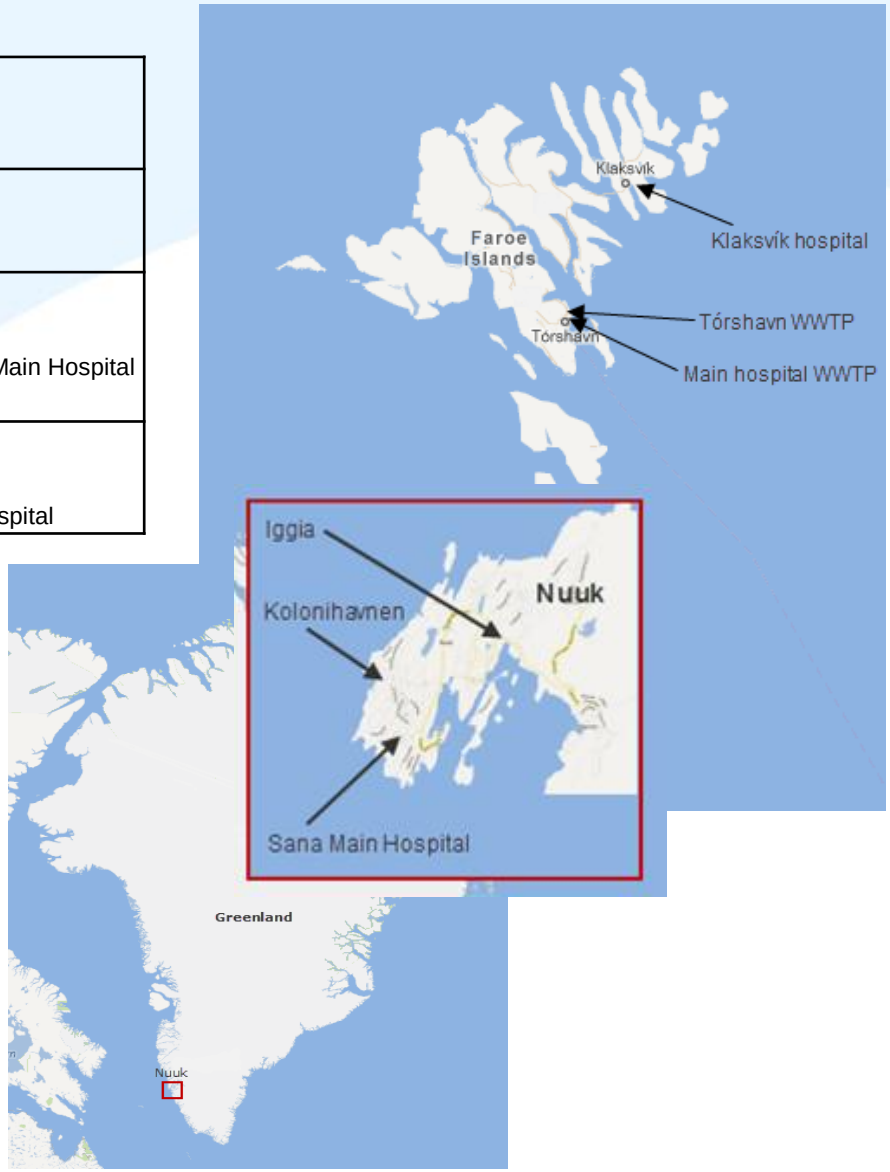
Sampling sites and sample selection

Country	Waste water treatment plants, WWTP, or sewage lines, SL.	Hospitals	Recipients
Faroe Islands	Tórshavn WWTP (Sersjantvíkin)	Main Hospital Klaksvík Hospital	Tórshavn Klaksvík
Iceland	Akureyri WWTP Reykjavík WWTP (Klettgørðum) Hverðagerði WWTP	Fossvog Main Hospital	Akureyri Reykjavik Reykjavik: Fossvog Main Hospital
Greenland	Kolonihavnen SL Iggia SL	Sana (Dronning Ingrid) Main Hospital	Nuuk: Kolonihavnen Nuuk: Iggia Nuuk: Sana Main Hospital





Results

most present pharmaceuticals of this study:

- paracetamol (antipyretic)
- metformin (antidiabetic)
- salicylic acid (non steroidal anti-inflammatory)
- atenolol (cardiovascular drug)
- dipyridamole (cardiovascular drug)

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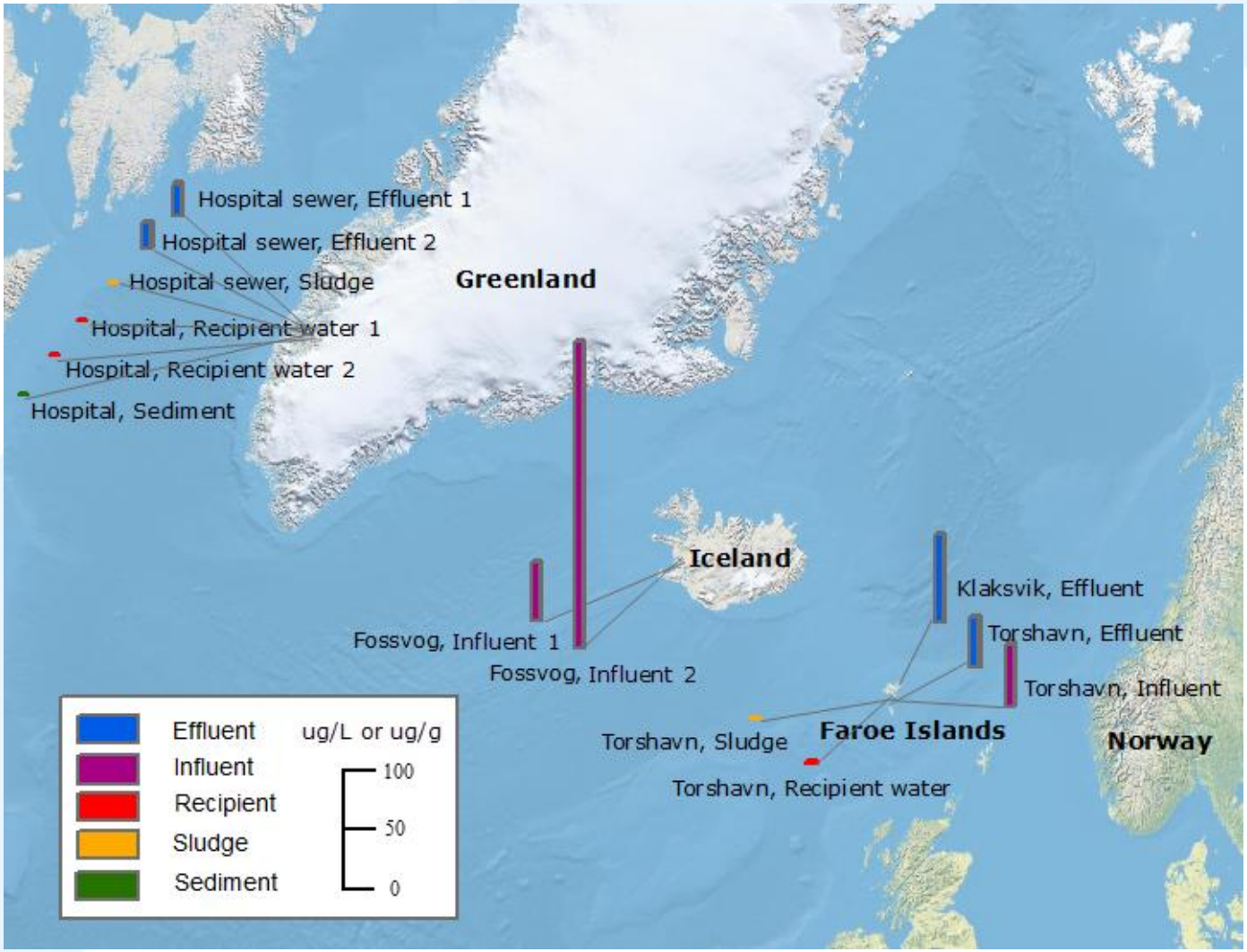
Concentrations of paracetamol in different matrix samples at hospital sites



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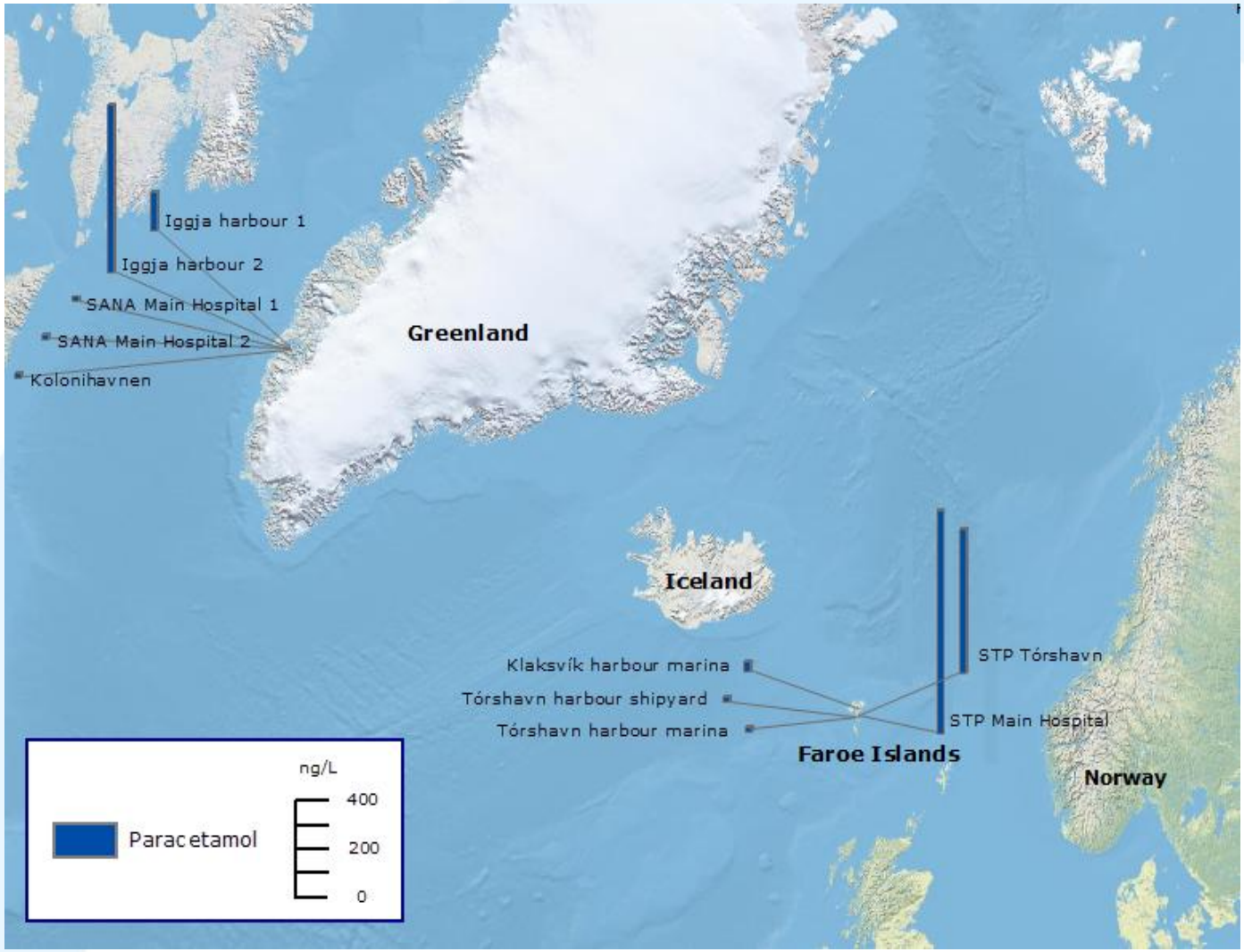
Concentrations of paracetamol in recipient water samples at all sites



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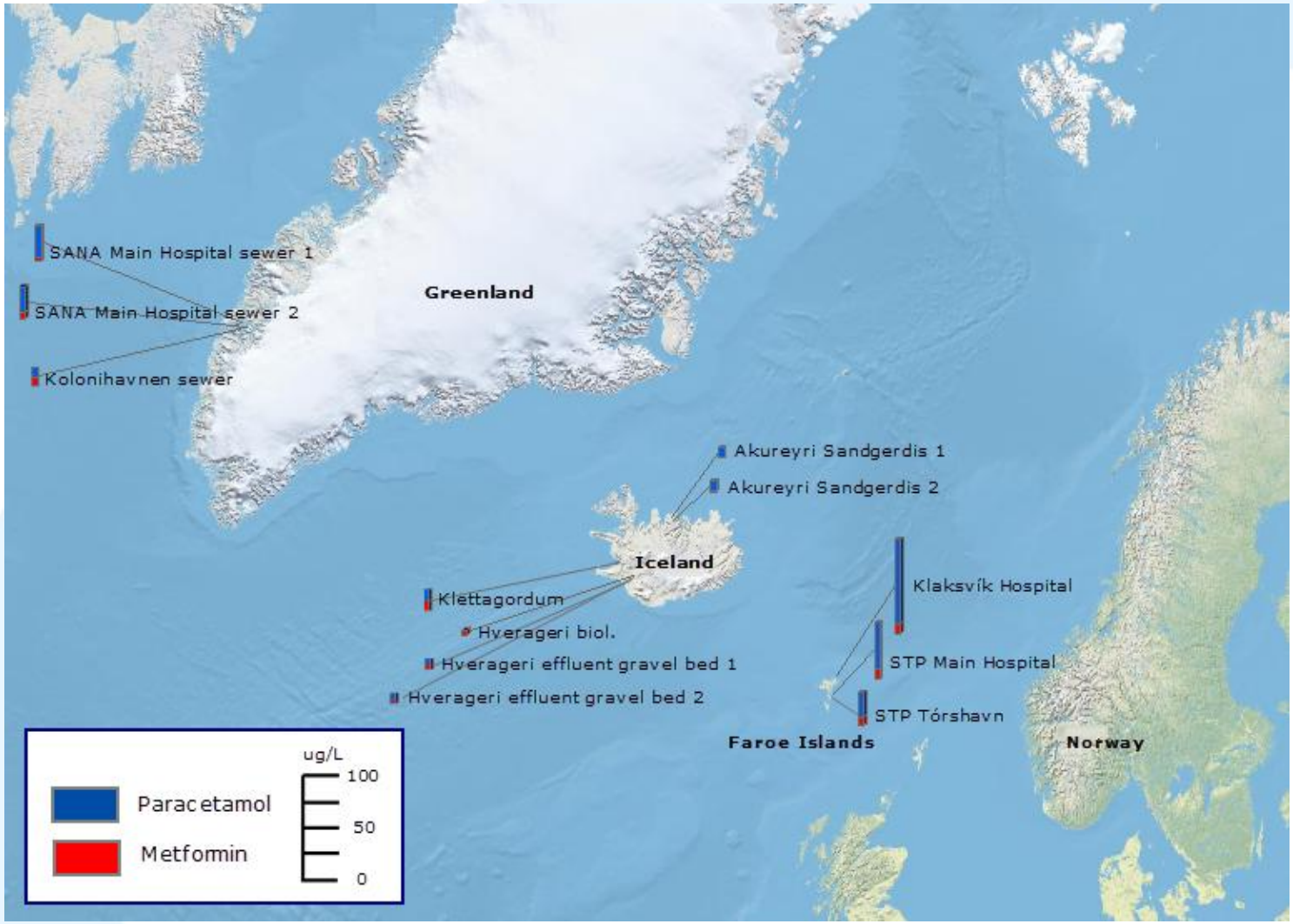
Concentrations of paracetamol and metformin in effluent waters



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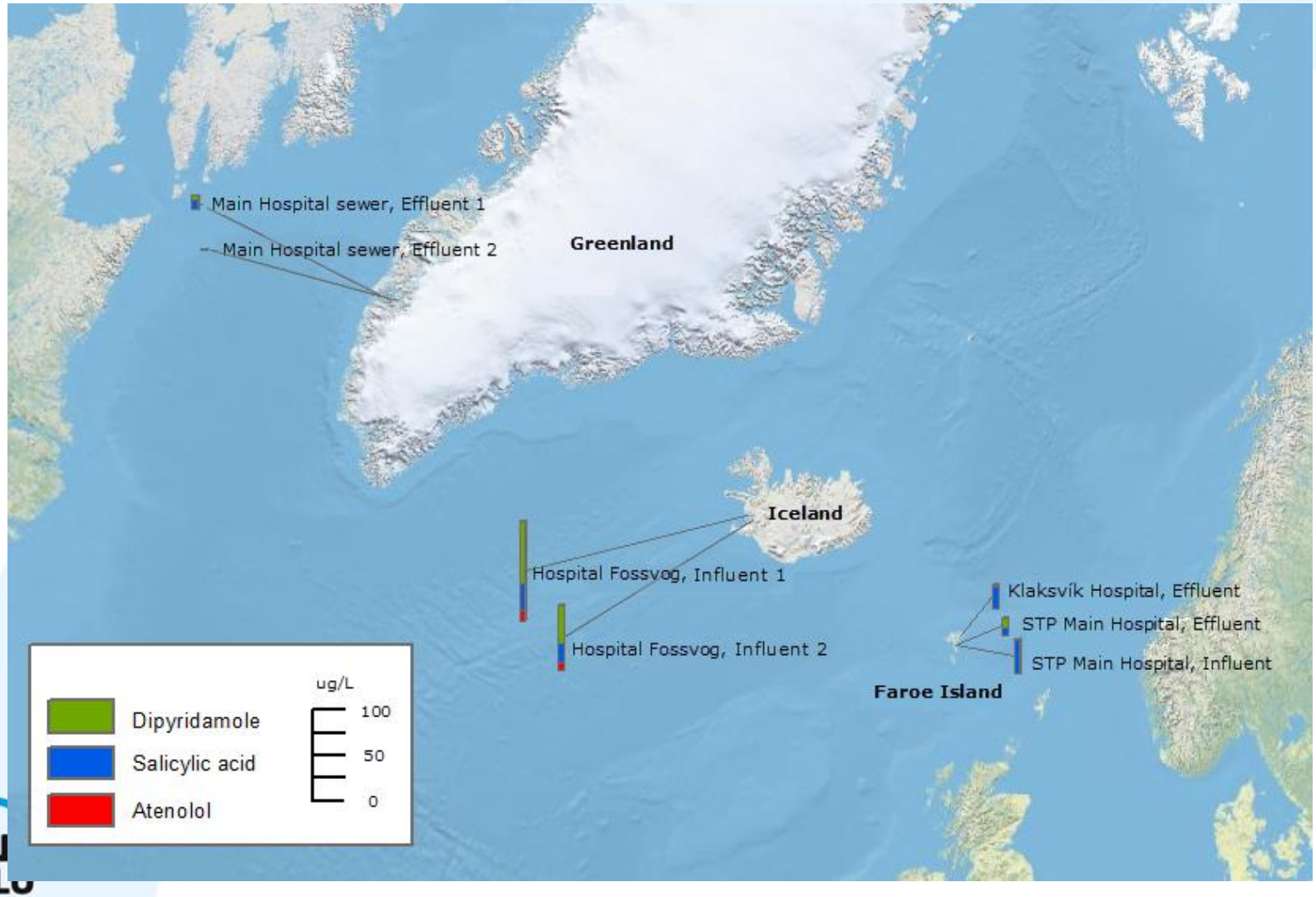
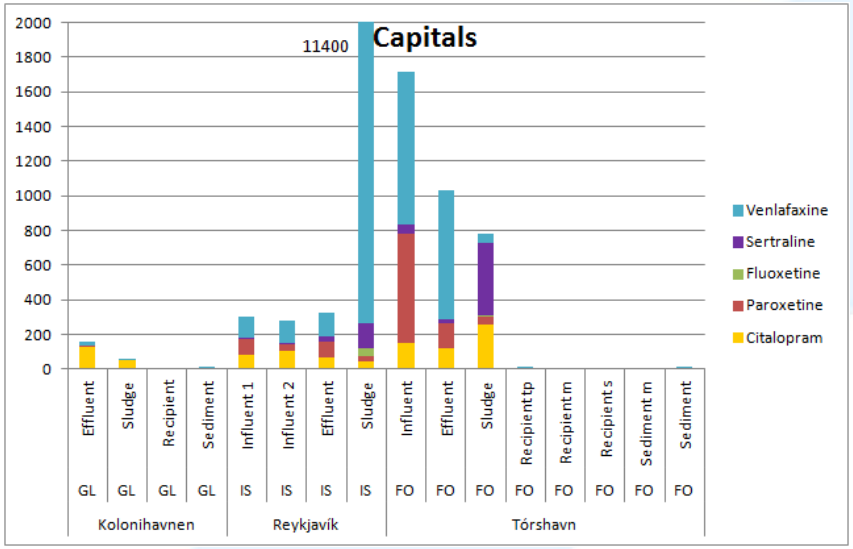
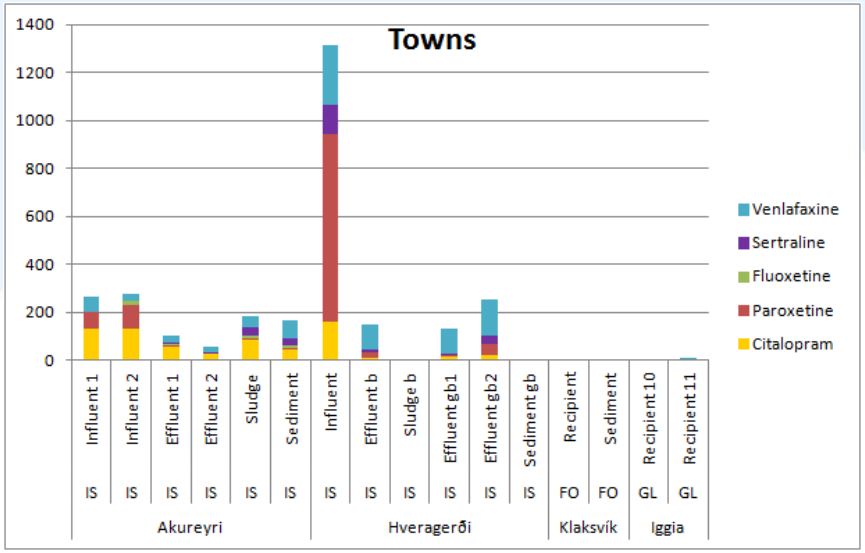
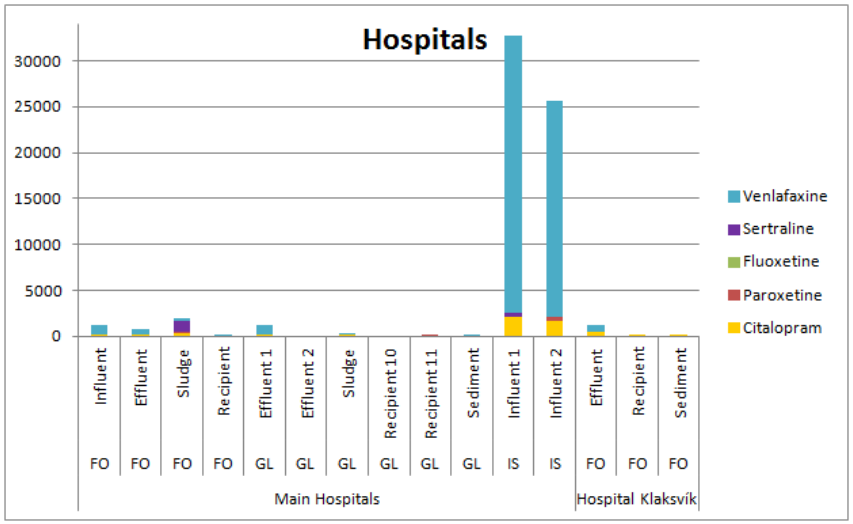
Concentrations of salicylic acid, atenolol and dipyridamole in WWTP influent and effluent samples at hospital sites



Antidepressants







ng/L and µg/kg d.w.

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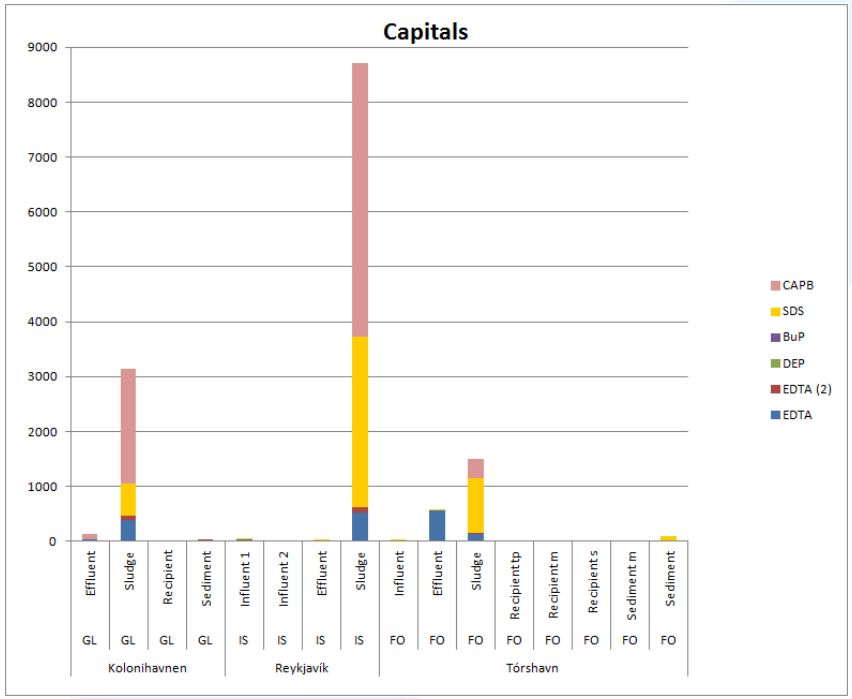
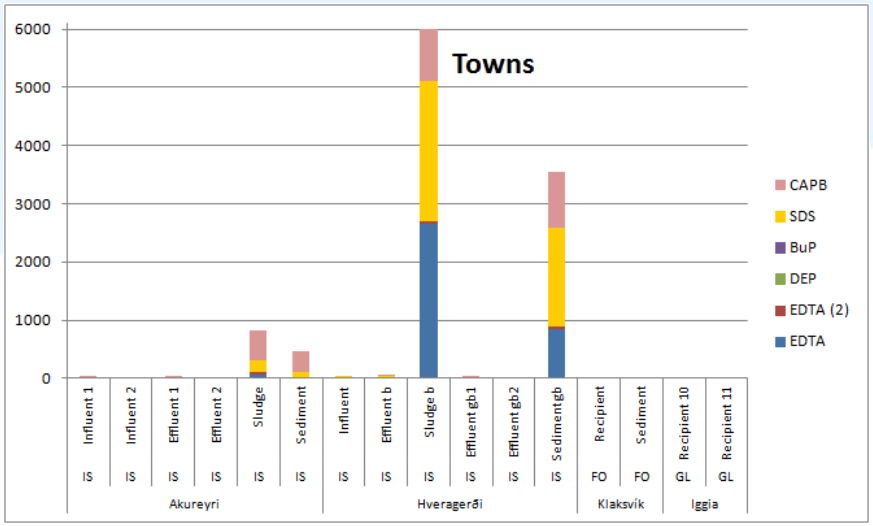
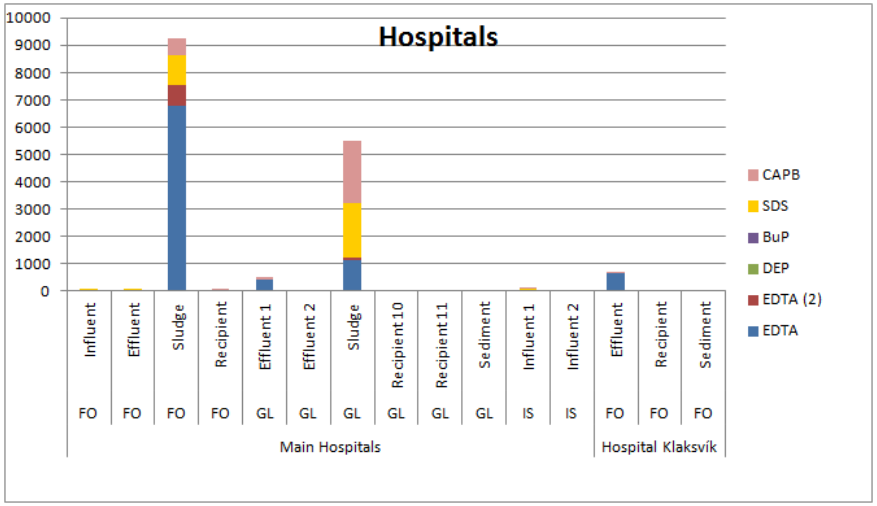
Additives in personal care products I







µg/L and µg/kg d.w.
EDTA 2 in µg/kg w.w.

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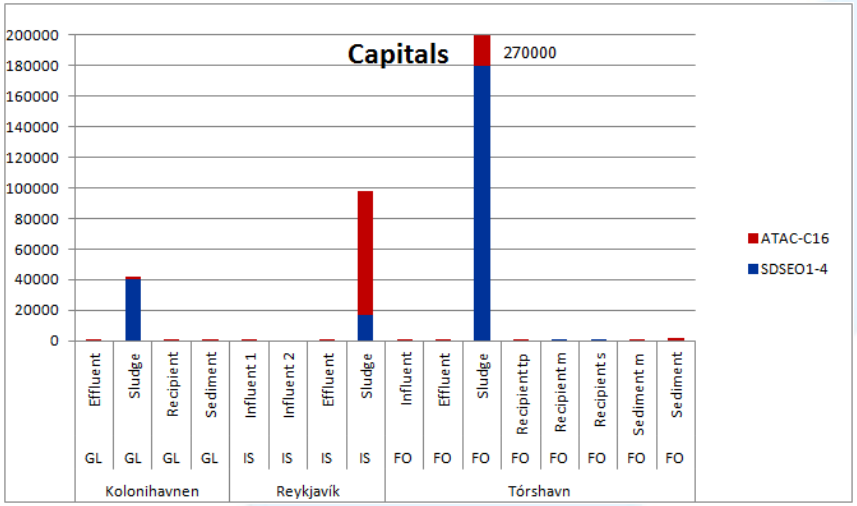
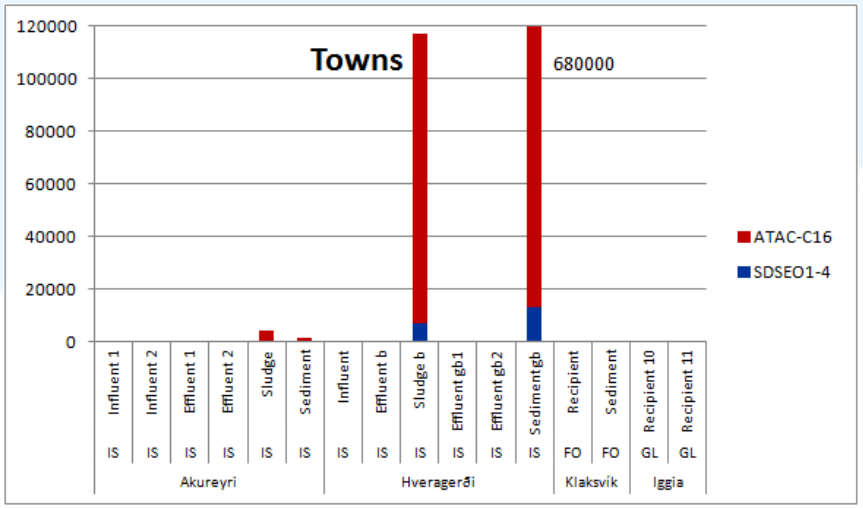
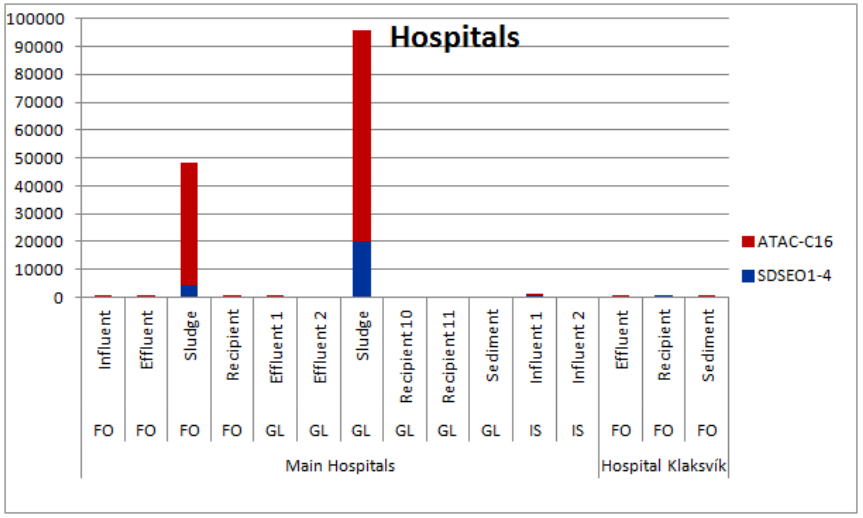
Additives in personal care products II





µg/L and µg/kg d.w.



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Initial ecotoxicological risk assessment

- Collection of predicted no-effect concentrations (PNEC)

- no initial ecotoxicological risk assessment could be performed for 12 of 37 compounds (amiloride, atenolol, dipyridamole, enalapril, enalaprilat, estrone, glicazide, paroxetine, perindopril, perindoprilat, sulfamethizole and zopiclone)

- Ratios between measured environmental concentrations (MEC = measured concentrations in recipient waters of this study) and PNECs are calculated and used as indicator of risk.

MEC/PNEC	< 1	no risk
MEC/PNEC	> / >> 1	risk and high risk of effects to the environment

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Initial ecotoxicological risk assessment

- For **all investigated pharmaceuticals** MEC/PNEC < 1 and << 1

  → no riks for the environment
- Caution has to be taken: MEC/PNEC data for **17β-estradiol, estriol and 17α-ethinylestradiol**

  → PNEC values are below the limits of detections
- The MEC/PNEC ratio for personal care products **DEP and butylparaben** <1, **SDS** <<1

  → no risk for aquatic organisms
- But for the surfactant **SDSEO1-4, CAPB and ATAC-C16** MEC/PNEC ratios >1

  → risk for chronicle toxicity

Limitations:

- No recipient waters from Iceland
- Availability of PNEC data for sediments and the the estimation of risk regarding the results from sediment samples → only PNEC data available for water

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Summary

This screening study was the **first assessment** of concentrations from **pharmaceuticals and additives in personal care products** in waste water treatment plants and recipients from **Faroe Islands, Greenland and Icland**.

33 substances of the 37 investigated pharmaceuticals and **all of the seven investigated additives of personal care products** were detected. 17α-Ethinylestradiol, omeprazole, sulfamethizole and zopiclone have not been detected above the limit of detections.

11 pharmaceteuticals (amiloride, candesartan, dipyridamole, enalaprilat, glicazide, hydrochlorothiazide, levothyroxine, lidocaine, losartan, metformin and perindoprilat) were investigated for the **first time in Nordic countries**.

7 pharmaceuticals (amilodipine, bendroflumethiazide, enalapril, enalaprilat, fluoxetine, sertraline and zopiclone) were investigated the **first time in sediment samples in the Nordic countries.**

Simvastatin and warfarin were the **first time** investigated in **WWTP sludge, recipient water and sediment samples from the Nordic countries.**

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Summary and Conclusion

Highest concentrations were found for **paracetamol** (antipyretic) > **metformin** (antidiabetic) > **salicylic acid** (non steroidal anti-inflammatory) > **atenolol** (cardiovascular drug) > **dipyridamole** (cardiovascular drug).

Antidepressants were generally found in **highest concentrations in Iceland.**

Samples from **hospital sites** showed generally **higher concentrations in all type of sample materials**. The main hospital **Fossvog in Iceland showed outstanding high concentrations for many of the pharmaceuticals** in WWTP effluent samples. This might be due that the sample is comming from a sewage line, which has no real purification step compared to WWTPs.

Highest concentrations of additives of personal care products were detected for the **surfactants** (**SDSEO1-4, ATAC-C16, and CAPB**) and **EDTA**. The concentration was high in sludge compared to the water concentration. It was **concluded** that the **sediment and the sludge act as a sink** for these compounds.

The more readily degradable personal care chemicals, **DEP and butyl paraben**, were detected at **low concentrations** (low ng/l to low µg/l). DEP and butyl paraben have low affinity to organic particles and are **not concentrated in sludge and sediment.**

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Conclusion

The conclusions are based on **relatively few samples per site and not always complete sample sets** were available, however, the **screening has identified the occurrence of a high number of the investigated substances** in waste water treatment plants and recipients from Faroe Islands, Greenland and Iceland.

A complete risk assessment could not be performed within this study due to limitations in sample material and availability of measured PNEC values.

Follow-up studies are therefore recommended!

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Acknowledgements

Faroe Islands:
Katrin Hoydal
Sanna í Túni Nielsen
Regin Olsen
Martin Gregersen
Julian Dam
Rakul Mortensen

Greenland:
Anette Hansen
Mathias Barfoed
Kåre Hansen
Kristian Nielsen

Norway:
Inger-Christin Steen
Terje Vasskog
Morten K. Moe
Linda Hansen
Silje Winnem

Iceland:
Gunnar Steinn Jónsson
Sigurður Skarphéðinsson
Kristján Tómasson
Egill Sölvason
Guðmundur Baldursson
Árni Svavarsson
Gunnþór Hákonasson

Thank you for your attention!