Pharmaceuticals as new emerging contaminants in the Arctic environment:Implications and Perspectives

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Pharmaceuticals and personal care products (PPCPs)

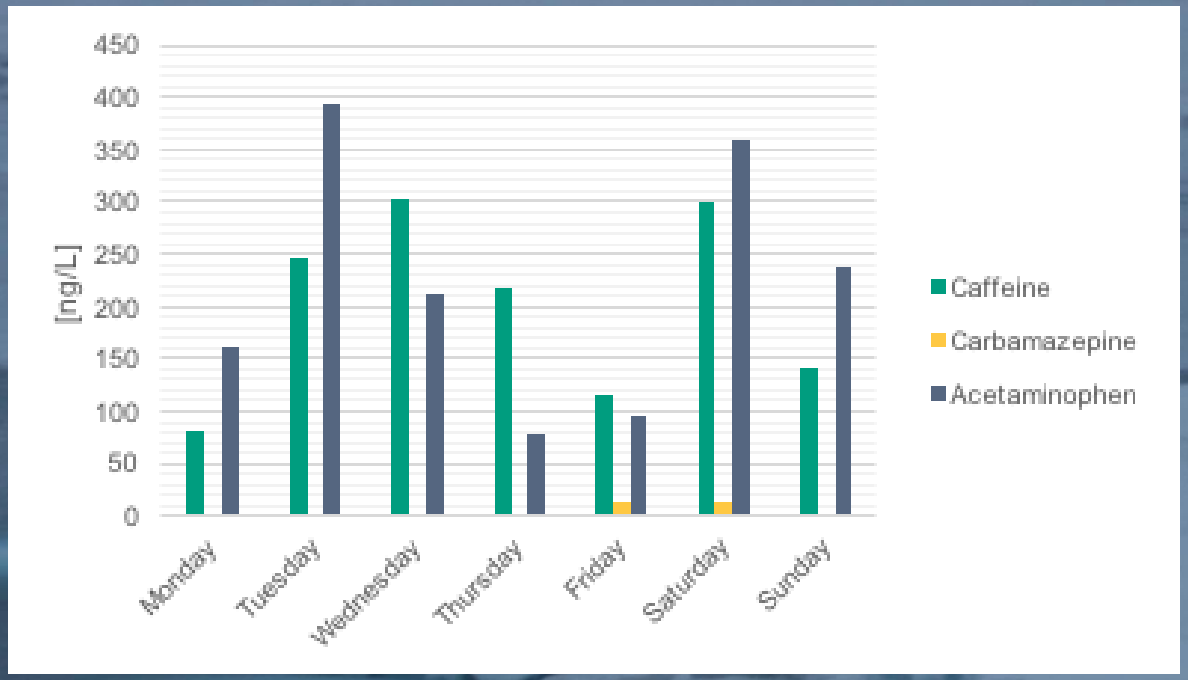
- Indicator chemicals for human activities
- **Sources:** Hygiene products, Cosmetics, supplementary food, Veterinary & Human therapeutic applications etc.
- **Accessibility:** PPCPs open available; vendors, stores; Medical therapy: Over the counter (uncontrolled) & Prescriptions (controlled)
- **Release:** Introduction mainly via Sewage and sewage treatment (faces & urine), Direct (husbandry, aquaculture), uncontrolled disposal of outdated products via sewage/ manure and/or garbage dumps.
- **Environmental relevance:** Many PPCPs are pseudo-persistent - Continuously present due to permanent replenishment (although considered as degradable).

Photo: Wikipedia

Sampling Location in Tromsø: October 2016

3 km

PPCPs in Tromsø

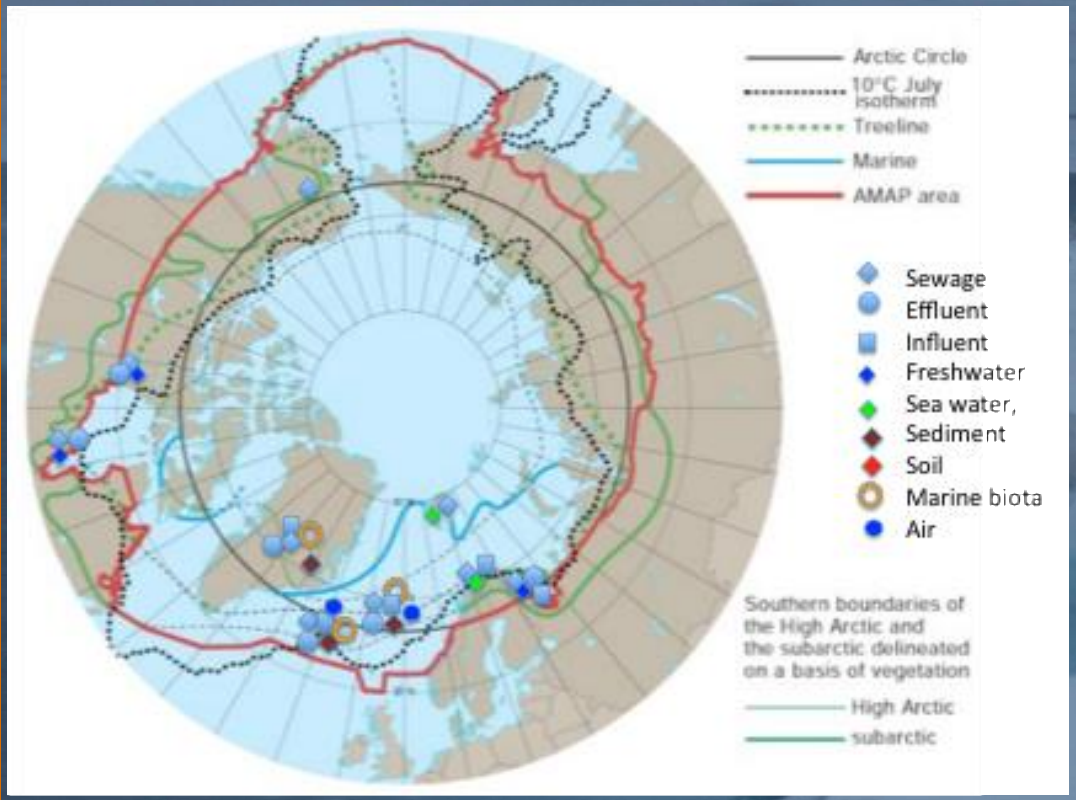


Caffeine, Carbamazepine and Acetominophen (Paracetamol) are the most abundant PPCP compounds (out of 25 target substances)in harbor water from Tromsø taken in 2016.

Caffeine levels for 2016 were at the same order of magnitude than first measured in 2004 (Weigel et al. 2004).

Arctic Monitoring and Assessment Programme (AMAP)

AMAP report 2015, Pollutants of Emerging Concern, Chapter 10: Pharmaceuticals and Personal Care Products (PPCPs) in the Environment



- 110 PPCPs (including transformation products) identified
- Based on 22 published reports
- 7 sample categories
- Conc. range: ppb – ppm
- Distribution patterns, environmental mobility, transformation pathways largely unknown

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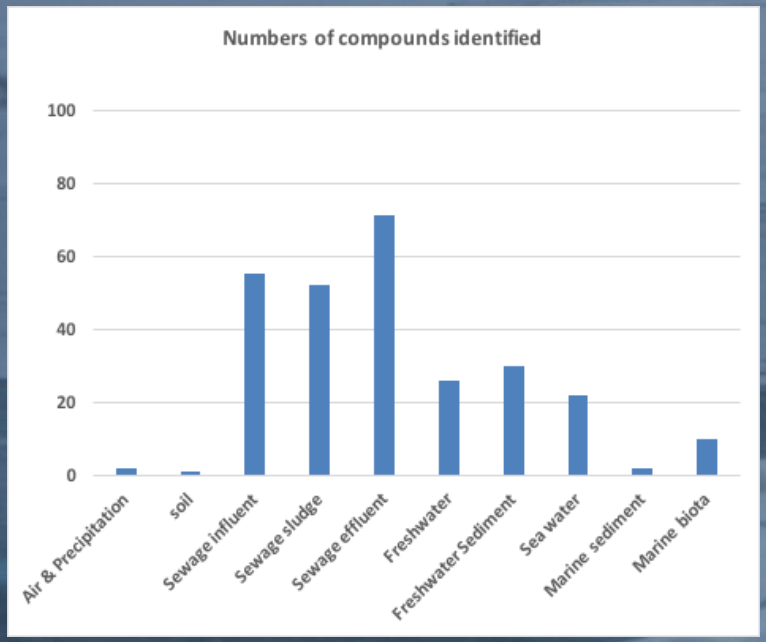
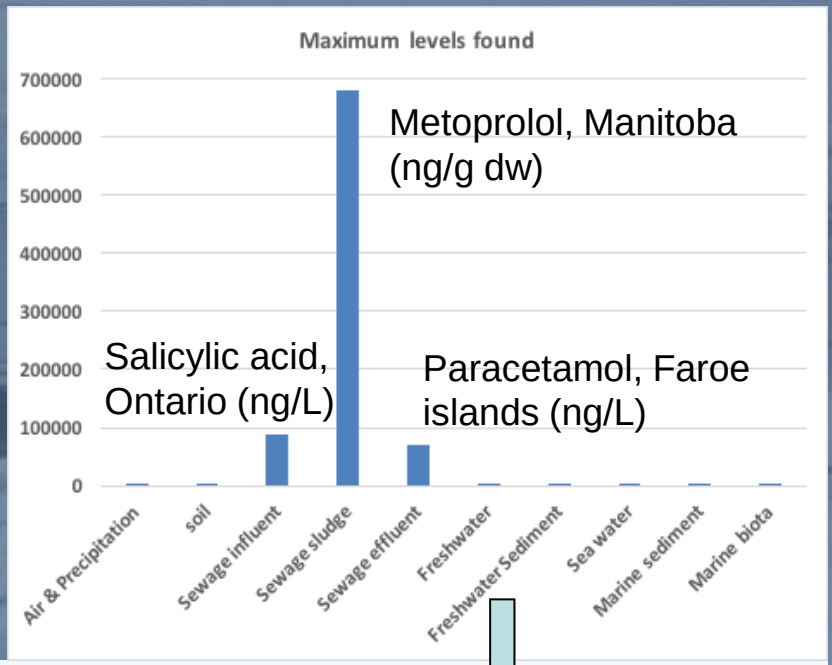
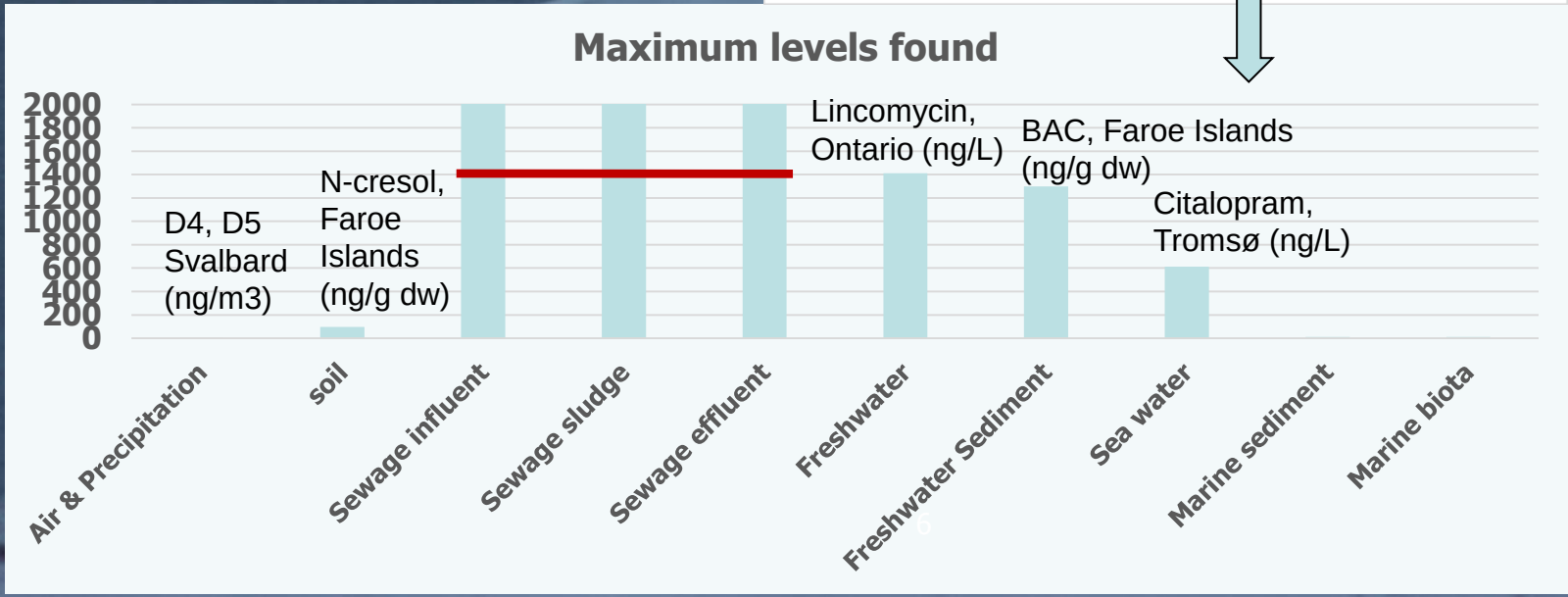
PPCPs in the Arctic environment







Trend indications (Found in > 3 locations)

Sewage effluent [ng/L]; relevant comparison of maximum levels quantified

Location/ Region	Ibuprofen	Diclofenac	Aceminophen/ Paracetamol	Sertraline	Paroxetine	Citalopram
Ontario	4000	n.a.	740	n.a.	n.a.	n.a.
Greenland	2800	n.a.	25800	2	20,8	192
Iceland	5800	390	8540	299	89,3	69,2
Faroe Islands	4500	597	71500	23	149	540
Longyearbyen (Svalbard)	403	1074	n.a.	n.a.	n.a.	n.a.
Tromsø (North Norway)	448	48	n.a.	90	13	102

n.a. = not analysed

- No clear spatial trend identified
- Strong level variations are mainly governed by day-to-day fluctuations (application and usage patterns) a well as Sewage treatment technologies

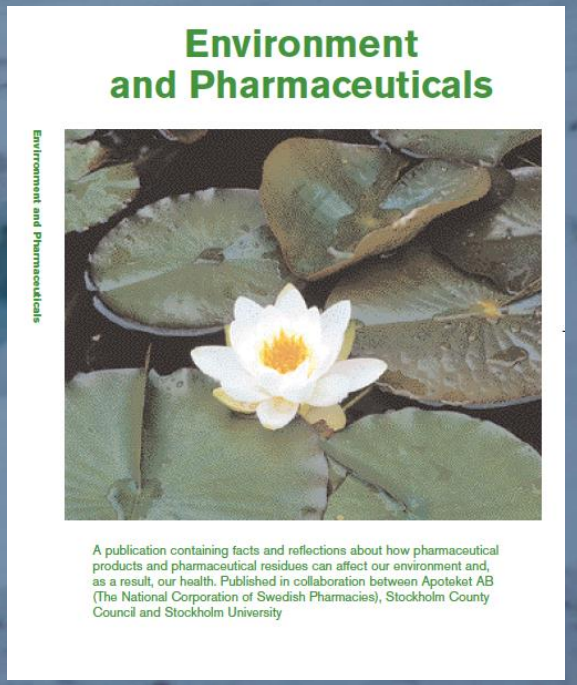
Comparison with other regions (examples)

Conc. Unit	Compounds	Sample matrix	Levels Arctic [max]	Other regions	Non Arctic sampling location	Reference
ng/m^3	Siloxanes (D4, D5)	Air	4	1100	Chicago	Yucuis et al. (2013) Chemosphere 92: 905-910
ng/g	cresol	soil	96	2000	Russian soil	Korenman et al. (2001) J. Anal. Chem. 56/2: 166-169
ng/L	Ibuprofen	Sewage influent	87400	3600	Källby (SWE)	Bendz et al. (2005) J. Haz. Materials 122/3: 195-204
ng/g	Metoprolol	Sewage sludge	680000	500	WWTP Terrassa, Spain	Radjenovic et al. (2009) Water Res. 43: 831-841
ng/L	Paracetamol	Sewage effluent	71000	150	Källby (SWE)	Bendz et al. (2005) J. Haz. Materials 122/3: 195-204
ng/L	Lincomycin	Freshwater	1413	40	Biscayne Bay (Florida US)	Wang & Garinaldi(2012) Anal. Bioanal. Chem. 404: 2711-2720
ng/g	BAC	Freshwater Sediment	1300	1500	Long Island (NY)	Li & Brownawell (2010) Env. Sci. Technol 44: 7561-7568
ng/L	Citalopram	Sea water	612	27	San Francisco Bay	Nödler et al (2014) Marine Pol. Bull. 85: 50-59
ng/g	Bisphenol A	Marine sediment	11	10500	Taiwan	Huang et al (2012) Environ. International 42: 91-99
ng/g	Siloxanes (D5)	Marine biota	10	36	Walleye (Canada)	Goldrick et al. (2014) 186: 141-148

Due to Arctic specific environmental conditions, application patterns and treatment strategies differences in environmental stability and degradation pathways were found.

Remediation and mitigation strategies

- Coordinated sanitation strategies required
- High technological standards for Sewage treatment for decentralized systems
- Community awareness: Disposal strategies and public awareness in the communities (i.e. pharmacies as return points for outdated pharmaceutical products)
- Continuous communication of all critical aspects with the public
- Development of sanitation technology for cold High North environments



Knowledge gaps identified

- Medium and long term monitoring data are not available
- Time and spatial trend investigations for PPCPs are needed.
- Comprehensive information on source apportionment and assessment of source strength is missing
- The elucidation of transformation processes as an integrated part of fate assessment is not available.
- Reliable environmental toxicology and effects studies for the Arctic environments are missing.
- Joint Research & Development strategies for PPCP remediation and abatement in the Arctic

Conclusions

- PPCPs are present in Arctic environments close to human settlements/ activities
- STP release into aquatic environments identified as major environmental source
- Level can reach μg range in contaminated sites
- No spatial trends identified in the registered studies
- Level can be higher than for middle latitude regions
- Low Technological standards or even absence of Sewage treatment
- Concentration range depends on usage patterns and sanitation treatment

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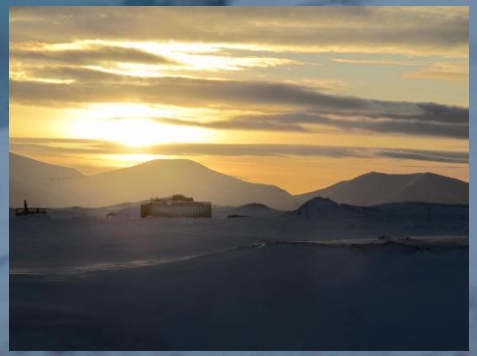

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Thank you for your attention