OUT TO SEA: ANTARCTIC RESEARCH STATION EFFLUENTS AS A SOURCE OF ORGANIC MICROPOLLUTANTS IN COASTAL WATERS

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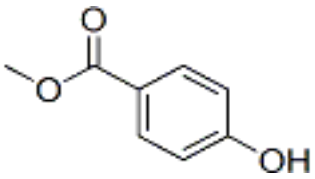
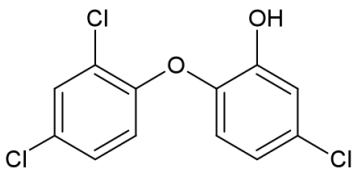
Pharmaceuticals and Personal Care Products (PPCPs)

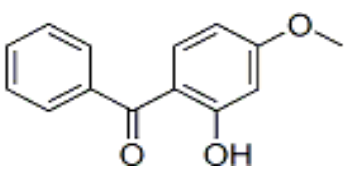
- Pharmaceuticals includes prescription and over the counter medications
- Personal care products include sunscreens, moisturizers, toothpastes, make up….
- Personal care products contain wide range of chemicals
  - Preservatives (e.g. parabens)
  - Antimicrobials (e.g. triclosan)
  - UV-filters (e.g. benzophenones)
  - Plastics (e.g. BPA)
- Widely used, including Antarctica



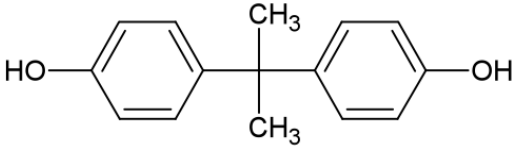
mParaben



Triclosan



Benzophenone-3



Bisphenol-A

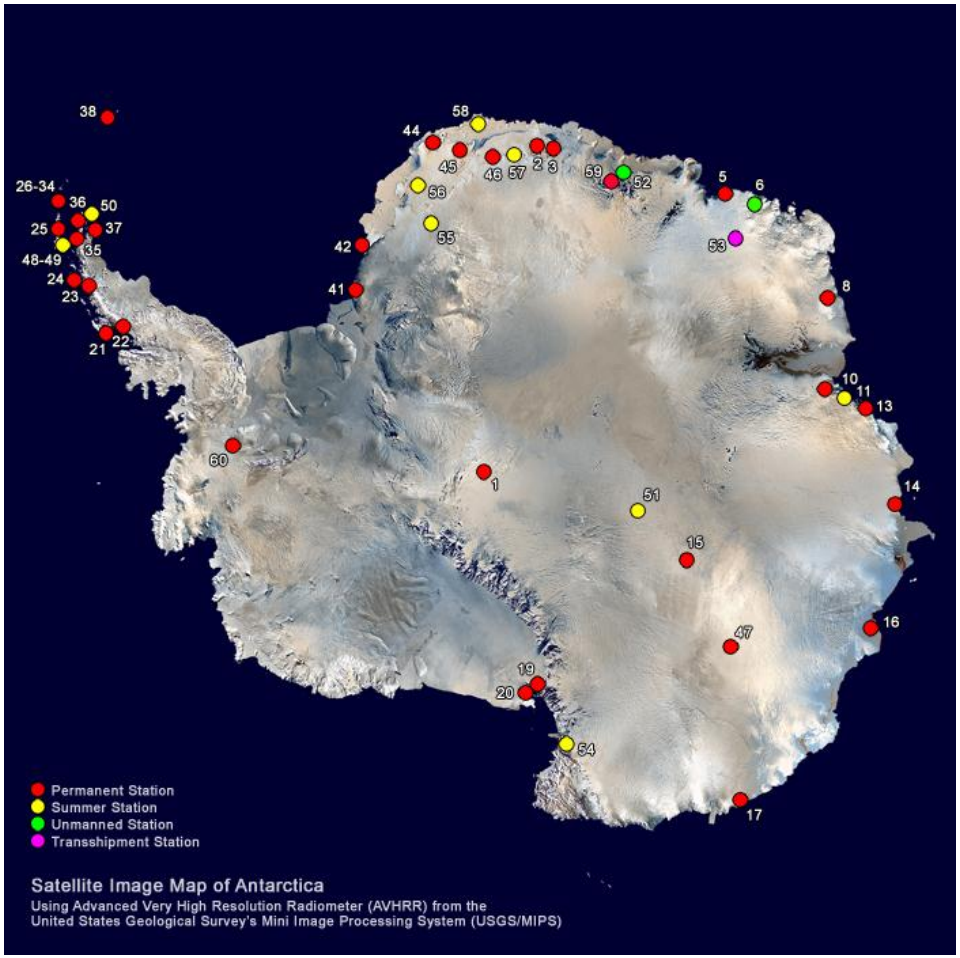
http://chemistscorner.com/the-10-different-types-of-cosmetic-formulas-you-must-know/

Pharmaceuticals and Personal Care Products (PPCPs)

- Wastewater effluent is a major source of PPCPs
- Found in surface waters worldwide
  - Low-mid parts per trillion
  - Continuous release causes pseudo-persistence
- Concern due to
  - endocrine disrupting effects
  - impacts on microorganisms
  - behavioural effects

http://plumbing-pipes.sewerdrainss.com/effluent/

Relevance to Antarctica



- Permanent stations
- Summer stations

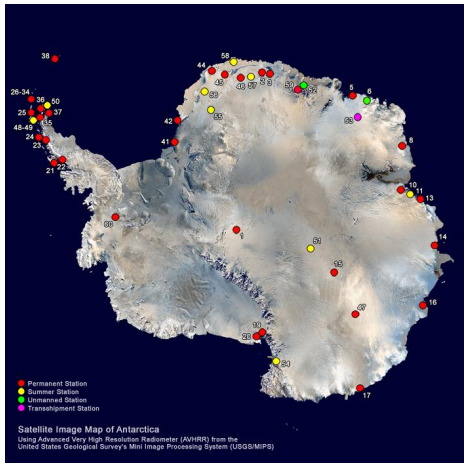
http://www.ecophotoexplorers.com/AntarcticaStations.asp

Relevance to Antarctica

- 37% of permanent and 69% of summer stations do not have sewage treatment

- Treatment plants can malfunction
  - Fluctuating water volumes
  - Low temperatures can freeze pipes
  - Complete treatment failure possible

- Environmental conditions may enhance persistence of organic micropollutants
  - Cold temperatures
  - Variable light conditions
  - Presence of sea-ice

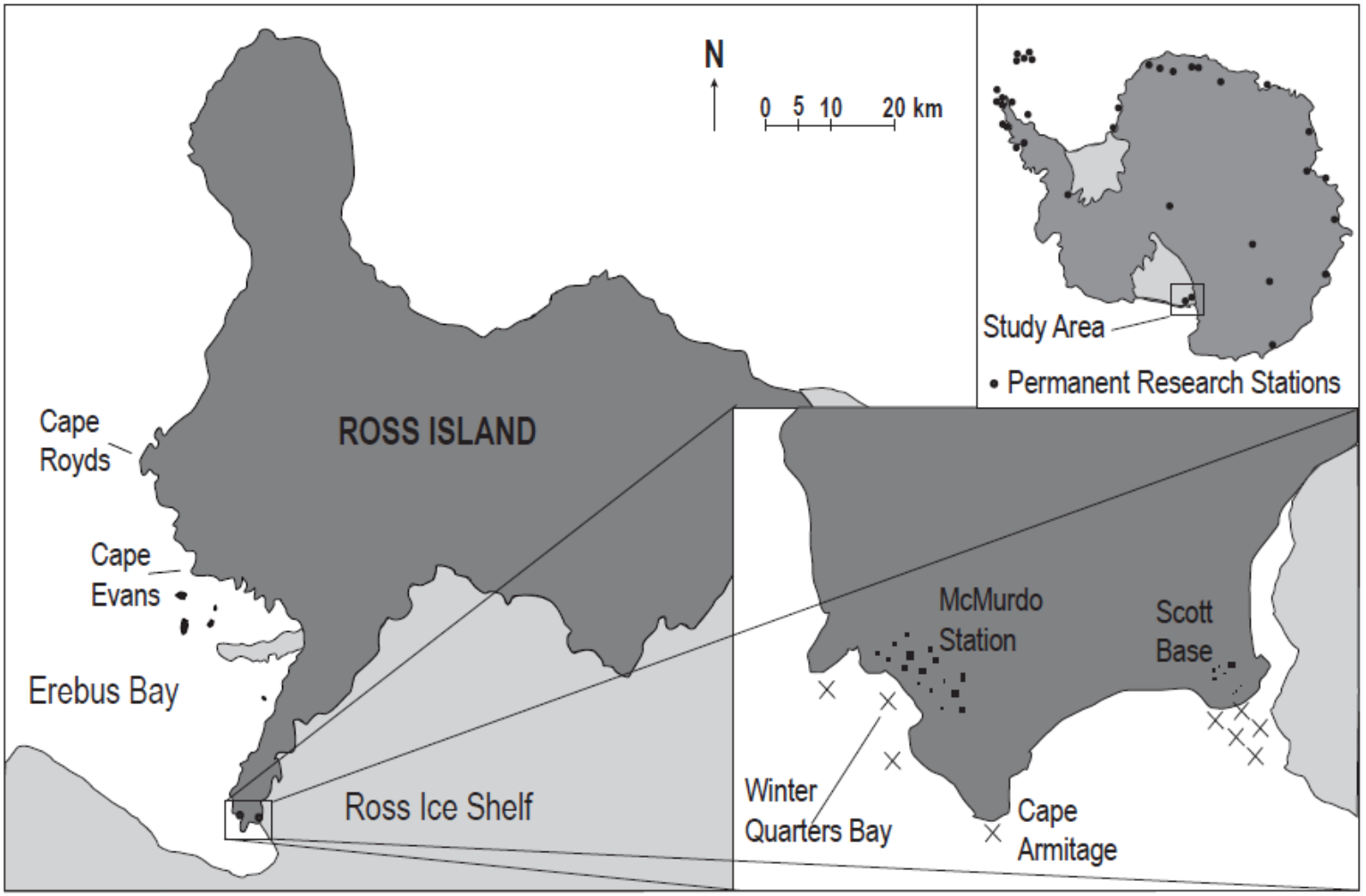


Research Questions

- Are PPCPs present in sewage effluents and the ocean waters in the proximity of research stations?

- Are PPCPs present in marine biota in the proximity of research stations?

Study area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0 5 10 20 km
Study Area
• Permanent Research Stations
Cape Royds
ROSS ISLAND
Cape Evans
Erebus Bay
Ross Ice Shelf
McMurdo Station
Scott Base
Winter Quarters Bay
Cape Armitage

Study outline

- 09/10 Field season
  - Sewage effluents from McMurdo and Scott Base
  - Coastal seawater
  - Clams (*Laternula elliptica*), fish (*Trematomus bernachii*) and sea urchins (*Sterichinus neumayeri*)

- 12/13 Field season
  - Sewage effluents from Scott Base
    - Monthly sampling for 6 months plus 7 day study
  - Coastal seawater
  - Sea ice

Methodology

- Water collected through sea ice drill holes
- Sewage effluent discharge before released into ocean
- Solid Phase Extraction
  - Ocean water (4 L)
  - Sewage effluent (1 L)
  - Reference site (10 L)
  - C_{13} surrogates
- Florosil clean-up
- Kept at -80 °C until analysis
- BSTFA/TMSI derivatization (NZ)
- GC-MS SIM analysis (NZ)

Target analytes

- Preservatives & antimicrobial compounds
  - 4 parabens, triclosan and methyl triclosan
- Uv-filters
  - BP-1, BP-3, 4-MBC, OMC
- Natural and synthetic steroid hormones
  - E1, E2, E3 and EE2
- Surfactants
  - Octyl-phenol and nonyl phenol
- Plastic monomer
  - BPA

09/10 Season results: Sewage effluents

Analyte (ng L^{-1})	Use	Scott Base	McMurdo	Literature Range	Reference
Octylphenol	Surfactant	39 – 118	–	37 – 470	[1,4,5]
4-MBC	UV-filter	173 - 234	–	42 – 2,300	[8,9]
BP-3	UV-filter	70 – 105	110 – 130	3 – 300	[8,9,12]
BP-1	UV-filter	143 – 358	7	<2 – 41	[14-16]
Triclosan	Antimicrobial	225 – 292	–	10 – 5,370	[13]
Bisphenol A (BPA)	Plastics	23 – 87	28	6 – 3642	[17]
E1	Natural steroid	40 – 60	–	<1 – 110	[4,5]

09/10 Season: Coastal waters

Analyte (ng L^{-1})	Use	Range	Literature Range	Reference
mParaben	Preservative	1.9 – 33.3	2.1 – 51	[1]
pParaben	Preservative	<LOQ – 3.0	<0.5 – 7.9	[1]
bParaben	Preservative	<LOQ – 2.3	<0.2 – 0.7	[1]
Octylphenol	Surfactant	0.3 – 1.7	<1.2 - 81	[1-3]
4-MBC	UV-filter	45.1	13.1 – 798.7	[6-7]
BP-3	UV-filter	12.0 – 88.4	1.8 – 3,300	[6,10,11]
BP-1	UV-filter	<LOQ – 10.3	280	[11]
OMC	UV-filter	<LOQ – 32.3	7.4 – 389.9	[6,7]
mTric	Triclosan metabolite	0.2	N/A	N/A
Triclosan	Antimicrobial	0.2 – 1.8	0.008 – 28.9	[13]
Bisphenol A (BPA)	Plastics	2.2 – 29.5	<0.04 - 330	[17]

Target analytes were detected at the Cape Evans reference site

09/10 Season: Biota

- Clams
  - BP-3, E2, EE2, mParaben and pParaben
- Fish
  - BP-3 and pParaben
  - Detected in fish from Cape Evans, the reference site
- Sea urchin composite
  - BP-3, mParaben and octylphenol
- Concentrations comparable to those reported internationally
- Issues with the extraction method – other analytes may be present

12/13 Season: sewage effluent

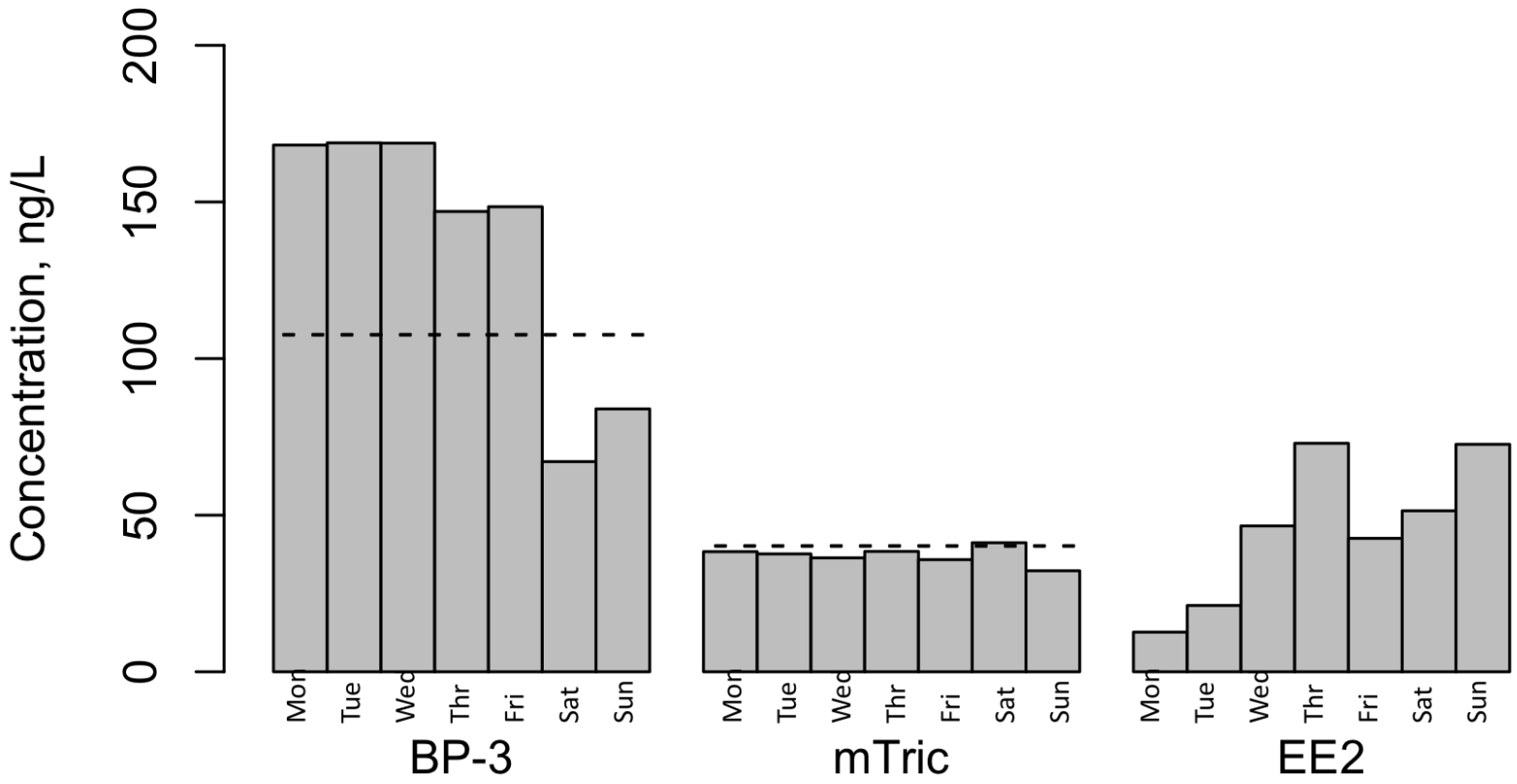
- Nine most commonly detected analytes were uv-filters (4-MBC, BP-1, BP-3), BPA, E1, triclosan and its degradation product methyl triclosan

- No correlation between PPCP concentrations and WWTP operating temperature or the number of people at Scott Base

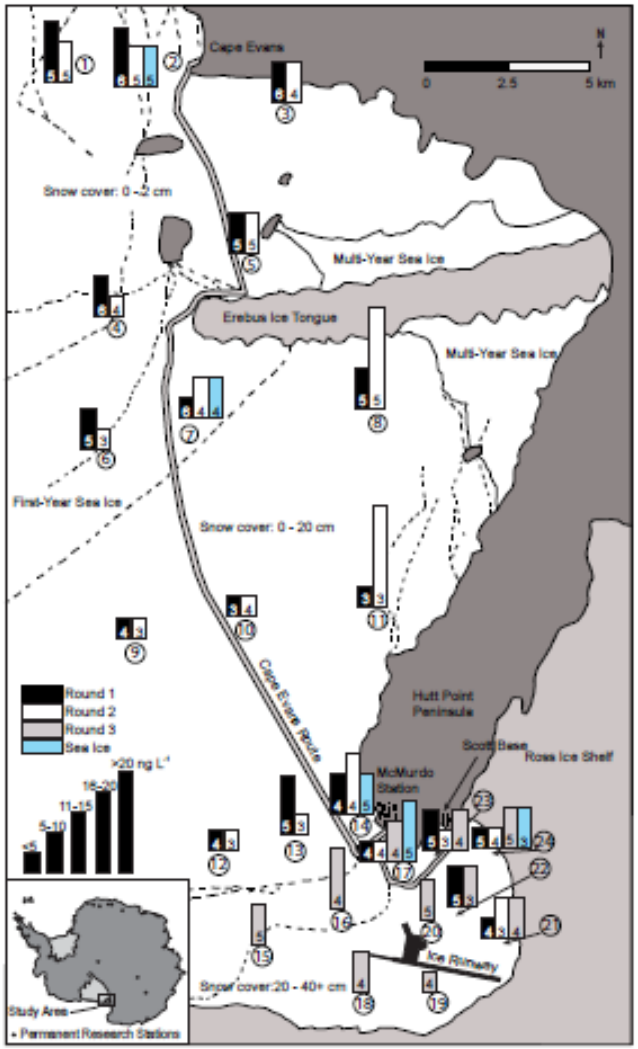
- Higher concentrations were measured during the 7 day study than in the monthly samples

- EE2 was detected during the 7 day study

12/13 Season: Seven day effluent study



12/13 Season: Coastal waters and sea ice



- 24 sampling sites for coastal waters
- Fewer analytes detected in coastal waters than in 09/10
- Concentrations generally lower than in 09/10
- Target analytes still detected 25 km from the research bases
- Sea ice concentrations of PPCPs were comparable to those in coastal waters

Tide cracking

- Tide cracking
  - NZ field parties
  - Ice Runway
  - Overall can discharge 1000+ L of wastewater each season

Conclusions

- First report of PPCPs in Antarctic coastal waters and sewage effluent
- PPCP concentrations were comparable to studies in temperate climates
- WWTPs are ineffective at removing PPCPs
  - Stations with no treatment likely to release higher concentrations
- WWTPs are potentially not the only sources of PPCPs into Erebus Bay
- Larger geographic areas than initially suspected may be impacted

Implications

- Further assessment of organic micropollutants in Antarctic ecosystems is required
- Protocols for use of PPCPs in Antarctica need to be developed
- Upgraded or new waste water treatment plants should be designed to remove organic micropollutants including PPCPs

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