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Water Resources Management in Cold Climates

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Webinar - Frontiers in Water Resources Management
Tuesday, 5th May 2020

University of Nis

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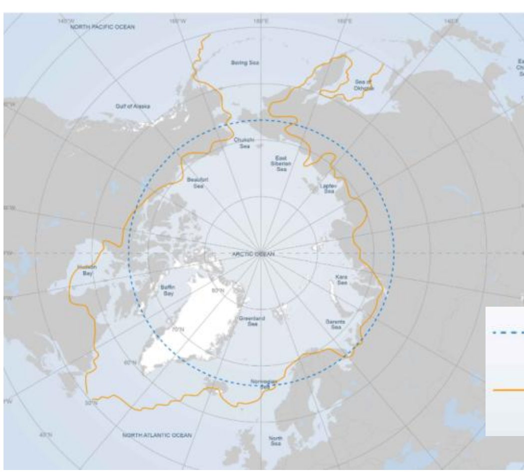
Definition of the Arctic



the Arctic Circle (66° 33′ 44″ North)
The Arctic Circle is the southernmost latitude in the Northern Hemisphere at which the sun can remain continuously above or below the horizon for 24 hours

10°C July isotherm
defined as being the area where the average temperature for the warmest month (July) is below 10°C / 50°F.

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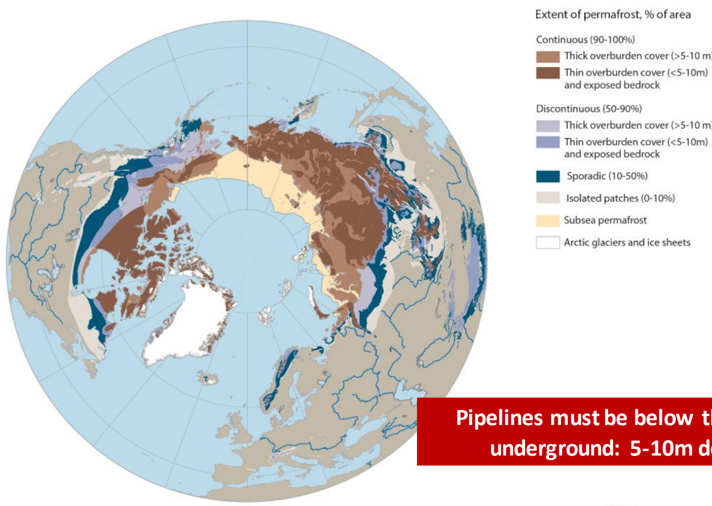
Extent of permafrost



Pipelines must be below the permafrost if underground: 5-10m deeper=costly

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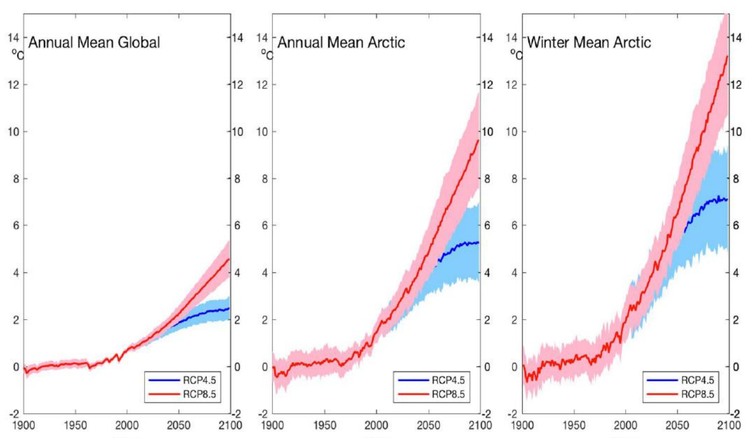
Impact of Climate Change: Arctic Temperatures rise faster

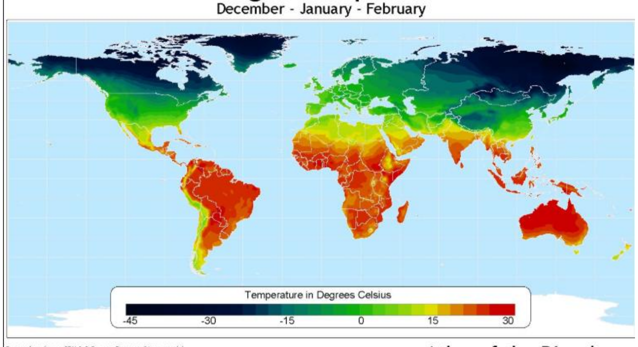


An advantage in some aspects….

J. Overland, NOAA

Climate Change Impacts: Availability of water will increase

Why Cold Climate issues are relevant also to non-Arctic regions?



Temperate climates (> 10°C difference)

Treatment processes slow down = larger facilities = higher investments

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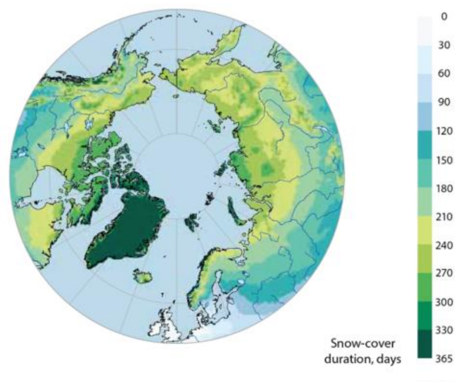
Snow coverage and utilities



Open DWTPs and WWTPs are not suitable with heavy snow coverage

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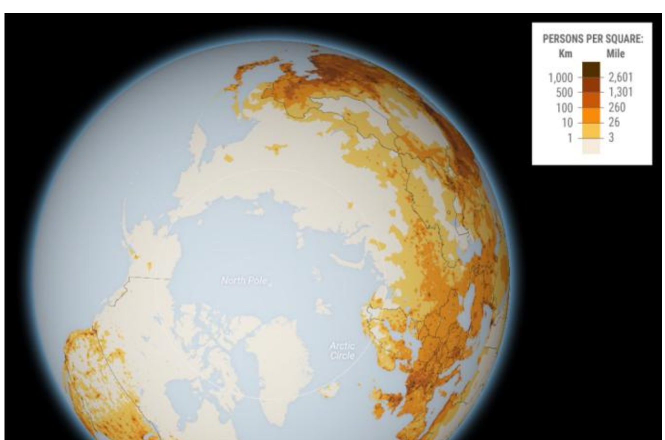
Low population density



Low population density = long distances within and between settlements. ➔ expensive piping

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Challenges are many…

Frost heaving problems

Water leakage due to cold wather

Freezing protection of water pipes

Local systems – septic tanks

- **Frozen tank components**
  - Insulation?
- **Compacted snow and soil**
  - Careful with the surface over
- **Improperly functioning pipes**
  - Leakages, frozen pipes
- **Improper use from holiday guests**
  - Overload, improper use
- **Difficulty in emptying the tanks**
  - Empty before the winter..

© ADB Construction Septic Blog

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Decentralised systems

- Wetlands – functions well if properly managed
- Low temperature: reduced biological activities
- Frozen soil: reduce the volume for treatment

- Insulation layers?


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Wastewater transport

- Frozen sewers, pumps
  - Sufficient wastewater from homes (warm!)
  - insulation?


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Colder WW due to CC

Climate Change: Air temperature ↑
Wastewater temperature ↓
A paradox?

Increased snow melting events

Combined sewers

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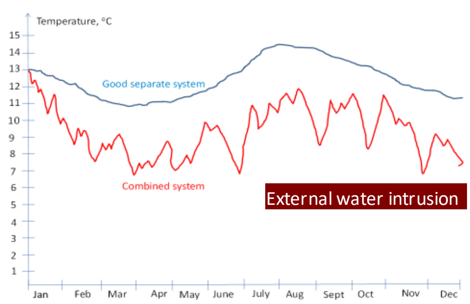
Separate sewers vs combined sewers



Good separate system vs Combined system or system with much external intrusion water

Ødegaard, Rusten, Ratnaweera, EWA-WMCC2016

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Managing challenges of varying temperatures – and snow-melt water

- Use separate systems – do not mix wastewater with rainwater
- Select processes that can stand better variations in temperature

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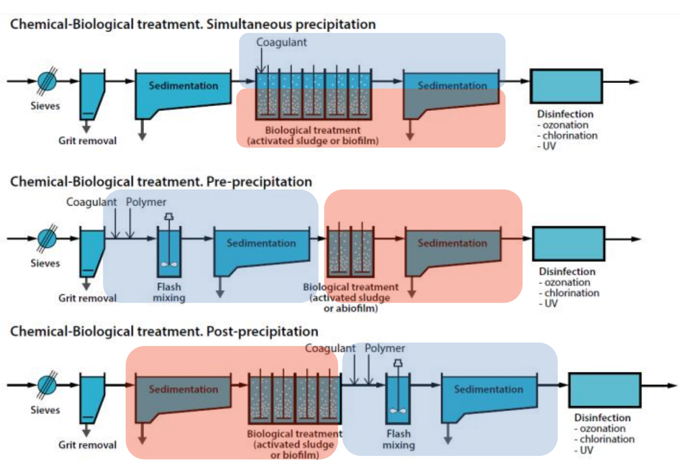

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Most WWTPs in Norway are covered = advantage

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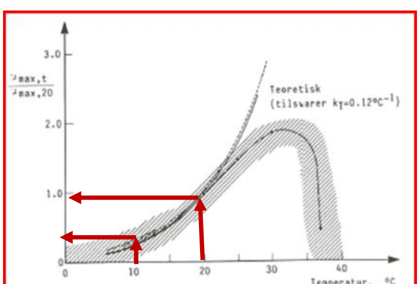
Cold climate: efficiency ⬇ cost ⬆



Nitrifikasjonens avhengighet av temperatur (Henze et al, 1990)

Enzyem producing bacteria

⬇ 10 degrees = ⬇ of 50% of Nitrification rate

➔ will require bigger reactor volumes to achieve the same treatment efficiencies

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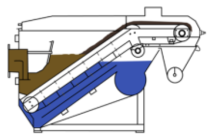
More compact processes – primary treatment



Advantages in cold climates

- Compact technology – in-door
- High DS in sludge (> 25 % if screw press)
- Higher SS-and COD-removals may be achieved with, for e.g. polymers

Disadvantages in cold climates

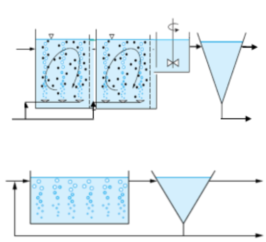
- Mechanical parts to be supervised
- Possible clogging of filter mesh

Common practice: setting tanks.
Needs large space – costly if in-door, Low sludge DS, Unstable sludge

Experience from Tromsø (350km North of Polar circle):
Fine sieves may give about the same treatment results as primary settling

Secondary/tertiary treatment

Suspended vs Attached growth



Advantages in cold climates

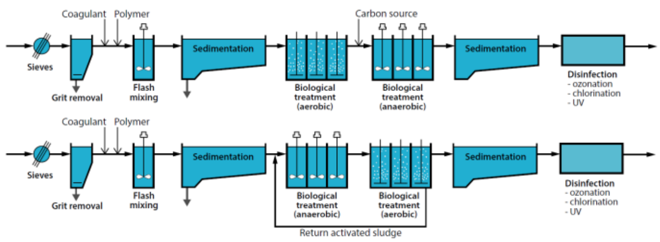
- Less influenced by fluctuations in Q & load
- Easy to operate (most reactor types)
- Lower foot-print (e.g. MBBR)
- Nitrification easily established at lower volumes
- All separation processes may be used

Disadvantages in cold climates

- Carrier needed – more costly
- Higher DO (energy) needed

Combined chem/biol systems:

more compact and more flexible systems



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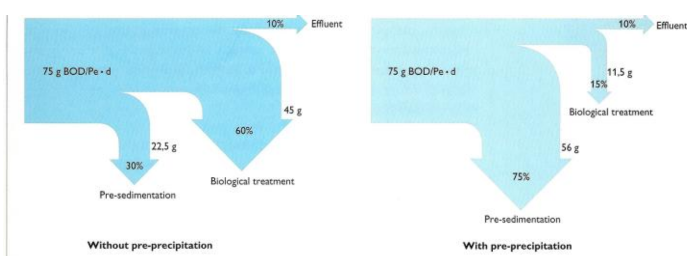
Pre-precipitation may drastically reduce load to biological processes

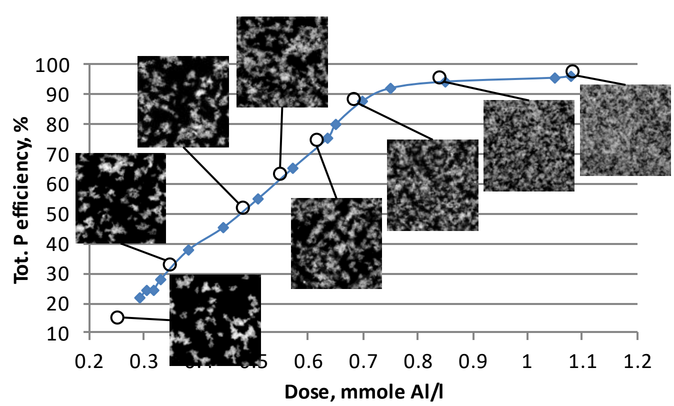


Impact of temperature on coagulation

- Floc formation during wastewater coagulation is known to be slower at lower temperatures
- Sedimentation / flotation can therefore be negatively influenced.

  – ↑ sedimentation volumes
  – ↑ coagulant/flocculent demand

Image analysis as a tool for cold climate process optimisation?



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Summary and conclusions

- Groundwater usually a good source – groundwater from below permafrost layer is less polluted.
- Surface water with variable quality: more stable in winters and more polluted in summers (freezing/thawing-processes, erosion etc)
- Climate Change impacts: mostly negative and but there are positive impacts on water supply and WWT.
- Higher repair and maintenance costs in Cold Climates
- Higher temperatures are in general favourable for treatment processes
- Climate change results in challenges with the volumes and WW temperatures
- The experiences with pre-treatment by the use of fine-mesh sieves in cold climates are good
- Chemical coagulation has several advantages over biological processes for secondary treatment in cold climates
- Combined biological/chemical treatment by the use of MBBR directly followed by coagulation/separation could be advantages