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Pathogen considerations for safe 'Arctic' household water systems

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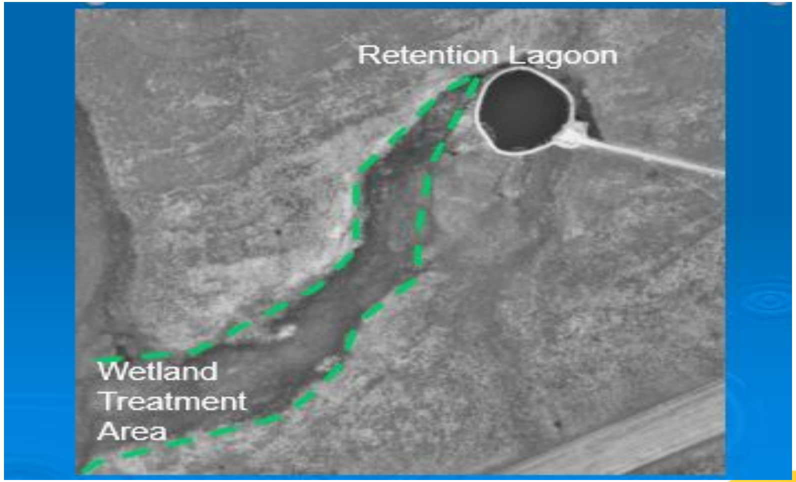
Canadian example:

A piped water and sewer system envisioned to service a community of 2500 people was built in 1975, and has ultimately served a population of only 250 – replacement of the entire piped system is costing $40 million : **Information from Ken Johnson**

Hence Canadian preference for lagoon & wetland processes

Lagoon systems remain the most common form of sewage treatment, in spite of demands for more sophisticated technologies. Improving upon the performance of lagoons is occurring with the application of wetlands for tertiary treatment.



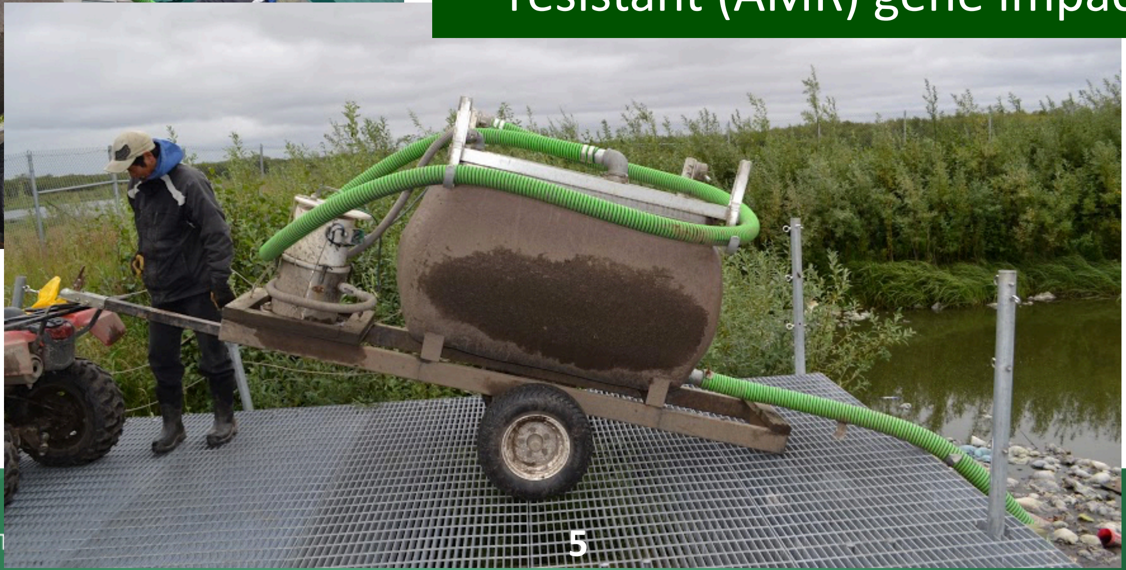
Ulukhaktok, Northwest Territories
Source: Ken Johnson

‘Honey’ buckets, Atmautluak, Alaska

http://watersewerchallenge.alaska.gov/photogallery.html

Covered Wastewater Haul & dump!

http://watersewerchallenge.alaska.gov/photogallery.html



Even this ‘preferred’ sewage management has major chemical, pathogen & antimicrobial resistant (AMR) gene impacts

Water needs for Arctic health

- Residents may use 4 to 20 litres per capita per day for all current household uses (drinking, cooking, washing)
  - significantly below recommended by Institute of Medicine / WHO for water-wash disease control (~50 L/person.d)*
- But supplying more water to homes may not be the answer nor do washeterias necessarily help consumers' health
  - **Because it is costly, generates more wastewater pollution and communal facilities increase respiratory disease transmission (the largest water-related health concern in Arctic communities)**

*Howard & Bartram (2003). *Domestic Water Quantity, Service, Level and Health; WHO/SDE/WSH/03.02*

Circumpolar-relevant water pathogens

- **Enteric** waterborne (**human & zoonotic**) diseases
  - *Hepatitis A* liver disease*, Norovirus* gastro, *Shigella* dysentery
  - *Giardia* giardiasis, enteritis *Yersinia & Campylobacter* spp.
  - *Echinococcus multilocularis* (lung disease) via foxes/voles
- **Water-based** (saprozoic) diseases
  - Non-tuberculous mycobacteria (wound/lung), *Helicobacter pylori*?
  - *V. parahemolyticus/vulnificus* gastro via seafood if seawater > 15 ° C
- **Person-to-person** spread & **Water-Washed** infections:
  - *Norovirus, Cryptosporidium, Staph aureus, P. aeruginosa* & **helminths**
  - TB, *Strep. pneumoniae, Haemophilus influenzae* along with various multi-drug resistant bacterial and fungal pathogens

Parkinson & Evengård (2009) *Glob Health Action 2: 1-3*
Dudarev *et al.* (2013) *Int J Circumpolar Health 72*: 1-10

Pathogen control starts with a toilet

Loowatt-toilet (http://loowatt.com)

Vacuum toilet components

Flush water needs
0 – 0.5 L – 1.5 L

Air-water forced toilet

Blackwater energy recovery: socio-economic driver for alternative systems

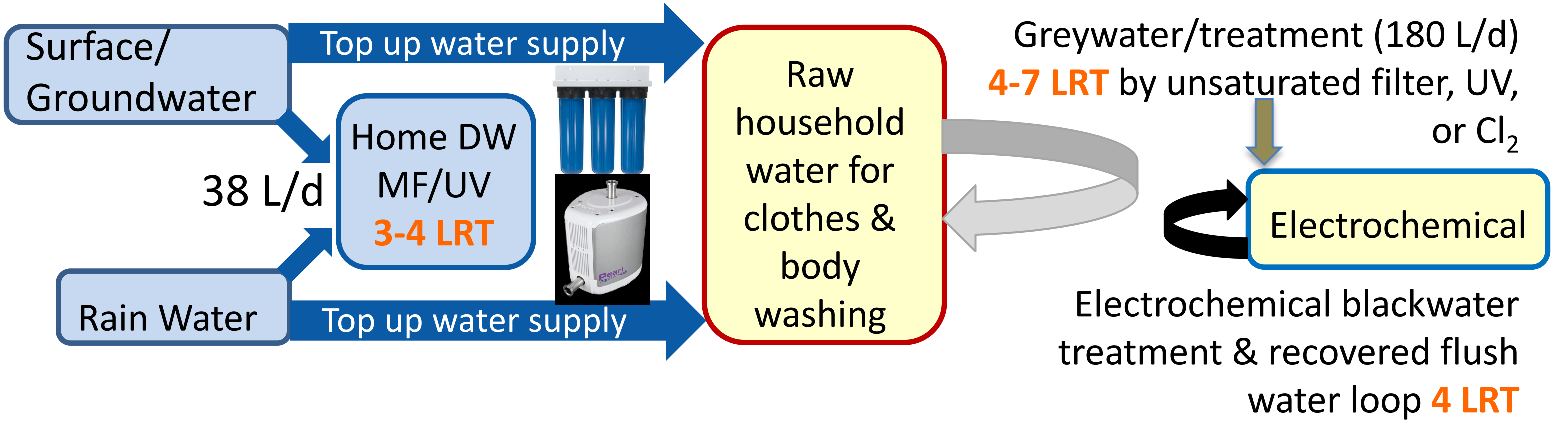
- Household-scale
  - Possible, but community energy & nutrient recovery better
- Community-scale
  - Full-cost recovery & net energy generation
  - Also provides local economy with jobs

Blackwater sewer (daily pulsed flow, not heated?)

Wood *et al.* (2015) *J Environ Manage 150*: 344-54

Alternative systems: suitable for Arctic?

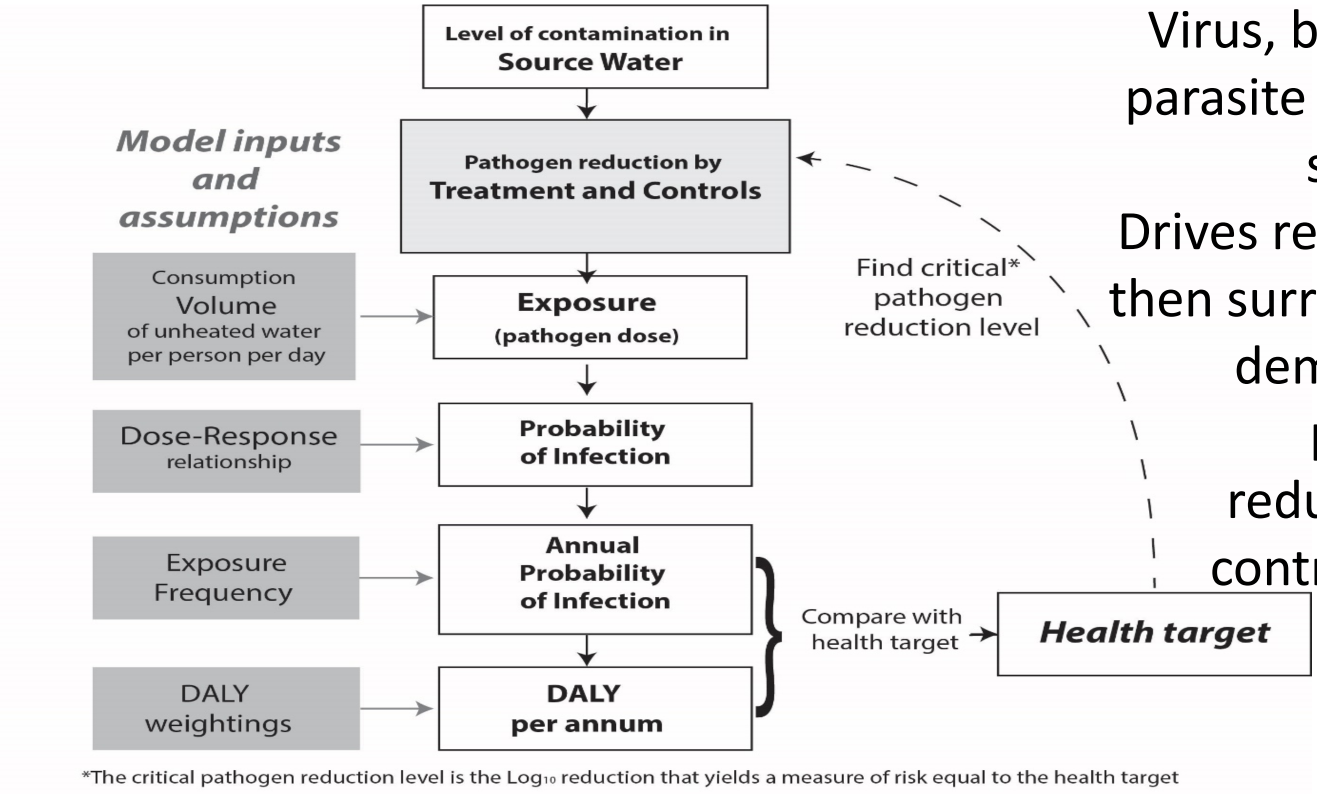
Four person household (pathogen log reduction target – LRT)



Different financial model & political will for:

- Within home treatment of drinking water and re-circulated shower and clothes greywater & separate blackwater loops
- Fit-for-purpose, QMRA modeled water safety plan

Risk-defined treatment requirements



Virus, bacteria & parasite levels for safe uses.

Drives regulations then surrogates to demonstrate pathogen reductions at control points are met

Petterson & Ashbolt (2016) J Wat Health 4(4): 571-589

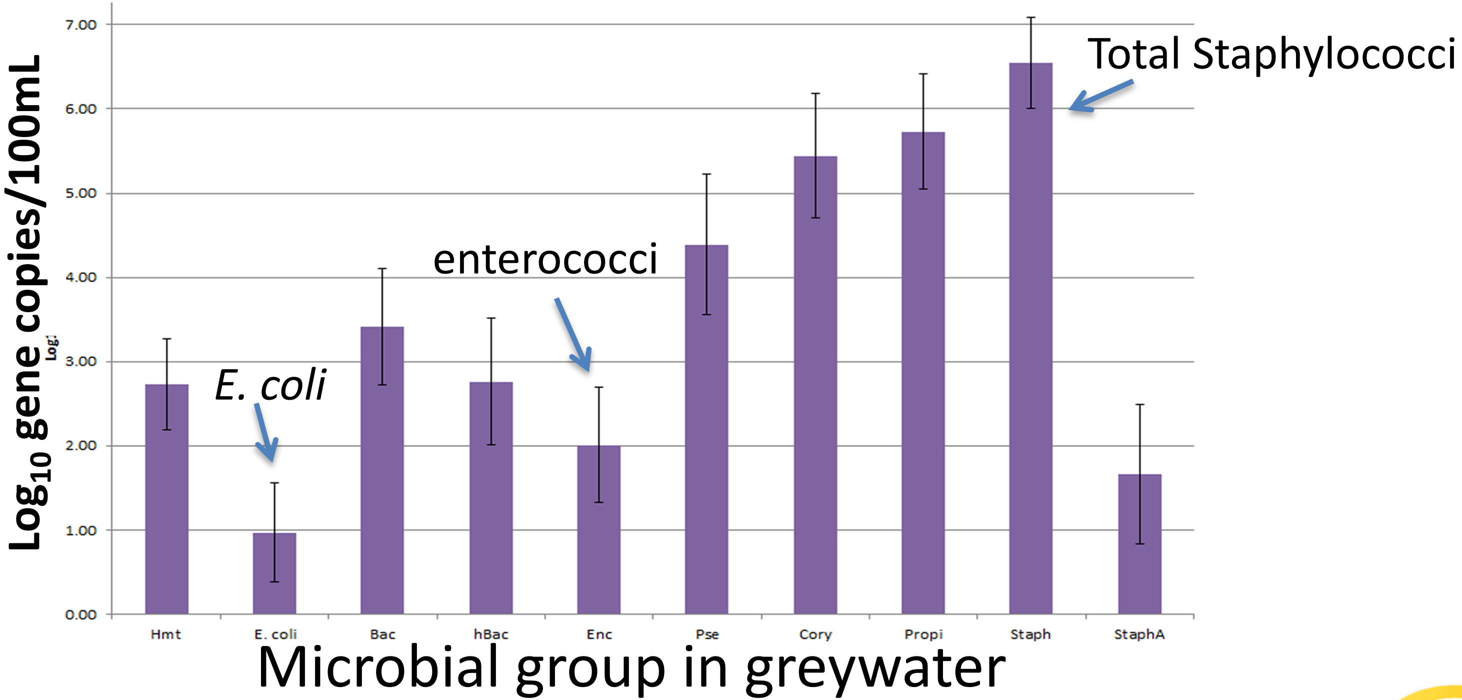
WHO (2016) *Quantitative Microbial Risk Assessment, Geneva*

Pathogen log reduction targets for various household uses

Water Source	Use	Pathogen log_{10} reduction target to meet < 1 infection / 10,000.y			How?
		Viruses	Bacteria	Parasites	
Roof	Drinking	?	3.5	?	MF + UV
Roof	Washing	?	3.5	?	MF + UV
Snow-melt	Drinking	4.0	3.5	4.0	MF + UV
Snow-melt	Clothes washing	3.0	3.0	3.0	MF + UV
Shower/clothes	Showering	7.0	4.5	5.5	UF + UV
Shower/clothes	Clothes washing	6.0	3.5	4.5	UF + UV

Adapted from: Sharvelle, S.; Ashbolt, N.; Clerico, E.; Hultquist, R.; Leverenz, H. L.; Olivieri, A. I(2016). *Risk Based Framework for the Development of Public Health Performance Standards for Decentralized Nonpotable Water Systems.* Water Environment Research Foundation Alexandria, VA

Bacterial genera in laundry greywater – identifying[1] & demonstrating[2] treatment surrogate



[1]Zimmerman *et al.* (2014) *Env Sci Tech 48: 7993-8002*

[2]Shoults & Ashbolt (2017) *Environ Sci Pollut Res:* 10.1007/s11356-017-9050-1

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Your tasks

- **Building on your case study with Petter Jenssen or another system recently inspired from this course to provide sustainable/adaptable water services to a circumpolar community**
  - Identify relevant waterborne/water-wash reference pathogens and the management information you seek from a QMRA
  - Identify exposure pathways from your water system
  - Clarify data needs to undertake a QMRA
  - Explain how you could monitor your system & how would you use the results to aid in setting water policy