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An Investigation of Human Pathogen Removal in A Single Cell Wastewater Stabilization Pond in Arctic Canada

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STEWART



Background

❖ Use of waste stabilization ponds (WSPs) has been proposed as an appropriate biological wastewater treatment solution for remote communities in the Canadian far North. However, the biological treatment processes in WSPs are strongly influenced by climatic conditions.

❖ The new Wastewater Systems Effluent Regulations (WSER) implemented by Environment Canada do currently not apply to wastewater treatment facilities in the far North (Nunavut, the Northwest Territories and northern regions of Quebec and Newfoundland and Labrador). Instead, a five-year research period (ending in 2014) was implemented to allow studies of the performance of wastewater treatment systems in the far North, and to determine suitable approaches in these regions.

❖ There is limited information about the removal of human pathogens in Arctic WSPs, which experience an extreme environment and short treatment seasons.

Challenges in Northern Wastewater Treatment

- ❖ Small and remote communities
- ❖ High capital and maintenance cost of infrastructure
- ❖ Scarcity of qualified wastewater technicians
- ❖ Cold long winters with short summers characterized by high solar irradiance
- ❖ Highly variable climates across the Arctic

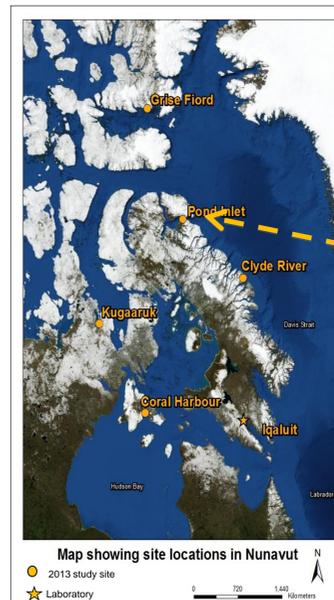
Purpose of Research

❖ This study focused on public health aspects of the current wastewater treatment system process in Pond Inlet (72°41'57"N 077°57'33"W), Nunavut.

❖ Pond Inlet was chosen as a study site to assess the presence of human pathogenic microorganisms in its single-cell WSP system and the final effluent being discharged once annually into the environment during each of three treatment seasons (2012-2014). **Here we present results from the decant event during each of three treatment seasons.**

❖ In the public health perspective, the main objective was to determine if human bacterial pathogens were present in the final effluent being discharged into the marine environment in the Arctic community of Pond Inlet from September 2012 to September 2014.

Location of Community



Pond Inlet
Single-celled WSP system
Population 1550
Latitude 72° N
Surface area: 4.0 ha
Operational depth: 2 m

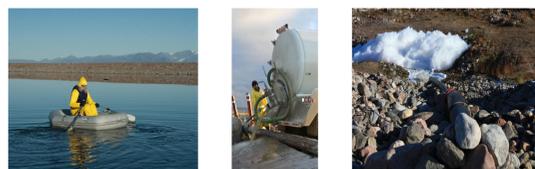


(Pond Inlet vor der Kullisse der Bylot Island)
http://de.wikipedia.org/wiki/Pond_Inlet

Methodology

Field work

- ❖ Seven sampling trips (from September 2012 to September 2014)
- ❖ Grab samples (raw wastewater, WSPs, compliance point, final effluent)
- ❖ Shipped samples under refrigeration to the Northern Water Quality Lab in Iqaluit within 24 hours
- ❖ For pathogenic tests, shipped samples under refrigeration to our laboratory at Dalhousie University in Halifax, Nova Scotia.
- ❖ Upon arrival, samples were processed immediately.



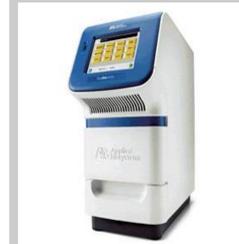
Methodology

❖ The quantitative polymerase chain reaction (Q-PCR) methods using TaqMan probes have been developed to detect the presence of four human pathogens

- ❖ *Listeria monocytogenes*
- ❖ *Campylobacter* spp.
- ❖ *Salmonella* spp.
- ❖ *Escherichia coli* O157:H7

❖ Assessment of Wastewater Quality

- ❖ Carbonaceous Biological Oxygen Demand (CBOD₅)
- ❖ Total Suspended Solids (TSS)
- ❖ Total Ammonia Nitrogen (TAN)
- ❖ *E. coli* and coliforms



Results

❖ Presence of human bacterial pathogens in wastewater samples

Table 1. Presence or absence (in 10 ml) of human bacterial pathogens in wastewater samples from WSP in Pond Inlet from September 2012 to September 2014.

Wastewater Samples	2012 September	2013 September	2014 September
Trucks	N/A	L+S+E	L+S+E
WSP	L	L+S+E	L+S+E
Decant	L	L+S+E	L+S+E
Outfall	L	L+S+E	L+S+E

L: *Listeria monocytogenes*, C: *Campylobacter* spp., S: *Salmonella* spp., E: *E. coli* O157:H7, and N/A: not available indicating that no samples were collected.

Results

❖ Wastewater quality in the Pond Inlet WSP in September 2013 prior to the beginning of the decant

Table 2. WSP effluent water quality parameters in Pond Inlet, NU from September 2012 to September 2014.

Wastewater quality parameter	WSER	Nunavut Water Board (NWB)	September	
			2012	2103
CBOD ₅ (mg/l)	25	80 - 120	180	114
TSS (mg/l)	25	100 - 180	110	64
Ammonia (Un-ionized) (mg/l - N)	1.25	N/A ^c	0.186	0.74
<i>E. coli</i> (CFU/100 ml)	<200 MPN/100 ml ^a	10 ⁴ - 10 ⁶	1 x 10 ⁶	9.1 x 10 ⁵
Total Coliform (CFU/100ml)	5000 ^b	N/A	1.6 x 10 ⁷	1.3 x 10 ⁷

a: Atlantic Canada Wastewater Guidelines for Collection, Treatment, and Disposal, 2006 (MPN, Most probable number)

b: Newfoundland and Labrador Regulation 65/03: Environmental Control Water and Sewage Regulations, 2003 under the Water Resources Act.

c: Not applicable

Discussion

❖ Overall, the quality of wastewater in the WSP system in Pond Inlet does not meet the standards of the new WSER except ammonia parameters, but did meet the current NWB license requirements except CBOD₅ parameter obtained in September 2012.

❖ Anaerobic conditions and an absence of algal blooms in the WSP were observed during the 2012-4 treatment seasons. pH stayed constant between 7.5 and 7.8.

❖ Human bacterial pathogens were detected in all wastewater samples throughout the 3-year study.

❖ In summary, the results of the study indicated that the Pond Inlet WSP system did not achieve adequate removal of human pathogens during the 2012-4 treatment cycle.

❖ Future research should quantify the levels of human pathogens being released into the environment and perform an environmental and human health risk assessment.