University of Victoria | Graduate Studies

Notice of the Final Oral Examination
for the Degree of Master of Applied Science

of

CLAIRE REMINGTON

BA (Reed College, 2011)

"Countering the Porcelain Dream: Key Findings from an Evaluation of the Global Nitrogen Cycle, a Fundamental Characterization of Fresh Faeces, and a Campus Composting Toilet"

Department of Civil Engineering

Thursday, December 12, 2019
8:30 A.M.
Engineering / Computer Science Building
Room 468

Supervisory Committee:
Dr. Caetano Dorea, Department of Civil Engineering, University of Victoria (Supervisor)
Dr. Cheng Lin, Department of Civil Engineering, UVic (Member)

External Examiner:
Dr. Rebecca Ryals, Life & Environmental Sciences, University of California-Merced

Chair of Oral Examination:
Dr. Andrew Rowe, Department of Mechanical Engineering, UVic

Dr. David Capson, Dean, Faculty of Graduate Studies

Abstract

When we consider global sanitation from within the framework of sustainable development, we are both failing to meet the needs of the present and are jeopardizing the capacity of future generations to do so. The primary function of sanitation and waste treatment is the protection of public health, but it is urgent that we also consider the long-term sustainability of sanitation and waste treatment systems. Our choice of sanitation and waste treatment systems is intimately connected to the greatest equity and sustainability challenges of our time, and we need something better than the Porcelain Dream (i.e. flush toilets, sewerage, and centralized conventional wastewater treatment). This thesis explores the design of sustainable sanitation systems from three different but complementary perspectives:

1. In a material flow analysis (MFA), we evaluate the positive impact of ecological sanitation (or the reuse of nutrients in excreta for agriculture) as an intervention to mitigate nitrogen pollution and improve stewardship of the global nitrogen cycle. We find that ecological sanitation can substitute 51% of nitrogenous fertilizer use, reduce discharge of nitrogen to waterways by 71%, decrease nitrous oxide (N_2O) emissions by 34%, and improve the circularity of the agriculturalsanitation nitrogen cycle by 22%.

2. Through environmental engineering research, we derive fundamental drying characteristics of fresh faeces to support the development of ecological and sustainable sanitation. Based on this characterization, we propose the use of the Guggenheim, Anderson, and de Boer (GAB) model for predicting the relationship between water activity (a_w) and equilibrium moisture content, calculating the heat of sorption, and estimating the corresponding energy requirements for drying of fresh faeces. Given an anticipated range of initial moisture contents of 63 to 86%, we estimate an energy requirement of 0.05 to 0.4 kJ/mol to inactivate pathogens in fresh faeces.

3. Via an evaluation of the composting toilet project at the University of Victoria (UVic), we explore factors critical to promoting a paradigm shift from the conventional to more ecological and sustainable systems. We identify the following as factors that facilitated implementation in the Exploration and Adoption/Preparation phases: supportive and self-reinforcing research and outcomes, favorable adopter characteristics, and the technology's beneficial features.

The overall objective of the research is to communicate that the design of sustainable sanitation systems is urgent, with implications both locally and globally, and to provide information to support a shift towards more sustainable sanitation systems.