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Vermicomposting toilets, an alternative to latrine style microbial composting toilets, prove far superior in mass reduction, pathogen destruction, compost quality, and operational cost

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ABSTRACT

Composting toilets aim to recycle excrement into safe, stable humus. Preceding this, low costs, low risks, and mass reduction should be ensured. Source separating vermicomposting toilets (SSVCs) outperformed mixed latrine microbial composting toilets (MLMCs) in all categories. MLMCs: incurred ten times greater operational costs; created 10x more operator exposure; employed no proven pathogen reduction mechanism since solid end-products averaged $71,000 \pm 230,000$ CFU/g (fecal-origin) *Escherichia coli* and $24 \pm 5\%$ total solids, consistently failed NSF/ANSI Standard 41; failed to reduce volatile solids compared to raw fecal matter; increased total contaminated dry mass by 274%, and produced alkaline end-product (8.0 ± 0.7) high in toxic free ammonia (Solvita® 2.6 ± 1.5). SSVCs have low maintenance costs and risks; adequate worm density for pathogen destruction (0.03 ± 0.04 g-worm/g-material); reduced *E. coli* 200 ± 244 CFU/g in neutral (7.4 ± 0.3), stable ($60 \pm 10\%$ volatile solids), and mature (4 ± 0 Solvita® NH_3) end-product.

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1. Introduction

Human waste management at remote or decentralized sites is very challenging. These sites lack standard municipal infrastructure including road access, sewerage, electricity, and water supply. Without these basic services proper human waste management becomes expensive, intensive, and offensive but is essential in order to prevent occupational hazards, environmental contamination, disease transmission, and meet legal requirements. Systems with low maintenance costs are sought after and usually include a waste treatment process and onsite disposal of liquids and/or solids. However, the permitting, construction, function, and maintenance of onsite systems in remote areas can be challenging where shallow soils, steep terrain, limited vegetation, and short seasons exist (Weissenbacher et al., 2008).

Composting toilets are marketed as waterless human waste treatment systems suitable for public service at remote sites. The overall goal of most compost toilet manufacturers is to facilitate the decomposition of human waste without reliance upon the surrounding soils to the point that end-products can be safely disposed onsite without further treatment. Marketing information from compost toilet manufacturers indicates that liquid leachate and solid end-products are suitable for on-site disposal in public parks, providing an attractive alternative to the expense incurred transporting biosolids offsite for disposal or further treatment.

There are risks associated with the operation of a compost toilet which continually discharges leachate and requires the periodic discharge of solid end-product including: direct pathogen transmission during maintenance; indirect pathogen transmission by vectors to visitors or environment; phytotoxicity; immobilization of nutrients in soil, reduced oxygen supply to plant roots, and eutrophication of aquatic environments (Fuller and Warrick, 1985; Cilimburg et al., 2000; Wichuk and McCartney, 2010; Moore, 2010).

Operational hazards associated with composting toilets are managed by workplace safety codes and commonly include: training in

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