Understanding performance variability of highly decentralized wastewater treatment systems
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Introduction

As communities rapidly urbanize, the imperative to improve the performance of sanitation systems becomes more urgent. The issue of sanitation globally is a pressing health, aesthetic and social concern.

Sewer systems can be costly to implement and so use of onsite wastewater treatment systems (OWTS) is increasing in both developing and developed countries. These OWTS provide cost-effective access to sanitation, but the state of current knowledge in this field to date does not effectively capture the reliability of OWTS over their life cycle and the reasons these systems often fail. The objective of this research is to identify factors such as demographic, financial, social and climate events that may cause systems to fail even when they are built to appropriate technical specifications to create a generalized linear model (GLM) to characterize OWTS performance variability to better inform OWTS regulations and planning.

Observed Problem

While the problem is often characterized as one in ‘poor’ developing world communities, in fact all wastewater systems are vulnerable to instability and even failure, although small decentralized systems may be overall less reliable and less resilient (EPA, 2002)(Weirich et al., 2011). Considering US sanitation, in 1998, over 5,281 water bodies did not meet pathogen standards and 4,773 were impaired by nutrients often from wastewater sources. The U.S. Bureau of the Census reported that 10 percent of OWTS had stopped functioning entirely, and some communities reported OWTS failure rates as high as 70 percent, contributing to almost one third of groundwater contamination (EPA, 2003). Outside the US, failure rates are estimated to be higher.

OWTS such as septic tanks and soil absorption units are often implemented in communities due to their affordability and the avoided cost/challenge of connecting to centralized collection systems. In some areas, simple forms of OWTS such as latrines are implemented almost excessively, because of the notion that some sanitation is better than none. In the US, OWTS serve the majority of mobile home communities, as well as 30 percent of the new homes as development occurs beyond the reach of existing municipal collection systems (Oakley et al., 2010). In the Gold Coast region of Australia, 15,000 reported homes are served by OWTS of which 90 percent are not meeting the appropriate standards adopted by the local government (Carroll et al., 2006).

Literature

Currently there are no models to predict OWTS performance especially their reported vulnerability to failure; yet tools to improve our understanding of onsite wastewater system performance would be of great value to planners and regulators. As populations grow and people continue to migrate into cities, the challenge will increase but so will the opportunity for appropriate, cost–effective and sustainable waste management systems that will result from reliable performance models.

An improved understanding of system performance and the causes of its variability are required to realize this opportunity. OWTS failure has been widely studied in the lab and at the field scale, by researchers from the School of Urban Development at Queensland University of Technology, Colorado School of Mines, USEPA, and WERF. The general conclusion from these studies is that poor performance is attributed to inadequate site and soil assessment and characterization. Such results have been integrated into existing OWTS regulations. Onsite wastewater treatment systems however, continue to fail indicating that technology is not the only factor and existing research has not adequately identified all the causes of system failure.
Approach

My work addresses the issue systematically by developing a data-driven model to determine the relevant factors inclusive of but not limited to technology. The model will then be used to assess the risks and benefits of highly decentralized sanitation systems to support effective planning and sustainable management of onsite wastewater collection and treatment.

A variation of multiple regression analysis will be used to define the relevant variables and then be used to develop the models of OWTS network reliability and resilience. The overall purpose of multiple regressions is to quantify the relationship between a group of independent or predictor variables and a criterion (dependent) variable (Helsel et al., 2002). The generalized linear model (GLM) can accomplish the above with the flexibility to model a wide variety of data distributions and it allows the consideration of more than one independent variable without a linear relationship assumption between the independent and dependent variable (Helsel et al., 2002). Of special interest for planning purposes, the GLM models for wastewater systems have been used to generate time series to predict levels of contaminant release and failure risk over decadal time scales, providing the ability to generate life-cycle performance estimates for wastewater systems under a variety of scenarios, (e.g., new technologies, climate change) or constraints (e.g., costs, environmental and health protection regulations) (Weirich et al., 2011).

The model for this study will start with available data from Boulder County in Colorado. The sample will be selected to capture variability in geography, neighborhood/community affluence, density, climate, and distance to/from services to allow for future application in diverse communities/regions. The dataset will be expanded as preliminary results become available to create a more encompassing global model.

Summary

By creating a data-driven model to highlight factors that differentiate functioning and failing onsite sanitation systems, this research helps inform decision makers on the non-technological factors which are key to improving sanitation safety and resilience among communities.

References


