EXECUTIVE SUMMARY

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State of the Science: Review of Quantitative Tools to Determine Wastewater Soil Treatment Unit Performance

Proper onsite wastewater treatment system (OWTS) selection, design, installation, operation, and management are essential. While OWTSs vary widely in their design and implementation, conventional OWTSs rely on the soil treatment unit (STU) for wastewater constituent treatment, hydraulic capacity, and eventual recharge to water resources.

The literature review identified current best practices for using models and other tools to predict soil treatment unit performance.

The literature review described in this report is part of a larger research project to assess STU performance with respect to treatment of important wastewater constituents. The overall goal of the project was to provide a toolkit and tool-use protocol that is easy to implement and available to a wide range of users to assess STU performance. The review provides an analysis of the information and data, to help guide tool development. All tools developed were based on rigorous experimental data and quantitative models verified with field data from operating systems. The literature review focused on STU performance, key conditions or factors potentially affecting STU performance, and the current best practices for using models and other available tools to predict expected STU performance. Constituents of interest include nitrogen (N), phosphorus (P), microbial pollutants, and emerging organic wastewater contaminants (OWCs).

Soil Treatment Unit Performance

At present, few models help understand the movement and treatment processes of N or P in OWTS. Nonetheless, adapting the CW2D model for STUs that will predict the effect of different soil types (texture, structure, and drainage class) appears promising. CW2D is a module of the well-known HYDRUS-based model of a sand filter that incorporates most of the features one might consider in a comprehensive microbial growth model, including a variable rate of denitrification due to changes in dissolved oxygen (DO) concentrations.

- Nitrogen in soil pore water was often reported at concentrations higher than the concentration in the applied wastewater.
- Hydraulic Loading Rate (HLR) appears to be more important than soil texture and soil depth with respect to N treatment or depth for field soils. Soil type was the most important variable in laboratory experiments. Soil depth and soil texture remain important variables to consider for tool development.
- Septic Tank Effluent (STE)-derived P is involved in several chemical processes in the STU, including degradation of polyphosphates to orthophosphates, adsorption and chemical precipitation. Little information exists in the literature to determine the P retention in the STU based on soil type.
- There are clear differences in factors controlling the fate of different types of pathogenic organisms found in STE.

BENEFITS

- Provides an explanation of soil treatment processes required for developing predictive tools to aid design of effective onsite wastewater treatment systems (OWTS).
- Describes commonalities in the removal of various constituents in OWTS, including the presence of organics in soil water, soil-water saturation, and hydraulic loading rates.
- Presents the factors controlling the fate of different types of pathogenic organisms found in STE which pose challenges for optimization of removal of these organisms in conventional soil-based systems.

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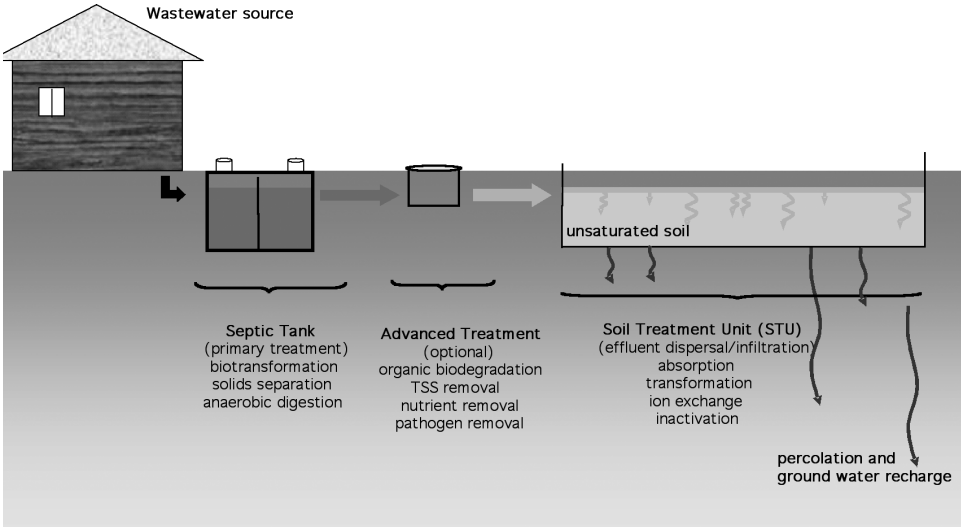

Figure 1. Schematic of a Conventional OWTS with STU.

- Preliminary analysis suggests that multivariate statistical methods are more likely to produce reliable predictive tools. Statistical analysis of literature data suggests that factors such as soil depth or soil type are not useful for developing predictive statistical tools for removal of most wastewater constituents.
- The most relevant removal processes for OWCs in STUs are sorption, biodegradation, and volatilization even with little research conducted in these areas.

Soil Treatment Unit Modeling Tools

- Many N models are available for agricultural applications but very few exist for OWTSs and the processes that occur in the STU. One HYDRUS N model adapted for OWTSs was most sensitive to the denitrifcation rate (an input parameter). Variations exist in the literature values.
- Several studies indicate that differences in soil texture, structure, or drainage class are likely to affect denitrification, largely through their effect on soil water and oxygen availability.
- The CW2D model for STUs predicting the effect of different soil types (texture, structure, and drainage class), and the model DrainMod-N-II are promising. However, model DrainMod-N-II is not well supported, one-dimensional, and thus cannot simulate many scenarios related to OWTS design. Adapting the multi-component transport model CW2D for P fate and transport in STUs is an option.
- A few models and laboratory experiments associated with P do not consider both soil sorption and precipitation. P pollution from OWTS is not a concern for most geographic locations.
- The review of existing public domain and commercial models demonstrate that simulation of microbial characteristics in OWTSs is still largely unknown. Research underway will better understand these processes and include them in future models.
- No single model exists that is appropriate for modeling all wastewater constituents in this study.

Conclusions

The information gained during this literature review will direct the design of field experiments as needed to fill any data gaps and/or develop the design tools to assess STU performance. This report will help designers and decision makers guide future tool development and monitoring.

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