Perspectives on the Science and Engineering of Onsite Wastewater Systems

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Wastewater infrastructure includes a continuum of approaches that range from highly centralized systems serving densely populated urban areas to decentralized onsite systems serving sparsely populated rural areas.

Centralized systems serve approximately 75 percent of the population and generally include gravity piping networks that convey wastewaters from remote generation to centralized treatment plants. There, engineered, tank-based biological processes are supported by physicochemical processes, and the effluent is disinfected and discharged to a receiving surface water near the plant location.

Onsite and decentralized systems serve approximately 25 percent of the U.S. population and are characterized by collection distances that are short or negligible. Tank-based pretreatment followed by natural systems for advanced treatment before discharge to the land with recharge to groundwater. In the past, onsite systems have often been viewed as a temporary approach to wastewater management and acceptable for use only until a centralized approach could be implemented. Yet there are many situations within the U.S. (and more so in developing countries) where centralized systems are neither cost-effective nor sustainable due to a variety of factors (e.g., low-density development, rugged topography, limited water and energy supplies, and lack of skilled labor). In these situations, decentralized systems can and should be considered as long-term solutions (EPA, 1997).

Decentralized approaches to wastewater infrastructure are based on the use of onsite wastewater systems (OWS). These have evolved greatly during the 20th century from early cesspool and seepage pit designs that were focused simply on waste disposal to contemporary OWS designs that include unit operations to achieve advanced treatment as well as disposal and, in some cases, beneficial reuse. OWS can now be designed from a rapidly increasing array of options. These include engineered tank and packed-bed reactors, as well as natural system treatment operations that can be tailored for a given application to yield high treatment efficiencies over a long service life at low cost while protecting public health and environmental quality (Crites and Tchobanoglous 1998, Siegrist et al. 2001).

Today, there is a considerable knowledge base regarding OWS design, implementation, and performance that enables experienced practitioners to effectively implement most commonly used systems. While much is known through research and field experiences, the current state-of-knowledge does not fully support rational system design to predictably and reliably achieve specific performance goals.

It is often difficult for someone unfamiliar with the field of OWS to understand how systems are identified, evaluated, designed, and implemented for a service life that often is expected to be 10 to 20 years or more. Moreover, it is often difficult, if not impossible, to discriminate between optional OWS approaches in order to make decisions that will lead to a cost-effective approach for reducing wastewater related risks to an acceptable level. Two possible outcomes of the current state of OWS science and engineering are that (1) current onsite system technology is not being exploited fully and effectively and that innovations are being stymied and not being rapidly deployed, or (2) inappropriate and even harmful applications may occur.

Advancing the science and engineering of onsite wastewater systems involves at its core, fundamental and applied research and testing to increase the understanding of a given wastewater system or its components, as well as the translation of that understanding into decision aids and modeling tools that enable a rational design and implementation practice. In addition, advancing the science and engineering of this field involves gaining acceptance for a given OWS practice and thereby encouraging its widespread use.

Current State of OWS Science and Engineering

Scientific understanding of OWS has been gained through fundamental and applied research, field testing, and practical experiences. The knowledge base has been documented and