Residential Nutrient Reduction

The U.S. EPA Environmental Technology Verification (ETV) Program's Water Quality Protection (WQP) Center, operated by NSF International under a cooperative agreement with EPA, has verified the performance of six technologies for reducing the nutrient nitrogen in domestic wastewater discharged from single-family homes.[1] These technologies are designed for homes that rely on onsite wastewater disposal, and remove total nitrogen from the wastewater by biological nitrification and denitrification. Unlike traditional onsite systems consisting of septic tanks and soil adsorption systems, the ETV-verified technologies are designed to actively promote nitrogen removal via nitrification/ denitrification processes.

Test Description and Results

ETV testing of the six residential nutrient reduction technologies verified the nitrogen reduction performance of systems designed to treat residential wastewater. Verification testing of five of the systems was conducted over a 12 to 13 month period at the Massachusetts Alternative Septic System Test Center (Otis Air National Guard Base, Bourne, MA). Sanitary sewage from base residential housing was used for the testing. The sixth system, the RetroFAST®, was tested over a 12 month period at the Mamquam Wastewater Technology Test Facility located at the Mamquam Wastewater Treatment Plant (British Columbia, Canada). Verification testing of all six systems included, at a minimum, monthly sampling of influent and effluent wastewater and five test sequences designed to test the unit response to differing load conditions and power failure (washday, working parent, low load, power/equipment failure, and vacation conditions). Monitoring for nitrogen reduction was accomplished by measuring nitrogen species (TKN, NH_3, NO_2, NO_3) in influent and effluent wastewater. Total and carbonaceous five-day biochemical oxygen demand (BOD_5/$CBOD_5$) and other basic parameters

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Residential Nutrient Reduction at a Glance

EPA and states recognize septic systems as major sources of ground water contamination. States have identified septic systems as the second most frequently reported contaminant source. Typical pollutants from septic systems include nitrogen. Nitrogen compounds also present concerns to the nation's surface waters. EPA and states have identified nutrients, which include both nitrogen and phosphorus, as the leading pollutant in lakes, reservoirs, and ponds. For surface waters, no data are available concerning the nationwide distribution of nutrient or nitrogen loading by source, but septic systems are thought to contribute a significant source of nutrients.

While nitrogen is an essential nutrient for plants, excessive levels in surface waters can have detrimental ecological effects, such as large algae blooms and proliferation of nuisance rooted aquatic plants. EPA has also established drinking water quality standards for nitrogen species such as nitrate and nitrite because of human health concerns.

Conventional septic system technology relies on primary treatment (settling) for solids and organic reduction prior to dispersion to the ground. The ETV-verified technologies combine the primary treatment with biological treatment to achieve a higher level of treatment. **Table 1** shows the residential nutrient reduction technologies verified by ETV and the types of biological processes used by the technologies to achieve nutrient reduction. The biological processes utilized by the verified technologies promote the removal of nitrogen from wastewater through the multi-step bacterial conversion of ammonia and organic nitrogen to nitrates (nitrification) and the reduction of nitrates to gaseous nitrogen (denitrification).

Table 1. Verified Residential Nutrient Reduction Technologies

Technology Name	Design Capacity (gallons per day)	Technology Description: Biological Process
Aquapoint, Inc., Bioclere™ Model 16/12	400	Fixed film trickling filter biological treatment system
BioConcepts, Inc., ReCip® RTS ~500 System	500	Media filter biological treatment system
Bio-Microbics, Inc., RetroFAST® 0.375 System	375	Submerged attached-growth biological treatment system
F. R. Mahony & Associates, Inc., Amphidrome™ Model Single Family System	400	Submerged growth biological treatment system
SeptiTech, Inc., SeptiTech® Model 400 System	440	Fixed film trickling filter biological treatment system
Waterloo Biofilter Systems, Inc., Waterloo Biofilter® Model 4-Bedroom	440	Fixed film trickling filter biological treatment system

[1]The ETV Program operates largely as a public-private partnership through competitive cooperative agreements with non-profit research institutes. The program provides objective quality-assured data on the performance of commercial-ready technologies. Verification does not imply product approval or effectiveness. ETV does not endorse the purchase or sale of any products and services mentioned in this document.

Test Description and Results

(continued from page 1) (pH, alkalinity, TSS, temperature) were monitored to provide information on overall system performance. Operational characteristics such as electric use, residuals generation, maintenance and labor, noise and odor production were also monitored. ETV verified that the six technologies reduced influent total nitrogen by a range of approximately 51% to 64%, resulting in effluent total nitrogen concentrations of 14 to 19 milligrams per liter as nitrogen. **Table 2** summarizes selected performance data for the verified residential nutrient technologies. More detailed performance data are available in the verification reports for each technology which can be found at http://www.epa.gov/etv/verifications/vcenter9-3.html.

Selected Outcomes of Verified Residential Nutrient Reduction Technologies

The most recent U.S. Census data estimate that 25,976,000 homes used septic tanks as of 2005, representing approximately 22% of homes in the United States (U.S. Dept. of Commerce, 2006). ETV conservatively estimates that the potential market for the ETV-verified residential nutrient reduction technologies is about 10% (2.6 million homes) of the 2005 Census estimate.[2] Based on two market penetration scenarios, 10% and 25% of the total potential market, ETV estimates that:

- The ETV-verified residential nutrient reduction technologies could be applied at approximately 260,000 to 640,000 homes nationwide where nitrogen could be a threat to ground water or surface water (out of an estimated potential market of 2.6 million homes).
- The technologies could reduce nitrogen loading to ground water by 1,300 to 4,000 tons per year (assuming they are applied by 260,000 to 640,000 homes), with associated benefits of improved compliance with drinking water standards and reduction of environmental problems associated with nutrient loading.

The technologies also can address public policy concerns associated with nitrogen and nutrient releases to ground and surface waters from non-point sources such as septic systems. Other benefits include the establishment of a well-accepted protocol that has advanced efforts to standardize protocols across programs. At least four states (North Carolina, Massachusetts, Pennsylvania, and Florida) are currently using or are considering use of ETV protocols in the evaluation of alternative technologies for the management of septic systems or discharge of nitrogen.

[2] Note that these estimates are based on a rough assumption about the percent of homes with septic systems that represent a threat to ground water or surface water. The 10% estimate is intended to provide an approximation for the potential market for the ETV-verified systems given a lack of quantitative estimates. For more information on how this approximate potential market was developed, see Section 3.2 of *ETV Case Studies: Demonstrating Program Outcomes* (U.S. EPA, 2006).

Table 2. Selected Performance of Residential Nutrient Reduction Technologies

Vendor and Model[A]	Average Total Nitrogen, mg/L as N[B]		% Reduction[C]
	Influent	Effluent	
A	36	15	58%
B	37	14	62%
C	39	14	64%
D	37	15	59%
E	39	19	51%
F	37	16	57%

[A] Because the ETV Program does not compare technologies, the performance results shown in this table do not identify the vendor associated with each result and are not in the same order as the list of technologies in Table 1.
[B] mg/L as N = milligrams per liter as nitrogen
[C] Table in Metcalf and Eddy shows the following values of nitrogen reduction using older technologies: Total Nitrogen Raw 35-80 mg/L and effluent of septic systems, 25-60 mg/L, corresponding to 25 - 30 % removal. These numbers show that the new ETV technology is an improvement - doubling previous removal rates.

References

U.S. Dept. of Commerce, 2006. *American Housing Survey for the United States: 2005*. U.S. Census Bureau. July.

U.S. EPA, 2006. *ETV Case Studies: Demonstrating Program Outcomes, Volume I*. EPA/600/R-06/001. January. (Primary source, with updates based on data from U.S. Dept. of Commerce, 2006).

U.S. EPA ETV, http://www.epa.gov/etv.

Tcobanoglous, G. and F. Burton. Wastewater Engineering:Treatment, Dispossal and Resue. Metcalf & Eddy, Inc-3rd Edition McGraw-Hill, Inc 1991.

Mamquam Test Facility

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