www.epa.gov
TECHBRIEF
Environmental Technology Verification Program
ETV

On-line Wastewater Nutrient Monitoring

Identifying and testing continuous monitoring technologies to track and control nutrients in source and product waters, including treated effluents, is important to achieving further reduction of nutrients in the aquatic environment. In 2005, the U.S. EPA Environmental Technology Verification (ETV) Program's Advanced Monitoring Systems (AMS) Center, operated by Battelle under a cooperative agreement with EPA, verified the performance of two nutrient monitors at an industrial wastewater treatment facility (see **Table 1**)[1]. One technology measured nitrate only, with results expressed as total nitrogen. The other technology measured total nitrogen and total phosphorus. Additional testing of nitrate monitoring technologies is being planned under the AMS Center for environmental applications for measuring nutrients in ground water.

Nitrogen and Phosphorus Pollution at a Glance

High levels of nitrogen and phosphorus, or nutrient pollution, in bodies of water result in harmful algal blooms, reduced spawning grounds and nursery habitats, fish kills, and oxygen-starved hypoxic or "dead" zones. This can be a public health concern since this process can lead to impairment of drinking water sources and increased exposure to toxic microbes such as cyanobacteria.

EPA and states have identified high nutrient loading as the leading cause of pollution in lakes, reservoirs, and ponds. Almost every U.S. state and territory has been impacted by nutrient-related degradation of the country's waterways. All but one state and two territories have Clean Water Act Section 303(d) listed impairments for nutrient pollution. States have listed over 10,000 nutrient and nutrient-related impairments. Fifteen states have more than 200 nutrient-related listings each (EPA, 2002). For these reasons, EPA regional offices have identified nutrient pollution reduction as a priority for EPA. Underlying any approach to the reduction of nutrients (nitrates and phosphorus) in the environment is the need to measure concentrations in a timely manner.

Verification Testing Description

In 2005, the ETV Program conducted verification testing for 42 consecutive days at an industrial wastewater treatment facility in Richmond, VA. The final outfall flows into the James River. Accuracy, bias, linearity, limit of detection (LOD), reproducibility, span and zero drift, matrix effects, data completeness, and operational factors were determined. On-line monitoring results were compared to results obtained from water samples analyzed using Standard Methods for the Examination of Water and Wastewater, 18th Edition (APHA, 1992). During off-line testing, the technologies were challenged with multi-level nutrient standards and deionized (DI) water for total nitrogen (TN) and total phosphorus (TP) to determine LOD, percent recovery, and other performance metrics. In the off-line testing, the technologies were also challenged with additional nutrient standards for the determination of accuracy for several forms of nitrogen and phosphorus. **Table 1** provides a description of the nutrient monitoring technologies included in the test. Selected performance data are available in **Table 2**, and detailed performance data are available in the verification reports for each technology at http://www.epa.gov/nrmrl/std/etv/vt-ams.html#nmtfia.

ETV Advanced Monitoring Systems Center

John McKernan, EPA Project Officer
Phone: (513) 569-7415
Email: mckernan.john@epa.gov

Amy Dindal, Battelle
Phone: (561) 422-0113
Email: dindala@battelle.org

Final outfall sampling location for nutrient monitor testing

[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.

Table 1. Description of Nutrient Monitoring Technologies	
Technology Vendor and Name	Technology Description
Shimadzu Scientific Instruments, Inc. TNPC-4110(C) On-Line Water Quality Analyzer	The analyzer can monitor total nitrogen, phosphorus, and organic carbon (TOC) in source and product waters. TOC monitoring was not verified in this test, although TOC measurements were taken during on-line effluent monitoring. The analyzer can be used for nutrient monitoring and process control and automatically performs sampling, pretreatment (physical and chemical), digestion, and analysis. Total phosphorus is measured through a photochemical oxidation process, with colorimetric quantification. Total nitrogen is measured using a catalytic combustion method, with chemiluminescent quantification.
ZAPS Technologies, Inc. Multi-Parameter Analyzer (MP-1)	The analyzer was designed as a first-alert system for water treatment plants for monitoring of nitrate in source and product waters. The analyzer uses a sequential fiber-optic spectrometer that measures nitrate by its light absorption at 220 nanometers. Because it can operate from 200 to 800 nanometers, the analyzer is capable of providing > 100 channels of optical data by monitoring absorption, fluorescence, and total reflection bands. The verification test was configured to measure corrected nitrate absorption, temperature, and several other channels related to dissolved organic carbon, complex hydrocarbons, bacterial abundance, and chlorophyll *a*. Only measurements of nitrate were verified.

Selected Outcomes of Verified Nutrient Monitoring Technologies

To address nutrient levels in surface and ground waters and reduce potential human health and environmental concerns, the EPA has established regulations and standards under the Clean Water Act (CWA) and Safe Drinking Water Act (SDWA) that require nutrients to be at or below recommended or established levels. Under the CWA, the EPA requires states to establish total maximum daily loads (TMDL) to regulate nutrient loadings in impaired water bodies. TMDLs have been established for total nitrogen and phosphorus within various segments of the watershed of the Chesapeake Bay in Virginia, where the verifications were conducted. The SDWA has established maximum contaminant levels (MCL) of 10 milligrams per liter as nitrogen (mg/L as N) for nitrate and 1 mg/L as N for nitrite. There is no established MCL for phosphorus. The primary health risks of nitrate and nitrite in drinking water are to infants. Drinking nitrite or nitrate containing water can result in increased incidence of methemoglobinemia, a blood disorder that interferes with the body's processes for carrying oxygen to cells and tissues (EPA, 2002). Along with compliance monitoring initiatives, real-time monitoring technologies, such as those verified, can be used to provide temporal analysis of when changes in nutrient loading occur and assist in determining when enhanced control of wastewater treatment systems is needed. Below are the benefits of the nutrient monitoring verification tests.

Table 2. Selected Performance of Nutrient Monitoring Technologies			
Technology	Test Range, mg/L	LOD, mg/L	Average Recovery, %
MP-1	TN: 0.1 - 5	TN: 0.232	TN: 157
TNPC-4110(C)	TN: 0.5 - 20	TN: ND[a]	TN: 131
TNPC-4110(C)	TP: 0.5 - 5	TP: 0.141	TP: 118
[a] Not determined, total nitrogen was not detected in samples to determine the LOD			

- A peer-reviewed test protocol has advanced efforts to standardize protocols.
- The verifications conducted support the use of on-line monitoring technologies for detecting nutrients in source and treated effluent waters.
- Verification activities support EPA's objective to manage and reduce nutrient loadings by providing effective tools for wastewater and environmental monitoring.

References

APHA. 1992. Standard Methods for the Examination of Water and Wastewater, 18th Edition, American Public Health Association, Washington D.C.

U.S. EPA. 2002. Integrated Risk Information System (IRIS) Health Assessment Information for Nitrates and Nitrites. Updated December.

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

U.S. EPA, Water Quality Criteria for Nitrogen and Phosphorus Pollution, http://www.epa.gov/waterscience/criteria/nutrient/basic.htm

www.epa.gov/etv
September 2009
EPA/600/S-09/028