Drinking Water Analysis Guide

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Drinking Water Analysis

OI Analytical has been a leading supplier of instrumentation for drinking water analysis since 1978. This guide provides an overview of the drinking water treatment process, U.S. regulations governing water monitoring, the instrumentation and expertise OI Analytical brings to testing drinking water for chemical contaminants.

In 1974 the Congress of the United States passed Public Law 93-523; the Safe Drinking Water Act (SDWA) to protect public health by regulating the nation's drinking water supply and protecting sources of drinking water.[1] The SDWA first went into effect on June 24, 1977 and has been amended multiple times.

The U.S. Environmental Protection Agency administers the SDWA in conjunction with states. The SDWA authorizes states to assume primary oversight and enforcement responsibility for public water systems provided that they adopt regulations at least as stringent as federal regulations and establish effective enforcement programs.

The SDWA empowers the U.S. EPA to establish enforceable standards for contaminants in drinking water, along with monitoring requirements and analytical test methods.[2]

The U.S. EPA has set standards for 90 chemical, microbiological, radiological, and physical contaminants in drinking water.

Drinking Water Testing Applications Supported by OI Analytical Instruments

- BTEX
- Cyanide
- Disinfection By-Products (THMs / HAA5)
- Drinking Water Security
- Endocrine Disruptors (EDCs)
- Fuel Oxygenates (MTBE)
- Nutrient Pollutants
- Pesticides
- Total Organic Carbon (TOC)
- Volatile Organic Compounds (VOCs)

Drinking Water Treatment

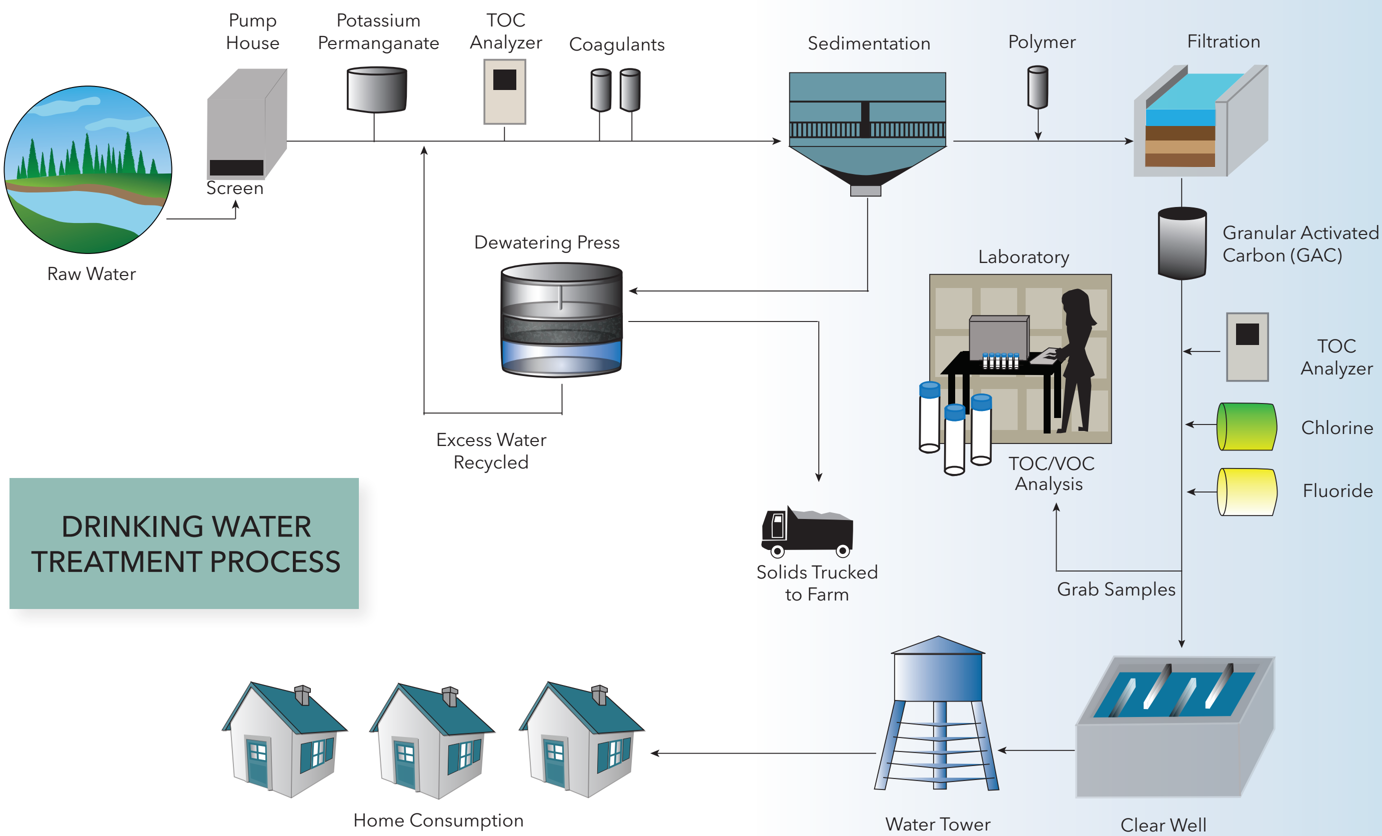
Community water systems serving large populations generally rely upon surface water sources such as rivers, lakes, and reservoirs. Systems serving smaller populations tend to use groundwater. The quality of water from these sources determines the treatment process employed. The basic steps of the drinking water treatment process are depicted and described below.

Raw source water is pumped through a screen to remove large debris. Potassium permanganate ($KMnO_4$) may be added to treat algae. The water is then clarified by flocculation and sedimentation. Alum, iron salts, or organic polymers are added to coagulate small particles into larger ones that settle out as sediment. The clear water is then filtered through a bed of sand and gravel to remove remaining particles and natural organic matter (NOM).

After filtration water may also be directed through a bed of granular activated carbon (GAC) to adsorb and remove residual NOM and disinfection by-product precursor compounds (e.g.; humic acid). The efficiency of post-filtration GAC treatment is monitored by TOC analysis. Reducing the TOC level enables a utility to reduce the formation of trihalomethanes (THMs) and haloacetic acids (HAA5) and comply with the Disinfection Byproducts Rule.

Before drinking water is released into a distribution system it is disinfected by either chlorination or ozonation to kill dangerous microbes. Chlorine (Cl), chloramines (NH_2Cl), and chlorine dioxide (ClO_2) are highly effective disinfectants. Ozone (O_3) and ultraviolet (UV) radiation are effective in treating relatively clean water but are not relied upon to control microbial contaminants throughout a distribution system.

Drinking Water Treatment



DRINKING WATER TREATMENT PROCESS

Drinking Water Monitoring

Regulatory Framework

The SDWA defines two types of drinking water systems. A Public Water System (PWS) serves at least 25 persons or 15 service connections for at least 60 days each year. There are approximately 161,000 public water systems in the United States. A Community Water System (CWS) is a public water system that supplies drinking water to homes year-round. The majority of people in the U.S. (268 million) obtain their drinking water from one of the 54,000 community water systems.

Both PWS and CWS utilities must comply with federal and state drinking water standards. Private wells serving less than 25 persons are not required to meet federal standards, however some states do set standards for private wells. Bottled water is regulated by the U.S. Food and Drug Administration as a food product, and must meet the same standards set by the U.S. EPA for tap water.

The U.S. EPA follows regulatory and scientific protocols in establishing enforceable, health-based drinking water standards. The 1996 SDWA amendments require the U.S. EPA to produce a contaminant candidate list (CCL) every five years.[3] The U.S. EPA must also determine if five contaminants on the CCL meet criteria for possible regulation every three years.

Community water systems are required to monitor drinking water for more than 90 contaminants under National Primary Drinking Water Regulations. Major classes of contaminants include volatile organic compounds (VOCs), synthetic organic compounds, inorganic compounds, and microbial organisms.

A maximum contaminant level (MCL) is defined for each contaminant and sets the highest level of that contaminant allowed in drinking water.

National Secondary Drinking Water Regulations cover contaminants that affect the aesthetic, or sensory properties of drinking water (color, taste, odor). The U.S. EPA recommends maximum contaminant levels for these secondary parameters but does not enforce compliance. Individual states may choose to adopt these parameters and MCLs as enforceable standards.

DBPR

The U.S. EPA has issued regulations establishing monitoring requirements for disinfection byproducts in drinking water to mitigate the risk of cancer, and reproductive and developmental health effects.[4] The Stage 2 Disinfectants and Disinfection Byproducts Rule (DBPR) set MCLs for chloroform, total trihalomethanes (TTHMs) and five haloacetic acids (HAA5s) and approved analytical methods for testing DBPs.[5, 6]

Drinking Water Security

The U.S. Government has passed legislation and issued directives to protect the nation's water supply infrastructure.[7] Title IV of the Public Health Security and Bioterrorism Preparedness and Response Act requires drinking water systems serving more than 3,300 people to develop response measures to incidents that could disrupt the supply of safe drinking water, or pose serious public health concerns.[8] Under Homeland Security Presidential Directive 9, the U.S. EPA is responsible for developing a "robust, comprehensive surveillance and monitoring program to provide early warning in the event of a terrorist attack using biological, chemical, or radiological contaminants." [9]

Hydraulic Fracturing

Chemicals used for hydraulic fracturing of shale formations for natural gas extraction include potentially toxic substances such as diesel fuel and disinfectants which can contaminate underground sources of drinking water. In some cases methane has been detected in drinking water from wells in the vicinity of shale gas production.[10, 11] Methane is not a regulated contaminant under U.S. National Drinking Water Regulations. The SDWA amendments of 2005 exempt hydraulic fracturing from regulation under the U.S. EPA Underground Injection Control Program (except in cases where diesel fuel is employed).

A Congressional Appropriations Committee report in 2010 directed the U.S. EPA to conduct studies to assess the potential impacts of hydraulic fracturing on drinking water resources.[12]

Gas Chromatography Instruments

Gas chromatography (GC) and gas chromatography-mass spectrometry (GC-MS) instruments analyze raw and finished drinking water for contaminants such as VOCs, TTHMs, pesticides, fuel and fuel additives.

Groundwater from aquifers, public and domestic wells supplies about 50 percent of the U.S. population with their drinking water.[13]

Solvents such as trichloroethylene (TCE) and perchloroethylene (PCE) are common contaminants in groundwater. Leaking underground storage tanks (LUSTs) can also contaminate groundwater aquifers and wells with gasoline, methyl tertiary butyl ether (MTBE), or diesel fuel. Treatment steps employed to remove VOC contaminants from groundwater include; air stripping, adsorption on granular activated carbon, or oxidation processes.

The Eclipse 4660 Purge-and-Trap Sample Concentrator processes samples for GC/GC-MS analysis of VOCs in groundwater and drinking water using USEPA-compliant methods.

The 4551A Water Autosampler docks directly underneath the Eclipse 4660 purge-and-trap sample concentrator and enables unattended automated analysis of 51 water samples.

The 4100 Water / Soil Sample Processor automates the handling and processing of samples in 40-mL VOA vials for purge-and-trap analysis of VOCs in drinking water, groundwater, and soil samples.

The 4100 efficiently processes up to 100 water samples and operates with a single or dual Eclipse 4660 purge-and-trap instruments to improve sample throughput and laboratory productivity.

The 5350 Tandem PID / ELCD Detector is cited in U.S. EPA Method 502.2 for measurement of 60 aromatic and halogenated VOCs in drinking water. The photoionization detector (PID) detector measures aromatic compounds, while the electrolytic conductivity (ELCD) detector measures halogenated compounds.

Eclipse 4660 Purge-and-Trap Sample Concentrator

4100 Water/Soil Sample Processor

Total Organic Carbon Analyzers

Total organic carbon (TOC) analysis is often used as a surrogate indicator of natural organic matter (NOM) in raw source water. The DBPR requires water systems treating surface water to remove a percentage of TOC from the influent source water. Monitoring and comparing TOC levels in raw and finished drinking enables facilities to assess and improve removal of DBP precursors in the treatment process.

OI Analytical offers both on-line and laboratory TOC analyzers to measure organic contamination levels for optimization of the water treatment process and regulatory compliance reporting.

The Aurora 1030W Laboratory TOC Analyzer is used for testing grab samples for regulatory compliance purposes and to confirm the calibration and performance of on-line TOC monitors.

The 9210p On-line TOC Analyzer performs continuous on-line monitoring of organic contamination levels and can output data to a Supervisory Control and Data Acquisition (SCADA) system for process control and optimization.

Both the Aurora 1030W and 9210p TOC analyzers employ the heated sodium persulfate oxidation technique in USEPA-approved methods 415.3 and SM 5310C.[14] Virtually all organic compounds dissolved in water can be oxidized by heated sodium persulfate ($Na_2S_2O_8$). Concentrated solutions (1 or 1.5 M) of sodium persulfate effectively oxidize organic matter present in the form of colloids, macromolecules, and suspended solids.[15]

The 9210p TOC analyzer responds to all types of organic carbon dissolved or suspended in water including compounds without a chromophore. This detection capability can be used to provide real time warning of organic chemical contamination from accidental or intentional incidents.

Aurora 1030 TOC Analyzer

9210p On-line TOC Analyzer

Total Organic Carbon Analyzers

Automated Chemistry Analyzers

Automated Chemistry Analyzers perform wet chemistry procedures that test raw and finished drinking water samples for contaminants such as nutrient pollutants and cyanide using USEPA-compliant methods.

Nitrate is a common contaminant in groundwater aquifers and surface waters. Infants exposed to excess levels of nitrate in drinking water can become seriously ill and develop methemoglobinemia known as blue-baby syndrome. The U.S. EPA has established an MCL of 10 mg/L for nitrate in drinking water to mitigate the health risk it poses.

A study conducted in Iowa and Texas found that mothers with higher intake of nitrate from drinking water in the first trimester of pregnancy were at increased risk of having babies with some types of birth defects.[16]

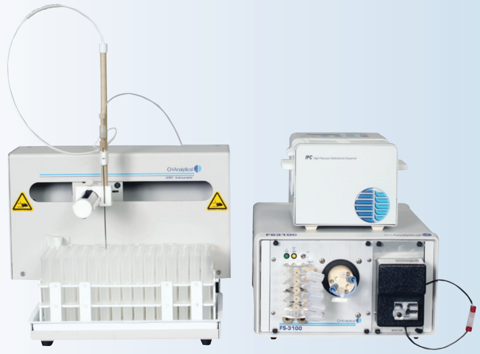
Excess levels of phosphate (PO_4) in source water accelerates aquatic plant growth and algal blooms which can affect the organoleptic properties of drinking water. Water with phosphate levels above 5ppm is dangerous for human and animal consumption.

The FS 3100 Automated Chemistry Analyzer performs high-throughput continuous flow analysis on large batches of samples for a single or multiple analytes at a time. The FS 3100 measures all nutrient pollutants (nitrate, phosphate, ammonia), along with other ions using USEPA-compliant methods.

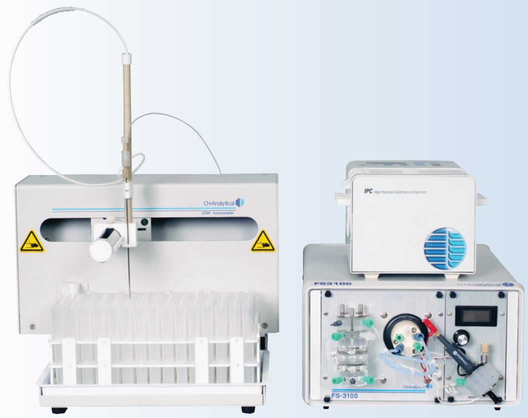
The CNSolution 3100™ Cyanide Analyzer measures free, available, and CATC cyanide in drinking water by USEPA-approved methods.

OI Analytical has been a leader in cyanide analysis since 1990. Research supported by OI has made significant contributions to the science of cyanide analysis and reliability of testing methods.

U.S. EPA Method OIA-1677 for available cyanide was developed in cooperation with the University of Nevada – Reno. This method was approved for SDWA reporting on March 12, 2007.[17]



FS 3100
Automated Chemistry Analyzer



CNSolution™ 3100
Cyanide Analyzer

References & Links

References & Links

References

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[2]Manual for the Certification of Laboratories Analyzing Drinking Water, U.S. EPA Office of Water, EPA 815-R-05-004, January 2005.

[3]The Safe Drinking Water Act: Current and Future, J.A. Cotruvo, Journal of the AWWA, Vol. 104:1, January 2012.

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[6]Comprehensive Disinfectants and Disinfection Byproducts Rules (Stage 1 and Stage 2): Quick Reference Guide, U.S. EPA Office of Water, EPA 816-F-10-080, August 2010.

[7]http://cfpub.epa.gov/safewater/watersecurity/legistration.cfm

[8]Public Health Security and Bioterrorism Preparedness and Response Act of 2002.

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[10] Methane Contamination of Drinking Water Accompanying Gas-Well Drilling and Hydraulic Fracturing, S. Osborn, A. Vengosh, N.R. Warner, and R.B. Jackson, PNAS, Vol. 108, No. 20, 8172-8176, May 17, 2011.

[11]Purge-and-Trap GC Analysis of Methane in Water Samples Associated with Hydraulic Fracturing, OI Analytical Application Note # 37920312.

[12]Plan to Study the Potential Impacts of Hydraulic Fracturing on Drinking Water Resources, U.S. EPA Office of Research and Development, EPA/600/R-11/122, November 2011.

[13]Volatile Organic Compounds in the Nation's Ground Water and Drinking-Water Supply Wells, U.S. Geological Survey, Circular 1292, 2006.

[14]A Comparative Study of On-line and Laboratory TOC Analyzers for Analysis of Raw and Finished Drinking Water, OI Analytical Application Note # 39450313.

[15]Online Monitoring for Drinking Water Utilities, American Water Works Association, 2002.

[16]Higher Daily Nitrate Intake from Drinking Water During Pregnancy Associated with Birth Defects, Water Online, July 3, 2013, www.wateronline.com

[17]Federal Register, Vol. 72, No. 47, March 12, 2007.

Links

U.S. EPA Office of Water; www.epa.gov/safewater

American Water Works Association; www.awwa.org

Water Environment Federation; www.wef.org

Association of State Drinking Water Administrators; www.asdwa.org

National Drinking Water Clearing House, West Virginia University; www.nesc.wvu.edu/drinkingwater.cfm

World Health Organization; www.who.int

Water Online, www.wateronline.com

xylem
Let's Solve Water

OI Analytical is a Xylem brand. We design and manufacture instrumentation for chemical analysis. Data from our instruments serve as the basis for informed decisions affecting human health and safety, environmental protection, industrial operations, and product quality.

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