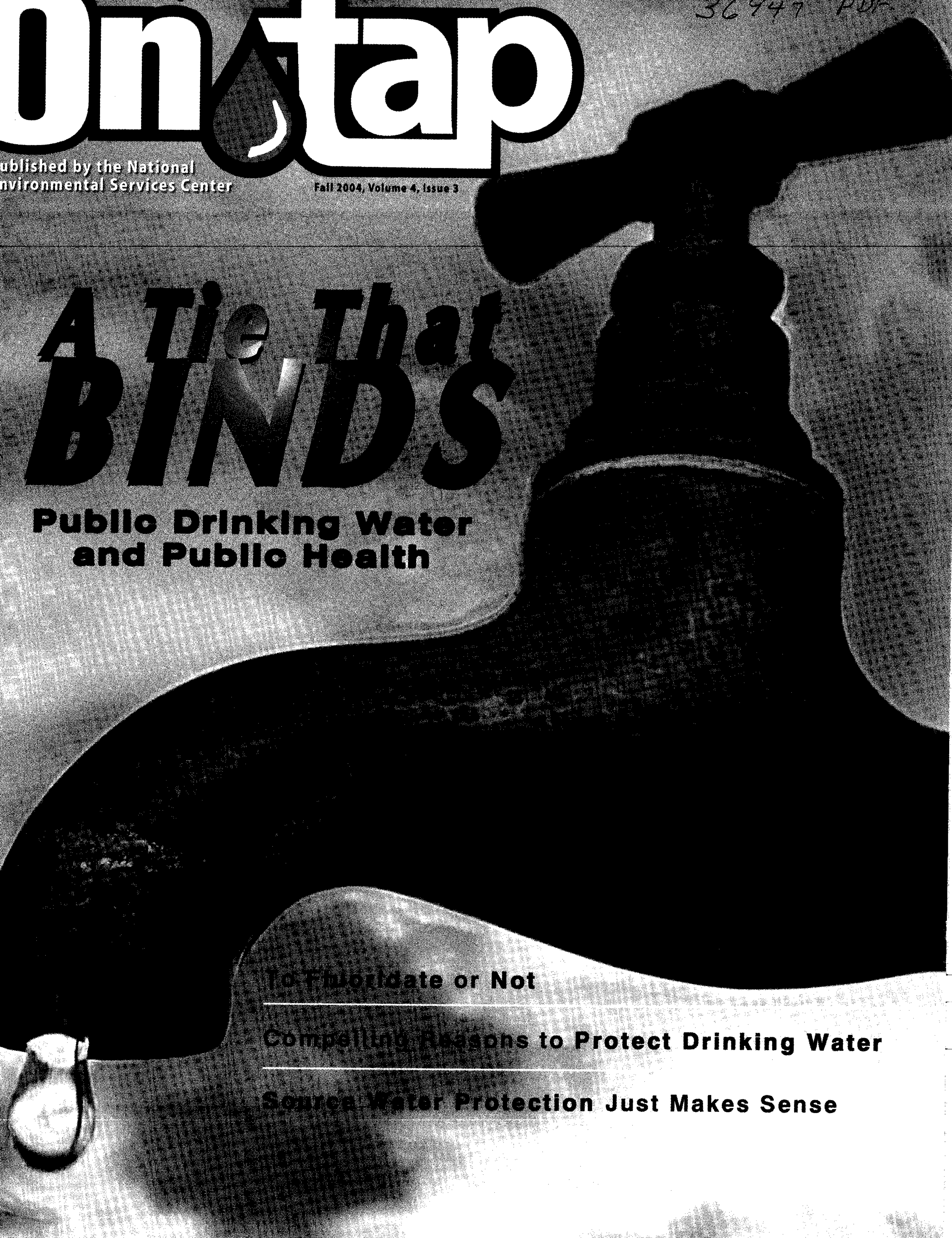
Drinking Water News for America's Small Communities

On tap

ublished by the National
nvironmental Services Center

Fall 2004, Volume 4, Issue 3



A Tie That BINDS

Public Drinking Water and Public Health

To Fluoridate or Not

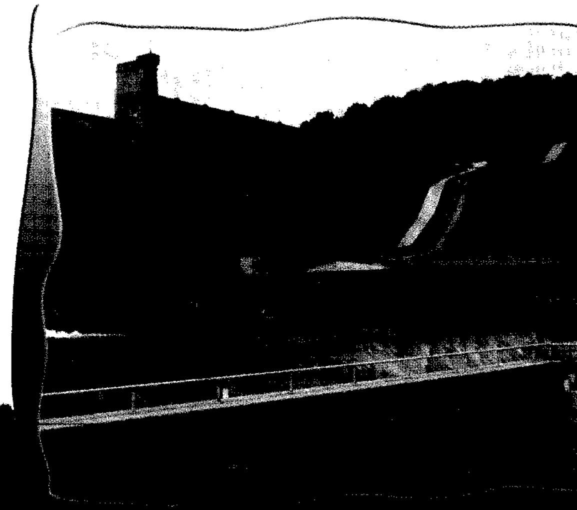
Compelling Reasons to Protect Drinking Water

Source Water Protection Just Makes Sense

Responsible Environmental Actions Embrace Source Water Protection

Tygart Lake is a popular fishing and recreation spot for tourists and area residents. But the lake also provides the source water supply for the Taylor County, West Virginia, public service district, which serves more than 10,000 customers, including connections and purchasers. Because of its distinction as a drinking water source, the lake must be protected from potential pollution sources, such as oil, waste, and debris. For more information about source water protection, see the article on page 41.

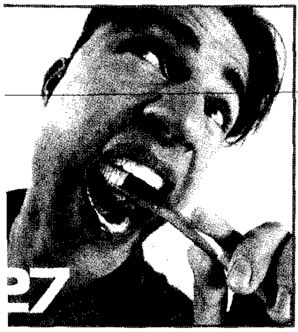
Photos by Chris Metzgar

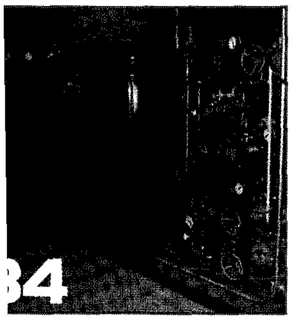


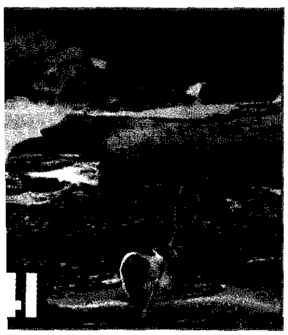
On tap MAGAZINE

Fall 2004, VOL. 4, ISSUE 3

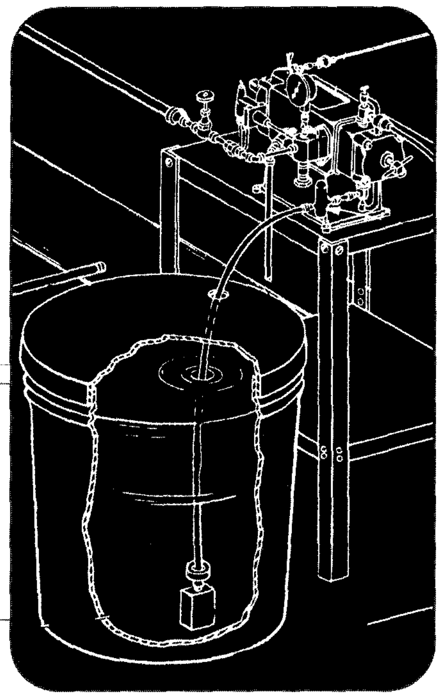
Features







In Every Issue

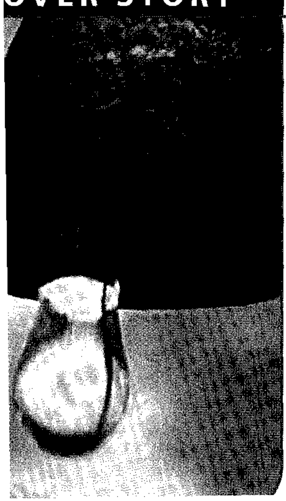


Tear Out Insert

Tech Brief • Chlorination

Chlorine provides good disinfection and is effective against a wide range of pathogens in drinking water. Recently, however, many water treatment plants have altered their disinfection strategies because of regulation changes concerning disinfection byproducts.

OVER STORY



A Tie That Binds • Public Drinking Water and Public Health

16 Two concepts that cannot be separated are **public drinking water** and **public health protection**. In fact, an entire industry was built on the bond between these two notions.

On tap

Drinking Water News and Information
for America's Small Communities

Fall 2004 • Volume 4 • Issue 3

Sponsored by USDA Rural Development

Hilda Gay Legg Administrator
Steve Saulnier Loan Specialist

Rural Development

USDA's Rural Development Utilities Service strives to serve a leading role in improving the quality of life in rural America by administering its electric, telecommunications, and water and waste programs in a service-oriented, forward-looking, and financially responsible manner. Founded in 1947 as the Farmer's Home Administration, Rural Development has provided more than $20 billion for water and wastewater projects. For more information, visit their Web site at *www.usda.gov/rus/.*

The National Environmental Services Center

The National Environmental Services Center (NESC) is a nonprofit organization providing technical assistance and information about drinking water, wastewater, infrastructure security, utility system management, solid waste, and environmental training to communities serving fewer than 10,000 people.

To achieve this mission, NESC offers a toll-free technical assistance hotline, hundreds of low-cost or free products, quarterly magazines and newsletters, and several searchable databases. We also sponsor conferences, workshops, and seminars. Visit the NESC Web site at *www.nesc.wvu.edu* or call *toll-free (800) 624-8301 and request an* information packet.

NESC is located at West Virginia University, one of the nation's major doctoral-granting, research institutions.

ISSN 1061-9291
Printed on Recycled Paper

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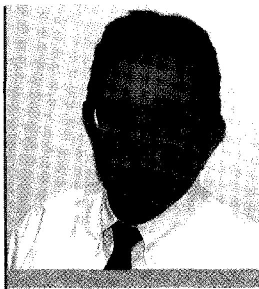

The Director's Perspective

"A fundamental promise we must make to our people is that the food they eat and the water they drink are safe," former President Clinton said during the reauthorization of the Safe Drinking Water Act in 1996.

A safe, dependable drinking water supply is, indeed, fundamental to the health of all Americans, now and in the future. For that reason, the connection between public health protection and safe drinking water cannot be disregarded. That bond is why regulations exist.

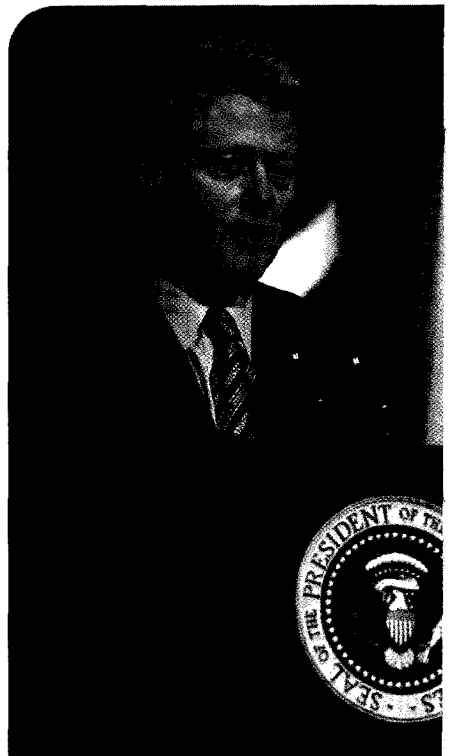

Photo by NATO Photos, April 24, 1999

Former US President, Bill Clinton, speaks at a press conference at the NATO 50th Anniversary Summit in Washington, DC.

Public health protection is the motivation for communities to maintain infrastructure, for systems to employ skilled operators, and for governments to educate drinking water industry leaders. It also inspires to researchers to develop new treatment technologies.

Vigilance by local governments, public water systems, the states, and the U.S. Environmental Protection Agency is vital to ensure that all public water supplies are safe. This awareness leads to a better understanding that our activities affect water quality, and better efforts to improve water quality help prevent waterborne diseases and avoid epidemics.

On Tap Explores Public Health

In this issue of *On Tap*, you will find articles that explore the link between public health and safe drinking water. We worked hard to include as much information relating to the public health aspects of drinking water as we could. From the

Rick Phalunas, Interim Executive Director
National Environmental Services Center

cover article, which is an all-inclusive primer about public health and safe drinking water, to articles that explain how difficult it is to collect accurate data, you will find specifics about the link between public health and public water. You may use this information to:

- improve public health awareness,
- develop training materials for operators,
- create presentations to board members,
- justify funding requests,
- design source water protection strategies, or
- prepare for future public health challenges.

Please let us know if this issue helped you in your work. And, let us know what other kinds of information you might find useful.

New Name, Same Services

In the last issue, I told you about organizational changes we were undertaking and how we will be performing our numerous services under the National Environmental Services (NESC) name. Initial feedback from our audiences shows that people generally support this idea. "It'll be easier to remember," some say. "I never could keep track of which program did which thing," others report, or, "I didn't know you were involved in wastewater as well." These are three of the many reasons we have for becoming NESC.

Thank you very much for your comments. Again, let me reassure you that everything you have come to expect from us is still in place and that we believe this new arrangement will allow us to serve you better now and in the future.

With warm regards,

Rick Phalunas
Interim Executive Director
National Environmental Services Center

National Environmental Services Center

NESC *Assistance. Solutions. Knowledge.*

Who We Are

A number of people are responsible for putting *On Tap* magazine together each quarter. We encourage our readers to contact us with ideas and suggestions. An e-mail address is provided for each staff member below, as well as their phone extension. Call our main number toll free at (800) 624-8301 and enter the appropriate extension at the prompt.

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www.nesc.wvu.edu

Denotes an event where the National Environmental Services Center will have a booth or that staff will attend. Look for us at these conferences.

Calendar of Events

December

2004 Congress of Cities & Exposition
National League of Cities
December 1–3, 2004
Indiana Convention Center and RCA Dome
Indianapolis, IN
Phone: (202) 626-3000
Fax: (202) 626-3043
www.nlc.org

National Ground Water Association Annual Conference
December 12–15, 2004
Las Vegas Convention Center
Las Vegas, NV
Kathy Butcher
Phone: (800) 551-7379
Fax: (614) 898-7786
www.ngwa.org

January

AWWA Source Water Protection Symposium
January 23–25, 2005
Palm Beach Gardens, FL
Linda Moody
Phone: (303) 347-6201/ (800) 926-7337
Fax: (303) 347-0804
www.awwa.org

February

AWWA Water Conservation Workshop
February 17–19, 2005
Savannah, GA
Linda Moody
Phone: (303) 347-6201
Fax: (303) 347-0804
www.awwa.org

March

National Environmental Services Center/ National Small Flows Clearinghouse 7th Annual Onsite State Regulators and 5th Annual Captains of Industry Conference
March 7–12, 2005
Radisson Hotel
New Orleans, LA
Phone: (800) 624-8301
ext. 5536 (Sandy Miller)
E-mail: *smiller2@wvu.edu*
www.nesc.wvu.edu

Water Quality Association Annual Convention and Exhibition
March 29–April 2, 2005
Las Vegas Convention Center
Las Vegas, NV
Phone: (630) 505-0160
Fax: (630) 505-9637
www.wqa.org

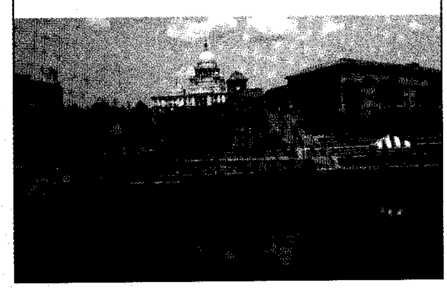
If you are sponsoring a water-related event and want to have it listed in this calendar, please send information to Lori Stephens, National Environmental Services Center, West Virginia University, P.O. Box 6064, Morgantown, WV 26506-6064. You also may call Lori at (800) 624-8301 or (304) 293-4191 ext. 5522 or e-mail her at *Lori.Stephens@mail.wvu.edu.*

April

National Association of Environmental Professionals Annual Conference
April 16–19, 2005
Alexandria Mark Center
Alexandria, VA
Phone: (888) 251-9902 or (301) 860-1140
Fax: (301) 860-1141
www.naep.org

June

National Environmental Health Association Annual Educational Conference and Exhibition
June 26–29, 2005
Providence, RI
Phone: (303) 756-9090
Fax: (303) 691-9490 Phone (303) 756-9090
www.neha.org

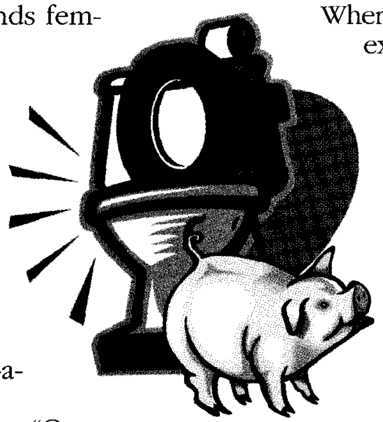


American Water Works Association Annual Conference and Exposition
June 12–16, 2005
Moscone Center
San Francisco, CA
Phone: (800) 926-7337 or (303) 794-7711
Fax: (303) 347-0804
www.awwa.org/ace2005/

Livestock Flood Environment with Estrogen

Based on information obtained from estrogen sampling at eight dairy and 11 swine waste storage facilities, researchers concluded that farm animals in the U.S. flood the environment with estrogen hormone compounds, according to a press release on the *Environmental Science and Technology Online* Web site. Previous studies have found that these compounds feminize male fish.

The study's authors estimate that the nation's 10 million cows and 43 million swine excrete a daily estrogen mix of 10 to 30 kilograms (kg) of 17-b-estradiol and 20 to 80 kg of estrone; 17-a-estradiol was found mainly on dairy farms. "Our best estimate is that the amount of estrogen coming out of pigs and cows is over an order of magnitude higher than what the human population puts out," says study author Raj Raman, associate professor of biosystems engineering and environmental science at the University of Tennessee.



In addition to feminizing male fish, scientists are not completely certain what estrogen pollution does. Estrogenic compounds have different levels of activity.

When estrogens are first excreted, they are actually conjugated with other molecules, rendering them biologically inactive. However, the microorganisms in sewage systems can break this bond and reactivate the hormones. Whether this occurs in the muck piles and lagoons found on farms is an open question.

Human and animal waste also enters the environment differently. Animal excrement is applied across large fields, normally diluting any harmful effects. However, human waste is usually treated at wastewater facilities and then discharged as effluent, creating a point source for pollution. It is not known whether waste treatment removes all estrogenic compounds.

Most of the estrogen in human waste comes from ethinyl estrogen, the synthetic hormone used in birth control pills. The ethinyl group blocks metabolic breakdown and hinders environmental degradation, allowing the hormone to hang around in streams for up to a couple of weeks.

For more information about estrogen in the environment, visit the Environmental Science and Technology Online *Web site at* pubs.acs.org/subscribe/journals/esthag-w/2004/jun/science/pt_livestock.html.

Drugs in Drinking Water Making Headlines

Phoenix's Environmental Quality Commission is concerned about drugs in the valley's water supply. So much so that the commissioners are considering a "Don't flush it" campaign. They decided to study the problem after learning that traces of steroids, drugs, caffeine, disinfectants, and other chemicals have been found in Arizona rivers and may be making it into drinking water, *The Arizona Republic* reported.

Commissioners want to look at how the city could affect residents' behavior by teaching people to throw medications in the garbage instead of in the toilet.

The problem of pharmaceuticals in the water supply emerged about 10 years ago, noted Michael Gritzuk, Phoenix water services director.

In 2002, hydrologists with the U.S. Geologic Survey released the first nationwide government study about medicine, hormones, and other organic waste in streams around the U.S., including the Santa Cruz, Salt, and Gila rivers in Arizona. They found low levels of 82 chemicals. The most common were steroids, but other chemicals included cholesterol lowering drugs, nonprescription drugs, insect repellant, detergent chemicals, and disinfectants.

Chemicals also find their way into water when people or animals that have taken medications excrete them, in addition to people who flush medications down the toilet, Hartmann said. Scientists aren't clear what effects all those chemicals may have in water. Some studies link hormones in the water to deformed reproductive organs in fish. Another concern is that antibiotics in the water may lead to bacteria becoming resistant to those medications.

For more information about drugs in public water supplies, view the On Tap *article "They're in the Water They Make Fish Change Sex: Endocrine Disruptors—What are they doing to you?" at* www.nesc. wvu.edu/ndwc/articles/OT/WI03/WI03Index.htm.

OIG Study Says States Progressing with SWAP

According to a May 2004 study released by the U.S. Environmental Protection Agency's (EPA) Office of Inspector General (OIG), states are making progress in assessing existing and potential threats to public drinking water sources, despite a number of reported concerns and delays.

The Safe Drinking Water Act Amendments of 1996 required states to develop a Source Water Assessment Program (SWAP) aimed at providing public water systems with information they could use to protect drinking water sources. The original deadline for SWAP completion was May 2003.

As of September 2003, however, OIG reported that only 40 percent of states—or 69 percent of community water systems—had completed their source water assessments and made them available to the public. States noted that a number of reasons for non-compliance transpired, including limited human resources, data issues, public participation, and desire for a quality product.

The OIG study also listed homeland security as a growing concern for states attempting to fulfill their SWAP obligations. According to the report, states are meeting resistance from EPA about making potentially sensitive information readily available to the public, such as maps of drinking water wells and contamination sources.

OIG recommended that EPA create guidance for states, clarifying what information is appropriate to release to the public and how it should be released. EPA has agreed to provide this information.

To learn more about the OIG's findings and recommendations concerning SWAP, download a full copy of the report, States Making Progress on Source Water Assessments, But Effectiveness Still to Be Determined, *available on the EPA Web site at* www.epa.gov/oigearth/reports/2004/20040527-2004-P-00019.pdf.

RDUS Loans: Poverty Rate Unchanged; Others Down

The Rural Development Utilities Service (RDUS) recently announced interest rates for water and wastewater loans. RDUS interest rates are issued quarterly at three different levels: the poverty line rate, the intermediate rate, and the market rate. Each has specific qualification criteria.

The rates, which apply to all loans issued from October 1 through December 31, 2004, are:

poverty line: 4.5 percent (unchanged from the previous quarter);
intermediate: 4.5 percent (down 0.25 percent from the previous quarter); and
market: 4.625 percent (down 0.375 percent from the previous quarter).

RDUS loans are administered through state Rural Development offices, which can provide specific information concerning RDUS loan requirements and applications procedures.

For the phone number of your state Rural Development office, contact the National Environmental Services Center at (800) 624-8301 or (304) 293-4191. The list is also available on the Rural Development Web site at www.rurdev.usda.gov/recd_map.html.

Plan Aims to Save Great Lakes Water

Source: www.photos.cc

Although still up for public comment, a plan to make it nearly impossible to divert large amounts of water from the Great Lakes to other regions of the country is making waves, according to an *Associated Press* news release. Provisions of this interstate compact and international agreement are aimed at protecting and improving the water system.

The proposed Great Lakes Charter Annex would allow new or increased withdrawals from any of the five Great Lakes only if water were immediately returned and the condition of the lakes were improved. The measure would leave the door open for Great Lakes water to be shipped to areas within the region that are outside the basin but prevent it from heading to other parts of the country, such as the Southwest.

"That's intentional," said Noal Hall, senior manager of Great Lakes Water Resource Program c the National Wildlife Federation. "We basically want to do everything that's possible to stop dive sion that is going to hurt water levels."

The compact would require the eight Great Lakes governors, in consultation with the premier: of the Canadian provisions of Ontario and Quebec, to unanimously approve any new diversion that would remove from th basin an average of one million gallons a day over a 120-day period.

Clean, Adequate Water Supply Requires Research

The U.S. needs to make a new commitment about water resources research to confront the increasingly severe water problems that all parts of the country face, says a new report from the National Academies' National Research Council. In particular, the country needs a new mechanism to coordinate water research currently fragmented among nearly 20 federal agencies.

"Water crises are not confined to western states," says committee chair Henry J. Vaux, professor emeritus and associate vice president emeritus, department of agricultural and resource economics, University of California, Berkeley.

Vaux cites the recent conflict between Maryland and Virginia over Potomac River water rights as an example. Certainly, semi-arid, western states still need new water supplies for fast-growing populations, a problem that drought complicates. And regulation of water levels and flows in the Klamath and Missouri rivers have sparked considerable debate as well.

"Decision-makers at all levels of government are going to have to make difficult choices in the coming decades about how to allot limited water supplies, and they need sound science to back them up," Vaux adds.

Given the competition for water among farmers, environmental advocates, recreational users, and other interests—as well as emerging challenges such as climate change and the threat of waterborne diseases—the committee concluded that an additional $70 million in federal funding should go annually to water research, with the aim of improving institutional decision making.

The committee notes that overall federal funding for water research has been stagnant in real terms for the past 30 years, and that the portion dedicated to research on water use and related social science topics has declined considerably.

Federal agencies and the states have tended to focus on short-term research likely to yield more immediate results. But it is long-term, basic research that will provide a solid foundation for applied science a decade from now, the committee says, urging the federal government to commit one-third to one-half of its water research portfolio to long-term studies.

In recent years, there have been substantial declines in the measurement of stream flow, groundwater levels, water quality, and water use, the committee found; in some areas measurements have been completely eliminated.

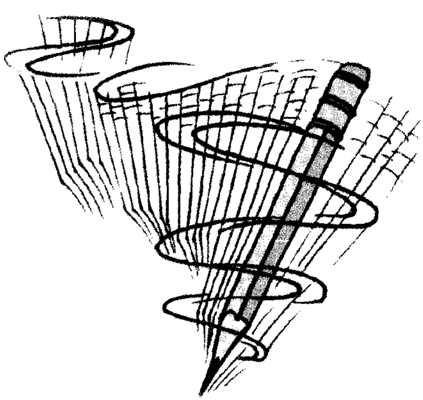
The committee also recommends that a new entity is needed to coordinate water research at the national level. Either an existing interagency body, a neutral organization authorized by Congress, or a public-private group led by the Office of Management and Budget (OMB) could serve as the coordinating mechanism, the committee said.

Copies of Confronting the Nation's Water Problems: The Role of Research *will be available later this summer from the National Academies Press by calling (202) 334-3313 or (800) 624-6242. It also will be available on the Internet at* www.nap.edu.

CORRECTIONS

Correction to Organizations Guide from the Summer 2004 issue of *On Tap:*

South Central RCAP
Community Resource Group, Inc.
P.O. Box 1543
Fayetteville, AR 72702
(479) 443-2700
www.crg.org



The Price of Blue Gold

Source: *www.clipart.com*

Water can be controversial in the U.S. But in some of the world's thirstier places, the discussion is not just about dams and pollution. It's about life itself, according to an article in *Sierra* magazine.

In Israel, for example, water is so precious that Prime Minister Ariel Sharon has announced he is willing to give weapons to Turkey to get an ample supply. Under an agreement signed in March 2004, Israel will import 50 million cubic meters of water per year for 20 years from Turkey's Manavgat River. Israeli tankers capable of transporting the massive amounts are being built. The weapons Turkey will get in exchange will be worth about $50 million.

Sharon has described water as "a stark issue of life and death" for his people, saying that the Six Day War in 1967 was ignited not by border disputes with Syria, but by that nation's attempt to divert water from the Jordan River, noted the article.

For more information, visit Sierra *magazine's Web site at* www.sierraclub.org/sierra/200407/lol.asp#price.

Sodium in Drinking Water: Is your water too salty?

Let's face it, Americans love salt. We spill it over french fries, sprinkle it over popcorn, and shake it over every other mouth-watering morsel coming from the kitchen. But did you know that it's in our drinking water, too?

Sodium, or salt, occurs in drinking water naturally. However, it also can find its way into water from road salt, water treatment chemicals, and ion-exchange water softeners. Sodium intake from the tap normally isn't a problem for the majority of Americans. But for those facing heart disease, hypertension, kidney disease, circulatory illness, or a sodium-restricted diet, there are some legitimate concerns.

According to the Kansas State University (KSU) Agricultural Experiment Station and Cooperative Extension Service, nearly 15 million people in the U.S. have a daily diet characterized by moderate to severe restrictions for sodium intake because of health-related concerns. Excess dietary sodium has been linked to an increased risk for a heart attack, stroke, or damage to other body organs. Controlling the amount of sodium intake from drinking water is just one precautionary step in reducing the risk of being struck by one of these illnesses.

The American Heart Association and the National Academy of Sciences recommend sodium levels between 500 and 2,400 milligrams (mg) per day. The average American consumes nearly twice this amount daily.

Two Steps to Reduce Salt

KSU recommends the following two steps to control sodium intake from drinking water:

Sodium Levels in Public Water

While the U.S. Environmental Protection Agency (EPA) reports that sodium levels in most public water supplies are unlikely to contribute significantly to adverse health effects, checking the local water supplier's most recent consumer confidence report is the best way for those concerned about their sodium intake to know exactly how much is in their water. EPA has a draft guideline for sodium in drinking water of 20 milligrams per liter (mg/L).

Conducting a water test is the best option for private water consumers to determine the amount of sodium in their water.

Sodium Softens Water

Home water softeners are hailed for removing minerals that cause hardness, such as calcium and magnesium. They also get high marks for making soap lather better, getting clothes cleaner, and erasing unsightly rings around the bathtub. But most of them also add a significant amount of sodium to the water. According to KSU, a person who drinks two liters of softened, extremely hard water each day will consume about 480 mg more sodium than if unsoftened water is consumed.

Drinking unsoftened tap water, low-sodium bottled water, or using water treatments, such as reverse osmosis and distillation to remove sodium from tap water, are all reasonable alternatives to drinking softened water.

To learn more about sodium in drinking water and its associated health concerns, read the Kansas State University Agricultural Experiment Station and Cooperative Extension Service publication, "Sodium in Drinking Water," *available online at* www.oznet.ksu.edu/library/H2OQL2/MF1094.PDF.

Also read: *U.S. Environmental Protection Agency.* 2004. "Sodium in Drinking Water" *www.epa.gov/safe/water/ccl/sodium.html*, and *Muskoka-Parry Sound Health Unit* "Sodium in Drinking Water" *www.mpshu.on.ca/WaterQuality/sodiumin.htm.*

CORRECTIONS

In the Spring 2004 issue of *On Tap*, in the article "Regionalization Forced, Voluntary, and Somewhere in Between," the pull quote: "There needs to be a very good reason to regionalize. We should not be regionalizing simply because it is a good idea. There needs to be an obvious and over-riding reason or need to consolidate," was incorrectly attributed to Jenny Bielanski, drinking water utilities team leader, of the Office of Ground Water and Drinking Water at the U.S. Environmental Protection Agency. This quote should have been attributed to Gary Larimore, executive director of the Kentucky Rural Water Association.

Also, in the article "Distribution System Operator Certification: Is your state's program up to speed?" *On Tap* incorrectly printed that there is a deadline for implementing guidelines. The correct information is that there is no deadline.

We apologize for any inconvenience our readers may have been caused by these oversights.

Letters to the Editor

Write to us! ***e-mail:*** *mkemp@mail.wvu.edu* or *kathy.jesperson@mail.wvu.edu* or
mail to: National Environmental Services Center • West Virginia University
P.O. Box 6064 • Morgantown WV 26506-6064

Dear Editor,

I recently read the letter in *On Tap* from Tesfaye Bekalu about Ethiopia. I read it with great interest as my late husband Douglas DeWalt and I traveled to Ethiopia in 1974 to assist with water exploration and drilling through a group effort with the Oxfam, Catholic Secretariat from Ireland and the Presbyterian efforts from the U.S. We worked out of Addis Ababa and as far out as Combulcia, Bati, and the Danakil Desert. One of my husband's projects was to drill a fairly deep well at Bati that produced 60 to 70 gallons of water per minute. (I could be off on this number, but it was a good well.) After we left Ethiopia, we heard that one of the big refugee camps for the Somalis and Eastern Ethiopians was at Bati. I am curious if there is any way to find out if that well is still producing. We loved our stay in Ethiopia. We made many good friends and worked with the water board for several years after leaving and moving to Nairobi, Kenya, where we were based with Ingersoll-Rand Company for the next 10 years.

I agree about the loss of Larry Rader. I wish we could have known him. I feel the same about my husband's death. He took such a wealth of knowledge with him also. I am grateful that he kept a daily journal that is priceless.

I enjoy your magazine and get it in conjunction with my work as administrative assistant to Indian Health Service engineers. Again, thank you.

Louaina (Lou) DeWalt
Indian Health Service
9A S. Brown Street
Rhinelander, WI 54501-3456

Tesfaye Bekalu responds:

I know Bati, Kombolcha, Dessie, and most of the places around. As a rural water supply project officer, I had been working there for the last eight years before my move to Addis Ababa. I also got a chance to know Jerry Garvey and engineer Brehane, who were working in that area probably when you were around.

As you may recall during that time, there was much involvement in the water sector by the donor community around the Wollo province because of the drought. Present day Bati is quite different from what it used to be. There are about four or five wells serving it now. Bati started to expand because it became a food distribution area, and there were two big camps for drought-affected people (not refugees from Somali).

Editor's Note: The editors and staff of On Tap *are pleased that these two found each other through our magazine. We will keep readers informed if Mr. Bekalu finds out the status of the well about which Ms. DeWalt wrote.*

JOBS AT NESC

On the Web

Take Action to Promote Environmental Health
www.envirohealthaction.org

EnviroHealthAction is an education center for health professionals and others interested in environmental health. The site contains valuable information about the health effects of environmental contaminants, including arsenic, mercury, and *E. coli.*

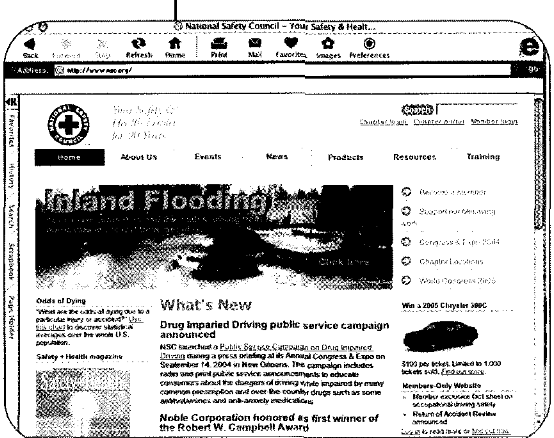
Chronic exposure to environmental contaminants can cause an array of health effects, including cancers, neurological effects, reproductive and developmental outcomes, rashes, heart disease, diabetes, and immunity problems.

To learn more about environmental health, call the Physicians for Social Responsibility, at (202) 667-4260, write them at 1875 Connecticut Avenue, NW, Suite 1012, Washington, DC, 20009, or e-mail the organization at info@envirohealthaction.org.

Safety Council Promotes Environmental Health
www.nsc.org

The National Safety Council's Environmental Health Center (EHC) mission is to educate and influence society to adopt safety, health, and environmental policies, practices, and procedures that prevent and mitigate human suffering and economic losses arising from preventable causes.

EHC conducts a variety of outreach and education activities on various water issues, including drinking water and coastal and marine issues. In addition to these services, EHC also has information about flooding, hurricanes and costal storms, and first aid.



For more information about EHC and its services, you may write to them at 1121 Spring Lake Drive, Itasca, IL 60143-3201. You also may call them at (630) 285-1121, or e-mail them info@nsc.org.

DRINK Makes Public Debut
www.epa.gov/safewater/drink/intro.html

The U.S. Environmental Protection Agency (EPA) developed the Drinking Water Research Information Network (DRINK) as a publicly accessible, Web-based system to track ongoing research that EPA and other partners from national, regional, and international research agencies and organizations conduct. DRINK will be used as a tool for assessing future research priorities to support regulatory development and implementation.

DRINK maintains descriptive information on research projects, including project title, abstract, start and end dates, principal investigator, and contact information. Users can conduct searches of this information to identify potentially relevant projects and to obtain detailed information from the partner, such as complete data sets and reports.

This site offers users and partners:

- an efficient means of determining the status of research across multiple organizations,
- a system to minimize duplication of research,
- a practical approach for locating research gaps, and
- a forum for communicating project status within the research community and with the public.

DRINK is capable of simultaneously searching two databases:

- The DRINK database, which will be populated with drinking water research information from EPA and other partners, and
- EPA's Environmental Information Management System (EIMS) database, which currently contains research information relevant to drinking water.

Through the connection of the two databases, DRINK provides a single source for ongoing research information. This resource is critical for the development of strategies to fill data gaps, identify key personnel for workgroup and public meetings, and strategically plan for rules under development.

For more information about DRINK, contact the U.S. EPA Office of Water, Office of Ground Water and Drinking Water, Standards and Risk Management Division, or e-mail gonder.sharon@epa.gov.

IRIS Helps Public Understand Health Risks

www.epa.gov/iris/

The Integrated Risk Information System (IRIS) database, prepared and maintained by the U.S. Environmental Protection Agency (EPA), contains information about how environmental exposure to various chemicals can affect human health. Although initially developed for EPA staff needing consistent information about these chemical substances, the information in IRIS is now available to the public.

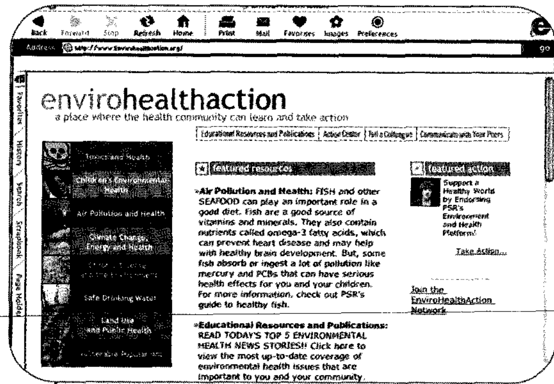
EPA primarily uses the information for risk assessment. In a risk assessment, the extent to which a group of people has been or may be exposed to a certain chemical is determined. The agency then considers the kind and degree of hazard the chemical poses, thereby permitting it to estimate the present or potential health risk.

EPA uses the information it gathers in the risk management process to protect public health. Examples of risk management actions include:

- deciding how much of a chemical a company may discharge into a river;
- clarifying which substances may be stored at a hazardous waste disposal facility;
- verifying to what extent a hazardous waste site must be cleaned up;
- setting permit levels for discharge, storage, or transport;
- establishing levels for air emissions; and
- determining allowable levels of contamination in drinking water.

The heart of the IRIS system is its collection of computer files covering individual chemicals. These chemical files contain descriptive and quantitative information in two categories: oral reference doses and inhalation reference concentrations for chronic noncarcinogenic health effects, hazard identification, oral slope factors, and oral and inhalation unit risks for carcinogenic effects.

For more information about IRIS, call (202) 566-1676 or email hotline.iris@epa.gov.



Site Supplies Environmental Health News

www.EnvironmentalHealthNews.org

This newsletter is published online daily at *www.EnvironmentalHealthNews.org* by Environmental Health Sciences, a not-for-profit organization founded in 2002 to help increase public understanding of emerging scientific links between environmental exposures and human health. The site contains news about environmental health issues, and visitors may sign up for a free newsletter, *Above the Fold*.

For more information about www.environmentalhealthnews.org, *write to Environmental Health Sciences, P.O. Box 125, White Hall, Virginia. 22987-0125.*

www.nesc.wvu.edu

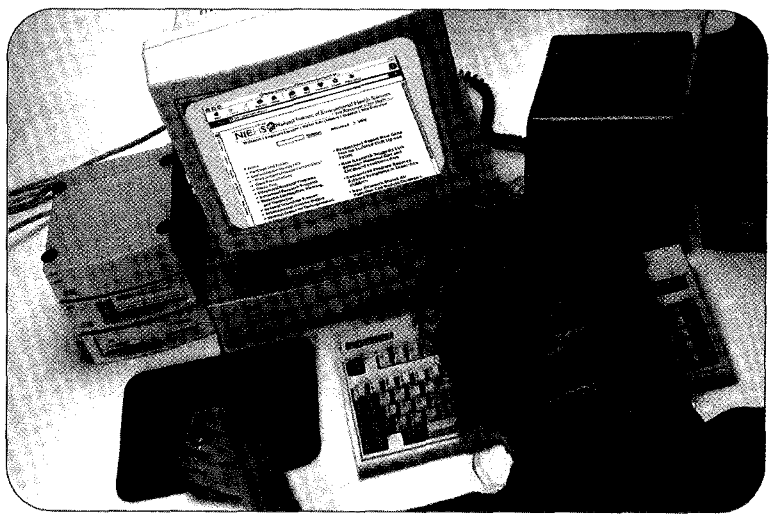
NIEHS Offers Environmental Health Information

www.niehs.nih.gov

The National Institute of Environmental Health Sciences (NIEHS) is one of 27 institutes and centers of the National Institutes of Health (NIH). NIEHS achieves its mission through multidisciplinary biomedical research programs, prevention and intervention efforts, and communication strategies that encompass training, education, technology transfer, and community outreach.

The institute's Web site contains an alphabetical listing of environmental health topics, along with fact sheets, pamphlets, research initiatives, and news features. The site also maintains a link to the Environmental Health Sciences Education page, which contains environmental health information for students, teachers, and scientists, including classroom materials, NIEHS resources, and professional development opportunities.

For more information, you may write to the National Institute of Environmental Health Sciences, P.O. Box 12233, Research Triangle Park, NC 27709, or visit their Web site at www.niehs.nih.gov.



Source: www.photos.com

Ask the Experts?

Each issue, we ask members of the *On Tap* Editorial Advisory Board to answer a drinking water-related question. We then print as many responses as space permits. The opinions expressed are not necessarily those of NESC.

In your opinion, are there reasons to avoid adding fluoride to drinking water? If so, what are they, and why do you believe fluoride should be avoided? Or do you think fluoridation works? Why?

Editor's Note: *Many public health departments and community health organizations think that the addition of fluoride to drinking water has been one of the biggest boons to public health since the polio vaccination. However, some environmental groups differ on that outlook, and think that adding fluoride to water is just asking for an increase in cancer rates and other problems (e.g., fertility problems, thyroid disease, etc.).*

What's the big deal? Fluoridation works.

Since the days of the "Colorado Brown Stain" of the early 1900s, fluoridation has been an issue in the center of public health practices. In fact, I would suggest that the addition of fluoride to public drinking water systems has been one of the most controversial public health programs that has even been implemented in the U.S. And while I try, I just don't understand why it is such a big issue.

Fluoride is a naturally occurring element in our environment and can be found in soil, water, plants, and animals; therefore, we can't avoid it. However in most cases those trace amounts are not enough. That is when we can receive its maximum public health benefit by the upward adjustment of the fluoride level that we ingest. And the most effective and practical way to accomplish that is by adding fluoride to the water we drink. I would admit that there is a right way and a wrong way to do just about everything. And fluoridation is no different. Not enough fluoride means reduced benefits, while too much can result in undesirable health effects. But that fact is the same for a whole host of other nutrients that we may find in our diets.

I have researched the literature on fluoridation; I have examined the issues; I have been involved in the design and implementation of numerous fluoridation systems. I have talked with dental professionals, and the bottom line is that fluoridation works. Fluoride helps prevent tooth decay. It has a much higher benefit during the formative years of tooth development, but it has some benefit for all of us.

Fluoridation has been very widely researched. In fact, there are close to 100 different national and international health services and professional organizations that recognize the public health benefits of optimally fluoridated water. I'm aware of situations where a water utility reduced or discontinued the addition of fluoride to their water system, and in a short time (a few years), the local dentists noticed an increase in dental decay among the young kids of that community. For a few cents worth of chemical, you can significantly reduce the costs of dental health care.

Rod Coker
Tribal Utility Consultant
(Retired)
Indian Health Service

Leave It Up to Individuals

I think it should be up to individual consumers and families to decide whether they want to use fluoride. Fluoridated toothpastes and mouthwashes are commonly available at pharmacies and grocery stores. Individuals, in consultation with their dentist and physician, should decide whether or not they need fluoride. There are too many divergent opinions on the benefits and risks of fluoride to justify force-feeding it to people through public drinking water supplies.

Amy Vickers
Engineer and Water
Conservation Specialist
Amy Vickers and Associates

Need to Consider Financial Issues

Fluoride has been hotly debated for years. It was recently a highly contested issue in Pierce County, Washington, where most of Peninsula Light Company's (PLC) water systems are located. However, because of the size of our systems (the largest serving fewer than 2,000 people), recent regulation mandating fluoridating drinking water did not impact our systems.

In April 2002, the Tacoma-Pierce County Board of Health passed a regulation requiring fluoridation of public water systems that serve more than 5,000 people. This regulation affected 15 water systems and about 250,000 people. Around 300,000 people in the county already had fluoride in their drinking water, including residents in Tacoma, University Place, Fircrest, Fort Lewis, and McChord Air Force Base. The total population of Pierce County is 734,000 people.

In November 2002, the Washington Dental Service foundation donated $420,000 to water purveyors to help defray the cost of implementing the regulation. In December, the Board of Health appropriated an additional $850,000 for the same purpose.

Lakewood Water District, the City of Bonney Lake, and four other water utilities challenged the health department last year but lost in Pierce County Superior Court in 2003. They wanted a public vote to decide whether or not to add fluoride. They then appealed to the state superior court, which overturned the regulation in May 2004.

In the meantime, six additional water systems are currently fluoridating or under contract to fluoridate. The estimated cost for five of these systems ranges from $69,500 to $800,000, with the total cost being more than $1.4 million. Of course, the more wells these systems have to treat, the higher the cost.

Bonny Lake, one of the systems participating in the litigation, estimated it would cost about $750,000 to fluoridate but chose to spend $116,000 in legal fees instead. But, the issues they had were not about the initial capital expense.

I am relieved that PLC did not have to participate in this process primarily from a financial standpoint. Putting aside all the pros and cons of fluoridating water, we would never have been financially able to implement this type of regulation. We own and or manage more than 100 very small water systems. However, the entire population we serve is slightly more than 5,000 people, including the schools we operate. But it also means we would have more than 100 fluoride injection and monitoring stations.

We only have a few systems that are fluoridated, and it takes a good portion of one of our water technician's time to schedule the daily monitoring requirements and travel between systems. If you consider the potential risk associated with overdosing of fluoride, in my opinion, this would be difficult, if not impossible, to implement at the level of safety necessary to protect human health. Our water rates and contract fees would most likely have to rise significantly.

Couple that with the fact that we are also border line with the lead and copper regulation (i.e., corrosivity problem) on a few of our systems. We may have ended up having to provide corrosion control due to the fact that fluoride is corrosive.

I am a mother, and I have not been swayed by the arguments of dental health for children as the reason for medicating the entire population, considering there are other ways for children to receive fluoride. I have read enough of the studies and am aware of many respectable professionals in the medical field who are also against the addition of fluoride.

I think fluoride has its medical purposes. But the dosage ingested should be an amount that a doctor specifies for each individual's age and weight and not based on the amount of water a person drinks. Furthermore, I am also intimately familiar with hypothyroidism and osteoporosis, both of which have been shown to have a scientific correlation with fluoride. There are other ways to ensure children receive fluoride. Parents along with their dentist or family doctor should be the ones to determine the best approach.

Lisa Raysby
Water Department Manager
Peninsula [Washington]
Light Company

The Drop Box

Do you have a suggestion for improving this magazine or an idea for an article we should explore?

Do you have a question for our "Ask the Experts" column or a Web site that you find particular helpful?

On Tap editors are always eager to learn from you. Here's how to contact us:

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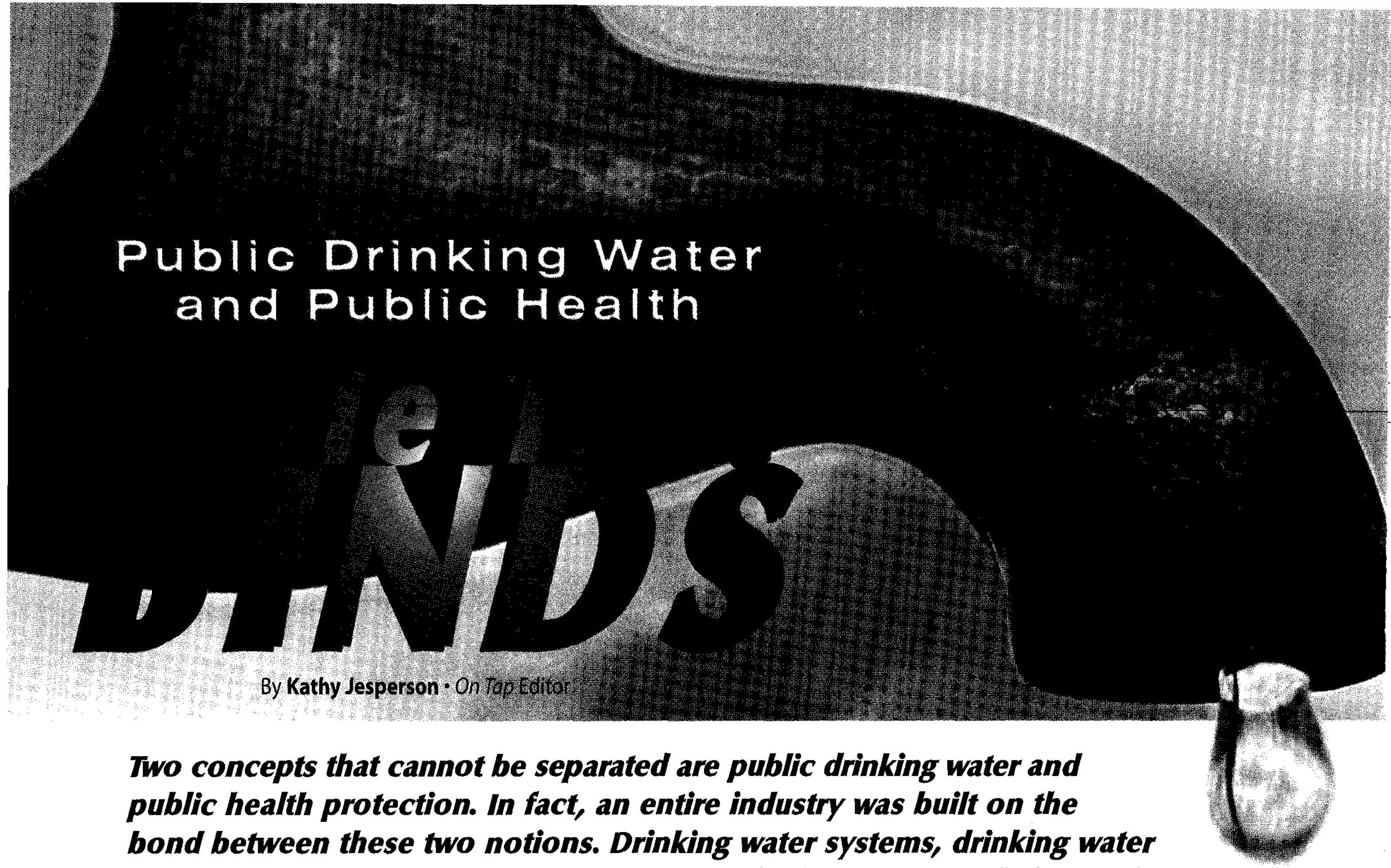
e-mail: *mkemp@mail.wvu.edu*
phone: (800) 624-8301
ext. 5523

Kathy Jesperson
e-mail:
Kathy.Jesperson@mail.wvu.edu
phone: (800) 624-8301
ext. 5533

Or write to us at:
National Environmental
Services Center
West Virginia University
P.O. Box 6064
Morgantown, WV 26506-6064

Public Drinking Water and Public Health



By **Kathy Jesperson** • *On Tap Editor*

Two concepts that cannot be separated are public drinking water and public health protection. In fact, an entire industry was built on the bond between these two notions. Drinking water systems, drinking water organizations, and, yes, even the dreaded drinking water regulations exist because safe drinking water and public health have an alliance that cannot be divided.

U.S. drinking water suppliers demonstrate their awareness of this tie everyday. The water they distribute to their customers is among the cleanest and safest in the world. But the country's status as a public health leader didn't happen by accident. Extensive regulations, guidelines, and water quality testing were the drive to the destination.

After years of complying with new regulations, however, it may seem more like the regulations are a burden than a blessing. Believe it or not, the U.S. Environmental Protection Agency (EPA) is not deliberately trying to hinder us with ever increasing regulations just for fun. The agency is doing what it's been charged to do—making sure that public water systems provide safe drinking water to their customers.

"More than 260 million Americans rely on the safety of tap water provided by water systems that comply with national drinking water standards," says Veronica Blette, special assistant to the director, EPA Office of Ground Water and Drinking Water (OGWDW).

Considering the multitude of people who depend on public drinking water supplies, making sure that it's safe is a responsibility that cannot be taken lightly.

Health Effects Emerge

Within the past century, contaminated water was widespread and uncontrolled. Most people had no idea that such a situation might be a problem. For that matter, most people didn't know there was a problem. After all, it was a time of prosperity. The Depression had ended. World War II was over, and the U.S. was fast becoming a world leader. It was the 1950s—a time when the living was easy.

Life was relaxed for drinking water treatment operators as well. Few regulations for drinking water existed. And, surprisingly, drinking water standards that had been set were only considered non-enforceable guidelines. The only exception was the coliform standard, and then, only when interstate commerce was involved.

Most water systems did disinfect their drinking water supplies. The U.S. Public Health Service (PHS) considered the use of chlorine as a disinfectant for public drinking water supplies to be a stroke of genius. This simple act was responsible for saving tens of millions of lives and would be recognized as one of the leading public health advances in the 20th century.

Concerns about chemical contamination, however, had not yet become a priority. That was likely because no one knew it was a health threat. The PHS had set guidelines for the maximum permissible concentrations for lead, fluoride, arsenic, selenium, and hexavalent chromium—all of which were naturally occurring.

During the 1950s and 1960s, chemical makers embarked upon a manufacturing heyday, and "better living through chemistry" became a reality. An abundance of new manmade chemicals was hitting the U.S. industrial and agricultural markets. Chemical manufacturers boasted that these modern miracles would rid us of pests, degrease our machinery, and, quite simply, infinitely improve the quality of life on this planet.

But as with all things that appear too good to be true, these new chemicals would soon show a dark side. Vast amounts of these chemicals were turning up in the nation's water supplies. Uncontrolled factory discharge, unimpeded farm runoff, and unrestrained waste disposal were all creating a substantial mess.

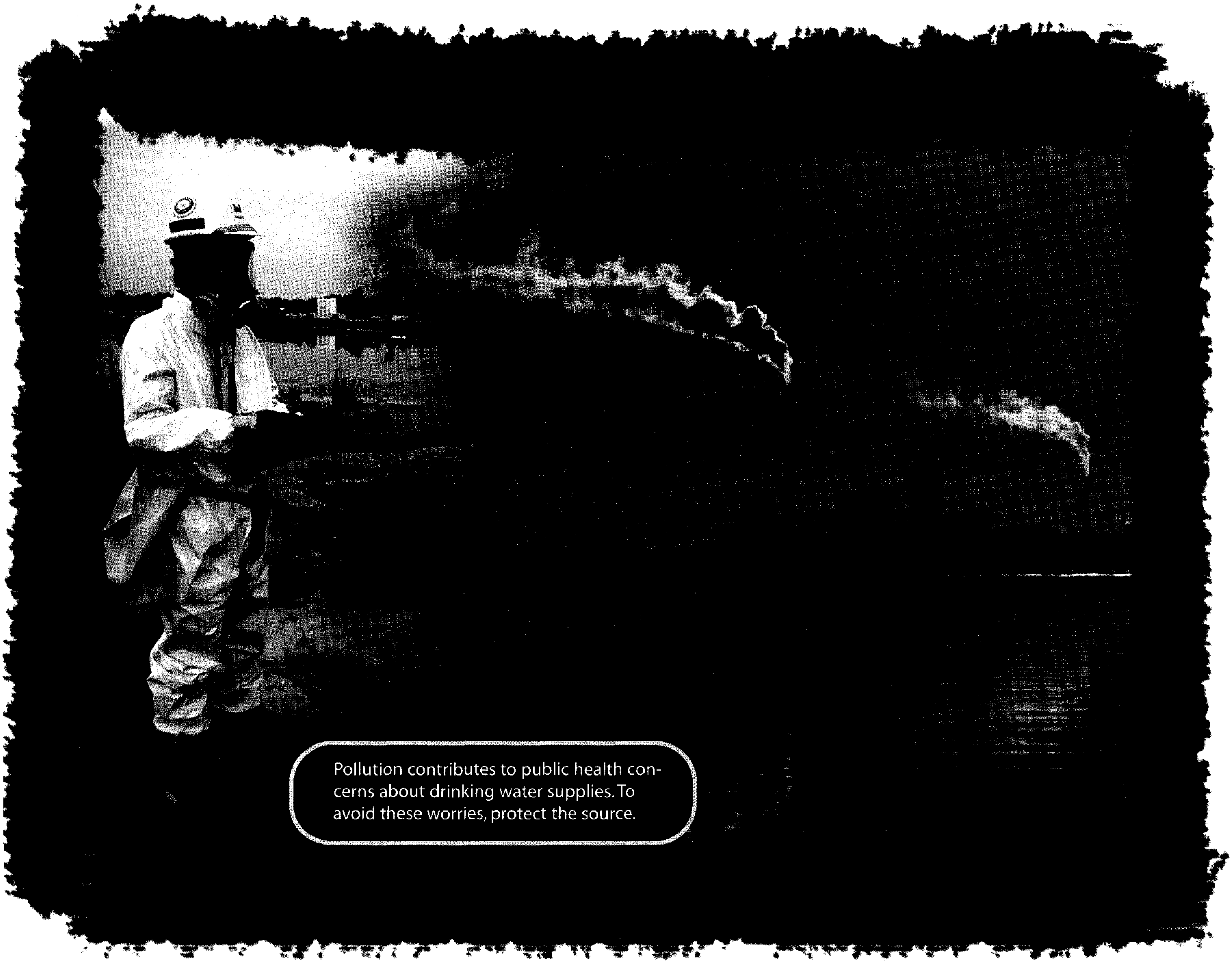
By the time the 1970s rolled around, the sight and smell of grossly polluted waterways couldn't be avoided. The chemicals that had once been peddled as modern marvels were now suspected as the cause of many emerging health problems.

Congress couldn't escape the inquiring public prompting it to commission several studies about the nation's water supplies. In 1972, the report, *Industrial Pollution of the Lower Mississippi River in Louisiana*, was released. It confirmed that chemicals were, indeed, in our water supplies. Researchers presented evidence that they had detected 36 chemicals in the treated water that systems along the Mississippi River were distributing to their customers.

The chemicals that the researchers found included synthetic organic chemicals (SOCs) and trihalomethanes (THMs). SOCs are organic, manmade chemicals that include pesticides and industrial chemicals. They are suspected to be cancer-causing agents and are considered toxicants. THMs are disinfection byproducts. They form when disinfection chemicals, such as chlorine, come in contact with organic material. They are also suspected to be cancer-causing agents. (See related article on page 34.)

Up until this time, researchers had lacked sophisticated laboratory techniques that would detect these chemicals. But technological advances were happening faster than they ever had. Analytical chemistry and measurement techniques could now reveal the chemicals that were polluting the waterways.

A number of other studies were creating even more fervor. Researchers had uncovered volatile organic chemicals (VOCs), inorganic chemicals, and



Pollution contributes to public health concerns about drinking water supplies. To avoid these worries, protect the source.

Photo on the left by Anthony Bley, *http://images.usace.army.mil/*, photo on the right from www.photos.com

Protecting America's Public Health

Risks to drinking water come in many forms, such as municipal and industrial discharges, recreational activities or simply natural conditions and events. This full-color poster illustrates urban, rural, industrial, and suburban examples of potential pollution sources and provides a detailed graphic description of these risks and the barriers in place to help ensure the safety of drinking water. To order this poster, call the National Environmental Services Center at (800) 624-8301 and ask for product #DWPSPE125.

radionuclides in drinking water supplies. When drinking water consumers got hold of this news, they demanded something be done.

EPA Established

One of the most important events was the formation of EPA, which occurred in July 1970. Prior to the establishment of the EPA, the federal government was not structured to coordinate an all out assault on the pollutants that harm human health and degrade the environment.

Once EPA was formed, it was assigned the daunting task of repairing the damage already done to the natural environment and to establish new criteria to guide Americans in making a cleaner environment a reality.

One of the first things that the agency did was to conduct additional water quality studies that reached similar conclusions. These studies determined that the country's natural resources, once thought indestructible, were vulnerable after all.

This revelation eventually led to the passage of several laws regarding environmental and public health. One of those new laws was the Safe Drinking Water Act (SDWA). Its passage, along with the Clean Water Act, enabled the U.S. to clean up its waterways and eventually have some of the safest drinking water in the world.

"We have cleaned up most of the 'big dirties' of the 1950s and 1960s," says Kenneth Olden, director, National Institute of Environmental Health Sciences (NIEHS), adding that we can't afford to become complacent when it comes to public health and that prevention is the most cost-effective and life-enhancing means we have to protect human health.

For 30 years, the SDWA has been protecting the nation's drinking water supplies and, thus, preventing public health tragedies. When the SDWA became law in 1974, it required EPA to set enforceable standards for health-related drinking water contaminants. The act was reauthorized in 1986 and again in 1996.

"EPA establishes health-based standards, which state drinking water programs adopt and implement," Blette explains.

She says that EPA's strategy for ensuring safe drinking water over the next several years includes four key elements:

1. developing or revising drinking water standards that are based on sound science,

2. supporting states, tribes, and water systems in implementing standards and drinking water programs,
3. promoting sustainable management of drinking water infrastructure, and
4. protecting drinking water sources from contamination to ensure the safety of critical water infrastructure.

Setting a Standard

We rely on water to survive. We use water to digest food, absorb and transport nutrients, circulate blood supplies, build tissues, carry away waste, and maintain body temperature. But for water to maintain good health, it has to be safe from contaminants that can compromise wellbeing.

It should come as no surprise that researchers have linked exposure to some environmental hazards with specific diseases. According to the Centers for Disease Control and Prevention (CDC), one of the most well-known links is exposure to lead and decreased mental function in children. And many other links exist. That's why EPA sets contaminant level limits.

Before it can set a standard, however, the 1996 SDWA Amendments require the agency to evaluate contaminants. It pays particular attention to those that:

- may have an adverse health effect, particularly on sensitive sub-populations,
- occur or are likely to occur in public water systems, and
- can be removed through treatment methods so that public health risks are reduced.

Only after this risk assessment period does EPA develop a regulation. But odds are the agency doesn't work alone. EPA enlists other government agencies to help it create new standards.

"NIEHS provides data on the toxicity/carcinogenicity of drinking water contaminants, including disinfection byproducts, that EPA can use to set drinking water standards," says Ronald Melnick, toxicologist, Division of Intramural Research Environmental Toxicology Program, NIEHS.

The institute also provides information about microbial and chemical contaminants because of concerns about their adverse health effects. He also notes that some microbial contaminants produce chemicals that are toxic to the liver and other organs.

Under Surveillance

According to NIEHS, epidemiology is the type of research upon which most health regulations are based because epidemiological studies are the best known, best understood, and most accepted tools in the environmental health sciences.

Epidemiological studies use surveillance techniques to track disease occurrence in people who have been exposed to a natural or manmade factor in the environment over a number of years. During that time, scientists look for relationships between a toxic substance and a health effect, comparing those exposed to the contaminant with those who have not been exposed.

In all, these kinds of studies supply researchers with solid data. But researchers must be aware that epidemiological studies have their limits. For example, significant barriers exist to conducting effective surveillance for waterborne microbial disease, such as the possibility of multiple routes of exposure, the fact that exposed people may not stay in one place, and the length of time between exposure and evident health effects.

Because of these limitations, investigators do not rely on just one research method.

Of Mice and Men

Scientists do not want illnesses to go untreated for years before they discover the cause, so they also use screening tests called animal assays. NIEHS notes that mice and men share many genetic characteristics, and most substances known to cause cancer in humans—including aflatoxin, asbestos, benzene and radon—also cause cancer in animals.

In a typical assay, mice and rats are exposed to various levels of a substance for two years and checked for changes in their development. To determine if changes have occurred, researchers ask questions such as:

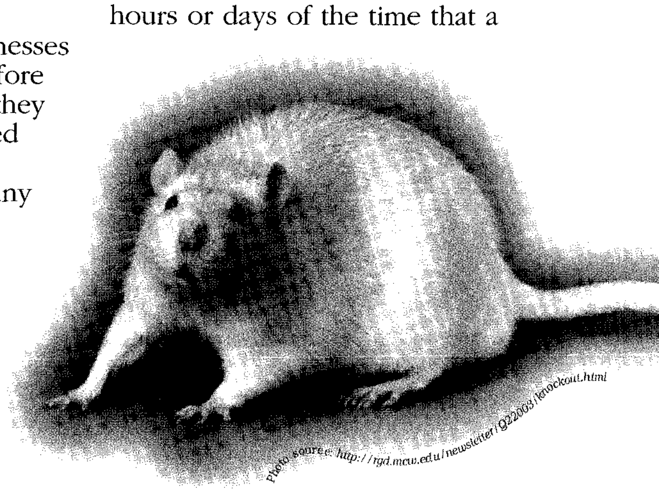
- Do the animals have more cancers than normal?
- If cancers are found, are they types that are not usually found in these animals?
- Do the exposed animals have changes in their reproductive, cardiovascular, immune, or nervous systems?

This research not only helps EPA determine a toxic dose for a particular contaminant, it also helps them clarify whether a contaminant can be ingested at low levels and not cause a health effect. This information helps the agency establish a maximum contaminant level goal (MCLG).

MCLGs are the level of a contaminant for which no adverse health effects are expected to occur. EPA considers MCLGs to be non-enforceable goals because they only consider the public health risks of a contaminant and exclude other limiting factors such as whether a system has the equipment to detect a particular contaminant, the available technology to treat for it, and how much it will cost to remove it from the water. Most MCLGs are set at zero.

When EPA sets the maximum contaminant level (MCL)—the enforceable standard—it includes limiting factors in its final decision but considers a contaminant's health effects first. The agency uses two contaminant health-effect classifications: acute and chronic.

"Acute effects occur within hours or days of the time that a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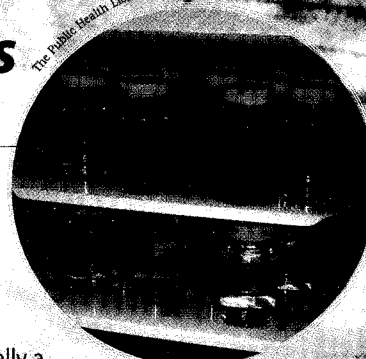
Microbial Pathogens



Microbial pathogens in drinking water have serious, acute health effects. (See the article "A Lesson in Microbiology" in the Winter 2004 *On Tap*.) Pathogens are disease-causing microorganisms that include bacteria, such as:

- **Coliform bacteria** are common in the environment and are generally not harmful. However, the presence of these bacteria in drinking water is usually a result of a problem with the treatment system or the pipes that distribute water and indicates that the water may be contaminated with germs that can cause disease.

- **Fecal coliform** and ***E.coli*** are bacteria whose presence indicates that the water may be contaminated with human or animal wastes. Microbes in these wastes can cause short-term effects, such as diarrhea, cramps, nausea, headaches, or other symptoms.

- ***Cryptosporidium*** is a parasite that enters lakes and rivers through sewage and animal waste. It causes cryptosporidiosis, a mild gastrointestinal disease. However, the disease can be fatal for people with weakened immune systems. EPA and CDC have prepared advice for those with severely compromised immune systems who are concerned about *Cryptosporidium*.

- ***Giardia lamblia*** is a parasite that enters lakes and rivers through sewage and animal waste and causes gastrointestinal illness (e.g. diarrhea, vomiting, cramps).

- **Turbidity**—the cloudiness of water—has no health effects, but it can interfere with disinfection and provide a medium for microbial growth. Turbidity may indicate the presence of disease-causing organisms. These organisms include bacteria, viruses, and parasites that can cause symptoms such as nausea, cramps, diarrhea, and associated headaches.

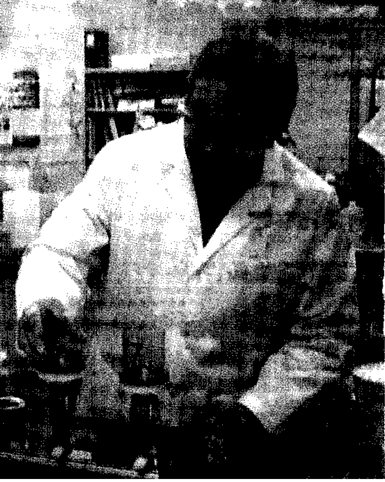


Photo Source: The Philadelphia Water Department, *http://www.phillywate* person consumes a contaminant," says Jenny Bielanski, drinking water utilities team leader, EPA's OGWDW. "People can suffer acute health effects from almost any contaminant if they are exposed to extraordinarily high levels, as in the case of a spill.

"In drinking water, microbes such as bacteria and viruses are the contaminants with the greatest chance of reaching levels high enough to cause acute health effects," she notes. "Most people's bodies can fight off these microbial contaminants the way they fight off other germs, and these acute contaminants typically don't have permanent effects.

"Nonetheless, when high enough levels occur, they can make people ill and can be dangerous or deadly for a person whose immune system is already weak due to HIV/AIDS, chemotherapy, steroid use, or another reason," Bielanski warns. "EPA has released several rules in the past few years that are aimed at tightening standards for microbial contaminants, and the agency is working to finalize additional rules over the next several months.

"Chronic effects occur after people consume a contaminant at levels over EPA's safety standards for many years," she explains. "Drinking water contaminants that can have chronic effects are chemicals such as disinfection byproducts, solvents, and pesticides; radionuclides, such as radium; and minerals, such as arsenic. Examples of the chronic effects of drinking water contaminants are cancer, liver or kidney problems, or reproductive difficulties."

But there are situations where water systems do not have feasible methods for measuring for contaminants at particularly low concentrations. In these instances, EPA designates a treatment techniques (TT) rather than an MCL.

A TT is an enforceable procedure or level of technological performance that public water systems must follow to ensure control of a contaminant. Examples are the Surface Water Treatment Rule that uses disinfection and filtration as the TT, and the Lead and Copper Rule that specifies optimized corrosion control procedures.

After determining an MCL or TT, EPA must complete an economic analysis to determine whether the benefits of that standard justify the costs. If not, EPA may adjust the MCL for a particular class or group of systems to a level that "maximizes health risk reduction benefits at a cost that is justified by the benefits." EPA may not adjust the MCL if the benefits justify the costs.

EPA has already set limits for many microbial and chemical contaminants but has not established an exhaustive list. It adds new contaminants regularly. To track down contaminants that may be a public health risk, the agency relies on the contaminant candidate list (CCL) to develop new standards. The CCL is a list of contaminants that are not currently regulated but have a significant public health concern. EPA published the first CCL in 1998 that included 50 chemical and 10 microbial contaminants. Since then, as required by the 1996 SDWA amendments, EPA has added new contaminants every five years.

Because contaminants have many varying qualities, they are grouped into four categories: microbial pathogens, organics, inorganics, and radionuclides.

Organic Chemicals

Organics that cause the most worry include:

- trihalomethanes (THMs), which form when chlorine in treated drinking water combines with naturally occurring organic matter;
- pesticides, including herbicides, insecticides, and fungicides; and
- volatile organic chemicals (VOCs), which include solvents, degreasers, adhesives, gasoline additives, and fuel additives. Some of the common VOCs are benzene, trichloroethylene (TCE), styrene, toluene, and vinyl chloride.

Some of the possible health effects of organic chemicals include cancer, central nervous system disorders, liver and kidney damage, reproductive disorders, and birth defects.

Inorganic Chemicals

Inorganics include toxic metals, such as arsenic, barium, chromium, lead, mercury, and silver. These metals can get into drinking water from natural sources, industrial processes, and materials used in plumbing systems.

Toxic metals are regulated because they can cause acute poisoning, such as lead or copper poisoning. But they do have chronic health effects, including cancer.

Nitrate is an inorganic contaminant that requires special attention because of its health effects on infants. It is found in mineral deposits, fertilizers, sewage, and animal wastes. Nitrate has been associated with methemoglobinemia or "blue baby syndrome."

Methemoglobinemia is a condition that causes an infant's hemoglobin, which carries oxygen, to be converted to methemoglobin, which cannot carry oxygen. Without oxygen, symptoms of cyanosis usually appear. Babies with cyanosis have bluish mucous membranes and may also have digestive and respiratory problems. When methemoglobin levels reach 20 to 30 percent or above, anoxia occurs. Anoxia is a condition characterized by the absence of oxygen supply to an organ or a tissue. At methemoglobin levels around 50 to 70 percent, brain damage or death is likely.

Once diagnosed, however, methemoglobinemia is readily reversed. However, if anoxia has occurred, oxygen-deprived organs or tissues may be permanently damaged.

Radionuclides

Alpha emitters, beta/photon emitters, and combined radium 226/228, come from minerals that give off radiation. Some people who drink water containing these radioactive emitters in excess of EPA's standard over many years may have an increased risk of getting cancer.

Radon gas is another radioactive material. It can dissolve and accumulate in underground water sources, such as wells, and in the air in your home. Breathing radon can cause lung cancer. It is considered to be more dangerous in air than in water. However, drinking water that contains radon presents a risk of developing cancer.

SWP Programs Reduce Risks

If all of these contaminants can enter drinking water supplies, what can be done to stop them? Source water protection programs are the key to keeping water secure. They help safeguard public health, and they reduce the overall treatment challenges and costs. (See article on page 41.)

"While treatment installed to address regulated contaminants may also remove unregulated contaminants, when one considers the number of pesticides, herbicides, and other organic pollutants that are used in agriculture and industry, it is clear that preventing contamination of sources of drinking water makes good public health, economic, and environmental sense," says Blette.

"Congress required that every state carry out assessments for every water system under their jurisdiction to characterize the susceptibility of drinking water to potential sources of contamination," she explains. "These assessments have largely been completed. States, water utilities, and local communities should now use this new information to develop strategies for ensuring that their drinking water is safe from contamination from chemical and microbial pollutants.

"All water contains some impurities that are picked up as water dissolves or absorbs the substances with which it comes into contact. So there is no such thing as naturally pure water."

Reiterating the Link

The public health concerns of providing safe drinking water are the reasons that this industry exists. Those concerns drive the need for new regulations, and subsequently, new treatment technologies. They also power the need for sustainable infrastructure, skilled operators, and educated drinking water industry leaders.

If there were no concern about drinking water straight from the source, there would be no reason to protect the public's well being in the first place. Drinking water systems could simply pump water in and out. The industry would consist of a few pipe manufacturers, construction companies, and possibly some firms that deal with water's aesthetics. The rest of us would be doing other things.

But that is not the case. As new chemicals and microbes emerge, drinking water contaminants will continue to change. The public health effects of those contaminants will continue to be the motivation of the drinking water industry's evolution. Researchers will need to find better ways to detecting contaminants, engineers will need to develop new treatment technologies, and regulators will need to monitor source water for contaminants. The challenge, however, will be in protecting the public from those contaminants from drinking water before they reach consumers.

For more information about how EPA establishes regulations, visit the agency's Web site at: www.epa.gov/safewater/index.html . *To read CDC's view of safe drinking water priorities, visit their Web site at* www.cdc.gov/health/water.htm. *NIEHS's safe drinking water Web site is online at* www.niehs.nih.gov.

References:

Bredickas, Vincent, and Kim Hartnett. 2003. *Water Treatment Primer: Safe Drinking Water Act.* Civil Engineering, Virginia Polytechnic Institute and State University: Blacksburg, VA.

Centers for Disease Control and Prevention (CDC). *Chemical Contaminants in Drinking Water and Public Health. www.cdc.gov/nceh/ehhe/water/drinkwater.htm.* Accessed on June 21, 2004.

CDC. Division of Parasitic Diseases Web page. *www.cdc.gov/ncidod/dpd/healthy water/index.htm.* Accessed on May 21, 2004.

CDC. National Center of Infectious Diseases Web page. *www.cdc.gov/ncidod/dis eases/list_waterborne.htm.* Accessed on May 21, 2004.

Department of Health and Human Services. 2004. *National Toxicology Program.* National Institutes of Health: Washington, DC.

Kendall, P. 1992. Food and Nutrition Series: Drinking Water Quality and Health. Publication number 9.307. Colorado State University Cooperative Extension: Fort Collins, CO.

National Library of Medicine. 2004. *Toxicology Tutor: Basic Principles. www.sis.nlm.nih.gov/ToxTutor/Tox1.* Accessed on July 23, 2004.

National Toxicology Program. 2002. *Human Exposure Assessment.* NTP Factsheets. NIEHS/NTP: Research Triangle Park, NC.

Parkin, Rebecca Tyrell, MPH, Ph.D. 1998. *Implementation of the Safe Drinking Water Act Amendments.* American Public Health Association. Washington, DC.

Physicians for Social Responsibility. 2004. *Drinking Water and Disease: What Health Care Providers Should Know.* Physicians for Social Responsibility: Washington, DC.

Rubin, Ken. *Ask An Earth Scientist.* University of Hawaii: Honolulu. *www.soest.hawaii.edu/GG/ASK/.* Accessed on July 23, 2004.

Smith, Kerry, and Randy Walsh. 2000. *Do painless environmental policies exist?* Kluwer Academic Publishers: Dordrecht, Boston, New York, and London.

U.S. Environmental Protection Agency (EPA). *Setting Standards for Safe Drinking Water. www.epa.gov/safewater/standard/set ting.html.* Accessed on April 29, 2004.

EPA. 1999. *Drinking Water and Health: What You Need to Know.* EPA: Washington, DC.

EPA. 2002. *Drinking Water Contaminants. www.epa.gov/safewater/hfacts.html.* Accessed on June 2, 2004.

EPA. 1999. *Understanding the Safe Drinking Water Act.* EPA 810-F-99-008. EPA: Washington, DC.

EPA. 1999. *Drinking Water Treatment.* EPA 810-F99-013. EPA: Washington, DC.

Zaslow, Sandra, A., and Glenda M. Herman. 1996. *Health Effects of Drinking Water Contaminants.* Publication number HE-393. North Carolina Cooperative Extension Service. North Carolina State University: Raleigh, NC.

On Tap Editor **Kathy Jesperson** is very interested in public health and is pursuing a master of public health degree at West Virginia University.

Emerging and Re-emerging Pathogens:

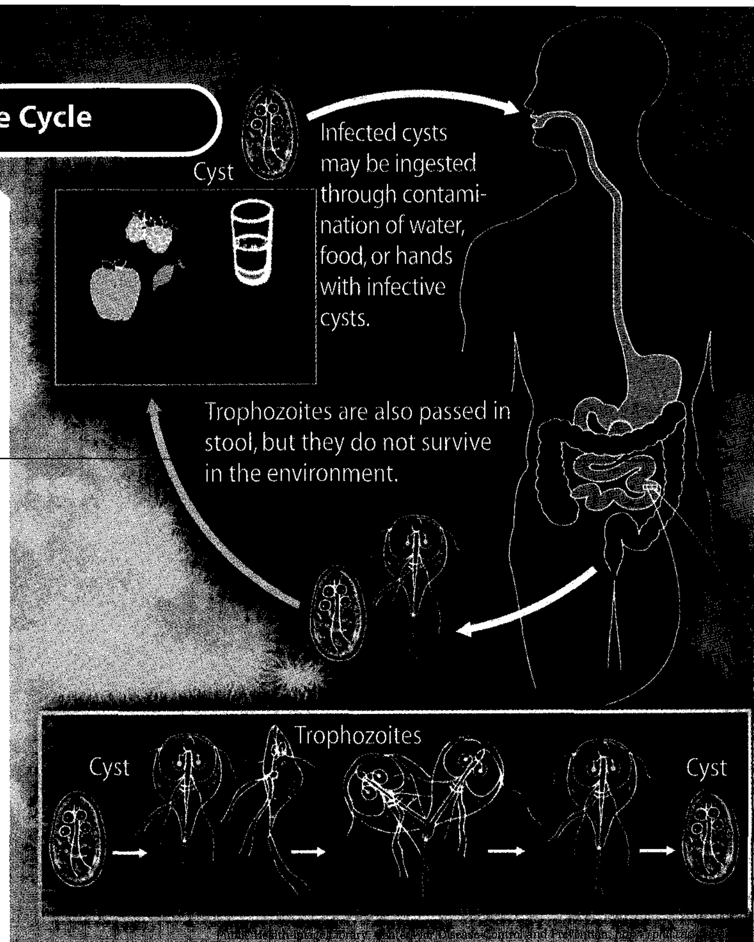
Compelling Reasons to Protect Drinking Water

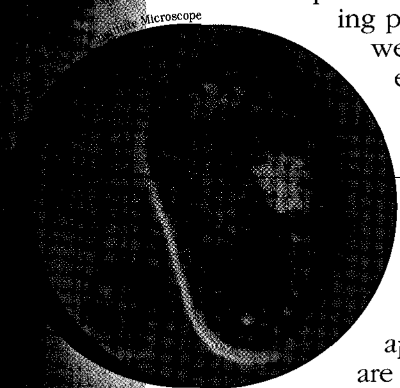
By **Kathy Jesperson** • *On Tap* Editor

According to Centers for Disease Control and Prevention (CDC) surveillance data, between 1999 and 2000, 25 states reported a total of 39 outbreaks associated with drinking water. Included among them was one *Salmonella* outbreak that spanned 10 states. Altogether, the waterborne illnesses affected an estimated 2,068 people and were linked to two deaths.

At one time, it seemed that science had defeated waterborne disease. But now that doesn't appear to be the case. Emerging and re-emerging pathogens have become a great concern for public health officials and drinking water systems around the country.

Giardiasis · *Giardia intestinalis* · The Cycle




Microscope

Emerging pathogens are either new to the environment or only recently identified as potential health threats. Re-emerging pathogens are pathogens that we know about but haven't encountered in a while. They cause diseases such as cholera and shigellosis. According to the World Health Organization (WHO), new pathogens show up for many reasons. One of the biggest reasons that they appear is that microorganisms are constantly evolving, adapting, and changing their structure. Another reason is that we've gotten better at detecting the microbes that cause waterborne disease because we have developed new tools and methods to study the organisms and their health effects.

Pathogens Have Greatest Health Impact

Pathogens present the greatest waterborne threat to the public's health because it only takes a small number of microbes to cause illness—especially for people who may have unique health risks, such as those with compromised immune systems, says the U.S. Environmental Protection Agency (EPA).

In addition, emerging pathogens, such as *Cryptosporidium*, *Giardia lamblia*, and Hepatitis E, share the following characteristics:

- They are often resistant to chlorination or other forms of disinfection.
- The pathogens are often resistant to antibiotics or other medical treatment.
- They are often highly infectious.

EPA notes that emerging and re-emerging pathogens include pathogens from fecal sources, such as *Cryptosporidium*, *Campylobacter*, and rotavirus, as well as pathogens that are able to grow in water distribution systems, such as *Legionella*, mycobacteria, and aeromonads.

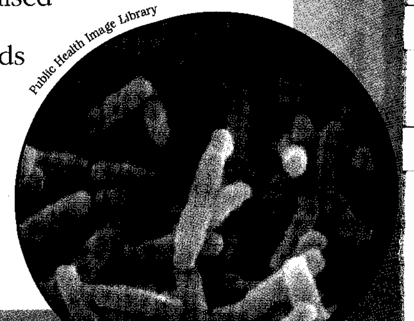
The following list of emerging pathogens was developed from information from the CDC, EPA, the U.S. Geological Survey, the National Institutes of Health, and WHO.

Bacteria

Aeromonas is a bacterium that normally lives in an aquatic environment. *Aeromonas* represent a high percentage of heterotrophic microorganisms in a variety of aquatic systems. Heterotrophic microorganisms are bacteria and other microorganisms that use the organic matter that other organisms synthesize for energy and growth. For this reason, their potential public health threat cannot be ignored. *Aeromonas* have been found in sewage and sewage effluents, surface water, fish ponds, soils, natural mineral springs, stagnant water, chlorinated and unchlorinated drinking water, and fresh waters. They act as primary pathogens and significantly sicken the fish that they invade.

Campylobacterium is a bacterium from the genus *Campylobacter*. Most people who become ill with campylobacteriosis get diarrhea, cramping, abdominal pain, and fever within two to five days after exposure to the organism. The diarrhea may be bloody and can be accompanied by nausea and vomiting. The illness typically lasts one week. Some people who are infected with *Campylobacter* don't have any symptoms at all. In those with compromised immune systems, *Campylobacter* occasionally spreads to the bloodstream and causes a serious life-threatening infection.

Cholera is the illness caused by a bacterium called *Vibria cholerae*.


Public Health Image Library

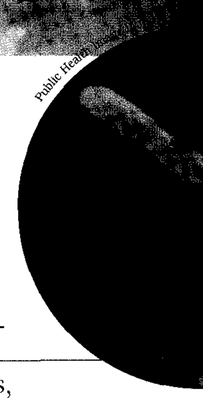
It infects people's intestines, causing diarrhea, vomiting and leg cramps. It seems like every time there are floods, earthquakes or any disasters in developing countries of the world, an outbreak of cholera follows quickly. Infect-ion is acquired primarily by ingesting contaminated water or food; person-to-person transmission is rare. Since 1961, *V. cholerae* has spread from Indonesia through most of Asia into Eastern Europe and Africa, and from North Africa, to the Iberian Peninsula. In 1991, an extensive epidemic began in Peru and spread to neighboring countries in the Western Hemisphere. In 2001, nearly 185,000 cases from 58 countries were reported to WHO.

Cyanobacteria (blue-green algae) are found in ponds, lakes, and reservoirs. They are aquatic and photosynthetic, meaning they live in the water and can manufacture their own food. Cyanobacteria are unicellular bacteria that often grow in colonies large enough to see with the naked eye. They can produce toxins—usually neurotoxins or hepatoxins. There is good evidence that certain hepatoxins promote liver tumors. Currently, most worldwide reports of cyanobaterial toxin poisonings have involved livestock, dogs, and waterfowl. Well-documented cases of effects on humans are relatively few, but there are some reports of dermatitis, eye irritation, and gastrointestinal symptoms.

E.coli O157:H7 is a bacterium that has been associated primarily with undercooked beef and raw milk. But waterborne outbreaks have been reported, including one in Missouri that sickened 243 people and left four dead, and one in Wyoming that sickened at least 50 people.

Helicobacter pylori is a bacterium linked to gastric ulcers. Penn State University (PSU) researchers report that they have found a direct link between the presence of a bacterium in Pennsylvania drinking water and stomach ulcers. The research team tied *Helicobacter pylori* in well water and clinical infection in people drinking from that supply. PSU researchers made the association between water containing *H. pylori* and the infection through tests of private wells supplying drinking water to individual households. Interviews with residents who consumed the water found a significant correlation between presence of the bacterium and cases of stomach ulcers.

Legionella pneumophila is a bacterium that was discovered in 1976 at an American Legion convention in Philadelphia.

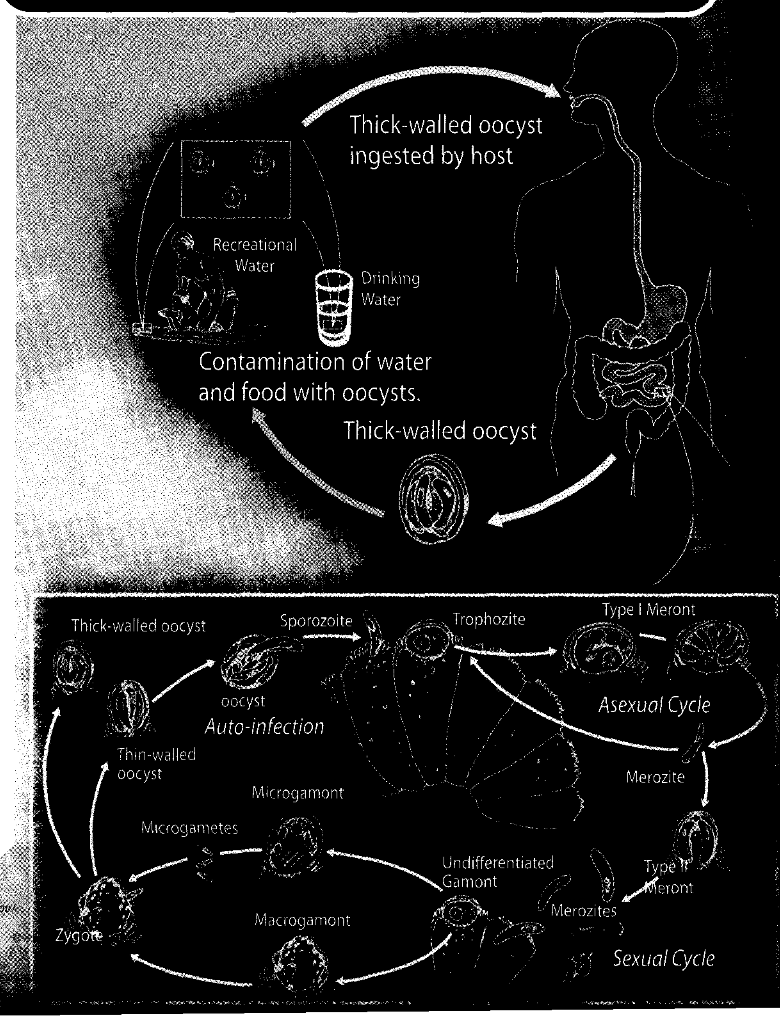


Investigators originally believed that an abandoned cooling tower was its source, but recent research indicates that the *Legionella* might have been introduced through a potable water system. While *Legionella* are relatively resistant to standard water disinfection procedures, research has produced effective ways to control and prevent it in potable water systems, including hyperchlorination, ultraviolet light, and ozonation.

Mycobacterium has been linked to tuberculosis. *M. avium* and *M. intracellulare* complex, long considered a group of organisms that rarely infects humans, is now recognized as one of the leading opportunists associated with AIDS. *M. leprae* causes leprosy, which remains a major disease in the third world. *M. bovis* causes tuberculosis.

Salmonella is a bacterium that causes salmonellosis. Most people infected with *Salmonella* develop diarrhea, fever, and abdominal cramps 12 to 72 hours after infection. The illness usually lasts four to seven

Cryptosporidiosis · *Cryptosporidium* · The Cycle



Public Health Image Library, Centers for Disease Control and Prevention. http://phil.cdc.gov/

days, and most people recover without treatment. However, in some people diarrhea may be so severe that the patient needs to be hospitalized. In these patients, the *Salmonella* infection may spread from the intestines to the blood stream and then to other body sites and can cause death unless the person is treated promptly with antibiotics. The elderly, infants, and those with impaired immune systems are more likely to have a severe illness.

Shigellosis is an infectious disease caused by a group of bacteria called *Shigella*. Most who are infected with *Shigella* develop diarrhea, fever, and stomach cramps starting a day or two after they are exposed to the bacterium. The diarrhea is often bloody. Shigellosis usually lasts five to seven days. In some people, especially young children and the elderly, the diarrhea can be so severe that the patient needs to be hospitalized. A severe infection with high fever may also be associated with seizures in children less than two years old. Some people who are infected may have no symptoms at all but may still pass the *Shigella* bacteria to others.

Protozoa

Cryptosporidiosis is a diarrheal disease caused by *Cryptosporidium parvum*—a protozoan that can live in the intestine of humans and animals and can be passed in the stool. Both the disease and the parasite are also known as crypto. An outer shell protects the parasite and allows it to survive outside the body for long periods of time. The shell also makes it very resistant to chlorine disinfection. During the past two decades, crypto has become recognized as one of the most common causes of waterborne disease in humans in the U.S. The parasite is found in every region of the U.S. and throughout the world.

Giardia lamblia is a protozoan that is most frequently the cause of non-bacterial diarrhea in the U.S. Human giardiasis may involve diarrhea within one week of ingestion of the cyst. Cysts are resistant to adverse environmental conditions and are passed in the feces of an infected host, and the next host is infected when it ingests cysts in food or water contaminated with feces. Normally, illness lasts for one to two weeks but there are cases of chronic infections lasting months to years. Chronic cases, both those with defined immune deficiencies and those without, are difficult to treat.

Viruses

Hepatitis E generally affects young adults and usually is not life threatening. The exception is in pregnant women, who have had fatality rates of 15 to 20 percent. According to CDC, virtually all cases of hepatitis E have occurred among travelers returning from developing countries where the disease is endemic and spreads through contaminated drinking water. Nevertheless, tests show that between one and five percent of healthy blood donors in the U.S. have hepatitis E antibodies in their blood.

Rotavirus infects the digestive tract. It is the most common cause of severe diarrhea in infants and young children in the U.S. *Rotavirus* is easily spread by hand-to-mouth contact with stool from an infected person. Most children with *rotavirus* diarrhea recover without medical treatment. Some children, however, become very ill with severe vomiting, diarrhea, and life-threatening loss of fluids.

If you need to report a waterborne disease outbreak, call CDC's Division of Parasitic Diseases, NCID, at (770) 488-7760 or by fax at (770) 488-7761.

For more information, contact: EPA's Safe Drinking Water Hotline at 800-426-4791, visit their Web site www.epa.gov/safewater, *or e-mail them at* hotline-sdwa@epa.gov; *or contact CDC's National Center for Infectious Diseases at* www.cdc.gov/ncidod. *Call the CDC at (888) 232-3228, or send a fax to (888) 232-3299.*

References:

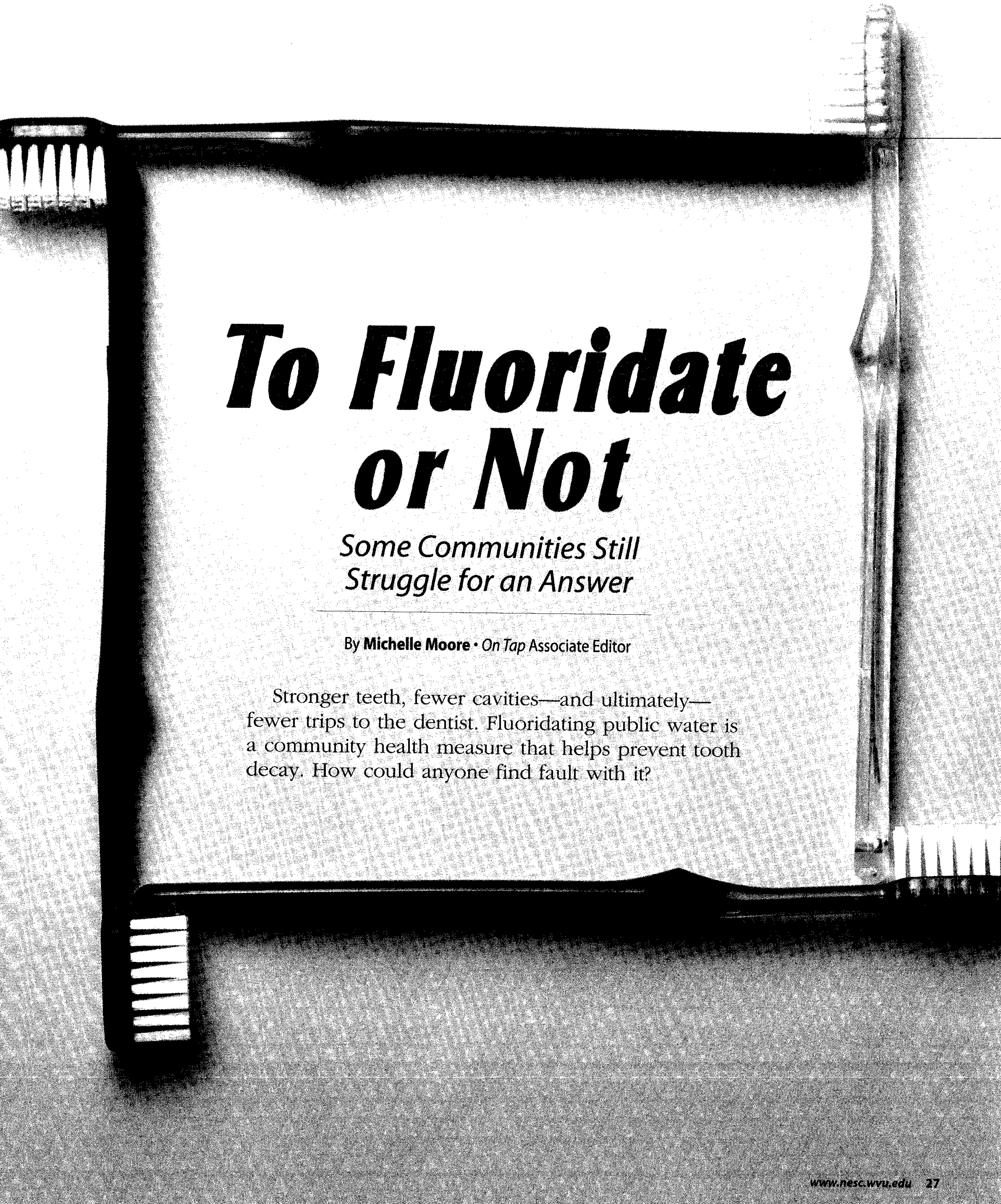
Lee, Sherline H., M.P.H., Deborah A. Levy, Ph.D., Gunther F. Craun, M.P.H., Michael J. Beach, Ph.D., and Rebecca L. Calderon, Ph.D. *Surveillance for Waterborne-Disease Outbreaks–United States, 1999—2000 www.cdc.gov/mmwr/preview/mmwrhtml/ss5108a1.htm*. Accessed on August 27, 2004.

National Institutes of Health. National Environmental Health Sciences Institute. *www.niehs.nih.gov*. Accessed on August 24, 2004.

U.S. Geological Survey. *Water Resources of the United States. www.water.usgs.gov*. Accessed on August 24, 2004.

U.S. Environmental Protection Agency. "List of Drinking Water Contaminants and MCLs" *www.epa.gov/safewater*, Accessed on August 24, 2004.

World Health Organization. Drinking Water Web page. *www.who.int/topics/drinking_water*. Accessed on August 24, 2004.



To Fluoridate or Not

Some Communities Still Struggle for an Answer

By **Michelle Moore** · *On Tap* Associate Editor

Stronger teeth, fewer cavities—and ultimately—fewer trips to the dentist. Fluoridating public water is a community health measure that helps prevent tooth decay. How could anyone find fault with it?

Those of us who live where water has been fluoridated for decades take it for granted. We drink it and cook with it, and for that matter, we brush our teeth with water whose fluoride level is adjusted so we can have healthier, brighter smiles. Like the other 40 or so chemicals that might be used in a water treatment facility, fluoride is just one of the behind-the-scenes ingredients in the drinking water mix.

But in other communities across the country, debates go on over continuing or even starting fluoridation. Arcata, California, city council wants voters to decide the fate of their fluoridation program. Clearwater, Florida, just started fluoridating following decades of opposition. Juneau, Alaska, fluoridated for years, but then stopped in 2003. Residents protested, and fluoridation resumed, but a task force is waiting for a National Academy of Sciences report before they make a final decision about how to proceed.

Fluoridation as a Public Health Measure

Water fluoridation is not only supported, it's encouraged by nearly 100 public health organizations, government agencies, and medical associations. The American Water Works Association (AWWA), the World Health Organization (WHO), the Centers for Disease Control (CDC), the U.S. Public Health Service (PHS), the American Cancer Society, the American Dental Association (ADA), and the Canadian Dental Association represent just a few of the respected organizations that recommend fluoridation as a simple, cost-effective means of promoting dental health.

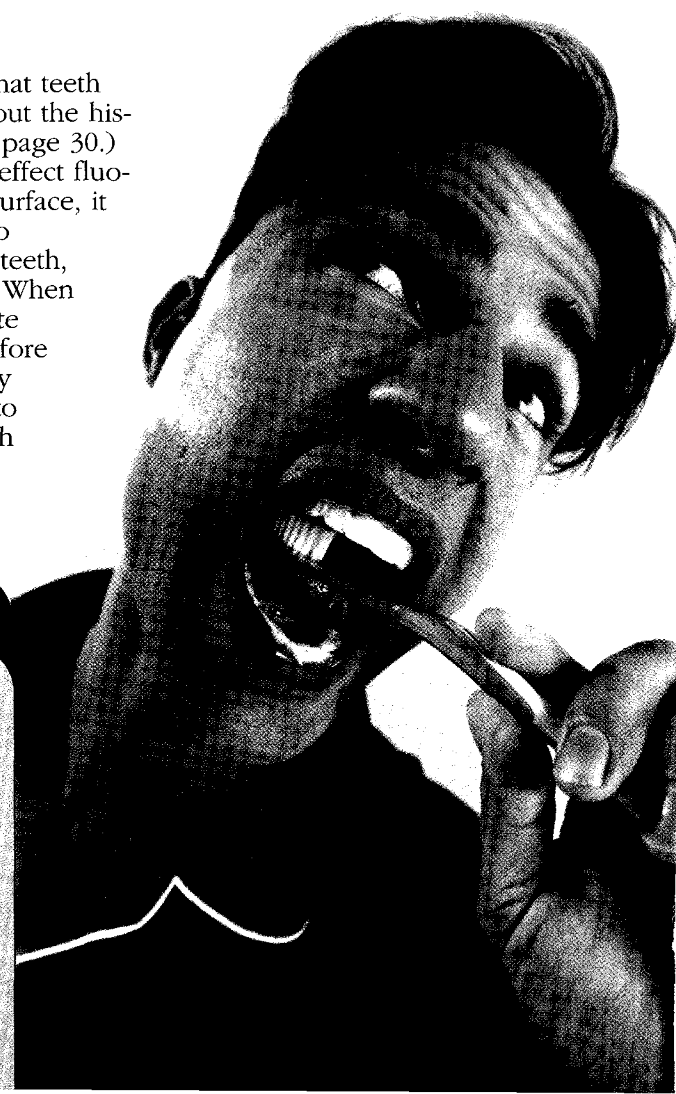
It's not news to anyone that fluoride makes teeth stronger and more resistant to cavities; our dentists have been telling us that for years. We can buy fluoride toothpaste, rinses, drinks, and tablets. Fluoridating water is a public health strategy intended to add an additional safeguard for all people, young children especially, to help ensure that teeth grow strong. (Read about the history of fluoridation on page 30.)

Besides the topical effect fluoride has on the tooth surface, it also acts systemically to strengthen developing teeth, according to the ADA. When children ingest adequate amounts of fluoride before their teeth emerge, they have better resistance to tooth decay. Once teeth are full-sized, fluoride helps strengthen and repair the surfaces.

CDC statistics for the year 2000 show that approximately 162 million people, or 65.8 percent of the U.S. population who rely on public water supplies, receive fluoridated water. Still, 100 million people in the country do not.

Like many chemicals and simpler substances we encounter in life, fluoride in large doses or in a concentrated form can hurt us. Studies showing harm from ingesting excessive amounts of fluoride have helped fuel public fears. But large amounts of plenty of things can be toxic. The ADA lists normally innocent things like salt, iron, vitamins A and D, oxygen, and even plain water as being harmful in large quantities.

"Fluoridation is the most cost-effective, practical, and safe means for reducing the occurrence of tooth decay in a community." —Former Surgeon General David Satcher, 2001

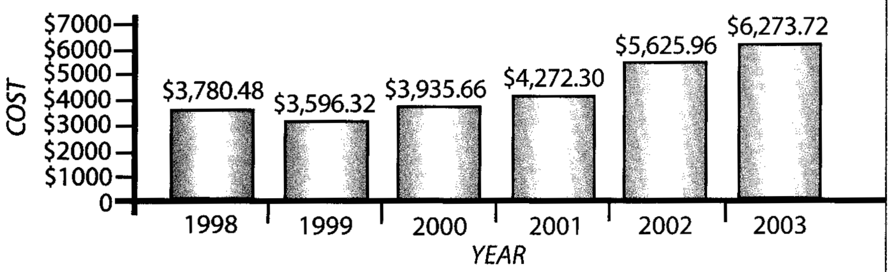


Status of Water Fluoridation in the U. S. in 2000:

- Total U.S. Population 281,421,906
- U.S. Population on Public Water Supply Systems 246,301,290
- U.S. Population Not Served by Public Water Supply Systems 35,301,290
- Total U.S. Population on Fluoridated Drinking Water Systems 162,067,341
- Percentage of U.S. Population Receiving Fluoridated Water 57.6 percent
- Percentage of Total U.S. Population on Public Water Supply Systems Receiving Fluoridated Water 65.8 percent

Source: *Centers For Disease Control Oral Health Resources*

Total Cost of Fluoride Used Each Year from 1998 to 2003



Fluoride Costs

YEAR	Price for #	Price for 155# Drum
1998	$0.09	$14.26
1999	$0.09	$14.10
2000	$0.09	$14.26
2001	$0.10	$15.50
2002	$0.12	$18.60
2003	$0.14	$22.47
2004	$0.14	$22.47

= pound

- Average use of 135 to 140 pounds a day at a cost of $19.57 a day.
- Average use of 5.6 pounds an hour at a cost of $.81 an hour.
- Approximately 15 to 20 drums on hand due to storage restrictions.

Source: Weirton, West Virginia, Population 20,000, Weirton Water Treatment Plant, *Treatment Efficiency Report*

CDC Asserts Safety Fluoride

Some people worry that with all the potential fluoride sources that are available we might be overdosing on the stuff. Kip Duchon, the national fluoridation engineer with the CDC in Atlanta, says that is unlikely.

"We're not talking about a lot of fluoride in water," he says. "All the research shows that even with these other methods you're really not anywhere near overdosing."

According to the ADA, in 1993 the National Academy of Sciences' National Research Council reported to the U.S. Environmental Protection Agency (EPA) that adjusted drinking water fluoride levels posed no health risk and that the maximum level of 4 parts per million (ppm) "would protect against adverse health effects with an adequate margin of safety." (For more information about what parts per million measurements mean, read the article on page 38.)

To effectively prevent tooth decay, the U.S. PHS determined a range for fluoride of 0.7 to 1.2 ppm. EPA established standards for safe fluoride levels in drinking water with the optimal level at 1 ppm. One ppm is equivalent to 1 milligram of fluoride per liter of water. ADA compares this measure to "1 inch in 16 miles, one minute in two years, or one cent in $10,000."

As stated above, the agency set fluoride's primary maximum contaminant level at 4 ppm and the secondary contaminant level at 2 ppm—levels at which the agency believes fluoride will safely prevent cavities without chronic toxicity becoming an issue. (To read about how EPA determines safe contaminant levels, see the article on page 46.)

ADA says that it is impossible for someone to suffer from acute fluoride toxicity by drinking water fluoridated at optimal levels. The amount of fluoride necessary to cause the death of an adult 155-pound man has been estimated to be 5–10 grams of sodium fluoride ingested at one time. Because 1 gram is equal to 1,000 milligrams, this amount is more than 10,000–20,000 times as much fluoride as is consumed at one time in a single eight-ounce glass of optimally fluoridated water.

The association also notes that someone would need to drink water fluoridated at approximately 5 ppm for 10 years or more before showing clinical signs of osteosclerosis, a mild form of skeletal fluorosis (increased bone density with outgrowths).

ADA and CDC have both published statements on the safety and effectiveness of fluoridation, and they refute charges from opponents who say that fluoride is responsible for a list of ailments, such as cancer, lead poisoning, increased bone fractures, hormonal imbalance, and lowering of IQs. Fluoridation opponents cite articles that show problems with fluoride, despite the overwhelming number of peer-reviewed, scientific studies that demonstrate its safety.

These claims are posted on Web sites, arousing fear in many people. Statements on these sites are repeated on additional Web sites and by supposedly well-meaning individuals who have been frightened by what they've read. The misinformation is then passed from person to person and group to group until many of these statements are accepted as fact. The ADA's *Fluoridation Facts* book refers to a kind of "pseudo-scientific literature" that is based on misquoted material, partial truths, and outright fabrication.

"The public often sees scientific and technical information quoted in the press, printed in a letter to the editor, or distributed via an Internet Web page," says the ADA. "Often the public accepts such information as true simply because it is in print. Yet, the information is not always based on research conducted according to the scientific method, and the conclusions drawn from the research are not always scientifically justifiable. In the case of water fluoridation, an abundance of misinformation has been circulated."

Duchon says that about 6,000 fluoride research articles have been published in the last 30 years, and that nearly all of them support the safety of water fluoridation. "There's a handful—and it's literally a handful—that have had results not consistent with the rest," he says. "Almost all of those, when they were peer reviewed, have been found to have mistakes in epidemiology or some kind of faulty consideration.

"A perfect example is one study that showed communities that have been fluoridated have higher lead in the bloodstreams [of the residents] than communities that have not been fluoridated. When you go back and look at the epidemiology, they were comparing older cities that were fluoridated to newer cities that were not fluoridated. By an epi-

The Mystery of Colorado Brownstain

Back in 1901, a young fellow fresh from dental school in the East moved to Colorado Springs. Once he'd opened his dental practice, Frederick McKay began to notice that many of the people in the area had mottled, brown stains on their teeth. McKay was puzzled by the condition and set out to find what caused it. None of the journals he read indicated what this strange discoloration might be or what caused it. So, McKay took it upon himself to find an explanation.

In 1909, McKay was joined by respected dental researcher Dr. G.V. Black in his investigation. Black became interested in the mystery when the Colorado Springs Dental Society reported that nearly 90 percent of children born in the area had the mottling, known as Colorado Brown Stain, on their teeth.

Over the next six years, Black and McKay learned two things about the disorder. They found that it resulted from problems during tooth development in children, meaning that adults whose teeth had no staining would not get the condition. And, teeth with the staining had much better decay resistence.

Some local theories for the staining were a little far-fetched, but one had to do with the possibility of it being related to the water. When McKay traveled to Oakley, Idaho, in 1923 to investigate staining on children's teeth there, he was reminded of the water theory. The staining began to show up after Oakley developed a public water supply. Although McKay couldn't find anything wrong with the water, he suggested that they use another source. The town made the change, and after a few years, the mottling no longer showed up on younger children's teeth.

Further investigation at other communities eventually led to the discovery that excess fluoride in water was causing the staining that today is called fluorosis.

In 1931, Dr. H. Trendley Dean with the National Institutes of Health furthered the investigation. He began studying the relationship between fluoride and dental health. Part of his focus was to find out at what point fluoride caused staining. Dean and his staff, along with chemist Elias Elvove, who devised a way to accurately measure the fluoride content of water, found that fluoride levels of 1 part per million did not cause fluorosis, whereas higher levels did.

McKay's and Black's earlier research showed that people with fluorosis also had unusually decay-resistent teeth. Dean wanted to see if adding fluoride to drinking water at that optimal amount would help prevent dental problems. In 1944 in Grand Rapids, Michigan, various public health organizations worked with the city commissioners to institute a fluoridation program for their drinking water. The next year Grand Rapids began fluoridating its water. The National Institute of Dental and Craniofacial Research says on its Web site that "During the 15-year project, researchers monitored the rate of tooth decay among Grand Rapids' almost 30,000 schoolchildren. After just 11 years, Dean—who was now director of the NIDR—announced an amazing finding. The caries rate among Grand Rapids children born after fluoride was added to the water supply dropped more than 60 percent. This finding, considering the thousands of participants in the study, amounted to a giant scientific breakthrough that promised to revolutionize dental care, making tooth decay for the first time in history a preventable disease for most people."

Condensed from "The Story of Fluoridation" National Institute of Dental and Craniofacial Research, a part of the National Institutes of Health located on the Web at www.nidcr.nih.gov/HealthInformation/OralHealthInformationIndex/Fluoride/StoryFlouride.htm.

demiological perspective, the big differentiator is that the older cities have lead paint and a lot of other lead sources. When they went back and tried to repeat that with old cities that were unfluoridated with old cities that were fluoridated and new cities that were unfluoridated with new cities that were fluoridated, there was absolutely no correlation. That pretty much debunked the study and showed it was based on poor controls."

Fluoridation opponents contend that other countries don't fluoridate, pointing to Western Europe, in particular, as having banned fluoridation. The ADA says that this is not true. Fluoridation is merely impractical in many European countries "because of complex water systems with numerous water sources." They also note that fluoridation is "available in approximately 60 countries benefiting over 360 million people." The list includes the U.S., Australia, Brazil, Canada, Hong Kong, Malaysia, United Kingdom, Singapore, Chile, New Zealand, Israel, Columbia, Costa Rica, and Ireland.

Duchon says that when countries choose not to fluoridate, even though it is recommended by WHO, they frequently promote salt fluoridation instead. Similar to iodized salt, fluoridated salt offers consumers an easy avenue for ingesting a nutrient they otherwise may have to do without.

"You've heard of going to places in Europe where they say don't drink the water?" Duchon asks. "It's the same way in South America. A lot of people drink bottled water, or they might drink very little water; they might drink a lot more wine or beer. Their beverages are different, and because of the inconsistent nature of the water quality in some of these countries, a lot of them have chosen to go to a salt fluoridation program."

In Switzerland, for instance, you can buy regular table salt, iodized table salt, fluoridated table salt, or you can buy salt that is both fluoridated and iodized. "By law, fluoridated and iodized table salt cost the least, and just plain salt costs the most," Duchon says.

Where is fluoride found?

Fluoride is an ion of the element fluorine, a gas that readily combines with other elements to form fluoride compounds. These fluoride compounds exist in rocks and soil in the Earth's crust. Water dissolves some of the fluoride, carrying it along with other minerals in underground streams and rivers and in surface water. This process results in a tiny amount of dissolved fluoride occurring naturally in all waters, including the ocean.

The Agency for Toxic Substances and Disease Registry reports that fluoride levels in surface water are approximately 0.2 ppm and usually range in groundwater from 0.02 to 1.5 ppm. Groundwater fluoride levels may be higher in some parts of the country, especially in the Southwest.

Communities that have adequate fluoride already present in their drinking water obviously don't need to fluoridate. Those with too much fluoride have to remove the excess through their water systems' treatment processes. Much more common are communities with sub-optimal levels. When they choose to fluoridate, it is added either at the source or during treatment.

Three fluoride compounds are used in drinking water: sodium fluoride (NaF), fluorosilicic acid (H_2SiF_6), and sodium fluorosilicate (Na_2SiF_6). Depending upon which compound is used, the fluoride is added to water supplies directly as a liquid (H_2SiF_6) or as a solution of water mixed with the dry chemical powder (H_2SiF_6 or NaF).

Most of the fluoride comes from apatite rock, which is also the source of phosphorus for agricultural fertilizer. Nearly all fluoride for drinking water is a product of the phosphate extraction process in making the fertilizer.

Opponents say that these fluoride compounds contain toxic levels of impurities. AWWA sets safety standards for fluoride that water utilities obey. These standards say, in part, that the fluoride "shall contain no soluble materials or organic substances in quantities capable of producing deleterious or injurious effects . . ."

Jane McGinley, a spokesperson for ADA says "no chemical, even pharmaceutical grade chemicals, are 100 percent pure, so they do contain impurities. However, all the chemicals used in water fluoridation, as with all chemicals used in water treatment plants, meet [AWWA's] standards."

This is not to say that fluoride itself is not toxic. It is one of 11 or so chemicals used in water treatment that the CDC lists as a "very hazardous material for plant operators."

"Like many chemicals, fluoride in a concentrated form is dangerous," Duchon says. "But, chlorine also will really injure you. Alum—aluminum sulfate—will burn you. Lime will burn you. I mean there are all these chemicals that we deal with in water treatment and other places, which in a concentrated form need safe handling. If you have industrial exposure, you can have some negative consequences.

"Think of it this way: A doctor says to take two aspirin because it will be good for you. But what happens if you take 40? You might die. A little bit of something can be quite beneficial. A lot of something might not be. Fluoride's the same way. Are there cases where fluoride could be a poison? Yes. Are there cases where it could injure you? Yes. Will that happen at the concentration that we're talking about for optimal fluoridation? There's absolutely no evidence that that's the case."

CCR Tracks Flouride

A public water system's annual consumer confidence report gives residents a record of water quality, including information about fluoride. Operators are required by EPA to test the water's fluoride level at least once a day. Darle Setler with the Taylor County Public Service District (PSD) in Grafton, West Virginia, says that he checks more often if he feels it is warranted. He might seem to be extra cautious, but he says that fluctuations in the flow rate at the plant site will alter the dosage.

"The entire operation has to be watched carefully—turbidity levels, chlorine levels, disinfection byproducts, it goes on and on. If you're doing the job properly, you're going to be concerned about all those issues—not the least of which are the fluoride concentration levels."

Conscientious plant personnel play the greatest role in making sure fluoride in water is at a safe level for consumers. Setler, whose PSD was recognized by the CDC for maintaining the optimum fluoride level and meeting fluoridation requirements, says they've got a fail-safe plan for their fluoride feed system so that, no matter what might happen, no significant overdosing can occur.

"Our system here has an atmospheric drop, an air gap," Setler says. "The fluoride is introduced into our water system by a metering pump. We adjusted the metering belt setting to the lowest output on the chemical feed pump based on our average rate of flow of 3,100 gallons a minute. If the pump was accidentally left up at 100 percent, we couldn't overfeed more than 2ppm into the system."

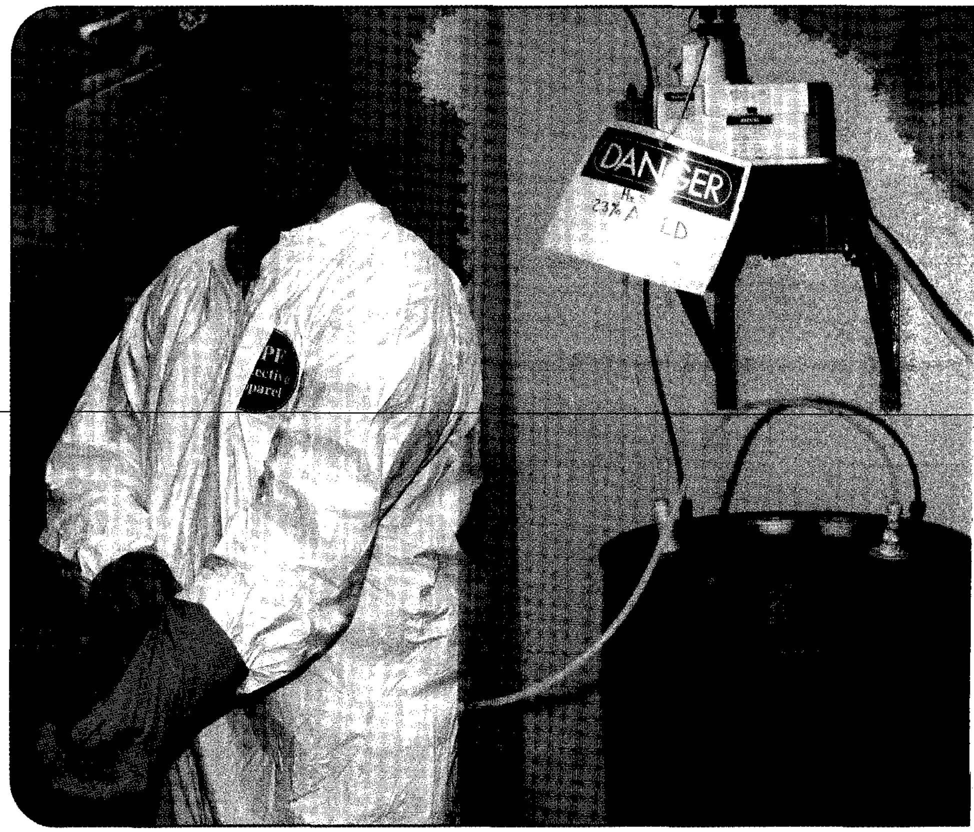
West Virginia's operating range for acceptable fluoride levels is between 0.8 and 1.3 ppm with the optimum level set at 1ppm. Setler says the dilution is checked and monitored, not only through daily fluoride samples in the plant, but also through the distribution system. They keep a close watch on the accuracy of their scales and the metering pump output.

"We also have a partial barometric pressure loop," Setler says. "We have to pump up to a point about 30 feet and then it drops to a point where there is a physical air gap between the fluoride feed line and the filter effluent trough, making it impossible for a 55-gallon drum of HFS to accidentally be fed into our drinking water at one time.

"The two-foot air gap in place between our effluent trough and the fluoride feed line makes it impossible for any back-siphoning to occur as well. Our system has built-in redundancy checks from start up to shut down with a written plan of each phase of the operation. We take our responsibility very seriously."

Part of good treatment plant management is keeping accurate records and submitting them to the state regulatory agency. Copies have to be kept for at least 10 years. As noted in *Water Fluoridation: A Manual for Water Plant Operators*, these records should include:

- daily fluoride tests with date, place, time of sampling, and the name of the sample collector
- daily weight measurements
- make-up water used for saturators
- weekly/monthly fluoride check sample tests
- dosage rates
- identification of the sample (routine distribution systems sample, check, raw or processed water, or other)
- date of analysis
- analysis lab and technician's name
- analysis method
- results



(For more information about record keeping, see the Summer 2004 *On Tap*.)

Costs and Benefits

According to current cost information, a community with 5,000 residents will spend approximately $3 per person for water fluoridation. The ADA says that fluoridation is worth the price to the community, and for individuals, the "lifetime cost per person to fluoridate a water system is less than the cost of one dental filling."

A town can expect to spend $6,000 to $10,000 for a fluoridation system, says the CDC's Duchon, including the equipment (storage tank and metering pump for liquid H_2SiF_6 or a saturator and pump for the dried chemical) and installation. For a cash-strapped small town, which is the rule more than the exception, the cost, plus the potential for controversy, add up to a situation that many water boards and town councils may choose to avoid.

Phil Fishburn, who works with the Midwest Assistance Program (part of the Rural Community Assistance Partnership) in Kansas, says that getting small communities to incorporate water fluoridation into their water treatment process may be harder than one might expect. More than anything, local officials don't want to "rock the boat" when it comes to any kind of controversy or debate. Plus, towns are already trying to figure out how to finance the ever-growing load of regulatory requirements with tighter budgets, so an additional drain on their funds may be a tough sell.

"The bottom line," Fishburn says, "is that for most of the smaller communities, you're going to have a lot of difficulty in finding boards and councils with the political will to jump into such a controversial decision. And, the cost factor is a very legitimate concern. It's difficult enough to encourage people to look at the rates on a yearly basis and raise them to keep their systems viable financially and on a sustainable basis. Throwing in additional costs is another factor that I think would cause some communities to shy away from it."

A fluoridation debate was on the table in Hutchinson, Kansas, for a number of years. Influenced by claims (similar to those previously mentioned) from individuals in the community, the city council voted to not fluoridate five years ago. But, a new council is in office now, and they've recently decided to begin the practice.

Hutchinson would receive help from a local group, the Methodist Health Ministry Fund, who offered a $247,000 grant to get the fluoride process going and to support operating costs for the first two years. To get the matter settled, City Planner Joe Palacioz said that residents were given three-weeks notice that fluoridation would be on the agenda at an upcoming council meeting.

"People could express their viewpoints, both pro and con," Palacioz said. "Then, after we had about an hour and a half debate on each side of the issue, the decision [to fluoridate] was made."

Should people be concerned?

In 2001, Former U.S. Surgeon General David Satcher reported that "More than 50 years of scientific research has found that people living in communities with fluoridated water have healthier teeth and fewer cavities than those living where the water is not fluoridated. . . . A significant advantage of water fluoridation is that anyone, regardless of socioeconomic level, can enjoy these health benefits during their daily

Tech Brief

PUBLISHED BY THE NATIONAL ENVIRONMENTAL SERVICES CENTER

Chlorination

By Lorene Lindsay, NDWC Engineering Scientist

Summary

Beginning with its use for the Jersey City drinking water supply in 1908, chlorination has been the most commonly used disinfection technique for public drinking water. Chlorine provides good disinfection and is effective against a wide range of pathogens in drinking water. Recently, however, many water treatment plants have altered their disinfection strategies because of regulation changes concerning disinfection byproducts. Nevertheless, chlorination remains the most cost-effective and reliable disinfection method available.

What is chlorine?

Chlorine is greenish-yellow in its gaseous form and is 2.5 times heavier than air. It is extremely corrosive and will react violently with organic substances. For example, when petrochemicals are mixed with chlorine, they produce a dangerous explosive. Stored chlorine must be kept away from all sources of organic chemicals, and it must be protected from sunlight, moisture, and high temperatures.

Chlorine's corrosive nature requires that systems use special materials on all chlorination equipment. Systems must use corrosion-resistant piping, valves, and metering equipment and keep this equipment free from contaminants, including oil and grease.

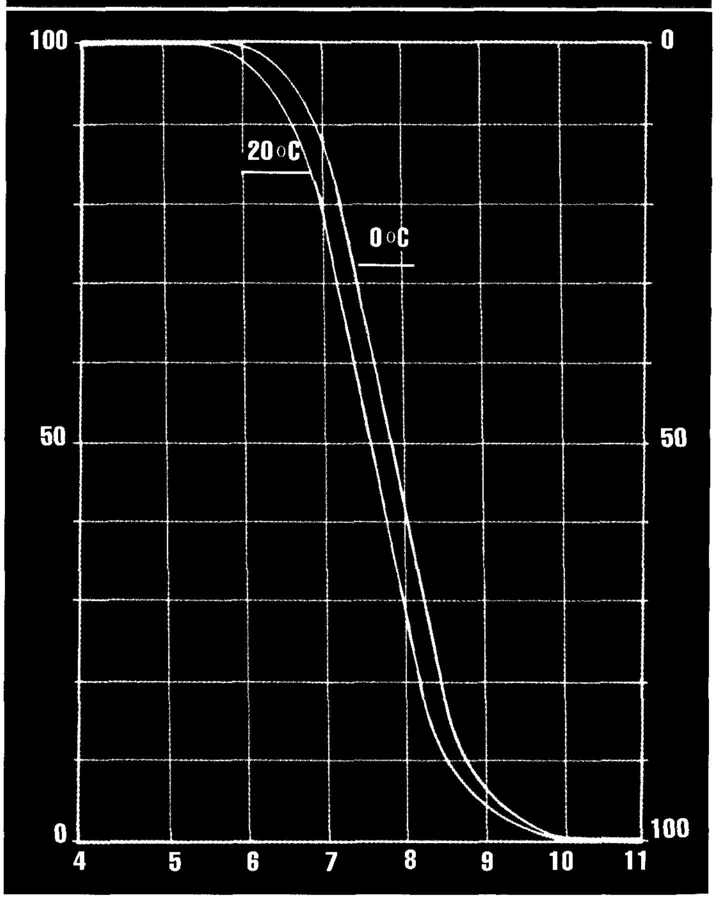
All operators who use chlorine should have chlorine safety training. If they use gaseous chlorine, they should have special safety equipment, such as an SCBA [self-contained breathing apparatus] on hand. Operators should also make sure that all personnel are trained to use the equipment and respond to a leak. The SCBA must be stored near but outside the chlorine room. (For more information about chlorine safety, see the fall 1998 issue of *On Tap* for the article "Chlorine Safety: Know What You're Doing.")

Forms of Chlorine

Chlorine is a strong, oxidizing agent that systems may use as a liquid or gas. Either form is stored and used from gas cylinders under pressure. The chlorine cylinders may be 150-pound, ton, or rail-tank car size. Small drinking water systems commonly use 150-pound cylinders.

Systems may use either calcium hypochlorite or sodium hypochlorite. Calcium hypochlorite may be a solid or powder and provides 65 percent available chlorine. Calcium hypochlorite is more stable than other forms of chlorine. Sodium hypochlorite comes in a liquid solution of five to 15 percent chlorine. Both calcium hypochlorite and sodium hypochlorite can be

Figure 1 - Relationship between hypochlorous acid (HOIC), hypochlorite ion (OCl) and pH



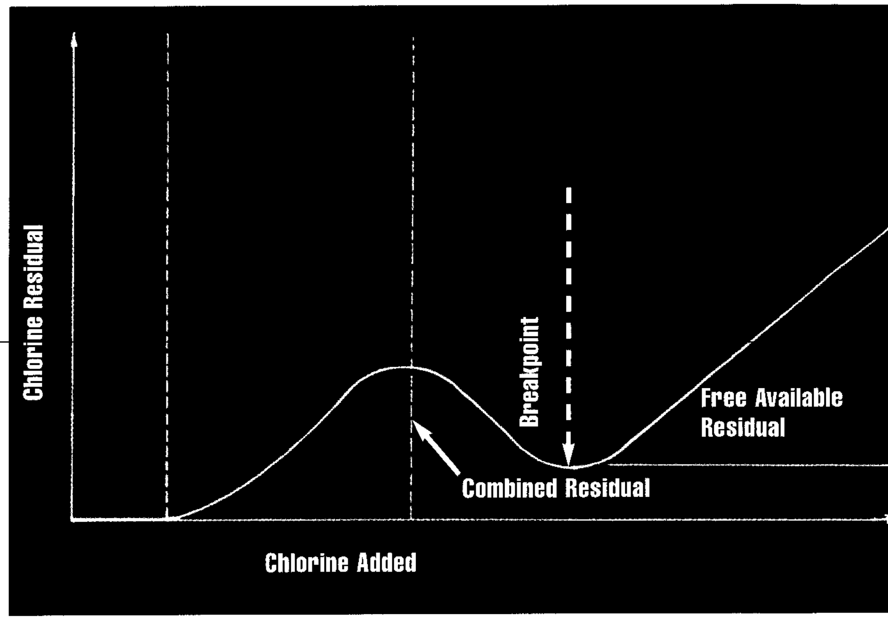
Source: Water Plant Operation, Volume 1, *California State University, Sacramento, CA Dr. Ken Kerri, Project Director* fed using a liquid solution tank with a small chemical feeder pump.

Storing Chlorine

A drinking water system should always have a one- to two-week supply of chlorine on hand, and many plants keep a 30-day supply. Calcium hypochlorite is more stable than other forms of chlorine and may be stored for up to a year. Sodium hypochlorite should not be stored for more than one month. If a system stores more than 2,500 pounds of chlorine onsite, a risk assessment and an emergency response plan are required.

A risk assessment requires that the facility determine the worst-case scenario for an accidental release. If the worst-case scenario could affect the general public, a prevention program must be developed. The prevention program should include identification of hazards, written operating procedures, training, maintenance, and accident investigation. If employees from the system respond to a leak, the system must develop an emergency response plan and submit it to the U.S. Environmental Protection Agency (EPA). The public also must have access to this plan.

Figure 2 - Breakpoint Chlorination Curve



Source: Water Plant Operation, Volume 1, *California State University, Sacramento,CA Dr. Ken Kerri, Project Director*

Chlorine Reactions in Water

Chlorine mixed with water forms hypochlorous and hypochlorite ions. The hypochlorous ion is a more effective disinfectant and is formed in greater concentration at lower pH values. At pH 7.3, the hypchlorous and hypochlorite ions will be present in equal numbers. The hypochlorite ion predominates above pH 8.3 and is not as effective as a disinfectant. For this reason, better disinfection occurs at a lower pH. The graph shown in Figure 1 displays the relationship between different forms of chlorine over a range of pH.

Chlorination should be applied after treatment to remove the precursors that combine with chlorine to form the trihalomethanes and haloacetic acids that EPA now regulates. Some water treatment systems have begun using chlorine, ultraviolet (UV), or ozone as a primary disinfectant, then using chloramines as a secondary disinfectant to minimize the production of disinfection byproducts.

Chlorine Demand

Because chlorine is a strong oxidant, it combines with many other substances in the water, including inorganics, such as ferrous iron, hydrogen sulfide, and ammonia. This reaction is instantaneous, and no disinfection occurs until the chlorine has combined with the organic and inorganic substances present in the water. The substances with which chlorine combines exert a demand on the chlorine that must be satisfied before a free-chlorine residual is formed. The free-chlorine residual produces the most effective form of disinfectant and is a measure of the hypochlorous and hypochlorite ions.

Chlorine also combines with ammonia that may be present to form chloroamines. The chloroamines provide disinfection, but the process is much slower. A longer contact time is required for complete disinfection to occur. The chloroamines are part of the combined chlorine residual and will provide disinfection but at a slower rate than free chlorine.

Chloramines do provide a longer disinfection contact time and are very beneficial in the distribution system where monochloramine, dichloramine, and trichloramine continue to kill microorganisms and extend the effective contact time.

The total residual chlorine is the sum of the combined and free residuals:

> Total residual, milligrams per liter (mg/L) = combined residual, mg/L + free residual, mg/L

For example, if the free chlorine residual is 1.0 mg/L and the combined residual is 2.0 mg/L, then the total residual is 3.0 mg/L.

The total chlorine demand must be satisfied and then the addition of more chlorine will produce a rapid increase in free-chlorine residual. Figure 2 illustrates how the chlorine residual is produced as more chlorine is added. The point at which the free-chlorine residual begins to rise in direct proportion to the amount of chlorine added is called the breakpoint. At the breakpoint, the chlorine demand has been satisfied, and the addition of more chlorine produces a free-chlorine residual in a one-to-one ratio. Most water treatment systems try to produce a free chlorine residual of 0.6 mg/L in the finished water and maintain at least 0.2 mg/L total residual in the distribution system.

Chlorine Dose

The required chlorine dose can be calculated by determining the desired residual, the volume of flow, and chlorine demand. For example, to treat 1 million gallons per day (MGD) of water and produce a chlorine residual of 0.6 mg/L with water having a 1.0 mg/L chlorine demand, the chlorine dose rate in pounds per day would be calculated as follows:

Chlorine, pounds/day = Vol. MGD x 8.34 lbs/gal x total concentration, mg/L

= 1.0 MGD x 8.34 lbs/gal x 1.6 mg/L
= 13.3 lbs per day

Using this example, the chlorination feed equipment should be calibrated to provide a dose of 13.3 pounds of chlorine per day. When gaseous chlorine is used, the chlorine cylinder should be set up on a scale, and the total pounds per day should be recorded.

When using a solution tank of calcium hypochlorite or sodium hypochlorite, the equation above must be modified because the amount of chemical used is not 100 percent chlorine. In the case of a hypochlorite solution that is 65 percent available chlorine, the dose of hypochlorite needed to produce 13.3 pounds per day of chlorine would be 20.5 pounds per day (13.3 pounds per day/0.65). The hypochlorinator must be calibrated to feed 20.5 pounds of calcium hypochlorite per day.

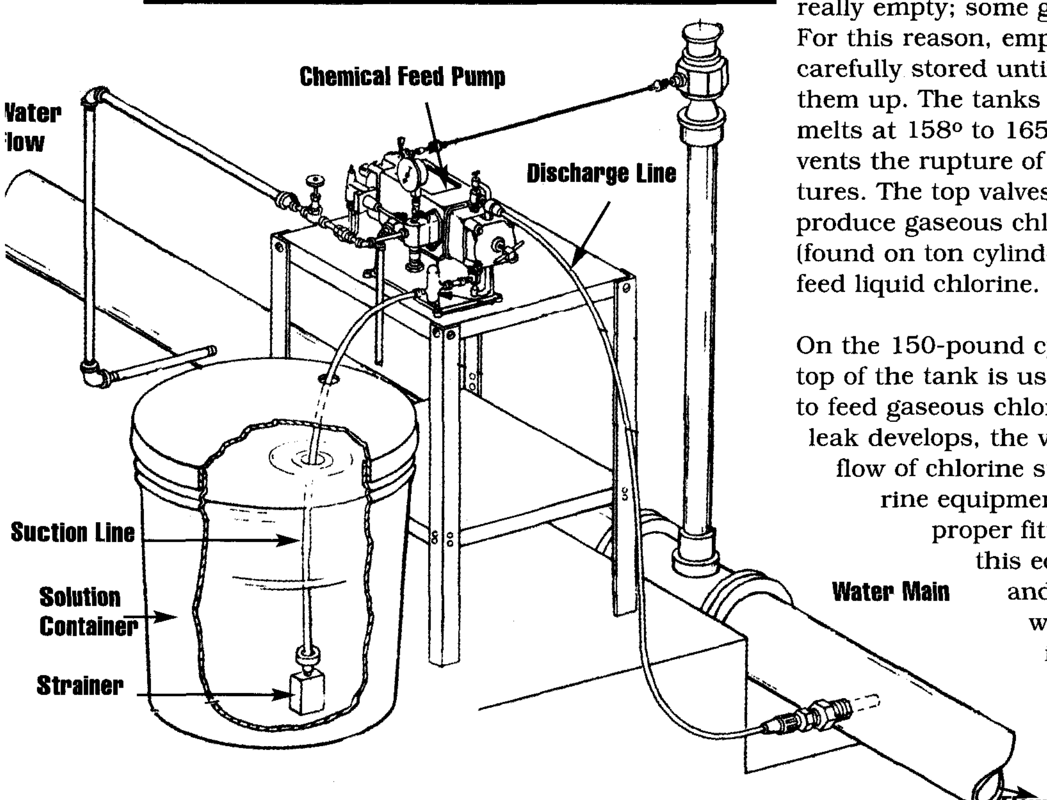
The contact time and dose are extremely important to achieve good disinfection. A contact time of 30 minutes is a minimum, and the contact time may need to be increased at low temperatures or higher pH to achieve the same level of disinfection if the dose remains constant. A higher chlorine dose may allow for a shorter contact time, but that may not be the best way to optimize the disinfection process.

Chlorination Equipment

As previously stated, the cylinders used for gas or liquid chlorine are made of steel, and the chlorine is under pressure. Operators must remember that the chlorine cylinders are never really empty; some gas will remain in the tank. For this reason, empty chlorine tanks must be carefully stored until the manufacturer picks them up. The tanks have a fusible plug that melts at 158° to 165° F. The fusible plug prevents the rupture of the tank at high temperatures. The top valves on a chlorine cylinder produce gaseous chlorine, and the lower valves (found on ton cylinders and rail tank cars) will feed liquid chlorine.

On the 150-pound cylinder, the valve on the top of the tank is used with a vacuum system to feed gaseous chlorine into the water. If a leak develops, the vacuum is broken and the flow of chlorine stops. The threads on chlorine equipment are unique, and only proper fittings may be used with this equipment. New gaskets and washers should be used when a new cylinder is put into service, and the chlorine valve is designed to provide maximum discharge with only one revolution. This safety feature allows

Figure 3 - Hypochlorinator



Source: Water Plant Operation, Volume 1, *California State University, Sacramento,CA Dr. Ken Kerri, Project Director* a rapid shut-off for the cylinder if a leak develops. Many plants use an automatic shutoff safety valve to provide more protection against the accidental release of chlorine. Never use a wrench larger than six inches when working on a chlorine cylinder. Small leaks in the 150-pound cylinder may be repaired with Emergency Kit A, which contains different types of repair plugs and clamps that are specific for the 150-pound cylinder. Likewise, if ton cylinders are being used, then Emergency Kit B is required, which contains different types of repair plugs and clamps that are specific for the one-ton cylinder.

Chlorine leaks may be detected using a rag soaked in ammonia. To find a leak, pass the ammonia-soaked rag slowly over the chlorine piping. If a leak is present, the ammonia will combine with the chlorine and form a white cloud. Using an ammonia spray bottle is not recommended because if the leak is large, a large white cloud will form that may impair vision. Many leaks occur at the valve and may be stopped by tightening the packing gland around the valve.

Calcium hypochlorite, or sodium hypochlorite, is more commonly used to treat flows of 100,000 gallons per day or less. The hypochlorinator is composed of a solution tank, chemical metering pump, storage tank, and associated piping. Figure 3 shows the basic set-up for a hypochlorinator. The hypochlorinator requires mixing and filling the solution tank, usually on a daily basis. The hypochlorinator equipment is less expensive than gas feeder equipment. The upkeep and maintenance for solution feeders is easier to perform but requires more frequent attention. The suction feed line from the solution tank has a tendency to clog and should be checked frequently. The solution tank and the screen on the suction line should be cleaned monthly or quarterly, as needed.

The chlorine feed solution is extremely corrosive so all materials must be corrosion resistant and checked for evidence of failure. The liquid chlorine solution from calcium hypochlorite or sodium hypochlorite is easier to work with than gaseous chlorine, but the solution is still very hazardous.

Chlorine Testing

The only acceptable method for chlorine testing is DPD, [N,N-diethyl-p-phenylenediamine]. This method requires the addition of DPD to the sample and then measuring the intensity of color production in a colorimeter. Always check the expiration date on the DPD and protect it from high temperatures. Chlorine samples must be collected and analyzed immediately. No holding time or sample preservation is acceptable for chlorine samples. Agitation and sunlight will destroy chlorine in the sample, so field-testing kits should be used when taking samples from the distribution system.

Samples of drinking water should be tested for both free and combined chlorine residual. Personnel should collect samples from several locations throughout the distribution system, including the farthest point to ensure that adequate chlorine residual is maintained. The number and frequency of samples required depends upon the volume of drinking water produced. The Surface Water Treatment Rule requires some systems to provide continuous chlorine residual testing. The price of in-line monitoring equipment and keeping this equipment in good working order may be a significant expense for small water treatment systems.

Chlorination provides good disinfection to protect drinking water supplies from pathogens. For small drinking water systems, chlorination is the least expensive form of disinfection available in either the gaseous, solid, or liquid form. However, chlorine is a dangerous, corrosive chemical that requires special handling, storage, and use procedures. The challenges for many small systems are to provide chlorine safety training, minimize the production of disinfection byproducts, and still supply safe drinking water at a reasonable cost.

Where can I find more information?

American Water Works Association. 1973. *Water Chlorination Principles and Practice, 1973, AWWA manual M20.* Denver, CO: AWWA.

Small Water System Operation and Maintenance, 3rd Edition, 1995. California State University. Sacramento, CA: Hornet Foundation.

American Water Works Association. 1992. *Back to Basics, Guide to Disinfection with Chlorine.* Denver: AWWA.

American Public Health Association, American Water Works Association, Water Environment Federation. 1998. *Standard Methods for the Examination of Water and Wastewater, 20th Edition,* Washington, DC: APHA, AWWA, WEF.

Lorene Lindsay has 26 year's experience in water and wastewater treatment and is a certified operator in the state of Missouri. She now serves as a part of the technical assistance unit for the National Environmental Services Center.

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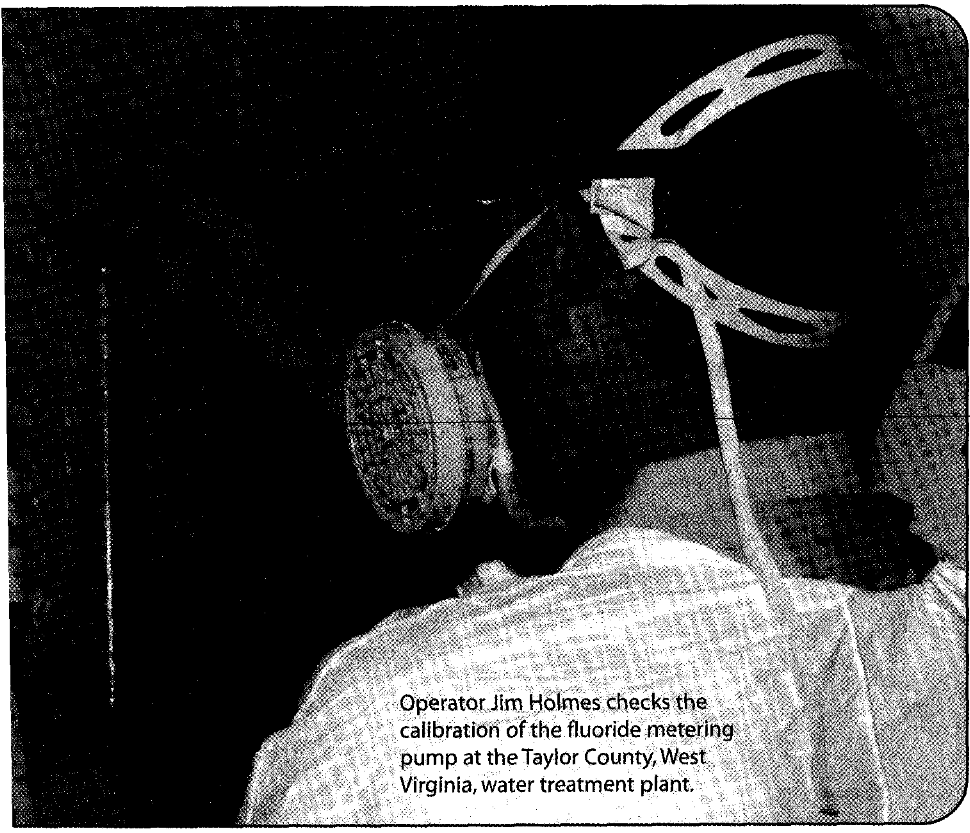
Published by The National Environmental Services Center at West Virginia University, P.O. Box 6064, Morgantown, WV 26506-6064



Operator Jim Holmes checks the calibration of the fluoride metering pump at the Taylor County, West Virginia, water treatment plant.

Photos by Michelle Moore and Julie Black

lives—at home, work, or at school or play—simply by drinking fluoridated water or beverages prepared with fluoridated water."

The benefits appear to be obvious. But, as much as proponents of water fluoridation might want the controversy to be resolved, there is no sign that it will be. Communities will continue to debate the issue as long as there are still questions being raised.

Groups who support water fluoridation have no agenda but to encourage better public health for everyone. "The CDC's opinion is that we're not here to promote things," Duchon says. "We're here to provide a scientific basis and a health perspective and to establish an overall framework so that when other people actually do something they've got some good scientific grounding. With the antifluoridation groups, there is plenty of passion but not much science."

Fluoridation opponents assert that they are only concerned for public health also. But one charge they put forth has nothing to do with science or safety, and many people agree with this one. They say that the practice disregards an individual's right to choose whether they want to have fluoride added to their water or not. They claim that water fluoridation is "mass medicating" a city's or smaller community's residents.

The Santa Cruz County Public Health Commission in California notes in their fluoridation position statement that many public health measures have been instituted for the "greater public good, including chlorinating water, pasteurization of milk and the addition of vitamin D, childhood immunizations, mandatory use of passenger restraints in cars, helmets for children bicycle riders and motocycle riders, and restriction of smoking in public places."

Fluoridating water, they say, is merely one in many instances where individual rights are foregone for the greater good of the community. As the health director of Manchester, New Hampshire, said in a *The Union Leader* newspaper article, "This is not really an issue debated at the local level. If we debated immunization or Vitamin D in milk or folic acid in bread, we wouldn't have them."

Still, the debate continues. Community leaders and water system managers will be with what to do for their residents. They need to educate themselves about fluoride and fluoridation, weed out the misinformation from the valid, and use that knowledge to make the best decision for the town.

To Learn More

You can order the 57-page book *Fluoridation Facts* from the ADA. Call them at (800) 947-4746 or visit their Web site at *www.ada.org* or write to American Dental Association Council on Access, Prevention, and Interprofessional Relations, 211 East Chicago Avenue, Chicago, IL 60611-2678.

The ADA also has several fact sheets available on their Web site at *www.ada.org/prof/resources/topics/fluoride.asp.*

Some states and private organizations offer grants to help communities with water fluoridation. Contact your state oral health department to see if any grants are available in your area.

Small systems may also use state revolving loan funds for fluoridation equipment and installation. Contact your state department of environmental protection for more information.

AWWA has an updated fluoridation manual, *Water Fluoridation Principles and Practices* (M4) 5th Edition, available at *www.awwa.org/bookstore/product.cfm?id=30004.*

The CDC offers *Engineering and Administrative Recommendations for Water Fluoridation, 1995* (MMWR Vol. 44, No. RR-13) available via download from their Web site or through the Division of Oral Health, National Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and Prevention, e-mail: *oralhealth@cdc.gov.*

The CDC also posts fluoridation and oral health fact sheets on their Web site at *www.cdc.gov/OralHealth/factsheets/index.htm.*

Darle Setler can answer questions about the fluoridation system at the Taylor County Public Service District in Grafton, West Virginia. Call him at (304) 265-5569.

Michelle Moore, *On Tap* associate editor, welcomes reader feedback—both positive and negative—on her articles. Contact her at *michelle.moore@mail.wvu.edu.*

CHLORINE

Disinfection Byproducts and Waterborne Disease: The Need For Balance Is Essential

By **Vipin Bhardwaj** • NESC Engineering Scientist

Using chlorine to disinfect drinking water was the single, most important public health practice in preventing waterborne diseases in the 20th century. Disinfection has virtually eradicated a number of waterborne diseases, such as typhoid, cholera, and dysentery, and has literally saved millions of lives. But all of the news about chlorine isn't good.

In 1974, J.J. Rook discovered that free chlorine reacts with organic matter and forms a wide range of substances known as disinfection byproducts (DBPs). The reaction happens when naturally occurring carbon compounds, such as decayed vegetation, fish, or aquatic organisms, disintegrate. Other chlorine-based disinfectants, such as chloramines and chlorine dioxide, also may form DBPs.

Some of these DBPs can cause cancer, as shown in experiments on animals in laboratory studies, and others can cause acute health problems, such as liver damage. The discovery of DBPs and their adverse health effects highlights the necessity for better understanding the disinfection process. And, it also means that researchers must strike a balance between preventing waterborne disease and the health effects that DBPs cause.

Types of Disinfection Byproducts

When chlorine reacts with organic matter, hundreds of DBPs may form. Two major classes make up the bulk: trihalomethanes (THMs) and haloacetic acids (HAA).

THMs include chloroform, bromoform, bromodichloromethane, and dibromochloromethane. HAAs are commonly abbreviated as HAA5, and include chloroacetic acid, dichloroacetic acid, trichloroacetic acid, bromoacetic acid, and dibromoacetic acid.

Although THMs and HAAs are the major DBPs, there are a variety of other disinfection compounds, such as haloacetonitriles, haloketones, haloaldehydes, chloropicrin, cyanogen chloride, and chlorophenols.

Recently, alternative disinfectants, such as chloramines, chlorine dioxide, and ozone, also have been found to react with organics and can form DBPs.

Health Effects of Disinfection Byproducts

THMs

The four THMs are regulated together as total trihalomethanes (TTHMs). The current maximum contaminant level (MCL) for THMs is 0.080 milligrams per liter (mg/L). The sum of the concentrations of each compound cannot exceed 0.080 mg/L. Samples are taken quarterly and the average of the four samples must not exceed 0.080 mg/L.

Chloroform affects liver and kidney function in humans in both acute and chronic exposures. In lab studies on mice and rats, three THMs, bromoform, bromodichloromethane, and dibromochloromethane caused changes in kidney, liver, and serum enzyme levels and decreased body weight.

Haloacetic Acids

Dichloroacetic acid (DCA) and trichloroacetic acid (TCA) are found more often among the HAA5s. The MCL for HAA5s as a whole group is 0.060 mg/L.

The U.S. Environmental Protection Agency (EPA) has classified DCA as a human carcinogen. Human exposure studies indicated that people exposed to DCA for six to seven days at 43 to 57 mg/kg/day showed mild sedation, reduced blood glucose, reduced plasma lactate, reduced plasma cholesterol, and reduced triglyceride levels. Studies in mice and rats showed that it causes liver tumors.

Studies have shown that TCA can produce developmental malformations in rats, particularly in cardiovascular systems.

What do the regulations say?

The Stage 1 Disinfectants and Disinfection Byproducts Rule took effect on January 1, 2004, and applies to community water systems and non-transient non-community systems, including those serving fewer than 10,000 people that add a disinfectant during any part of the treatment process. In addition, a Stage 2 DBPs Rule has been proposed to supplement the Stage1 DBP Rule. It will require systems to comply with a DBP MCL at each location of the monitoring site.

The Stage 1 DBP Rule applies to all systems that add chlorine, chloramines, or chlorine dioxide as a disinfectant. It requires new maximum residual disinfectant levels (MRDLs) for chlorine (4 mg/L), chloramines (4 mg/L), and chlorine dioxide (0.8 mg/L). MRDLs are like MCLs that are applicable to disinfectants. The MRDLs keep disinfectant levels low enough to minimize DBP formation and limit health effects.

The rule specifies MCLGs for four trihalomethanes:

- chloroform (zero),
- bromodichloromethane (zero),
- dibromochloromethane (0.060 mg/L),
- bromoform (zero).

Chlorine is hard to beat when it comes to disinfecting. The operators at Tygart Valley Water Plant take all of the necessary precautions when dealing with their chlorine disinfection system.

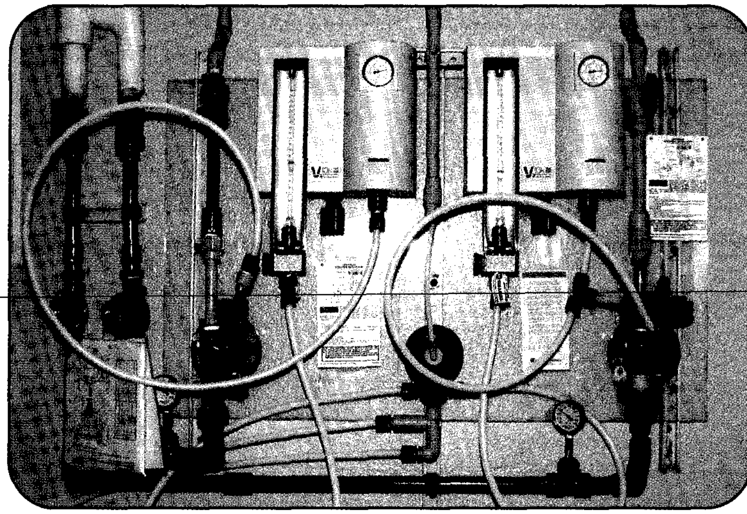


Photo by Julie Black

Two groups of haloacetic acids:

- dichloroacetic acid (zero) and trichloroacetic acid (0.3 mg/L),
- bromate (zero) and chlorite (0.8 mg/L).

The rule requires treatment techniques to remove natural organic matter and specifies MCLs for:

- total trihalomethanes—the sum of the four listed above (0.080 mg/L),
- haloacetic acids (HAA5) (0.060 mg/L)—the sum of the two listed above plus monochloroacetic acid and mono- and dibromoacetic acids, and
- two inorganic disinfection byproducts (chlorite (1.0 mg/L) and bromate (0.010 mg/L).

The Stage 1 Rule requires systems to develop a monitoring plan that outlines schedules for collecting samples and their locations. The plan must cover the entire distribution system. The number of people that the system serves determines sampling frequency. Table 1 gives the frequency of samples.

Compliance is based on the running annual average (RAA) of monthly averages of all compliance samples collected in the last 12 months. Compliance must be calculated each quarter, using the results from the previous 12 months. Any RAA of monthly averages that exceeds the MRDL is a violation.

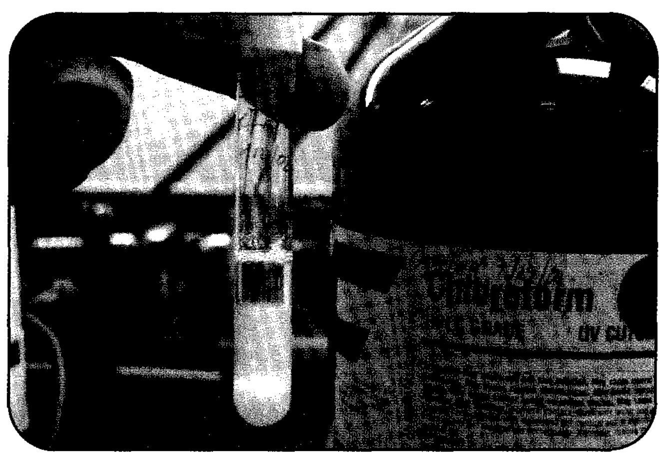


Photo by David B. Fankhauser, Ph.D., *http://biology.clc.uc.edu/fankhauser/*

Stage 2 Rule

The Stage 2 DBP Rule goes a step further. It requires systems to evaluate themselves and identify locations within their distribution systems that have higher residence time or pockets of water that stay in the distribution system longer. Samples would have to be taken at these sites. EPA calls this process initial distribution system evaluation (IDSE). Under the Stage 2 DBP Rule, MCLs for TTHMs and HAA5s will be calculated at each monitoring site. This is known as a locational RAA, (i.e., running yearly averages of each sample collected at the specified location).

The Stage 2 Rule is more difficult for systems to comply with because DBP levels in some parts of a distribution system can be higher than when water is standing at one point. The Stage 2 Rule is expected to take effect by 2005.

Methods to Treat DBPs

There are four approaches to alleviate DBPS:

1. minimizing precursors,
2. reducing disinfectant doses,
3. removing DBPs after their formation, and
4. using alternative disinfectants.

Minimizing Precursors

One way to prevent DBPs is to prevent the occurrence of natural organic matter in the source water. System operators can:

- reduce the precursor content of raw water, such as blending source waters,
- remove precursors in the plant,
- disinfect the water after all other treatment has been completed, or
- a combination of the three.

Adsorption with granular activated carbon (GAC) and coagulation with alum and ferric salts may reduce natural organic matter levels.

Reducing Disinfectant Dosages

Reducing the primary and secondary disinfection dosages and introducing booster chlorination later in the distribution system can reduce the overall disinfectant dosage. Eliminating prechlorination altogether also will prevent organic matter from coming in contact with chlorine. Also, including an anthracite layer in the filter or feeding activated carbon before the filtration step will adsorb organic matter before filtration. Chlorination can then be performed later.

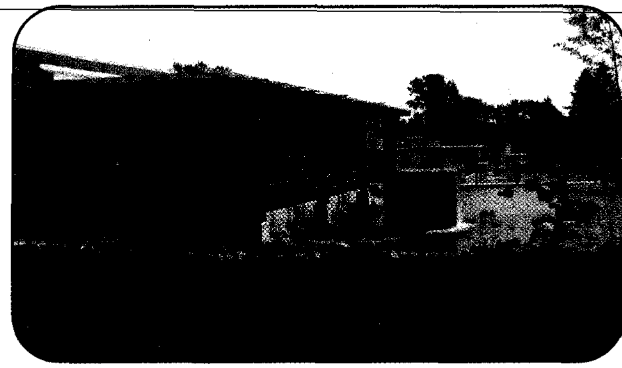
Removing Disinfection Byproducts

EPA identified enhanced coagulation, enhanced softening, or granular activated carbon as the best available technologies (BATs) for removing THMs and HAAs. However, these methods are expensive and must be used only after other methods have been tried. GAC adsorption method requires long columns with substantial carbon content.

Alternative Disinfectants

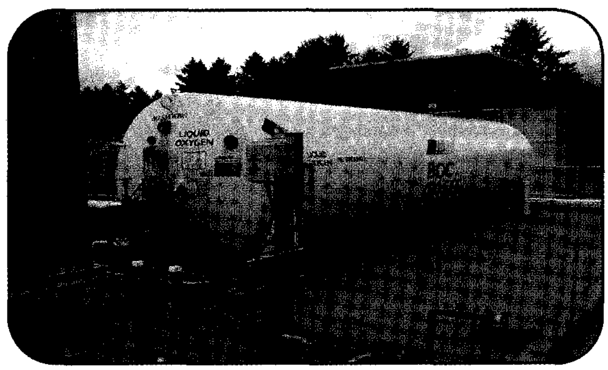
Alternative disinfectants are ultraviolet light (UV), potassium permanganate, ozone, or a combination of chlorine dioxide and chloramines.

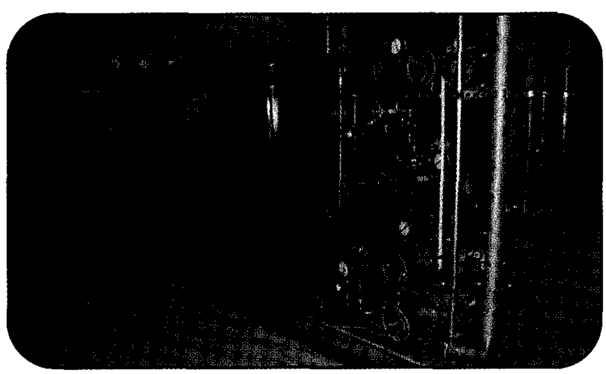
Chlorine gas is inexpensive and effective. None of the other disinfectants are as economical as chlorine. Ozone is a powerful disinfectant, which does not produce chlorinated organics but does create other byproducts. Additonally, ozone does not have a residual so it is used along with chloramines that



Photos Source: Wilsonville, Oregon Water Treatment Plant

Wilsonville, Oregon, is a city of approximately 14,000 people. Their water treatment plant, located on the Willamette River, has enhanced methods of water treatment incorporated into the design of their multi-barrier system, which includes an ozonation disinfection process.





Photos Source: Wilsonville, Oregon Water Treatment Plant

Liquid oxygen is used to generate ozone for the treatment process. The machine pictured above converts the oxygen gas (O_2) into ozone (O_3). After the ozone is bubbled through the water in the treatment process, the ozone is converted back to oxygen gas and released to the atmosphere. For more information visit their Web site at *www.ci.wilsonville.or.us/departments/pw/water/WRWTP.htm.*

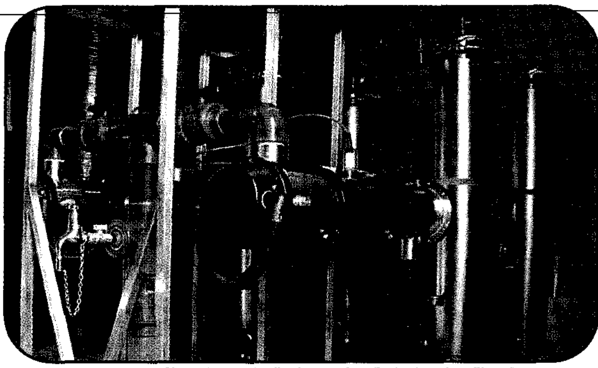
provide a residual. When UV disinfection is used, it also has the same problem of no residual, and chloramines or chlorine is used for the residual. UV is not effective for turbid waters, and UV effectiveness decreases with increasing turbidity.

Some states do not recognize other disinfectants and will not approve them unless they are used along with chlorine or chloramines that provide a residual. Systems need to check with their primacy agencies before selecting alternative disinfectants.

Chlorine Is Hard to Replace

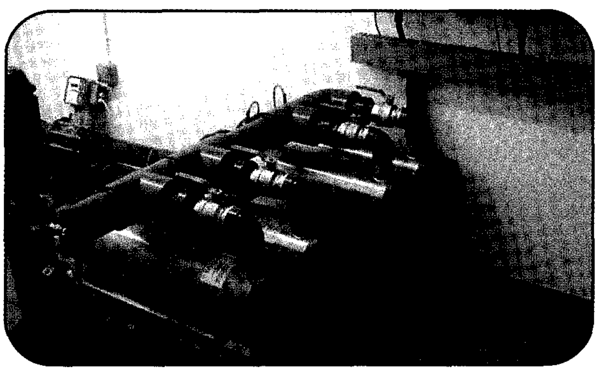
Chlorine is the traditional chemical disinfectant in drinking water, used since the early 20th century to inactivate or chemically kill microorganisms in our drinking water. Chlorine has a proven record of reliability in drinking water safety, which is hard to replace.

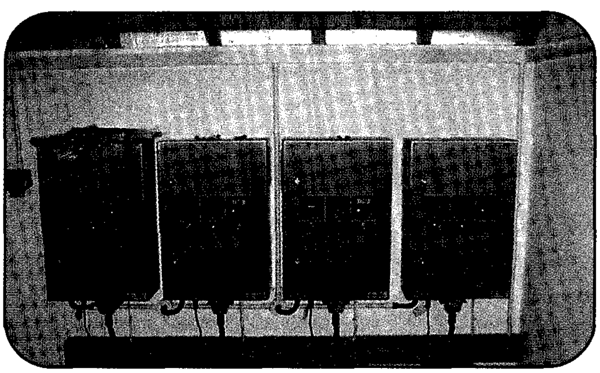
With the new disinfection byproduct rules, utilities have to balance the benefits of safety of public health through disinfection, on one hand, and the risk of byproducts of disinfection, on the other.



Photos Source: Snodland Town, Kent, England Drinking Water Services

Snodland Town, Kent, England has a population of approximately 9,000. The town installs a variety of small water treatment systems to meet individual needs. A wide range of disinfection options are offered including small UV treatment units, filters, and monitors.





Photos Source: Snodland Town, Kent, England Drinking Water Services

For more information visit their Web site at *www. drinking-water.co.uk/index.htm.*

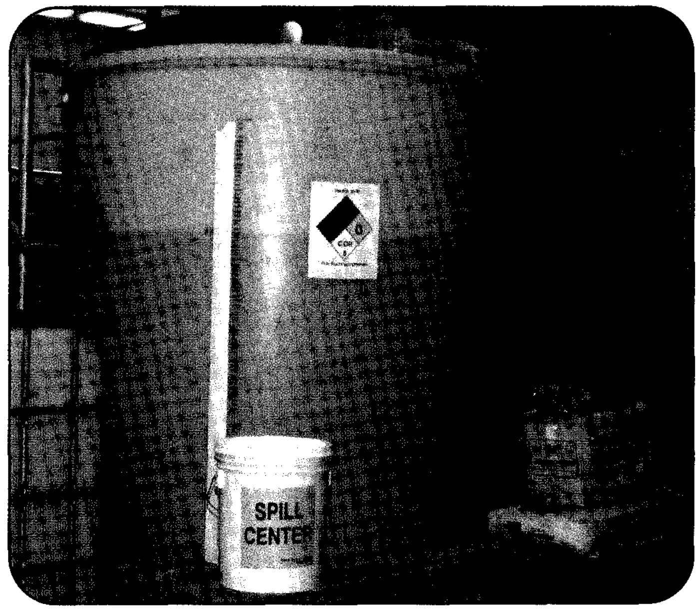


Photo by Julie Black

Many small drinking water plants in the U.S. use chlorine disinfection because of its proven record.

Where Can I Find More Information?

U.S. Environmental Protection Agency, Office of Ground Water and Drinking Water. *www.epa.gov/OGWDW/mdbp.html.*

American Water Works Association. 1999. *Water Quality and Treatment, A Handbook of Community Water Supplies, Fifth Edition.* McGraw Hill.

American Water Works Association. 1993. *Controlling Disinfection Byproducts.* AWWA: Denver, Colorado.

HDR Engineering, Inc., 1991. *Handbook of Public Water Systems, Second Edition,* John Wiley and Sons:Omaha, NE.

U.S. Environmental Protection Agency Satellite Training, *Stage 1 Disinfectants and Disinfection Byproducts Rule.* May 18, 2004.

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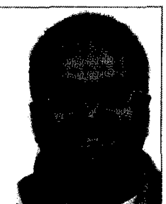


What does ppm or ppb mean?

By **Zane Satterfield, P.E.**
NESC Engineering Scientist

What is ppm and what does it mean?

Most contaminants are expressed as parts per million (ppm). This means that the concentration of a particular substance is very low even though the regulatory agency may consider it a significant amount.

One ppm is 1 part in 1 million or the value is equivalent to the absolute fractional amount multiplied by one million. A better way to think of ppm is to visualize putting four drops of ink in a 55-gallon barrel of water and mixing it thoroughly. This procedure would produce an ink concentration of 1 ppm. Would that be safe to drink? Well, that depends on what the ink is made of, and what was in the barrel before the water.

Parts per million also can be expressed as milligrams per liter (mg/L). This measurement is the mass of a chemical or contaminate per unit volume of water. Seeing ppm or mg/L on a lab report means the same thing.

The University of Minnesota provides some other analogies that may help you visualize the scale involved with ppm and ppb. One ppm is like:

- one inch in 16 miles,
- one second in 11.5 days,
- one minute in two years, or
- one car in bumper-to-bumper traffic from Cleveland to San Francisco.

Is 1 mg/L equal to 1 ppm?

Metric system units go in steps of 10, 100, and 1,000. For example, a milligram is a thousandth of a gram (moving the decimal point three places to the left) and a gram is a thousandth of a kilogram (again a difference of three places to the left on the decimal point). Thus, a milligram is a thousandth of a thousandth, or a millionth of a kilogram moving the decimal point six places.

1,000.	kilogram	kg	10^3
100.0	hectogram	hg	10^2
10.00	dekagram	dag	10^1
1.000	gram	g	-
0.1	decigram	dg	10^{-1}
0.01	centigram	cg	10^{-2}
0.001	milligram	mg	10^{-3}
0.000,001	microgram	µg	10^{-6}

So, a milligram is one ppm of a kilogram; therefore, one ppm is the same as one milligram per kilogram.

- milligram/kilogram or
- mg/kg or
- 0.001/1,000 or
- $10^{-3}/10^3$

One milligram in a kg is 1 ppm (by mass). One liter (L) of pure water at 4°C and 1 standard atmosphere pressure weighs exactly 1 kg, so 1 mg/L is 1 ppm. Another way to say it is a liter of water weighs 1,000 grams or 1 million milligrams. Therefore, 1 mg in 1 liter is 1 mg in 1 million milligrams or 1 part per million.

What is ppb?

An even smaller concentration measurement is parts per billion (ppb). One ppb is one part in 1 billion. One drop of ink in one of the largest tanker trucks used to haul gasoline would be an ink concentration of 1 ppb. It is important to know the difference between ppm and ppb.

A common mistake is reporting a concentration as ppm when it is really ppb. This is a big difference, such as the difference between $1 and $1,000. As a ppm is equal to mg/L, then ppb is equal to microgram per liter (µg/L). A µg/L is 1 thousandth of a mg/L. Most water analysis will have the concentration reported in ppm or mg/L and/or ppb or µg/L. When reading the lab results, be careful as they could switch the units back and forth between contaminants. For example:

- 1 ppm = 1 mg/L = 1/1 million = 0.000001
- 1 ppb = 1 µg/L = 1/1 billion = 0.000000001

Some labs will report their analysis in ppb instead of ppm. Labs will do this to have the results in whole numbers instead of a bunch of zeros with a number on the end, because some people think that whole numbers are simpler to read and understand. EPA uses ppm in most of their literature for the National Primary Drinking Water Standards.

Four drops of ink in one 55-gallon barrel of water (mixed thoroughly) would produce an ink concentration of 1 ppm.

Below are some examples of how important it is to pay attention to the units or the concentration amount.

Take the inorganic chemical arsenic, for example. On January 23, 2006, the maximum contamination level (MCL) will be 0.010 ppm or mg/L. The MCL also can be stated as 10 ppb or µg/L. It is important to get the units straight because it could possibly mean the difference between the system violating the MCL or not.

Another inorganic chemical, beryllium, has an MCL of 0.004 ppm or mg/L, where, again, the MCL can also be stated at 4 ppb or µg/L. If units are not correct, it could mean the possibility of intestinal lesions for the system's customers. The point is: Be sure of the units. If you are more comfortable seeing ppm instead ppb, request that the lab report the results in the units you want. If the results are going to be reported in the consumer confidence report (CCR), be sure to check with your state primacy agency. They may require a certain unit to be used. Therefore, be careful when converting from one unit to another. Moving the decimal the wrong way can make all the difference.

Because a ppb is a much lower concentration, other analogies would be:

- one silver dollar in roll stretching from Detroit to Salt Lake City,
- one sheet in a roll of toilet paper stretching from New York to London,
- one second in nearly 32 years, or
- one pinch of salt in 10 tons of potato chips.

Why are ppm and ppb important measures?

These measurements refer to exposure standards and guidelines created to protect the public from harmful substances that can cause serious health effects. Exposure standards and guidelines are created from risk assessments that include dose-response, exposure, and hazard identification assessments.

The dose-response relationship is a fundamental and essential concept in toxicology. If toxicologists know that a substance is toxic or poisonous at a particular level, they can use this information to develop exposure standards. Knowledge of the dose-response relationship:

- establishes causality that the chemical has, in fact, induced the observed results,
- determines the lowest dose where an induced effect occurs—the threshold effect, and
- verifies the rate at which injury builds up—the slope for the dose response.

The threshold effect refers to the point where the body's ability to detoxify itself has been exceeded. The slope for the dose response refers to the predictability of how toxic a substance will be at specific doses to a wide range of people. Major differences may exist not only in the point at which the threshold is reached in some people but also in the percent of the population responding to small changes in the dose.

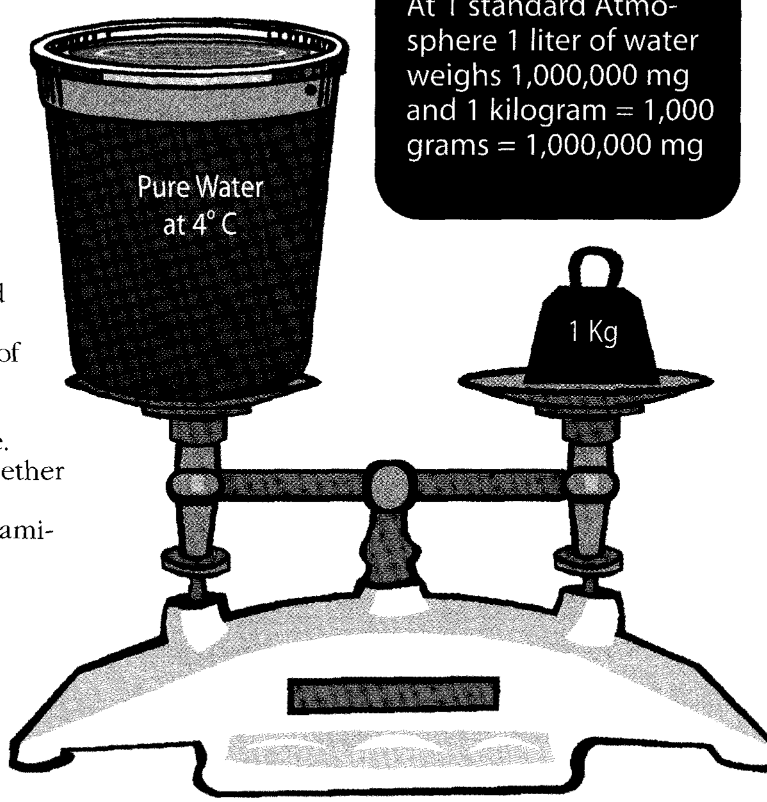
To uncover whether people have been exposed to a contaminant, researchers conduct tests to determine if a contaminant is present and at what levels.

Hazard identification means that a contaminant has been recognized to be a risk.

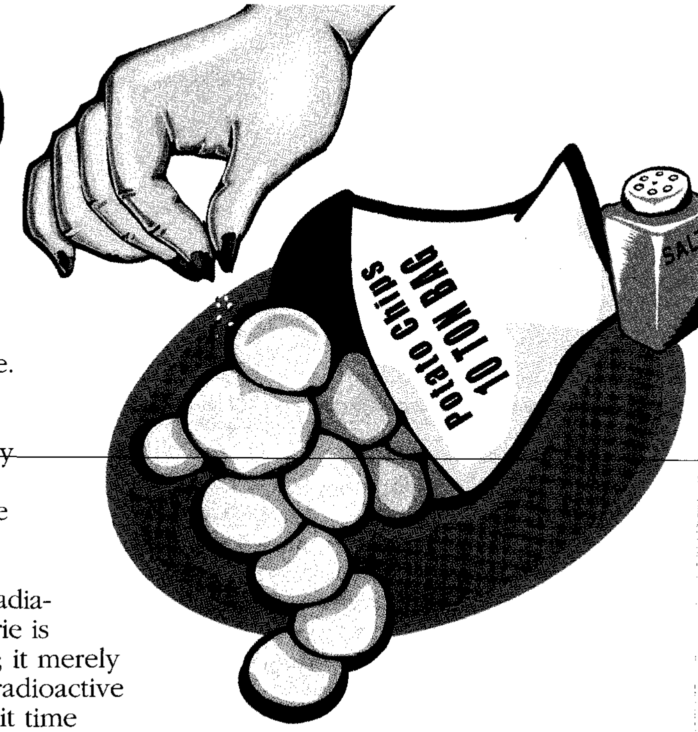
What are some other units that might be seen on a water analysis?

Other units or concentration that may be seen on a lab report besides ppm, mg/L, ppb, or µg/L, might be color units, threshold

At 1 standard Atmosphere 1 liter of water weighs 1,000,000 mg and 1 kilogram = 1,000 grams = 1,000,000 mg



One ppb is like adding a pinch of salt to a 10 ton bag of potato chips.



odor number, pH index, corrosive index number, and, for radionuclides, the units pCi/L [picocuries per liter] and millirems per year are used.

Pronounced py-coe-cure-ee, pCi/L is a measurement of radioactivity in water. Radioactivity is commonly measured in picocuries (pCi). This unit of measure is named for the French physicist Marie Curie, who was a pioneer in the research of radioactive elements and their decay. One pCi is equal to the decay of about two radioactive atoms per minute.

Because the level of radioactivity is directly related to the number and type of radioactive atoms present, radon and all other radioactive elements are measured in picocuries. A picocurie is 1 million millionth, or a trillionth, of a curie, and represents about 2.2 radioactive particle disintegrations per minute. One curie equals 3.7 x 1010 disintegrations per second.

A millirem is 1 thousandth (10^{-3}) of a Roentgen Equivalent Man (rem) and a rem is a radioactivity unit—a measure of radioactivity, which is the dosage of ionizing radiation that will cause the same amount of injury to human tissue as 1 roentgen of X-rays. The name Roentgen comes from Wilhelm Conrad Röntgen.

Röntgen's name is chiefly associated with his discovery of X-rays. In 1895 he was studying the phenomenon accompanying the passage of an electric current through a gas of extremely low pressure. To give you a better idea of how much a millirem is a chest x-ray is about 6 millirem (mrem). The rem is the unit of absorbed dose measuring the energy imparted by ionizing radiation to matter. The Curie is not a measure of dose; it merely states the amount of radioactive disintegrations per unit time (radiation activity).

Using these analogies may help in understanding how the measurements ppm and ppb are used in water system laboratory reports.

For more information about how to decipher a lab report, call the National Environmental Services Center at (800) 624-8301 and ask for a technical assistant.

One ppb is like one sheet in a roll of toilet paper stretching from New York to London.

References:

The American Heritage Dictionary of the English language; fourth edition
www.bartleby.com/61/34/M0303450.html

The Cardinal Surveys Company
www.cardinalsurveys.com/glos.htm

The Free Dictionary dot com
www.thefreedictionary.com/REM

Informationsphere.com
www.informationshere.com/html/493.htm

Kimball's Biology Pages *users.rcn.com/jkim ball.ma.ultranet/BiologyPages/P/Ppm.html*

Michigan State Department of Environmental Quality
www.michigan.gov/deq/0,1607,7-135-3310_4104_4196-10588--,00.html

Michigan State University Extension
www.msue.msu.edu/msue/imp/mod02/0 1500585.html

The National Safety Council Radiation
www.nsc.org/issues/rad/exposure.htm)

The NOBEL e-MUSEUM
www.nobel.se/physics/laureates/1901/ront gen-bio.html)

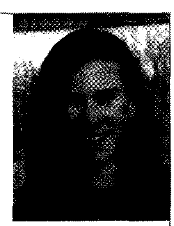
University of Minnesota Web site
www.seagrant.umn.edu/water/report/help fulinformation/concentrations.pdf

The University of the West Indies, Chemistry Department, Dhanial De Lloyd
delloyd.50megs.com/photo.html

Water on the Web–understanding
wow.nrri.umn.edu/wow/under/units.html

Wikipedia, the free encyclopedia
en.wikipedia.org/wiki/Parts_per_million

Zane Satterfield came to the National Environmental Serivices Center from the West Virginia Bureau of Public Health, where he worked as a system inspector. He also has worked for the Fairmont, West Virginia, engineering office, gaining valuable experience with water and wastewater treatment.



Julie Black has been the graphic designer of *On Tap* for more than three years. She also moonlights as a writer/photo journalist for an online magazine.

In New England, Source Water Protection Just Makes Sense

By **Chain-Wen Wang**, Ed. D, • NESC Contributing Writer

When more than 450 people showed up at a June 2003 U.S. Environmental Protection Agency's (EPA) National Source Water Protection Conference in Washington, DC, the intense interest in the topic surprised the agency. Besides the number of attendees, the diversity and number of presentations indicated the complexity that protecting our drinking water sources entails.

Source water protection is not a new concept. But, the reality of limited resources and the increasing demand for both quality and quantity of drinking water makes it more important than ever.

Protecting source water makes sense for several reasons: it improves public health, reduces treatment challenges and costs, and enhances overall environmental stewardship. What is new to source water protection, however, is its expanding scope. It has gone beyond the watershed level and has developed into a strategy that emphasizes partnerships, coordination, technology, and communication. The completion of 165,000 source water assessments across the country means that implemention of these protection programs is at hand.

Photo by Chain-Wen Wang

Members of the New England Interstate Water Pollution Control Commission discuss ways to implement source water protection in their region.

Group Epitomizes Teamwork

Implementation is exactly what the member states of one interstate agency are doing. The New England Interstate Water Pollution Control Commission (NEIWPCC) member states, which includes Connecticut, Maine, Massachusetts, New Hampshire, New York, Rhode Island, and Vermont, have not only worked together sharing information while developing their source water assessment program (SWAP) reports, but they also

Photo by Julie Black

Many source water areas in New England need to be protected not only for drinking water, but for recreation activites as well.

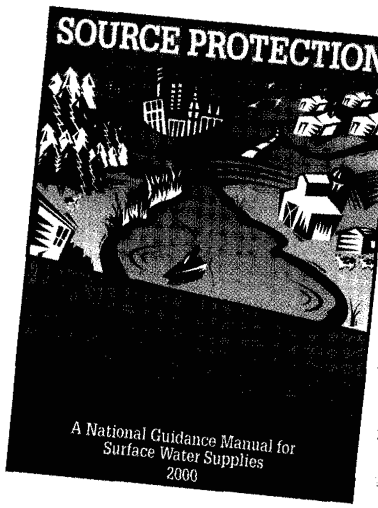
plan to continue working together when the time comes to implement plans and provide public education.

To demonstrate the degree of collaboration among its members, Kara Sergeant, NEIWPCC's groundwater and source water protection workgroup coordinator, uses a SWAP interstate data gathering grant as an example. In 1998, NEIWPCC received an EPA grant to assist the New England states and New York with interstate source water assessments. NEIWPCC gathered data and coordinated information exchange among the states, including SWAP-related geographic information system (GIS) reports, wellhead protection programs, and information about local efforts to protect interstate drinking water sources.

"It was a big effort to get states to share resources and data, especially in source protection areas that overlapped into other states," says Sergeant.

"They discussed everything from how they ranked water systems to recalculating protection zones," she recalls. "Although the data gathering project was primarily aimed at interstate uses, the information was useful for all SWAPs."

Project Produces Guide



The project produced several documents that state source water protection coordinators can use as guides to help them understand and compare state and local source water protection efforts, including the *New England States' and New York's GIS Coverages Index: A Guide to States SWAP Related GIS Coverages; Susceptibility Assessment and Contaminant Inventory Summaries*; and *Source Protection Program Summaries.*

According to Sergeant, even though the project is finished and most member states have completed their SWAP reports, the states continue to work together through the NEIWPCC workgroup. They are now working with each other on ideas for implementation and getting communities to understand and use the information in their SWAP reports.

Coordination and communication has long been a tradition among NEIWPCC's member states. Even so, the workgroup faced some tough challenges along the way. Sergeant explained that underground storage tank programs (USTs) were one of the group's most daunting challenges.

"USTs are a major threat to drinking water supplies, yet most states continually find it difficult to coordinate UST programs about source protections issues," she says. "[But, because of the SWAP reports] the state groundwater workgroup is able to document and identify that USTs are one of the top five threats to drinking water supply in our region."

In May 2004, the groundwater workgroup held a joint session with the NEIWPCC UST workgroup to discuss ways to work together on source water protection issues. The groups identified successful communication efforts and also looked for areas they could improve. As a result of the workgroups' efforts, the program directors of EPA's Office of Groundwater and Drinking Water (OGWDW) and UST programs became interested in the idea and issued a memo discussing ways the two national programs could work together.

Integration Leads to Cooperation

Another challenge the workgroup faced was integrating Clean Water Act (CWA) programs with Safe Drinking Water Act (SDWA) programs so that the outcome would lead to adequate source water protection measures.

"Clearly, some CWA programs impact drinking water quality," observed Sergeant. "However, these programs view water resources from a different perspective, which includes supporting aquatic life and recreation activities. Because of this, they do not always view drinking water as the highest priority."

To overcome this challenge, Sergeant's group, as well as many other state agencies and organizations, have been exploring links with CWA-associated programs, such as the Total Maximum Daily Load (TMDL) program and the Non-Point Source (NPS) program in an integrated watershed management approach to protect water quality.

Can't Work Alone

In addition to the help that NEWIPCC provides, other organizations, such as state Rural Water Associations and local universities, provide source water protection technical assistance to the New England states.

The Rhode Island Department of Health is partnering with the University of Rhode Island to develop the Rhode Island Source Water Protection Program.

New Hampshire partners with numerous state and regional organizations to promote effective source water protection plans. These organizations include the Northeast Rural Water Association (NeRWA), the Society for the Protection of New Hampshire Forests, Northeastern Rural Community Assistance Partnership (NeRCAP), the New Hampshire Department of Agriculture, and the New Hampshire Water Works Association. The state also looked into how to use key federal and state programs, such as the non-point source program and agricultural programs to benefit source water protection activities.

Kevin McGraw, a source water protection specialist with NeRWA, sees things from a slightly different perspective. Unlike Sergeant, McGraw doesn't deal with source water protection at the interstate level. Working within the state of Vermont, McGraw regards source water protection as a more personal experience.

"When we talk about source water protection now, we are talking about a source water protection plan," McGraw says. "And the plan is to identify the sources of potential contamination, which is what the source protection assessment is about.

"In Vermont, source water protection plans are required for many public water systems. These plans identify potential contamination, assess the risk that those contaminants pose, and present a management plan to help reduce the risk to drinking water sources. At this point, most of the plans have been completed, and we are now focusing on helping water systems implement their water management plans.

"We want to have a management plan—a plan that will help us reduce the risk of contamination and ensure the quality of our source waters. Then, we should have an implementation plan that will lead to the actual protection our source waters." Sounds simple. But reality proves otherwise.

Small Systems Face Biggest Challenges

One of the biggest challenges small Vermont drinking water systems faced was that it was too hard for them to make source water protection a priority.

According to McGraw, "[small systems] don't even have enough personnel or resources to do what they are supposed to do as is—not to mention the lack of support from local officials on something that is not required by law.

"As I already mentioned, these source water protection plans are required for many public Vermont water systems. It is true, however, that many systems do not have the resources or know-how to prepare a source water protection plan or implement the protection strategy."

So what's the solution?

"Education," McGraw explains. "Educating the public, educating the local officials, and

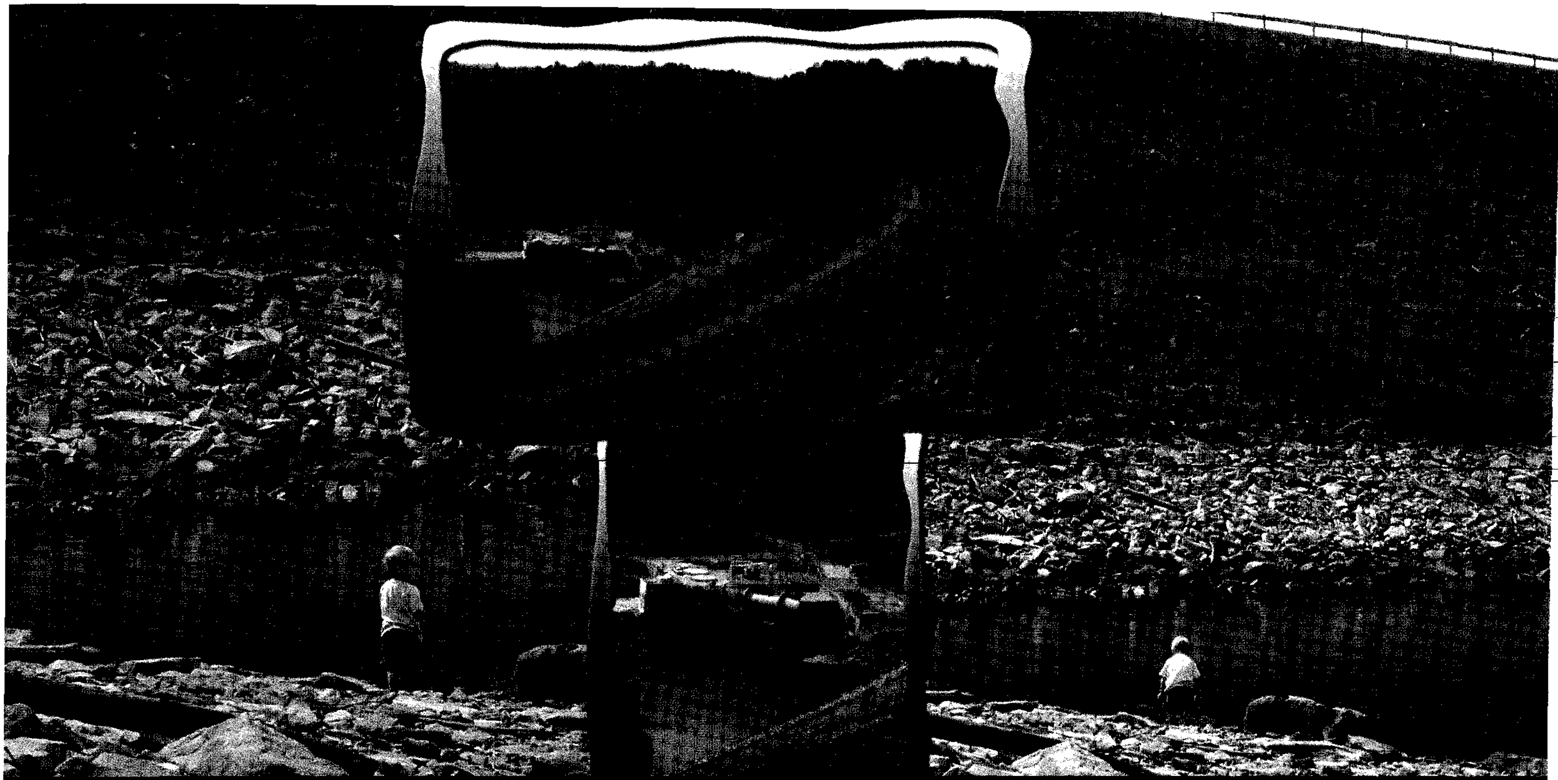
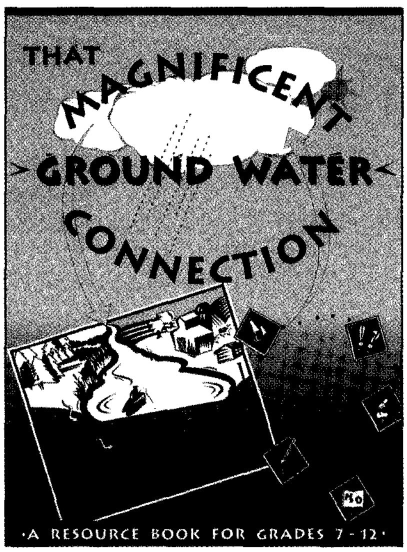


Photo by Julie Black

People not only contribute to environmental deterioration, they also are its potential victims. Teaching people how to take care of the water they drink, and use for recreational activities is fundamental to environmental protection.

educating the land owners. They need to understand where their drinking water comes from, how their actions affect its quality, and to support efforts to protect it.

"We've been lucky. In Vermont, we haven't had the developmental or population pressures that often make source water protection difficult, if not impossible."



Rodney I. Pingree, water resources section chief, Vermont Department of Environmental Conservation, shares McGraw's view and says that the biggest challenge for Vermont will be "to act now to prevent potential impacts from future development" because land-use activities directly affect water quality.

Pingree points out that many source water protection issues are not related to land-use activities, such as naturally occurring contaminants, source construction, and water shortages, and they also will need to be incorporated into any source water protection strategy. But, he argues that many of Vermont's source water threats point straight to common, land-use activities, such as septic systems and agricultural practices.

Drought Causes Changes

Sergeant also cites the issue of water quantity as a future challenge New England states will have to face. Although New England states are historically water-rich areas, the region experienced a fairly intense drought a few years ago. That experience caused the states to increase their focus on water quantity issues, such as how to enhance the amount of water available and how to keep water resources local.

The drought was one of the main reasons that NEIWPCC's workgroup started looking into the possibility of artificial recharge. To date, she points out that none of the states have policies managing artificial recharge. "It will be an ongoing process,we'll continue to invite states and other experts to share what they know with us."

Security Sets Off Alarms

But does having a designated source water protection area jeopardize system security? "EPA was concerned this posed a security issue because maps in the SWAP report show the location of drinking water wells," Sergeant replied. "EPA was being careful after 9/11 to protect water supplies from possible terriorist attack. Because of this, some states decided not to post their SWAP reports on their Web sites, others chose to remove the actual location from the map and just have a delineated protection area, or they placed the report online, but not the map."

McGraw explains that Vermont has no specific requirement for security issues to be part of the source water protection plan—at least not directly." But, he pointed out that systems still have to take any security threat seriously, "even if it is just an act of vandalism by some high school kids—the system still has to treat it like any potential terrorist attack.

"Source water protection plans in Vermont need to include a contingency plan for responding to emergency loss of the water supply," he explains. "These contingency plans outline steps that the water systems should follow in the event that their drinking water sources become contaminated, are at risk of becoming contaminated, decline in yield, or need mechanical repair. The contingency plan also can help systems respond to vandalism or possible terrorist threat."

New Hampshire promotes security in a number of ways, according to Sarah Pillsbury, program supervisor, New Hampshire Office of Environmental Services. The state assists water systems with vulnerability assessments and emergency response plans, provides planning grants to large systems to address mutual aid/interconnection needs, establishes protocols for roles in an emergency, and funds security measures.

Source: www.photos.com

New England systems have to take security threats seriously. Vulnerability assessments help small drinking water plants evaluate the chance of a real threat.

Efforts Create Framework

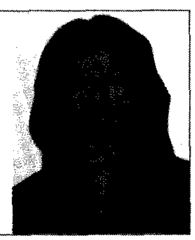
Between the New England states' efforts, combined with assistance from NEIWPCC and NeRWA, the region is in good shape when it comes to source water protection resources. And the organizations that supply the region with so much support vow to be there when they are needed.

"The workgroup is not done with source protection," says Sergeant. "It has a long history of collaborating and tackling source protection issues. In the future, the workgroup will be looking for ways to expand its federal, state, and local partnerships to bring home the message on source water protection." She says that good old "Yankee ingenuity" will help the states cope with future challenges.

The major messages that come out of New England's successful source water protection programs provide the framework for other states or regions that may need a little help in developing their own programs. Those messages convey that partnerships are priceless, coordination is essential, outreach and education are imperative, and communication is key. Putting those ingredients together creates a recipe that won't disappoint even the most finicky tastes.

New opportunities to support source water protection are just starting. The efforts of the New England states provide a testimony to the truth of the statement "shared problems, shared solutions."▲

Contributing writer **Chain-Wen Wang** is actively involved with watershed groups, including the Downstream Alliance, in northern West Virginia.



Obtaining Accurate, Complete Information

By **Natalie Eddy** · NESC Staff Writer

How good is the database that the U.S. Environmental Protection Agency (EPA) uses to track the nation's drinking water quality? EPA's own Office of the Inspector General (OIG) raised that issue recently in a 20-page memo questioning the accuracy of the data.

The March 2004 OIG memo, *EPA Claims to Meet Drinking Water Goals Despite Persistent Data Quality Shortcomings*, states that EPA incorrectly reported meeting its drinking water goal under the Government Performance and Results Act (GPRA) from 1999 to 2002.

"In each of those years, EPA reported that it met its annual goal of 91 percent of the population drinking water that met health-based standards," OIG's memo states. "However, EPA's own analysis, supported by our review, indicated the correct number was unknown but less than what was reported."

Despite questions of data quality shortcomings, Ben Grumbles, EPA acting assistant administrator, says the data is accurate, but incomplete.

"The data is improving, but it's still inadequate," says Grumbles. "We have an aggressive plan to improve it. We are putting a priority on working with state partners to improve the completeness of the data and plan to follow up on that."

Grumbles stresses that the incomplete data in no way implies unsafe drinking water conditions exist in the U.S. The OIG report agrees, noting that "this inaccuracy in reporting does not necessarily indicate a direct or immediate threat to human health."

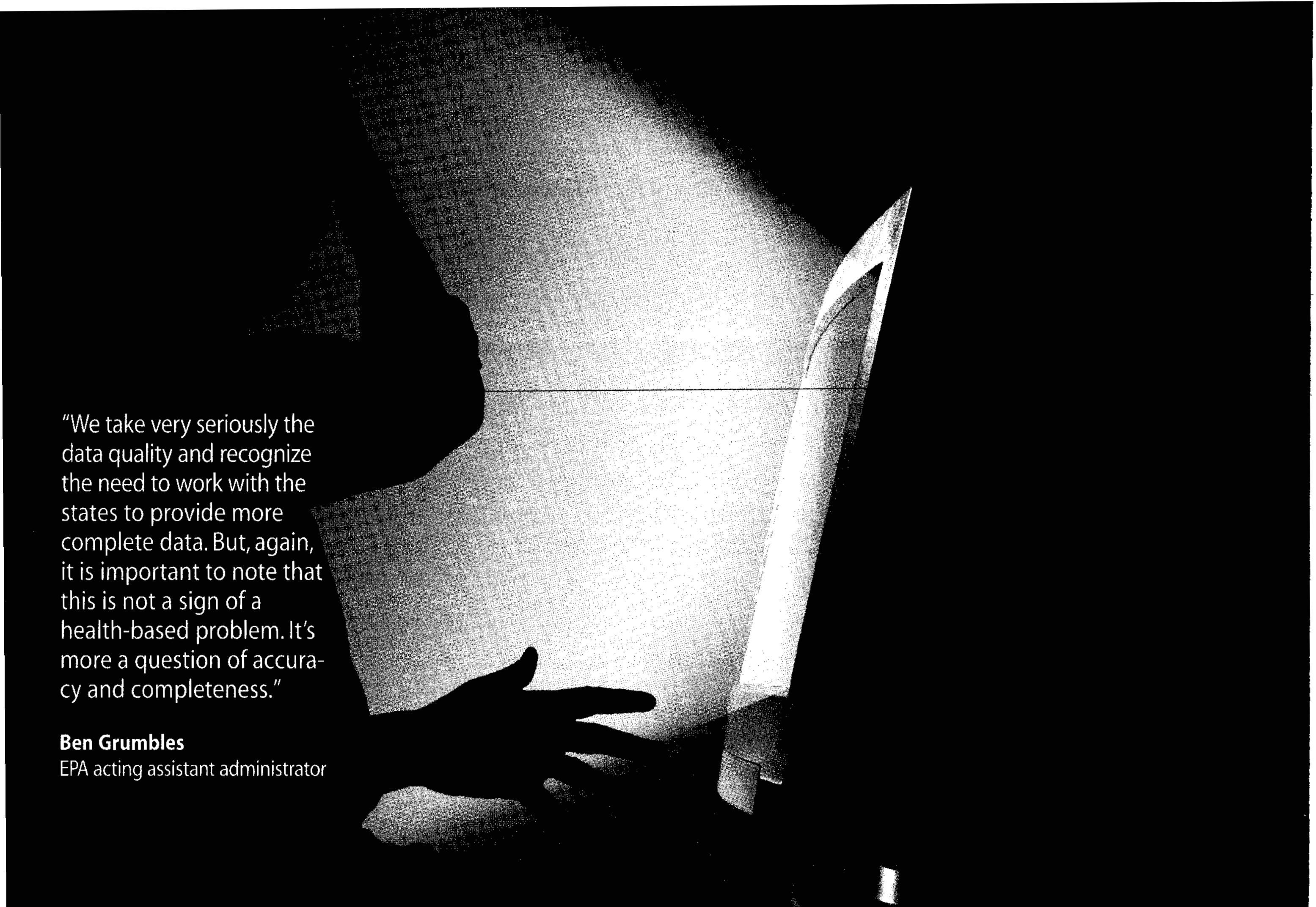
Safe Water Is the Goal

Under the GPRA, federal agencies are required to present an annual progress report to Congress about achieving specific goals. EPA's overall goal is that 95 percent of the population that community water systems serve will receive water that meets all health-based drinking water standards by 2008.

Under the Safe Drinking Water Act (SDWA), EPA sets standards for drinking water quality and oversees the states, localities, and water suppliers who enact those standards.

Data used to track this drinking water performance goal comes from the Safe Drinking Water Information System/ Federal Version (SDWIS/FED), a computer-based program that stores tracking information about program management of 84 contaminants for more than 160,000 public water systems (PWS) in 56 state and territorial programs and on tribal lands.

States provide this data to EPA, including limited descriptions of water system information, violations of regulatory standards, and information on state enforcement actions. EPA regulations establish maximum contaminant levels, treatment techniques, and monitoring and reporting requirements to ensure that water is safe for drinking.



"We take very seriously the data quality and recognize the need to work with the states to provide more complete data. But, again, it is important to note that this is not a sign of a health-based problem. It's more a question of accuracy and completeness."

Ben Grumbles
EPA acting assistant administrator

OIG Findings

The OIG report states that the review of SDWIS/FED was initiated to determine two things:

1. How do incomplete or inaccurate drinking water data affect the drinking water GPRA calculation?
2. What actions has EPA undertaken to ensure that the data are reliable and valid?

During the preliminary research phase, the OIG report states that it learned the EPA Office of Water was conducting analyses that overlapped their own. "Since we already completed work on our first question but not the second, we are reporting the results on the first and suspending our work on the second," the OIG report adds.

Despite claims that EPA had met its performance goals from 1999 to 2002, the OIG report states "due to missing data on violations of drinking water standards, the agency did not, in fact, meet its drinking water performance goals for these four years."

It adds, "EPA officials and reports consistently noted that national drinking water performance goals were being achieved. . . .This was also repeated by the media."

EPA Outlines Its Findings

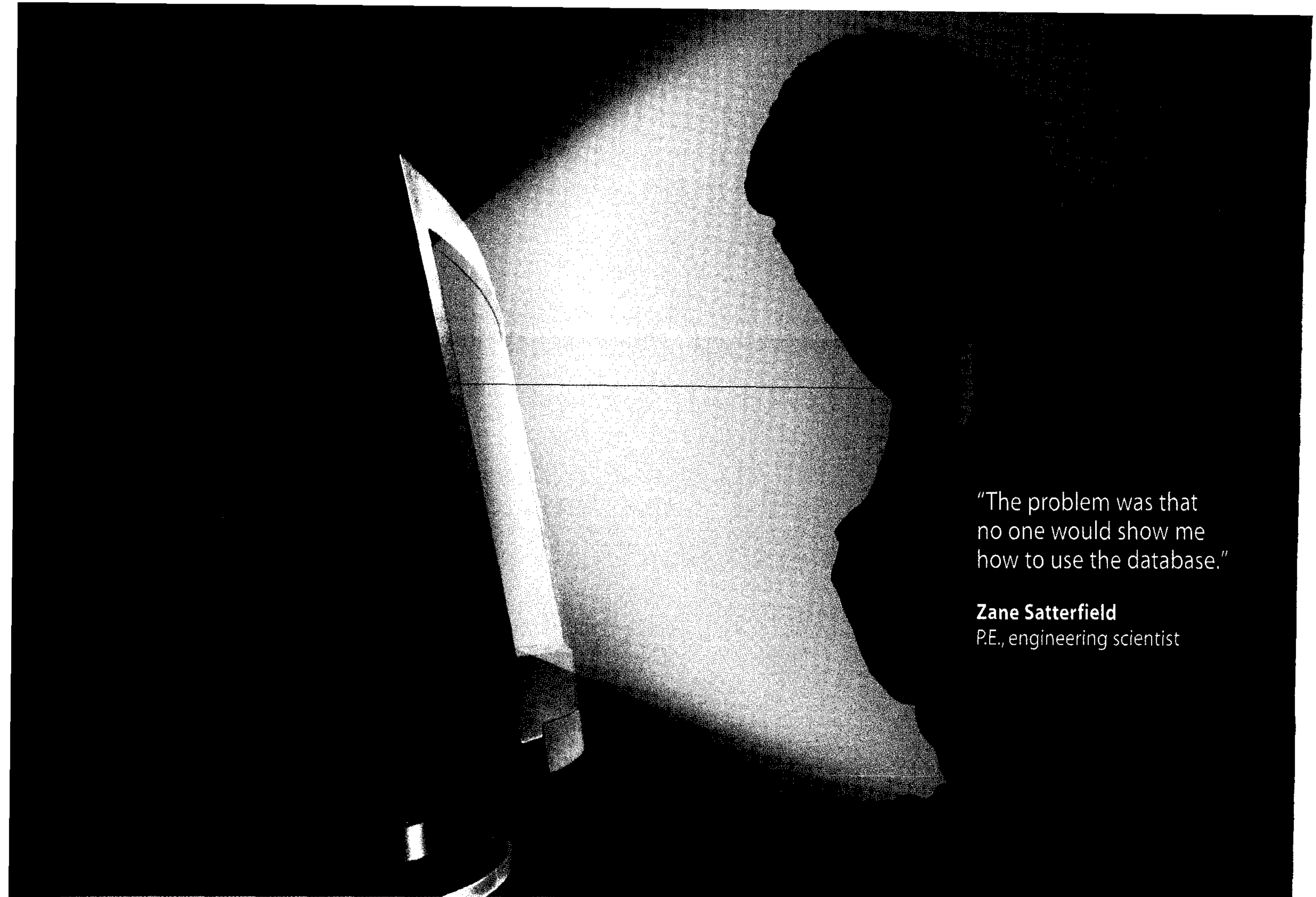
EPA issued its investigatory results of SDWIS/FED in its *Drinking Water Data Reliability Analysis and Action Plan* (2003). The report states that overall, data quality has improved since the first data quality assessment released in 2000, echoing Grumbles earlier statements that the accuracy is good, but the data are incomplete.

Concerning the media reports of the alleged incorrect information, Grumbles said EPA uses the best available data that the states report. In addition, many of EPA's reports and Web sites related to SDWIS/FED note that EPA is aware of inaccuracies and underreporting of some data in the system. He adds that some of the discrepancy problems are a result of the reporting process itself.

"There are a lot of decisions that the states need to make when they are compiling the data," says Grumbles. "We have found that they don't have all the information under the various drinking water rules. That's one of the key areas for us to work with the states to improve upon, collecting more of the information and putting it into the data system."

In addition, many states do not meet the 90-day deadline for reporting violations, and a significant number of states still periodically do not report violations of certain rules—particularly radionuclides.

States have indicated that regulatory complexity and competing demands of their programs have affected their operation of PWS programs. "They operate their PWS regulatory programs in the best manner they can, which is now stressed by limited and often reduced resources and, most recently, security requirements," the EPA report adds.



"The problem was that no one would show me how to use the database."

Zane Satterfield
P.E., engineering scientist

Simple human error may also be a cause, according to the EPA report. "An analysis of data rejected from SDWIS/FED found that 90 percent of the inventory, violations, and enforcement data error types incurred were for data entry errors," it states. "If the quality of the data measured and reported to SDWIS-FED is not high, then EPA's ability to report on program progress is hindered."

Addressing the Issues

Despite these apparent hurdles, Grumbles says EPA has been trying to address the issues. "When we look back at our triennial national review of the state data systems, we do see an important trend toward improved data quality, which is a combination of accuracy and completeness. But we have a lot of work to continue doing with the states to improve the data systems under the SDWA."

To continue that effort, EPA has two standing committees to identify, analyze, and evaluate implementation, as well as review data management, and recommend corrective or implementation actions.

"Part of our effort here is to work with states to improve and follow-up on the loading in of data and reporting," Grumbles says. "On an annual basis, we will be entering into work plans with states. And we will be seeing results immediately in terms of the quality of the data."

Grumbles adds that EPA is increasing the number of random data verification audits from eight to 12. "I think this shows we're really taking this seriously and have an aggressive plan in place."

He also says that the SDWIS database is currently undergoing upgrade. "Our efforts to modernize the SDWIS program add up to approximately $6 million a year, which is very significant. We are putting a lot of money into it and giving it a priority."

The EPA report adds that modernization of SDWIS should address some of the problems of data submission. "With respect to resolving state compliance determination errors, greater efforts will be focused on defining areas of disagreement in regulation interpretation between EPA and states," the EPA report states.

"Resolution will be achieved through clarification of regulatory requirements, training and technical assistance, and other state-specific program oversight and support activities. For monitoring and reporting, attention will focus on developing mechanisms by which results can be transmitted electronically from laboratories to public water systems and states."

Other actions taken by EPA and states include:

- improved data entry processes, tools, and training for regions and states;
- improved and simplified data retrieval and reporting tools;
- improved data verification audit procedures; and
- accelerated ongoing data quality improvement activities, such as electronic reporting between utilities, labs, and states.

Other Voices

In an editorial in the January/February 2004 *Water Environment Research* magazine, G. Tracy Mehan III, who was EPA assistant administrator for water at the time the piece was written, outlined his opinion on the issue. In the editorial, he asks if it is time to turn our national water-monitoring program in a new direction.

He notes that in the EPA *Draft Report on the Environment 2003*, the water quality chapter, "which was intended to address the condition of the U.S. waters and watersheds, concluded 'at this time, there is not sufficient information to provide a national answer to this question with confidence and scientific credibility.'"

Why is that? Mehan says, "According to a recent survey of state water quality agencies conducted by the Association of State and Interstate Water Pollution Control Administrators (Washington, D.C.), states are operating their monitoring programs with about one-half of the resources they need with an annual funding shortfall of approximately $170 million.

"As a result, the condition of the majority of state waters is unknown. And because state water quality standards and assessment methods vary, we find we cannot add up the existing state data to get a clear picture of how well our national programs are working."

Mehan speculates that we are in this position today because, in the 1970s, the nation focused more on enforcement compliance issues related to pollution discharge while monitoring, rightfully, took a back seat.

Zane Satterfield, P.E., engineering scientist with the National Environmental Services Center, worked with SDWIS when he was employed by the West Virginia Bureau of Public Health.

Satterfield said the problem he encountered with SDWIS was a lack of training for engineers using the system. "The problem was that no one would show me how to use the database," Satterfield says. "I think that was a fairly common practice at the time."

Despite that hindrance, Satterfield feels the database is accurate. "There's always room for improvement," he says. "I know West Virginia's database is fairly accurate, but I would say it is not complete. "States need more money for personnel. Some states don't use engineers to do what we did. The money is just not there."

In the previously published editorial, Mehan outlined four steps that he thinks need to be taken to improve the overall monitoring system, including:

1. improving and strengthening state monitoring programs,
2. developing and promoting multiple monitoring tools, such as statistically based surveys, predictive monitoring, and remote sensing,
3. improving electronic data systems to manage and share monitoring information and make data more accessible to the public, and
4. building stronger partnerships at the federal, state, and local levels to facilitate the sharing of comparable data and the use of multiple monitoring tools.

The Bottom Line

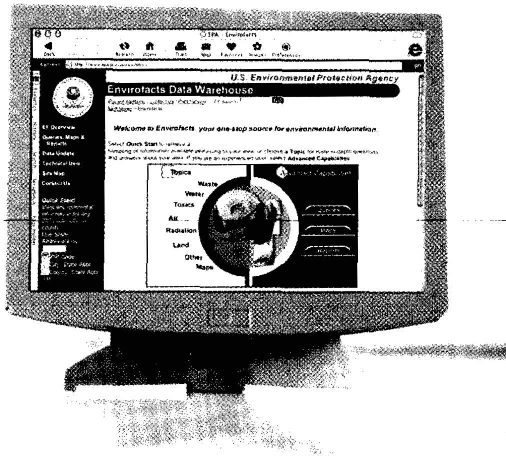
"We take very seriously the data quality and recognize the need to work with the states to provide more complete data. But, again, it is important to note that this is not a sign of a health-based problem. It's more a question of accuracy and completeness," says Grumbles.

He adds that states are compiling violations of the health-based standard in the SDWIS/FED system. "We review all the data, and we are finding that less than one percent of the state determinations are violations of those health-based standards. Stated more simply, the vast majority of state compliant determinations are that systems are complying with health-based standards.

"We want states to properly manage their drinking water programs and to be able to communicate accurately what degree of risk there might be so we can provide the information to the public," he continues. "Good government demands good data. It is critical, and the public health focus of the drinking water program requires the best data. But this will not be an overnight project. This is a long-term effort."

For more information, contact Grumbles at (202) 564-5777. The public version of SDWIS/FED may be accessed at www.epa.gov/enviro/html/ *to check a particular drinking water supplier's violations and enforcement history since 1993.*

EPA's Envirofacts Data Warehouse
http://www.epa.gov/enviro/html/



In addition to working as a staff writer for NESC, **Natalie Eddy** is an adjunct faculty member at West Virginia University School of Journalism, teaching media writing.

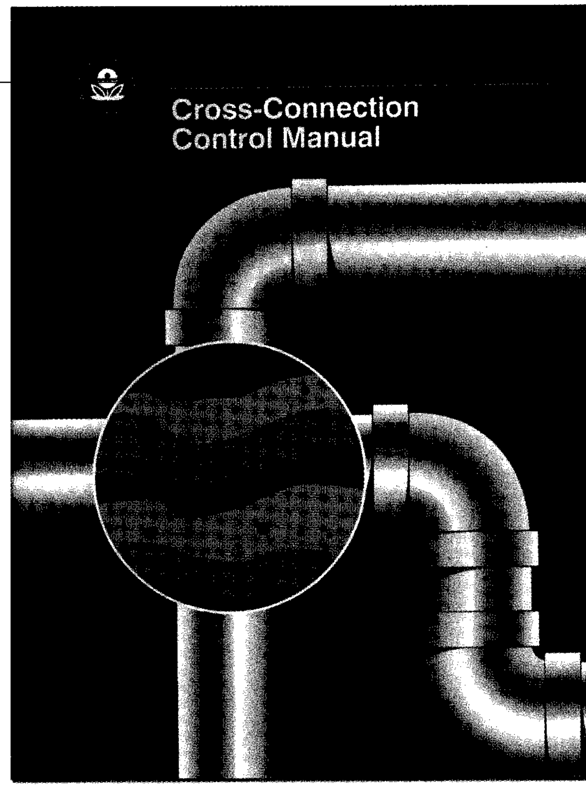
Featured Products

To order, call the National Environmental Services Center at **(800) 624-8301** or **(304) 293-4191**. You also may send an e-mail to *info@mail.nesc.wvu.edu*.

Cross Connection Control

Plumbing cross-connections, defined as actual or potential connections between a potable and nonpotable water supply, constitute a serious public health hazard. This manual is an educational and technical reference for conducting cross-connection control programs. Water contamination case histories and cross-connection control practices are provided.

Item #DWBLDM03



Nitrate Removal

This handbook was prepared to help utility managers, engineers, operators, and municipal managers understand and deal with excessive nitrate levels in their water supplies. It explains nitrate problems, helps to develop and evaluate proposed solutions, and estimates the costs of control to consumers.

Item #DWBKDM07

Small System Guide to Rate Setting

Most small systems are reluctant to raise water rates. But changes in regulations and increased costs of doing business make it necessary to review water rates annually. This booklet helps decision makers keep track of a system's finances, make changes in rates structures and analyze customer usage, set minimum rates, gain customer support for rate increases, and more.

Item #DWBKMG49

Lead in Drinking Water Regulation

Four sections in this guidance manual summarize public education requirements water suppliers must meet to comply with federal regulations about lead in drinking water. It describes how to develop a public education action plan and how a community-based task force can create a program.

Item #DWBKRG21

Drinking Water Quality in Indian Country

Many tribes have seen treatment costs rise in the last decade, and contaminant threats continue to increase as old infrastructures deteriorate. This fact sheet outlines threats to drinking water, some solutions to the problem, and resources to learn more about protecting drinking water on tribal lands.

Item #DWFSPE118

Mycobacteria in Drinking Water

Mycobacteria have been referred to as the "ducks of the microbial world" due to their thick, waxy coating, which enables them to thrive in aquatic environments. This fact sheet describes these organisms, where they occur in the environmental, their health effects in humans and animals, and water treatment methods for their removal.

Item #DWFSPE183

Healthy Water Healthy People (Children's Book)

Clean, healthy water supports and sustains life. This illustrated book for children gives an overview of water quality monitoring and describes point and nonpoint source pollution. Games and activities further explain concepts related to keeping the Earth's waters clean.

Item #DWBLGN61

History of DW Treatment

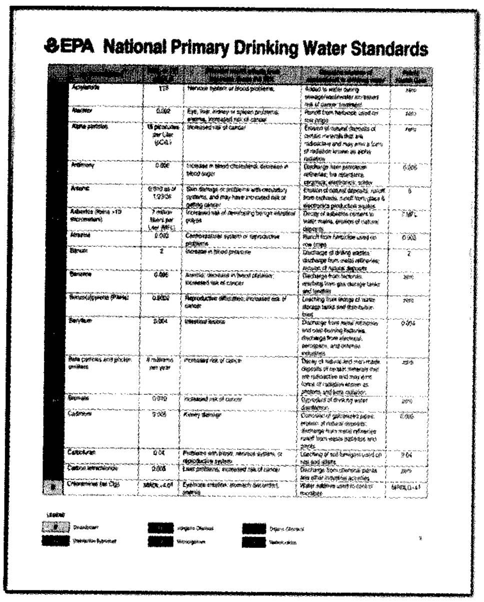
Water treatment originally focused on improving the aesthetic qualities of drinking water. It took thousands of years for people to recognize that their senses of taste and odor were not accurate judges of water quality. This fact sheet gives an overview of drinking water treatment through the centuries up to today's filtration and disinfection technologies.

Item #DWFSGN52

DW Standard Setting Q & A's

This question and answer format book explains how EPA develops, oversees, and enforces drinking water regulations under the Safe Drinking Water Act.

Item #DWBKRG50



National Primary Drinking Water Standards

Drinking water standards enforce limits on contaminants. This booklet charts contaminants and lists their allowable maximum level (MCL), their potential health effects above the MCL, and their common sources.

Item #DWFSRG77

Lead in Drinking Water

Evidence shows that even moderate levels of lead can be harmful to human health and particularly to the health of small children and developing fetuses. This fact sheet discusses lead in the environment and in drinking water. Recommendations are included for correcting lead contamination in water, including private wells.

Item #DWFSGN60

Arsenic in Drinking Water

Arsenic is a natural part of our environment, and everyone is exposed to small amounts. This brochure discusses arsenic in its toxic and nontoxic forms and how it gets into water supplies, its health effects, testing to determine arsenic levels, and water treatment processes for its removal.

Item #DWBRGN58

National Environmental Services Center

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Drinking Water Products List

All of the products listed are free!

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ITEM NUMBER BREAKDOWN

First two characters of item number:
(Major Product Category)

DW	Drinking Water
FD	Funding

Second two characters of item number:
(Document Type)

BK	Book, greater than 50 pages
BL	Booklet, less than 50 pages
BR	Brochure
CD	Compact Disk/ROM
FS	Fact Sheet
PK	Packet
PS	Poster
QU	Quarterly
SW	Software
VT	Video Tape

Third two characters of item number:
(Content Type)

DM	Design Manual
FN	Finance
GN	General Information
MG	Management
NL	Newsletter
OM	Operation and Maintenance
PE	Public Education
PP	Public-Private Partnerships (P3)
RE	Research
RG	Regulations
TR	Training

Last two characters of item number:
(Uniquely identifies a product within a major category)

Our newest products are highlighted in **blue**.

DESIGN

DWBKDM16	Improved Protection of Water Resources from Long Term and Cumulative Pollution
DWBKDM14	Manual for the Certification of Laboratories Analyzing Drinking Water; Criteria and Procedures Quality Assurance: Fourth Edition
DWBKDM06	Manual of Individual and Non-Public Water Supply Systems
DWBKDM05	Manual of Small Public Water Supply Systems
DWBKDM01	Manual of Water Well Construction Practices
DWBKDM12	Radionuclide Removal for Small Public Water Systems
DWBLDM02	Rainwater Cisterns: Design, Construction, and Water Treatment
DWBKDM08	Regionalization Options for Small Water Systems

FINANCE

DWBLFN12	Action Guide for Source Water Funding: Small Town and Rural County Strategies for Protecting Critical Water Supplies
FDBKFN12	Alternative Financing Mechanisms for Environmental Programs
DWBKFN08	Alternative Funding Study: Water Quality Fees and Debt Financing Issues
DWBKFN30	Catalog of Federal Funding Sources for Watershed Protection
DWBKFN15	Catalog of Financial Support Sources for U.S. - Mexico Border Water Infrastructure
DWFSFN36	**Drinking Water Costs & Federal Funding**
DWBKFN09	Drinking Water Infrastructure Needs Survey: First Report to Congress
DWBKFN33	Drinking Water Infrastructure Needs Survey: Second Report to Congress
FDBKFN34	The Drinking Water State Revolving Fund: Financing America's Drinking Water—A Report of Progress
DWBKFN14	Financial Accounting Guide for Small Water Utilities
DWBKFN05	Financing Models for Environmental Protection: Helping Communities Meet Their Environmental Goals
DWBLFN38	Guide to Using EPA's Automated Clearing House for the Drinking Water State Revolving Fund Program
DWBLFN07	Innovative Options for Financing Nongovernmental Public Water Supplies' Needs
DWFSFN35	Partners in Healthy Drinking Water Grants
DWSWFN01	PAWATER Users Manual: Financial Planning Model New, Small Community Water Systems (Version 2.2)
DWFSFN37	Protecting Drinking Water with the Clean Water State Revolving Fund
FDBLFN15	Road to Financing: Assessing and Improving Your Community's Creditworthiness
DWBKMG45	Small Water System Byproducts Treatment and Disposal Cost Document
DWBLFN40	**Small System Guide to Financial Management**
FDBLFN14	State and Local Government Guide to Environmental Program Funding Alternatives
DWFSFN32	Using DWSRF Funds to Comply with the New Arsenic Rule

DWFSFN39 **Use of the Drinking Water State Revolving Fund (DWSRF) to Implement Security Measures at Public Water Systems**

FDBLFN13 Utility Manager's Guide to Water and Wastewater Budgeting

FDBLFN03 Water and Wastewater Manager's Guide for Staying Financially Healthy

GENERAL INFORMATION

DWBRGN58 **Arsenic in Drinking Water**

DWVTPE25 Careers in Water Quality

DWBLGN62 **Celebrate Wetlands!**

DWVTGN20 Clean Ground Water: Virginia's Endangered Inheritance

DWFSGN53 Community Involvement in Drinking Water Source Assessments

DWBKGN28 Designing a Water Conservation Program: An Annotated Bibliography of Source Materials

DWBRGN56 **Drinking Water Academy Training for Federal, State, and Tribal Drinking Water Professionals**

DWCDGN50 Drinking Water. Know What's In It For You.

DWPSGN49 Drinking Water. Pour Over the Facts.

DWBLGN24 Drinking Water Glossary: A Dictionary of Technical and Legal Terms Related to Drinking Water

DWFSGN47 Drinking Water Treatment

DWFSGN44 A Guide to Home Water Treatment

DWBLGN61 Healthy Water, Healthy People

DWFSGN52 The History of Drinking Water Treatment

DWBKGN06 Improving the Viability of Existing Small Drinking Water Systems

DWFSGN46 Iron in Drinking Water

DWBRGN02 Lead Ban: Preventing the Use of Lead in Public Water Systems and Plumbing Used for Drinking Water

DWFSGN60 **Lead in Drinking Water**

DWBLGN19 Lead in Drinking Water: An Annotated List of Publications

DWBKGN48 National Water Quality Inventory: 1998 Report to Congress—Ground Water and Drinking Water Chapters

DWBLGN43 Nutrient Management to Protect Water Quality

DWBKGN36 Outreach Resource Guide

DWBLGN41 Providing Solutions for a Better Tomorrow: A Progress Report on U.S. EPA's Drinking Water Treatment Technology Demonstrations in Ecuador, Mexico, and China

DWBLMG41 Public-Private Partnerships for Environmental Facilities: A Self-Help Guide for Local Governments

DWBRGN03 Public Water Systems: Providing Our Nation's Drinking Water

DWBLGN55 The Quality of Our Nation's Waters—A Summary of the National Water Quality Inventory: 1998 Report to Congress

DWBLGN64 **Safe Drinking Water Act Section 1429 Ground Water Report to Congress**

DWFSGN51 Safe Drinking Water Information in Envirofacts

DWBKOM35 Summary Report: Small Community Water and Wastewater Treatment

DWBKGN20 Technical & Economic Capacity of States & Public Water Systems To Implement Drinking Water Regulations

DWBRGN45 Using Water Wisely in the Home

DWBRGN59 **Volatile Organic Chemicals in Drinking Water**

DWFSGN54 Water Facts

DWBLGN17 Water Quality Self-Help Checklist

DWBLGN63 **The Water Story**

DWBRGN57 **Wellhead Protection: An Ounce of Prevention**

MANAGEMENT

DWBKMG22 Consolidated Water Rates: Issues and Practices in Single-Tariff Pricing

DWBKMG39 **Disinfection Profiling and Benchmarking Guidance Manual**

DWBKMG09 Drinking Water Handbook for Public Officials

DWBLMG20 **Ensuring Safe Drinking Water for Tribes**

DWBKMG14 Environmental Planning for Small Communities: A Guide for Local Decision Makers

DWBKGN09 Environmental Pollution Control Alternatives: Drinking Water Treatment for Small Communities

DWBLMG50 Guidance for Water Utility Response, Recovery & Remediation Actions for Man-Made and/or Technological Emergencies

DWBLMG26 Handbook for Capacity Development: Developing Water System Capacity Under the Safe Drinking Water Act as Amended in 1996

DWBLMG12 Helping Small Systems Comply With The Safe Drinking Water Act: The Role of Restructuring

DWBKMG21 Information for States on Implementing the Capacity Development Provisions of the Safe Drinking Water Act Amendments of 1996

DWBLMG32 Institutional Solutions to Drinking Water Problems: Maine Case Studies

DWBLMG52 **Instructions to Assist Community Water Systems in Complying with the Public Health Security and Bioterrorism Preparedness and Response Act of 2002**

DWBLTR13 Methods for Assessing Small Water System Capability: A Review of Current Techniques and Approaches

DWBLMG31 National Characteristics of Drinking Water Systems Serving Populations Under 10,000

DWBLMG40 NDWC Consumer Confidence Report

DWBKMG30 Optimizing Water Treatment Plant Performance with the Composite Correction Program

DWBLMG27 An Owner's/Operator's Handbook for Safe Drinking Water for Transient Noncommunity Public Drinking Water Systems

DWBKMG15 Practical Personnel Management for Small Systems

DWBKMG19 Preparing Your Drinking Water Consumer Confidence Report: Guidance for Water Suppliers

DWBLMG33 Protecting Sources of Drinking Water: Selected Case Studies in Watershed Management

DWBKMG36 Protocol for Conducting Environmental Compliance Audits for Public Water Systems Under the Safe Drinking Water Act

DWBLMG42 Risky Waste Disposal Practices Can Cost You Plenty: A Manager's Guide to Protecting Community Drinking Water

DWBLMG48 Safe Drinking Water: How can we provide it in our community?

DWPKMG37 Securing Water Package (RUS)

DWBLMG01 Self-Assessment for Small, Privately Owned Water Systems

DWBKMG43 Self-Evaluation Guide for Decision Makers of Small Community Water Systems

DWBLMG49 Small System Guide to Rate Setting

DWBLMG44 Small Systems Guide to Risk Management and Safety

DWBKMG24 Source Water Protection: A Guidebook for Local Governments

DWBLMG34 State FOIA Laws: A Guide to Protecting Sensitive Water Security Information

DWPKMG29 Staying Ahead of the Curve: How well do you know your water system?

DWBKMG25 State Programs to Ensure Demonstration of Technical, Managerial, and Financial Capacity of New Water Systems

DWBKMG28 State Strategies to Assist Public Water Systems in Acquiring and Maintaining Technical, Managerial, and Financial Capacity: A Comprehensive Summary of State Responses to Section 1420(c) of the Safe Drinking Water Act

DWBKMG46 Strategies for Effective Public Involvement: Drinking Water Source Assessment and Protection

DWBLMG38 **System Partnership Solutions to Improve Public Health Protection**

DWBKMG05 Water Board Bible: The Handbook of Modern Water Utility Management

DWBKMG47 Water Conservation Plan Guidelines

DWBLTR05 Water Rates: Information for Decision Makers

DWBLMG51 **Water Security Strategy for Systems Serving Populations Less than 100,000/15 MGD or Less**

DWBLMG03 Water System Self-Assessment for Homeowners' Associations

DWBLMG02 Water System Self-Assessment for Mobile Home Parks

ON TAP MAGAZINE

DWQUNL01 *OnTap*, Volume 1, Issue 1; Spring 2001

DWQUNL02 *OnTap*, Volume 1, Issue 2; Summer 2001

DWQUNL03	*OnTap*, Volume 1, Issue 3; Fall 2001
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DWQUNL05	*OnTap*, Volume 2, Issue 1; Spring 2002
DWQUNL06	*OnTap*, Volume 2, Issue 2; Summer 2002
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DWQUNL08	*OnTap*, Volume 2, Issue 4; Winter 2003
DWQUNL09	*OnTap*, Volume 3, Issue 1; Spring 2003
DWQUNL10	***OnTap*, Volume 3, Issue 2; Summer 2003**
DWQUNL11	***OnTap*, Volume 3, Issue 3; Fall 2003**

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DWBKOM17	Arsenic Removal from Drinking Water by Coagulation/Filtration and Lime Softening Plants
DWBKOM12	Arsenic Removal from Drinking Water by Ion Exchange and Activated Alumina Plants
DWBKOM33	Arsenic Removal from Drinking Water by Iron Removal Plants
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DWBKOM26	Technologies and Costs for the Removal of Radon From Drinking Water: Public Comment Draft
DWBKOM18	Treatment of Arsenic Residuals from Drinking Water Removal Processes
DWCDOM23	Troubleshooting Guide for Small Ground Water Systems with Hypochlorination
DWBKOM54	Water Audit and Leak Detection Guidebook: Water Conservation Guidebook No. 5

PUBLIC EDUCATION

DWFSPE60	21 Water Conservation Measures for Everybody
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DWBRPE124	Answers to your Questions about Groundwater
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DWCDPE138	**Desdemona's Splash**
DWBRPE28	De sus Ninos del Plomo en el Agua Potable (Protecting Your Kids from Lead in Drinking Water)
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DWBLPE147	**Domestic Water Treatment for Homeowners**
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DWBLPE74 Fact Sheet: Water Conservation Measures
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DWBLPE178 The Future Adventures of Captain Hydro: Hero of Water Conservation
DWBLPE180 The Further Adventures of Captain Hydro Teacher's Guide
DWFSPE172 Giardiasis
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DWBKPE115 Ground Water and Surface Water: A Single Resource
DWBLPE151 Ground Water A Source of Wonder: Drinking Water From Wells
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DWFSPE153 Groundwater Contamination & Your Septic System
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DWFSPE46 Household Hazardous Waste: Where it Goes in Monongalia County
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DWFSPE68 How to Protect Your Well
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DWBLPE77 Improving Home Water Quality
DWBLPE112 Interpreting Drinking Water Quality Analysis: What Do the Numbers Mean?
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DWBLPE113 It's YOUR Drinking Water: Get to know it and protect it!
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DWFSPE183 Mycobacteria: Drinking Water Fact Sheet
DWFSPE126 Nitrate–A Drinking Water Concern
DWBLPE176 The Official Captain Hydro Water Conservation Workbook
DWBLPE177 The Official Captain Hydro Water Conservation Workbook (Spanish Version)
DWBLPE164 Pesticide Properties That Affect Water Quality
DWBLPE86 Pesticides in Drinking Water Wells
DWBKPE135 Plain Talk About Drinking Water: Questions and Answers About the Water You Drink
DWBRPE166 Plugging Abandoned Water Wells
DWBKPE79 Private Drinking Water Supplies: Quality, Testing, and Options for Problem Waters
DWBLPE121 Protect Our Health From Source to Tap: National Drinking Water Program Highlights
DWBKPE66 Protect Your Ground Water: Educating for Action
DWBLPE133 Protecting Drinking Water Through Underground Injection Control
DWBLPE33 Protecting Local Ground Water Supplies Through Wellhead Protection
DWFSPE143 Reverse Osmosis for Home Treatment of Drinking Water
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DWFSPE160 Sampling for Bacteria in Wells
DWFSPE161 Sampling for Bacteria in Wells (Spanish)
DWBLPE02 Science Demonstration Projects in Drinking Water (Grades K–12)
DWBLFN13 Source Water 2000: Funding and Assistance Programs To Protect Small Town and Rural Drinking Water
DWBLPE182 Source Water Protection Practices Bulletin: Managing Highway Deicing to Prevent Contamination of Drinking Water
DWBLPE89 Springs: Early Warning Systems for our Groundwater
DWBLPE156 SPRINGS: Their Origin, Development, and Protection
DWBLPE38 Student Activity Sheets for Drinking Water Projects
DWBLRE17 Summary Results of EPA's National Survey of Pesticides in Drinking Water Wells
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DWFSPE170 Your Actions Can Help Preserve Drinking Water Quality (Spanish)
DWBLPE167 Your Guide to Public Drinking Water
DWBLPE168 Your Guide to Public Drinking Water (Spanish)
DWBRPE45 Your Home Could Contain Hazardous Waste: What You Need To Know

REGULATIONS

DWBLRG64 25 Years of the Safe Drinking Water Act: History and Trends
DWBLRG76 25 Years of the Safe Drinking Water Act: Protecting our Health from Source to Tap
DWFSRG86 Arsenic and Clarifications to Compliance and New Source Monitoring Rule: A Quick Reference Guide
DWFSRG69 Arsenic in Ground-Water Resources of the United States
DWBLRG96 Arsenic Rule Planning and Monitoring Worksheets
DWBRRG70 Class II Injection Wells and Your Drinking Water
DWFSRG91 Class V Injection Wells: EPA Announces New Regulatory Requirements for Certain Class V Injection Wells
DWFSRG67 The Class V Rule
DWBLRG26 Consolidated Rule Summary for the Chemical Phases
DWBLRG52 Drinking Water Contaminant Candidate List
DWBLRG44 Drinking Water Regulations and Health Advisories
DWBKRG50 Drinking Water Standard Setting Question and Answer Primer

DWBKRG82	Enhanced Coagulation and Enhanced Percipitative Softening Guidance Manual
DWFSRG68	Filter Backwash Recycling Rule: A Quick Reference Guide
DWBLRG62	Final Drinking Water Public Notification Regulations
DWBKRG81	Implementation Guidance for the Arsenic Rule: Drinking Water Regulations for Arsenic and Clarifications to Compliance and New Source Contaminants Monitoring
DWBLRG89	Interim Enhanced Surface Water Treatment Rule: Frequently Asked Questions
DWBKRG22	Lead and Copper Rule Guidance Manual
DWBLRG87	**Lead and Copper Rule Minor Revisions: Fact Sheet for Public Water Systems that Serve 3,300 or Fewer Persons**
DWFSRG95	**Lead and Copper Rule Minor Revisions Fact Sheet for State Primacy Agencies**
DWBLRG88	**Lead and Copper Rule Minor Revisions: Fact Sheet for Tribal Water System Owners and Operators**
DWBKRG21	Lead In Drinking Water Regulation: Public Education Guidance
DWBKRG61	Microbial and Disinfection Byproduct Rules: Simultaneous Compliance Guidance Manual
DWBLRG12	Monitoring Guidance Document for the Lead & Copper Rule (Systems serving 3,301–10,000 people)
DWBLRG13	Monitoring Guidance Document for the Lead & Copper Rule (Systems serving 501–3,300 people)
DWBLRG14	Monitoring Guidance Document for the Lead & Copper Rule (Systems serving 101–500 people)
DWBLRG15	Monitoring Guidance Document for the Lead & Copper Rule (Systems serving less than 100 people)
DWFSRG77	National Primary Drinking Water Standards
DWVTRG34	Nontransient Noncommunity Drinking Water: Requirements for Suppliers
DWFSRG60	Proposed Ground Water Rule: Questions and Answers
DWFSRG83	Public Notification Rule: A Quick Reference Guide
DWBKRG84	**Radionuclides Notice of Data Availability Technical Support Document**
DWFSRG66	Radionuclides Rule: A Quick Reference Guide
DWBLRG58	Regulations on the Disposal of Arsenic Residuals from Drinking Water Treatment Plants
DWBLRG90	**Report to Congress: Small System Arsenic Implementation Issues**
DWBKRG80	Research Plan for Arsenic in Drinking Water
DWPKRG25	Safe Drinking Water Act and 1996 Amendments
DWBLRG30	Safe Drinking Water: Health/Safety Requirements and Resulting Costs
DWPKRG47	Safe Drinking Water Is in Our Hands
DWPKRG65	A Small Systems Guide to the Total Coliform Rule
DWBLRG63	Small System Regulatory Requirements Under the Safe Drinking Water Act as Amended 1996
DWFSRG92	**Stage 1 Disinfectants and Disinfection Byproducts Rule**
DWBLRG93	**Stage 1 Disinfectants/Disinfection Byproducts Rule: Frequently Asked Questions**
DWBKRG46	State Source Water Assessment and Protection Programs Guidance (Final Guidance)
DWFSRG73	Technical Fact Sheet: Final Rule for Arsenic in Drinking Water
DWFSRG59	Technical Fact Sheet: Proposed Ground Water Rule
DWFSRG97	**Total Coliform Rule: A Quick Reference Guide**
DWBLOM04	Training Guide: Introduction to Water Loss and Leak Detection
DWFSRG85	**UCMR: Screening Survey for Aeromonas at Selected Public Water Systems**
DWBLRG79	Unregulated Contaminant Monitoring Regulation Guidance for Operators of Public Water Systems Serving 10,000 or Fewer People
DWFSRG78	Using DWSRF Funds to Comply with the Radionuclides Rule
DWFSRG75	Using DWSRF Funds to Comply with the Stage 1 Disinfectants and Disinfection Byproducts Rule
DWBLRG04	Your Drinking Water: From Source to Tap, EPA Regulations and Guidance

RESEARCH

DWBLRE06	Benefits of Water and Wastewater Infrastructure
DWBKRE29	Drinking Water and Ground Water Data Within the 305(b) Program
DWBKRE26	Drinking Water Progress Review Workshop for the 1995-1998 Science to Achieve Results (STAR) Grants
DWBLRE20	Drinking Water Treatment for Small Communities: A Focus on EPA Research
DWBLRE24	Estimating the Likelihood of MTBE Occurrence in Drinking Water Supplied by Ground-Water Sources in the Northeast and Mid-Atlantic Regions of the United States
DWBKRE27	A Field Study to Compare Performance of Stainless Steel Researc[h] Monitoring Wells with Existing On-Farm Drinking Water Wells in Measuring Pesticide and Nitrate Concentrations
DWBLMG17	Initial Summary of Current State Capacity Development Activitie[s]
DWBKRE21	Laboratory Study on the Oxidation of Arsenic III to Arsenic V
DWBKRE25	Methods for the Determination of Organic and Inorganic Compounds in Drinking Water: Volume 1
DWBLRE18	National Pesticide Survey: Update and Summary of Phase II Resu[lts]
DWBLRE19	Occurrence and Distribution of Methyl tert-Butyl Ether and Othe[r] Volatile Organic Compounds in Drinking Water in the Northeast and Mid-Atlantic Region of the United States, 1993-98
DWBLRE30	Occurrence of Selected Radionuclides in Ground Water Used for Drinking Water in the United States: A Reconnaissance Survey, 1998
DWBLRE22	Occurrence and Status of Volatile Organic Compounds in Groun[d] Water from Rural, Untreated, Self-Supplied Domestic Wells in the United States, 1986-99
DWBKRG49	Providing Safe Drinking Water in America: 1996 National Public Water Systems Compliance Report and Update on Implementation of the 1996 Safe Drinking Water Act Amendments
DWBLRE07	Radium Removal from Water by Manganese Dioxide Adsorption and Diatomaceous Earth Filtration
DWBKGN64	Safe Drinking Water Act, Section 1429 Ground Water Report to Congress
DWBLRE08	Strengthening the Safety of Our Drinking Water: Report on Progress & Challenges & Agenda for Action
DWBKRE15	Ultraviolet Light Disinfection Technology in Drinking Water Application —An Overview

TECHNOLOGIES

DWBKDM15	Corrosion Manual for Internal Corrosion of Water Distribution Systems
DWBLDM03	Cross-Connection Control Manual
DWBKDM07	Nitrate Removal for Small Public Water Systems
DWBLRG48	Small System Compliance Technology List for the Surface Water Treatment Rule
DWBKDM04	Technologies for Upgrading Existing or Designing New Drinkin[g] Water Treatment Facilities
DWBLGN11	USEPA Fact Sheets on POU/POE Units and Home Water Testing

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WATER TRIVIA

Q: How many community water systems are there in the U.S.?

Answer: 56,000

Q: How much water does it take to process one barrel of beer?

Answer: 1,500 gallons

Anti-Depressant Found in UK Drinking Water

Britons could unwittingly be swallowing traces of the anti-depressant Prozac® and other drugs in drinking water, according to an August 2004 report from the *Scotsman.com.*

Environmentalists have labeled the situation "hidden mass medication of the unsuspecting public." A study about the situation notes that pharmaceutical residues can travel through the sewage system and end up in the water. The levels of any such residue is unknown, and the United Kingdom's (UK) Environment Agency (EA) has called on the drug industry to prove its products are unlikely to cause significant harm to the environment.

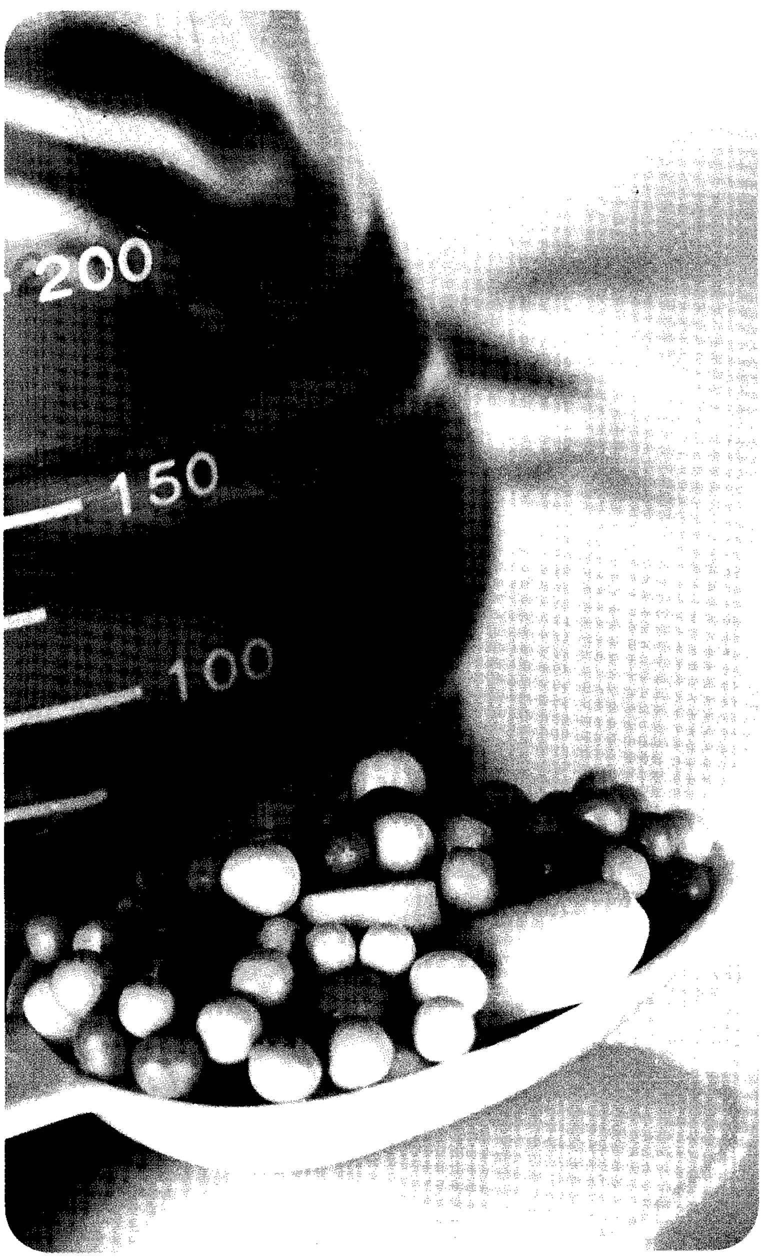


Photo Source: *www.photos.com*

Prozac® has been found by the EA to be "both toxic and persistent" and "a substance that could be of potential concern," according to the study by Norman Baker MP, environment secretary. There has been a 166 percent increase in prescriptions for anti-depressants in England since 1991—up to 24 million a year.

"The Government is quite simply not taking its responsibility to public health seriously. It is alarming that there is no monitoring of levels of Prozac and other pharmacy residues in our drinking water," says Baker.

"There also is no evidence that filtration eliminates these contaminants from water and Ministers don't even know which water works are fitted with which filtering devices anyway. From start to finish this is a demonstration of staggering complacency from a 'don't-know-don't-care government.' The public has a right to know what's in our water supplies and whether they are inadvertently taking drugs like Prozac®."

Last year, the EA announced it had completed research focusing on commonly used pharmaceuticals. In its study, the agency reviewed 500 of the most commonly used pharmaceuticals in England and Wales and monitored 12 thought to pose the greatest potential environmental threat, including painkillers, antibiotics, anti-cancer drugs, and anti depressants. Of these, 10 were found in sewage treatment work effluents and eight were detected in the rivers receiving these effluents.

The *LibDem* report says the DWI regulations do not specify limits for pharmaceutical residues in drinking water and these are not tested for during water quality assessments.

A spokeswoman for the Department of the Environment, Food and Rural Affairs, which includes the DWI, said: "It is extremely unlikely that there is a risk, as such drugs are excreted in very low concentrations and biodegraded during sewage treatment and in watercourses.

"There is also a large dilution effect. Furthermore, advanced treatment processes installed for pesticide removal are effective in removing drug residues—these are commonly found in waters abstracted from lowland rivers."

Drugs in Drinking Water Making Headlines

A group of "gender-bender" surfers protested outside a government office about what they claim is the cocktail of endocrine disrupting chemicals being discharged into recreational waters, according to an August 2004 report on the *Scotsman.com.*

The delegation of male surfers from the Cornwall-based environmental pressure group Surfers Against Sewage—wearing wetsuits, make-up, colored wigs, and high heels, and carrying surfboards—demonstrated outside the United Kingdom's (UK) Department of the Environment.

They called for urgent research into the public health risks from the unregulated discharge of what they say are endocrine disrupting compounds, antibiotics, and pharmaceutical products into the nation's rivers, lakes, and seas.

The group said the demonstration followed widespread concern for wildlife and human health from endocrine disrupting chemicals, prescription drugs, and antibiotics that are being found in significant quantities in effluent dominated waters after being discharged from sewage and waste water treatment plants.

The group said the sex change phenomenon in fish was already widespread in the UK and that a recent survey of UK rivers had found over a third of male fish exhibited female characteristics.

The contraceptive pill as a significant substance in domestic sewage effluent was also thought to have had an effect on the feminizing effects seen in fish, according to the group.

"It has also been reported that antidepressant drugs are finding their way into rivers from sewage treatment works, with some experts believing such drugs affect the ability to reproduce. The reports have made depressing news for recreational water users," says the group, adding that little research had been carried out on humans in relation to the rapid increase of feminizing hormones accumulating in the water environment.

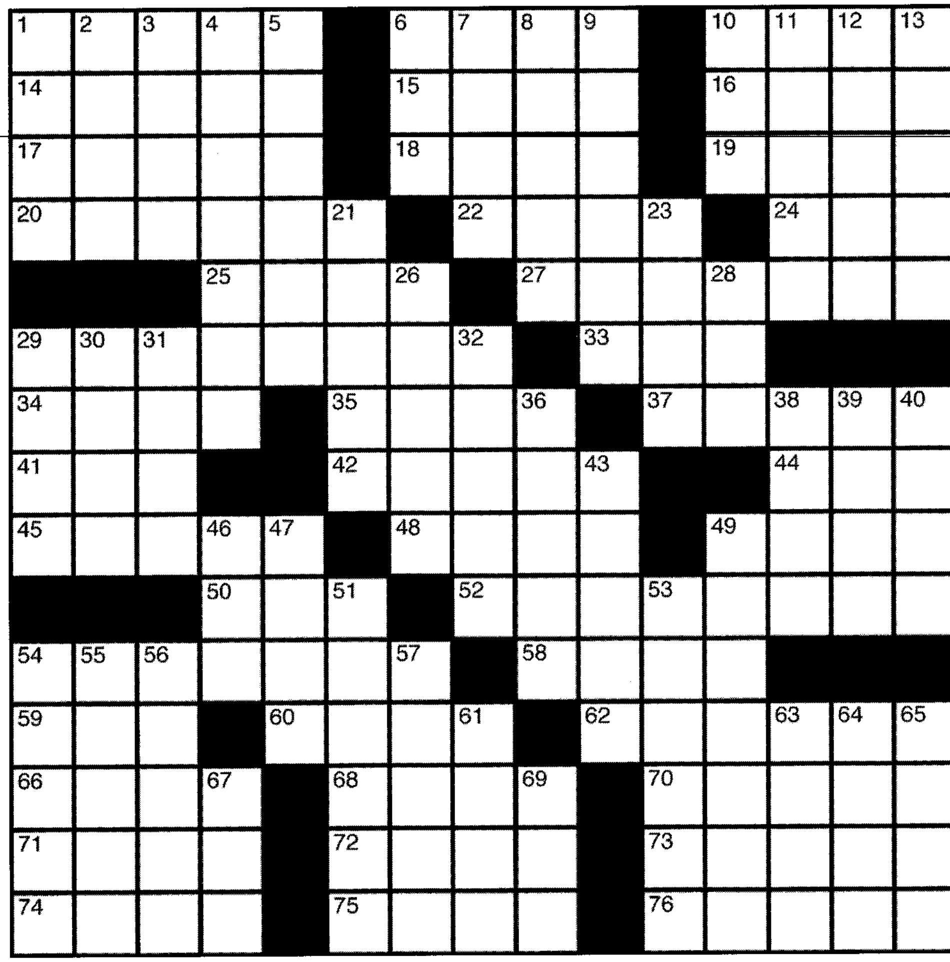
Photos by Surfers Against Sewage, *http://www.sas.org.uk*

Surfers Against Sewage (SAS) campaign for clean, safe recreational waters, free from sewage effluents, toxic chemicals and nuclear waste. Using a solution based argument of viable and sustainable alternatives, SAS highlight the inherent flaws in current practices, attitudes and legislation, challenging industry, legislators and politicians to end their 'pump and dump' policies. Find out more about them on their Web site at *www.sas.org.uk*.

"Recreational water users, such as surfers, are now becoming increasingly concerned over the long-term effects chemicals, hormones and antibiotics may be having on their bodies when marine and freshwater wildlife are already showing such alarming changes," according to the group.

"For years, surfers have been at risk from sewage-polluted water illnesses as they spend a lot of time immersing and ingesting water as part of the sport," says Richard Hardy, campaign director. "With the water environment coming under attack from a new cocktail of 'invisible nasties' with gender-bending capabilities, its time for an urgent assessment of the public health risks associated with such compounds and how they bypass the sewage treatment system."

Crossword



Solution on page 57

Crossword by Mark Kemp-Rye

ACROSS

1. Necessity for life on Earth
6. Northern Scandinavian
10. Egg cell
14. "Goodnight ____"
15. Pantyhose shade
16. European sea eagle
17. Tennis start
18. A drop (arch.)
19. Keroauc novel *On the ____*
20. Actress ____ Anderson
22. Snigler's prey
24. Mine find
25. Russian river
27. Quandary
29. Chemical added to drinking water
33. Rotating mechanism
34. Speech defect
35. Actor ____ Damon
37. One of the arts
41. Belonging to it
42. Plant pest
44. Historic period
45. Danger
48. Former Yugoslav leader
49. Berserk
50. Health research organization (abbr.)
52. Chemical added to drinking water
54. Publishers (var.)
58. Long times
59. Middle Eastern garment
60. Bucket
62. Smelled
66. National Environmental Services Center (abbr.)
68. Circuit
70. Harden
71. Largest continent
72. Ski lift
73. Song of mourning
74. For fear that
75. Red pigment containing iron
76. Thespian

DOWN

1. Tuft
2. Region
3. Semester
4. Enclose
5. Silk worker
6. Guided
7. Farm unit
8. Nosed
9. Safe Drinking Water Act concern (two words, with 51 down)
10. Over to poets
11. Engine sound in a cartoon
12. Render harmless
13. Jason's murderous wife
21. Jung's inner self
23. Grand ____
26. Accommodate
28. Large Australian bird
29. Toss a coin
30. Type of beer
31. Cold War country (abbr.)
32. Moral principle
36. Offering
38. Tractor trailer
39. Ductile material used in pipes
40. Birthday treat
43. Poetic grief
46. Writing fluid
47. Hobble
49. Atomic number 33
51. (see 9 down)
53. One of the Finger Lakes
54. Obvious and dull
55. Corpulent
56. Desert haven
57. Queen of Thebes
61. Rich soil
63. Rocker ____ Cobain
64. Therefore, to philosophers
65. Venison source
67. Feline
69. Start of a fix?

Word Search

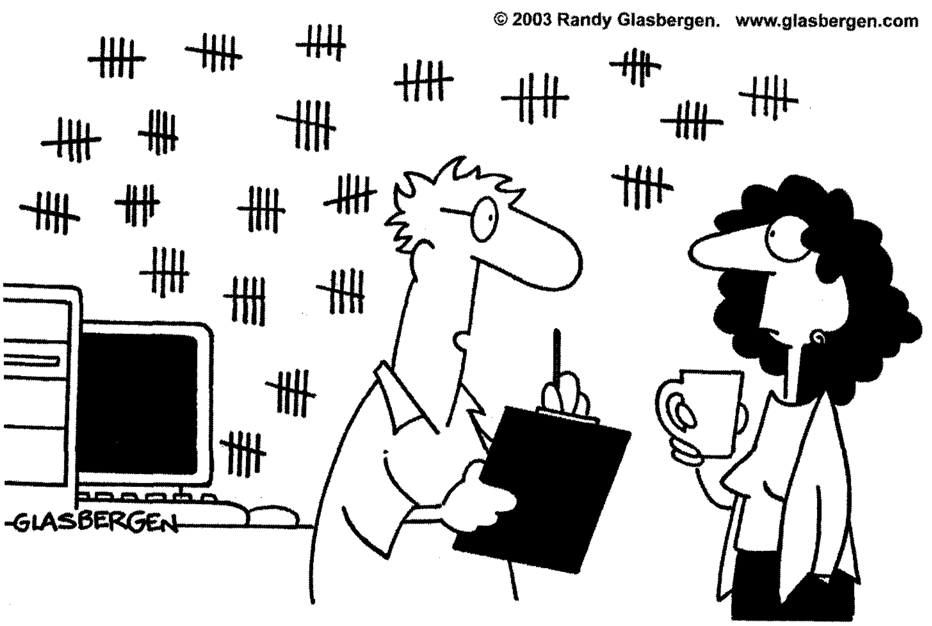
Find the following words in the puzzle.

health
contaminant
regulation
disinfection
chlorine
public
laboratory
microbial
chemical
contact time
parts per million
SIDWIS
communication

H	T	L	A	E	H	H	C	K	N	G	F	P	M	K	A	S	D	C	Q	W	M	K	S	A
A	N	T	O	I	M	M	U	M	O	C	A	L	R	X	Z	T	M	H	W	J	L	C	Z	K
B	A	K	Z	R	I	I	O	M	U	M	I	C	R	O	B	I	A	L	Y	N	C	H	P	I
L	N	C	D	O	X	D	T	L	M	I	N	U	J	O	H	L	R	E	X	S	T	E	M	R
J	I	T	Z	G	I	J	T	W	X	E	E	K	M	R	B	F	L	Q	Z	L	V	M	B	K
C	M	M	R	E	B	D	C	G	O	N	R	N	O	I	T	C	E	F	N	I	S	I	D	Q
F	A	Y	Z	R	J	B	A	Y	D	Z	O	S	X	F	W	O	A	K	R	S	I	C	B	E
G	T	T	L	W	C	A	T	T	A	I	X	P	V	O	U	S	D	B	E	I	O	A	N	O
N	N	F	X	A	C	I	N	H	T	P	U	O	C	X	S	T	R	A	P	F	U	L	Z	D
E	O	K	F	E	Y	H	O	A	R	E	K	G	C	I	M	H	S	P	W	S	J	E	R	M
E	C	O	L	O	G	Y	C	V	A	J	R	W	D	N	I	Y	T	L	P	D	G	H	X	A
N	J	N	Q	S	H	I	J	A	Y	F	V	W	I	B	L	J	O	L	N	U	K	K	T	E
I	T	G	E	J	N	N	O	H	O	S	I	C	V	J	L	M	R	Y	E	J	B	U	G	I
R	Q	P	N	U	C	V	S	I	X	S	O	J	D	X	I	I	Y	H	U	O	K	L	J	P
O	L	D	M	A	R	K	I	L	A	U	R	A	F	C	O	Q	O	I	P	C	A	J	I	L
L	J	M	A	X	O	W	E	L	L	N	J	D	U	R	N	Q	L	X	F	Z	A	C	H	C
H	O	T	L	A	B	O	R	A	T	O	R	Y	Y	Z	M	P	T	G	Q	V	Y	W	Q	B
C	A	D	R	I	E	N	N	E	O	O	Z	J	M	P	N	O	I	T	A	L	U	G	E	R

Solution on page 57

Wordsearch by Shelia Anderson



"Yesterday I changed everyone's password to 'password'. I sent it to everyone in a memo, put it on a big sign on the wall and printed it on all of the coffee cups. Guess how many people called me this morning because they forgot the password."

QUOTES

"Nothing on earth is so weak and yielding as water, but for breaking down the firm and strong it has no equal."

Lao-Tsze (604 B.C.–531 B.C.)

"Irrigation of the land with seawater desalinated by fusion power is ancient. It's called rain."

Michael McClary

"Whiskey is for drinking; water is for fighting over"

Mark Twain (1835–1910)

"The frog does not drink up the pond in which he lives."

American Indian saying

"The highest good is like water. Water gives life to the ten thousand things and does not strive. It flows in places men reject and so is like the Tao."

Excerpt from the Tao Te Ching, Chapter 8

"I always thought irony was the way the water tasted."

Red Green
From the Red Green Show

Solving the Water Crisis for Future Generations

By **Hal Furman**, Executive Director, U.S. Desalination Coalition

Photo by Jacques Descloitres, MODIS Rapid Response Team, NASA/G

Desalination technology has existed for many years in the Florida Keys.

With the current war in Iraq, it's pretty easy to imagine oil shortages and people lining up at gas stations. But try to imagine lines going around the block just to receive water. Pure, clean water is something that many of us take for granted. However, our sources of clean, drinkable water are rapidly diminishing. One solution to the water crisis does exist, however, and it needs to be brought to the nation's attention—desalination. As one expert recently said, "Desalination is no longer the crazy aunt in the attic."

Desalination is the process that converts seawater or brackish water into pure, clean drinking water for our homes, businesses, and farms. It has been an American dream for many decades. More than 50 years ago, John F. Kennedy said, "If we could produce fresh water from salt water at a low cost, that would indeed be a great service to humanity, and it would dwarf any other scientific accomplishment."

A growing number in Congress believe the time for action is now. H.R. 3438 is a bill aimed at providing assistance to qualified entities that develop desalination plants. Under this proposed program, the U.S. Department of Energy would be authorized to provide financial assistance for a limited period to partially offset the cost of the electrical energy needed to operate these facilities. The proposed funding level is $200 million a year over a five-year period.

The explosive population growth taking place in America, particularly in states such as California, Arizona, Nevada, Texas, and Florida, has placed heavy demands on our limited fresh water resources. Serious drought conditions in large parts of the country and increased competition for available water supplies from agriculture, business, and the environment have exacerbated this problem. Water conservation and recycling have stretched available supplies, but they can only solve the problem in the short term.

Desalination technology has existed for many years. In fact, the first crude plant was built in the U.S. in 1862 in Key West, Florida, to provide water to Fort Zachary Taylor. Today, more than 1,200 mostly small U.S. desalting facilities produce more than 300 million gallons of water each per day. The problem has been that, compared to other means of producing potable water, desalination has been cost prohibitive. But advances in technology over the past 10 years have begun to level the playing field. In 1990, it cost $2,000 to desalinate one-acre foot of seawater. Today, that cost has been cut to below $900. The incentives provided by H.R. 3834 would further reduce these costs and make desalinated water truly competitive with alternative supplies.

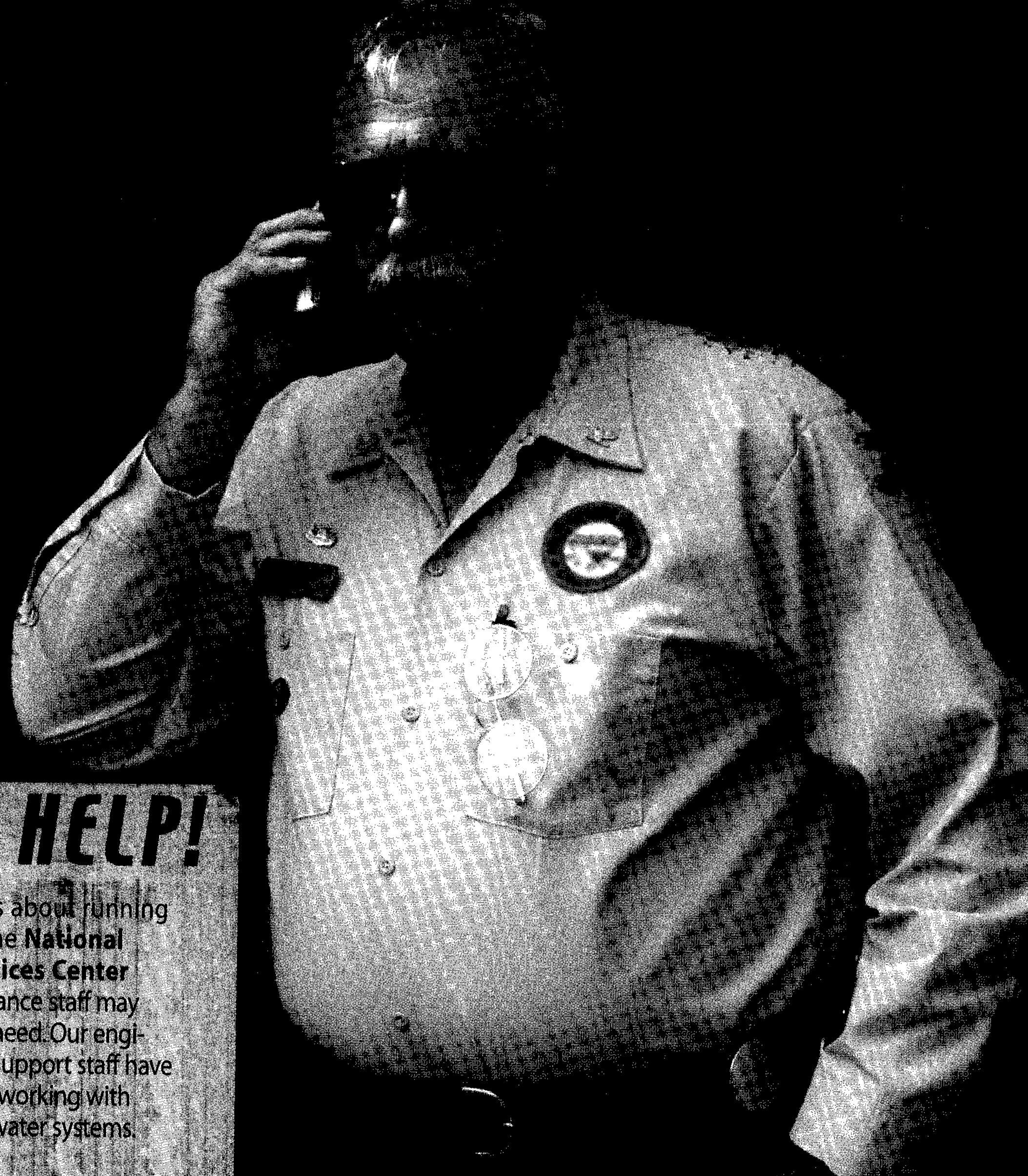
Throughout the U.S., a significant number of larger seawater and brackish water desalination projects exist in various stages of planning and development. The most notable is the recently completed facility in Florida that will eventually produce 28 million gallons per day of new water for the rapidly growing Tampa Bay region.

Whether these projects and others like them are built in time to address the nation's mounting water supply crisis is largely dependent on whether the federal government makes a commitment to invest in this new infrastructure.

The choice we face is stark: We can either begin to address America's looming water supply crisis by building economically viable and environmentally sound desalination facilities, or we can face the economic and environmental consequences of our own inaction.

Hal Furman served as deputy assistant secretary of the Interior for Water and Science during the Reagan Administration.

TECHNOLOGY TROUBLING YOU?



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