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Introduction

Water, water everywhere. But is it good and safe to drink or use? How can you tell if the water in your home is healthy for you, your family, and for that prized front-loading washing machine? What can you do if your water doesn't measure up? Read this updated version of *Water Treatment For Dummies* to find out.

This book answers your water quality questions. It shows that you have options and tools available to help you take steps to ensure good quality drinking water for you and your family.

Icons Used in This Book

We want to help you soak up the most important points, so we've used handy icons to get your attention.


REMEMBER

These sentences are among the most important ones when it comes to understanding your water quality.


TIP

You want to make your life easier? Then focus your attention on the items shown here.

TECHNICAL STUFF

We know you don't want a PhD in these topics, but here are extra details you might find interesting.

WARNING

We're talking matters of health here, so watch out when you see this icon.

Beyond the Book

Although this book is chock full of information, there's only so much I can cover in 64 short pages! So, if you find yourself at the end of this book thinking that you need to know more, simply go to `www.wqa.org`.

IN THIS CHAPTER

- Getting water to your tap
- Calculating the cost of water

Chapter 1

What Is Water, Anyway?

What is water? Water is a molecule called H_2O that contains two atoms of hydrogen and one atom of oxygen. It's a transparent, odorless, tasteless liquid that you can find in lakes, rivers, and oceans. It falls from the sky as rain or snow.

Water is bottled and sold commercially, but it is also a key ingredient in thousands of products, from lotions and cosmetics to cleaners and beverages.

Where Does Water Come From?

REMEMBER

If you're fortunate, water is all around you, in just the right amounts and in the right places. But it didn't just get there by magic. Ultimately, fresh water is the result of the Earth's water or hydrologic cycle (see Figure 1-1). Basically, the sun's heat causes surface water to evaporate. It rises in the atmosphere, then cools and condenses to form clouds. When enough water vapor condenses, it falls back to the surface again as rain, sleet, or snow. The process repeats itself in a never-ending cycle.

REMEMBER

The water we consume and use every day comes from two main sources: groundwater and surface water. Other sources such as snow melt, rain, and recycled wastewater have only limited use, but they're getting more attention these days because of water scarcity issues in dry climates. Just 1 percent of all water is accessible.

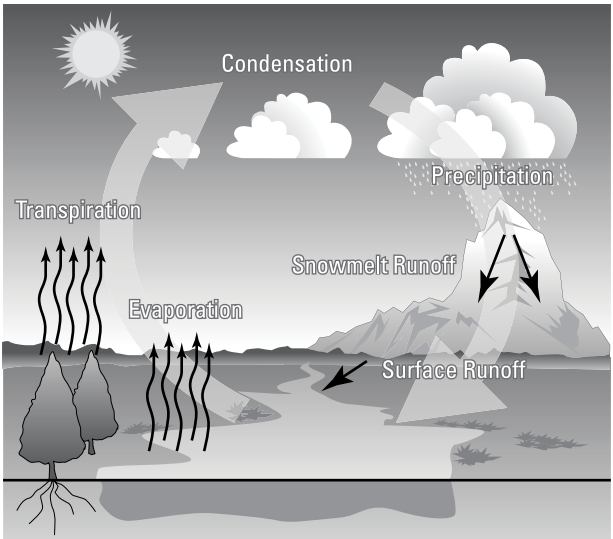

FIGURE 1-1: The water cycle.

Water from the ground

REMEMBER

When rainwater or melting snow seeps into the ground, it collects in underground pockets called aquifers, which store the groundwater and form the water table, another name for the highest level of water that an aquifer can hold. Water levels can reach the water table or fall well below it depending on

such factors as rainfall, drought, or the rate at which the water is being used. Groundwater usually comes from aquifers through a drilled well or natural spring.

Water on the surface

REMEMBER

Surface water flows through or collects in streams, rivers, lakes, reservoirs, and oceans — and not underground like groundwater. Surface water can be beautiful, even pristine looking, but most of it isn't directly fit for drinking. Fully 97 percent is found in the oceans and can't be used for drinking because of its salt content. The other 3 percent of water is fresh, and most of that is locked up in ice or glaciers.

How Water Gets to Your Home or Business

Typically, pipes bring the water supply from a facility that treats the water to your home or business. A well-built and maintained distribution system of pipes helps ensure its quality. Another format to provide water specific for drinking to a home or business would be the installation of a water cooler or the delivery of bottled water.

Treating the water

REMEMBER

Water treatment involves disinfecting and purifying untreated ground and surface water. The purpose of a public or private water treatment facility is to make water *potable* — that is to say, safe to drink — as well as *palatable* — good tasting. The facility also ensures that there's an adequate supply of water to meet the community's needs.

Given that many people think of water as something they use to clean other things, how exactly is water itself cleaned through water treatment? Raw and untreated water is obtained from an underground aquifer (usually through wells) or from a surface water source, such as a lake or river. In urban areas, the water is often channeled to a centralized treatment facility, while in more rural areas, in-home water treatment may be the only available option.

Public Water Systems - Centralized Treatment Plants

Under U.S. law (the Safe Drinking Water Act), a *public water system* is any system which "provides water for human consumption through pipes or other constructed conveyances to at least 15 service connections, or serves an average of at least 25 people for at least 60 days a year."

Public water systems are further broken down by law into community systems, versus non-community systems. A *community water system* is simply a public water system that serves the same people year-round. Examples of community systems include municipally-owned public water systems, which may be funded through tax money or user fees paid to the municipality, or privately owned utilities that sell water directly to their customers.

A *non-community water system* is a public water system that doesn't serve the same people year-round. There are two types of non-community water systems:

- **Transient water systems:** These serve different people throughout the year. Examples include interstate rest-stops, parks, department stores, and restaurants.
- **Nontransient systems:** These serve the same people for more than six months of the year but not year-round. Examples include schools, colleges, hospitals, and office buildings.

All of these public water systems are highly regulated (see Chapter 3 for more on regulation of public water systems).

Regardless of the classification, once the water reaches the treatment plant, it is pretreated to remove debris such as leaves and silt. Then, a sequence of treatment processes — including filtration and disinfection with

chemicals or physical processes — eliminates disease-causing microorganisms. It's a highly complex process, and you'll be glad to know that it's closely monitored for quality control. All public water systems must adhere to the water quality standards established by the U.S. Environmental Protection Agency (USEPA) as well as state and local regulations. When the treatment is complete, water flows out into the community through a network of pipes and pumps that are commonly referred to as *the distribution system*.

Private Wells

A well is a strategically placed access point drilled into an aquifer, combined with a pump to withdraw the water and a basic filtering or screening system.

REMEMBER

With individually owned private wells, the homeowner bears the full responsibility for ensuring water quality. According to the U.S. Geological Survey, about 13 percent of Americans, most of them in rural areas, rely on private wells.

Through your pipes to the faucet

Whether your water is coming in from a treatment plant across town or the well in your backyard, the final step to access clean water is your home plumbing. Water is called the *universal solvent*, because given enough time it can

dissolve nearly anything. Whenever water comes in contact with plumbing materials, whether it is the plumbing in your home or the plumbing in the distribution system, it can pick up dangerous contaminants or undesirable tastes and odors. Chapter 4 of this book discusses in-home treatment strategies which can be used to create a final barrier of protection against this type of contamination.

Water from a bottle

Bottled water is popular. Studies suggest that half of all Americans drink bottled water from time to time, and about a third consume it regularly. As with tap water, the source of bottled water is usually a municipal water system or a natural spring, and from there it may go through additional purification. As a packaged product, bottled water is regulated under the guidelines of the U.S. Food and Drug Administration (USFDA). To find out more, check out `www.fda.gov`.

Counting Your Gallons

How much water do you use? The average person in the U.S. uses about 82 gallons of water per day, according to the U.S. Geological Survey. If that sounds like a lot, consider that the total includes not just drinking water, but also the water you use for washing, watering your lawn and garden, and waste disposal.

Quenching your thirst

REMEMBER

Of all that water you use, you don't drink that much — people actually drink less than 1 percent of the water coming into their homes (according to the U.S. Geological Survey). The rest goes for other purposes.

Getting stuff (and you) clean

Given enough time, water can dissolve nearly anything. That means it's great for cleaning and explains why so much of our water usage is involved in washing one thing or another (or ourselves).

Quenching your plants' thirst

If you have a big yard or a thirsty vegetable garden, you probably already know that watering can really run up your water bill, especially in hot, dry climates.

Water down the drain

Flush a modern toilet and you just used about 1.6 gallons. Got an older toilet? The usage can be as much as 5 gallons per flush.

The Bottom Line

Unless you have your own well, you're likely to have to pay something for the water you use. In 2016, a typical U.S. household paid about $3.38 per 1,000 gallons, or $0.0034 per gallon, according to the U.S. Department of Energy. For a family of four using 100 gallons per person each day, that adds up to about $40 per month. However, some places are more or less expensive.

REMEMBER

Bottled water has a higher price tag, although it may be preferred for businesses or homes that want a low-maintenance source of quality drinking water. According to the Beverage Marketing Corporation, the wholesale cost of domestic, nonsparkling bottled drinking water was $1.11 per gallon in 2016. Drinking water sold in 20-ounce bottles may cost more than $6 per gallon.

Also, many homeowners have to pay for sewage (water that leaves the home). In the U.S. in 2016, the average monthly cost for sewage was about $57 a month, or $4.73 per 1000 gallons used according to the U.S. Department of Energy, but depending on the city, it can range from less than $20 to more than $200.

IN THIS CHAPTER

- Keeping healthy
- Maintaining appliances
- Listening to the EPA
- Ensuring that your water is clean

Chapter 2

Benefits of Good Water Quality

Understanding the effects of poor water quality can help you appreciate the benefits of good water quality.

Water and Health Are Linked

According to the Centers for Disease Control and Prevention (better known as the CDC), the top 11 causes of disease outbreaks related to drinking water are:

- Giardia
- Legionella
- Norovirus
- Shigella
- Campylobacter
- Copper
- Salmonella
- Hepatitis A
- Cryptosporidium
- E. *coli* and excess fluoride (tie)

Bad as that sounds, it's far from a complete list. There are also health risks related to water contaminated with organic and inorganic matter, other bacteria and viruses, and other pollutants.

Studies link high levels of lead in drinking water to delays in physical and mental development, short attention spans, and learning difficulties in children. Arsenic in

drinking water can lead to nerve, heart, skin, and blood vessel damage, increased risk of cancer, and neurodevelopmental difficulties in children similar to lead. And nitrate in drinking water used to prepare baby formula can cause life-threatening methemoglobinemia, or blue-baby syndrome, in children less than 12 months old.

Still, water is essential. The human body is, after all, 65 percent water, and although a human being can survive a month or more without food, a week without water can be fatal.

REMEMBER

Yes, bad water is bad for you, but safe water is key to life — and good for you! A study by the National Academies of Sciences, Engineering, and Medicine determined that an adequate daily fluid intake is about 91 ounces for women and 125 ounces for men, but this includes water from all drinks and from food. About 20 percent of your daily fluid intake typically comes from food, and the rest from drinks.

Good for Appliances, Too

REMEMBER

Good water is good for your home and appliances, too. A 2009 study commissioned by the Water Quality Research Foundation (WQRF) and conducted by the Battelle

Memorial Institute found that adding a water softener helps water heaters and major appliances operate as efficiently as possible, while preventing clogs in showerheads, faucets, and drains.

For example, researchers ran dishwashers and washing machines for 30 days and 240 wash cycles. They ran softened water through half of the units, while using a hard water source for the others. At the end of the month, the washers using softened water were nearly free of scale buildup, but the washers using hard water required scale removal to work well.

As for water heaters, the researchers found that when they used softened water, the units maintained their original factory efficiency rating for as long as 15 years. Running hard water through the units cut efficiency by up to 48 percent. Scale buildup shortened the lifespan of the heating elements inside electric water heaters, and some tankless water heaters using hard water failed after just 1.6 years!

The researchers found that showerheads performed well on soft water, but those running with hard water lost 75 percent of their flow rate in less than 18 months. When running hard water through faucets, the strainers on the faucets clogged within 19 days.

REMEMBER

Softened water can save you money by keeping appliances at top efficiency, and making them last longer. The amount of dish and laundry detergent you use can be cut by half, or even more, if you use softened water. You can also lower wash temperatures from hot to cold without a drop in performance, according to two other independent studies.

Studies conducted by the independent test firm Scientific Services S/D, Inc., of New York, showed that using softened water can:

- Reduce detergent use by 50 percent in washing machines and save energy by making it possible to wash in 60°F cold water instead of 100°F hot water, while achieving the same or even better stain removal along with whiter clothes.
- Achieve the same cleaning results in dishwashers while using less than half the detergent.

REMEMBER

Save appliances, save money, and save the planet, too. If you're using less energy to heat (softened) water, you're reducing your carbon footprint. And if you're using less detergent, that means less is going down the drain, reducing harm to the environment.

The USEPA Talks Sense

The USEPA WaterSense program helps you save water and protect the environment. Look for the WaterSense label on products for your home, yard, or business. To earn WaterSense certification, a product or service must be at least 20 percent more efficient than other similar products without any loss in performance.

An independent, third party certifies WaterSense-labeled products to meet USEPA standards for water efficiency and performance. WaterSense certifies showerheads, toilets, faucets, irrigation systems, urinals, and more. Look for a complete, searchable list of products at `www.epa.gov/watersense/product_search.html`.

REMEMBER

Is it worth the trouble? Yes. According to the USEPA, if one of every ten homes installed a WaterSense faucet, it would save about 6 billion gallons of water per year and more than $50 million in energy costs. And that's just one faucet in a tenth of all homes! Imagine how much water and energy could be saved if more homes took action.

Water Quality Tips

We've talked about water quantity and reducing usage. What about water quality?

Keep your water filters clean

TIP

If you have a filter to remove contaminants, maintain it according to the manufacturer's specifications. This might include cleaning it, replacing filter cartridges, and sometimes calling in a professional for service. Filters overdue for cleaning or replacing may no longer work properly to remove contaminants and may let foul tastes and odors remain in your tap water.

Wash water containers regularly

You can have the best water treatment in the world, but if you put clean water into a dirty container, it may no longer be safe or palatable to drink. It's critical to properly and regularly clean water containers, from household pitchers to water bottles.

TIP

Mix a few drops of dish detergent into clean water and pour it into the storage container. Agitate the liquid, and scrub the inside with a nonabrasive scrub brush or a clean dish rag, then rinse the container thoroughly. If you want to achieve a higher level of cleanliness, disinfect the container with a mixture of unscented chlorine bleach and water. Mix it according to instructions on the bottle, and then swish the mixture around inside the

container to ensure that it hits every surface. Leave the mixture inside the container for about 30 minutes, and then thoroughly rinse with tap water.

Maintain your water softener

REMEMBER

A typical water softener uses resin beads to capture hardness ions, and periodically uses salt to cleanse the beads and prepare the unit to remove more hardness ions. If you have a basic system, check salt levels at least once a month; it's easy to do. Just lift the tank lid and look inside; if the tank is less than half full, add more salt. Or find a water professional at `www.wqa.org`, and have them check and maintain it for you.

IN THIS CHAPTER

- Understanding water purity
- Diagnosing your water
- Examining the regulations

Chapter 3
What's in Your Water?

Know what's in your water, so, if a problem is found, you can do something about it.

How Pure Is Pure?

Your water isn't just molecules made up of two parts hydrogen to one part oxygen, or H_2O. *Pure water* is a relative term because almost all the water you'll encounter

contains minerals, impurities, contaminants, and microorganisms. These substances may be present in incredibly tiny amounts, and they don't necessarily have negative health impacts. Some of them might impart the flavor you expect from water — if you drank pure H_2O, you might not even like it.

REMEMBER

Knowing your household water has stuff in it besides just plain H_2O, the USEPA has created standards that enable water to be classified as potable water, even if it does have traces of other elements in it. Of course, these standards require that the water be free of disease-causing microbes, and also require it to be clear, palatable, odorless, noncorrosive, and free of any other objectionable particles or gases.

Water gains other ingredients in many ways. Acid rain, industrial waste dumping, runoff from storms, and pesticides can contaminate surface water. Contaminants may come from older combined sanitary/storm sewer systems that overflow during wet weather. Groundwater might be contaminated by chemicals leaching into soil from landfills, septic systems, or improper disposal of agricultural or household chemicals. Sediment can also build up in your own hot water tank, introducing more contamination. And corrosion of your pipes and fixtures can add metals such as lead and copper to your water.

TIP

Consumers connected to a public water supply should be aware that water can become impure after it leaves a treatment facility, and it can even pick up some additives from the facility itself. Most municipalities add chemicals such as fluoride, chlorine, or chloramines to treated water to help protect your teeth and to keep the water free of harmful germs on its way to your tap.

Beyond that, silt, sediment, and other minerals can build up inside water mains and household plumbing. When a water main breaks or is repaired or replaced, it's possible for silt, sediment, and microorganisms to enter the system.

Changes in the source water, such as when a public water supply turns off an old well or brings a new well online, changes in chemical additives such as a seasonal switch from chlorine to chloramines, and other changes impacting the water chemistry can cause a release of materials and contaminants which have built up inside the distribution system.

WARNING

Consumers relying on a private well should be aware that even in unpolluted areas far from sources of industrial or agricultural pollution, there are many dangerous contaminants which occur naturally in groundwater. For example, arsenic and radionuclides

are often found in groundwater due to natural geological deposits.

Diagnose Your Water

There are many ways to find out what's in your water and whether it's safe. Below are tips.

The most obvious possibilities

Your first diagnostic tools are your senses. You can, at times, see, taste, and smell contaminated water. Keep reading though because many serious contaminants are tasteless, odorless, and invisible.

Use your eyes

When artists show water in landscape scenes, they often make it blue or blue-green. But you wouldn't want water that color coming out of your tap. Quality water, when you view it up close, is clear and colorless.

Water that is red, orange, yellow, brown, or cloudy can signal iron, rust, or other contaminants in the mains or your household plumbing. Tannins from decaying vegetation and leaves can also give water a yellow or brownish hue.

Manganese may make water appear brown, red, orange, yellow, or even black. Iron may give it a reddish-orange cast, or it might even have a yellow, tealike appearance.

Like that scenic painting or photo, water might have blue or green in it. That may indicate the presence of copper, possibly coming from corroded plumbing. You might also see blue or green water if there's corrosion of the bronze alloys in pumps and valves, a sign that there also may be zinc in the water.

TIP

If your water has these issues, try to identify the source. Consider these tips for sleuthing.

Contamination from water mains will most likely show up in these three ways:

- Clear water suddenly becomes discolored.
- Cold water looks discolored but hot water looks clear.
- Discoloration from faucets continues even after the water has been running for a few minutes.

Or, if the issue comes from your home plumbing, there are two ways that it will reveal itself:

- There's discoloration after the water hasn't been run for a few hours.
- The water runs clear after a few minutes.

Follow your nose, trust your tongue

Stinky or bad-tasting water are signs of impurities.

Here are common water odor or taste problems you might encounter:

- A rotten-egg or sulfur smell or taste suggests the presence of hydrogen sulfide. That's often caused by a certain type of bacteria in the water. Sulfates can also cause the water to taste salty. Investigate further to pinpoint the source, such as bacteria growing in drains, water heaters, wells, or on the inside of pipes.
- Musty, earthy odors and tastes may signal dissolved solids. Such aromas and tastes may be caused by decaying organic matter in the plumbing or even in the source water itself.
- Then there's the smell and taste of chlorine. It's there for disinfection to make water safer to drink and originates during the normal chlorination treatment process, but to enjoy the taste you may want to get rid of it.
- If water smells or tastes like turpentine or other chemical (yikes!) that might indicate the presence of MTBE (short for methyl tertiary butyl ether) or

xylenes, byproducts of gasoline refining, paints, detergents, or inks.

- Metallic smells and tastes may be a sign of mercury, lead, copper, arsenic, or iron in the water. Manganese and zinc may also cause a metallic smell or taste. These chemicals may come from the pipes themselves.

Diagnosing stains and deposits

It isn't just the water that can be discolored. Discoloration of surfaces can also be a sign of impurities.

Got bathtub rings or white scale, spots on dishes and cutlery, or deposits on clothes coming out of the wash? Those are signs of hard water or excess total dissolved solids (experts call these TDS for short) in your water. The biggest culprits in hard water are calcium (limestone) and magnesium. TDS can include all minerals, salts, or metals dissolved in water, and might include plant material.

The invisible contaminants

It's bad enough to be able to see, smell, or taste a contaminant. But what if your water looks, smells, and tastes just fine — is it? Not necessarily.

Microbial and organic contamination

Microbial and organic contaminants aren't always seen, smelled, or tasted. You might go years before realizing a problem exists. Many folks never become suspicious until people in the community start to get sick.

WARNING

Although some waterborne microbes can cause illness, many microbes are harmless or even beneficial. Very small levels of microbes are naturally present in many water supplies, but some are more dangerous than others. Some of the more dangerous microbial contaminants, such as *E. coli, Giardia,* and *Cryptosporidium,* can cause gastrointestinal problems and flulike symptoms commonly attributed to undercooked or improperly stored food.

TECHNICAL STUFF

To kill or remove these microbes, water treatment facilities often use chlorination. Problem is, disinfection chemicals such as chlorine are reactive and can combine with other substances in water, such as natural organic chemicals and bromide compounds, to form hazardous byproducts such as bromate, chlorite, haloacetic acids (HAA5), and trihalomethanes (you might hear them described as total trihalomethanes or TTHM). The USEPA says that long-term exposure to

these hazardous chemicals can increase the risk of illnesses such as cancer and anemia, along with liver, kidney, and central nervous system problems.

WARNING

Water near agricultural areas may contain harmful organic material from pesticide or fertilizer application. Chemicals from pesticides and fertilizers in water may increase cancer risk and reproductive problems, and can impair eye, liver, kidney, and other body functions. Similar problems can result from exposure to water near industrial plants.

Inorganic and mineral substances

There are still more possible pollutants in water. These include:

- **Nitrates and nitrites:** Sometimes found in small amounts in well water in agricultural areas; can cause illness in adults, and be fatal to small children
- **Arsenic:** A natural well water contaminant which contributes to skin damage, circulatory system issues, and increased cancer risk
- **Lead:** From some plumbing fixtures and pipes, shown to impair physical and mental development

in children, contribute to kidney disease, and cause high blood pressure in adults

- **Mercury:** Usually from industrial pollution, can contribute to kidney damage and more

WARNING

At low levels typically found in water, these substances are invisible, odorless, and tasteless, but nevertheless harmful.

Taking the test

REMEMBER

The USEPA's Safe Drinking Water Act requires public water systems to test the water once, twice, or several times per year, depending on the potential contaminants and the size of the population served. But just because the water has been tested, you can't necessarily assume that all is well.

The Safe Drinking Water Information System produces a report titled *Annual Public Water System Statistics.* The report cites thousands of violations across the country, violations that affect millions of people each year. Likewise, the CDC reports that outbreaks caused by water quality issues lead to more than 4,000 illnesses every year. More than half of these illnesses were related to untreated or inadequately treated ground-water, says the CDC.

WARNING

Water that leaves the treatment facility can become contaminated by the time it shows up at your tap.

Municipalities don't continuously monitor the water pipes that transport water to homes.

The Consumer Confidence Report (CCR)

TIP

If your home is served by a community water system, request a copy of your CCR (sometimes referred to as the annual water quality report). Community water systems are required by the USEPA to issue a CCR every year. The report details what contaminants, if any, exist in the water supply and how these contaminants might impact health.

The CCR informs consumers about the source of their drinking water, details recent water quality testing results, then compares the results to the USEPA's health-based standard. The document also provides info about *Cryptosporidium* and lead, even if these contaminants aren't found in the water supply.

TIP

If your CCR states the water is considered safe, and yet it still tastes, smells, or looks bad, you may wish to do further testing through a certified water-testing laboratory. You can check with the Water Quality

Association (WQA) to find a water quality professional (www.wqa.org) or connect with a certified water-testing lab to test your water (https://www.epa.gov/dwlabcert).

Also, in some cases, home well water hasn't been tested in years, possibly not since the well became active. No standards govern the testing of private well water. There are rules in certain places — some states or the USEPA recommend annual testing, and in some cases require testing when a home or business is sold. Otherwise, private well water quality is largely undefined and unmonitored.

TIP

Private well owners should check with their local health department to see if they offer assistance to private well owners. Some public health agencies offer free well testing, advice, and information on local water quality issues.

Is My Water Hard or Soft?

Water hardness refers to the level of certain minerals, particularly calcium and magnesium, found in your tap water. Hard water causes problems such as spots on dishes or sink fixtures, scale buildup on showers, tubs,

sinks, and toilets, and poor soap lathering. It can also clog pipes, increase the energy necessary for heating water, and damage household appliances that use water.

In the U.S. *soft water* is defined by the American National Standard NSF/ANSI 44 as having less than 1 grain of hardness per gallon. This is a requirement in the standard for water treatment systems, which are certified to deliver soft water. This standard and the definition of soft water was established by a committee of subject matter experts and public officials who considered the benefits of softening, and the amount of hardness that needs to be removed from water in order to achieve those benefits.

The benefits of softening include things like:

- Protection of appliances such as dishwashers and water heaters
- Saving money on energy costs
- Reducing the amount of detergent needed for laundry
- Preventing clogs in showerheads and other fixtures

More information on the benefits of softening is included in Chapter 2.

Is My Water pH Neutral?

It's possible for water to be acidic, or the opposite, basic. Or, it could be in the middle — neutral, which is desirable. Acidic or basic water is measured on the pH scale.

What Do You Call Safe?

The USEPA has been in charge of the quality of U.S. drinking water since 1974, when the Safe Drinking Water Act (SDWA) passed. This law requires the USEPA to set standards for drinking water quality and monitor whether states, local municipalities, and water suppliers are in compliance.

The Safe Drinking Water Act (SDWA)

REMEMBER

Under the SDWA, the USEPA sets limits on levels of certain contaminants in drinking water. It also sets standards for testing schedules and test methods, and determines which water treatment processes are acceptable. The SDWA, doesn't regulate private wells.

Federal law also allows states and municipalities to supply in-home treatment systems as a strategy for complying

with the SDWA. This can be a very inexpensive solution for smaller communities that don't have enough tax revenue to build or upgrade a centralized treatment plant, or to pay for the infrastructure needed to support it. There is also an added benefit that these in-home devices are treating the water at the location of the end user, which means consumers don't need to worry about contaminants that might otherwise be picked up between the centralized treatment plant and the home.

Regulating the byproducts of disinfection


REMEMBER

In 1998, the USEPA began requiring public water systems to use treatments that reduce the formation of disinfection byproducts. Specifically, the rule regulates hazardous chemicals such as TTHM, HAA5, bromate, and chlorite.

Microbial regulations


REMEMBER

The USEPA's Surface Water Treatment rule focuses on pathogens or disease-causing microorganisms in drinking water. Under this rule, a public water system must have treatment sufficient to reduce water concentrations of *Giardia* and other pathogens. The ruling sets limits on disinfectant residuals

and turbidity, which is water discoloration or cloudiness from the particles suspended in water. The USEPA's list was later expanded to include *Cryptosporidium* and other harmful microorganisms in water, and acceptable levels of disinfection byproducts were lowered.

Emerging and Unregulated Contaminants

Although scientists continue to discover new contaminants in our drinking water, federal regulations can't always keep pace. Since its establishment in 1974, the SDWA has only been amended twice: in 1986 and again in 1996. Meanwhile, we have learned about many new potential contaminants which are not currently regulated in the SDWA.

PFAS

There is a growing concern about an entire class of chemicals called per- and polyfluoroalkyl substances (PFAS). These chemicals are used in a wide variety of industries including fire fighting foam, carpet, clothing, and even packaging. They've earned the nickname the "forever chemicals" within the scientific community, because nothing in nature will destroy them. The CDC performed

a national study in 2003 in which they found four of these chemicals in the blood of nearly every individual they tested. Research has shown potential health impacts include low infant birth weight, decreased fertility, elevated cholesterol, abnormal thyroid hormone levels, liver inflammation, weakening of the immune system, and testicular and kidney cancer.

Other concerning substances

In the late 1990s, scientists began realizing that many of the pharmaceuticals and personal care products we use end up in our waste water, and are not completely captured during the waste water treatment process. Once released from the waste water treatment plant back into the environment, these drugs can then end up in our drinking water supplies. Scientists have discovered hormones, mood stabilizers, antibiotics, insect repellents, and many similar products in drinking water. Although the levels tend to be very low, the health impacts of this exposure are still unknown.

What to do about these contaminants

If your home is served by a community water system, you can request information about emerging and unregulated contaminants from your water supplier. The officials who oversee your community water supply are highly

dedicated professionals who want to protect the health of their customers. Even though these contaminants are unregulated at the federal level, many states and municipalities have launched special programs to monitor and treat for unregulated contaminants once they have been identified in a water supply.

Private well owners should contact the local public health department. These officials are always monitoring for any local threats to health, and they may be aware of unregulated contaminants that have been found in local wells and groundwater. These agencies can also help private well owners connect with laboratories to get the well water tested, and they may even have programs to fund the testing or obtain testing at a reduced rate.

WQA is another great resource for finding out about emerging contaminants, and potential treatment strategies to deal with them (`www.wqa.org`).

IN THIS CHAPTER

- Solving your water problems
- Finding the right people and products
- Examining green treatment options

Chapter 4

Finding the Right Water Treatment Products

You often know when your water is "bad." It smells, doesn't lather your soap, has a funny taste, or comes out of the faucet in odd colors. Or, perhaps water testing has detected contaminants of concern. What do you do next?

Condition Your Water

Whether your water is hard or contaminated, there are effective water treatment technologies ready to help. Water conditioning is the treatment of water to modify, enhance, or improve it so it meets a specific water quality need, desire, or standard. Or just call it water treatment. There are many different treatment technologies that get the job done.

Exchanging ions to make water softer

Ion exchange water softeners are among the most common ways of softening water. The typical ion exchange system consists of a pressure tank filled with sulfonated, polystyrene beads that are capable of removing hardness ions from water, and replacing them with softer ions, such as sodium. These units are connected to a brine tank that's filled with salt, which periodically regenerates the resin beads.

The unit's tiny beads attract and hold onto calcium and magnesium ions as water passes through them. When the beads become so saturated they can't hold any more, the unit rinses them with salt, which scrubs off the mineral deposits and gets them ready to absorb hardness

ions again. The salt solution is then rinsed from the unit and sent down the drain.

If you've got this type of water softener, you can set it to regenerate at preset times, or if it's a bit more sophisticated, it can base regeneration on your actual water use. Systems that measure water use and regenerate accordingly, called *demand initiated regeneration (DIR),* may be more efficient because they only regenerate as needed. Systems that automatically regenerate on set time intervals, called *time clocks,* certainly simplify the process. But sometimes these regenerate more often than necessary, wasting salt, or they leave users with hard water when water demand is higher than normal.

Filtration may be the answer you need

REMEMBER

Although water softeners get rid of some heavy metals along with hardness, water filtration systems are the best way to remove organic and inorganic materials such as microbiological contaminants and particulates such as sand, rust, or silt. Water filters remove these impurities with a fine physical barrier, chemicals, or some other method to help clean water and make it suitable for drinking or other use.

There are many filtration solutions available, and they generally fit into two categories: point-of-use and point-of-entry. Both of these categories fall under the umbrella of final barrier treatment.

Final Barrier

Whether your home is supplied by a community water system or a private well, in-home treatment devices are a great way to ensure quality drinking water is available for your family. WQA calls this the *final barrier* concept. We all rely on our local fire fighters to be on call 24/7 in case of a fire, but many people deploy additional protections for their family, such as smoke detectors, fire alarms, or even sprinkler systems. The final barrier concept is very much the same, additional protections which can be deployed within your home or place of work.

For those serviced by a community water system, final barrier treatment can address:

- Disinfection byproducts formed after the water leaves the local treatment plant, as residual disinfectant in the water chemically reacts with other compounds present in the water
- Unexpected spikes of lead due to construction activity or disturbance of water lines

- Metals released due to corrosion of piping or in-home plumbing
- Bacteria and other microorganisms that might enter the system from pipe line breaks

For private well owners final barrier treatment can address:

- Naturally occurring contaminants in the groundwater, such as arsenic or radionuclides
- Bacteria and other microorganisms that might find their way into your pipes from a broken well cap, or a flood
- The corrosion of lead or copper from plumbing materials and fixtures in your home
- Nitrates, pesticides, herbicides, and other pollutants from agricultural activities

And regardless of the water source, sometimes the final barrier concept is needed to provide higher water quality requirements for pregnant women, children, elderly, the immunocompromised, or other individuals whose health depends on it.

Point-of-Use

Point-of-Use (POU) devices treat water at the point of consumption. The technology provides the *final barrier* to

the contaminants of concern before the water is consumed or used. Among the choices are:

- **Gravity devices:** Such as countertop pitchers that use carbon filters.
- **Inline filters:** Packed with filtration media or membranes and installed in, or perhaps underneath, a sink.
- **Reverse osmosis units:** Installed on, in, or underneath a sink.
- **Ultraviolet (UV) technologies:** Uses light to deactivate pathogens so they can't grow and reproduce.
- **Distillers:** Turns water into steam and back again, and in the process gets rid of nearly all kinds of biological pathogens and a host of contaminants.

Point-of-Entry

Point-of-Entry (POE) devices are whole-house treatment systems mainly designed to reduce contaminants in water intended for showering, washing dishes and clothes, brushing teeth, and flushing toilets. Options include:

- **Water softeners:** Discussed in the "Exchanging ions to make water softer" section.

- **Sediment and tank filtration systems:** Removes contaminants as water enters the home.
- **Large inline filtration systems:** Installed where water enters the home plumbing system.


TIP

Choose filtration media guided by the specifics of your situation. For example, you may need a system that uses greensand media. It's good for getting rid of contaminants such as hydrogen sulfide. As with the resin beads in a water softener, many types of media need recharging or replacement from time to time.


TECHNICAL STUFF

Activated carbon is a widely used filtration substance that targets various volatile organic compounds, such as benzene, trichloroethylene, and various pesticides and petroleum-related compounds. Maintenance is as simple as swapping out a cartridge once or twice a year. Activated carbon may be granular or in a solid block. Some carbon block filters can have greater filtration capabilities that can remove lead, asbestos, and some microbes out of the water.

You also may choose ceramic or synthetic fiber microfilters, which can sift out tiny contaminants including various microbes and tiny sediment particles.

Moving forward with reverse osmosis

Sometimes shortened to the acronym RO, these systems force water, under pressure, into a module that contains a semipermeable membrane and a number of other filtration steps. A typical RO system has a prefilter designed to capture larger particles, chlorine, and other substances; a semipermeable membrane that separates more contaminants and rinses them down a drain; an activated carbon filter that removes residual taste, odor, and some organic contaminants; and a storage tank to hold the treated water for use.

You can get a whole-house RO, but more commonly, a point-of-use RO system would be on your countertop or installed under the sink. They're great for treating water for cooking and drinking, but they don't usually produce large amounts of treated water — more like 25 to 50 gallons a day. For that reason, typically people choose to install RO-treated faucets in the most popular areas of the home such as kitchens and bathrooms, as opposed to installing it for every drinking tap.

Just like any other kind of filter technology, reverse osmosis systems require regular maintenance and sanitation. That includes periodically replacing the unit's prefilters, postfilters, and membrane modules.

Distilling purer water

REMEMBER

Distillation is one of the oldest water-purification methods around. Distillation will effectively remove minerals, most chemicals, and many bad tastes from tap water. These systems heat water until it reaches its boiling point and begins to vaporize, and then feed the vaporized water into a condenser that cools the steam and converts the water back to liquid form.

A vent to discharge gases is a common feature, and these units may also include an activated carbon filter to pull out even more contaminants. Most home distillers produce only small amounts of treated water daily. They require periodic cleaning and descaling to remove mineral buildup.

Disinfection is a clean choice for private well systems

Water disinfection is just what it sounds like — it gets rid of the stuff that's infecting the water. It removes, deactivates, or kills microorganisms, viruses, cysts, and bacteria. If water wasn't disinfected, it would likely contain disease-causing agents that would make a lot of people sick. Municipalities disinfect water at the water treatment plant. Consumers in homes with private wells must disinfect water themselves.

TECHNICAL STUFF

There are both chemical and physical ways to disinfect water. Chemical disinfection often uses halogens such as chlorine, iodine, bromine, or ozone, while common physical choices are ultraviolet (UV) light, ultrafiltration, and distillation. These processes can eliminate anywhere from 99.9 to 99.9999 percent of harmful microorganisms.

Ultraviolet light (UV)

REMEMBER

The UV disinfection method, which doesn't involve chemicals, has long been popular for commercial use, and it's becoming more common in homes. UV systems expose water to light at just the right wavelength for killing microbes. It's a way to kill bacteria, viruses, fungi, protozoans, and cysts that may be present in the water.

How effective it is depends on the strength and intensity of the light, the amount of time the light shines through the water, and, of course, the quantity of particles in the water in the first place. The light source must be kept clean and the UV lamp replaced periodically.

UV light treatment can't remove gases, heavy metals, and particulates, and for that reason higher-end systems may include additional filtration such as activated carbon. If so, that means you'll need to occasionally clean or replace those filters or perform other maintenance.

Chlorination

REMEMBER

This method of disinfection involves adding chlorine to water to make it safer to drink. It's common, cost-effective, quick, and effective, killing many pathogenic microorganisms. It can even oxidize or break down iron, manganese, and hydrogen sulfide, which can result in water that is clearer and tastes better.

Some people find that chlorine gives water its own objectionable chemical taste and odor. It also can produce disinfection byproducts (which may cause health issues) by reacting with other substances in water when stored. These byproducts can often be filtered out with activated carbon.

Ozone

You get ozone when you expose oxygen to high-voltage currents. Introduce ozone into the water treatment process, and you'll destroy viruses, bacteria, and other microorganisms, and also remove iron, sulfur, and manganese. Ozone does its job quickly and then rapidly decomposes, and that cuts down on the introduction of harmful disinfection byproducts and foul tastes or odors associated with chlorination. This process tends to be more costly and energy-consuming and is typically used commercially or by large municipalities.

Newer ideas for treating your water

Do you like cutting-edge technology? That may be a great idea when buying phones, electronics, or cars, but you should think twice about purchasing water treatment products that don't have third-party certified performance claims. Find out more about third-party product certification later in this chapter. Here are some of the latest concepts for treating your water along with notes about what to consider before a purchase.

Antiscaling treatment

Antiscaling treatment isn't new, but it's new for household use. These types of devices may use magnets, conductive ceramic plates, or even citric acid, to attract, disrupt, or remove hardness ions. Because they're new to the home, there aren't many conclusive studies about the efficacy of these devices for home use.

REMEMBER

Although some of these products may work at the industrial level, water quality varies from house to house. The appliances used in the home are also much different than those used in commercial and industrial applications: They operate at different energy levels and may have different water quality requirements. These factors make it more difficult

to predict the performance of antiscaling devices in the home. Consumers should investigate product claims prior to making a purchase, and as with all treatment devices look for antiscale systems that have been certified for performance by an accredited third-party.

Antiscaling technologies currently marketed for residential use include:

- Media-induced precipitation systems that use surface-treated resin beads to convert (not remove) hardness ions to scale-resistant forms.
- Electrochemical demineralization devices used to remove hardness ions and other dissolved solids.
- Electrically induced precipitation that uses a direct electrical current to precipitate water hardness and other compounds.
- Sacrificial media systems that release chemicals such as citric acid or phosphates into the water in order to discourage the formation of scale.
- Physical devices that utilize magnetism and/or electrical fields.

New standards and protocols may evolve over time that could affect product testing and certification of antiscale products in coming years. As always, feel free to check with WQA if you're having trouble finding certified products. Also see "Finding the Best Products" later in this chapter for more on product certification.

Alkalizer/ionizer

WARNING

These systems often try to capture consumers' attention by claiming health-related benefits. Be sure to thoroughly review these claims and don't be afraid to ask your family doctor for an opinion. Water treatment devices can be independently tested and certified to prove that they will remove specific contaminants from the water, but health-related benefits, such as a claim you will have more energy, or that injuries will heal faster, require years of academic research to verify.

In the U.S. market, the Food and Drug Administration (FDA) has jurisdiction over health supplements, while in Canada it falls under Health Canada. At the time this booklet was published, neither the FDA nor Health Canada had reviewed or provided an opinion on the health benefits that are associated with these products. So, be cautious if there isn't robust science backing up claims.

Maintenance Is Important!

No matter what type of system you chose, read and follow the manufacturer's maintenance instructions. For example:

- POU filters require periodic replacement of filter cartridges. POU Reverse Osmosis systems require periodic replacement of the RO membrane, plus there may be pre and post filter cartridges that require periodic replacement.
- UV bulbs have a finite lifetime after which they require replacement.
- Distillation units may require occasional cleaning of the evaporation tank.
- Water softeners require the replenishment of salt in the brine tank.

When to Seek Professional Help

If you've noticed your water has a bad taste, smells, doesn't lather, leaves scale or spots on surfaces, or if you've had lab testing done and you aren't sure how to solve the problems, it's time to contact a water quality

professional. A pro can help you sort through options because water is complex, has many potential contaminants, and there's no "one size fits all" when it comes to water treatment.


TIP

After finding a reputable water quality professional, be sure you're getting a high-quality treatment system, based on what you and your advisor decide you need.

Fortunately, there are ways to determine both the quality of the product and the professional (see Chapter 5 for a list of questions to ask when searching for a water quality professional).

FINDING A WATER QUALITY PROFESSIONAL

The Water Quality Association, which has more than 2,500 company members, is a not-for-profit international trade association representing the residential, commercial, and industrial water treatment industry. Its membership consists of both manufacturers/suppliers and dealers/distributors of equipment and services. WQA is a resource and information source, an educator of professionals, a laboratory for

testing, a certifier of products and professionals, and a means for helping the public make the best choices.

The WQA was founded in 1974, and started offering certification of water treatment professionals in 1977. It sets standards for water treatment businesses and equipment installers and promotes ethical selling practices among those offering water quality solutions. Professionals earn a three-year certification by meeting strict criteria, passing an exam on water chemistry and treatment technologies, and abiding by a strict code of ethics and legal requirements.

To find WQA-Certified Professionals or WQA-Certified Products, visit the WQA website at `www.wqa.org`.

Finding the Best Products

WQA provides third-party certification — notably its Gold Seal (see Figure 4-1) — for products consumers can buy for water treatment. This program, after decades in existence, is the oldest third-party testing and certification program in the water treatment industry. The Gold Seal is easily recognizable and informs consumers that products are safe and work properly.

The WQA Gold Seal Program is accredited as a reputable certification agency in the United States and Canada by ANSI (American National Standards Institute) and SCC (the Standards Council of Canada). Other accredited certifiers include NSF International, CSA Group, UL (Underwriter Laboratories), Truesdail Laboratories, and IAPMO.

FIGURE 4-1: The WQA Gold Seal.

Manufacturers and suppliers can seek Gold Seal certification for most products that contact household water. Certification covers everything from chemicals to plumbing components to filtration systems and water softeners.

REMEMBER

Product certification indicates a third-party organization has monitored the manufacturer's operations to ensure they meet guidelines for manufacturing processes and materials used. Products are tested to ensure compliance with industry standards, performance, and certification requirements.

Standards are detailed and rigorous and specific to the products certified. Some standards cover UV disinfecting systems, for example, while others ensure that reverse osmosis systems perform as claimed. Certification also helps verify that manufacturers have good customer service measures in place and offer adequate product literature or information.

Once companies go through this demanding process, they can't rest on their laurels. They must retest their certified products regularly and submit to annual facility inspections.


TIP

There are more than 10,000 Gold Seal-certified products. Search for desired products on the WQA website at www.wqa.org.

Greener Water Treatment

WQA also has a Sustainability Mark (see Figure 4-2) to help consumers select greener water treatment products that help ensure safe drinking water while showing sensitivity to the environment.

Products earn the mark only after they demonstrate best practices in manufacturing for sustainability. Rigorous examination is required to audit and assess the

manufacturer according to independent standards developed by a WQA task force of environmental experts, consultants, regulators, manufacturers, industry professionals, and other stakeholders.

FIGURE 4-2: WQA's Sustainability Mark.

IN THIS CHAPTER

» Questions to ask

Chapter 5

(More Than) Ten Questions to Ask

Before you choose and install a water treatment system, you should know what to ask the water quality professionals you're thinking about working with. This chapter goes over a few important questions.

Be aware that WQA doesn't sell water treatment devices (for more on this, see the "Watch out for scams" sidebar).

Make sure you ask:

- Are you a WQA-Certified Water Specialist, WQA-Certified Sales Representative, or a WQA-Certified Installer?
- Do you have a contractor's license, business license, and liability insurance (if these things are required in your area)?
- How long have you been in business, and who can I call for a referral?
- What do my water testing results show?
- How do I know that the test results cover the main contaminants of concern for my home? Could you be missing something?
- Do these results indicate health hazards in my water?
- Do the water quality issues in my home require whole-house treatment, or will I be okay with a single-tap or other point-of-use device?
- Will the device you're recommending treat enough water to accommodate my family's needs?
- What is the total purchase price, and how much more can I expect to pay to maintain the system year in and year out?

- Will you be installing and servicing the device? Is that free, and if not, what will it cost?
- Can I maintain the system myself? Will you show me how to do this?
- Has a third-party organization certified the performance of the products you offer?
- What type of warranty comes with this product?
- How will I know if the equipment is operating correctly?
- What secondary effects might this water treatment unit have on my water quality? Any byproducts?
- Will you provide free follow-up water testing a few months after installation to ensure that the equipment is doing its job?

TIP

If you're thinking about buying a certified product, the certification can easily be verified by going to the website of the certification body. Once you're on the website, look for the product certification page and then search for the model number. You can also contact the certification body directly and ask them to verify the certification. Also ask them to explain the scope of the certification so you know exactly what was tested.

WARNING

WATCH OUT FOR SCAMS

Employees of WQA will never try to sell you anything. WQA is a quality certification organization. They don't sell water treatment products of any kind.

However, some of the best qualified water treatment professionals in the world are *members* of WQA. Don't be alarmed if a salesperson says they're a member of WQA.

Highly trained, qualified, or certified water treatment professionals can be found through the WQA website (`www.wqa.org`). You can also use the website to verify membership in the association or by contacting WQA.

However, if sales representatives say they're *employees* of WQA, they're trying to scam you. These individuals should be reported to WQA and your local authorities for fraudulent sales tactics.

FOR ADDITIONAL

Consumer Information

Visit www.wqa.org

Find a Water Professional

- Locate WQA member professionals in your area by searching via state, province, zip/postal code, company name, or country.
- Find WQA water professionals who have demonstrated a certified level of professional expertise and a dedication to high industry standards.

Find the Best Products

- WQA provides Gold Seal certification of water treatment products. The Gold Seal is easily recognizable and lets consumers know at-a-glance that products are safe and work as they're supposed to.
- WQA's Sustainability Mark helps consumers select greener water treatment products that help ensure safe drinking water while showing sensitivity to the environment.

International Headquarters & Laboratory
Lisle, Illinois USA

www.wqa.org

This updated version of the book can help you solve your water quality problems!

You drink and use water every day (well, duh!), and you want that water to be clean and safe. You don't want to earn a PhD in water quality — you just want to be able to turn on the tap and be confident in the H_2O that comes out.

This little book can help you understand common water quality problems and find the facts on water treatment technologies. It can also help you look for an effective partner to solve any water problems you find.

Inside…

- How to achieve cost-effective water treatment
- A list of proven technologies as well as new ones
- What you need to know to find the right products
- Discover more about water contaminants

Water Quality Association

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Homemade Water Purifier

Suggested grade level: K-6

Duration:
30 minutes

Setting:
Classroom
Outdoors

PURPOSE: To introduce students to the concept of water filtration and water borne diseases and help them become aware of drinking water safety.

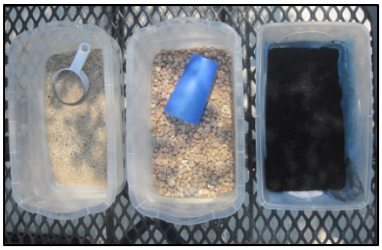
SUMMARY: By building their own water filters, students will learn what water filtration is, how it works and what it can and cannot affectively remove.

BACKGROUND: Water we use comes from lakes, rivers, and groundwater. Before we can use this water domestically, it must be cleaned. This process generally has 4 main steps, coagulation, sedimentation, filtration and disinfection.

1. **Coagulation**: removes dirt, metals and other particles suspended in water. Chemicals like Alum are added to the water that form sticky particles called "floc" which attract the dirt particles.
2. **Sedimentation**: the combined weight of the sediment and chemicals stuck together become heavy and sink to the bottom.
3. **Filtration**: smaller particles are removed as water passes through a series of filters (sand, gravel, charcoal)
4. **Disinfection**: to kill bacteria or microorganisms found in the water, a small amount of chlorine is added.

This lesson focuses on the filtration and disinfection steps. This experiment shows that even a simple purifying system can help clean dirty water through understanding the physical process of removing solid impurities of varying sizes and the chemical process of removing dissolved solids.

MATERIALS:



Picture 1: Filtering materials

1-liter soda bottles cut in half
Napkins or paper towels
*Gravel
*Sand
*Potable Aqua Chlorine Dioxide, water purification drops or tablets
Cups or scoops (for gravel and sand)
Activated Filter Carbon (available at pet stores)
Large water container for dirty water (pitchers or gallon jugs)
Dirty water (made by adding dirt, twigs, leaves, etc., to water)
Large waste container (plastic container or thick garbage bag for used filtering materials)
2 clean pitchers for filtered water
Pathogen pictures (at the end of this lesson)

*Available at hardware stores

LESSON PREPERATION:

1. Precut enough 1-liter soda bottles for each student or for each group of students
2. Create dirty water
3. Set up spots for scooping in the filter materials (charcoal, sand, gravel, etc.)
4. Have copies of the water-borne disease pathogens to show students

PROCEDURE:

1. Ask students: What is clean water? What makes water dirty? *(Discuss how "clean water" is defined by how it is used. For example, what we consider clean water for drinking may not be considered clean water for fish and vice versa.)*

2. Show students the dirty water and explain the general process of water treatment to make water safe to drink (see the background section at the beginning of this lesson for information on water treatment).

Picture 2: Dirty water

3. Guide students through building their own filter.
    a. Have students put the top half of the soda bottle-upside down (like a funnel) inside the bottom half. The top half will be where they build their filter; the bottom half will hold their filtered water.
    b. Show the students the filter materials they will be using (gravel, sand, and carbon). Ask the students: What will each of these layers remove? (*Gravel and sand remove large and small particles, carbon removes pesticides, chlorine and other chemicals and improves the taste of water*).
    c. Let each student or group decide on an order of the filtration materials for their own filter with the exception that the napkin or paper towel should go first at the bottom (into the neck of the bottle).

Picture 3: Filter

4. Once students have made their filters, put the filter on a stable surface and pour in the dirty water.

5. As their filters drip water, ask students: What does the filtered water look like? (*Help the students to think about how the filter is working, what is being filtered out and what might not be filtered out, even if the water looks clean.)* Students may need to run the water through the filter a few times in order to purify the water. Excess dust from the activated filter carbon may turn the water slightly gray. In order to save time you may want to rinse off the carbon beforehand.

Picture 4: Filter with water

6. Compare the water from each filter and discuss what order of

materials cleans the water best. (*The recommended order from bottom to top in the bottle is napkin → sand → charcoal → gravel.*)

7. Discuss how even if the water looks clear that does not necessarily mean it is clean and safe for us to drink. Ask the students: Is the water clean enough for us to drink? What else might be in the water that we can't see? *(There could still be harmful bacteria and microorganisms in the water.)*

8. Have students empty the bottom of their filters into the pitchers and add chlorine-dioxide drops or tablets according to label instructions in order to remove harmful bacteria and microorganisms.

9. Discuss with the students the terms **parasites** and **microorganisms**. Show pictures of each water-borne disease pathogen, explaining that these are commonly found in lakes, streams, etc. Discuss how they get into our water, their life cycles inside us, and how they make us sick. See the "Further Discussion" section at the end of this lesson for more information.

10. Explain that filtering water is important, but cleaning it chemically is also important to kill pathogens before we drink it. Show the dirty and clean water and ask the students: Which would you rather drink? Why? Compare the dirty and clean water and ask any other follow-up questions.

FURTHER DISCUSSION:

1. **What are pathogens and which pathogens should we be concerned about in our water?**
   Pathogens are disease-causing organisms which may include types of bacteria, viruses, protozoan parasites, and other organisms. United State Environmental Protection Agency (USEPA) regulates the following pathogens in drinking water:
   - *Cryptospridium: This is a single-celled protozoa parasite found in lakes and rivers, especially in waters with sewage or animal waste pollution. This protozoan parasite can cause gastrointestinal illness like diarrhea, vomiting and stomach cramps.*
   - *Giardia lamblia: This is a single-celled protozoan parasite that can be found in the intestines of infected humans and animals, in soil, food, or water contaminated by feces from infected humans and animals. This pathogen can cause nausea, stomach cramps, diarrhea, and associated headaches.*
   - *Legionella: This is a type of bacteria that is naturally found in the environment, usually in water. It grows best in warm water (hot tubs, cooling towers, hot water tanks, large plumbing systems or air-conditioning systems of large buildings are ideal places for this bacteria). Legionella bacteria in water can become a health risk if the bacteria are aerosolized (e.g., in an air conditioning system or a shower) and then breathed in. Inhaling Legionella bacteria can cause a type of pneumonia known as Legionnaires disease.*

2. **What are other methods of cleaning or filtering water?**
    - *Boiling water: Boiling water can kill harmful bacteria and microorganisms. Do not boil water in order to remove nitrate, lead or some other substances. Boiling water will actually increase the concentrations of these substances, not remove them.*
    - *Filters: Most water filters available at stores remove 99.99% of waterborne viruses, bacteria and protozoan parasites and have carbon which will improve the taste of the water. This is the recommended way to completely clean water for drinking purposes.*
    - *UV water purifiers: UV light can kill bacteria and microorganisms in water because the energy emitted by the light is absorbed by the cells of microbes which prevents the cell enzymes from "reading" DNA. Without intact DNA microbes cannot reproduce.*

REFERENCES/ADDITIONAL SOURCES:

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FUN SCIENCE: Filter Magic

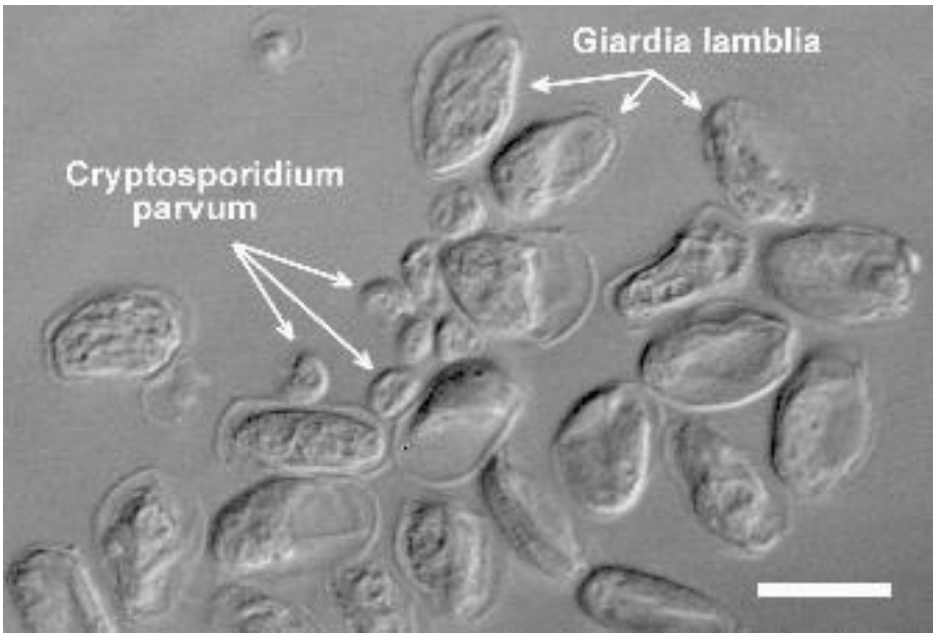
http://www.thefreelibrary.com/Fun+science%3A+filter+magic.-a0119071356

Zoom Water Filter

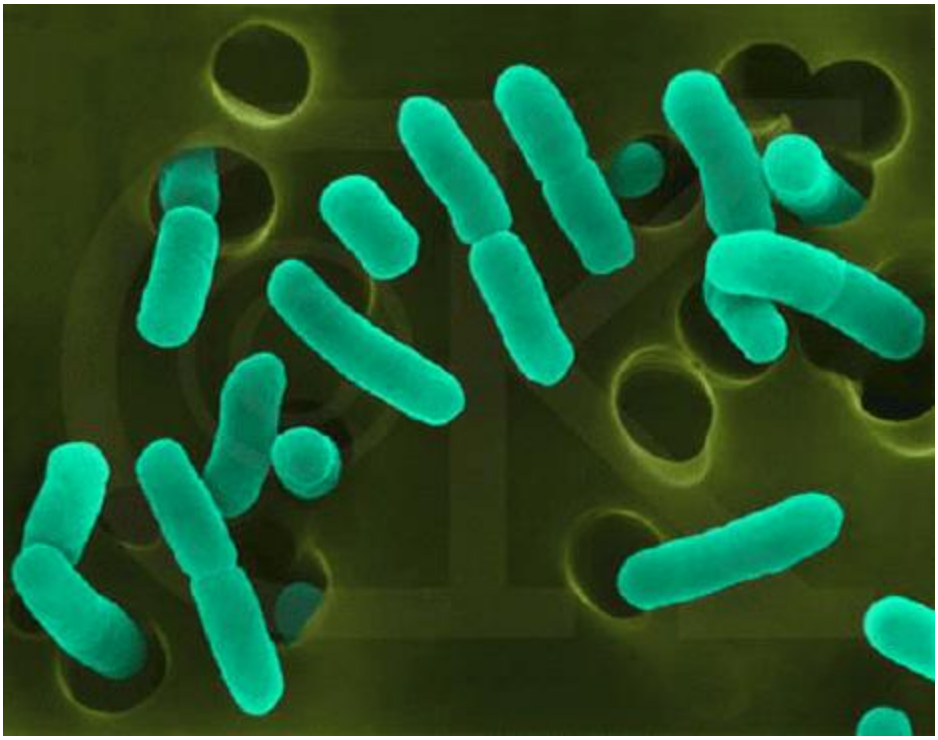
http://pbskids.org/zoom/activities/sci/waterfilter.html

Basic Information about Pathogens and Indicators in Drinking Water

http://water.epa.gov/drink/contaminants/index.cfm#Microorganisms



Cryptosporidium and Giardia Lamblia
Photo Credit: http://www.epa.gov/



Legionella
Photo Credit: http://www.epa.gov/