teaching the LifeStraw®

An Educator's GUIDE to Water Issues Around the World

Explore water-related issues from multiple perspectives. Introduce humanitarian design as a viable and necessary solution for a more sustainable future.

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THE FRESHWATER CRISIS

Most of us don't have to look farther than the nearest faucet for clean drinking water, and if that is not available, bottled water usually is. Not so for nearly a billion[1] people in the world who do not have access to clean, safe drinking water. In communities all over the Earth, including in the United States, drinking water cannot be taken for granted. In this day and age when scientists are discovering water on Mars, and inventors are designing phones the size of a credit card, millions of families around the world live in homes without running water, household wells, or even a nearby clean water source.

Unhealthy and inadequate drinking water has numerous negative consequences. Water is the body's principal chemical component and makes up between 60 to 70 percent of human body weight. Nearly every system in the human body depends on water, and when there isn't enough, the body becomes dehydrated and cannot carry out normal functions. Doctors estimate we need between two and three liters of water a day to stay healthy,[2] but what happens if the only available drinking water is not clean?

More than two million people die every year from waterborne illnesses; many of them are children.[3] In addition, dirty water prevents children from attending school and adults from working, keeping them from earning an income.[4] In communities where there is no source of clean water, people—mostly girls and women—have to walk long distances to find and fetch water. In many developing countries where economies and infrastructure are not yet fully established, a woman walks for water an average distance of 3.7 miles a day.[5] She typically carries a load weighing 40 lbs.[6] For much of the world, water is scarce, distant and heavy. And, for too many, the "freshwater" is far from truly fresh.

ENTER LifeStraw

It all started with the Guinea worm. Guinea worm disease, also called dracunculiasis, is caused by the Guinea worm parasite that develops in water fleas living in stagnant surface water. The painful, dangerous disease is transmitted by ingesting this dirty water, and the tiny water flea.[7]

Mikkel Vestergaard Frandsen in Kenya

Enter Vestergaard Frandsen, a family-owned business based in Switzerland. Originally a textile company, Vestergaard Frandsen manufactured work clothing, and later fabric, for tents and blankets which the company sold to relief organizations working in Africa. Alarmed by the prevalence of Guinea worm disease and the suffering it caused, the Vestergaard Frandsen family resolved to help prevent it. Applying their background in textiles, they set about making water filters. Vestergaard Frandsen made the early filters out of cloth, inserting a mesh material in portable straw-like pipes.

Although the product concept was excellent, Vestergaard Frandsen executives wanted to tweak the design to make it even more effective. "More than one thousand tests were needed to find the right design and combination of filters and chambers inside the straw," explains Torben Vestergaard Frandsen.[8] He enlisted help from designers and engineers, and in 2005, the LifeStraw® filter was born. A portable, plastic tube, with internal filters and no moving parts or batteries required, LifeStraw® removes over 99.9999 percent of the bacteria and 99.9 percent of parasites that cause waterborne disease.[9] When dealing with microscopic yet potentially deadly microbes, every decimal point matters and can be the difference between sickness and health.

Three years later, LifeStraw® Family was introduced as a larger and longer-lasting filtration device for the home. Equipped with a more comprehensive filtration mechanism that also blocks virtually all viruses, LifeStraw® Family filters up to 20,000 liters of water, enough to supply a family of five with "microbiologically clean" drinking water for three years.[10]

Filtration, combined with education, has proven to be an effective prevention of waterborne disease transmission, including transmission of Guinea worm disease.[11] As a result, the Centers for Disease Control and Prevention reports that the number of Guinea worm disease cases has shrunk from 3.5 million per year in 1986 to fewer than 1,800 in 2010.[12]

A filter may not lessen the weight or distance of freshwater, but once filtered, that water will be far less likely to sicken those who drink it. ***Teaching LifeStraw® Educator's Guide*** examines water-related topics and offers engaging activities for multiple age groups. Consider the *Guide* a powerful telescope allowing you to observe different locations around the world and explore their water stories (see Water Stories Supplement). The *Guide* enables students to dive into freshwater as a precious and vital resource, and investigate why close to a billion people in the world lack access. Readers get a taste of how filters can clean water, and how pollution poisons it. The *Guide* also introduces humanitarian design as a solution to water-related problems for developing countries and struggling communities around the globe. Use this *Guide* to connect water, health and design topics to your curriculum and inspire students to think about how they too can change lives, locally and globally.

H_2O: EARTH'S ESSENTIAL COMPOUND

Water has existed on earth since the beginning of geological time. Water is the stuff of poetry and art, of myth and religion. It is essential for all life, from the tiniest ant to the tallest tree, to you and me. A drop of water is miniscule but mighty; its internal atomic bonds are extremely hard to break. In huge amounts—floods, giant waves—water can cause formidable damage. Fresh, clean water is a resource so valuable and increasingly scarce that individuals, villages, states, even nations struggle over access and ownership of it. Water enables us to live—certainly we can't live without it—but when water is polluted it can kill us too. Take a closer look at this precious, powerful compound, water.

A molecule of water

Ahhh, a glass of cold water. That water you're drinking may be "fresh," but it might also be very, very old! H_2O—water—is a basic molecule made up of two hydrogen atoms and one oxygen atom. When these three atoms join together, they form a strong polar bond that is difficult to break. The strength of this bond keeps a water molecule together for millions of years. Experts think that the water we drink today may consist of some very old molecules. A water molecule can spend an estimated 3,200 years[13] in an ocean before changing form and continuing through the **water cycle**.

Students may already know about water's many forms (liquid water, water vapor, ice) and the processes it goes through to reach those different states (evaporation, condensation, precipitation). However, the water cycle is much more complex than a water molecule cruising around converting from one state to another. The process is often compared to the body's circulatory system. As with blood in the body, water is constantly interacting with the environment. Photosynthesis, precipitation, runoff, infiltration and snowmelt are all processes that are critical to the health of the planet and the many ecosystems it harbors.

Water is life

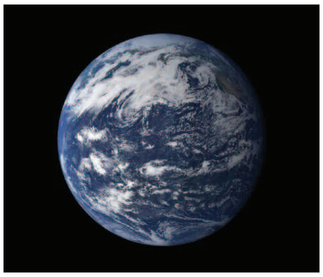
Thales of Miletus, an ancient Greek philosopher, believed that "the earth rests on water" and that water is "the nature of things."[14] From the beginning of time, water has been the source of life, of wonder, and occasionally danger. Every life form on Earth—from the largest mammal to the smallest microbe—depends on water for a variety of internal functions.

Humans rely on water for much more than simply physical survival. Water has always played an important role in religion and creation stories. Early Egyptians believed that Nu or Nun, a god representing the primordial waters, was the source of all life.[15] Certainly the beauty and mystery of water have not been lost on poets, painters and composers across the ages.

The ways in which human societies depend on water are innumerable, and on freshwater in particular; for drinking, washing, cooking, irrigating crops, raising livestock, transporting goods, and powering industry. Since the dawn of civilization, human communities have thrived near rivers and other waterways. Humans use freshwater in other less essential ways also: to irrigate lawns and landscapes, for recreation, and to fill swimming pools and aquariums. The *Guide* invites students to examine how they and others around the world use water and to reflect on the role it plays in their daily lives.

WATER SCARCITY

The Earth is dubbed "the water planet" because water covers 71 percent of the Earth's surface.[16] The water component of our planet, the hydrosphere, is made up of salt water and freshwater. Earth's water is a finite resource contained in a closed system, so the total amount of water on the globe won't change, it will simply shift in form as it moves through the water cycle.



How much is there? Experts estimate about 326 million trillion gallons.[17]

So what's the crisis?

For many of us, freshwater appears virtually free and limitless. In reality, it is neither. Unfortunately, only a very small percentage of the Earth's water is fresh. Nearly 98 percent of the planet's water is in the oceans and not suitable for drinking or irrigating crops. The problem is salt**.** Only about two percent of the planet's total water is fresh and of that, nearly 70 percent is frozen in polar ice caps and glaciers.[18] Only a tiny fraction of the Earth's freshwater is available for human use. That water is underground in our water tables, accessible by wells and aquifers, and on the surface in our lakes, rivers, and wetlands. It's still a lot of water—thousands of trillions of gallons—but a very small amount compared to the total amount of water on the planet. So although "water planet" may be an apt name for Earth, "salt water planet" might be more accurate!

Not a drop to drink?

If the water we have is not going away, why should we worry? The issue we face now is as much about quality as it is quantity, the relatively small amount of freshwater available for human (and animal) use is increasingly becoming depleted and polluted.[19] What's worse, freshwater is not evenly distributed across the planet. Some of the most populated areas in the world have little or no access to clean freshwater.[20] About three-quarters of our annual rainfall takes place in areas where less than one-third of the world's population resides.[21] Ironically, the huge Lake Baikal which contains 20 percent of the world's total unfrozen freshwater reserve, is situated in Siberia, one of the Earth's least populated places.[22]

Water scarcity already affects every continent. How do we know? Unfortunately, we don't have to look far to see the evidence. A growing number of the world's great rivers, in all hemispheres, no longer reach the sea, including the Indus, Rio Grande, Colorado, Murray-Darling and Yellow rivers. According to World Wildlife Fund (WWF), "Rapid population growth, economic development and industrialization have led to the unprecedented transformation of freshwater ecosystems and consequent biodiversity loss." More than 20 percent of the world's 10,000 freshwater species have become extinct, threatened or endangered in recent decades.[23] Nature is thirsty. So are almost a billion people.

What's YOUR water footprint?

Experts agree that 20 liters (5.28 gallons) of clean water is the minimum amount humans require to meet their daily basic needs.[24] This includes water for drinking, bathing, and other household uses. One in six people in the world do not have adequate, clean water.[25] The United Nations (UN) estimates about a billion people live on less than 5 liters (1.3 gallons) of water a day; a single toilet flush in the developed world uses more water.

In Europe, the estimated average daily water consumption exceeds 200 liters (about 53 gallons). In the United States, water use amounts to more than 500 liters, or about 140 gallons per person per day.[27] Activities in the *Guide* encourage students to compare and contrast water usage across the globe.

Why is freshwater scarce?

There are three main reasons: population, pollution and climate change. Because the amount of water on our planet is finite, it does not increase or decrease. So, seven billion of us inhabiting the earth must share the same resource that 300 million people shared in the beginning of the first millennium, 2000 years ago.[28] There isn't less water now; there are just many, many more of us who need it.

Our huge and growing population stresses the water cycle not just by drinking and washing, but by eating.

Nearly three quarters of the freshwater in the world is used for agriculture and food production,[29] and many irrigation systems are antiquated and inefficient. In addition, certain foods require more water than others to produce; meat from grain-fed livestock in particular, like beef and pigs, but also certain grains and fruits like rice, apples and melons.

In the developed world, much of our water goes toward industry and energy production. And our clothing soaks up a lot, too—an estimated 400 gallons of water is required to manufacture a cotton shirt.[30] According to water experts, our water use has grown at TWICE the rate of the population[31]—astounding, considering the population has increased at a remarkable speed, reaching seven billion in October 2011.

Of course, as our population increases we create more waste. About two million tons of waste are dumped every day into rivers, lakes and streams. In developing countries, 70 percent of industrial waste is dumped untreated into waters where it pollutes the usable water supply. [32]

Population and pollution have reduced freshwater. But there is further stress on water supply: climate change. UN scientists estimate that warming world temperatures will decrease the quantity and quality of freshwater significantly in the coming decades.[33] Currently, shrinking snowcaps are reducing river flows and water supplies across China, India and Pakistan, countries already suffering from poor sanitation and lack of freshwater reserves.[34]

It's happening here, too

It's not just "over there"! Experts say water scarcity is affecting the United States, too. How? Increased evaporation rates across the country due to higher temperatures reduce important water sources like the Sierra Nevada snowpack, for example, and the Colorado River, which supplies water for seven western states. The Great Lakes are shrinking, affecting the Midwest, as is Lake Mead reservoir in Nevada which provides water to several southwestern states. Southern states are already experiencing early stages of water shortage.[35]

Although experts can't attribute specific extreme weather events to climate change, scientists do say that statistics point to an increased number of those events, and that warming global temperatures are to blame.[36] Evidence suggests that the eastern United States may be getting wetter as the West gets even drier. Warmer sea surface temperatures have increased water vapor, therefore producing heavier precipitation dumps. Nor'easters, ice storms, and coastal flooding are predicted to become more common in New England.[37] Throughout the country, and indeed the world, droughts and deluges, flooding and fires are increasingly common, and their results are devastating, especially to freshwater.

A thirsty world can be an angry world

According to the UN Food and Agriculture Organization, more than 200 river systems cross international boundaries, and 13 rivers and lakes are shared by 96 countries, complicating the issue of water scarcity.[38] Overuse or pollution by those upstream can spell disaster for those downstream. In drought-ridden areas of Africa struggles over water have become violent.

What to do?

Fortunately, many concerned experts are working toward effective, innovative answers to the world's water scarcity problem. You can join them. Learn and teach ways to conserve water and decrease pollution; already you will be part of the solution.

WATER POLLUTION

Every living organism consumes nutrients and creates waste. Nature, under normal conditions, takes care of its byproducts. However, the environment is less successful with the byproducts of human activities. Freshwater has a limited capacity to process the pollutants humans expel from our ever-expanding urban, industrial and agricultural activities. As water grows more polluted, clean water grows scarcer.

What is water pollution and why is it a problem?

Freshwater by definition contains less than 1,000 milligrams of dissolved solids per liter. Water is considered polluted when there is an accumulation of too many dissolved solids that can't break down naturally, and may harm humans, plants or animals.[39] Pollutants can be chemicals, such as pesticides, industrial compounds or byproducts from manufacturing processes—or bacterial pathogens that transmit disease. These pollutants come from a vast variety of sources, mostly human-made: fertilizers, pesticides, industrial waste, leakage from landfills, sewage, and even improperly-discarded prescription drugs. Other sources are naturally occurring; flooding and heavy winds can carry suspended solids of soil, silt and sediment creating a buildup of particles in water bodies. These particles can provide a place for harmful microorganisms to settle and grow.

Pollution = Problem!

If the only accessible water is polluted, humans will still bathe in it, cook with it and drink it. Inevitably, they will become sick. Waterborne diseases are the number one killer of children under five years old,[40] and according to the UN Secretary-General in 2010, more people die from contact with unsafe water each year than from all forms of violence, including war.[41] Almost 5,000 children die each day from unsafe water and lack of basic sanitation facilities.[42]

How does our water become polluted?

When experts refer to water pollution, they distinguish two categories, point and nonpoint source pollution. Point source pollution occurs when there is a single identifiable source of pollution, as from a factory or sewage plant. Pollution that does not originate from a single source, or point, is called nonpoint source pollution. NPS pollution is caused by water runoff—usually from rain or snow—picking up natural and human-made pollutants and carrying them to lakes, rivers, wetlands, coastal and ground waters. Floods and extreme weather affect water quality by transporting large volumes of contaminants, and overwhelming storm drains and waste water systems.[43]

In many parts of the world, lack of adequate, or any, toilets means that almost three billion people defecate in the open.[44] According to UNICEF, one gram of feces can contain 10 million viruses, one million bacteria, 1,000 parasite cysts and 100 parasite eggs.[45] Untreated sewage washing into water sources can be deadly.

Scientists established the link between disease, human waste and unclean water in the late 1800s, but it was another 100 years before modern pollution control laws developed in the United States. The first U.S. environmental regulation, the Federal Water Pollution Control Act, was established in 1948. It wasn't until almost 25 years later, after a number of environmental disasters (groundwater contamination at Love Canal and the Cuyahoga River fire in Ohio) and publication of Rachel Carson's *Silent Spring,* that U.S. citizens began to demand more effective environmental protection.[46] In the late 1960s a framework of anti-pollution laws began to emerge and by 1970 the U.S. Environmental Protection Agency (EPA) was created. The EPA established the primary regulations we have today to help protect and monitor our harbors and drinking water sources: the Clean Water Act and the Safe Drinking Water Act.

Other industrialized countries have adopted their own set of water safety regulations and the World Health Organization publishes drinking water quality guidelines. The guidelines are voluntary, which means they are not enforceable.

Clean water laws are always evolving, playing catch up with humans' amazing ability to pollute. Even in the United States more than one-third of the nation's waters do not meet quality standards for swimming or fishing.[47] Most regulations focus on point sources of pollution, but nonpoint sources continue to contaminate waterways. Watershed monitoring and volunteer efforts are essential to water quality control because water pollution continues…everywhere, every day.

Fortunately, there are solutions to many of the harmful effects of water pollution! One is filtration.[48] Vestergaard Frandsen has distributed LifeStraw® to communities where safe drinking water is not an option. Millions living in the Ivory Coast, Ghana, Haiti, India, Israel, Kenya, Madagascar, Pakistan, South Africa, Turkey, Zambia and Zimbabwe have all avoided disease, loss of employment, missed school, and more because families and individuals could filter their contaminated water.[49 *]

FILTRATION

This ancient Egyptian clarifying device was inscribed on the wall of the tomb of Amenophis II at Thebes, carved in 1450 B.C.[50]

Seven billion humans create a lot of waste, and we require a lot of water. We know waste and water are not compatible, but as of yet we are unable to live without either. So what to do? As necessity is the mother of invention, filtration resulted from human need for clean water and our proclivity for polluting it. Even before scientists had identified the connection between dirty water and disease, water was being purified for taste.

Some 4,000 years ago, early Sanskrit writings detailed methods of purifying water including boiling, exposing to sunlight and dipping heated iron into it. Filtering water through course gravel or sand was also a recorded means of purification, even as far back as 2000 BC. According to historians, ancient Egyptians operating the water purifier pictured here allowed impurities to settle, siphoned off the clean water using wick valves and finally, stored the water in containers.[51]

Feces & water = DISEASE

It wasn't until the early 1800s that filtration systems were expanded for wider use. In 1804 the first municipal water treatment plant in Paisley, Scotland employed sand and gravel filters.[52] Evidence supporting the use of filtration grew more obvious; towns that used filtration for water purification had fewer outbreaks and incidence of waterborne disease than communities that did not filter water. In 1854, British physician John Snow traced multiple cholera deaths to a single pump on Broad Street in London which was contaminated by a nearby leaking cesspool.[53] It was the final clue that persuasively connected contaminated water—particularly water polluted with feces—with disease. Snow's theory was not widely accepted for many years, but his comprehensive investigation of cholera outbreaks is considered perhaps the earliest epidemiology, or disease detective work.

Since John Snow's discoveries in the late 1800s, water filtration and purification systems have evolved and improved dramatically. Municipalities around the industrial world purify their citizens' water. Modern water treatment systems disinfect water using a variety of techniques including chlorine, ozone, or ultraviolet light.[54] Given our ability to provide pure public water, why then does contaminated water persist in killing so many around the world?

Municipal water distribution and treatment systems are expensive. Fortunately, public health workers and humanitarian entrepreneurs continue to develop low-cost solutions to provide safe water. Communities across the world lacking facilities to disinfect and filter their water can use point-of-use water treatment, often the most cost-effective immediate method.[55]

Joshua Scott

"Point-of-use" means treating the drinking water at the individual point of consumption. Vestergaard Frandsen designed Life-Straw® to provide a point-of-use water treatment option for those many millions who have no other access to clean, safe drinking water. Here's how it works:

Water filters consist of a series of layers that act as a strainer, capturing particles and microscopic pathogens. The objective of a filter is to trap the microorganisms and other particles in the water, preventing users from ingesting them. The filter's effectiveness is determined by what is known as the pore-size efficiency.[56] This is the measurement of the fiber openings in the filter. Pore size is measured in micrometers (μm)—one millionth of a meter—and nanometers (nm)—one billionth of a meter.[57] Both LifeStraw® and LifeStraw® Family consist of two levels of filtration. Dirty water begins its journey to clean with a trip through the pre-filter. This filter is made out of textile materials with openings 80 μm. (A micrometer is one millionth of a meter.) This pore size filters out coarse materials, such as gravel and other particulate matter. Whether using LifeStraw® or LifeStraw® Family, gravity-fed pressure from tubing material or from suction carries water to the next filtration level. This level consists of many hollow fibers with a microscopic pore size (LifeStraw® microfiltration pore size: ~0.2μm; LifeStraw® Family ultrafiltration pore size: ~.02μm) which blocks out bacteria and parasites, and, for LifeStraw® Family, even viruses.*

*LifeStraw® does not filter heavy metals, chemicals or salt. LifeStraw® Family aligns with WHO guidelines on the evaluation of household water treatment, it falls into the "highly protective category" with LOG 6/5/4 (bacteria/virus/parasite) removal efficacy—or 99,9999%, 99.999% and 99.99%.

HUMANITARIAN DESIGN

When Vestergaard Frandsen began working on a filter to prevent Guinea worm disease, the company was already forming its core business mission; create and sell lifesaving products for the most vulnerable citizens of the world.

"We innovate for the developing world, rather than developing products for wealthier regions, and then trying to adapt to those who actually need them the most," says CEO Mikkel Vestergaard Frandsen of the company's humanitarian design approach.[59]

Traditionally, product designers respond to a need or a desire, and market a product to those who can pay for it, a small percentage of the world's population. Think about everything you have used today—from your electric toothbrush, to your toaster oven, to your cell phone. Not to mention your refrigerator, your toilet, your kitchen faucet. Most people don't have the most basic of our everyday products and services. In fact, more than half the world lacks adequate food, sanitation, shelter or healthcare.

Patagonia upcycled fleece

Design can improve lives

Increasingly, experts are seeking innovative, inexpensive solutions for the world's majority who are in desperate need, and designers are answering the call. Inventors are teaming up with organizations and working with local partnerships to assess and address challenges faced by underserved populations.

"Designers, engineers, students and professors, architects, and social entrepreneurs from all over the globe are devising cost-effective ways to increase access to food and water, energy, education, healthcare, revenue-generating activities, and affordable transportation for those who most need them," explains Cynthia E. Smith, Curator for Socially Responsible Design at the Cooper Hewitt National Design Museum. The museum's traveling exhibit "Design for the Other 90%" opened in 2007 and features LifeStraw® among other innovative products. More and more designers and engineers are working directly with the communities they intend to assist with their products as a collaborative co-design endeavor, whether it is an urban playground or an irrigation system. Many such projects employ indigenous artists or farmers and their income benefits the entire community. More designers are also considering the effects of their products on the environment, both in manufacturing and use as well as disposal.[60] Upcycling is a recent design trend aimed at items that have reached the end of their usefulness in their originally intended form—in other words, stuff that is ready for the trash heap. Upcycling gives these objects new lives. Soda-can flip tops become purses, old seatbelts become bags or furniture, and plastic water bottles are reincarnated as cozy fleeces. Upcycling keeps items out of the waste stream, and creates attractive and useful products without using new raw materials.

In the developing world, upcycling is nothing new. When resources are scarce, one can't afford to waste anything that may be used again. The LifeStraw® has found new purpose in a variety of ways. According to Vestergaard Frandsen, used filters have become money holders, necklaces and even musical instruments. The plastic packaging for the LifeStraw® Family has been repurposed as school book bags, diaper bags or even flexible pots for plants. Upcyclers and humanitarian designers can transform products and "waste," thereby improving the world.

As a student, teacher or community member, you too can learn more about water issues locally and globally—find a problem and create a solution.

VOCABULARY

Aquifer
An underground geological formation or structure that stores and/or transmits water, such as to wells and springs.

Bacteria
Single-celled microorganisms which can exist either as independent (free-living) organisms or as parasites (dependent upon another organism for life).

Cesspool
An underground tank or pit intended for the collection of waste, especially sewage.

Cholera
A contagious intestinal infection caused by eating food or drinking water contaminated with the bacterium Vibrio cholera.

The Clean Water Act (CWA)
A federal law passed in 1972 that protects surface water from unregulated pollution.

Climate change
A significant change in global measures of climate such as temperature, precipitation and wind over time, due to natural or manmade factors.

Developing countries
Countries whose infrastructure, economy, industry and technological capacity are still emerging and where the average citizen experiences a lower level of material well-being than in more industrialized nations.

Epidemiology
The study of patterns, causes and control of disease and health-events.

Filtration
The process of removing impurities. A water filter may remove particulate matter, pathogens (bacteria, viruses) and other impurities by means of a fine physical barrier, a chemical process or a biological process.

Guinea worm

A long threadlike nematode worm parasite (Dracunculus medinensis) of tropical Asia and Africa. Guinea worm disease, also known as dracunculiasis, is caused when the guinea worm larvae are eaten by water fleas which are in turn ingested by humans drinking unfiltered water from ponds and other stagnant surface water sources. Filtration, education, and improved water sources have greatly reduced the number of Guinea worm disease cases.

Hollow fiber technology

A method of filtration that uses membranes resembling hollow strands of spaghetti. The walls of the membranes have billions of pores that act as a strainer to filter out particles, turbidity and pathogens while allowing water to flow through with virtually no pressure drop.

Humanitarian design
A product or system intended to relieve suffering or improve lives of those in need.

Hydro engineer
An expert who develops, designs and monitors systems, projects or products that interact with water, from dams and canals to irrigation systems and water pumps.

Hydrosphere
The water component of Earth in liquid, frozen or vapor stages.

Infiltration
The process by which water on the ground surface enters the soil.

Irrigation
The method by which crops are watered.

LifeStraw® and LifeStraw® Family
Point of use water interventions from Vestergaard Frandsen that address the concern for affordably obtaining safe drinking water at home and outside. These filters to prevent users from contracting common diarrheal diseases from drinking contaminated water.

Microbiologically clean
A (water) sample that is completely absent of living organisms.

Micrometer
A unit of measurement equal to one-millionth of a meter. A micron is represented by the symbol μm.

Microorganisms

Tiny one-celled organisms—viruses, fungi, and bacteria—found everywhere in the world, in all living things. Microorganisms can live in the air, on land, and in fresh or salt water environments. Some of them, pathogens, can be harmful and causes diseases, but some are beneficial.

Nanometer

A unit of measurement equal to one billionth of a meter. It is represented by nm.

Nonpoint Source Pollution

Water pollution that can't be attributed to a clearly identifiable source. NPS pollution includes runoff from any land use—croplands, feedlots, lawns, parking lots, streets, forests, etc. that then enters and contaminates waterways. It also includes pollution that enters waterways from the air, groundwater or septic systems.

Parasite

An organism that lives on or in another "host" organism.

Pathogen

(germ) A microbe or microorganism such as a virus, bacterium, prion or fungus that causes disease in plants or animals.

Point Source Pollution

Pollution that occurs when there is a single identifiable source of pollution. Point sources from agriculture may include animal feeding operations, animal waste, pesticides, fertilizers, and petroleum. Commercial and industrial waste may include pollutants such as solvents, petroleum products or heavy metals. Municipal point sources might include wastewater treatment plants, landfills or construction sites.

Pore-size efficiency

The measurement of the fiber openings in the filter through which the liquid passes.

Runoff

Excess water from rain, snowmelt or other sources flowing over land, often carrying pollutants it picks up along the way.

Sanitation

The promotion of public health by means of preventing human contact with the hazards of wastes.

Sediment

Rock or soil material broken down by erosion, water or wind which can cause natural pollution by disrupting amount of light in water, affecting the ecosystem.

Upcycling

The creation of a new or different product from the materials of another product that has reached the end of its intended useful life.

Water scarcity

When the amount of available fresh water is insufficient to meet needs of humans, plants and animals.

Water footprint

The total volume of freshwater that is used by individuals or communities to fulfill their daily needs, or to produce the goods and services consumed.

Water rights

A complex set of privileges or entitlements designed to define, determine and protect the use and enjoyment of water that travels in streams, rivers, lakes, and ponds, or collects underground. The rights are defined by law or by contract. In the United States there are a variety of water rights, based on very different philosophies. In general, the eastern water rights are based on ownership of shoreline (riparian rights), and western water rights are based on "first use, first right" (prior appropriation).

Watershed

A dividing ridge such as a mountain that separates one drainage area from others, or an area of land that drains all its water into a particular river or lake.

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RESOURCES & LINKS

For additonal information on topics found in this *Educator's Guide* we recommend the following links:

Carrying Water:

http://www.mywonderfulworld.org/pdf/WaterWalkGuide.pdf;
http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2939590/

Climate Change:

EPA:
http://www.epa.gov/climatechange/index.html
UN and climate change:
http://www.un.org/wcm/content/site/climatechange/pages/gateway/the-science/consequences-for-the-future

Consequences on Nature:

http://www.wmo.int/pages/prog/wcp/ccl/faqs.html
World Wildlife Fund for Nature (WWF):
http://www.worldwildlife.org/science/ecoregions/WWFBinaryitem8903.pdf
http://wwf.panda.org/about_our_earth/all_publications/living_planet_report/2010_lpr/
In the United States:
http://www.nwf.org/Global-Warming/What-is-Global-Warming/Global-Warming-is-Causing-Extreme-Weather.aspx

Humanitarian Design:

Design for the Other 90%:
http://www.cooperhewitt.org/EXHIBITIONS/other/
http://d-lab.mit.edu/projects
Water solutions:
http://www.hipporoller.org/
For teens:
http://indexaward.dk/index.php?option=com_content&view=article&id=30&Itemid=8
http://web.mit.edu/inventeams/index.html
Invent a toilet:
http://www.gatesfoundation.org/watersanitationhygiene/Pages/home.aspx
Kenya:
http://www.eoearth.org/article/Water_profile_of_Kenya
http://water.org/projects/kenya/

Millennium Goals:

http://www.unmillenniumproject.org/documents/tf7interim.pdf

Water:

US Geological Survey:
http://ga.water.usgs.gov/edu/earthwherewater.html
http://education.usgs.gov/
Supernova.org: (animated)
http://www.suprnova.org/shows/the-infographics-show/water.html
Arctic Climate Modeling Program:
http://www.arcticclimatemodeling.org/index.html

Water Filtration:

Vestergaard Frandsen:
http://www.vestergaard-frandsen.com/lifestraw
EPA Water Treatment Process:
http://water.epa.gov/learn/kids/drinkingwater/filtration.cfm
CDC:
http://www.cdc.gov/healthywater/drinking/public/water_treatment.html
History of Water Filtration:
http://www.historyofwaterfilters.com/clean-water-act.html

Water Footprint:

World Water Council:
http://www.worldwatercouncil.org/index.php?id=25
Products:
www.waterfootprint.org
Countries:
http://www.treehugger.com/clean-water/we-use-how-much-water-scary-water-footprints-country-by-country.html
Tips:
http://kids.nationalgeographic.com/kids/stories/spacescience/green-tips-resources/

Water Pollution:

Clean Water Act:
http://www.epa.gov/owow/watershed/wacademy/acad2000/cwa/
Drinking water standards:
http://water.epa.gov/drink/contaminants/index.cfm
Rivers:
http://www.sciencedaily.com/releases/2010/09/100929132521.htm;
Bronx River:
www.bronxriver.org/
Ganges:
p://www.smithsonianmag.com/people-places/ganges-200711.html
Cuyahoga River:
http://www.cleveland.com/science/index.ssf/2009/06/cuyahoga_river_fire_40_years_a.html
WWF:
http://wwf.panda.org/about_our_earth/teacher_resources/webfieldtrips/water_pollution/

Water Pollution and Disease:

UN:
http://www.unwater.org/statistics_pollu.html
World Bank:
http://water.worldbank.org/water/topics/sanitation-and-hygiene
United Nations Millennium Project:
http://www.unmillenniumproject.org/documents/tf7interim.pdf
CDC:
http://www.cdc.gov/healthywater/global/wash_statistics.html
Cholera and Dr. John Snow:
http://www.ph.ucla.edu/epi/snow.html

Water Scarcity:

National Geographic:
http://environment.nationalgeographic.com/environment/freshwater
WWF:
http://wwf.panda.org/about_our_earth/about_freshwater/people_freshwater/
United Nations:
http://www.unwater.org/index.html20;
www.unwater.org/downloads/190_filename_globalwater_eng.pdf
http://www.unwater.orglobalw_eng.
World Water Day:
www.unwater.org/worldwaterday/

World Health Organization:

http://www.who.int/features/factfiles/water/en/index.html

World Water Assessment Programme (WWAP):

http://www.unesco.org/water/wwap/facts_figures/
US water shortages:
http://www.gao.gov/new.items/d03514.pdf
UN Food and Agriculture Organization:
http://www.fao.org/docrep/u8480e/u8480e0c.htm

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Earth Day Network: edu.earthday.org
The Groundwater Foundation: www.groundwater.org
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