Lake Roosevelt

National Park Service
U.S. Department of the Interior

Lake Roosevelt
National Recreation Area

The River Mile

Water Quality

Lesson # 2

Water Quality: Fecal Coliform

T.R.M.

Developed by the Lake Roosevelt Forum to support "The River Mile" National Park Service Program

Suggested duration:
[90 minutes]

Inquiry Question:
How do you know if it is safe to drink the water?

Inquiry Process:
Experimental design
Multiple trials

Standards:
LS1, LS2, LS3

Formative Assessment:
Reliable data collection
Written Communication for filter design replication

Materials:
Funnel, plastic bottle or Beaker, Mesh cloth (panty hose), cheesecloth, or filter paper, sand, mulch, gravel, soil with or without grass, plants and roots, Lake Roosevelt water, pond samples, or "polluted test samples Alum, Water quality testing probe

Handouts:
Student Handout: Water Quality: Fecal Coliform – Design a Water Filter
Teacher Information
Ecology Focus on *"Fecal Coliform Bacteria"*

Credits/Citations:
WA Dept of Ecology
Mary Carroll Alexander NC – Water Filter Lesson idea
MEEC Pathogen data

LESSON # 2
Water Quality: Fecal Coliform

INTRODUCTION:
Many countries, like Kenya in Africa and India do not have access to enough clean water as seen in the video, "Water for Life." Here in Washington State, according to a Seattle Time article, dated 11/18/07, Lake Roosevelt is plagued by human waste which is, "… a great threat to the health and vitality of the recreation area". In Lake Roosevelt the issue is a serious annoyance to vacationers and potential death to fish & wildlife from decomposition and the resultant lack of oxygen, but around the world a child dies every 15 seconds due to fecal coliform, water born illnesses and dehydration. Clean water is a matter of life and death.

STUDENT WORK AND ASSESSMENT
Explore how water quality altered by the natural process of filtration through various types of soils?

QUESTIONS TO EXPLORE/INSTRUCTIONS/PROCEDURE
Build a Water filter: What is the most effective design for a simple water filter made of natural materials?

1. Observe and describe the water sample (provided by teacher)
2. Work in teams to design a water filter. Use any of the materials available. Discuss the water cycle how the land filters water.
3. Draw a detailed diagram of your model that could be replicated.
4. Observe and describe the water sample after filtration.
5. Perform multiple filtration trials. Does the appearance change significantly after 1, 3, or 6 filtrations?
6. Is your experimental filter effective? Do you have ideas for a redesign? How will you know when it is safe to drink? What other tests are available to determine water quality?

View & Discuss - Fecal Coliform Power point (PP can be used as an introduction or follow-up to building the water filters.)

Homework or Optional Activities

7. Analyze the data provided by the Department of Ecology, on Hawk Creek. Why do FC levels change with the seasons? www.ecy.wa.gov/apps/watersheds/riv/station.asp?sta=53C070
8. Research how Waste Water Treatment Facilities reclaim water

RESOURCES

- Leave No Trace – NPS Video 9min 42 sec www.nps.gov/features/wilderness/leavenotrace/popup.html
- Lake Roosevelt Shoreline Plan www.nps.gov/laro/parkmgmt/

TEACHER INFORMATION FOR
INQUIRY INVESTIGATION – DESIGN A WATER FILTER

Note to Teachers: For students who have had little or no previous experience with inquiry investigations you may wish to provide a greater level of instruction for building the water filter.

Suggested Filter Materials:

Funnel and plastic bottle or Beaker
Mesh cloth (panty hose), cheesecloth, or filter paper,
Sand, mulch, gravel, soil with or without grass, plants and roots,
Lake Roosevelt water, pond samples, or "polluted test samples
Alum
Water quality testing probe (ph, DO, temperature, conductivity, turbidity…)

Water Sample for Filtration Options:

1. Use a sample of local pond, lake or river water, or
2. Prepare a water sample from tap water and add some combination of the following: cinnamon, colored sugar crystals, salt, parsley, oregano, vinegar, cocoa, soy sauce, etc...

Directed Option: Water Filtration Model

1. Observe sample of pond water and describe contents.
   a. What do you see?
   b. What color is it?
   c. How does it smell?
2. Begin the filtration process by removing any large particles from your sample of water
3. Cover the beaker with three layers of cheesecloth; pour the water through the cheesecloth into the beaker.
   a. 1st filtration how effective was it?
   b. What types of materials were removed?
4. Add 1 tsp Alum to the water sample. Alum is a coagulant.
   a. What is the purpose of a coagulant?
   b. How did it affect your sample?
5. Fold the filter paper so that it fits into your funnel, then add sand or gravel
6. Pour the water sample through the funnel containing gravel and collect it in another beaker. The process represents the 2nd filtration.
   a. How effective was it?
   b. What does your water sample look like now?
7. Pour your sample into a plastic bottle with a lid. Make sure the bottle is not completely full. Shake the bottle vigorously
8. Pour the water out of the bottle into a beaker. Pour the water back and forth between the beakers for a total of ten times. This process represents aeration.
   a. How has your sample changed? (hint: don't forget to smell the sample)

Water Quality Testing Discussion:

Ph paper will be required for this lesson. All other water quality tests for this lesson are done with the senses and no additional equipment. A brief discussion of turbidity as it relates to visual water clarity is all that is needed now. Turbidity will be more fully addressed in lesson 3.
Discuss the chart of water quality parameters for testing the water filter. These are subjective more than quantitative as an opportunity to discuss the need for quantitative measurements and accurate descriptions of WQ.

Ask students if these tests are sufficient to determine that water is safe to drink and healthy for fish and other aquatic life. This discussion will lead into Lesson 3 in which the other water Quality testing parameters are introduced using a power point presentation. Each quality parameter will be addressed in further depth in subsequent lessons 3-8.

WATER QUALITY: FECAL COLIFORM
INQUIRY INVESTIGATION – DESIGN A WATER FILTER

Name: ________________________Water Filter Design: ___________________Date: ______________

Essential Question:

How is water quality altered by the natural process of filtration through various types of soils?

Inquiry Question:

What is the most effective design for a simple water filter made of natural materials?
What data will I collect to prove or improve the design of my water filter?

Objectives:

You will:

- Initiate an inquiry by formulating questions that can be explored through scientific investigation
- Articulate a testable hypothesis with dependent and independent variables
- Design and conduct experimental procedures
- Collect and analyze relevant data
- Interpret data and draw conclusions
- Assess the validity of the conclusions
- Search for relevant information from a variety of sources

Introduction:

Many countries around the world do not have access to clean water. One example is in Kenya from an article dated March 5, 2010, "Africa Water Project Captures Difficulty of Global Struggle" by Joseph B. Treaster. Here in Washington State, according to a Seattle Time article, dated November 18, 2007, Lake Roosevelt, is plagued by human waste which is, "… a great threat to the health and vitality of the recreation area". In Lake Roosevelt, the issue is a serious annoyance to vacationers but in Kenya and around the world clean water is a matter of life and death.

Preparation from Lesson 1: Read the Seattle Times article and view the You Tube Video "Water for Life"

Assignment:

You are a Peace Corps volunteer in Kenya, Africa. You have been sent to Kenya to assist the local community in building a water filtration process. You must be able to prove that your filtration process has made the water safe to drink.

Hurry! People are dying daily of cholera and diarrhea. Your task is to create a water filter that people can use to improve local water quality. As much as possible, use materials that are readily available and simulate the way in which the earth naturally filters water.

Think Time:

What materials will you need?

How will you test the water quality?

What data will you collect?

Materials:

Collect the materials you have decided to investigate or use the materials provided by your teacher.

Materials to test:

Procedure:

1. **Work in teams**. Each team will create a different water filter models for the Kenyan community.

My Team Members are:

2. **Draw a model** of each filter design you investigate. Describe exactly how you built the filter(s).

Water Filter Designs:

3. **Collect data** on water quality parameters before filtration and after filtration. Conduct multiple tests. Note: Fecal Coliform – will not actually be tested due test apparatus required and health considerations. Apple cider vinegar will be used as simulated fecal coliform
4. Make design changes in your water filter based on the results and test again

WQ	Water Sample	Filter test #1	Filter test #2	Filter test #3	Filter test #4	Filter test #5	Filter test #6
Ph							
Turbidity							
Particulate Matter							
Smell							
Color & Appearance							
Design Changes							

5. **Analyze the data** for changes in water quality. Compare and contrast the data you recorded on your water sample from the beginning of the activity to the end

Analysis & Conclusions:

- How has the data changed?
- Has anything remained the same?
- Was your filter equally effective in altering all of the water quality parameters?
- Do you consider your water sample safe to drink now that you have filtered it?

- Why or why not?

6. **What, if anything needs to be revised or changed?**

7. When you are satisfied your water filter is the best it can be, give it a name and write out an instruction sheet that you will use to teach families how to use your water filter

Water Filtration Process:____ *(name)*

Directions for use:

Instructions for maintenance and replacement of parts:

<u>Optional: Research Water Reclamation/Waste Water Treatment Process</u>:

How was your water filtration process different from a water reclamation/waste water treatment facility?

If differences exist, why are the steps or procedures so important in reality?

Public water systems are required to deliver safe and reliable drinking water to their customers 24 hours a day, 365 days a year. If the water supply becomes contaminated, consumers can become seriously ill. Fortunately, public water systems take many steps to ensure that the public has safe, reliable drinking water. One of the most important steps is to regularly test the water for coliform bacteria.

What are coliform bacteria?

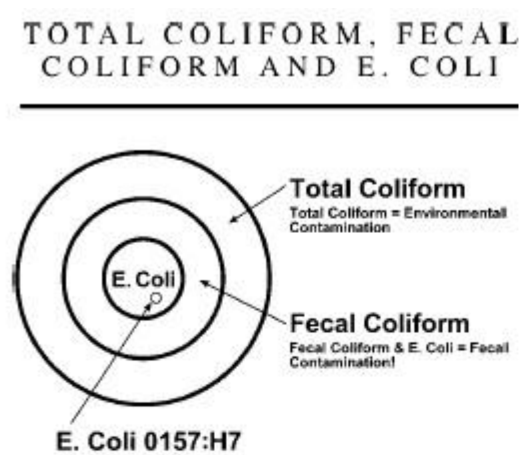
Coliform bacteria are organisms that are present in the environment and in the feces of all warm-blooded animals and humans. Coliform bacteria will not likely cause illness. However, their presence in drinking water indicates that disease-causing organisms (pathogens) could be in the water system. Most pathogens that can contaminate water supplies come from the feces of humans or animals. Testing drinking water for all possible pathogens is complex, time-consuming, and expensive. It is relatively easy and inexpensive to test for coliform bacteria. If coliform bacteria are found in a water sample, water system operators work to find the source of contamination and restore safe drinking water. There are three different groups of coliform bacteria; each has a different level of risk.

Total coliform, fecal coliform, and E. coli

Total coliform, fecal coliform, and *E. coli* are all indicators of drinking water quality. The total coliform group is a large collection of different kinds of bacteria. Fecal coliforms are types of total coliform that mostly exist in feces. *E. coli* is a sub-group of fecal coliform. When a water sample is sent to a lab, it is tested for total coliform. If total coliform is present, the sample will also be tested for either fecal coliform or *E. coli*, depending on the lab testing method.

Total coliform bacteria are commonly found in the environment (e.g., soil or vegetation) and are generally harmless. If only total coliform bacteria are detected in drinking water, the source is probably environmental. Fecal contamination is not likely. However, if environmental contamination can enter the system, there may also be a way for pathogens to enter the system. Therefore, it is important to find the source and resolve the problem.

Fecal coliform bacteria are a sub-group of total coliform bacteria. They appear in great quantities in the intestines and feces of people and animals. The presence of fecal coliform in a drinking water sample often indicates recent fecal contamination » meaning that there is a greater risk that pathogens are present than if only total coliform bacteria is detected.



E. coli is a sub-group of the fecal coliform group. Most *E. coli* bacteria are harmless and are found in great quantities in the intestines of people and warm-blooded animals. Some strains, however, can cause illness. The presence of *E. coli* in a drinking water sample almost always indicates recent fecal contamination » meaning there is a greater risk that pathogens are present.

A note about *E. coli:* *E. coli* outbreaks receive much media coverage. Most outbreaks have been caused by a specific strain of *E. coli* bacteria known as ***E. coli* O157:H7**. When a drinking water sample is reported as "*E. coli* present" it does not mean that this dangerous strain is present and in fact, it is probably not present. However, it does indicate recent fecal contamination. Boiling or treating contaminated drinking water with a disinfectant destroys all forms of *E. coli*, including *O157:H7*.

What happens if coliform bacteria are found in my water?

When coliform bacteria are found, water systems investigate to find out how the contamination got into the water. They collect additional, or "repeat," water samples for testing, and often inspect the entire system. Taking repeat samples helps determine whether an actual problem exists in the system. If any of the repeat samples detect coliform bacteria, the initial findings are considered confirmed.

What happens if total coliform bacteria are confirmed in my water?

If total coliform bacteria are confirmed in your drinking water, your water system should be inspected to find and eliminate any possible sources of contamination. Once the source is identified, it can usually be resolved by making system repairs, flushing, and adding chlorine for a short period of time. The state Health Department works with water systems and utility managers to help resolve such problems. When total coliform bacteria are confirmed in drinking water, a water system or utility is required to notify its customers within 30 days about the situation. The Health Department recommends that this notice be distributed as soon as possible. The notice will inform you of actions being taken to correct the problem, when the problem will likely be resolved, and what you may need to do until then.

What happens if fecal coliform bacteria or *E. coli* are confirmed in my water?

Confirmation of fecal coliform bacteria or *E. coli* in a water system indicates recent fecal contamination, which may pose an immediate health risk to anyone consuming the water. Responding to health emergencies is the state Health Department’s highest priority. A "Health Advisory" will be issued within 24 hours to alert all water users that there is a health risk associated with the water supply. In most cases, the use of boiled or bottled water will be recommended for drinking and cooking. The notice will inform customers of actions being taken to correct the problem, and when the problem will likely be resolved. The department will inspect the system as soon as possible to assist the water system in resolving the problem. More water samples will be taken to find and eliminate potential contamination sources, and chlorination and flushing of the system will most likely occur. The Health Advisory will remain in effect until the situation is resolved and the water.

Regulation of Toxic Substances in Drinking Water and Wastewater

Other legislation protects us by limiting concentrations of toxic substances in the water we drink and in the treated wastewater that we discharge to the environment.

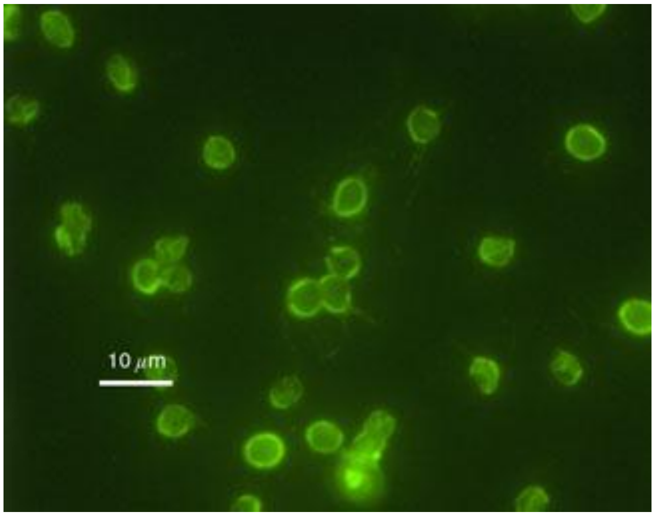
The Safe Drinking Water Act (1974) sets levels of toxic metals and organic chemical permitted in water delivered to the public. These limits are called maximum contaminant levels or MCLs. For example, the MCLs for cadmium and PCBs are 5 and 0.5 parts per billion, respectively.

The Clean Water Act (1977) seeks to make all of our nation's waters 'fishable and swimmable'. Under this legislation, 127 priority pollutants (metals and organic chemicals) are identified and limits set for their concentrations in wastewater treatment plant effluent and in the lakes and rivers which receive those discharges. All wastewater treatment facilities are required to get a permit which specifies the quality of the treated wastewater that they discharge to the environment.

Pathogens

Bacteria: *E. coli* Protozoa: *Cryptosporidium*

Pathogens are organisms that cause disease. Viruses, bacteria and protozoa are the three types of organisms responsible for most waterborne disease. The contamination of water with fecal matter from humans or other animals is the source of these diseases. In most cases, the intestinal tract is affected and symptoms include diarrhea, vomiting, fever, chills and headaches. Some waterborne diseases can cause death.



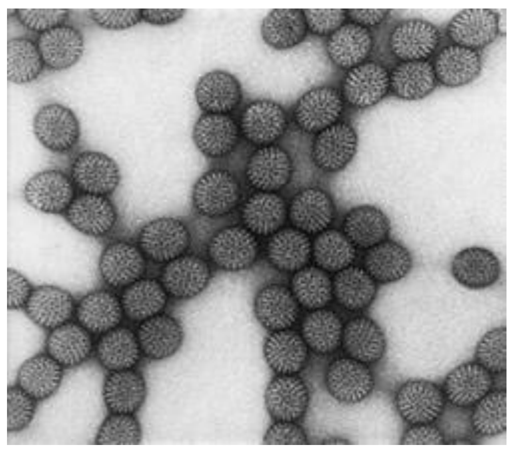
Viruses

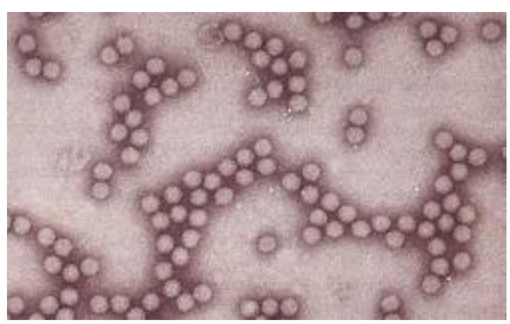
Pathogens are organisms that cause disease. Viruses, bacteria and protozoa are the three types of organisms responsible for most waterborne disease. The contamination of water with fecal matter from humans or other animals is the source of these diseases. In most cases, the intestinal tract is affected and <u>symptoms</u> include diarrhea, vomiting, fever, chills and headaches. Some waterborne diseases can cause death.

Rotavirus

Viruses cause a number of waterborne diseases:

- **poliomyelitis (polio) – which can cause paralysis**
- **viral hepatitis (Type A) – affecting the liver**
- **Norwalk <u>gastroenteritis</u> – most common cause of gastroenteritis**
- **rotavirus diarrhea – very common in children**

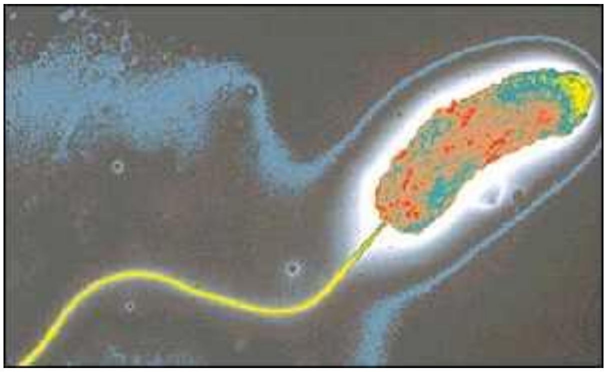




Vaccines are available for poliomyelitis, but not for the other virally-<u>transmitted</u> diseases. Prevention is accomplished by maintaining good public health practices, including a safe water supply.

Viruses

Bacteria



Bacteria are simple, single celled organisms that may also exist in colonies. These microorganisms perform many important functions in nature and some of them also cause diseases.

Examples of the waterborne diseases caused by bacteria are:

- **cholera – in severe cases, can cause death within hours**
- **traveler's diarrhea**
- **typhoid fever – can persist in the body, making survivors disease carriers**

Cholera and traveler's diarrhea are typically treated by replacing the fluids and salts lost from the body and sometimes antibiotics are given to shorten the duration of the symptoms. Vaccines are available to prevent typhoid fever and antibiotics are given to persons who have been infected. As with viruses and waterborne disease, maintaining good public health practices is the best prevention.

Cholera

EXPLORE: Typhoid Mary – the most dangerous woman in America and Peel it, boil it, cook it, or don't eat it

Protozoa

Giardia lamblia **cyst**

Protozoa are microorganisms with several animal-like characteristics: they can eat other organisms

(like bacteria) and they can move around. The protozoan life cycle often alternates between an active stage (which causes damage to the human body) and an encysted stage (which is the form that is passed along and causes infection). Cysts are resistant to the acids present in the digestive systems of animals and thus pass out of the body with fecal material. Protozoan diseases often lead to diarrhea and cramps. In the case of amoebic dysentery, the protozoans can destroy internal tissues, where bleeding accompanies diarrhea.

Examples of the waterborne diseases caused by bacteria are:

- **amoebic dysentery – 34,000 deaths worldwide each year**
- **giardiasis**
- **cryptosporidiosis**

Medicines are available to treat persons suffering from these diseases. Protozoan cysts are difficult to destroy, even by the normal methods used to eliminate pathogens from drinking water. Backpackers are encouraged to boil their drinking water. Protozoan pathogens are removed from public drinking water supplies by filtration.

Indicator Organisms

How do we KNOW that there aren't any pathogens in our drinking water or in the water down at the old swimming hole? There are so many different kinds of organisms that cause diseases that it would be too expensive and time consuming to test for each one.

Diseases are spread when water is contaminated with fecal matter. We can test for that pollution by using indicator organisms. These are microbes whose presence in water signals the presence of fecal matter, and potentially, pathogens. One such indicator organism is Escherichia coli, a bacterium that is normally found in the guts of humans and other warm-blooded animals. Water that is highly polluted with fecal matter may have E. coli counts in the tens of millions of bacteria per liter. In the State of Michigan, beaches are ordered closed if the E. coli count exceeds a monthly average of 130 or a maximum of 300 bacteria per 100 milliliters. A drinking water source is declared safe only if these bacteria are not detected in the sample.

Pathogen Protection

Our drinking water supply and wastewater treatment plants are designed to protect against the transmission of waterborne disease. Raw drinking water is filtered to remove protozoan pathogens and then disinfected with chlorine to kill bacteria and viruses. Treated water contains some disinfectant (a residual) to protect the supply if there is a leak in the pipes that distribute the water.

Disease Detectives

As little as 150 years ago, it was not known that diseases originated in a microbiological world and people were unaware of the dangers of contaminated drinking water. Epidemic diseases such as cholera were thought to be a consequence of living in sinful ways, as many of those affected lived 'dissolute … and filth ridden lives.' Scientists of the time believed that cholera was caused by an "influence in the atmosphere", a miasma or poison contracted by those who were weakened by participating in certain behaviors. Those who lived a clean and upright life would not be affected.

In 1854, an outbreak of cholera occurred in London, England. A doctor named John Snow had been promoting a new theory of waterborne disease transmission, but his warnings were ignored by officials. Through a masterful and scientific bit of detective work, Dr. Snow eventually determined that the source of the 1854 epidemic was a drinking water pump that had been contaminated by a broken sewer pipe that passed close by. When he showed the results of his detective work to local officials, they took action immediately to eliminate the source of the problem. How do you think that they accomplished this? Today, disease detectives are called epidemiologists and they are a very important part of the public health profession.

Joseph B. Treaster

The World -- Knight Center for International Media, University of Miami

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Mar. 5 2010 - 8:29 am | 13 views | 0 recommendations | 0 comments

Africa Water Project Captures Difficulty Of Global Struggle

By JOSEPH B. TREASTER

Image by hdptcar via Flickr

MIAMI—Steven Solomon was just starting the research on a huge book on the global water problem when his wife Claudine got the idea – independently – to take some of her middle school students to Africa to work on a water project.

In three weeks in southeastern Kenya, near the border with Tanzania, Mr. Solomon, his wife, their three teenage daughters and three other young people managed to help install a couple of miles of pipe and a water tank that brought clean drinking into the heart of a cluster of homes in the area of Chyulu Hills.

To provide water for all of the roughly 8,000 people living in Chyulu Hills, three more water lines and tanks were needed. The Solomons figured the job could be done for about $80,000. They went home to Washington eager to round up the money and return to East Africa to do the work.

But, it turned out, they could not find anyone to pay for the project. Maybe they didn't know enough about development. And maybe, Steven Solomon concedes, they didn't try hard enough. Mr. Solomon managed to publish a nearly 600-page book, *Water, the Epic Struggle for Wealth, Power and Civilization*, in January. So I doubt that the Africa water project failed for lack of trying.

The Solomon's expanded project failed to get off the ground several years ago. But nothing much has changed. Water projects around the world often fail or don't get started at all for a common, fundamental reason: No one is in charge on this issue. There is no dominant, agreed upon policy that could knit together the many well-intentioned small projects and, at the same time, encourage the multitude of political leaders to step in and do something meaningful. The work that is being done is fragmented, sometimes contradictory. Maintenance is often overlooked. The issue is near the bottom of everyone's agenda.

For decades, at least one billion of the world's now 6.8 billion people have not had regular access to clean drinking water. It could be 2 billion, even 3 billion. The statistics are not reliable. But the numbers are huge and the needle is not moving much in the right direction.

The water that people haul into their homes from rivers and lakes is often contaminated with bacteria and parasites. As many as 2.5 billion people do not have toilets. So there is a problem of human waste, too. When people have barely enough drinking water to survive, they don't wash their hands as often as they should. Sometimes the water starts out clean. But dirty hands transform drinking water into something you shouldn't drink.

The result is a lot of sickness. A high percentage of all the hospital beds in the developing world are taken up by people with what are often referred to as water-borne diseases. Each year the diseases kill about 2 million people, mostly children under five. That is about 5,000 deaths a day, mostly children, children who should not be dying.

The technology to get clean water to everyone exists. The work is not overwhelmingly expensive. In the course of writing his book, Mr. Solomon has become an expert on water. "This is a solvable problem," he said. "It is a logistical, political, organizational problem."

Often, it is a matter of scale. When Mr. Solomon's wife Claudine was trying to raise money, one expert told her: "This project is too small for us. We need to have a big project to make it worthwhile." But, experts have told me, big water projects often get shunted aside for other big projects. Hospitals, for example, seem to be more attractive. Yet if the water problem were solved, fewer hospitals would be needed.

Strong leadership is missing. A few members of Congress have been working on the water problem and Matt Damon, the actor, has made it his cause. But the issue is not getting traction.

Al Gore, the former vice president of the United States, has done wonders in raising consciousness about global warming and climate change. Water needs someone like him.

"We need somebody of stature to step forward," Mr. Solomon said. "We need an Al Gore of water." #

Epilogue from Steve Solomon's Water The Epic Struggle for Wealth, Power, and Civilization

January 5, 2010

The close of economic journalist Steven Solomon's book is a reflection on the new meaning of water given today's scarcity crisis. Solomon connects freshwater's past and present to paint a future, and potentially very unstable picture of human civilization. By redefining facets of this precious resource, however, he presents the foundation of finding global solutions.

Photo Courtesy Claudine Mace

Author and journalist Steven Solomon says during his travels he was struck by the universality of water issues. A 2004 trip to Kenya, featured in the above image, was especially galvanizing for Solomon.

By Steven Solomon
Special to Circle of Blue

Looking back over time brings into relief the close association between breakthrough water innovations and many of the turning points of world history. From about 5,000 to 5,500 years ago, following several millennia of experimentation and development, largescale irrigated agriculture in the arid, flooding river valleys of the Middle East's Fertile Crescent and the Indus River, and along the Yellow River's soft loess plateaus, provided the technological and social organizational basis for the start of modern human civilization. During the same period, man began transporting large cargoes on rivers and along seashores in reed and wooden sailing vessels, eventually aided by a steering rudder. Sailing in turn, nurtured the rise of international sea trade and Mediterranean civilizations where indigenous agricultural conditions were relatively poor. Civilization's slow march through rain-watered, cultivatable lands began in earnest a little under 4,000 years ago with the spread of plow agriculture that allowed more intensive farming over a greater expanse of cropland through the application of animal power.

Mastery of the art of quenching red hot iron in water to make steel weapons and tools about 3,000 years ago made possible construction of qanats and aqueducts, which reliably conveyed enough freshwater to sustain the rise of the great cities that anchored every civilization. The inland expansion of civilization was facilitated by the innovation of transport canals that connected natural waterways, starting in China 2,500 years ago and replicated everywhere with great impact over the centuries from southern France's seventeenth-century Canal du Midi to America's nineteenth-century Erie Canal. Some 500 years ago, globaldistance barriers were defeated by Europeans' momentous discovery of how to sail back and forth across the open oceans; from the midnineteenth century, interoceanic sailing times were compressed by the cutting of great sea canals for new, speedy steamships and gunboats that forged the world order of the colonial age.

Just prior to start of the Christian Era 2,000 years ago the seminal invention of the waterwheel captured the power of flowing water to turn mills to grind man's daily bread; a thousand years later waterpower was applied with more complex gearing to a widening array of industrial applications and ultimately, a quarter of a millennium ago, to power the first factories. The waterpower barrier was finally shattered by the steam engine in the late eighteenth century—arguably the greatest invention of the last millennium which catalyzed the defining innovations of the Industrial Revolution—and was transcended yet again by hydroelectric power in the late nineteenth century and a panoply of water-assisted power generation inventions in the twentieth century. The sanitary revolution helped foment transformations in human health, demography, and clean drinking water that sustained massive modern industrial urban concentrations. Less than a century ago, 5,000 years after the original big dams of antiquity, history's first giant, multipurpose dams began harnessing the planet's great rivers to deliver electricity, irrigation water, and flood control on a massive scale that remade landscapes at a stroke and was vital to launching the worldwide Green Revolution that nourished humanity's stunning population surge.

Modern industrial technologies also permitted man to mine the earth of water from its deep underground reservoirs as he had drilled oil, and to pump the water unprecedented distances over and beyond mountains in long-distance aqueducts.

Photo Courtesy Claudine Mace

Northern Europe's many navigable and fast-running rivers became arteries of commerce and production. Waterwheel-powered bread flour gristmills, like this old wooden waterwheel mill in northwestern France, were ubiquitous.

By the end of the twentieth century, an ocean fleet of intermodal supercontainers speedily delivering goods ordered from foreign factories from a nearly realtime information web to local markets across the planet served as the transport backbone of the new, integrated global economy.

With each major breakthrough, civilization had been transformed by the conversion of a key water obstacle into a source of greater economic power and political control; invariably its accessible water resources became more productively utilized and more voluminous in absolute supply. Time and again, the world order of the age was recast, elevating societies to preeminence that proved most adept at harnessing the new form of water's catalytic potency and pushing the laggards toward decline. Today, man has arrived at the threshold of yet a new age. His technological prowess has reached the point that he possesses the power, literally, to alter nature's resources on a planetary scale, while soaring demand from swelling world population and individual levels of consumption among the newly prospering urgently impel him to use that prowess to extract as much water as he can. The alarming, early result is a worsening depletion of many of Earth's life-sustaining water ecosystems that, nonetheless, are not keeping pace with the growing global scarcity.

Until now, all history's water breakthroughs have fallen into four traditional categories of use—domestic needs, economic production, power generation, and transport or strategic advantage. At the dawn of the twenty-first century, civilization faces an imperative fifth category that defines the era's new water challenge: how to innovate new governing organizations and technical applications that make available sufficient supplies of freshwater for man's essential purposes in an environmentally sustainable manner and relieves the scarcity of an increasingly thirsty planet. No technological panacea that extracts more renewable water from nature is available or on the near-term horizon to answer the call. Some societies may borrow time by mining Earth's underground reservoirs or transferring freshwater from river basin to river basin until their total water reserves give out. For others, comprising many hundreds of millions of people, the day of reckoning has already arrived. For everyone sharing the planet, the destiny of human civilization as we know it hinges on the responses to this challenge. History suggests those societies that make big breakthroughs that maximize productive use of their renewable water resources and possibly usher in a turning point in practices and applications are the likeliest to be rewarded with rising economic wealth and international power.

The most obvious, environmentally sustainable large source of freshwater at hand to alleviate the crisis is simply to use the current supplies more efficiently. Tapping them, however, is more difficult than it seems at first glance. For starters, it requires major organizational changes in the way water is managed, politically and economically. Enormous inefficiencies, waste, and political favoritism have been built up in the government command systems that controlled water use in almost every society through the centuries—the true paradox of water is that despite its scarcity, it nearly everywhere remains the most shortsightedly and poorly governed critical resource. Reform can come in one of two main ways: by foresightful, effective, top-down political leadership that uproots its own embedded systems and then makes wise choices about the governing technologies and methods to replace them; or by turning loose the proven reorganizing power of impersonal market forces within a properly regulated, governing framework to winnow out the inefficiencies and redeploy the existing water resources from less to more productive hands.

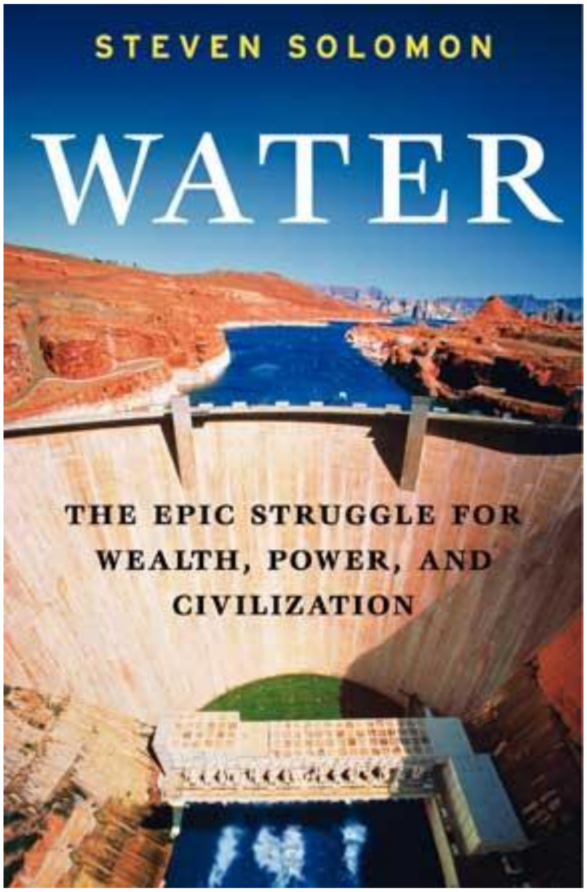

Photo Courtesy HarperCollins Publishing.

Solomon's WATER maps the links between historic social and political changes and water that were endured by major civilizations.

It is, of course, conceivable that uncommon leadership might arise within a handful of governments around the world to implement the necessary internal reforms. Yet judging from history, it seems highly imprudent, even fanciful, to bet that such exceptional leadership will arise across many continents at one time. Better—more pragmatic—odds of success almost surely lie with greater reliance upon the self-interested, profit motive of individuals organized by the politically indifferent market anchored in a pricing mechanism for valuing water that reflects both the full cost of sustaining ecosystems through externally imposed environmental standards and a social fairness guarantee for everyone to receive at affordable cost the minimum amounts necessary for their basic needs. Those uneasy with the market system's history of yielding widely unequal wealth distribution patterns should be partially heartened by the fact that competitive, free markets' singular devotion to lucre has on its side the considerable merit of being one of history's most subversive and undiscriminating enemies of unfairly entrenched privilege and deserves credit as a prodigious creator of the wealth that necessarily precedes any debate about how to make its distribution more equitable.

A second obstacle is that the precondition for any effective organizational innovation, either market-based or government-imposed, is adequate water infrastructure and control for basic delivery, protection against shocks, waste removal, and measurement of use. In vast swathes of the world this precondition is in shocking deficit. The dearth of infrastructure is central, for example, to the deplorable failure to achieve the elementary, universally sought goal of providing at least 13 gallons, or 50 liters, to meet the minimum basic daily domestic sanitary needs for each individual. This is a minuscule drop—equivalent of eight low-flow toilet flushes—that even the water poorest societies have enough supply to provide. Any legitimate government would readily strive to do so. Moreover, many

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nongovernmental and official international institutions have been trying to assist countries to achieve it and other very basic water needs. Prominent water experts are campaigning for this tiny amount to be recognized as a universal human right to water. Yet it is unachieved for two-fifths of mankind for one overriding, simple reason—the deficit of existing infrastructure and competent, institutional governance.

Photo Courtesy Claudine Mace

One fifth of humanity still lacks access to enough clean, fresh water for basic domestic needs and two-fifths for adequate sanitation, compelling hundreds of millions, especially children (left) and women, to forgo education and productive work to walk several miles each day to fetch water for daily survival.

Finally, there is no one-size-fits-all remedy for the global crisis of water scarcity. Each society's hydrological reality and challenges, like its political, economic and social conditions, are unique. Some societies have to cope with monsoonal seasonality, others with perennial rainfall, and some with almost none at all. Some entire regions, such as Africa, have scarcely tapped their hydroelectric power development and irrigation water storage potential; while in America and Europe, additional giant damming has mostly yielded environmentally counterproductive and diminishing economic returns. Investing local, mostly poor stakeholders who have historically been dispossessed by large waterworks in the success of a new water project is a paramount challenge in many developing countries but almost nonexistent in leading industrial democracies with responsive governing structures. Some nations' most urgent need is to resurrect and expand traditional small-scale, low-tech methods for water storage and terracing, while for others it is to apply modern water technologies on a large scale as rapidly as possible.

Pragmatism, not universality or bias of principle, is what is called for: It is, quite frankly, hypocritical and even morally obscene, to witness activists and officials from water-Have nations whose material benefits— albeit often gained with ugly social, economic, and environmental side effects—have been so visibly aggrandized by giant dams to use their international clout to reflexively oppose virtually all similar development in water poor ones. In short, the world water crisis is a multidimensional crisis. It requires myriad responses targeted at each specific layer and situation, much trial and error adaptation of what works elsewhere, vast capital investment in infrastructure, relentless hard work governed by a pragmatic intelligence and a few, flexible guiding principles. The world has no previous model or institutional framework for coping with it. Everything has to be invented on the fly.

Every society in the age of scarcity faces its own particular version of the era's defining water challenge. How each copes with its challenges, and which societies make the most dynamic breakthroughs, will partly dictate the winners and losers in a century where water's role is of increasingly paramount importance. History is agnostic as to whether a water rich society is likeliest to seize upon its opportunity to exploit its initial water resource advantage in a dynamic new way or whether its relative comfort instead will make it a complacent onlooker while some water indigent society, driven to innovation by the dire necessity of survival, makes the pathbreaking innovations that unlock a new, hidden aspect of water's extraordinary, catalytic properties and transforms the obstacle of scarcity into a propellant of expansion toward wealth and possible global leadership. Whether in the end it is a Western liberal democracy, China's authoritarian, state directed market system, a resurgent totalitarian, command economy state like antiquity's hydraulic societies and the industrialized twentieth century's Nazi Germany or Soviet Union, or a nation rising on some other new model, which proves most adept at making the breakthrough responses, will influence the type of governing model that prevails in this round of history's endlessly shifting contest between political economies.

Throughout history water has been a great uniter and a great divider, a barrier and a conveyance, but always a great transformer of civilization. As history's most critical natural resource, vital in virtually every aspect of human society, and one that interactively leverages food, energy, climate change, and other grave problems facing a world rising toward 9 billion souls, all striving for first world material standards, water also represents an early proxy test for human civilization's impending survival challenge of learning how to sustainably manage Earth's total planetary environment. Geographer Jared Diamond has grimly concluded that, on current trajectories, there are simply not enough planetary environmental resources, including accessible freshwater, to even come close to satisfying the aspirations of several billions to move up the development ladder to industrial-world levels of consumption and waste. As in previous eras, human population and available environmental resources are again widely out of balance. Famines, genocides, wars, disease, mass migrations, ecological disasters, and untold miseries are history's remorseless mechanisms for reequilibration. In the end all nations will be buffeted, if not engulfed, by the myriad feedback channels of water crises that originate elsewhere. How much tumult and suffering lies ahead depends in significant measure upon how well mankind manages the total global freshwater crisis on our shared planet. Looking farther ahead, the extraordinary, unique substance that gave life to man and shaped the destiny of human civilizations is still the indispensable, prerequisite stepping-stone to some day transplanting our species beyond Earth's sphere to colonize other orbs in the solar system.

There is one more special attribute about water that must inform any study of its role in history: The inextricable affinity between water and our own essential humanity—not merely with human life, but with a dignified human life. My visit to Kenya in the summer of 2004 set off a personal alarm of just how dehumanizing and economically crippling the lack of water for basic needs could be. It drove home the mind-numbing inequity that a majority of humanity still struggles to extract its meager material surplus from nature using obsolete and even ancient water technologies. In the semiarid, rural Chyulu Hills in southeast Kenya on the edge of the Great African Rift Valley congeries of otherwise vibrant, culturally robust communities live in literally dirt-poor subsistence for one overriding reason—insufficient freshwater.

Photo Courtesy Claudine Mace

Hand-built, water-storage earthen dams, like the one being reinforced by rural Kenyan villagers in 2004 pictured above, were mainstays of Egyptian and Mesopotamian hydraulic civilizations five millennia ago.

It shocked my sense of common humanity to see the small group of men and women work so tenaciously with hand tools such as picks, shovels, and sisal sacks to perform the backbreaking manual labor of digging and carrying the reddish dirt week after week to reinforce the earthen dam they'd built nineteen years earlier—precisely like those built in ancient times–to trap the seasonal monsoonal rainwater through the dry season so that their cattle can survive, when they and I knew that one-day access to a simple bulldozer could do the job of a whole season, and a few days with a cement mixer could alleviate the task for years. In the nearby Machacos Hills, where low-tech terracing has improved water management and agricultural production, Kenyan farmers step up and down for hours each day on a treadle water pump—much as Chinese rice farmers did using bamboo tubes centuries ago and modern Westerners do at the gym on their exercise StairMasters—to lift water from a muddy creek up the hillside in plastic tubes to fill cans they use to hand water their crops.

More striking still is the ubiquitous sight of large numbers of women and children acting with their feet by marching two to three hours or more per day on dusty roads to fetch clean water from wells or other sources in large, yellow, plastic "jerry" cans, which they carry on their heads, on the ends of poles laid across their shoulders, and packed on bicycles or donkeys. A family of four needs to transport around 200 pounds of water each and every day to meet its most minimal drinking, cooking, and cleaning needs. To manage such an impossible weight, two trips to the well each day by mother and children are not uncommon.

Carrying water for basic subsistence devours school time for children and places a dispiriting burden on the enterprising will of parents to struggle out of their material privation. That the water carrying falls traditionally on women adds the insult of gender inequity to the tragedy. There was genuine rejoicing when the two miles of piping our small, humanitarian group of American volunteers had financed, for a pittance in Western terms, was connected to the well pump and began to deliver water directly to a simple, plastic water tank located in one of the villages.

I will never forget the sense of disempowered injustice we felt when we met a thoughtful young man as enterprising, vivacious, and worthy of a fair opportunity as anyone his age in industrial America, Europe, or Asia who was studying on his own every night, in a home without electric lighting, for a high school equivalency exam on the remote chance that he could qualify for a special scholarship to attend the University of Nairobi; his family was too poor to pay the couple of hundred dollars for his formal high school education, and I knew that had the water pipes we financed arrived years earlier and been put to productive economic use for modest, gravity-fed irrigation as well as drinking and cleaning, this young man might well have gotten the professional chance he deserved and which my own daughters take for granted. His country would also have gained important human capital in its struggle for development. In Ethiopia, where my wife, a high school teacher, traveled in the summer of 2008, the situation was similar, and the poverty even more desperate.

When she arrived in the beautiful, remote mountain highlands that provide the headwaters of the Blue Nile, she felt as if she had been dropped back into medieval times as she saw farmers scratching out meager livelihoods with oxen-pulled wooden plows.

At the end of the day, how each member of the world community ultimately acts in response to the global freshwater crisis is not just a matter of economic and political history, but a judgment on our own humanity—and the ultimate fate of human civilization.

As recently as the 1950s in early postwar France, my Bretagne mother-in-law was still washing clothes with river water and carrying upstairs water buckets of captured rainwater with which to bathe her children and cook the family's food. It further illustrates how much water history was everywhere a layered history: Ancient, medieval, and modern methods always coexist; yet, crucially, it is an unevenly layered history, imparting enormous—and easily overlooked—advantages to the comfortable water Haves and crippling disadvantages, starting with a life handicapped by malnutrition, ill health, and sacrifice of education to the daily search for water, to the world's water Have-Nots. The need for water trumps every human principle, social bond, and ideology.

It is literally indispensable. With extreme water scarcity showing through as a root cause of many of the world's famines, genocides, diseases, and failing states, I am inclined to believe that if there can be a meaningful human right to any material thing, surely it starts with access to minimum clean freshwater.

At the end of the day, how each member of the world community ultimately acts in response to the global freshwater crisis is not just a matter of economic and political history, but a judgment on our own humanity—and the ultimate fate of human civilization. As one scientist succinctly put it: "After all, we are water."

Economic journalist Steven Solomon has written for numerous publications, including The New York Times, BusinessWeek, The Economist, Forbes, and Esquire. Solomon has also written The Confidence Game, which examined the new role of central bankers in contemporary economies. Read more of Solomon's work on water here and here.

WASHINGTON—Dirty water is killing kids–lots of kids. The magnitude of the deaths is staggering, perhaps 5,000 a day, 1.8 million a year – more deaths annually than the combined total from malaria, measles and HIV/AIDS.

And who's talking about it? Who is outraged? Practically no one. It is a problem that is virtually unknown in the United States and Europe. The victims are poor children in poor families throughout most of Africa and in remote parts of Asia.

Specialists in water and health are working on the problem and spending lots of money. But some experts say that progress has been meager and that the situation could be getting even worse.

The deaths come quickly and simply. Kids drink the only water they can get. It is loaded with bacteria. They get diarrhea, which is a manifestation of many diseases, including cholera. They get dehydrated and before their parents realize how bad things have gotten the kids are gone. Some grownups die, too. But mostly the 1.8 million victims annually are children, five years old and younger. Millions of kids don't die from diarrhea. But their illnesses strain already strained hospitals and clinics. By some estimates kids sick with diarrhea miss nearly 300 million school days a year.

This has been going on for decades, almost unbelievable rates of death and sickness among millions of kids. They and their families cannot solve the problem on their own. And they are not getting enough help to break the pattern. They are stuck in a vast pool of nearly 1 billion people around the world who do not have dependable access to clean water every day. Most of them are also among the 2.5 billion people who do not have even the most basic toilets. Without a good supply of clean water and without toilets, disease, sickness and death are almost guaranteed.

The International Federation of Red Cross and Red Crescent Societies, which works in the most awful places and is not given to hysteria, said earlier this year that it had been seeing an increase in cases of water-related diseases that cause diarrhea, including cholera. Uli Jaspers, the head of water and sanitation for the federation at its headquarters in Geneva, said in a statement that "data suggests we may be losing the battle."

Hundreds if not thousands of people in government and private agencies are devoting their energies to stopping the silent epidemic. Often times the work is one person, one-village, one school at a time. Paul Faeth, the president of Global Water Challenge, a group of organizations here in Washington committed to working against water-related diseases, is getting soap and water to schools in Africa. Sally Cowal, a water expert at Population Services International, also in Washington, provides several low-cost ways of purifying water. They are both having successes, they said at a conference here presented by UPI.com, the Internet incarnation of a former news agency that competed with the Associated Press and Reuters. But they also acknowledge that what they are doing is not enough.

Katherine Bliss, a deputy director at the Center for Strategic and International Studies in Washington, said at the UPI conference that about $18 billion a year is needed to meet the United Nations' goal of deeply reducing the problem of water and disease or about three times more than is now being spent worldwide.

But the barrier to a solution is not just money. Often people with the best intentions are working at cross purposes. According to a recent report by several environmental groups, including units of the United Nations and the Nature Conservancy, efforts around the world to provide clean water and sanitation are "plagued by institutional fragmentation that may result in governmental agencies working against each other" in pursuit of their own strategic objectives.

There is no coordinating body or global clearing house for work related to water, Ms. Bliss said, no one seeing that the work of governments and non-governmental organizations complement each other, don't duplicate, don't cancel out some other effort. For HIV/AIDS there is the United Nations organization, UNAIDS. Tuberculosis, malaria and HIV/AIDS come under the aegis of the Global Fund to Fight Aids. Water has no similar counterpart.

“Within the United Nations,” Ms. Bliss said, “water and sanitation activities are managed across 26 different technical agencies.” And no one is in charge. The work of the agencies is officially coordinated by the United Nations Water Office. But it does not have enough clout to have much impact.

For now, this is a problem that looks like it can be fixed. But it is a problem that is not getting the attention, the money and the coordination it needs.

Water Crisis

http://www.worldwatercouncil.org/index.php?id=25

While the world's population tripled in the 20th century, the use of renewable water resources has grown six-fold. Within the next fifty years, the world population will increase by another 40 to 50 %. This population growth - coupled with industrialization and urbanization - will result in an increasing demand for water and will have serious consequences on the environment.

People lack drinking water and sanitation

Photo by ADMVB bokidiawe@yahoogroupes.fr

Already there is more waste water generated and dispersed today than at any other time in the history of our planet: more than one out of six people lack access to safe drinking water, namely 1.1 billion people, and more than two out of six lack adequate sanitation, namely 2.6 billion people (Estimation for 2002, by the WHO/UNICEF JMP, 2004). 3900 children die every day from water borne diseases (WHO 2004). One must know that these figures represent only people with very poor conditions. In reality, these figures should be much higher.

Water resources are becoming scarce

Agricultural crisis

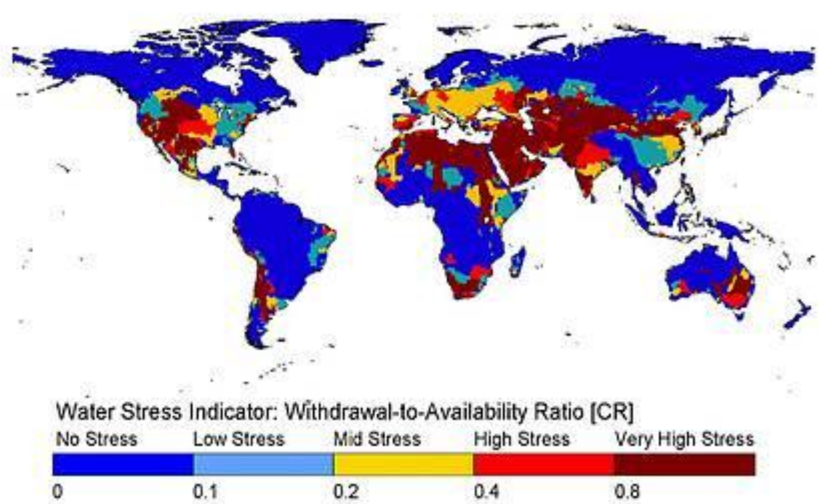
Although food security has been significantly increased in the past thirty years, water withdrawals for irrigation represent 66 % of the total withdrawals and up to 90 % in arid regions, the other 34 % being used by domestic households (10 %), industry (20 %), or evaporated from reservoirs (4 %). (Source: *Shiklomanov, 1999*)

As the per capita use increases due to changes in lifestyle and as population increases as well, the proportion of water for human use is increasing. This, coupled with spatial and temporal variations in water availability, means that the water to produce food for human consumption, industrial processes and all the other uses is becoming scarce.

Environmental crisis

It is all the more critical that increased water use by humans does not only reduce the amount of water available for industrial and agricultural development but has a profound effect on aquatic ecosystems and their dependent species. Environmental balances are disturbed and cannot play their regulating role anymore. (See Water and Nature)

The concept of Water Stress



Source: WaterGAP 2.0 - December 1999

Water stress results from an imbalance between water use and water resources. The water stress indicator in this map measures the proportion of water withdrawal with respect to total renewable resources. It is a criticality ratio, which implies that water stress depends on the variability of resources. Water stress causes deterioration of fresh water resources in terms of quantity (aquifer over-exploitation, dry rivers, etc.) and quality (eutrophication, organic matter pollution, saline intrusion, etc.) The value of this criticality ratio that indicates high water stress is based on expert judgment and experience (Alcamo and others, 1999). It ranges between 20 % for basins with highly variable runoff and 60 % for temperate zone basins. In this map, we take an overall value of 40 % to indicate high water stress. We see that the situation is heterogeneous over the world.

An increase in tensions

As the resource is becoming scarce, tensions among different users may intensify, both at the national and international level. Over 260 river basins are shared by two or more countries. In the absence of strong institutions and agreements, changes within a basin can lead to transboundary tensions. When major projects proceed without regional collaboration, they can become a point of conflicts, heightening regional instability. The Parana La Plata, the Aral Sea, the Jordan and the Danube may serve as examples. Due to the pressure on the Aral Sea, half of its superficy has disappeared, representing 2/3 of its volume. 36 000 km^2 of marin grounds are now recovered by salt.

Towards a way to impove the situation

"There is a water crisis today. But the crisis is not about having too little water to satisfy our needs. It is a crisis of managing water so badly that billions of people - and the environment - suffer badly." World Water Vision Report

With the current state of affairs, correcting measures still can be taken to avoid the crisis to be worsening. There is a increasing awareness that our freshwater resources are limited and need to be protected both in terms of quantity and quality. This water challenge affects not only the water community, but also decision-makers and every human being. *"Water is everybody's business*" was one the the key messages of the 2nd World Water Forum.

Saving water resources

Whatever the use of freshwater (agriculture, industry, domestic use), huge saving of water and improving of water management is possible. Almost everywhere, water is wasted, and as long as people are not facing water scarcity, they believe access to water is an obvious and natural thing. With urbanization and changes in lifestyle, water consumption is bound to increase. However, changes in food habits, for example, may reduce the problem, knowing that growing 1kg of potatoes requires only 100 litres of water, whereas 1 kg of beef requires 13 000 litres.

Improving drinking water supply

Water should be recognized as a great priority. One of the main objectives of the World Water Council is to increase awareness of the water issue. Decision-makers at all levels must be implicated. One of the Millenium Development Goals is to halve, by 2015, the proportion of people without sustainable access to safe drinking water and sanitation. To that aim, several measures should be taken:

- guarantee the right to water;
- decentralise the responsibility for water;
- develop know-how at the local level;
- increase and improve financing;
- evaluate and monitor water resources.

Improving transboundary cooperation

As far as transboundary conflicts are concerned, regional economic developement and cultural preservation can all be strengthened by states cooperating of water. Instead of a trend towards war, water management can be viewed as a trend towards cooperation and peace. Many initiatives are launched to avoid crises. Institutional commitments like in the Senegal River are created. In 2001, Unesco and Grenn Cross International have joined forces in response to the growing threat of conflicts linked to water. They launched the joint *From Potential Conflicts to Co-Operation Potential* programme to promote peace in the use of transboundary watercourses by addressing conflicts and fostering co-operation among states and stakeholders.

More about this program: www.gci.ch/en/programs/natural_02.htm

www.unesco.org/water/wwap/pccp

http://www.watermonitoringalliance.net/

Mapping and Interlinking Monitoring & Reporting Activities on Water

In brief

This programme builds on the recommendations made at the 3rd World Water Forum in Kyoto. It aims to facilitate better coordination of monitoring activities in the water sector by mapping out various existing activities and identifying possible links among them.

Objectives

- To create an inventory of existing activities;
- To analyse interrelations, respective scopes, definitions, indicators and objectives;
- To propose methods and tools to strengthen complementarities;
- To create a platform for exchange of information and experiences and to provide access to websites, publications and databases;
- To improve access to information and to raise awareness on the importance of monitoring.

Outcomes

- Greater visibility for organisations and programmes involved in water monitoring;
- Improved exchange and sharing of information among those organisations and programmes;
- Better use of existing information;
- Better access to information on water for decision-makers, the media and the general public;
- Better coordination among the various monitoring activities on water.

Water Monitoring Alliance

A portal website has been created in order to present the results of this mapping exercise and to provide a platform for organisations involved in monitoring. This platform, called the "Water Monitoring Alliance" serves to:

1) Create a common tool that facilitates access to databases and reports from various organisations;
2) Create an alliance among organisations involved in activities related to monitoring and reporting, that would like to create better links between their activities and others.

The Water Monitoring Alliance can be visited at www.watermonitoringalliance.net

Other activities

A Side-event was organised on April 20, 2005, during the Commission on Sustainable Development (CSD 13) to raise awareness on the importance of monitoring. This event was organised in cooperation with the Governments of France, Japan, the United Kingdom, Italy and Denmark, as well as the European Union, the European Union Water Initiative, the African Bank of Development, the African Ministers Council on Water and the International Secretariat for Water.
Read the report of the side-event (PDF, 597 KB)

Global List of Activities

The following activities are available. Activities are classified according to the 3 categories here-below. Select the category you are interested in and click on the activity name to display the related sheet.

Do not hesitate to visit the "How to use the WMA" page to know what kind of information can be found under each topic and facilitate your search.

African Household Survey Databank (AHSD)
Aquastat
Blue Plan Mediterranean Environment and Development Observatory
Canadian Environmental Sustainability Indicators (CESI)
Catalogue of European Watersheds
Central Asia Regional Water Information Base Project (CAREWIB)
Danube Regional Project (DRP)
Earth Trends - The Environmental Information Portal
European Environment Agency (EEA): Data Service EEA
Eurostat - Environment Statistics: water
European Space Agency River-Lakes Project (RLP)
Famine Early Warning Systems Network (FEWS NET)
FAO Country Profiles & Mapping Information System
Global Information & Early Warning System (GIEWS)
FAO Water Quality and Environment Programme: Wastewater Database
Flood Forecasting and Warning Centre of Bangladesh
Global Climate Observing System (GCOS)
Global Environment Monitoring System – Water (GEMS – Water)
Global Environment Outlook (GEO)
Global International Waters Assessment (GIWA)
Global Ocean Observing System (GOOS)
Global Runoff Data Centre (GRDC)
Global Resource Information Database (GRID)

Global Terrestrial Observing System (GTOS)
Great Lakes Information Network (GLIN)
Hydrology and Water Resources Division of Malaysia
Human Development Report (HDR)
IGAD Climate Prediction and Applications Centre for the Greater Horn of Africa (ICPAC)
Integrated Global Observing Strategy (IGOS)
International Benchmarking Network for Water and Sanitation Utilities (IBNET)
International Groundwater Resources Assessment Centre (IGRAC)
International Lake Environment Committee World Lake Database (ILEC)
International Water Management Institute - Remote Sensing and Geographic Information System Unit (IWMI - RS/GIS)
Joint Monitoring Programme for Water Supply and Sanitation (JMP)
Lake Victoria Environmental Management Project (LVEMP)
Living Lakes Partnership
Mediterranean Hydrological Cycle Observing System (MED-HYCOS)
Millennium Ecosystem Assessment
Millennium Project - Task Force 7 on Water and Sanitation
Network for Long Term Ecological Monitoring Observatories (ROSELT)
Organisation for Economic Cooperation and Development - Development Assistance Committee (OECD - DAC)
Southern African Development Community – Drought Monitoring Centre (SADC – DMC)
Sustainable Management of the Usangu Wetland and its Catchment Project (SMUWC)
Test
Tiger Initiative
Water Resource Management Information System (WARMIS)
UNEP World Conservation Monitoring Centre (WCMC)
World Bank World Development Indicators (WDI)
World Hydrological Cycle Observing System (WHYCOS)
World Water Assessment Programme (WWAP)
World Water Monitoring Day (WWMD)

http://www.who.int/water_sanitation_health/diseases/diseasefact/en/

Water and sanitation related diseases fact sheets

- Anaemia
- Arsenicosis See also: Arsenic in drinking-water
- Ascariasis
- Campylobacteriosis. See other WHO related activities
- Cholera. See also other WHO related activities
- Cyanobacterial Toxins
- Dengue and Dengue Haemorrhagic Fever. See other WHO related activities
- Diarrhoea . See other WHO related activities
- Drowning
- Fluorosis
- Guinea-Worm Disease (Dracunculiasis). See other WHO related activities
- Hepatitis. See other WHO related activities
- Japanese Encephalitis. See other WHO related activities
- Lead Poisoning. See also lead in drinking-water
- Leptospirosis
- Malaria . See also: WHO Activities on Malaria
- Malnutrition . See also Global Database on Child Growth and Malnutrition

- Methaemoglobinemia
- Onchocerciasis (River Blindness). See other WHO related activities
- Ringworm (Tinea)
- Scabies
- Schistosomiasis. See other WHO related activities
- Spinal Injury
- Trachoma. See other WHO related activities
- Typhoid and Paratyphoid Enteric Fevers. See WHO related activities

Water-related diseases

Arsenicosis

Drinking water rich in arsenic over a long period leads to arsenic poisoning or arsenicosis. Many waters contain some arsenic and excessive concentrations are known to naturally occur in some areas. The health effects are generally delayed and the most effective preventive measure is supply of drinking water low in arsenic concentration.

The disease and how it affects people

Arsenicosis is the effect of arsenic poisoning, usually over a long period such as from 5 to 20 years. Drinking arsenic-rich water over a long period results in various health effects including skin problems (such as colour changes on the skin, and hard patches on the palms and soles of the feet), skin cancer, cancers of the bladder, kidney and lung, and diseases of the blood vessels of the legs and feet, and possibly also diabetes, high blood pressure and reproductive disorders.

Absorption of arsenic through the skin is minimal and thus hand-washing, bathing, laundry, etc. with water containing arsenic do not pose human health risks.

In China (Province of Taiwan) exposure to arsenic via drinking-water has been shown to cause a severe disease of the blood vessels, which leads to gangrene, known as ‘black foot disease’. This disease has not been observed in other parts of the world, and it is possible that malnutrition contributes to its development. However, studies in several countries have demonstrated that arsenic causes other, less severe forms of peripheral vascular disease.

The cause

Arsenicosis is caused by the chemical arsenic. Arsenic is a toxic element that has no apparent beneficial health effects for humans.

Natural arsenic salts are present in all waters but usually in only very small amounts. Most waters in the world have natural arsenic concentrations of less than 0.01 mg/litre.

Arsenicosis is caused by exposure over a period of time to arsenic in drinking water. It may also be due to intake of arsenic via food or air. The multiple routes of exposure contribute to chronic poisoning. Arsenic contamination in water may also be due to industrial processes such as those involved in mining, metal refining, and timber treatment. Malnutrition may aggravate the effects of arsenic in blood vessels.

WHO's Guideline Value for arsenic in drinking water is 0.01 mg /litre. This figure is limited by the ability to analyse low concentrations of arsenic in water.

Distribution

Natural arsenic contamination is a cause for concern in many countries of the world including Argentina, Bangladesh, Chile, China, India, Mexico, Thailand and the United States of America.

Scope of the Problem

Because of the delayed health effects, poor reporting, and low levels of awareness in some communities, the extent of the adverse health problems caused by arsenic in drinking-water is unclear and not well documented. As a result there is no reliable estimate of the extent of the problem worldwide. WHO is presently collecting information in order to make such an estimate.

Case reports on the situation in various countries have been compiled and the arsenic problem in Bangladesh in particular has prompted more intensive monitoring in many other countries. In Bangladesh, 27 % of shallow tube-wells have been shown to have high levels of arsenic (above 0.05mg/l). It has been estimated that 35 - 77 million of the total population of 125 million of Bangladesh are at risk of drinking contaminated water (WHO bulletin, volume 78, (9):page 1096). Approximately 1 in 100 people who drink water containing 0.05 mg arsenic per litre or more for a long period may eventually die from arsenic related cancers.

Interventions

The most important action in affected communities is the prevention of further exposure to arsenic by provision of safe drinking-water. Arsenic-rich water can be used for other purposes such as washing and laundry. In the early stages of arsenicosis, drinking arsenic-free water can reverse some of the effects. Long term solutions for prevention of arsenicosis include:

For provision of safe drinking-water:

- Deeper wells are often less likely to be contaminated.
- Rain water harvesting in areas of high rainfall such as in Bangladesh. Care must be taken that collection systems are adequate and do not present risk of infection or provide breeding sites for mosquitoes.
- Use of arsenic removal systems in households (generally for shorter periods) and before water distribution in piped systems.
- Testing of water for levels of arsenic and informing users.

In order to effectively promote the health of people the following issues should be taken into account:

- Monitoring by health workers - people need to be checked for early signs of arsenicosis - usually skin problems in areas where arsenic in known to occur.
- Health education regarding harmful effects of arsenicosis and how to avoid them.

References

Arsenic in Drinking Water. WHO Fact Sheet No. 210. Revised May 2001.
Bulletin of the World Health Organization, volume 78, (9):page 1096
Prepared for World Water Day 2001. Reviewed by staff and experts from the Programme for Promotion of Chemical Safety (PCS), and the Water, Sanitation and Health unit (WSH), World Health Organization (WHO), Geneva

Lead poisoning

Exposure to lead causes a variety of health effects, and affects children in particular. Water is rarely an important source of lead exposure except where lead pipes, for instance in old buildings, are common. Removal of old pipes is costly but the most effective measure to reduce lead exposure from water.

The disease and how it affects people

Lead is a metal with no known biological benefit to humans. Too much lead can damage various systems of the body including the nervous and reproductive systems and the kidneys, and it can cause high blood pressure and anemia. Lead accumulates in the bones and lead poisoning may be diagnosed from a blue line around the gums. Lead is especially harmful to the developing brains of fetuses and young children and to pregnant women. Lead interferes with the metabolism of calcium and Vitamin D. High blood lead levels in children can cause consequences which may be irreversible including learning disabilities, behavioral problems, and mental retardation. At very high levels, lead can cause convulsions, coma and death.

The cause

People are exposed to lead through the air they breathe, through water and through food/ingestion. Toxic effects are usually due to long term exposure. The population groups at greatest risk of exposure are young children and workers. A recent report suggests that even a blood level of 10 micrograms per decilitre can have harmful effects on children's learning and behavior (CDC, 2000). People can be exposed to lead contamination from the motor vehicle exhaust of leaded gasoline, as well as from industrial sources such as smelters and lead manufacturing and recycling industries, from cottage industry uses and waste sites (e.g. contaminated landfills).

Exposure to lead through water is generally low in comparison with exposure through air or food. Lead from natural sources is present in tap water to some extent, but analysis of both surface and ground water suggests that lead concentration is fairly low. The main source of lead in drinking water is (old) lead piping and lead-combining solders. Removing old piping is costly and lead continues to dissolve even from old pipes. The amount of lead that may dissolve in water depends on acidity (pH), temperature, water hardness and standing time of the water. Secondary pollution from industry can contaminate water through the effluents produced.

Other sources include use of lead-containing ceramics for cooking, eating or drinking. In some countries, people are exposed to lead after eating food products from cans that contain lead solder in the seams of the cans. Very small children are especially at risk to exposure, for example through the ingestion of paint chips from lead-based paint.

Scope of the Problem

The major sources of lead vary according to the region and include: industrial use of lead, lead recycling, leaded gasoline and lead piping used in water distribution systems. Lead in the environment is distributed mostly by air but there is some discharge into soil and water. Water is not normally considered the major source of pollution exposure to lead. In individual households with lead piping and soft waters it may be important. As other sources of exposure to lead are increasingly controlled, water attracts increasing attention.

Interventions

Preventive measures include :

- Environmental standards that remove lead from petrol/gasoline, paint and plumbing.
- If lead pipes cannot be removed, water (cold should be flushed through in the morning before drinking).
- Enforcement of occupational health standards.
- Surveillance of potentially exposed population groups, especially the vulnerable ones (small children, pregnant women, workers).
- Water treatment.
- Removing lead solder from food cans.
- Use of lead-free paint in homes.
- Screening of children for blood levels over acceptable limit and referral for medical care as necessary.

The health based guideline for lead in drinking water is 0.1 milligrams per litre (WHO, 1993). If high levels are detected in a supply, alternative supplies or bottled water maybe necessary to protect young children.

References
CDC Childhood Lead Poisoning Prevention Program
WHO. Guidelines for drinking water quality. 2nd edition. Volume 1: Recommendations. Geneva: WHO, 1993 p49-50
Prepared for World Water Day 2001. Reviewed by staff and experts World Health Organization (WHO), Geneva.

Cyanobacterial Toxins

Cyanobacteria or blue-green algae occur worldwide especially in calm, nutrient-rich waters. Some species of cyanobacteria produce toxins that affect animals and humans. People may be exposed to cyanobacterial toxins by drinking or bathing in contaminated water. The most frequent and serious health effects are caused by drinking water containing the toxins (cyanobacteria), or by ingestion during recreational water contact.

The disease and how it affects people

Disease due to cyanobacterial toxins varies according to the type of toxin and the type of water or water-related exposure (drinking, skin contact, etc.). Humans are affected with a range of symptoms including skin irritation, stomach cramps, vomiting, nausea, diarrhoea, fever, sore throat, headache, muscle and joint pain, blisters of the mouth and liver damage. Swimmers in water containing cyanobacterial toxins may suffer allergic reactions, such as asthma, eye irritation, rashes, and blisters around the mouth and nose. Animals, birds, and fish can also be poisoned by high levels of toxin-producing cyanobacteria.

The cause

Cyanobacteria are also known as blue-green algae, so named because these organisms have characteristics of both algae and bacteria, although they are now classified as bacteria. The blue-green colour comes from their ability to photosynthesize, like plants.

Cyanobacterial toxins are classified by how they affect the human body. Hepatotoxins (which affect the liver) are produced by some strains of the cyanobacteria Microcystis, Anabaena, Oscillatoria, Nodularia, Nostoc, Cylindrospermopsis and Umezakia. Neurotoxins (which affect the nervous system) are produced by some strains of Aphanizomenon and Oscilatoria. Cyanobacteria from the species Cylindroapermopsis raciborski may also produce toxic alkaloids, causing gastrointestinal symptoms or kidney disease in humans. Not all cyanobacteria of these species form toxins and it is likely that there are as yet unrecognized toxins.

People are mainly exposed to cyanobacterial toxins by drinking or bathing in contaminated water. Other sources include algal food tablets. Some species form a scum on the water, but high concentrations may also be present throughout the affected water. Surface scums, where they occur, represent a specific hazard to human health because of their particularly high toxin contact. Contact, especially by children, should be avoided.

Distribution

The organisms can grow rapidly in favourable conditions, such as calm nutrient-rich fresh or marine waters in warm climates or during the late summer months in cooler parts of the world. Blooms of cyanobacteria tend to occur repeatedly in the same water, posing a risk of repeated exposure to some human populations. Cyanobacterial toxins in lakes, ponds, and dugouts in various parts of the world have long been known to cause poisoning in animals and humans; one of the earliest reports of their toxic effects was in China 1000 years ago (Chorus and Bartram, 1999).

Scope of the Problem

Cyanobacteria have been linked to illness in various regions throughout the world, including North and South America, Africa, Australia, Europe, Scandinavia and China. There are no reliable figures for the number of people affected worldwide. The only documented and scientifically substantiated human deaths due to cyanobacterial toxins have been due to exposure during dialysis. People exposed through drinking-water and recreational-water have required intensive hospital care.

Interventions

- Reducing nutrient build-up (eutrophication) in lakes and reservoirs, especially by better management of wastewater disposal systems and control of pollution by fertilizers (including manure) from agriculture.

- Educating the staff in the health and water supply sectors, as well as the public, about the risks of drinking, bathing or water sports in water likely to contain high densities of cyanobacteria.
- Water treatment to remove the organisms and their toxins from drinking-water supplies, where appropriate.

References

Toxic Cyanobacteria in Water: a guide to their public health consequences, monitoring and management, edited by J. Bartram& I. Chorus. Geneva, World Health Organization, 1999.

Prepared for World Water Day 2001. Reviewed by staff and experts at the Federal Environmental Agency, Germany, and the Water, Sanitation and Health Unit (WSH), World Health Organization (WHO), Geneva.

UN-Water Global Annual Assessment of Sanitation and Drinking-Water (GLAAS)

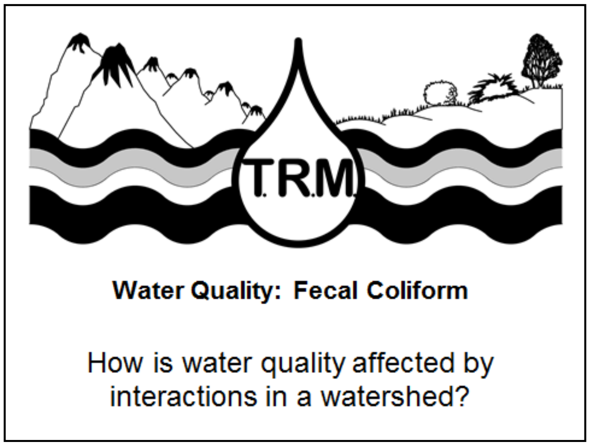
The Global Annual Assessment of Sanitation and Drinking-Water (GLAAS) is a UN-Water pilot initiative led by the World Health Organization (WHO). UN-Water GLAAS constitutes a new approach to reporting on progress in the sanitation and drinking-water sectors that aims to strengthen evidence-based policy-making towards and beyond the Millennium Development Goals (MDGs).

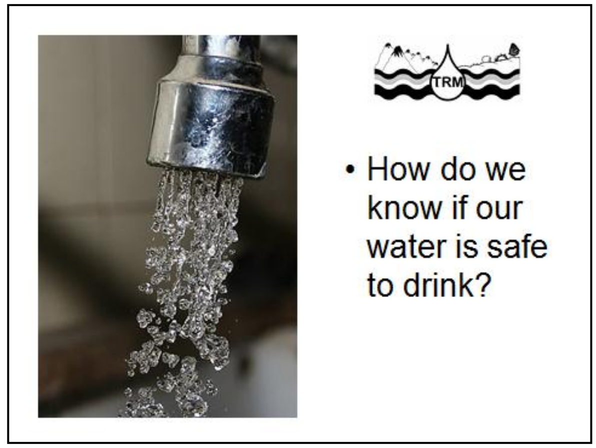
UN-Water GLAAS complements other UN-Water reports, such as the WHO/UNICEF Joint Monitoring Programme for Water Supply and Sanitation or the World Water Development Report, by concentrating on the factors affecting the capacity of countries and external support agencies to progress towards the sanitation and drinking-water MDG target.

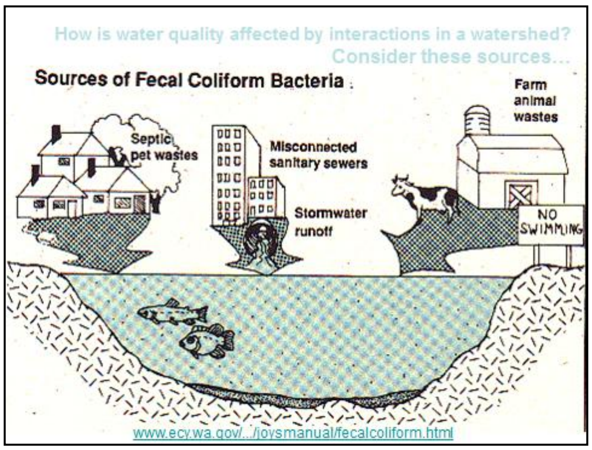
The 2010 UN-Water GLAAS report is planned for publication in early 2010 and will be used as a basis for the strategic discussions that will take place at the first High-Level Meeting on Sanitation and Water Supply, hosted by UNICEF in spring 2010.

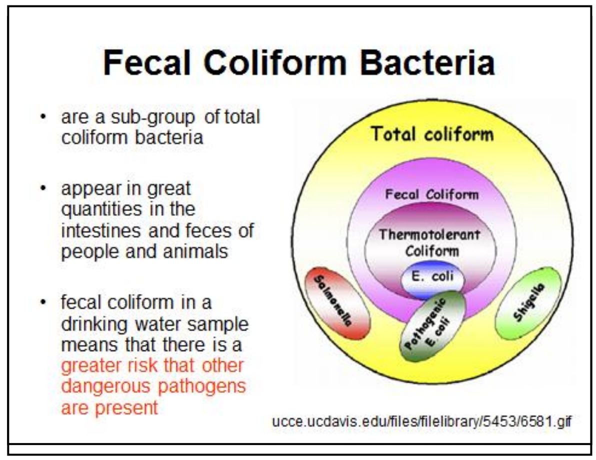
http://www.waterandclimate.org/index.php?id=5thWorldWaterForumpublications810

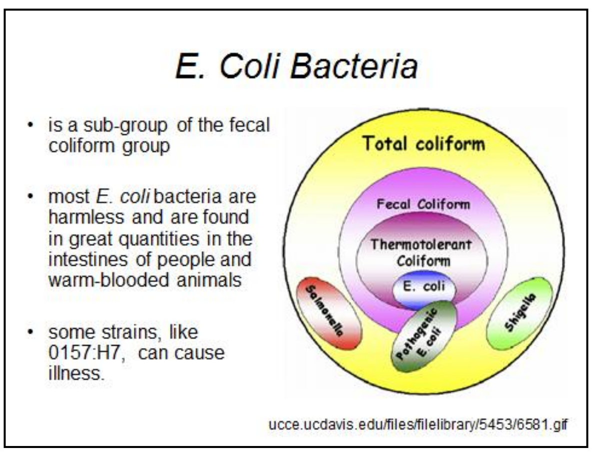
Fecal Coliform PowerPoint

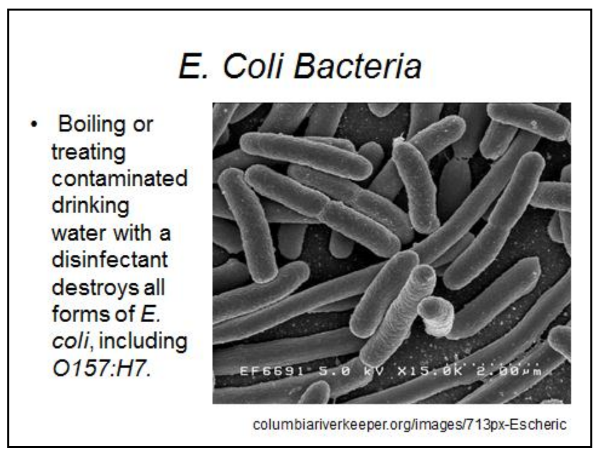












Pathogens

- Most pathogens that can contaminate water supplies come from the feces of humans or animals. Testing drinking water for all possible pathogens is complex, time-consuming, and expensive. It is relatively easy and inexpensive to test for coliform bacteria.

Testing for Coliform Bacteria

www.dnr.mo.gov/env/esp/fecalcoliformanalysis.htm

- The membrane filter technique involves filtering a water sample through a membrane to trap bacteria that are present in the sample. This filter is then placed on growth media and incubated at 44.5°C for 24 hours.

- The combination of selective media and high temperature favors the growth of fecal coliform bacteria while suppressing the growth of non-fecal coliform bacteria.

Pathogens

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- Just a few of the organizations and public agencies that work to protect our water quality.

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- DOH Pub #331-181(Updated)