Drinking Water: Which Is Better, Bottled or Tap?

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INTRODUCTION

Water is one of the most essential components of living things. It covers nearly 75 percent of the earth's surface and comprises 60 percent of the human body. Water is near the top of the hierarchy of the basic needs for both animals and plants, exceeded only by air. Man can live only four days without water, even less depending upon the temperature of the environment. Homeostasis of the body depends largely upon the intake of water. The body is being depleted of water through various body functions. Kidneys need to be flushed, cell turgidity needs to be maintained, body fluids move through the transport system nourishing cells, keeping the body healthy, fighting diseases, and building and rebuilding various parts of this human machine known as the human body. It stands to reason that the body needs a reliable amount of "potable" drinking water daily.

In the U.S., we take our drinking water for granted. We feel that it will always be available and safe for drinking. Yet, the September 11 terrorism has been a reminder for Americans of the fragility of our civilization. Clean water is part of our civilization as it too cannot be taken for granted. This unit will attempt to explore water issues dealing with its quality. How can the quality of water be preserved? Who regulates water quality? Who monitors the safety of drinking water? Is there a role in managing our water quality for the consumer? Students must learn answers to these critical questions. As students become water wise, they will harvest new ideas, new challenges for the conservation of our drinking water.

There is a strong correlation between sanitation, water borne diseases, and overall public health. From the Middle Ages through the nineteenth century, largely because of overcrowding and poor sanitation, contaminated water and related diseases persisted in urban areas. Inventions and medical advances by such scientists as Anthony Van Lienwenhioek (microscope to explore world of bacteria and parasites), Edward Jenner (vaccinations) did not start to impact public health and water quality until the nineteenth century. Lead and mercury poisoning were relatively common in industrialized locations. Toxic wastes were routinely discharged into rivers and estuaries. People actually preferred drinking ale and wine to drinking water for safety reasons. There were numerous outbreaks of diseases from contaminated water in the United States in the early nineteenth century – cholera in 1833 in New Orleans; in Chicago and Philadelphia, typhoid was endemic. Diarrheal diseases were the third leading cause of death in the United States during this period.

Public health awareness developed with the discovery of microbiology and organic chemistry. The scientific methods were used by both Louis Pasteur and Robert Koch to show that microorganisms in organic nature (human or animal waste), found in even low concentrations, caused diseases and that the removal of microorganisms from water supplies could control and prevent epidemics.

The discovery that these diseases were infectious and water transmissible led to the development for methods of purification. The first water filtration system using sand as a filtering medium was founded in Lawrence, Massachusetts in 1867. Shortly after, mechanical and sand filters were installed in municipal water supplies throughout the United States. Typhoid fever dropped tremendously.

Chlorine had been found to inactivate pathogenic microorganisms in the water by damaging cell walls of infecting agents thus poisoning them. Chlorination was first used in 1909 in Jersey City, New Jersey when the city's reservoir of drinking water would periodically become contaminated from river sewage. Bacteria counts in the water supply dropped to negligible levels, which proved that chlorination was an effective method of disinfection. Currently in the United States, chlorine is used in 75 percent of the larger municipal systems and 95 percent of the smaller systems.

REGULATORY AUTHORITY

During the nineteenth century, through the collaboration of the United States, England, and France, a realization that the government has a moral and ethical responsibility for protecting the welfare of its people was realized. In England, public water commissions and uniform standards for water purification were developed from the work of an English physician, John Snow in 1854. Public access pools, dumping of untreated human waste and animal entrails from slaughterhouses were stopped. England became sort of the birthplace for control of waterborne infections. In the United States, Congress passed the River and Harbors Act in 1899, which prohibited the discharge of refuse in navigable waters.

By 1948 the Federal Pollution Control Act was passed into law. This act later became known as the Clear Water Act. This act regulated procedures of pollution and required them to pre-treat their effluents to minimize water pollution at its source. This measure along with bacteriologic standards for water quality – the common causes of water borne infection – became controllable. Outbreaks of typhoid, cholera, and other diarrheal diseases became almost unheard of and when occurrences arose, they were quickly contained. Although the public was enjoying a high quality of drinking water, the industrialization of the United Stated following World War II led to an increase use of synthetic chemicals which gave rise to chemical pollutants in water sources associated with the disposal of the chemical byproducts. Fish and mammals living in or near their water supplies began to die. Many of the fish had developed disfiguring tumors. Public awareness of the adverse effects of chemical toxins, fear of cancer, the instrumentation technology developed for measuring chemical levels of toxin all led to a more effective law passed by congress in 1974 known as the Safe Drinking Water Act (SDWA). It is the most comprehensive act on water regulation and is under the auspices of the Environmental Protection Act (EPA).

The Safe Drinking Water Act of 1974 (P.L.93-523) was passed to set standards for safe drinking water, to protect “sole source” aquifers, and to protect drinking water aquifers from underground injection of water. It mandates the EPA to set drinking water standards to protect public health and welfare. SDWA regulates standards for both ground and surface water sources.

Groundwater is water found below the surface of the earth in crevices of soil and rocks. It is sometimes called percolating water and does not occur in underground rivers or lakes, as sometimes stated, except in a few cases such as in limestone formations. Groundwater is found filtering in porous and permeable subsurface geologic formation known as aquifers. Some believe that groundwater and surface water are separate and distinct. This is a misconception. In fact, the two are often interrelated. Springs and streams are fed by groundwater, which in turn recharges the groundwater reservoirs.

This separation myth that groundwater and surface water are unrelated has been an issue for Texas water laws in as much as different laws govern the different bodies of water. Each state in the United States must adopt drinking water quality standards that are at least as strict as those of the federal government. Each state ranks its own water supply as “in compliance” or “out of compliance.” If a state is out of compliance its water supply must be improved. Usually the state health department has the responsibility for enforcing the federal regulation for safe drinking water. Many states post at their city limits the compliance status of their drinking water. If the water quality is of threat to the health of a community, the community must be notified and informed as to what measures should be followed to minimize health risk. Some of the regulatory laws aimed at preventing the contamination of ground and surface water are listed below. They show what is being done to keep harmful chemicals, toxins, and other hazardous wastes from polluting our water sources.

Federal Water Pollution Control Act of 1972 (P.L. 92-500)
Clean Water Act Amendments of 1977 (P.L. 95-217)

The objective of this act and its amendments is “to restore and maintain the chemical, physical and biological integrity of the nation’s water.” National goals to achieve a degree of water quality that would make the waters of the United States “fishable and swimmable” by 1983 and to eliminate the discharge of pollutants into the waters of the United States by 1985 were established. The act sets water-quality standards, establishes minimum national effluent standards, requires pollution discharge permits, and has a construction grant program for public sewage-treatment plants.

The 1986 Amendments to the Safe Drinking Water Act of 1974

The 1986 amendments to the act enlarged the list of substances to be regulated. Maximum contaminant levels and maximum contaminant level goals are to be established for toxic and carcinogenic compounds as well as secondary maximum contaminant levels for substances with no health risk but that do create aesthetic concerns. Congress directed the states to develop plans to protect the surface area around public water supply wells from potential contamination from such sources as hazardous wastes, pesticides, and leaking underground storage tanks. The underground injection of hazardous waste and other materials is also regulated under the Safe Drinking Water Act. Current drinking-water aquifers as well as other aquifers with total dissolved solids less than 10,000 mg/L are protected by regulating injection of liquid waste into deep boreholes. Class I wells dispose of hazardous waste into isolated strata below current or potential drinking-water aquifers. Class II wells are for the recirculation of oil-field brines. Class III wells are used in solution-mining of ores. Wastes are not to be injected into or above potable water aquifers.

Toxic Substance Control Act (TOSCA) (P.L. 94-469 as amended by P.L. 97-129)

The purpose of this act is to protect human health and the environment by requiring testing and use restrictions for chemicals that may present an “unreasonable” risk to health and the environment. This is an umbrella act that regulates toxic compounds during research and development, manufacturing, processing, and distribution. It has been interpreted to permit controls on the use, disposal, or storage of toxic compounds where groundwater contamination from such compounds has occurred or may be expected to occur. Federal agencies and state governments come under the jurisdiction of this act.

Federal Insecticide, Fungicide and Rodenticide Act (FIFRA) (P.L. 92-516 as amended by P.L. 94-140, P.L. 95-396, P.L.96-539, and P.L. 98-201)

The primary purpose of FIFRA is to regulate the manufacture, use, and disposal of pesticides. It requires pesticides to be labeled and restricts their use where appropriate. Use restrictions can be applied in areas where groundwater contamination by pesticides has occurred or could be expected to occur.

Surface Mining Control and Reclamation Act (SMCRA) (P.L. 95-87)

The SMCRA was passed with the intent of preventing imminent danger to the health and safety of the public and significant, imminent environmental harm that might be caused by both underground and surface-mining operations. One aspect of the law is that it requires that a hydrogeological study be performed prior to the covering or burial of acid-forming or toxic waste materials from mining or when any mine is to be filled with waste material.

In spite of all the regulatory laws, the big question still lingers in people minds. Is drinking water that meets federal and state regulations absolutely safe? That is the big question! Dr. James Symons (Symons, 2001) states that safety is relative, not absolute. He further states that an aspirin or two may help a headache but if one consumes the entire bottle at once, he will probably die. So, is aspirin safe? When setting safe drinking water standards, the federal regulatory agencies use the concept of reasonable risk, not risk free. Symons further states that risk free would cost too much. So his answer to the question is no, drinking water isn't absolutely safe. He concludes that the likelihood of getting sick from drinking water that meets the federal standards is very small, approximately one chance in a million. All water suppliers must test treated water for microbes against a list of nearly a hundred chemicals a specified number of times each year. These tests must be done in federally certified laboratories using federally approved methods. Thus a constant vigilance is necessary to insure that our water supply remain of high quality. Although the SDWA provides a system to monitor and regulate standards for safe drinking water, new regulations will be needed to prevent disorders related to human infertility, heart disease, and dementia (deteriorating memory) as new health problems are shown to be linked to contaminates in drinking water.

The U.S. Food and Drug Administration (FDA) requires bottled water quality standards to be equal to those of the EPA for tap water, but the quality of the finished product is not government monitored. Bottled water companies must test their source water and finished products once a year. They must label any bottled water "sub-standard" if contaminants in excess of government regulations are found. There are many brands of bottled water on the market shelves today. None of the brands have tested positive for lead recently, but microbes may grow in bottles even while on grocer shelves. Some states require bottlers to list the expiration dates on bottled water. In New York, the expiration date is two years from the date of bottling. Regulations also require that "bottled water" contents be included on the label. Labels also include the type of water source. Some examples are artesian water, artesian well water, spring water, sterile water, and mineral water. All spring bottled water labels should include the name of source and its location. Where as bottled water may be no healthier or safer than tap, it sells at a price 1000 times greater than tap water according to a study done by a Swiss-based conservation group, the World Wide Fund for Nature and cited by Dr. Symons. The International Bottled Water Association says that if tap water is the source of bottled water, then it must undergo further processing for quality, taste, and safety.

WATER QUALITY AND USE

In physiological terms a human needs about ½ gallon a day of water. Cooking, sanitation, washing, and other uses add another 52,500 gallons of water a year in the U.S. and earn the nation the number one spot in the world when it comes to water usage. Quality affects use; use impacts quality. Water is a commodity that is constant in its quantity. It is a limited resource supplying the need of an ever-increasing population. The quality of water is being compromised by the heavy demand made on it by consumers as well as industrial and commercial plants. A direct correlation between water quality and its use exists. *As the quality of water is diminished, so is its use.*

The population explosion taking place over the last several decades and drought conditions in Texas led to a great increase in water demand. Withdrawal and consumption are two kinds of water uses. Water is withdrawn for municipal, agricultural, domestic, or commercial purposes. All water withdrawn by users may not be consumed. The unused portion may be returned to its source as treated effluent, or may enter the hydrologic cycle through evaporation and plant transpiration. In 1980, the Texas Water Resource Institute stated that agriculture was the biggest consumer of water in Texas (72%), municipalities were the second largest users of water (16%), and industrial use (12%). Agriculture is also shown to be the biggest consumer of surface water (54% annual water use) followed by industrial uses at about 22%. Water quality is always diminished after its use with respect to its suitability for a particular purpose. The same water may be acceptable for one purpose or use but unacceptable for another, depending on its characteristics and requirements for the particular use. Water quality is an issue that must be dealt with in the future. People are concerned about water safety and water availability. Many consumers will not drink tap water in fear that it may not be safe.

Man is the primary culprit for the pollution of our water sources. He has the responsibility and obligation for cleaning up and controlling the pollution of our fresh water supply if safe water is to be available for future generations. Our students should be encouraged to become advocates for a cleaner environment including our water sources.

WATER SOURCES, QUALITY, AND TREATMENT

"Water, water, everywhere but not a drop to drink" is a famous quote from *The Rime of the Ancient Mariner* by Samuel Taylor Coleridge. The quote sounds so poetic, so distant, so far away. But is it really? There are more than one billion people with no access to safe drinking water. In comparison, we here in the United States still enjoy an ample supply of safe drinking water. But will it last forever? Our sources of drinking water are nearly constant but the demand for their use is growing exponentially. What are the primary sources of our drinking water? Why is it important to know the sources of our tap or bottled water? Have you ever given thought to the old saying that "you don't miss your water until your well has gone dry"? In the United States, our drinking water comes mainly from surface water and groundwater. Surface water includes lakes, rivers, and reservoirs. Groundwaters are from aquifers into which wells have been drilled. Aquifers are underground geological formations that contain water.

The source of one's water depends on where one lives. Cities built near rivers derive their water from rivers; those near lakes from lakes. Others may get their water from large underground aquifers or transport water from distant watersheds (areas in which water naturally collects). Typically, large municipalities use surface water. Smaller ones use groundwater. Private groups and individuals use groundwater as well for their source of drinking water. Water is a precious limited commodity. If it is not used wisely, then it will soon be relegated to non-potable drinking water. Its quality will become compromised and mankind will be forced to find new water sources or new places to live. Here in Houston our water is supplied primarily by Lake Houston and the Trinity River, with a large fraction also from groundwater.

This unit on Drinking Water is aimed at helping students develop critical thinking skills. Why is bottled water preferred over tap water? Is it because of taste or safety? The concept for this unit is to examine drinking water quality and treatment methods. Student activities will also include the comparison of municipal supplied water (EPA) versus bottled water (FDA) regulated. The unit will be taught to students on Homebound (instruction is one-on-one) in Biology or Environmental Science classes over a ten-day interval. The students will be expected to use the scientific method during laboratory investigations to make wise choices in the use and conservation of resources and the disposal or recycling of materials – a ***Texas Essential Knowledge and Skills Objective (TEKS).***

I will have students write responses to the following questions in preparation for a research unit on a water topic:

A) What do you know about water?
B) What would you like to know about water?
C) Do you feel our water supply is adequate and safe?

I will have them write down everything they know about the questions. Then, I will list all responses on the board. As a class we will take off what is not reasonable, true, or wanted. I will use a strategy called scaffolding to solicit guided student responses. Scaffolding is a technique used to access prior knowledge and to get students to think more critically. Scaffolding builds on lower levels of questioning to achieve inquiry type questions and responses. The result is maximum student participation and a desire to learn more about the subject. Getting students to write is an informal type of assessment. At the end of the discussion, I will have students share what they learned. The benefit of this strategy is that students feel ownership, show progress in learning and develop self-esteem. At this point, I will have enough information about what each student would like to further investigate to guide him or her in selecting a topic for his or her individual research projects. Students will use the bibliography in this unit, the website for HTI and other available resources. Students will be required to select a display model from the portfolio of ideas found in the appendix at the end of this unit.

Next, I will design vocabulary assessments to evaluate student understanding of water terminology. By this time students will have defined drinking water and its quality. Vocabulary assessments will be given frequently. Hands on demonstrations showing how water may be purified using coffee filters, clay pots, sand, and soil layers and/or the

Alum Dose Method will be presented. They will develop a glossary of terms as the water unit develops. They are to be kept in the word bank section of the student portfolio.

Surveys always seem to pique student interest. Students will take the Taste Test Survey outlined in Activity 2. I will use tap water and some brand of bottled water and have students determine which tastes better (more flavorful).

Finally, I will visit a Houston Wastewater Treatment Plant and a Drinking Water Treatment Plant. I will create a video during each tour. Students will use the videos to assess how our drinking water is treated before consumer use and how wastewater is treated for safe release into our natural waters. Students will use the website called *Kids Stuff – Drinking Water* to complete additional activities and experiments on water. Finally, a post-test will be given over the entire unit on water and each student completing the water unit will receive a certificate.

LESSON PLANS

Lesson One: What Do You Know about the Water You Drink?

Overview
Have student(s) take the test in Activity 1 as a pre-test.

Objective
To identify vocabulary, to assess prior knowledge, and to research water topics.

Materials
Varies, depending upon individual research projects selected.

Procedures
Take the test found in Activity 1: What Do You Know about the Water You Drink? Have teacher grade the test. Record your grade on your assignment sheet. At the end of the water unit, take the test again. Calculate your progress. Next select a water topic and research according to teacher directions. Present and display results using a suggestion found in Appendix 1. Submit on Day 7 after topic is approved.

Activity 1A: What Do You Know about the Water You Drink?

A. Match the vocabulary words to their meanings.

____ 1. All water beneath property belongs to the property owner.
____ 2. Disease causing materials.
____ 3. The formula for water.
____ 4. Materials essential for life.
____ 5. Freezing temperature of pure water.

____ 6. Safe drinking water.
____ 7. Water from a hole, bored, drilled in the ground that taps the water of an aquifer.
____ 8. Water that has been produced by distillation, deionization or reverse osmosis.
____ 9. Water that flows naturally from an underground formation to the surface of the earth.
____ 10. The act of removing contaminants from source water by addition of chemicals, filtration, and other process, making it safe for human consumption.

A. Nutrients
B. 32º F
C. Purified Water
D. Water Treatment
E. English Rule
F. Potable
G. Spring Water
H. H_2O
I. Well Water
J. Pathogens
K. None of these

TRUE OR FALSE

B. Mark each statement below as true or false.

____ 1. Water that meets federal drinking water standards is absolutely safe.
____ 2. Drinking just ocean water will cause death in humans.
____ 3. Bottled water can cost up to 1000 times more than municipal drinking water.
____ 4. Residential water use by an average person per year in the United States is about 7,320 gallons.
____ 5. Houston municipal water comes mainly from the Galveston Bay.
____ 6. Calcium in drinking water decreases the incidence of tooth decay when the water is consumed during period of enamel calcification.
____ 7. Soft water causes increased soap or detergent consumption.
____ 8. Alkaline waters may have a distinctive unpleasant taste.
____ 9. Chloride may give a salty taste to drinking water.
____ 10. Fluoride tends to cause incrustations on cooking utensils.

Activity 1B: Water Unit Research Project.

Display the result of your research unit by selecting one of the models from the *Student Displays on Drinking Water Portfolio* located in Appendix 1.

Lesson Two: Bottled Water Versus Tap Water

Overview
This lesson activity will focus on a single comparison, tap versus bottled water, to stimulate student interest, awareness, and critical thinking. The comparison is chosen

because tap water and bottled water are ubiquitous in our society, yet there is a safety perception related to each.

The bottled water industry has grown tremendously in spite of the high cost per ounce. Why do consumers spend so much money on water in a bottle that comes from the same primary source? This lesson will discuss the sources of our drinking water, how it is processed and delivered to the consumer. With this knowledge hopefully, the student's will become lifelong water-conscious individuals. When asked which is better, bottled or tap, they will respond intelligently with scientific inquiry. By better, do you mean preference? Do I prefer bottled or tap because of taste, flavor, color, convenience, or safety concerns? Maybe, there is no preference.

Which is better tap or bottled water? Ask any consumer on the street or anywhere today this question and without hesitation most will say, "Bottled." If asked why, you get many different answers with the leading ones being, 1) it taste better; 2) it is safer; 3) it is clear water; 4) it is just more convenient; 5) I don't know. I just never thought about why I like "bottled" better. I just do; 6) the pipes to the tap system may contain lead or they may have some other contaminant such as asbestos, rust, or microbes; 7) tap water may contain raw sewage; and 8) tap water smells.

There is a marked difference between tap and bottled water. First, there is an economic difference. The cost for bottled water is higher per ounce, in some cases much higher. It is more of the norm to pay three dollars for an eight-ounce bottle of water at some of the large conventions or finer restaurants. I will have the students to check some of the grocery stores, sporting events and restaurants to compare prices of bottled water. Secondly, the flavor of most bottled water may be preferred over the flavor of tap water. Tap water has many minerals in it that may not be found in bottled water. Water has minerals in it that are unique to a specific segment of the country. These minerals adversely affect the taste of the water. However, the safety of the drinking water is not compromised as long as federal standards are met. Third, chlorine is added to the tap system as a disinfectant to kill certain microorganisms. Often a taste and a smell are associated with the chlorination of water. Fourth, the purer bottled water is usually derived from reverse osmosis. It is preferred over the purest form of distilled water because of taste, which has been enhanced by the adding of oxygen.

In addition, I will have students bring a variety of bottled water to class. Labels and contents will be noted on an analysis chart as to name of water, content, expiration date, dietary data, source (well, etc.), name and location of spring (city/state) and cost per ounce. Students will discuss which water is the better buy. Afterwards, they will compare the tap water and bottled water costs. Next, the students will complete the Taste Test Survey in Activity 2.

Objective
To determine which is better, bottled or tap water.

Vocabulary
Bottled water, tap water, bar graph, survey.

Materials
Bottled water, tap water, small paper cups, red and green circular stickers, graphing technology.

Procedures
The teacher should place green circular stickers on half of the cups and the red circular sticker on the remaining half. (Allowing each student to have one on each cup.) Place the bottled water in the green cups and the tap water in the red cups. Do not let the students know which type of water is being placed into the cups. Give each student a cup of each type of water. Have students to rate the water for taste, smell, color and safety concerns. Now, reveal to the students the type of water in each cup. Have students complete Activity 2.

Activity 2: Taste Test Water Survey

After the taste test is completed graph the data on a bar graph using the following codes below.

T = Taste
O = Odor
C = Color
S = Safety Concerns
TW = Tap Water Preference
BW = Bottled Water Preference

According to the results of the water survey, ________% of the students preferred _________________ water over _______________ water.

Lesson Three: Groundwater Pollution

Overview
As long as man has lived on this earth, he has created waste materials and has disposed of them in a variety of ways influenced by such factors as proximity of space, expedience, expense, and available technology. Methods of disposal often lead to leachate from wastes that yielded far-reaching consequences for years to come. Groundwater pollution may lead to minor issues such as taste, smell, odor, color, and even hardness, but when pathogens, toxic chemicals and other harmful by products infiltrate the water system,

then more serious issues occur. Once groundwater becomes polluted, it may remain in an unusable or hazardous condition for decades or even centuries. Thus, long time health effects may be booming on the horizon.

Groundwater has a low velocity, which prevents a great deal of mixing and dilution. A slow moving contaminated plume may contain high concentrations of contaminates as it moves from points of recharge to zones of discharge. The migration of leachate plumes originating at landfills are becoming more abundant. Water quality diminishes in response to the environment in which leachate plumes are found. This activity will explore groundwater quality problems originating both on the land surface and in the ground above the water table.

Objective

To test how surface or subsurface pollutants might enter an aquifer that is supplying water to a well.

Vocabulary

Plume, leachate, sanitary landfills, contaminates, sulfates, aquifers.

Materials

A narrow plastic or glass tank for tracking groundwater movement or a groundwater model if available, sand, clay (Kaolin clay is best), fine pebbles, course pebbles, pump and tube used as a pumping system, two different flavors of Kool Aid, plastic cups, graduate cylinder.

Procedure

Students will simulate the geologic layers of the earth. They will determine which layers of materials will be placed first second and so on to build the best filtration system. Place the pumping system into the aquifer. Students will saturate the systems by adding water slowly, 50 mL per time. Record how much water was added to saturate the aquifer. Now, sprinkle one flavor of Kool Aid on the land surface. Build a landfill in the aquifer. Place the other flavor of Kool Aid in the landfill. Now, run water (rain) into the aquifer. Measure water going in and water going out. Start pumping. Determine how long it will take to clear the aquifer of the contaminated water. Equate 50 mL of water to the amount of rain in five years. Answer questions in Activity 3.

Activity 3: Groundwater Pollution

1. How much water was added to saturate the aquifer?

2. What happened when the pesticides (red Kool Aid) were sprinkled on the surface?

3. Was there any movement of the pesticides when water was added to the aquifer? Explain.

4. What happened to the landfill when it became contaminated with sulfate (grape Kool Aid)?

5. Add water again to the aquifer. Was there any movement of the sulfate out of the landfill?

6. Repeat adding water to the aquifer. Conclude how long would it take to clear the aquifer of the contaminants.

Lesson Four: Municipal Water and Wastewater Treatment Systems

Overview

Disinfections for all water systems and some type of filtration designed to treat pathogens that are difficult to detect such as viruses, Giardia, and Cryptosporidium, were established in 1986 by amendments to the Safe Drinking Water Act. In addition to regulating water quality these amendments also addressed the potential for lead contamination in water distribution systems, including the plumbing systems in homes and nonresidential facilities. Lead-free pipe, solder, and flux for all such systems were all now part of the federal standards for safe drinking water. The amount of lead permitted in solders is set at no more that 0.2 percent lead down from the previous 50 percent lead content prior to the passing of the 1986 amendments. All large municipal water systems are required by Congress (1996) to report annually to their customers on the quality of their drinking water. In addition, controls on harmful pollutants such as Crptosporidium are also required by EPA.

Drinking water falls into two categories both regulated by the EPA. Primary standards specify maximum contaminant levels (MCLs) and are based on health-related criteria. The EPA also sets unenforceable maximum contaminate level goals (MCLGs) at levels that present no known or anticipated health effects, including a margin of safety, regardless of technological feasibility or cost. The MCLGs for carcinogens are usually set to zero since any exposure to carcinogens pose some degree of health risks. The Safe Water Drinking Act establishes contaminants for MCLs and MCLGs and updates acceptable concentrations for the following categories: inorganic chemicals, organic chemicals, radionuclides, or microbiological-turbidity.

In spite of SWDA regulations, many people are still questioning the safety of their municipal drinking water. Two critical systems are responsible for the quality assurance of our drinking water. The water treatment systems' primary goal is to bring raw water (groundwater or surface water) up to drinking water quality. Secondary standards, which are unenforceable guidelines, are based on both aesthetics characteristics such as taste, odor, and color of drinking water, and non-aesthetic characteristics such as corrosiveness and hardness. Most large municipal cities source of water is from surface water. Surface water presents a higher chance of microbid contamination due to its higher turbidity.

Filtration is usually always required to correct this problem. On the other hand, smaller towns or cities rely more on groundwater, which is usually uncontaminated and carries few suspended solids. Filtration is not usually a factor; however, objectionable dissolved gases and hardness removal are usually needed. Disinfection is added to insure that the water is free of harmful pathogens. *Filtering and disinfecting are the two main factors in treating the tap water we drink and use in our everyday lives.* On the other hand, the wastewater and collection treatment system removes contaminates from water that have been used in households, businesses, and industrial plants before the effluents are released back into the local streams, lakes, rivers, estuaries, or coastal waters. It also reduces BOD and nutrient loading on the receiving sources and also may remove toxic chemicals. Both the water and wastewater treatment systems serve to kill pathogens both before and after water is used.

Objective

To draw a schematic of typical water treatment plant for surface water. To draw a schematic of a typical wastewater treatment plant.

Procedures

View the videos on Houston Water Treatment Plant and Houston Wastewater Treatment Plant. Discuss the video in class. Visit the website *Kids Stuff: Drinking Water*.

Activity 4: Water Treatment

A) List five facts stated in each video on 4 x 6 index cards and place them in your portfolio.
B) Visit the Internet site on related topics. Select and perform one activity from the *Kids Stuff: Drinking Water* website. Summarize the activity on 4 x 6 index card and place in your portfolio.
C) Draw a schematic of either a water treatment plant or a waste treatment plant showing how the water is treated before consumer use or before it is released back into a water source.

Lesson Five: Post Test

A) Administer the test from Activity 1. Compare student growth since the pre-test administration. Track growth on an assessment chart.
B) Upon completion of the Safe Water Drinking Unit, give each student a *Certificate of Completion* rewarding them for a job well done.

APPENDIX
Student Displays on Drinking Water

Select one project to complete.

1. **Notebook**
   The notebook should contain a minimum of 15 pages. Include pictures, illustrations, and descriptions on a water content. The first page of the notebook should be a title page and the second page should be a table of contents. The last page should be the bibliography page. Each page should be numbered. Descriptions can be hand written or typed. Illustrations may be colored. Do **not** reprint text from the Internet.

2. **Display**
   Use a tri-panel made from two pieces of poster board to display and describe some water topic. Titles and subtitles are required. Text can be handwritten or typed. Accompanying pictures can be hand drawn, internet pictures, or photographs. Please do **not** reprint text or illustrations from the Internet. Do not write directly on the display. Cut, mount, and paste text and illustrations to the display.

3. **Collage**
   A collage is a collection of magazines pictures mounted in an overlapping manner on heavy-duty paper. The minimum size is 18” x 24” poster board. The collage should be accompanied by a directory of written descriptions of each aspect of the different water scenes. The collage must be named, signed, and dated by artist.

4. **Video**
   Using standard VHS tape, record and narrate a minimum of 10 minutes of a topic on drinking water.

5. **Models**
   Create a model on a specific water topic. The model should be clearly labeled and accompanied by a notebook explaining the model.

6. **Song/Rap**
   Compose and perform the lyrics to a song or a rap about the water we drink. The composer must provide a written copy of the lyrics and an audiotape of the song. Taping can be done at home, in class, or student’s choice. Others may participate in the singing of the song. Consult with teacher for any equipment or arrangement assistance.

7. **Poem or an Ode**
   Compose a poem or write an ode about drinking water. It must have a minimum of 12 lines. The poem must be recited in class and submitted a regular 8 ½ ” x 11” paper with illustrations. Oral explanations explaining poem must be given during the recitation period.

8. **Costume and Dance**
   Choreograph a dance on a water concept lasting 2 to 3 minutes. The dance may be accompanied by music or words. Provide music and appropriate costume for the performance. The dance may be performed solo or with a partner(s). Give a brief oral interpretation of the dance after performance.

9. **Power Point Presentation**
   Create a power point presentation of at least 12 slides on drinking water. You **may** use **pictures** from the Internet, photographs, digital, or any other available program or source. All text should be expressed in your words.

10. **Demonstrations**
    Using the Water Wise Activity Resource listed in the bibliography, perform a taped demonstration of Adams Apple Activity. Display the activity on a tri-panel poster board. Using a camera, have pictures made of the demonstration as you are performing it.

11. **My Little Water Sports Book**
    Create a 10 page My Little Water Sports Book. Include pictures, illustrations, or photographs. See teacher on how to design the book.

12. **Words, Words, Words**
    Using your water glossary, select at least 15 of the words and create one of the following:

    1) Word Find
    2) Word Scramble
    3) Word Game
    4) Water Trivia

    Technology may be used. Answers must be included on a separate copy. Use at least 8 ½” x 11” paper. Border or add illustrations to the copy.

13. **Art**

Create a slogan for a T-shirt promoting water conservation. Acquire a sponsor to assist in having the shirt printed. Computer program generated or hand-painted shirts are acceptable. Use a 4"x 6" index card to explain the slogan used on the shirt. Photograph a picture of the T-shirt and mount it on a 6"x 8" index card.

14. **Clubs**

Research and join or participate in one of the following clubs below. A log containing information about the organization, why you decided to join the organization, and activities you participated in are to be kept.

1. The Trash Bash at Little White Oak Bayou.
   Contact: Shanna Barnstone at the Wildlife Discovery Program at
   (713) 284-8336.
   Houston, Texas
   Focus: Non-Point Source Pollution

2. The WET in the City.
   Contact: Council for Environment Education,
   5555 Morningside Drive, Suite 212
   Houston, Texas 77005
   Phone: (713) 520-1936
   Fax: (713) 520-1936
   Email: info@wetcity.org

Focus: Responsible Water Stewardship

ANNOTATED BIBLIOGRAPHY

Teacher Resources

Barzilay, Joshua I. *The Water We Drink: Water Quality and Its Effect on Health*. Piscataway, N.J.: Rutgers University Press, 1999.
This book is an excellent resource on the history of drinking water, sanitation, and diseases. It discusses the modern ear of drinking water regulation, drinking water sources, water treatment, health issues, and water safety and conservation.

Environmental Protection Agency, Seminar Publication. *Protection of Public Water Supplies from Ground Water Contamination.* Cincinnati, Ohio: Center for Environmental Research Information.
This governmental resource is great for the study of groundwater pollution and its treatment.

Goubert, Jean-Pierre. *The Conquest of Water.* Princeton, N.J.: Princeton University Press, 1989.
This resource views water as one of the subdivisions of the religion of progress. It focuses on early regulatory laws governing water quality and health related issues in France during the period between 1853 and 1940.

Kaiser, Ronald A. *Handbook of Texas Water Law: Problems and Needs, Texas Water Resources.* College Station, Tex.: Texas Water Resources Institute, Texas A&M University, 1991.
This handbook is an excellent resource on Texas laws, water quality, and water facts, water use, and public access.

Symons, James M. *Plain Talk about Drinking Water*. Denver, Colo.: American Water Works Association, 2001.
James Symons presents facts about the water we drink in a format that is plain and simple. This easily read book discusses drinking water and related issues such as health, testing, conservation, and federal regulation.

Symons, James M., Lee C. Bradley, Jr., and Theodore C. Cleveland. *Drinking Water Dictionary.* Denver, Colo.: American Water Works Association, 2000.
An excellent resource useful for defining water terminology.

Texas Water Commission. *The Underground Subject: An Introduction to Groundwater Issues in Texas.* The Texas Water Commission.
Sources of groundwater and how it becomes contaminated with various chemicals and other pollutants are discussed.

Drinking Water Health Effects Task Force. *Health Effects of Drinking Water Treatment Technologies.* Washington, D.C.: Lewis Publishers, 1990.
The seven chapters comprising this book address both the regulatory community and the general public. It is written to be useful for the layperson and the technical reader. This book evaluates raw water quality and its treatment technologies and their related associated health risks.

The Energy Foundation. *Learning to be Water Wise, A Resource Action Program of the Nonprofit Energy Foundation*. Salt Lake City, Utah.
This book is an excellent resource for teachers and contains great activities for students. Interactive Website @ www.getwise.org

Student Resources

Pankratz, Tom M. *Wastewater Treatment, An Environmental Primer.* Houston, Tex.: Lone Oak Publishing, 1993.
This book is to help one understand the processes and equipment used in the treatment of municipal wastewater. It is an excellent resource on showing the average person what happens to the 50 to 100 gallons of wastewater that is generated daily by each individual after it is flushed down the drain. The diagrams are simple to follow and the materials are easily readable and interesting.

Senior, Dorothy A. G. and Phillip R. Ashurst. *Technology of Bottled Water.* Sheffield, England: Sheffield Academic Press, 1998.
This book is geared towards beverage and packaging technologists, microbiologists, analytical chemists and other health and safety personnel. This book contains "comprehensive" information concerning the safety and quality of bottled water.

Wiesenberger, Arthur Von. *Oasis. The Complete Guide to Bottled Water Throughout the World.* Santa Barbara, Calif.: Capra Press, 1978.
This book is a three-part volume dealing with the nature of water the body needs, the fluoride controversy, the importance of drinking hard water, health issues related to various minerals and new information on carcinogens in tap water. An encyclopedia of bottled waters from around the world and a comprehensive listing of water bottlers are discussed in detail.

Symons, James M. *Plain Talk about Drinking Water*. Denver, Colo.: American Water Works Association, 2001.
James Symons presents facts about the water we drink in a format that is plain and simple. This easily read book discusses drinking water and related issues such as health, testing, conservation, and federal regulation.

Symons, James M., Lee C. Bradley, Jr., and Theodore C. Cleveland. *Drinking Water Dictionary.* Denver, Colo.: American Water Works Association, 2000.
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Texas Water Commission. *The Underground Subject: An Introduction to Groundwater Issues in Texas.* The Texas Water Commission.
Sources of groundwater and how it becomes contaminated with various chemicals and other pollutants are discussed.

The Energy Foundation. *Learning to be Water Wise, A Resource Action Program of the Nonprofit Energy Foundation*. Salt Lake City, Utah.
This book is an excellent resource for teachers and contains great activities for students. Interactive Website @ www.getwise.org

Internet Resources

http://www.epa.gov/safewater/kids/exper.html
Water Sourcebook Series. Kids Stuff-Drinking Water.
Good for Experiment Simulations

http://www.capitol.state.tx.us/statutes/wa/html
Groundwater Management / Water Quality Control
Good for Policy and Management

http://www.mines.edu/outreach/cont-ed/esrc.shtml
Plastic Groundwater Model

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