Intro into Drinking Water Treatment

Subject Area(s) **Environmental Systems, Chemistry**

Associated Unit **Drinking Water Treatment Process**

Lesson Title **Introduction into Drinking Water Treatment**

Header

Image 1

Image file: water_droplet_Lesson1.jpg

ADA Description: A clean clear water droplet falls into a clear volume of water and makes a splash.

Caption: Water is essential to life but not all water starts out as clean, clear and safe to drink and not all water sources on Earth are practical for treatment.

Grade Level 10 (9-12)

Lesson # 1 of 3

Lesson Dependency

Lessons:

1. Drinking Water Treatment: Coagulation, Flocculation, and Sedimentation
2. Drinking Water Treatment: Filtration and Disinfection

Activities:

1. First Steps to Treating Surface Water
2. The Clean-Up Crew: Filtration and Disinfection

Time Required **35 minutes**

Summary

In this lesson students are introduced to the general concepts of drinking water treatment. The lesson begins with the foundation of understanding how water is distributed throughout the earth and from what sources we gather drinking water. The students learn about common drinking water contaminants, where they come from, and how they are measured. Lastly, students learn about the general types and classes of drinking water treatment.

Engineering Connection

The current technologies and methods used to provide clean drinking water is a testimony to many years of research and exploration by scientist and engineers. In this lesson the students learn to think like an environmental engineer, considering the pros and cons of water sources, and how to detect different types of contaminants. Additionally, engineering technologies that have been developed by engineers for the purpose of drinking water treatment are introduced and briefly discussed.

Engineering Category = 1

Choose the category that best describes this lesson's amount/depth of engineering content:
1. Relating science and/or math concept(s) to engineering
2. Engineering analysis or partial design
3. Engineering design process

Keywords
contamination, ground water, surface water, treatment, water

Educational Standards

National and State
Texas, science, 2009, Environmental Systems, 5 (B): identify source, use, quality, management, and conservation of water.

ITEEA Educational Standard(s)
ITEEA, Standard 5, Grades 9-12, G. Humans can devise technologies to conserve water, soil, and energy through such techniques as reusing, reducing, and recycling.

ITEEA, Standard 5, Grades 9-12, K. Humans devise technologies to reduce the negative consequences of other technologies.

ITEEA, Standard 15, Grades 9-12, M. Conservation is the process of controlling soil erosion, reducing sediment in waterways, conserving water, and improving water quality.

Pre-Requisite Knowledge
Students should have a basic understanding of biology and chemistry.

Learning Objectives
After this lesson, students should be able to:
- **Describe the ideal sources of drinking water in relation to the global water supply.**
- **Identify the four main groups of drinking water contaminates and describe where they come from.**
- **Identify the basic types of drinking water treatment techniques that are used for water coming from the ground, surface, or saline sources.**

Introduction / Motivation
"So who knows where the water comes from when they take a drink out of the water fountain or tap?" (possible student answers: ocean, treatment plant, lakes, rivers, ground). Today we will be introducing the topic of drinking water treatment and by the end of the lesson everyone should have a good understanding of where the water that you drink out of the tap comes from.

As we introduce drinking water treatment, it is first important to understand the bigger picture of what water we can access for the use of drinking water. While there are abundant amounts of water on the earth, about 97% of that water is in the oceans (draw a long rectangle on the board and hash what would be about 3% of the rectangle). It is possible to take ocean water and remove the salts to make it drinkable, but that process is very expensive and should not be the first choice if there are any other alternatives. With the 3% of water that is fresh, much of that is locked in the ice caps, glaciers, and snow and is therefore inaccessible for drinking water. All of this to say, that while there is plenty of water on the earth, only about 0.8% of it can be accessed and treated for drinking (cross hatch what would be about 0.8% of the rectangle within the original 3%). In order to treat water, we must first access water to drink, which is not as easy as some might think.

The two main sources that compose the 0.8% of water that can be used for drinking are groundwater and surface water. We will briefly discuss these two source options as we begin to understand the fundamentals of drinking water treatment.

Lesson Background & Concepts for Teachers

Ground water

A little less of than 1% of the earth's water is groundwater which does not seem significant, however, groundwater makes up 30% of all of earth's fresh water. Because of its abundance ground water is a significant source of drinking water and has been used throughout history as a reliable source of water especially in more arid climates. Groundwater, simply defined, is the water contained in the pore space of subsurface soils and rock formations. Regions of subsurface soils or rocks that are saturated with water are called aquifers. A simple illustration of an aquifer is a sponge. Just like water is trapped in the pore spaces of a sponge and can be drawn out with a straw, so too is groundwater stored in the pore spaces of rocks and can be drawn out by a well.

Understanding the topic of groundwater is a course of its own, so it is important to introduce ground water with the connection of its implications to drinking water treatment. With this said, a benefit of groundwater to drinking water treatment is that it is usually free of microorganisms, and therefore requires relatively simple treatment techniques. Most of the sources of contaminants are on the earth's surface, and as contaminated water infiltrated into the ground, the soil acts as a natural filter and remove most all microorganisms. The main contaminations that can occur in groundwater are from chemicals and metals that are dissolved in the water and are not filtered by the soil. A drawback to ground water is that it is only accessed by digging a well which requires machinery and expertise. To emphasize this dilemma, an example of a hiker walking through the forest and needing a drink of water can be used. Although there is plenty of clean water underneath his feet, he or she cannot freely access that water to satisfy his or her thirst.

Water that is pumped out of the ground for the purpose of human consumption is treated primarily to adjust the ion concentrations in the water. Because groundwater is stored in the ground, it acquires a high concentration of mineral and ions, such as calcium, that are not necessarily harmful to humans but can damage the distribution system that delivers water to the people. The process of treating ground water is called water softening in which the multivalent cations are reduced. A few techniques to soften groundwater are with the addition of lime, to precipitate out the calcium, or with ion exchange resins. In addition to softening, disinfectants are applied to eliminate the potential of microbial contamination. In a few rare cases, groundwater should be additionally treated to remove heavy metals such as arsenic.

Surface Water

Around 0.008% of all of earth's water is stored on the surface as lakes, rivers, swamps, etc. Despite this small fraction, fresh surface water is an ideal choice for drinking water because it is easy to access. The example of the hiker can be used again to demonstrate that if someone in the woods was thirsty and came along a stream, they could easily satisfy their thirst with a drink out of the stream. However, the drawbacks to surface water are that it can often cause sickness if not treated properly. Additionally, drinking water is subject to fluctuations in the climate, and in years of little precipitation surface water can be limited or completely eliminated as a source.

Water that is taken from lakes and rivers has to be thoroughly treated in order to eliminate both the harmful contaminates and the components that make the water unpleasant to drink. The main method of treating surface water, the ‘conventional method’, is through use of coagulation, flocculation, sedimentation, filtration, and disinfection. These treatment processes are commonly used throughout the world and are detailed in the following two lessons. Additional treatment techniques exist to treat surface water, such as membrane filtration and reverse osmosis.

Saline Water

In some locations, especially in arid coastal regions, there is little other choice than to treat saline water for drinking. Although not ideal because of the high energy and cost, there are treatment processes to get the job done. The more salt ions in the water the more difficult it is the make the water potable. Therefore, so locations near the coast are able to access groundwater that is less saline than the ocean water nearby. The methods commonly used to desalinating water are reverse osmosis, ion exchange, and distillation.

Water Quality

In addition to understanding where the water comes from, it is important to know what constitutes ‘clean’ or ‘dirty’ water. There are three main categories of contaminants that can be found in sources waters that can cause human illnesses: microorganisms, chemicals and parasites.

Pathogenic bacteria, protozoa, and viruses are the most common categories of microorganisms that are found in source water. Examples of some of these pathogenic organisms are *Giardia*, *Cryptosporidium*, *E. coli*, and many other. The primary source of these pathogenic microorganisms is from fecal contamination from warm blooded animals into a drinking water source. Some pathogenic microorganism can exist in natural soil environments, however, these do not cause as high of a threat as the species that are introduced through fecal contamination. Due to the numerous species of pathogenic microorganisms, it is difficult if not impossible to measure and detect the presence of all those pathogens. To simplify the process of detecting pathogenic microorganism, two tests are primarily used: turbidity and indicator organism. Turbidity is the measure of light scattering particle suspended in the water, simply put it is the ‘cloudiness’ or ‘murkiness’ of the water. While the amount of particles in the water is not always an indication that there are pathogenic microorganisms, it can be a good indication that there is a high potential of contamination. Inversely, low turbidity does not assure the lack or pathogenic organisms in the water. Despite its inconclusiveness, turbidity remains a rough but useful gauge of the waters overall quality in relation to microorganisms. Additionally, indicator organisms, such as *E. coli*, are species selected because they are easy to detect and accurately represent a larger group of pathogenic organisms. For example, if *E. coli* is detected in source water, it indicates that there has most likely been a fecal contamination and there could potentially be other pathogenic species of microorganisms. The detection and quantification of pathogenic microorganisms is a difficult task and is a continuing field of research.

Chemical contamination of source water is a growing concern due to the increasing use of chemical products over the past decade. Chemical contaminants can be sorted into two main classes: inorganic, chemicals not containing carbon atoms, and organic, chemicals that do contain carbon atoms. Inorganic chemicals that are of concern are most often heavy metals such as arsenic or mercury. These chemicals can come from natural sources, such as water being pumped from an arsenic rich soil, or they can come from human inputs into the environment. Alternatively, organic chemicals include a wide range of chemicals, including: Benzene, Dioxin, Polychlorinated biphenyls and Vinyl chlorides to name a few. A large majority of the contamination due to organic chemicals comes from human inputs into the environment, for example, leaking underground gas tanks, dry cleaner facilities, chemical refineries, and general spills and dumping. In addition to inorganic an organic chemicals, there are also a class of chemicals called radionuclides, which emit harmful radiation. Unstable isotopes such as uranium 235 and plutonium can come from both the natural environment and nuclear pollution. Radionuclides are usually isolated in specific sites and generally not a significant concern. Harmful chemicals as a whole are especially tricky contaminates to deal with because, opposite to microorganism, chemical contamination will not cause acute sickness, but rather chronic sicknesses such as cancer and neurological diseases, that do not surface until many years later. With this said, it is important that the drinking water treatment facilities stay vigilant in looking for these contaminates because years of contamination can go by without any reported sickness.

Lastly, parasites are a potential concern that can cause problems to a potential drinking water source. Parasites are not often discussed in developed countries because they have been largely eliminated and do not pose a constant threat, however, in many developing countries throughout the world, the presence of parasites is a real and continuing threat. Parasites often exist in natural cycles in the environment, but their presence can be encouraged by human factors, such as water that is polluted with eggs. One common example of a parasite are tapeworms, which attached to the intestinal wall and live inside the host.

There are many other factors that influence water quality, such as pH, alkalinity, dissolved oxygen, etc, but when considering the source water for drinking water treatment it is most important to focus of the factors of water quality that most greatly affect human health. The Environmental Protection Agency (EPA) regulates drinking water facilities by setting limits at which drinking water providers cannot exceed. A full list of the primary drinking standards can be found at < *www.nmenv.state.nm.us/dwb/contaminants/documents/MCLs.pdf*>, which can give a good idea of what the EPA prioritizes in terms of contaminates that can threaten human health.

Image Insert Image # or Figure # here [use Figure # if referenced in text]

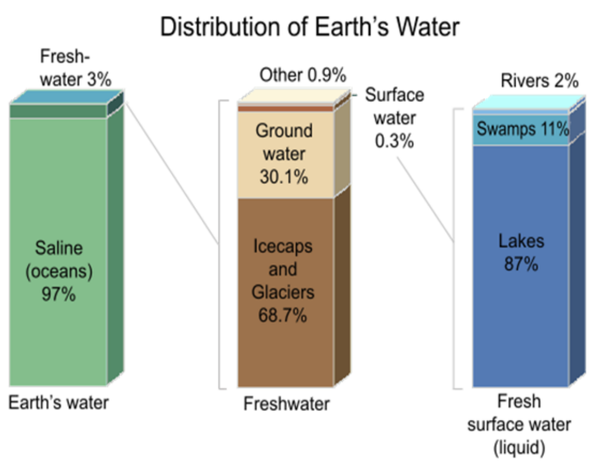

Figure 1

Image file: distribution_of_earths_water_Lesson1.PNG

ADA Description: The image shows three bar graphs with the left most bar representing the distribution of all of Earth's water between saline and fresh, the middle bar representing the distribution of all of Earth's fresh water, and the right most bar representing the distribution of all of Earth's fresh surface water.

Source/Rights: Copyright © https://en.wikipedia.org/wiki/File:Earth%27s_water_distribution.svg

Caption: Figure 1. The distribution of Earth's water.

Vocabulary / Definitions

Word	Definition
groundwater	Water that infiltrates through the ground and is stored in the pore spaces of subsurface soils and rocks.
surface water	Water that is stored on the surface of the earth in lakes, rivers, swamps, etc.

Associated Activities

Lesson Closure

Now that we have learned about where the water comes from and what are the potential contaminants in the water might be, we will begin our focus on how to treat the water so that it is safe for us to drink. Over the next two lessons we will be discussing specific process of drinking water treatment that is widely used in the United States and all over the world to treat surface water. There are five main steps to the conventional method of treating surface water, and those step are: coagulation, flocculation, sedimentation, filtration and disinfection. I know those words seem confusing and honestly sound a little funny, but we will be looking at each step of the drinking water process in detail and seeing how it works first hand during the activities you will be participating in.

Assessment

Summative Assessment: Following the completion of the TeachEngineering Unit: Drinking Water Treatment Processes the students will be given the attached summative assessment, Drinking Water Treatment Quiz.

Lesson Extension Activities

Additional Multimedia Support

References

Attachments

Lesson1_guided_notes.docx

Other

Redirect URL

Contributors

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