Water Systems (Pearson 8 Ch. 10,11,12)

Chapter 10: Water on Earth

Chapter 10.1: Earth's supply of water

Understanding how and where water exists on Earth helps us to understand how water systems affect our lives and how our activities affect water systems.

Water exists in 3 states: liquid, solid, and gas. Water in constantly changing from one state to another. Water goes from liquid to gas by **evaporating** when heat is added, solid to liquid by **melting** when heat is added, liquid to solid by **freezing** when heat is removed, and gas to liquid by **condensing** when heat is removed.

- Which processes would happen in succession? Which are opposites?

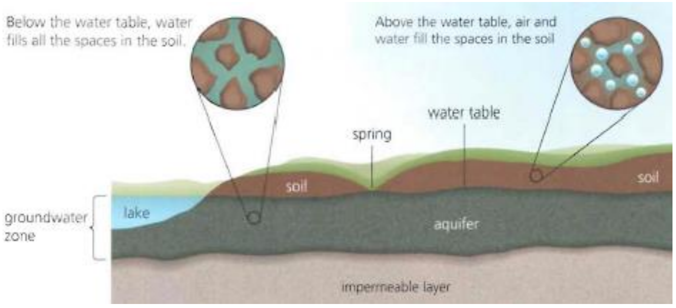
There are two kinds of water that we can find naturally on Earth: **fresh water** and **salt water**. Salt water has a dissolved salt concentration of 3.5%, while fresh water has a dissolved salt concentration of less than 1%. **Salinity** is the measure of how much salt is dissolved in water.

- Should you ever drink salt water? Why or why not?

Salt water makes up 97% of the water on Earth. Most of the fresh water on Earth occurs as ice, snow, and ground water.

About 70% of the Earth's surface is covered in water, most of which is salt water contained in the oceans. Fresh water exists on the Earth's surface, under the surface, and in the atmosphere. Most of Canada's fresh water is underground, rather than on the surface, and as much as 1/3 of the WORLD's fresh water is ground water.

As rainwater falls, it soaks into the soil and flows down between the soil particles. It continues draining downward through more soil and rocks until it reaches a layer that is difficult to permeate, or pass through. (What could this layer be?). This results in a **groundwater zone**, where water fills all the air spaces in the soil and in the cracks of the rock. Groundwater zones exist in all soils, but the depths differ from region to region (why?). The upper surface of the groundwater zone is the **water table**. The underground layers of water-bearing permeable rock or other material above the impermeable layer is called an **aquifer**. Drilling **wells,** or long, hollow shafts, into aquifers is a common way to access their water.



Much of the fresh water systems are in **watersheds**, which are an area of land in which ALL the water present eventually drains into one large main body of water. Activities that affect water in one part of the watershed will have an effect downstream in the watershed. Many small watersheds connect to bigger watersheds and finally empty into the ocean. North America has 5 ocean watersheds. As water cannot flow uphill naturally, high points in the land create “divides” (like?), and create boundaries that direct where water flows.

- Which watershed do we belong to?

All of the solid water on Earth is fresh water, as salt water freezes at a lower temperature (1.8degC) and the salt does not freeze within the water, meaning that any frozen “salt” water is actually fresh water ice. Most of the ice on Earth can be found in two different forms:

- Mountain **Glaciers**: In many mountain regions, temperatures are below freezing and the snow that falls never melts. As the snow accumulates over centuries, the layers of snow compact and become heavier and thicker, with most of the air spaces squeezed out. As this happens, the compacted snow begins to change into a solid mass of ice, also known as a **glacier.** Glaciers are a mass of ice and overlying snow that move slowly down a mountain slope under the influence of gravity.
- **Ice sheets**: An ice sheet is a very large glacier that covers the land. Only two ice sheets exist on Earth: one in Greenland, and the other in Antartica. These are sometimes called the **polar icecaps**, as much of these ice sheets are at the poles of the Earth. When an ice sheet reaches the ocean, it will float and is then called an **ice shelf**. Large portions of an ice shelf that break off are called **icebergs**, and smaller portions called bergy-bits. As they

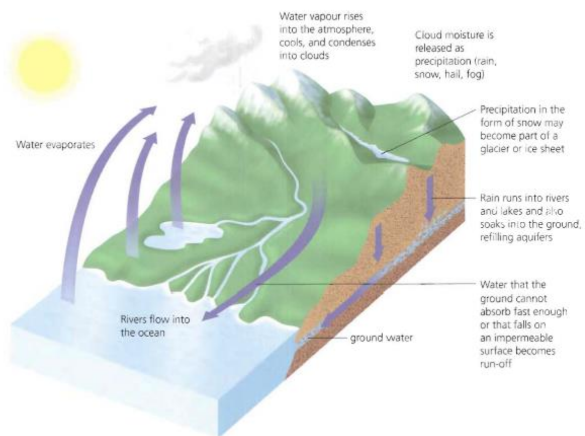
float, icebergs will melt, change shape, roll over, and eventually become part of the ocean water.

Gaseous water exists in the atmosphere (why?). Water vapour can evaporate from surface water (like?), and while we cannot see water vapour, we can feel it as humidity.

- Where do you experience more humid climates? Where do you experience more dry climates?

Warm air will hold more water vapour than cold air (why?), which is why it is often more humid in the summer rather than the winter. As water vapour is carried upwards in the atmosphere, it becomes colder and condenses into water droplets that form **clouds**. Plants and animals also contribute water vapour into the atmosphere, with animals exhaling water vapour with respiration and transpiration, or the process of water evaporation from plants.

Water is constantly changing states, and the non-stop circulation of water on Earth is called the **water cycle**.



Chapter 10.2: Water’s Influence on Weather and Climate

The atmosphere extends many km above the surface of the earth. Heat from the sun passes through the atmosphere (all of it?), and is absorbed by the Earth’s surface (all of it?). How much heat is absorbed depends on what is on the surface at any location.

Water has a higher **heat capacity** than land or air, which results in water heating up more slowly and staying warm for longer. Heat capacity refers to the ability of a material to absorb heat.

Large bodies of water then absorb and release a huge amount of heat over time into the atmosphere above them. Oceans and large lakes have a moderating effect on the air temperature of coastal areas, keeping these areas warmer in the winder and cooler in the summer compared to inland areas. (why?)

In particular, the Great Lakes are notable for strong moderating effects on the climate of bordering areas. The extensive water masses keep both winter and summer moderate and provide large amounts of moisture to the air. In the winter, this results in heavy snowfall. The Great Lakes are responsible for contributing to small pockets of **microclimates**, which are areas with a small, localized climate variation that differs from the larger climate area around it.

- What are some examples of microclimates, either natural or otherwise? (ex. Greenhouses)

Large bodies of water also affect global climate. In particular, the northern hemisphere is 61% water surface, while the southern hemisphere is 81% ocean. Temperatures in the north vary by 14.3degC, whereas they only vary by 7.3degC in the south.

The interaction of large water surfaces and the atmosphere above can produce severe storms. Hurricanes are a severe type of storm that start as a thunderstorm over warm ocean waters. The air begins to swirl rapidly, and once they reach speeds of 119 km/h, a hurricane is born. Hurricanes may then cross onto land, where they can wreak havoc. In less severe cases, large bodies of water can also create winter storms, such as the Great Lakes. The storms tend to form in the mid-west US and move up AND in Alberta and move down, and then pass over the Great Lakes and develop high winds and precipitation.

- What are some examples of severe storms?

Lab: D14

Chapter 10.3: The Effects of Ice on Water Systems

Some parts of this chapter in the text are out of date. The notes here reflect up-to date information, so when in doubt, trust my notes! Feel free to cross-check anything with me.

The global climate has undergone natural periods of cooling and warming since the Earth formed. (how old is the earth?) Some of these periods of heating or cooling have lasted 100,000s of years. When a period of global cooling occurs, Earth's temperature declines and ice begins to accumulate – causing glaciers and ice sheets to expand in size. These periods are called **glacial periods**. The last glacial period ended ~10,000 years ago, and affect North America, Europe, and northern Asia. Ice sheets covered almost all of Canada, and as the global climate began to warm again, the ice retreated. When a warming period occurs, Earth's glaciers and ice sheets begin to shrink and disappear. These periods are called **interglacial periods**. Earth is currently in an interglacial period.

When temperatures and precipitation amounts change significantly over time, glaciers and ice sheets are affected; either increasing or decreasing in size. In general, they increase in size with cold temperatures and shrink with warm temperatures (why?). With warm temperatures, precipitation will most likely fall as rain instead of snow. When glaciers and ice sheets begin getting smaller due to melting, they are said to be **receding** or **retreating**.

Glaciers often have short period of retreating and growing, often caused by normal seasonal variations in weather. However, when unusual weather lasts over several months or years, it will affect the size of glaciers. In recent decades, it has been confirmed that glaciers all over the world have been receding at a steady, unprecedented rate, which coincide with global trends such as warmer oceans and nighttime temperatures. Human activities that produce carbon dioxide and other gases into the atmosphere are a significant cause of this rise in temperatures and glacial melting. When the concentration of these gases builds up, heat that would normally be reflected back into space from Earth is blocked from doing so, and stays in the atmosphere and right above Earth's surface. This is called the **greenhouse effect**. (why?)

Changes in the size of glaciers and ice sheets influence local and global water systems. During glacial periods, most of the water on Earth is trapped in glaciers and ice sheets, and so less is available as liquid water and water vapour. For example, the sea levels on Earth were more than 100m lower than they are now during the last glacial period, when nearly 1/3 of the planet's surface was covered with glaciers. The opposite happens when glaciers and ice sheets shrink and release liquid water in particular back onto the Earth's surface. This results in the sea levels rising AND the salinity of the ocean decreasing (why?).

Assignment or project: D17

Chapter 11: Monitoring water systems

Chapter 11.1: Natural and Human Factors Affecting Our Water Supply

Demo: D20

We humans need fresh water as drinking water, however it's not always safe to drink (why?). One method for removing harmful bacteria from drinking water is adding **chlorine**, a chemical typically used to disinfect water. Too much chlorine can be an issue in drinking water by causing chlorine poisoning, and not enough may mean that harmful and potentially fatal bacteria stay in the drinking water.

Natural occurrences such as flooding, droughts, and earthquakes can cause changes in the height of the water table, which in turn can affect the water supply and quality (how?). A watershed receives a finite amount of water each year, and it is the watershed that **recharges**, or refills with water, above ground reservoirs, such as rivers and lakes, and underground reservoirs, such as aquifers. More water leaves a watershed than enters, a water shortage will result and the usual water levels in lakes and rivers will drop as well as the water table. Conversely, if more water fills a watershed than can leave it, water will fill up the soil and aquifers, causing the water table to rise along with the water level of lakes and rivers.

- What would happen in low-lying areas if more water enters a watershed than can leave it?
- What would happen in high-lying areas if less water enters a watershed than can leave it?

Flooding can be caused by heavy rainfall, ice-jams, sudden spring thaws, and storms – including flash floods, which come without warning, and are caused by heavy, concentrated rainfall (ex. Thunderstorms). The rain flows rapidly across bare ground and paved surfaces, causing the water level in storm drains to rise, overflow, and back up, resulting in surface flooding.

Drought are long periods of little or no precipitation, which results in the local watershed gradually losing water. This leads to surface water levels dropping, and the water table dropping.

Earthquakes can affect the water table directly, even in areas that are not earthquake prone. The water table can shift as much as 1m after a quake, affecting the ability to draw water from wells and the quality of the ground water (why?).

How much water we take from our environment, how we alter it, and how we dispose of it affects the supply and quality of water in the environment. For example, the overuse of wells can alter groundwater supplies permanently. More than 25% of Canadians rely on ground water from aquifers and wells for their drinking water and other water needs. Unusually dry seasons tend to cause less water collecting in aquifers, and thus well users will need to be cautious on how much water they pull from the ground.

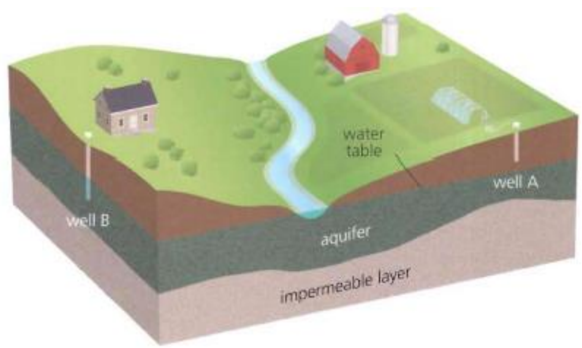


Figure 11.6 This cross-section of ground shows two wells. Well A has run dry because the depth of the water table has fallen below it. Well B is continuing to produce water because the well still reaches the aquifer.

- What activities would require large amounts of water, especially in rural areas?

Farming and industry need immense amounts of water to operate. This is one reason why industrial plants, power stations, etc. are located besides a river or lake. After water is used, it is **discharged**, or released, back into the environment.

- Is the water taken directly from use and discharged straight away? What are some potential complications with this?

The waste water is typically discharged into a wastewater drainage system, ground filtration system, or directly into a water body or the atmosphere. Typically, **wastewater**, or the water discharged from industry, is not as clean as it was originally and there is usually less wastewater than what was removed.

- What are some examples in Canada of industries that need a lot of water?
    - Oil sands, hydro&non-hydro electric, pulp&paper, mining, farming/crop irrigation

A surprising industry that removes large quantities of water from Canadian water supplies is the bottled water industry, of which the majority are in Ontario, Quebec, and BC (which watersheds are affected?). Millions of litres of water are removed from a variety of sources, and essentially is pumping water out of one location and shipping it to another. This ultimately means water is not returned to the original watershed.

Class discussion: D24

Chapter 11.2: Obtaining Water Quality

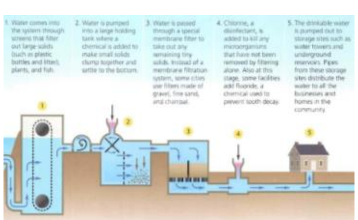
Water quality can be affected by **physical, biological, and/or chemical contaminants**. Contaminants are contents that are harmful to humans, other animals, and the environment. Biological contaminants can be visible (like zebra mussels) and microscopic organisms (bacteria and viruses). Chemical contaminants are dissolved substances that come from natural processes (such as limestone) or human activities (such as road salt). Physical contaminants are all materials that do not dissolve in water (such as rocks, animal waste, and plant debris).

This is why it is important to test and treat water to ensure its safety for use, and not to take treated water for granted. Many developing countries cannot afford to build facilities to treat or test drinking water, which leads to people in these countries washing and drinking water directly from the same sources that are also used to discard human and animal waste. Illnesses caused by contaminated water kill thousands of people every year.

D25 (1. Lake Ontario, 2. YES, but in low levels. There are 4 water treatment plants for the city alone, 3. 5 in the city, 1 outside the city, there are also ground level and underground reservoirs and temporary storage https://en.m.wikipedia.org/wiki/Toronto_Water#Storage)

Contaminants don't have to come from nearby to affect your local water sources. Any contamination that goes into a watershed affects ALL parts of the watershed.

We obtain the water we need from underground and aboveground sources, such as wells. Water that is removed from water systems must be treated and tested before it is safe to drink. Groundwater sources are typically filtered to remove contaminants. Water from above ground water sources often needs multiple treating options to remove all harmful contaminants (why?), and one common method to remove at least biological contaminants is boiling (why?). Most above ground water requires processing in a water treatment plant.



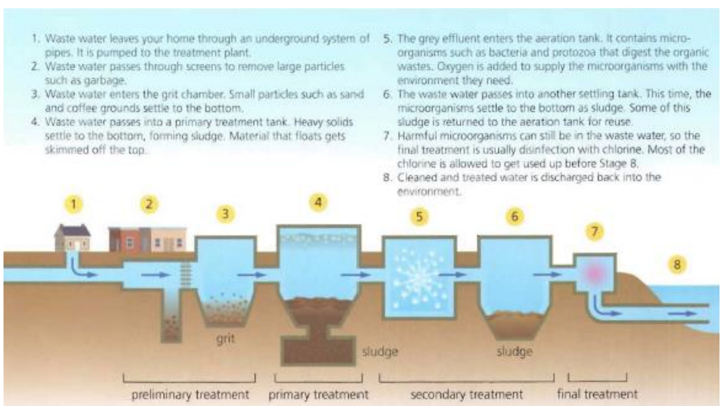
Water treatment plants are very sophisticated facilities with computerized systems of checks, rechecks, and alarms to ensure the treatment process is successful (what would happen if any of the steps DID fail?) Samples are often tested to ensure water quality.

Water samples are tested by scientists who have specialized in water quality and water contaminants. Sometimes these samples need to be sent to larger labs, and in large communities the samples can be tested in the water treatment plant. Wastewater and processed water are also routinely tested before being released back into the environment, and any issues found are addressed immediately and very seriously. Biological, chemical, and radioactive contaminants are what are usually tested for, and any contamination level above acceptable standards is deemed unsafe for use and must not be consumed.

Chapter 11.3: Managing Our Water Systems

How we dispose of processed and wastewater affects the quality of our water systems. (why?) Municipalities often manage the removal of wastewater, with sink drains, toilets, etc. connecting to a series of pipes that joins a system of underground pipes connected to pumping stations that send wastewater to a treatment plant. Waste water is then treated to remove chemincal and biological contaminants and then discharged to a nearby surface water source.

D29 (https://www.toronto.ca/services-payments/water-environment/managing-sewage-in-toronto/wastewater-treatment-plants-and-reports/, there are 4 wastewater treatement plants in Toronto, but it's not perfect! http://www.waterkeeper.ca/toronto-sewage)



Rural homes will use **septic systems** to dispose of wastewater. Wastewater from the home flows down through pipes in the home to a **septic tank**, which is typically underground. Bacteria in the tank begin to break down organic material, while solids sink to the bottom of the tank and liquids lighter than water (ex. Grease) rise to the top. The water layer in between then flows through underground, perforated pipes and into the soil. Bacteria continue to break down any remaining organic waste, and eventually the water returns to the groundwater supply.

Wetlands can also be used to filter a purify water. A wetland, such as a marsh or swamp, is land that is saturated with water for long periods of time. The water-loving plants that grow in wetlands can be used to treat wastewater by recycling nutrients. Smaller communities and businesses use artificially constructed wetlands to treat wastewater.

Protecting our water systems is important to maintaining safe drinking water sources, as typically treated wastewater is released back into drinking water sources. It is better for us, and the animals, plants, and environment we share our planet with to protect our water and prevent unnecessary treatments. All levels of government help to manage Canada's water systems, and local communities will have bylaws that manage the local water supply (like?).

PG 23, Figure 11.20

Lab: D32

Chapter 12: Stewardship of our water systems

Chapter 12.1: Stewardship through Water Conservation

As we have learned, our water supply is precious and finite. We can take action to protect our water systems by practising **environmental stewardship**, which means to take action to manage and maintain the environment to protect its well-being for current and future generations. This includes keeping our water usage **sustainable**, or to exist or be used at the same level for a long period of time without being damaged, harmed, or reduced for future use.

Canadian are large consumers of water compared to people in other countries on average. We consume about 335L per day EACH of water. The only higher consumers of water are Americans. Part of our high consumption is that we don't pay very much for water, compared to the cost for treating it.

People in rural communities tend to pay more attention to water conservation than people in municipalities (why?), but water conservation is beneficial for everyone for three main reasons:

1. Ensuring water supply
2. Putting less demand on water distribution and collection systems
3. Saving money

Actions taken today to conserve water will protect our future supply. Ways to reduce water consumption include adopting water-efficient machines and devices (like?), paying for water through a metered system, and taking direction from government bylaws and mandates. With regards to paying for water through a metered system, it was found that Canadian homes used 1/3 less water per day when their water was metered as opposed to being charged a flat rate.

Individual actions add up, so what you do matters.

Assignment/project: (~D37,D39) It was recently declared that the Ontario First Nation of Attawapiskat was no longer in a state of emergency regarding their lack of access to drinking water, but their plight of having access to safe drinking water has been an ongoing struggle for over a century (https://www.cbc.ca/news/indigenous/attawapiskat-water-hope-1.5224371,) and was reported by local politicians that adults were rationed 1.5L of bottled water per day and infants were rationed 1L of bottled water per day over the summer of 2019. This includes drinking water.

- How much water do YOU use in a day? Keep a "water journal" of the water that you use in a typical 24 hour period, including drinking water, water for cooking and cleaning, water for hygiene (ex. brushing your teeth, taking a shower, laundry, toilet), water for your plants or pets, and any other sources that you use in a typical day.
- Keep track of your water usage for 2 days in a row. Tally the water used in each day, and divide by 2 to find the average. You should try to be as accurate as possible, but it's OK to estimate!
- How does your average daily water consumption compare with the national average?
- How would you need to change your daily activities and behaviours to only use 1L of water a day? How do you think your life would be affected if you only had 1L of water to use per day for a long period of time, like a month? Outline at least 1 day of how you would use your 1L of water.
- How can you reduce the amount of water you currently use, WITHOUT impacting your quality of life? List at least 3 actionable items.

Useful measurements:

- Showers use 8L of water per minute on average. Ask your guardians about your shower setting, as you may have an efficient or economic shower head.
- Baths use an average of 136L of water.
- Garden hoses use 26.5L of water per minute on average.
- Faucets use 8L of water per minute on average.
- American style toilets use 6L of water per flush

Chapter 12.2: Issues Relating to Water Sustainability

People hold very differing opinions about how human activities affect water systems. Remember that opinions DO NOT replace facts and empirical evidence, but that there are multiple viewpoints and facets to every issue that need to be weighted and considered.

If facts about an issue are presented in a way that only shows one side of an issue, they may be presented with a **bias**, or an obvious opinion about an issue. If facts about an issue are presented from multiple viewpoints in a fair and unbiased way, they are being presented as **impartial,** or "not taking sides". It is important to approach issues at first in an impartial manner, so that your opinion can be formed with critical thinking.

Media such as newpapers, TV, radio, and the internet often present information about water issues from a biased viewpoint (why?).

Thinking critically about water issues is necessary if we are to make good decisions about managing our water systems. Look at the credible information available and decide for yourself!

What are some examples of multi-sided water issues?

Chapter 12.3: Water Sustainability through Science and Technology

Using water systems in a sustainable way will enable us to protect our natural ecosystems and protect the quality and supply of water for future generations.

Science and technology offer solutions to many water-related problems, but the impact of any innovation on local and global water systems must always be assessed.

One technique is **bioremediation**, which is the use of living organisms to clean up contamination in land and water, often specifically using microorganisms such as bacteria. A subset of bioremediation is **phytoremediation**, which is using plants as environmental clean-up remedies. These techniques can take a long time to complete (why?).

Another technique is **desalination**, or removing salt from water. This is specifically used for turning salt water into fresh water, and is used all over the world and on ocean-going ships. Desalination discharges very highly concentrated salty water which can be toxic even to saltwater organisms, and cannot be released directly back into the ocean.

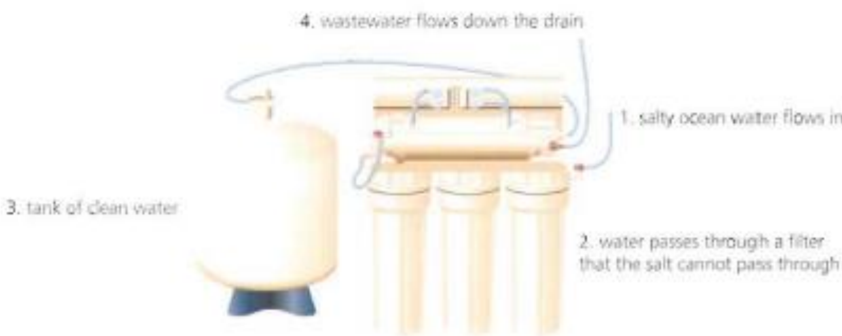


Figure 12.19 Reverse osmosis. In this set-up, salt water is pushed through a membrane or filter that the salt cannot get through. This is one way to desalinate water.

Unit project/excursion:

D27 - Test the quality and properties of water from several different sources. Explain why you think the water samples have the properties they do, where the water came from, where it's going, and what water shed(s) it belongs to.

Test for:

- Salinity
- Acidity (pH)
- Chlorine

Describe your water:

- Colour
- Smell
- Fresh or salt
- Visible contaminants

Use at LEAST the following 3 samples:

- Water from NL
- Water from Don River
- Tap water from school

Submit a report with your findings and explanations. 2-3 pages single spaced with 10-point font is expected, charts and diagrams are welcome.