Unit C – Environmental Chemistry

Focusing Questions:

1. What substances do we find in local and global environments?
2. What role do they play, and how do changes in their concentration and distribution affect living things?

Key concepts:

- chemicals essential to life
- substrates and nutrients
- air and water quality
- organic and inorganic material
- acids and bases
- ingestion and absorption of materials
- concentration and dispersal
- evidence of toxicity
- stability and biodegradability
- hazards, probabilities and risk assessment
- uncertainties in environmental monitoring and in assessing toxicity and risk

Learning outcomes:

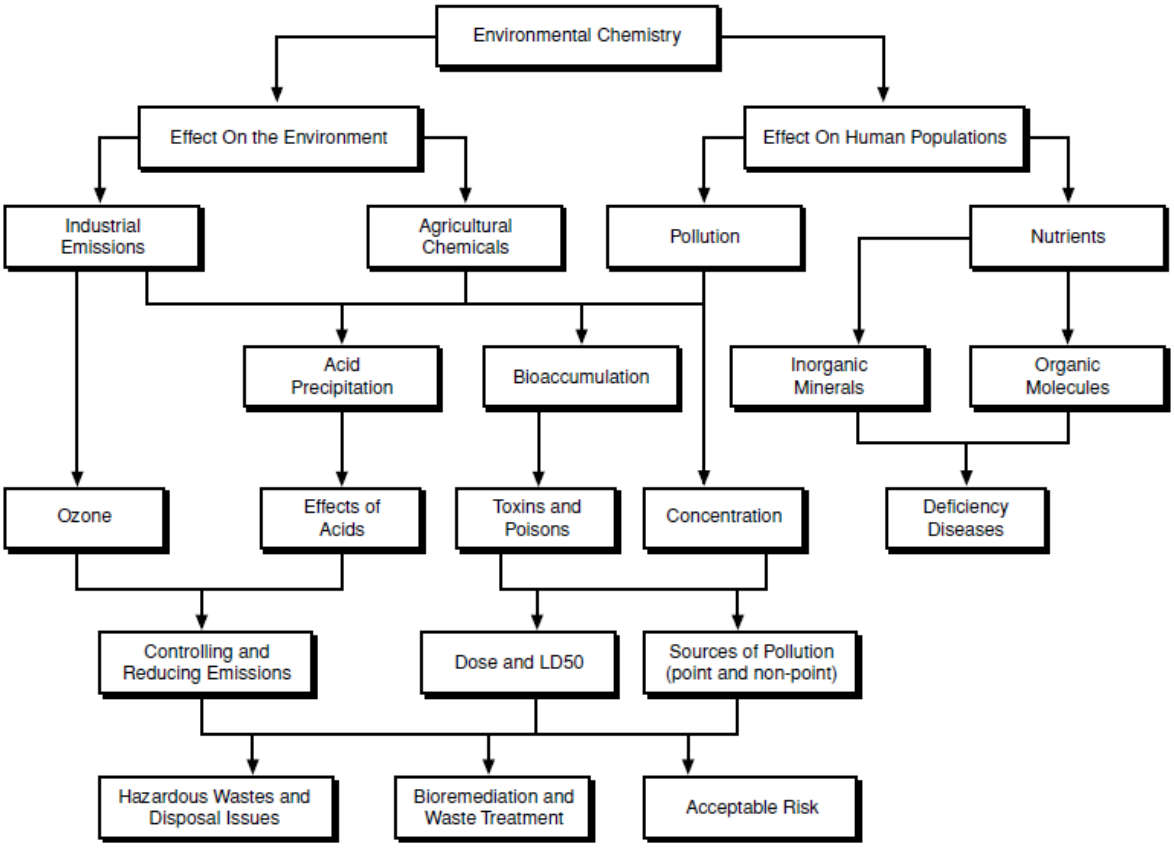
1. Describe the process by which chemicals are introduced into the environment.
2. Identify acids, bases and neutral substances based on measurement of their pH.
3. Describe the effect of acids and bases.
4. Identify common organic and inorganic substances that are essential to living things.
5. Describe organic matter synthesized by organisms.
6. Describe the uptake of materials by living things.
7. Identify substrates and nutrient sources for living things in a variety of environments.
8. Identify questions about the safe release of substances into the environment.
9. Describe and illustrate the use of biological monitoring as a method of determining environmental quality.
10. Identify chemical factors in the environment that might affect the health and distribution of living things.
11. Apply and interpret measures of chemical concentration in parts per million, billion, or trillion.
12. Describe the transport of materials through air, soil, and water.
13. Identify factors that may accelerate or retard the distribution of chemicals.
14. Describe how the concentration of substances can be changed in the environment.

15. Describe ways that biodegradation occurs and interpret information about the biodegradability of materials.

16. Demonstrate how hazardous chemicals can affect the local and global environments.

17. Identify potential risks resulting from consumer practices.

18. Evaluate information and evidence related to an environmental issue.



Topic 1 – A Hair Raising Dilemma

1. _____ is the process that breaks down the chemicals in food into **organic** and **inorganic** _____.

2. **Organic compounds**: The element _____ must be present for a molecule to be considered organic. Identify the role and *two* dietary sources of the following organic substances that are synthesized by plants and animals

Molecule	Role	Dietary sources
Carbohydrates		
Lipids		
Proteins		

3. **Inorganic molecules**: The mineral requirements of your body are classified as _____ (100 mg per day or more) or _____ _____ (less than 100 mg per day) depending on the amount needed. Receiving too much or too little can be harmful! Describe the function of each of the following minerals in our bodies:

   Nitrogen:

   Calcium:

   Phosphorous:

   Iron:

   Salt (NaCl):

4. What is the Canada Food Guide used for?

5. Most of the elements we need can be found in the soil but we can't eat soil (you're not supposed to!). So how do we get them out of the soil?

6. Which feature of plants makes them suited for extracting and concentrating minerals from the soil? Explain.

7. A bag of commercial fertilizer is labeled 10-15-20.

   a. What is fertilizer?

   b. What do these numbers mean?

   c. What do plants use each specific element for?

8. Nitrogen composes approximately 78 – 79% of the air we breathe. We need nitrogen to build proteins and DNA but we can't get it out of the air. So how do we get the nitrogen we breathe? Have Ferrige explain the nitrogen cycle.

9. Fertilizers have helped to double food production since 1950. Explain two problems associated with fertilizer use.

Topic 2 – A Growing Concern

1. In order to increase food production, many farmers spray their crops with _____ to kill _____. Differentiate between herbicides, insecticides and fungicides. What do we spray to kill rodents?

2. **DDT** (dichlorodiphenyltrichloroethane) was originally invented to kill _____ that spread the disease _____. In the 1950s, DDT was used to kill _____ that spread the disease _____.

3. Since the mid-1980s, DDT has been banned in Canada because of its affects on the ecosystem. Explain the term **biomagnification** (**biological magnification**, **bioaccumulation**, **biological amplification** etc.):

4. Read pages 189 – 190 so that you can answer questions 1 – 9 (page 191) in complete sentences in the space below:

    1.

    2.

    3.

4.

5.

6.

7.

8.

9.

5. Although DDT is potentially hazardous, there are people who take issue with its ban. Provide three of these issues.

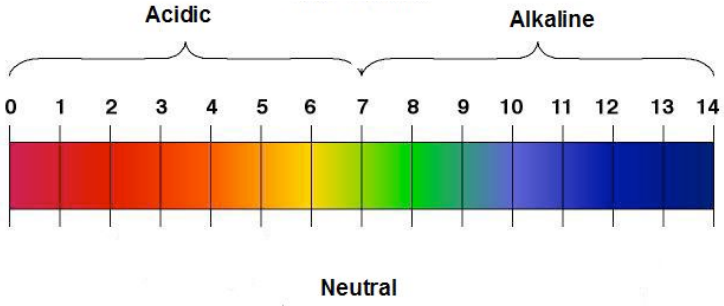
   -
   -
   -

6. What does the graph (Figure 3.6) on page 192 tell you about the attempts to develop new pesticides?

7. Define organic farming in your own words. Differentiate between organic and synthetic pesticides.

Topic 3 - How Do You Spell Relief?

1. Matter can be classified as **acidic**, **basic**, or **neutral** depending on its position on the _____ **scale** which ranges from number _____ to _____. Neutral substances have a scale value of _____.



2. According to this logarithmic scale, the numbers differ by factors of 10. Therefore a pH of 3 is _____ times more acidic than a pH of 4 and _____ times more acidic than a pH of 5.

3. **Acids** are substances that form _____ solutions when dissolved in water. Acids have a pH _____ than 7 and taste _____. We use acids for:

4. **Bases** are substances that form _____ or **alkaline** solutions when dissolved in water. Bases have a pH _____ than 7 and taste _____. We use bases for:

5. An easy way to determine if a substance is an acid or base is to use a **pH meter** or **indicators** such as **pH paper** (_____ **indicator**) and **litmus paper**. Explain how indicators such as pH paper work.

6. Use safety glasses when determining the colour of the following indicators in acidic and basic solutions:

Indicator	**Acidic colour**	**Basic colour**
Blue litmus		
Red litmus		
Bromothymol Blue		
Phenolphthalein		

7. Rain is naturally acidic however rain that has a pH value of less than 5.6 is considered **acid rain**. Explain the term **acid precipitation**.

8. When carbon, nitrogen, and sulfur _____ react with water, they are the major sources of acid precipitation. The addition of an acid to a lake will _____ the pH of the water.

9. Using pages 204 and 205 identify as many affects as possible of acid precipitation on the environment.

10. Airborne emissions can **disperse** (travel/spread) *long* distances therefore there is a need for countries to establish _____ _____.

11. Complete question 2a on page 206 in a complete sentence.

12. Complete question 2b on page 206 in a complete sentence.

13. Lakes in Western Canada are less sensitive to changes in pH because our rock bed is composed of _____ _____, which _____ the acids entering the lake.

14. Repeatedly adding calcium carbonate to acidified lakes will _____ or _____ their pH. This process is commonly referred to as _____.

15. Combining an acid and base together to produce a salt and water is called an (_____-_____) _____ reaction.

    Equation:

    Example:

16. The most practical way to deal with acid precipitation is to reduce the amount of harmful substances released into the environment. A device that helps remove polluting oxides from automobile exhausts is the _____ _____. They function for many years because _____ are not used up in the oxidation reaction.

17. Explain how scrubbers help to reduce the level of oxides. (p. 210)

18. Why do the pH values of Albertan lakes and rivers become more acidic in the springtime?

Topics 1–3 Review

Define:

1. nutrient _____

2. biological magnification _____

3. pesticide _____

4. indicator _____

5. leaching _____

Matching: Match each description in column A with the correct term in column B.

	A	B
6.	A mineral need in amounts greater than 100 mg per day.	litmus
7.	The process in which chemicals collect in the tissues of an organism.	scrubber
8.	A mixture of plant compounds extracted from certain lichens.	toxins
9.	Chemicals that cause serious illness or death depending on the dose amount.	macromineral
10.	A device that removes gases from industrial exhausts.	bioaccumulation

Short Answers

11. Why is a balanced diet important?

12. What important role do plants serve in providing us with the materials essential to continued health?

13. What characteristics would be important for a safe and effective pesticide?

14. What is the difference between a toxin and a poison?

15. List two characteristic differences between an acidic substance and a basic substance.

16. Describe the process by which acid precipitation occurs.

Topic 4 – How Much is Too Much?

1. Too much of something natural (heat, noise, carbon dioxide etc.) and the presence of something unnatural are both examples of pollution.

   Pollutant:

   Pollution:

2. There are many ways to indicate how much of something is present. Concentration can be expressed as percent by mass, percent by volume, parts per hundred (%), parts per million (ppm), parts per billion (ppb), or parts per trillion (ppt).

   Examples:

   a) A block of cheese states that it is 22% milk fat. How many grams of milk fat would there be in a 3 kg block of cheese?

   b) A 200 g serving of yogurt has 12 mg of cholesterol. Calculate the ppm of cholesterol.

   c) A 220 g of chips has 5 g of salt in it. Calculate the ppm of salt.

   d) 15 mg per 200 g is equivalent to how many ppm?

   e) A dissolved oxygen concentration of 6 ppm indicates that 6 mL of oxygen is dissolved in

Solve the following:

a) The label on a block of cheese indicates that it is 17% milk fat. If the block of cheese has a mass of 2 kg, how many grams of milk fat are present in the 2 kg block?

b) Calculate the ppm of cholesterol if a 250 g serving of yogurt contains 15 mg of cholesterol.

c) There is 3.5 g of salt in a 180 g bag of chips. Calculate the ppm of salt.

d) A label indicates 29 mg of sodium per 25 g serving. Calculate the ppm of sodium.

e) A 600 ml bottle of water contains 2.9 mg of fluorine. If 1 mL is equal to 1 g of water, calculate the ppm of fluoride.

f) 20 mg per 250 mL = _____ ppm

g) 8 mL of oxygen dissolved in 1 000 000 ml of water would have a dissolved oxygen concentration of _____ ppm.

3. Define **toxicity**:

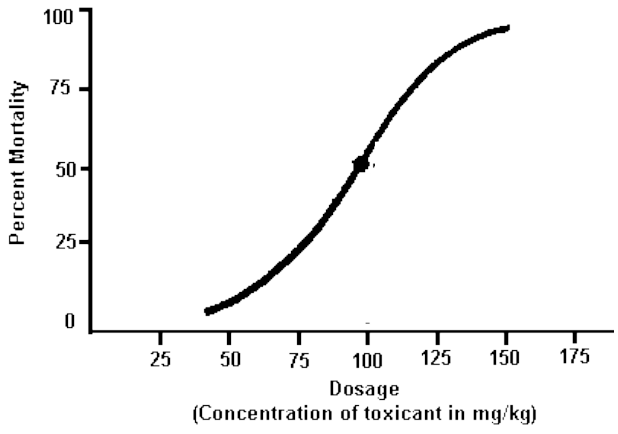
(T or F) Toxins can be absorbed through the skin

4. Differentiate between **acute** and **chronic toxicity**.

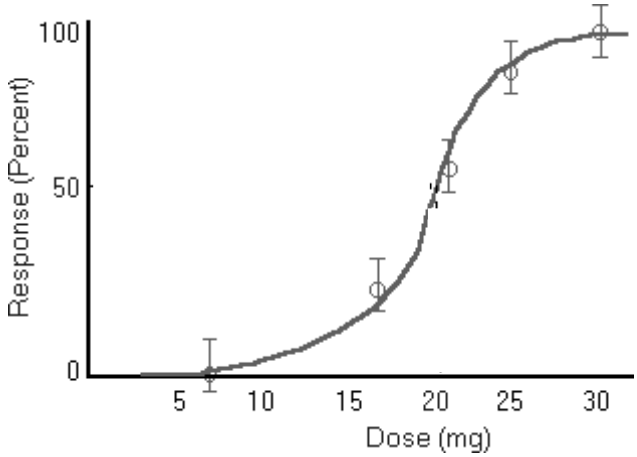
5. Because some pollutants take longer to act and some individuals are more resistant than others, a common measurement of toxicity is **Lethal Dose 50**. Define **LD50** and identify the most lethal bacterial poison.

6. Determine the LD50 of the following chemicals:

a.



b.



7. If the original population of cute little kittens was 500, how many would be left when the toxin released by Ferrige reached a level of LD50?

Visually Identifying a Pollutant

Goal	• Determine how many **dilutions** of a solution are required to produce another solution that appears to no longer contain the original solution.

In this investigation you will determine how many dilutions of a solution containing food colouring is needed to produce a solution that appears to have no remaining food colouring.

Problem: What is the effect of serial dilution on the intensity of colour in a solution?

Apparatus
10 mL graduated cylinder
eyedroppers or pipettes
grease marking pen
10 test tubes

Materials
food colouring
distilled water

Procedure

1. Label ten test tubes #1 to #10 using the grease pencil.
2. Carefully pour 9 mL of distilled water into each of the ten test tubes.
3. Place 1 mL of food coloring into the test tube #1 and swirl to mix the solution. The solution is now diluted to $1/10^{th}$ of the original concentration.
4. Rinse the eyedropper with distilled water.
5. Place 1 mL of the solution from test tube #1 into test tube #2 and swirl to mix the solution. The solution in now diluted to $1/100^{th}$ of the original concentration.
6. Repeat steps 4 and 5 for the rest of the tubes #3 to #10.
7. Construct a chart recording the tube number and calculate the concentration of food colouring within each tube in fraction form and ppm.

Analyze

1. In which test tube is the colour most intense? Why?

2. Are there any test tubes where the solution is colourless? Is there food colouring in these cells? How do you know?

3. In which test tube does the solution first appeared colourless? What is the concentration of the solution in this test tube?

Conclude and Apply

4. If the food colouring were poisonous, could you safely assume that a test tube containing a solution that appears colourless has none of the poison in it?

5. Would you rely on your eyesight to identify the presence of pollutants within a sample of water? How would you test for pollutants within a water supply?

Topic 5 - Getting Away From It All?

1. Pollutants are a concern if they become concentrated enough to harm living organisms. Differentiate between **non-persistent** and **persistent** pollutants *and* provide examples of each.

2. Identify two sources of excess phosphates and nitrates in our water systems. Explain how an excess of these nutrients can cause the eventual "death" of a lake. (page 225)

3. What can we do to reduce the amounts of phosphates and nitrates in our water systems?

4. An increase in the amount of pollutants such as phosphates and nitrates will cause the amount of dissolved oxygen to _____ and the amount of carbon dioxide to _____.

5. Explain the relationship between dissolved oxygen and water temperature. Draw and label a graph that represents this relationship.

6. Explain the relationship between dissolved oxygen and water turbulence.

7. Explain what **biological indicators** are and provide several examples.

8. Complete the following chart:

Water Quality	**Aquatic Worms**	**Stonefly and Mayfly Nymphs**	**Leeches**	**Dragonfly Nymph**	**Snail**
Good, Moderate or Poor					

Note: _____ would be most sensitive to pollution.

9. What is the relationship between the diversity of species and the concentration (ppm) of oxygen?

10. Differentiate between **point** and **non-point sources** and provide a few examples of each.

11. Complete #4 on page 235.

Topic 6 – There Is No Away in Throwing

1. Circle the correct term:

   Dispersion/Dilution is the scattering of chemicals in various directions in the atmosphere away from its source. Dispersion/Dilution reduces the concentration of a pollutant by mixing the substance with large quantities of air or water.

2. According to the map on p. 237, the problem of air pollution is a global issue. The biggest sources of airborne pollutants in the Southern Hemisphere are _____ sources (fires, volcanoes), but in the Northern Hemisphere, the biggest sources are _____ activities (oxides, soot, dust, heavy metals etc.).

3. Most **surface water pollution** is due to everyday activities such as _____ _____ or _____ _____.

4. Identify 4 pollutants that should be removed from **sewage** (waste water).

   -
   -
   -
   -

5. Identify and explain the 3 stages of a **waste water-treatment facility**.

   Primary:

   Secondary:

   Tertiary:

6. How do **aeration** and **disinfection tanks** aid in the sewage treatment process?

7. **Ground water:**

   The top of the groundwater zone is called the _____ **table**. Factors that affect the movement of groundwater include the number and connection or size of _____ (tiny spaces between soil grains)

   Aquifer:

8. In aquifers, water is naturally filtered of _____ _____, however, pollutants will be _____ in aquifers.

9. Identify possible pollutants of ground water and aquifers.

10. **Biodegradable** products are better than **non-biodegradable** products. Both defend and refute this statement.

11. What 3 things are needed to promote decomposition?

    -
    -
    -

    Note: some bacteria that are referred to as anaerobic perform optimally when the temperature is _____ and the oxygen levels are _____.

12. Define hazardous and provide 3 examples of household hazardous materials.

Hazardous:

-
-
-

13. **Solutions** are composed of solutes and solvents. Differentiate between **solutes** and **solvents**.

14. Identify *and* explain the **4 R's**.

-
-
-
-

15. Explain how a **sanitary landfill** works. (Don't forget to use the term **leachate** in your explanation)

16. Explain how a **secure landfill** differs from a sanitary. What do we use them for?

17. The use of living organisms such as water hyacinth to remove pollutants from water is an example of _____ (phytoremediation). Another example is the use of _____ which are container tanks that provide good conditions to support bacteria that break down toxic wastes.

Topic 4 – 6 Review

Definitions

1. pollutant _____

_____

2. toxicity _____

_____

3. point source _____

_____

4. biological indicator _____

_____

5. bioremediation _____

_____

Matching.

	A	B
6.	The ability to cause harm to a living organism after only one exposure.	pollution
7.	An alteration to the environment that results in harm to living things.	ground water
8.	Water that filters downward filling spaces in the soil and underlying rocks.	secure landfill
9.	The dose of a chemical that is lethal to half the population exposed to that chemical.	acute toxicity
10.	A solid waste site that is lined and capped with an impermeable barrier to prevent leakage or leaching.	LD50

Short Answers

11. What is the difference between acute and chronic toxicity?

12. Explain the concept of "acceptable risk" in your own words.

13. What characteristics make macroinvertebrates useful biological indicators?

14. List the steps involved in the process of sewage treatment? Describe the purpose of each step.

15. What makes a waste hazardous?

16. How is bioremediation used to reduce or eliminate contamination at a polluted site?

Unit 3 Review

Definitions:

1. trace elements _____

_____

2. biological magnification _____

_____

3. toxicity _____

_____

4. biodegradable _____

_____

5. hazardous _____

_____

True or False:

_____ 6. Plants are essential to human nutrition and health because they concentrate elements from soil and synthesize some essential organic molecules.

_____ 7. The tendency for DDT and other chlorinated hydrocarbon pesticides is to persist for long periods of time, thus making them safe and effective pesticides.

_____ 8. If blue litmus paper turns red in the testing of a substance, then that substance can be considered a base.

_____ 9. An acid and a base react to produce a mineral salt and water, which is best described as a combustion reaction.

_____ 10. The tendency of a toxic chemical to cause harm to living organisms depends on the dose of the toxin.

_____ 11. A point source for excess fertilizer and pesticide pollutants is the run-off from lawns, golf courses, and municipal parks following a rainstorm.

Multiple Choice:

12. The inorganic substances that are an essential part of a healthy diet are:
    (a) vitamins
    (b) minerals
    (c) carbohydrates
    (d) proteins

13. Most of the acid precipitation due to human activity is the result of :
    (a) acids in water and soils
    (b) chemical wastes in landfills
    (c) the release of CFCs into the atmosphere
    (d) sulfur and nitrogen oxide gases in the atmosphere.

14. The main purpose of the tertiary treatment step in sewage treatment is to:
    (a) remove nitrates and phosphates
    (b) decompose any remaining organic matter
    (c) physically remove solid matter
    (d) kill disease-causing organisms

15. The use of select micro-organisms and plant species to accumulate or degrade some of the metals and organic pollutants found in contaminated sites is referred to as:
    (a) waste reduction
    (b) bioremediation
    (c) ecological succession
    (d) genetic engineering

Fill in the Blanks:

16. A _____ is any inorganic substance that is needed in amounts of 100 mg per day or more to maintain health.

17. The three primary constituents in any fertilizer are in order of how they are listed on the package: _____, _____, and _____.

18. The common method for describing the toxicity of a substance by determining the amount that results in the death of half of the population tested in a given time is referred to as the _____ of that substance.

19. The three main types of pesticides are _____, _____, and _____.

20. An _____ is a chemical substance that changes colour when exposed to acids or bases.

21. A _____ is a device that removes oxides from industrial smokestacks.

22. Any substance that is broken down by the action of living organisms is referred to as_____.

23. Of the "4Rs" of the environmental movement — recycle, recover, reuse, and reduce — the principal that is the preferred first option is _____, because it has the most potential to change the amount of wastes generated.

Unit C Review – "I Can" Statements

I can: (Topic 1)

- Distinguish between organic and inorganic substances.
- Identify the roles served by common organic (carbohydrates, lipids, proteins) and inorganic nutrients: specific minerals affecting plant growth and animals.
- Identify sources of nutrients for plants and animals (carbohydrates, proteins, fats, vitamins, minerals)
- Describe how plants and animals obtain nutrients (absorption, digestion)
- Describe our dependence on fertilizers

I can: (Topic 2)

- Describe the process of biomagnifications (bioaccumulation) using the pesticide DDT as an example.

I can: (Topic 3)

- Identify acids, bases and neutral substance based on measures of their pH and indicator use.
- Describe the effect of acids and bases on living things (antacids, soaps, acid rain).
- Investigate and describe acid base neutralizations.
- Explain the issue of acid rain (causes and effects on the environment.
- Describe how calcium carbonate (lime) can be used to counteract acid rain.
- Describe neutralization reactions.

I can: (Topic 4)

- Define pollution.
- Calculate the concentration of a substance in ppm (parts per million).
- Define toxicity and differentiate between acute and chronic toxicity.
- Define LD50 and determine the LD50 of a substance of a graph.

I can: (Topic 5)

- Differentiate between persistent and non-persistent pollutants.
- Identify sources of nitrate and phosphate pollution and explain their effect on aquatic ecosystems. For example, how do they cause the “death” of a lake?
- Explain how the concentration of oxygen in a body of water is affected by temperature and other forms of pollution.
- Describe biological indicators and explain how their presence or diversity is affected by oxygen and pollutant levels.

I can: (Topic 6)

- Describe surface water pollution.
- Explain how a waste water treatment facility works.
- Describe how ground water moves and accumulates.
- Differentiate between biodegradable and non-biodegradable materials and provide examples of each.
- Differentiate between solutes, solvents and solutions.
- Describe the 4 R’s.
- Explain the purpose and structure of sanitary and secure landfills.
- Describe bioremediation.