



Investigating Wastewater

**Developed by:
Lisa Everingham, North College Hill High School Science Teacher**

Table of Contents

	<u>Page</u>
Curriculum Unit Overview - narrative	#3
Summary Chart	#4
Section One Chemistry	#5
Section Two Biology	#12
Section Three Communication	#23
Transfer Activity ECSI Environmental Crime Scene Investigation	#27
Appendix	#29

Investigating Wastewater Curriculum Unit Overview

Summary

Clean water is often taken for granted. This unit will make students think twice about what happens to the water they use every day. This unit was developed after working with the Metropolitan Sewer District in the Division of Industrial Waste. It takes a look at the environmental problems that some industries cause to the water as well as how wastewater is cleaned and treated. The unit incorporates chemical principles, earth science, and biology in the context of environmental science. The unit is aimed at grades 7-10 and is estimated to take approximately 5-6 hours to complete.

Big Picture

Have you ever wondered what happens to that water when you flush the toilet or turn on the shower? Where does it all go? Who takes care of it? How? What happens if something really toxic is dumped into it? Do we have unlimited sources of water? Brainstorm ideas to these questions with students to see where they are in their level of understanding regarding wastewater.

Preparation for the Unit

- Work with your local wastewater treatment plant to:
 - Obtain samples of wastewater effluent
 - Schedule a plant tour
 - Request data on local streams
- Contact your local park naturalist to accompany you on a field trip to a local creek.
- Order Water Quality Test Kits (see information in Section One ALT Three)

Overview

On the following page is a summary of the unit including brief summaries of each Authentic Learning Task (ALT). This table provides an overview of the tasks in the unit sections and shows how the activities in the different teaching areas relate to each other.

Investigating Wastewater Curriculum Unit Summary

Chemistry	Biology	Communication
<p>ALT 1 - Separating Solids Students will develop a plan to separate a mixture of sand, salt and iron. This process mimics what must be done to separate solids from wastewater.</p>	<p>ALT 1 – Microscopy: What is swimming in your water? Students observe samples of pond water and wastewater effluent and identify microorganisms living there.</p>	<p>ALT 1 Startling Statements Survey Students will interview peers and other adults regarding some startling statistics about water usage.</p>
<p>ALT 2 – Separating Liquids: Wastewater Treatment Simulation Students will be given some “dirty” water and must develop a plan to clean it.</p>	<p>ALT 2 – Macroinvertebrates as Water Quality Indicators Macroinvertebrates living in a local stream will be counted and used to determine water quality.</p>	<p>ALT 2 – – Powerpoint Show Students create a multimedia powerpoint show on a topic they choose from a list of possibilities.</p>
<p>ALT 3 – Monitoring the Chemistry of a Creek Students obtain samples of creek water and run tests on the pH, turbidity, phosphates, nitrates, and dissolved oxygen. Best to do on a field trip to a stream!</p>	<p>ALT 3 – Bioassay Lab Student experiment with different toxicity levels of wastewater using lettuce seeds.</p>	

Transfer Activity: ECSI Environmental Crime Scene Investigation

Students will be given a scenario in which a creek is found to be contaminated. They must trace the contamination to its source and test water samples from each of the potential industry suspects to determine the perpetrator.

Section One: Chemistry

ALT One: Separating Solids

Summary

Students will develop a plan to separate a mixture of sand, salt and iron. This process mimics what must be done to separate solids from wastewater.

Competencies

1. Identify properties of different materials
2. Separate a mixture using physical properties
3. Write an understandable step-by-step procedure

Time

Homework assignment to complete over a week period that includes a weekend.

Materials per Student

Sand (approx 10 grams)

Salt (approx 10 grams)

Iron Filings (approx 10 grams)

Film Canister with lid that fits tightly

3 Baggies

Instructions

1. Students are given a mixture of sand, salt, and iron in a film canister and three baggies. Their challenge is to bring you the items back separated into each bag.
2. Do not tell students how to do this. Encourage them to seek advice from parents, other teachers, siblings, etc. Give them about 5 days to complete this at home (include a weekend in those 5 days.)
3. Have students turn in their baggies along with a simple lab report. The report should include:
 - The materials needed to accomplish the task
 - A description of the properties of sand, salt and iron
 - STEP-BY-STEP procedure
 - A list of suggestions for how to improve the experiment if it were to be done again

Evaluation/Assessment of Student's Competency

50% of the points given should be for the successful completion of the task. In other words, the students should give you a bag with sand, bag with salt and bag with iron filings. Do not expect to get the full 10 grams back, but there should be a substantial amount if they did it correctly. Also look for students who cheat and place salt from a salt shaker in the bag. It is easy to spot, because the salt you gave them should turn out to be dirty looking and mushy, NOT perfect white crystals. Tell students in advance that you will dock them 50 points if they cheat like this. (Do NOT tell them how you will know they cheated)

50% of the points should be for a well written lab report. Most emphasis should be on a procedure that can be repeated and is easy to understand.

Closure

Wastewater Treatment plants often need to separate solids from the water before treatment can occur. In the next lab we will look at how different liquids can be separated.

Section One: Chemistry

ALT Two: Separating Liquids

Summary

Students will be given some “dirty” water and must develop a plan to clean it.

Competencies

1. Use the scientific method to solve a problem
2. Perform appropriate laboratory techniques to separate liquids
3. Understand the purpose of various methods to clean water

Time

Two hours.

Materials per Group of Students

Foul Water - Premake with:

¼ cup veg oil

1tsp garlic salt

1TBS coffee grounds

½ gallon water

Let sit overnight

Rubber hose to fit on end of a funnel or a plastic pipet or medicine dropper

Funnel with filter paper

Gravel and sand layered in a paper cup with a small hole in the bottom

Activated Carbon

Erlenmeyer flask

Ringstand, ring clamp, and clay triangle

Instructions

1. Each group obtains 100 mL Foul water and examines it for color, odor, clarity, etc and records observations.
2. Students then are asked to use the materials provided to “make the water clean”.
3. You will want to coach students as they go through the process. Some hints for you: The funnel with hose can be used to separate the water from the oil. The sand and gravel cup should be used filter and trap solids that are too large to fit between sand grains. The water should be allowed to sit in a flask with a teaspoon of activated carbon to remove bad taste odor or cloudiness. Finally water should be filtered through filter paper to remove any residual color or impurities.
4. Students should CAREFULLY record all the steps that they use to accomplish the task and observations they make along the way.

Evaluation/Assessment of Student's Competency

50% of the points given should be for the successful completion of the task. In other words, the students should produce approximately 100 mL of reasonably good looking and smelling water.

50% of the points should be for a well-written lab report. Most emphasis should be on a procedure that can be repeated and is easy to understand and careful OBSERVATIONS.

Closure

Wastewater Treatment plants need to clean the water that comes into the plant from toilets and showers, and industrial plants. The techniques used in this lab are comparable to ones that are seen at a wastewater plant. In the next activity, students will investigate the quality of water in nearby creeks. This is where water treatment plants release the water they have cleaned. Sometimes sewers overflow into local creeks and so streams need to be monitored by the city.

Section One: Chemistry

ALT Three: Monitoring the Chemistry of a Creek

Summary

Students obtain samples of creek water and run tests on the pH, turbidity, phosphates, nitrates, and dissolved oxygen. Best to do on a field trip to a stream!

Competencies

1. Explain the purpose of water quality testing
2. Describe the relationships between pH, nitrates, phosphates, turbidity, dissolved oxygen and temperature
3. Predict effects of pH, nitrates, phosphates, turbidity, dissolved oxygen and temperature on water quality.

Time

Four hours if done as a field trip in conjunction with Section Two ALT Two

Two hours if done in class

Materials per Group

Field Manual for Water Quality Monitoring by Mark Mitchell and William Stapp Published by Kendall/Hunt Publishing Company

Water Quality Test Kit – may be ordered from LaMotte 1-800-344-3100 or Hach 1-800-227-4224. Test kit should include pH, Nitrate, Phosphate, Turbidity, Dissolved Oxygen and Temperature.

Water sample from local creek – best if done at the local creek itself

Instructions

1. Before going on trip/ performing experiments in class, have students read excerpts from the *Field Manual for Water Quality Monitoring* about the different water quality tests and fill out the handout (Handout One). It is important for students to understand the purpose of the various tests before doing them.
2. Divide students into groups and set up 5 stations, one for each test listed above.
3. Have students rotate from station to station and follow the directions and record data for each type of test. (See the Handout Two)

4. After the tests are completed, use the *Field Manual for Water Quality Monitoring* to guide students through calculating the overall water quality index.

Evaluation/Assessment of Student's Competency

25% of the points should be given based on student participation and behavior during the trip/lab

75% of points should be given for a completed and accurate outline sheet and data sheet

Closure

Discuss the results you obtained with your class. Does this water appear to be healthy? Why or why not? Encourage students to survey the area where the samples were taken. Are there combined sewer overflows? Are there industries or farmers fields nearby? In the next activity, students will look at the life found in water they have been investigating.

Section Two: Biology

ALT One: Microscopy: what is swimming in the water?

Summary

Students observe samples of pond water and wastewater effluent and identify microorganisms living there.

Competencies

1. Employ proper technique when using a microscope.
2. Compare and contrast life forms found in different types of water
3. Identify helpful and harmful microorganisms in wastewater

Time

One hour

Materials per Student

Microscope with at least 100x power

Samples of creek water, tap water, pond water, and wastewater from a local treatment plant (ask for a sample of their activated sludge)

Slides

Cover slips

Latex gloves (if working with activated sludge)

Safety glasses

Instructions

1. Teacher or students (or both!) should visit the websites Microbiology of Activated Sludge <http://www.dnr.state.wi.us/org/water/wm/ww/tech/biol.htm> and Wastewater Microorganism Gallery <http://www.epa.gov/r5water/npdestek/micro.htm> to research the various microorganisms that are found in water. Have students investigate which microorganisms are helpful for the water and which are harmful.
2. Using the coverslips and slides, have students place drops of the various types of water under the microscope.
3. Students should record their observations and make drawings of what they see. Then, using the identification keys and pictures found on the internet, students should determine the identity of what they find and tell how it affects the water. Finally, students should compare and contrast the different types of water samples.

Evaluation/Assessment of Student's Competency

25% of points for participation and behavior during the lab

75% of points based on the student's lab report that should include detailed observations, analysis and identification of what is observed, and a written comparison of the water samples.

Closure

Wastewater Treatment plants rely on the naturally occurring microorganisms in the water to clean it. Remind the students of the separating solids and liquids labs done in section one. This activity was just one more way that the wastewater is treated. In the next activity, students will look at larger organisms living in creek water called macroinvertebrates.

Section Two: Biology

ALT Two: Macroinvertebrates as Water Quality Indicators

Summary

Macroinvertebrates living in a local stream will be counted and used to determine water quality.

Competencies

1. Identify benthic macroinvertebrates and classify by taxa.
2. Calculate water quality by determining diversity of macroinvertebrates.

Time

One hour at the creek (This should be done in conjunction with a trip to a local stream for chemical water monitoring as described Section One ALT Three)

Materials per Student

Kick seine net – Two wooden poles and a nylon mesh or burlap sack
Plastic tub
Magnifying glass
Identification Chart (Handout One)
Wading boots

You may wish to contact a park naturalist to accompany you on this trip.

Instructions

1. Choose a sampling site that is shallow enough to wade in and has rocks that water has to run over. Macroinvertebrates will be where the water has more oxygen, so that is why you want a site with water running over rocks.
2. Approach the site downstream so as to avoid disturbing the substrate below the water and place your net downstream of the site (one student should be holding the net open)
3. Wearing gloves, carefully pick up rocks and rub them in front of the net.
4. After all stones over 2 inches or larger have been removed, vigorously kick the streambed in front of the net. I call this the macroinvertebrate shuffle!
5. Finally, bring the net to a flat area, remove the critters you find and place them in a small tub filled with creek water.
6. Use the magnifying glass and ID chart to identify each one.

7. Classify each according to their taxa and calculate the water quality index (Use Handout Two)

Evaluation/Assessment of Student's Competency

25% of points awarded for participation and behavior

75% of points awarded for identification of macroinvertebrates and correct calculations of the water quality index.

Closure

Macroinvertebrates are yet one more indicator of water health. Because sewers often overflow into streams, there is great concern as to the health of local streams. The diversity of macroinvertebrates will help an investigator determine water quality. The next activity involves yet one more way that life can indicate the health of the water.

Section Two: Biology

ALT Three: Bioassay with Lettuce Seeds

Summary

Toxicology is the study of the effects of chemicals on living things. We tend to think of some chemicals as toxic and others as nontoxic, but in fact, any chemical is toxic at high enough concentrations. Environmental toxicology is the study of the effects of chemicals on plants, animals, and the ecosystems in which they live. Scientists use experiments called bioassays to determine the effects of chemicals on living things.

Competencies

1. Identify purpose of a control in a scientific experiment
2. Define bioassay and give examples of how it is done
3. Compare and Contrast the toxicity of several samples of water

Time

One hour

Materials per Student

Lettuce Seeds

Baggies

10% Bleach solution

Distilled water

Paper filter in a petri dish

Samples of water from the wastewater treatment plant – ask for some activated sludge, wastewater influent and wastewater effluent

Latex gloves (when working with the wastewater)

Instructions

1. Soak lettuce seeds for 20 minutes in a 10% bleach solution (add 1 part household bleach to 9 part deionized or distilled water). Then rinse five times. This kills fungal spores that can interfere with seed germination. Note: Tap water can be used if you do not have access to deionized or distilled water, but it will introduce more variability into your experiment because of the varied minerals and other compounds it contains.
2. For water samples, place a 7.5-cm paper filter in each 9-cm petri dish. Add 2 ml of water sample to each dish.

3. For sediment or soil samples, place 3 grams of sample in the bottom of each petri dish and cover with filter paper. If the sample does not contain enough moisture to saturate the filter paper, add up to 2 ml deionized water as needed.
4. Prepare a control by setting up dishes using 2 ml deionized or distilled water as your test solution.
5. To each dish, add 5 lettuce seeds, spaced evenly on the filter paper so that they do not touch each other or the sides of the dish.
6. Place the dishes in a plastic bag, and seal it to retain moisture. Incubate in the dark at constant temperature (preferably 24.5 degrees C) for 5 days (120 hours).
7. At the end of this time, count how many seeds in each dish have germinated, and measure the root length of each to the nearest mm. Look carefully at the plants to make sure you are measuring just the root (the radicle length), not the shoot as well.
8. Check your control (the dishes that contain deionized or distilled water rather than a sample). The purpose of the control is to identify how well the seeds will grow without any added contaminants. If fewer than 80% of the seeds in your control dishes sprouted, something may have gone wrong in your experiment. Perhaps the seeds were too old or stored improperly, so they are no longer viable. Or maybe something went wrong with the conditions for growth. Did the dishes get too hot, too dry, or contaminated in some way? Did you use tap water for your control, rather than deionized or distilled water? In many cases this works fine, but since tap water is highly variable from source to source, it gives less predictable results.
9. Within each treatment, how much variability did you find in your results? Did the replicate dishes show similar numbers of seeds sprouting, and similar average radicle lengths? If you think the data are much more variable than you would expect, you might want to explore the potential sources of variability for this type of experiment.

Evaluation/Assessment of Student's Competency

Students should submit a lab report with problem, hypothesis, materials, data table for observations and results, and a conclusion.

Closure

For environmental testing, bioassays provide an integrated picture of overall toxicity of an effluent or a sample of water, sediment, or soil from a contaminated site. Fathead minnows, various aquatic invertebrates, earthworms, protozoan, and seeds all are used for bioassays of

aquatic samples. The idea behind these bioassays is that the test organism will react in a predictable way to various types of environmental contaminants. The following are a few examples of ways in which lettuce seed bioassays have been used:

- to map areas for clean-up of Superfund sites
- to screen industrial effluents
- to test the effectiveness of clean-up of lead-contaminated soil

Section Three: Communication

ALT One: Startling Statements Activity

Summary

Students will interview peers and other adults regarding some startling statistics about water usage.

Competencies

1. Develop awareness of the vast amounts of water that are used each day
2. Gain interview skills by working with peers and adults.

Time

Half hour for discussion

Materials per Student

ALT Two Handout One
Blank paper and Pencil

Instructions

1. Students should create a list of at least 3 adults and 2 peers (outside of the class) to interview.
2. For homework, student will ask these 5 people the 17 questions on the survey and tally the responses.
3. As a class, discuss student findings. What question did people most often get correct? What question(s) were most likely missed? What answer was most surprising?

Evaluation/Assessment of Student's Competency

50% Completion of assignment
50% Participation in class discussion of findings

Closure

This activity is a good way to peak interest in water usage and promote water awareness. Other activities that follow relate to this one.

Section Three: Communication

ALT Two: PowerPoint Show

Summary

Students create a multimedia PowerPoint show on a topic they choose from a list of possibilities.

Competencies

3. Design a presentation using Powerpoint software.
4. Effectively summarize what was learned in the unit.

Time

One hour for introduction to PowerPoint and One hour for presentations
Three hours needed for research and preparation of the PowerPoint Show which may be assigned for homework if students have access to computers afterschool

Materials per Student

Computer with Presentation software (Like PowerPoint)
Internet Access

Instructions

1. Students will choose a topic from the following list and prepare a 2-5 minute presentation. I usually request that students include several pictures in their show and some animation. Remind them that only a few words should be on each screen and extra info they want to include should be spoken during their presentation.

Topics:

- Clean Water Act
- Macroinvertebrates
- Wastewater treatment plant overview
- The 5 Water Quality Tests
- Bioassay Methods

Evaluation/Assessment of Student's Competency

25% of points awarded for presentation: color, creativity, projection of voice, animation, etc.
75% of points awarded for content of the presentation

Closure

This activity should've provided everyone with an overview of what has been learned. Now it is time to take the skills we have learned and apply them to a transfer activity that involves an Environmental Crime Scene.

Transfer Activity

Summary

Students will be given a scenario in which a creek is found to be contaminated. They must trace the contamination to its source and test water samples from each of the potential industry suspects to determine the perpetrator.

Time

One hour

Materials per Student

Universal Indicator
Dropper
Microwell tray
Unknown samples from site A, B, and C

Instructions

1. Read students the following scenario:

At 0800 hours you receive a call. “Inspector, my name is Anne Tigris. I live near the Rubble Creek and last night I was walking along the banks with my husband when we came along what appeared to be a greasy contamination of the water. Would you be able to check it out?”

You grab your digital camera, laptop, and set out for the site she described. Sure enough, a greasy slime was beginning to coat the water and plant life along the creek. Opening up the laptop, you look up maps of the area using the Geographical Information System (GIS). Just as you suspected, there is a combined sewer overflow (CSO) nearby. Now it is time to do some research.

2. Give students the names of three businesses (local ones are fun to use) and tell them that they are the three places that drain into that area of the creek. Have students research the type of discharges these businesses make. Do they emit oil and grease? Heavy metals? Volatile organics?
3. Distribute samples A, B, and C that represent samples taken from the business sewer effluents. Prepare them in advance by placing plain water in two of them and dilute vinegar in the third.
4. Instruct students to use the Universal Indicator to see whether contamination has occurred. The one with the vinegar should turn pink, indicating contamination.
5. Invite an investigator from the Division of Industrial Waste to speak to students about environmental crimes.

Evaluation/Assessment of Student's Competency

Students should hand in a paragraph about each business that they researched as well as a data table with their results from the test.

Closure

This activity provides a real-life simulation of what can happen when wastewater is not carefully managed and treated. Hopefully in this unit, students have gained an understanding of the importance of investigating wastewater.

Section One: Chemistry

ALT Three: Handout One

Six Water Quality Indicators

1. Dissolved Oxygen (DO)

A. Where does DO come from?

a.

b.

B. What temperature water holds more dissolved oxygen? (circle one) Warm or Cold C.

What can decrease the amount of DO in the water?

D. What happens when the DO is decreased?

F. What units is DO measured in?

2. pH

A. What is pH?

B. On the pH scale, what number is the most acidic? _____

What number is the most basic? _____

What number is neutral? _____

Distilled (pure) *Water* should be what number? _____

Lemon juice is what number? _____

B~each is What number? _____

C. What produces acid rain?

D. What can happen to fish and other animals if pH changes?

3. Turbidity

A. What is turbidity?

B. What causes water to become turbid? (list examples)

C. What happens when turbidity gets too high?

a.

b.

d.

C.

f.

D. What units is turbidity measured in?

4. Phosphates (PO_4^-)

A. What are phosphates?

B. What are some source of phosphates?

C.

d.

What happens when there is too much phosphorous?

a.

b.

C.

5. Nitrates (NO_3^-)

A. What are nitrates needed by all organisms to build?_____

B. What are some sources of nitrates?

a.

b.

6. Temperature

A. What does temperature influence?

a.

b..

B. What is thermal pollution and what causes it?

Section One: Chemistry

ALT Three: Handout Two

Water Quality Data Sheet

Site Location: _____

School: _____

STATION 1: DISSOLVED OXYGEN

Water Temperature in Stream where sample was _____

DO Results _____

STATION 2: PHOSPHATES

Test Reading on color wheel _____

STATION 3: NITRATES

Reading: _____ times 4.4 = _____

STATION 4: PH

pH Test Result: _____

STATION 5: TURBIDITY

Number of 5mL drops = _____

Use chart to convert 4 drops to JTU's _____

Section Two: Biology

ALT Two: Handout One

Macroinvertebrate Counts

Section Three: Communication

ALT One: Handout One

Startling Statements Activity

1. A dripping faucet with a 1/16 inch hole allows how many gallons of water to be wasted each day?
2. How many gallons of water flow from a typical garden hose in five minutes time?
3. How many residential septic tanks are in operation in the United States?
4. According to the Massachusetts Audubon Society, how much water can one gallon of gasoline contaminate?
5. What percent of the world's total supply of drinkable water comes from groundwater?
6. How much municipal solid waste is disposed of annually in U. S. landfills? How much industrial solid waste?
7. In what year was the Federal Water Pollution Control Act Amendments (Public Law 92-500)— better known as the Clean Water Act—passed?
8. How many gallons of water does it take to produce 1 gallon of gasoline?
9. How many gallons of water does it take to manufacture 1 automobile (including the tires)?
10. How much water does U. S. industry use annually to cool, wash, circulate, and manufacture its materials?
11. How many gallons of water does it take to produce one *fast* food meal of a hamburger, french fries, and a soft drink?
12. How much water must a cow drink to produce 1 gallon of milk?
13. How much water is needed to produce 1 ear of corn?
14. How much water is used in the U. S. each day?
15. How much water does the average person in the United States use each day?
16. How much water does the human being need each day to digest our food, cool our system, lubricate our joints, soften tissue, cleanse our eyes, and remove our body's wastes?
17. According to statistics in *Home Energy* magazine, how much water would be saved daily if every American home installed low-flow faucet aerators?

Section One: Communication

ALT One: Handout Two

Startling Statements Answer Key

1. 100 gallons a day. *America's Clean Water Foundation*
2. 50 gallons. *America's Clean Water Foundation*
3. 23 million. *America's Clean Water Foundation*
4. 750,000 gallons. *50 Things You Can Do to Save the Earth*
5. 90%. *50 Things You Can Do to Save the Earth*
6. 160 million tons of municipal solid waste and 250 million tons of industrial solid waste are disposed of in more than 16,000 landfills throughout the country. *America's Clean Water Foundation*
7. 1972. *America's Clean Water Foundation*
8. 70 gallons. *America's Clean Water Foundation*
9. 39,000 gallons of water. *America's Clean Water Foundation*
10. 100 cubic miles of water (one cubic mile is over a trillion gallons.) *America's Clean Water Foundation*
11. 1,400 gallons of water. *America's Clean Water Foundation*
12. 3 gallons. *America's Clean Water Foundation*
13. 26 gallons of water. *America's Clean Water Foundation*
14. 400 billion gallons of water per day. *America's Clean Water Foundation*
15. 1,650 gallons. *America's Clean Water Foundation*
16. 2 liters. *America's Clean Water Foundation*
17. 250 million gallons of water every day. *50 Things You Can Do to Save the Earth*