LESSON TITLE	Chemicals in Wastewater				
SUBJECT (S):	Biology, Chemistry, Earth Science, Environment Science				
GRADE LEVEL:	6-12	**AUTHOR:**	Rebecca L. McKinney, MS		
TYPE OF LESSON (activity, lab, project…)	Lab			**DAY(S):**	2+

OBJECTIVE

Students will design and implement an experiment to test the effects of chemicals in wastewater on the growth of plants.

NGSS/CC STANDARDS

NGSS
Science and Engineering: 1, 3, 4, 5, 6, 8
Crosscutting Concepts: 2, 4, 7
Core Ideas: ESS3, LS1, LS2

PERFORMANCE EXPECTATIONS
Earth and Space Sciences: HS-ESS3-3, HS-ESS3-5; MS-ESS3-3
Life Sciences: HS-LS1-3, HS-LS2-7; MS-LS1-5

CC Math
HS - MP.2, MP.4, HSN-Q.A.1, HSN-Q.A.2, HSN-Q.A.3, HSS-IC.B.6; MS – MP.2, MP.4, 6.SP.B.5, 7.RP.A.2

CC ELA/Literacy
HS - RST.11-12.1, RST.11-12.8, WHST.9-12.2, WHST.9-12.5, WHST.9-12.7; MS – WHST.6-8.7, WHST.6-8.9, RST.6-8.7

ASSESSMENT(S) & GRADING/RUBRIC

Formal lab report (rubric provided), or:

- experimental board
- PowerPoint presentation of results
- brochure of data
- filled in worksheets

SUBJECT AREA(S):

This lab could easily fit within the following courses as follows:

EARTH or ENVIRONMENTAL SCIENCE: when talking about ecosystems, human interactions with the environment, what effects biodiversity, pollution, or water as a natural resource.

LIFE SCIENCE: Ecosystems (interactions and dynamics)

TEXTS/MATERIALS/TECHNOLOGY/AUDIO-VIDEO/OTHER RESOURCES:

Computers, fast growing seeds (radishes are suggested), soil, rulers, balance, containers for growing seeds, water, other items as needed by students

INSTRUCTIONAL STRATEGIES/PROCEDURES/GROUPING:

DAY 1
Pass out the worksheets. Have students read the top of the first page about wastewater. Most students will not know the meaning of the term bioaccumulate; therefore, make sure to state that this is the "build up of chemicals in an organism." You can then work as a class to discuss what sorts of items/chemicals are sent down the drain.

Have students spend the rest of the class period designing their experiment. Students can work solo or in a group of up to 4 to design the experiment. If computers are available, allow students to use computers to do research.

Students **must get approval for the chemical** they want to test. For students who are struggling with ideas for what to test, here is a list of a few chemicals: bleach, ammonia, soap, shampoo, conditioner, toothpaste, drain cleaner, powdered cleanser, mouthwash, caffeine, aspirin, acetaminophen. Make sure students do not choose any illegal or controlled substance or bodily fluid/waste. They must have the worksheets filled out, with the exception of the table and graph. They should show you their filled in worksheets before they may begin their experiment.

DAY 2: OPTIONS
Students can set up and perform their experiment at home

OR

Students can set up and perform their experiment in the classroom. If students run their experiment in class, you should allow 5 minutes every day for students to check their experiment.

This experiment should run for a minimum of two weeks if plants were already growing prior to the start of the experiment. If seeds need to germinate, add the germination time to the two weeks (2-4 weeks).

FINAL DAY:
For the final day of the experiment, you could allow students time to begin their lab report in class. Conversely, you could have students present their findings to their peers either as a PowerPoint presentation or poster presentation.

SAFETY/SECURITY ISSUES:

Depending upon the chemical students choose to test, goggles and gloves might be necessary.

REFERENCES

http://www.epa.gov/research/endocrinedisruption/wastewater.htm
http://water.usgs.gov/edu/wwvisit.html
http://news.nationalgeographic.com/news/2007/05/070521-sex-fish.html
http://www.scientificamerican.com/article/only-half-of-drugs-removed-by-sewage-treatment/
http://www.nextgenscience.org/next-generation-science-standards
http://www.cde.ca.gov/re/cc/

NOTES/REFLECTIONS/EXTENSIONS:

Instead of using plants, you could consider using daphnia, pill bugs or crickets. Chemicals should be diluted appropriately before testing. Assume that a solution of 1% or less is appropriate.

	1 Beginning or Incomplete	2 Developing	3 Accomplished	4 Exemplary	Score
TITLE	Title does not adequately address the laboratory experience	Title begins to address the laboratory experience, but is incomplete	Title almost addresses the laboratory experience, but is missing some minor points	Title of the lab is clearly stated	
INTRODUCTION	Very little background information is provided or the information is incorrect	Some introductory information, but still missing some major points	Background is nearly complete, missing some minor points	Background is complete and well-written; provides all necessary background principles for the experiment	
• **Purpose** (should be in introduction)	A purpose is not clearly stated or the information is incorrect	Shared some information, but still missing some major points	Purpose is nearly complete, missing some minor points	Purpose of the lab is clearly stated in 1-2 sentences	
• **Variable** (should be in introduction)	Independent, dependent and controlled NOT identified	1 of 3 variables properly identified	2 of 3 variables properly identified	Independent, dependent and controlled properly identified	
• **Hypothesis** (should be in introduction)	The hypothesis is not clearly stated or the information does not pertain to this lab	Began stating a hypothesis, but did not share what they thought would happen	The hypothesis is nearly complete, missing some minor points	The hypothesis is clearly stated and is easy to understand	
MATERIALS	Missing several important materials	Still missing some materials or experimental details	Important materials and experimental details are covered, some minor details missing	Well-written, all materials and experimental details are covered	
METHODS	Missing several important experimental details	Missing some experimental details	Important experimental details are covered, some minor details missing	Well-written, all materials and experimental details are covered	
RESULTS (at least one table and one graph)	Figures/graphs/tables contain errors/poorly constructed, missing titles, captions, numbers, units missing, etc. Calculations contain major errors	Most figures, graphs, and tables OK, some missing some important or required features Most calculations are OK, some are incorrect or omitted	All figures, graphs, tables are correctly drawn, but some have minor problems or could still be improved All calculations are correctly shown, but some have some minor problems or could still be improved	All figures, graphs, and tables are correctly drawn, are numbered, and contain titles/captions All calculations are clearly shown and contain all work, titles/captions	
CONCLUSIONS (accept/reject hypothesis, explain results, what could be done next/better, tie to real world)	Very incomplete or incorrect interpretation of trends and comparison of data indicating a lack of understanding of results	Some of the results have been correctly interpreted and discussed; partial but incomplete understanding of results is still evident	Almost all of the results have been correctly interpreted and discussed, only minor improvements are needed, accept/reject hypothesis	All important data comparisons interpreted correctly/discussed, understanding of the results is conveyed; discussion of the sources of error, what could do to improve the lab, accept/reject hypothesis	
--Spelling, grammar, and sentence structure--	Frequent grammar and/or spelling errors, writing style is rough and immature	Occasional grammar/spelling errors, generally is readable with some rough spots in writing style	Less than 3 grammar/spelling errors, mature, readable style	All grammar/spelling correct and very well-written	
--Appearance and formatting--	Sections out of order, too much handwritten copy, sloppy formatting	Sections in order, contains the minimum allowable amount of handwritten copy, formatting is rough but readable	All sections in order, formatting generally good but could still use some improvement	All sections in order, well-formatted, very easy to read	
LITERATURE CITED (need at least 2 sources)	All literature used is not cited or is cited incorrectly	All literature used is cited; however, it is not cited in the correct format	All literature used is cited; there are minor errors in the citation format	All literature is cited completely and in the correct format	

NAME _____ DATE _____

Chemicals in Wastewater

Wastewater is the water that comes from sewage, sinks, showers, industrial plants and agricultural facilities. Wastewater is cleaned at a treatment plant, and then eventually returned to local rivers or the ocean.

Though wastewater plants do an excellent job of removing the bulk of the waste, there are certain chemicals that remain in the water, many of which cause downstream effects in living organisms. Estrogen and related compounds from birth control pills and other sources have been shown to cause feminization and defects in reproductive development of fish. Triclosan, which is found in some soaps and toothpastes, is toxic to algae and can disrupt hormone interactions in fish. Long-term effects of antibiotics in the water can lead to bacteria with antibiotic resistance. Many of these chemicals bioaccumulate within organisms, but the long term effects of this bioaccumulation are not fully understood. Numerous research projects are ongoing to determine the overall dangers of these chemicals on biotic factors within ecosystems.

Take a moment to consider all of the chemicals and other items that you put down the drain. List as many as you can think of below.

PURPOSE: For this lab, you will design an experiment to test the effects of one of the above listed chemicals (with teacher approval) on the growth of plants.

Fill in the following information.

QUESTION: What are the effects of _____ on the

growth of _____?

State your hypothesis (Consider all areas of physical development of a plant: leaf size, color, height, root growth, stem growth, etc)

Why do you think this will happen?

Identify the variables of the experiment.

INDEPENDENT: _____

DEPENDENT: _____

CONTROLLED (list at least 3): _____

_____

List the materials you will need for this experiment:

To help you develop methods, fill in the following information.				
How long will the experiment last?	What type of plant will you use?	How many plants?	Where will your plants grow?	How much water will they receive? When?
How will you get your chemical?	What concentration of your chemical will you use?		What type of growing container will you use?	How will you measure your plants? What will you look for?

In the space below, make a table to collect the data from the experiment.

In the space below, make a graph of the data from the experiment.

GUIDELINE FOR LAB REPORT

You will write a formal lab report in order to properly present your findings. You will likely have to do some research either online or in a library in order to acquire all of the information that you need. You must have all of the following components:

Title: Provide an appropriate yet brief title that summarizes the experiment

Introduction: The introduction should be written in paragraph form and must include the following:

- briefly explain wastewater
- identify the purpose of the experiment
- identify the chemical
- describe the chemical and what it is used for
- identify sources of the chemical in a household
- what are the known effects of this chemical on living organisms (if any)
- state your hypothesis and explain why you think this will happen
- identify the variables of your experiment

Materials: List all materials used in the experiment

Methods: Provide step-by-step instructions on how to perform the experiment

Results: Include a properly labeled table and graph of the data

Conclusions: The conclusion should be written in paragraph form and must include the following:

- accept or reject the initial hypothesis
- briefly describe the results
- explain any unexpected outcomes
- identify sources of error
- What additional experiments could be done? What could have been done differently?
- Apply the information to the real world
    - According to your research, how could this chemical affect the biodiversity of an ecosystem?
    - Could this chemical effect the human population?
    - Do the dangers of this chemical to the environment outweigh the benefits to humans?
    - What could be a technological/scientific solution to remove this chemical from water?

Citations: Appropriately cite all sources used for the experiment or in writing the report