

Unit Title: Clean Water Preservation and Waste Water Treatment	
Time Frame: 5 LESSONS	
Unit Developer(s): Jennifer Pitt-Lainsbury	
Developed for Course Name and Course Code: Grade 11 Science: Chemistry, University Preparation (SCH 3U)	
Strand(s) and Curriculum Learning Expectations Addressed:	
SIV.01	A1. demonstrate scientific investigation skills (related to both inquiry and research) in the four areas of skills (initiating and planning, performing and recording, analyzing and interpreting, and communicating);
SIV.02	A2. Identify and describe careers related to the fields of science under study, and describe the contributions of scientists, including Canadians, to those fields.
SI1.01	A1.1 Initiating and Planning [IP] formulate relevant scientific questions about observed relationships, ideas, problems, or issues, make informed predictions, and/or formulate educated hypotheses to focus inquiries or research
SI1.10	A1.10 Analyzing and Interpreting [AI] draw conclusions based on inquiry results and research findings, and justify their conclusions with reference to scientific knowledge
SI1.11	A1.11 Communicating [C] communicate ideas, plans, procedures, results, and conclusions orally, in writing, and/or in electronic presentations, using appropriate language and a variety of formats (e.g., data tables, laboratory reports, presentations, debates, simulations, models)
SSV.01	E1. analyze the origins and effects of water pollution, and a variety of economic, social, and environmental issues related to drinking water;
SSV.02	E2. investigate qualitative and quantitative properties of solutions, and solve related problems;
SSV.03	E3. Demonstrate an understanding of qualitative and quantitative properties of solutions.
SS1.01	E1.1 analyze the origins and cumulative effects of pollutants that enter our water systems (e.g., landfill lactates, agricultural run-off, industrial effluents, chemical spills), and explain how these pollutants affect water quality [AI, C]
SS1.02	E1.2 analyze economic, social, and environmental issues related to the distribution, purification, or use of drinking water (e.g., the impact on the environment of the use of bottled water) [AI, C]
SS2.01	E2.1 use appropriate terminology related to aqueous solutions and solubility, including, but not limited to: concentration, solubility, precipitate, ionization, dissociation, pH, dilute, solute, and solvent [C]
SS2.02	E2.2 solve problems related to the concentration of solutions by performing calculations involving moles, and express the results in various units (e.g., moles per litre, grams per 100 mL, parts per million or parts per billion, mass, volume per cent) [AI, C]
SS2.04	E2.4 conduct an investigation to analyze qualitative and quantitative properties of solutions (e.g., perform a qualitative analysis of ions in a solution) [PR, AI]

Desired Results

Unit Description: Students will read articles, have small group discussions and debates, perform labs and complete a design project to gain a comprehensive understanding of how chemistry can be used for environmentally sound waste water treatment.

Enduring Understandings / Learning:

- 1) Students will understand how chemistry is used for wastewater treatment and how waste water treatment impacts the environment
- 2) Student will be able to articulate why proper waste water treatment is important for human health and the environment
- 3) Students will be able to describe how environmentally conscious treatment is conducted
- 4) Students will understand how human activities are affecting water sources (groundwater, oceans, drinking water, lakes)
- 5) Students will plan and describe how human activities can be modified to reduce negative environmental impacts

Assessment Tasks

Performance Tasks and Other Evidence That Will Demonstrate the Knowledge and Skills Acquired:

Students will build a water filter and filter a sample of teacher prepared “wastewater”.

Assessment Criteria:

A series of worksheets, evaluation rubrics, anticipation guides are included in the appendices.

Unit Planning Notes

Prior Learning Necessary:

Students should have a solid understanding of solutions. They should understand the concepts of concentration, solubility, solubility rules, precipitation and acids and bases

Preparation Notes:

Lesson 1 of this Unit should take place at least 3 weeks **before** Lesson 3. The lessons in this unit should not take place one day after the other. The students will need ample preparation time for construction of the filter, gathering of materials, research and group consultation.

Typically after Lesson 1 of this unit, the following concepts would be covered (not as part of this unit) before the filtration

test day, with lesson 2 of this unit placed somewhere amongst lessons on:

- the solubility rules and reactions in aqueous solution
- qualitative chemical analysis
- A lab on qualitative chemical analysis
- Stoichiometry in Solution Chemistry
- Acid/Base Theories
- A review day for the unit test
- The unit test (on solubility, not including acids and bases).

Typically, I finish teaching acids and bases after the filter evaluation day.

A computer room should be booked for Lesson 2 of this unit.

A chemistry lab will be needed for lessons 3, 4, and 5.

For lessons 3 and 4, waste water samples will need to be prepared by the instructor – recipes for waste water may vary but one example might be a bucket with 50 L of water, a few liters of vinegar, enough dirt to significantly muddy the waters, sand, toilet paper, band-aids, gummy worms, small chocolate bars (without peanuts because of potential allergies) or chocolate covered raisins, enough soap to cause a light bubbling, some vegetable oil. You might want to alter initial pH with different additives for different classes – students love seeing what you can come up with but remember to take into account potential food allergies which can be a problem for students even though they are ABSOLUTELY NOT drinking the filtrate.

For lesson 4 the teacher will have to a class set of sterile agar plates (one for each group). A few drops of the students filtrate will be placed on the plate (with a sterile dropper). The agar plate should be taped after the insertion of the drops to seal them and clearly labeled with the group members' names.

For lesson 5 – distillation apparatus will be required (if distillation apparatus is not available – the theory of distillation can be covered.)

Learning Plan

Lesson 1

Explanation of Filter Project. Articles on solutions to the environmental impact of Waste Water, Water treatment and sources of drinking water

This lesson should take place at least 3 weeks prior to the filter test date; see preparation notes for an explanation. You will need a class set of copies of the “Pee-cycling” article and “The Quest for a Clean Drink” article (see **Appendix A** #5 and #6) Number the copies of each article and have students hand these back to you so you can use them for future classes. You will also need copies of the project description (**Appendix A** page 2-3) and evaluation (**Appendix A** page 4), the anticipation guides (**Appendix A** page 5-6) and student homework questions.

- 1) Divide students into groups of four for the waste water challenge. You might want to allow them to pick one person they want to work with, put both names on a slip of paper and then randomly select two pieces of paper to make up the group of four. Remember the maximum number in a group is four and if you have absent students you will have to carefully think through how they will join another group so that the total is never more than four.

Distribute the “Waste Water Challenge” (**Appendix A** page 2) and the evaluation guide (**Appendix A** page 3). Post the rubric (**Appendix A** page 4) for students but do not give each of them a copy as you will need the copies on the filter evaluation day. Go through the expectations, due date (give them at least 3 weeks to collect materials) and project explanation with students. Explain that there will be 2 periods allocated to the theory and issues dealing with water sources, disposal of waste water and waste water treatment (this period being one of them) and then there will be a day allocated for filter testing, the filter test day and a day for a distillation lab for purifying the filtrate.

- 2) Distribute the pre-reading assignment for the “Pee-cycling” article (**Appendix A** pages 5-6). Assign roles to each member of the group 1- reader, 2-recorder, 3-timer, and 4-mediator (have them number themselves and then tell them which number has which role). The mediator will lead the group in a discussion about the pre-reading statements. He/she will read the statement and then record whether the group agrees or disagrees. The timer will ensure that discussion on each point will be no longer than 30 seconds (give each timer a stop watch and tell the time that he/she must also participate in the discussion). The other roles will be active in the next step.
- 3) After the group has come to an agreement on each of the 11 statements, have the timer come up to the front and collect 4 “Pee-cycling” articles for the group. Make it clear that the students are not to make any marks on the articles as they will be used for all of the classes, please record which numbered articles the students have taken (to further encourage them to take care with the articles). The reader should read the article aloud (quietly) once while others follow along, no note taking should take place during this time. As the teacher, make sure you have recorded all of the names of the students in each of the groups, do not do this until the students are working (to conserve time).
- 4) After the article has been read once, the mediator needs to lead a discussion on each of the points again to decide whether the point is supported or unsupported. The recorder will neatly prepare a discussion sheet with the names of all of the group members, a title (“Pee-cycling” article discussion) and a comment of a few sentences on each point outlining the group’s conclusion. The timer will ensure the discussion on each point lasts no longer than one minute (and the timer must also participate in the discussion. Once the group has finished the analysis, the timer should hand in the pre-reading sheet and discussion sheet for the group and return all four articles to the teacher (at the front of the class). Remember to keep all of the articles organized in numerical order in the folder for the next teacher. This part of the activity should take no more than 35 minutes (5 minutes pre-reading, 10 minutes reading and 20 minutes post discussion).
- 5) At the 35 minute mark, get the students’ attention (some may even have started the second assignment already). Have the time in each group come to the front and pick up a wastewater assignment sheet. Explain the purpose of the assignment, the requirements and the timeline to the students clearly. The “Pee-cycling” article sets the stage for the project and helps them understand the connection between wastewater treatment and chemistry. Spend about 15 minutes explaining the assignment (or less if it takes less)
- 6) Depending on the length of your class periods. The next article, “The Quest for a Clean Drink,” may be read in class or assigned for individual homework.
- 7) If you are doing this in class, have the members of the group switch roles recorder to mediator, timer to recorder, mediator to recorder and reader to timer. The mediator should lead the group discussion on the statements. The timer ensures that discussions are less than 30 seconds. Once the group’s decisions have been made, the timer should go and pick up the reading package. Students should read the article aloud; the reader should start with the

first page and then organize the group to pass around the reading page by page. They should indicate whether their pre-reading decisions about the statements were correct or incorrect but they don't need to write statements for this part. (approximately 20 minutes)

- 8) Stop the class a few minutes before the end, assign the individual follow-up assignment #1: student questions in **Appendix A** and further reading in **Appendix A** - due next class Remember to collect all of the articles and place them in order in the folder for the next teacher.

Lesson 2

Research and Understanding of the stages of Waste Water Treatment and water purification.

The purpose of this lesson is for students to gain a solid understanding of pollutants in Canadian water systems and the stages of treatment in municipal waste water treatment centres. The instructor will need to give the class access to the readings in the Nelson and McGraw Hill texts or choose other appropriate readings either on-line or in print. Before class make sure students bring their texts or as the instructor photocopy a class set of readings (which should be collected at the end to be used in future classes)

- 1) Have students get into their waste water challenge groups and assign roles similar to lesson 1. Distribute the waste water research assignment (**Appendix B**, pages 7-8) and allow students time to work on the assignment. Students should try to finish all of the reading and the 2 follow-up tasks during class and hand them to the instructor at the end of class.
- 2) Half-way through the class distribute the organizational task sheet (**Appendix B**, page 9) so that students have a clear idea of the expectations and the tasks that need to be completed by the filter test day. Teachers will have to fill in the blank spaces on the handout depending on the due date set and the reference pages in the particular text the class uses.

Lesson 3

Filter Test Day

The teacher will need to prepare sample waste water and copy task analysis sheets. Any chemicals requested by student that can be provided by the instructor should be set up before class.

This day is used entirely for student testing of the filter. Students need to bring in all of the materials that they will be using on the filter evaluation day. The instructor will distribute the task analysis sheet for students to start (**Appendix C**, pages 10-11). They can finish IN CLASS the next day but they should not take these sheets home – the instructor will collect the sheets at the end of the class.

The instructor should think about how he/she wants the class organized for set up and clean up. The instructor should have timers on hand to give students an idea of how long the filters are taking to filter the water and the instructor should prepare a bucket of sample waste water and fill 1 L beakers for students to take back to their work benches for testing.

Students should be told that on the evaluation day, they will be given 5 minutes at the beginning of class for the set up the

filter and then timing will start, so filters that take longer than a few minutes to set up are not feasible.

The teacher should not forget to prepare sterile agar plates for the filter evaluation day.

Lesson 4

Filter Evaluation Day

This day is entirely dedicated to waste water filtration. Teachers should have 1 or 2 L samples of waste water available on a cart for each group (set up before class). The teacher will need to prepare sterile agar plates before class. The teacher needs a timer. Students have 5 minutes to setup their filters and get their waste water sample.

- 1) After 5 minutes of filter set up, the teacher should instruct students to take a stirring rod and thoroughly mix their waste water sample (so that settling in the beaker does not give certain students an advantage). On the teacher's mark, students need to pour the "waste water" into their filter fairly quickly (to avoid settling). The entire contents of the samples need to be poured into the filters. Timing starts when students begin to pour. The teacher will be timing throughout the class (think about how this will work in your class) and groups should be indicating to the teacher when their filtrate is fully filtered (at which time, the group hands the beaker with the filtrate to the teacher for evaluation. I usually tell the students to clearly label the beaker and put it on my desk at the front of the class and then immediately after the class I take 10-15 minutes to check pH, soap, colour etc... and fill out the rubrics. I make sure, however, that when the timer stops for that group their filtrate beaker is immediately placed on my desk.
- 2) Once the filtration starts, the teacher can distribute the analysis sheets (**Appendix C**, Pages 10-11) that students started the previous day so that they can complete them by the end of the period (this sheet should not be taken home).
- 3) The teacher will be using the rubrics (**Appendix A** page 4) during the class to interview the groups and evaluate the quality of the filtrate. The interviews should be started within the first ½ hour of class and may be taking place while the filters are still filtering (at the teacher's discretion). Any interviews which cannot be conducted during class (because the group's filter is maybe not working well and they need time to be completely hands on) will take place in a short, full group interview at a teacher designated time. Each interview should be between 5 – 7 minutes and each member of the group should answer at least 2 questions. The way I set up the interviews is as follows:
 - a) I tell the students that they are all responsible for the information and that I will be asking questions to one student in the group at a time. If, after that student has answered, other members of the group want to add information, they are free to do so. I tell the groups that I will be taking notes on their answers throughout the interview.
 - b) I start with one student in the group and I ask: "How did you achieve the lack of turbidity in your filtrate?" I'm looking for an understanding of the physical and chemical processes used, and an understanding of how these processes work. Students should be able to give the chemical formula for chemicals used and explain how they work. The next question, (from the rubric), to a different student, would be: "How did you achieve a lack of odour in your filtrate? Did any of the chemicals added affect the odour? How did you control for the effect of added chemicals?" I would continue to ask questions of other group members until

the section on distillation, which would be evaluated the following day.

- 4) A few drops of filtrate from each group should be placed on the agar plates. The plates should be sealed and clearly labeled with the group members' names. This will be evaluated on the distillation day.
- 5) Before the end of class, the teacher should take 3 minutes to distribute the self and peer evaluation sheets (**Appendix D**, page 12) which each student should complete individually and confidentially without consulting other member of the group. These should be handed directly back to the teacher. (If time is at a premium, the evaluations can be done at the beginning of class on distillation day – lesson 5).
- 6) Assign “Waste Water Treatment Questions” (**Appendix D**, pages 13-14) for homework.

Lesson 5

Lab: Distillation of Waste Water

This day is entirely dedicated to waste water distillation and will require distillation apparatus (the lesson will not be possible in the present format if distillation apparatus is not available but a valuable discussion about distillation can still take place during a portion of the class). The teacher will have to set up one set of distillation apparatus as a model (I recommend doing this before class).

- 1) Students should check their agar plates and the teacher may want to complete the rubric while students are setting up the distillation apparatus.
- 2) The teacher should distribute the distillation activity (**Appendix E**, pages 15-18). The teacher should go through the set-up, purpose and safety. A lot of care is required when setting up distillation apparatus and the instructor should lead students through the set up as a class.
- 3) Students should then distill their filtrate and complete the activity sheet (students keep)
- 4) The teacher can evaluate the filtrate according to the waste water challenge rubric.

Appendices

APPENDIX A: Lesson 1

1. Introduction to Waste Water Challenge (Page 2)
2. Build Your Own Filter: Evaluation Guide (Page 3)
3. Waste Water Challenge: Evaluation of Filtrate Rubric (Page 4)
4. Anticipation Guide: Waste Water Treatment Article (Pages 5-6)
5. “Pee-cycling” Article from the *New Scientist Magazine*, 20 December 2006 by Graham Lawton *New Scientist Magazine* issue 2583. <http://www.newscientist.com/article/mg19225831.600-pee-cycling.html>

6. “The Quest for a Clean Drink” Article from *Chematters* – April 2008
<http://www.acs.org/content/dam/acsorg/education/resources/highschool/chemmatters/gc-quest-for-a-clean-drink.pdf>

APPENDIX B: Lesson 2

1. Waste Water Treatment Research Assignment (Pages 7-8)
2. Organizational Task Sheet for Waste Water Challenge (Page 9)

APPENDIX C: Lesson 3

1. Task Analysis Sheets (Pages 10-11)

APPENDIX D: Lesson 4

1. Self and Peer Evaluation Sheet (formative) (Page 12)
2. Waste Water Treatment Questions (homework) (Pages 13-14)

APPENDIX E: Lesson 5

1. Distillation Activity (Pages 15-18)