LESSON TITLE	Process and Impact of Desalination on the Environment				
SUBJECT (S):	Biology, Earth Science, Environmental Science				
GRADE LEVEL:	6-12	**AUTHOR**:	James Stockdale, MS		
TYPE OF LESSON (activity, lab, project…)	Lab			**DAY(S):**	3+ days

OBJECTIVE

Students will research, create and discuss various types of water desalination and evaluate them for potential use in large scale production in terms of benefits to humans and associated environmental costs. In an extension of this lab, students will test how osmosis works, then build a small scale solar still to observe a simple desalination process.

NGSS/CC STANDARDS	ASSESSMENT(S) & GRADING/RUBRIC
NGSS Science and Engineering Practices: 1, 2, 7 Crosscutting Concepts: 2, 3, 5 Core Ideas: LS2, ESS2, ESS3, PS1 **Performance Expectations** Earth and Space Science: HS-ESS2-3, HS-ESS2-5, HS-ESS3-1 Life Science: HS-LS2-7, MS-LS2-5 Physical Science: MS-PS1-6 **CC ELA/LITERACY** HS – SL.9-10.1; RST.9-10.2, RST.9-10.8, RST.9-10.9; MS – RST.6-8.3, WHST.6-8.1, WHST.6-8.7, WHST.6-8.9, SL.8.5	Rubric is provided

SUBJECT AREA(S):

This project could be used in life science, biology, earth science, or environmental science courses when discussing diffusion, osmosis, desalination, environmental analysis, or other related topics.

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

Internet enabled computers for research and creating Pecha Kucha
Projector linked to computer with internet and speakers
Printed worksheets & rubric

INSTRUCTIONAL STRATEGIES/PROCEDURES/GROUPING:

Day1-2: In this lesson students will work independently to become the experts at one type of

current or future method of water desalination as they create a modified Pecha Kucha presentation (http://www.pechakucha.org/) using Google Slides. Instead of a 20x20 format, however, have students do 10 slides of 15 seconds each as this is a default time available when Google Slides presentations are published. Give students some degree of freedom to decide what should go in the 10 slides, however, let them know that the total number of slides includes any title or reference slides and that the presentation should answer the questions of:

- What the method entails
- How it works
- How cost effective it is
- How quickly it can produce water
- How it can be scaled up for larger production
- How effective it is in cleaning the water

You may assign students which type they are to research or let them choose; either way, the following may be helpful in assigning topics for various available methods: http://onlinelibrary.wiley.com/doi/10.1111/j.1936-704X.2005.mp132001002.x/pdf

Students will have to repeat topics, if this is a concern for the presentation portion of this lesson see alternative presentation ideas below.

Day 3: Each Pecha Kucha presentation should take no more than 2.5 minutes, however there will be some time necessary for switching between students and questions. When students play their Pecha Kucha, they should be able to answer questions from the class about their topic. Depending on the size of your class this may take more than 1 day to complete. A rubric has been provided for these presentations. You can allow students to grade each other and themselves.

An alternative method for this (depending on available technology) to prevent redundancy in presentations would be to have students record their presentations and post them online (Youtube, Vimeo, or a host of others) instead of all presenting in front of the class. This is also helpful for any parent exhibition nights that the school is involved in as they can then be linked to QR codes (https://chrome.google.com/webstore/detail/the-qr-code-generator/gcmhlmapohffdglflokbgknlknnmogbb?hl=en) for parents to watch. If the presentations are made on Chromebooks (or similar), the camera on it is typically sufficient to accomplish this.

At this point, you have the option to stop here or continue on to have your students learn more about desalination.

Day 4: Building working models to better understand complex processes is often helpful in understanding them, however not always practical. Show the following video of the most widely used ocean desalination technique in the United States before having students perform their own experiments to better understand the associated principles: https://www.youtube.com/watch?v=mZ7bgkFgqJQ (Ocean desalination explanation video)

Following the video, it will be obvious that building a representative model of the ocean

desalination process isn't feasible, however, the principle of osmosis can still be explored and discussed as how it can be reversed and manipulated for industrial implementation. The following lab activity works well for this and could be set up during the remainder of this day. http://ed.fnal.gov/arise/guides/bio/1-Scientific%20Method/1f-OsmosisDiffChallenge.pdf

Alternatively, you could use the Water Education Today activity "Humans and Saltwater?"

Day 5: Use the beginning of this period to complete osmosis lab measurements.

Following the wrap-up of that lab, begin students on a final lab activity for this unit where they can explore small scale desalination by evaporation. Use the attached pdf for directions and the following link for more information on constructing your own solar still. http://science.howstuffworks.com/environmental/green-science/sun-clean-water.htm

For a more advanced desalination activity, you could use the "Desalination by Distillation" lab.

Day 6: Now that students are well versed in the various methods and applications for desalination, it is time to apply that knowledge to a real world application. California American Water Co. has a water desalination project via reverse osmosis underway in the Monterey Bay area. Information on it can be found at http://www.watersupplyproject.org/. Have students watch the following video: https://www.youtube.com/watch?v=TzHQL8b3IBc

After the video, have students (as a class) find information online then discuss the following (either as a class or in small groups).

- Why did Monterey need to find a new water source?
- Why did Cal Am choose this method of desalination for the project?
- What will happen to the salt that is removed from the water?
- How much water will be prepared per day?
- How do you think the public will respond to this project?
- What things are done in a project such as this to mitigate risks to the environment?
- What are the environmental effects of the project?
- What would be the environmental effects of trying to get water from another source?
- How do the various methods of water desalination compare?
- How much will this project cost? What is your opinion of the cost of this project?
- What do you predict are future changes to larger scale water needs for this country?
- Who should be responsible for providing water to communities?

SAFETY/SECURITY ISSUES:

Remind students about plagiarism and what type of sharing is appropriate and what is not.

References:

Scoring Rubric for Pecha Kucha

PRESENCE -body language & eye contact -contact with the public -poise -physical organization	**5**	**4**	**3**	**2**	**1**	**0**
LANGUAGE SKILLS -correct usage -appropriate vocabulary and grammar -understandable (rhythm, intonation, accent) -spoken loud enough to hear easily	**5**	**4**	**3**	**2**	**1**	**0**
ORGANIZATION -clear flow -logical structure -signposting (text usage, font, etc)	**5**	**4**	**3**	**2**	**1**	**0**
MASTERY OF THE SUBJECT -pertinence- answer posed questions for project -depth of commentary -spoken, not read -able to answer follow up questions	**5**	**4**	**3**	**2**	**1**	**0**
OVERALL IMPRESSION -very interesting / very boring -pleasant / unpleasant to listen to -very good / poor communication	**5**	**4**	**3**	**2**	**1**	**0**

TOTAL SCORE _____ / 25

Solar Still Lab Activity

Objective

Build a solar still that will demonstrate the utility of evaporation for a process to desalinate water. Measure the production rate of the process and evaluate it as a viable source of obtaining clean drinking water in intermittent drought cycles.

Equipment

- Large metal or plastic bowl
- Clean, shallow glass or cup
- Measuring cup and spoons
- Plastic wrap large enough to cover bowl
- Ruler
- Small weight like a fishing sinker or stone
- Hot water
- Food dye
- Salt

Method

1. Take all equipment to a sunny area to conduct lab activity
2. Add hot water to the bowl to premeasured height of 1 cm.
3. Add food coloring and 1 tsp of salt
4. Measure the volume of salt water and record in lab notebook
5. If available, use a salinity probe (Vernier or similar) to measure the salinity of the starting brine
6. Place the cup in the middle of the bowl
7. Cover the bowl with plastic wrap sealing the bowl
8. Place the weight in the middle of the plastic wrap directly above the center of the cup
9. Leave for at least one hour (more time is better)
   *Note- You may wish to initially set up this experiment early and have students rotate between periods, meaning that your first class will set up their experiment to be measured by the next class while they conduct the following steps on materials set up before they got there. This will allow them to move on without waiting but requires a starter batch so each class has something to measure as the day progresses.
10. Carefully remove the cup being sure not to spill any of the water and take materials back inside for measurement
11. Measure the amount of water collected in the cup and record in lab notebook
12. Measure the remaining brine in the bowl and record in lab notebook
13. If available, measure the resulting salinity of the brine
14. Calculate the percentage of water that was purified:
    % purified water = volume collected in cup/volume added to still x 100
15. Analyze results and answer follow up questions.

Follow Up Questions

1. From your observations during the activity, how would you say the still works?

2. Based on your data and observations, what do you predict the "purity" of the water is and why?

3. Do you feel that this would be a viable option for large scale water treatment? Why or why not?

4. Reflecting on this activity, how do you think the still could be designed to work better?

5. Draw a representation of your proposed improvements.