Should Our City’s Wastewater Treatment System Produce Ammonia?

Middle School • Discipline: Earth Science • Time: One 50-minute class period

Lesson Level Performance Expectation: Students construct an argument to explain how Will Tarpeh’s method of producing ammonia reduces negative effects on Earth.

What Students Will Figure Out
• Ammonia is currently a necessary component of large-scale agriculture.
• The traditional method of ammonia production requires burning fuels that release CO2 into the atmosphere.
• Will Tarpeh’s method of separating ammonia out from urine will minimize the release CO2 into the atmosphere.

Lesson Snapshot:
Middle school students, as scientists, investigate a new method of ammonia production to answer the following driving question: Should our city’s wastewater treatment system produce ammonia? Students obtain information from the Our Beautiful Planet: Liquid Gold film, two data sets, and resource materials from their local wastewater treatment agency. Students describe the effects of traditional ammonia production on the environment and compare them to the new method. Students evaluate this information and their previously built understanding of Earth Science ideas to construct an argument about whether their local wastewater treatment system should adopt the new method of ammonia production proposed in the film.
Phenomenon:
A new technology can produce ammonia while reducing negative impacts on Earth.

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<th>Science and Engineering Practices</th>
<th>Disciplinary Core Ideas</th>
<th>Crosscutting Concepts</th>
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<td>Engaging in Argument from Evidence</td>
<td>Patterns</td>
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<td>• Construct an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem.</td>
<td>• Typically as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise.</td>
<td>• Relationships can be classified as causal or correlational, and correlation does not necessarily imply causation.</td>
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This lesson could be one in a series of lessons building toward:
MS-ESS3-3. Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment. [Clarification Statement: Examples of the design process include examining human environmental impacts, assessing the kinds of solutions that are feasible, and designing and evaluating solutions that could reduce that impact. Examples of human impacts can include water usage (such as the withdrawal of water from streams and aquifers or the construction of dams and levees), land usage (such as urban development, agriculture, or the removal of wetlands), and pollution (such as of the air, water, or land).]

Materials

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<th>Teacher Materials</th>
<th>Optional Teacher Resources</th>
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<tr>
<td>Per Student</td>
<td>• Our Beautiful Planet: Liquid Gold film</td>
<td>• Should Our City's Wastewater Treatment System Produce Ammonia? collection of resources</td>
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<tr>
<td>• Liquid Gold Data Sets</td>
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<td>• Liquid Gold Evaluation Handout</td>
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<td>• Wastewater Treatment System Information</td>
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<td>• Optional: Tablet or computer for research</td>
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<td>Per Small Group (2 to 4 students)</td>
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<td>• none</td>
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Lesson Preparation

Recommended Prior Instruction
We recommend that this lesson be used after or near the end of a unit about human impacts on the environment. Students should bring an understanding of
• How human activities release carbon dioxide into the atmosphere.
• How increasing levels of carbon dioxide in the atmosphere is a major factor in the current rise in Earth's mean surface temperature.
• The effects of the rise in Earth's mean surface temperature (storms, sea level rise, heat waves, droughts, etc.)

Wastewater Treatment System Research
• Students will need information about your town or city's wastewater treatment system to complete their evaluation.
  - Ideally, students have access to information about the system, the number of gallons processed, and the cost of wastewater treatment.
  - Example: New York City Wastewater Treatment Process, Wastewater Treatment in New York City, and New York City Water and Wastewater Rate Report – FY 2020
• Determine how you will share this information with students. (handout, Google Doc, slide deck, etc.)
• If this is a practice you want students to develop, plan to add another 45 minutes for student research.
Experience the Phenomenon

What Students are Doing:
In this section, students analyze graphs about human population, arable land, and fertilizer use and generate a question to investigate.

Teacher Guidance

1. Tell students there are going to analyze several different graphs that represent large data sets showing changes over time.
   Direct students to create T-Charts and label one side of the chart “Notice” and the other side of the chart “Wonder.” Share the Part One Data Set (page 1) with students. Instruct students to begin writing their noticings and wonderings in their T-Charts.

2. Develop a “Notice and Wonder” chart for the class.
   Ask students to share what they have noticed and wondered about the two data sets. Use chart paper, an interactive projection screen, board, or other option where all students can see to record student ideas.
   Students will probably ask what “arable” means. If students surface this question, share with them the definition: used or suitable for growing crops.

   Some student observations and questions could include:
   - The world’s population will be over 9 billion by 2050
   - For the most part, the amount of the world’s predicted available arable land stays the same over time
   - How many people can live on Earth? (How many people can the Earth support?)
   - Why has the number of people on Earth increased over time? Why is it predicted to continue to increase?
   - What advances in technology/medicine/farming have allowed for the population to grow this much?

3. Point out that many students have asked questions about how the population growth happened and transition to Part Two of the Data Set.
   Note that some students suggested that the amount of food available is probably connected to the number of people, since humans need food to survive. Tell students that to continue thinking about the food-population connection, they will focus on the farming practices that have supported human population growth. Tell them that they will analyze additional data and add to their Notice/Wonder charts. Direct students to the Part Two data set (pages 2-4).
   Repeat the process of having students share their observations and questions.

   Some student observations and questions could include:
   - As the population increased, so did fertilizer consumption.
   - About half of the world’s population is fed using synthetic fertilizer.
   - More nitrogen fertilizer is made than other types of fertilizer.
   - Where does fertilizer come from?
   - How is fertilizer made?
   - What impacts do fertilizers have on the environment?

4. Tell students that they will next watch a film that discusses how scientists are investigating many of the questions they have raised. Project the Our Beautiful Planet: Liquid Gold film and play the entire video. Instruct students to continue to add to their “Notice/Wonder” charts as they watch the video.
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Suggested Prompts:

• Ask students who have identified information from the film that answers the following questions to share their ideas with the class: How is fertilizer made? What impacts do fertilizers have on the environment?
• Ask students who have questions and ideas related to how Will Tarpeh’s method works and how it reduces human impacts on the environment to share their ideas with the class.

5. Lead an initial ideas class discussion of questions about Liquid Gold. Create a class record of information shared on a poster, slide, or board. Encourage students to think about ways their city could help reduce the impact that producing ammonia has on the environment. Student questions should converge on a question similar to Should our city’s wastewater treatment system produce ammonia?

Suggested Prompts:

• What did the data set tell us about the world’s need for ammonia-based fertilizers?
• What effects on the environment does the current method of ammonia production have?
• What is Will Tarpeh trying to figure out?
• What is the next step Will Tarpeh is hoping will happen for his work?

Inform students that they will construct an argument to answer their question in the next section of the lesson.

Additional Guidance: Connecting to Students’ Background Knowledge and Prior Experiences
If time allows, consider starting the discussion by making connections to their prior experiences:
• Ask students if they have ever planted a garden or visited a large commercial farm?
• Ask students to review what they know about the causes and effects of human impacts on the environment.

Additional Guidance: Class Discussions
For more information about different types of class discussions and class discussion facilitation, consult the OpenSciEd resource 3 Discussion Types.

Investigate the Phenomenon

What Students are Doing:
In this section, students obtain information from the Our Beautiful Planet: Liquid Gold film and resource materials from their local wastewater treatment agency. Students describe the effects of traditional ammonia production on the environment and compare them to the new method. Students evaluate this information and their previously built understanding of Earth Science ideas to construct an argument about whether their local wastewater treatment system should adopt the new method of ammonia production proposed in the film.

Teacher Guidance

1. Tell students that they will now work with a partner to consider adopting Will Tarpeh’s method of producing ammonia at their local wastewater treatment plant.
Students will use evidence from the film, the data sets, and resources from their local wastewater treatment system to construct an argument. The argument should take into account the cause and effect relationships between each method of producing ammonia and their impacts on the environment.

2. Direct students to begin working. Provide students with the Wastewater Treatment Resources you chose and the Evaluation Handout.
Suggested Prompts to draw out cause and effect relationships:

- Consider showing the film an additional time if students need to include more evidence.
- How does the current method of ammonia production affect the amount of carbon dioxide in the atmosphere?
- How does the amount of carbon dioxide in the atmosphere affect the environment?
- How does Will Tarpeh’s method of ammonia production affect the amount of carbon dioxide in the atmosphere?
  How does the amount of carbon dioxide in the atmosphere affect the environment?

Students will likely share the following information obtained from the film, resources, and data sets:

- Humans need ammonia to grow plants for food.
- Will Tarpeh found a way to produce ammonia from urine.
- The current method of creating ammonia for fertilizer requires burning a lot of fuels that release CO₂ but this method would minimize the release of CO₂ because ammonia already exists in urine.
- Will Tarpeh’s method involves using membranes to separate the substances in urine. The first membrane separates substances based on the charge of the substances, the second membrane separates substances based on their phase (liquid, solid, or gas). The second membrane only lets gases in. Ammonia is the only substance that is a gas at the temperature inside the chambers.
- It is important to reduce the amount of CO₂ that human activities release into the atmosphere because higher amounts lead to higher temperatures which can lead to storms, drought, sea-level rise, etc.

Additional Guidance: Class Discussion of Arguments

If time allows, consider bringing groups or the whole class together to discuss their arguments. The following questions could be used in the discussion.

Questions:

- What evidence did you use to support your argument?
- How does ___ affect ___?
- How will the method you chose produce ammonia?
- How will the method you chose reduce human impacts on the environment?

Reflect on the Phenomenon

**What Students are Doing:**

In this section, students reflect on how to improve their argument.

**Teacher Guidance**

1. **Ask students to consider the following question:** What additional information would you need to make a stronger argument?

2. **Ask for volunteers to share their ideas with the class.**

   Student answers could include the following:

   - More information or a better understanding of how Will Tarpeh’s method separates ammonia from other substances in urine.
   - Information about how much it would cost for a city to implement Will Tarpeh’s method.
   - Information about how much money ammonia for fertilizer costs.
   - Information about how much fertilizer is used in the United States each year. The graph on Page 4 of the data set shows the world consumption of all types of fertilizers.