Disappearing Dipoles: The Irrigation Evaporation Enigma

By Diedre Young, Soybean Science Challenge

THIS IS A MULTI-DAY LESSON

Arkansas Integrated Chemistry and Engineering NGSS Suggestions:

Cl-ESS2-5: Plan and conduct an investigation of the properties of water and its effects on earth materials and surface processes.

Science and Engineering Practices: Planning and Carrying out Investigations (Cl-ESS2-5), Using Mathematics and Computational Thinking (Cl-PS1-7)

Crosscutting Concepts: Structure and Function (Cl-ESS2-5), Stability and Change (Cl-PS1-6)

Disciplinary Core Ideas: ESS2.C: The Roles of Water in Earth' Surface Processes (Cl-ESS2-5). ETS1.C: Optimizing the Designing Solutions (Cl-PS1-6).

Connections to Arkansas Disciplinary Literacy Standards: WHST.9-12.7, WHST.9-12.9

Connections to Arkansas Mathematics Standards: MP.2, MP.4, HSN.Q.A.3

Cl1-ETS1-2: Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

Science and Engineering Practices: Constructing Explanations and Designing Solutions (CL1-ETS1-2)

Crosscutting Concepts: Structure and Function (CL-ESS2-5)

Disciplinary Core Ideas: ETS1.C: Optimizing Design Solutions (CL1-ETS1-2)

Connections to Arkansas Disciplinary Literacy Standards: WHST.P-12.7, WHST.9-12.9

Connections to Arkansas Mathematics Standards: MP.2, MP.4, HSN.Q.A.3

Cl-ESS3-4: Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.

Science and Engineering Practices: Constructing Explanations and Designing Solutions (Cl-ESS3-4). Using Mathematics and Computational Thinking (Cl-PS3-1)

Crosscutting Concepts: Stability and Change (Cl-ESS3-4), Consistency in Natural Systems (Cl-ESS1-2).

Disciplinary Core Ideas: ESS3.C: Human Impacts on Earth Systems (Cl-ESS3-4)

Connections to Arkansas Disciplinary Literacy Standards: RST.11-12.7, RST.11-12.8

Connections to Arkansas Mathematics Standards: MP.2, HSN.Q.A.1, HSN.Q.A.2, HSN.Q.A.3

Cl3-ETS1-1: Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.

Science and Engineering Practices: Asking Questions and Defining Problems (Cl3-ETS1-1).

Crosscutting Concepts: Influence of Engineering, Technology and Science on Society and the Natural World (CL3-ETS1-1).

Disciplinary Core Ideas: ETS1.A: Defining and Delimiting Engineering Problems (Cl3-ETS1-1).

Connections to Arkansas Disciplinary Literacy Standards: RST.11-12.7, RST.11-12.8, RST.11-12.9

Connections to the Arkansas English Language Arts Standards: SL.11-12.5

Connections to Arkansas Mathematics Standards: MP2, MP4,

Objective: Students will use critical thinking to engineer an alternate solution to the large amount of water loss farmers encounter when irrigating their crops.

Assessment: Students in a group will do a round robin of their engineering projects, including cost and overall rate of water retention/loss.

Key Points: Evaporation, water loss, engineering projects.

Materials:

- Soybean Seeds
- Plastic containers (can be margarine tubs, yogurt tubs, cut 2L soda bottles etc.), at least four per group of four students (six plants in two for experimental and six plants in another two for control group).
- Potting soil (for optimum growth)
- Plastic straws glued together with consistent sized holes in them (to simulate a poly-pipe).
- Notebook for data collection
- Various materials for engineering design. Depends on student group.
- Humidity (or water) measurement devices.

Preparation:

Soybean plants work well for this lesson. They are easy to grow and sprout in about eight to ten days. Seeds can be obtained through the SSC on-line seed store. Go to the seed order link, (www.uaex.uada.edu/soywhatsup). Seeds are shipped out within a week of ordering. Students will need about a week to obtain materials for their engineering project. Another option is to have a set number of materials on hand for the whole class to use. Straws need to be glued and holes punched in them for use by students. Two straws per experimental and two for the control group should do it.

Time Duration:

Soybean plants take about a week to sprout so assume a week for the plants, a week for student brainstorming, planning and material acquisition (which can be done while waiting for plants to grow) and a week for building and experimenting. *Suggestion: to get the students invested in the lesson, have them plant the seeds in anticipation of the project.*

Teacher Note*: Ideas for designs could be different types of materials rather than plastic straws. Other ideas include insulating the straws, use thicker straws or make the holes smaller (reduce heat transfer). Another thought is to cool the water (increase the temperature difference). Students could also cover the straws and soil to increase condensation back to the soil.*

Elicit:

Start the lesson by asking students "What is evaporation?" and then "How does evaporation tie into the water cycle?" Get students thinking about evaporation and plants by inquiring "What do plants need to grow?" Students should mention water as an essential need for plants. Ask the question "How do plants receive water?" Comments such as rain, underground springs etc. will come up. Query the students, "If they are growing a garden, what will they need to do to ensure growth?" Water should be one of the answers. Examine the question "if it doesn't rain then what does a farmer do?" Irrigation should be the obvious response. Do a KWL chart about what students know about irrigation. Questions such as types of irrigation techniques and amount of water used should be addressed in the chart.

Engage:

Show the video *Irrigation for Agriculture* https://www.youtube.com/watch?v=24LJSJqpYuY to get students engaged in the project.

Explore:

Farmers are constantly aware of the amount of water they use to irrigate their crops. Water costs money and irrigation is a huge business when it comes to crop production. Farmers are always looking for ways to conserve water; lower water usage means less cost, better sustainability, and less erosion.

It is the students' job to design and implement an alternative to current irrigation techniques. This will require groups to brainstorm a project, acquire the necessary materials, build the prototype, and experimentally implement the prototype with soybean plants. Student groups will be looking for an overall decrease of evaporation from the control group. Have students brainstorm measurement ideas. Some ideas for measurement can be using a humidity tester or drying the soil of both the control and experimental plants and calculating the difference. Once measurements are complete, student groups will present their findings in a round robin setting.

Explain:

Irrigation literally feeds the world. It has opened the doors for large crop production and multiple season growths. The downside to irrigation is it comes with a lot of water evaporation. Evaporated water, while great for the water cycle, doesn't get to plants and this means more water is needed to add to crops to adjust for water loss. Increased water means more erosion, more runoff, an escalation of salts in the soil and an increase of cost to the farmer.

This would be a good time to cover the properties of water; its uniqueness (excellent solvation, dipole characteristics, different phases within a narrow temperature range, cohesion, and surface tension, etc.) and its crucial role in life.

There are several types of irrigation. The most common are surface irrigation (such as water running in ditches between rows), sprinkler systems and poly-pipe (pipes with holes in them run down rows to reduce evaporation and gets water to the plants at the spot). Of the three, poly-pipe is the best for water conservation, but can we do better? Can an alternative irrigation method be found that decreases evaporation to a lower level than poly-pipe?

Elaborate:

Break the students into groups and, based on what was seen on the video and what was just covered, have the students do literary research on different irrigation techniques. Students should include research on how to manually decrease evaporation through engineering as a way to block water loss. Students should come up with a research question, hypothesis, and engineering plan. If the engineering plan is doable and measurable, then a student group can try it. Students will need to present how they built their prototype and its success or failure at reducing water loss from evaporation compared to the poly-pipe irrigation at the end of the lesson.

Research website suggestions:

https://www.uaex.uada.edu/publications/pdf/mp197/chapter8.pdf

https://www.uaex.uada.edu/media-resources/news/june2017/06-21-2017-Ark-surge-irrigation-fact-sheet.aspx

https://www.uaex.uada.edu/counties/greene/docs/AG-files/22-29-irrigation-tools-beds-project.pdf

https://www.uaex.uada.edu/media-resources/news/november2015/11-06-2015-Ark-Poly-pipe-cost-share.aspx

http://www.fao.org/docrep/T7202E/t7202e08.htm

https://www.uaex.uada.edu/media-resources/news/november2015/11-06-2015-Ark-Poly-pipe-cost-share.aspx

https://www.uaex.uada.edu/publications/PDF/FSA-9512.pdf

Evaluate:

Students will do a round robin about their findings, presenting their engineered prototype and their data collected from the engineering experiment compared to the poly-pipe control. A research paper on the prototype and a reflection paper on what they learned will be handed in by each student.

Extend:

End the lesson with how evaporation and the properties of water have huge impacts on our food supply.

After the round robin, have students debate their project's success in comparison to other projects in the classroom.

Have the students do an economic impact paper on water savings using their engineering project.

Have a local farmer do a presentation in the classroom of the impact irrigation has on crops and the costs involved with irrigation.

Have the class do a presentation of their findings at the local County Extension Office.