Lesson 1- Soil Stabilization and Concrete Reduction

Whole Objective: ESWBAT compare solutions for soil stabilization and fugitive dust control in Arizona. Students will explain the environmental impact of proposed methods for concrete reduction and fewer dust emissions as well as economic implications of soil stabilization.

Evidenced by (Learner Evidence):

- Completed lab report for soil stabilization and fugitive dust control
- Comparative analysis poster (1 per group of 4) explaining the problem, proposed solutions, research, lab results, and future applications.

Arizona Standard(s): Concept 2: Science and Technology in Society Develop viable solutions to a need or problem.

- PO 1. Propose viable methods of responding to an identified need or problem.
- PO 2. Compare solutions to best address an identified need or problem.

NGSS: Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions (MS-ETS1-1.)

ELA/Literacy -

Cite specific textual evidence to support analysis of science and technical texts.
Gather relevant information from multiple print and digital sources, using search terms effectively; assess the credibility and accuracy of each source; and quote or paraphrase the data and conclusions of others while avoiding plagiarism and following a standard format for citation.

Mathematics -

Reason abstractly and quantitatively.
Solve multi-step real-life and mathematical problems posed with positive and negative rational numbers in any form (whole numbers, fractions, and decimals), using tools strategically. Apply properties of operations to calculate with numbers in any form; convert between forms as appropriate; and assess the reasonableness of answers using mental computation and estimation strategies.

Length of time: 160 min (2 class periods) Lecture and Lab. 5 days of data collection.

Materials: Powerpoint presentation, card stock paper, masking tape, multipurpose sand, aluminum containers, xanthan gum, spray bottles, transfer pipettes, Enzyme solution for EICP mimicry, paver bricks, spray bottles, distilled water.

Sub Objective	Teacher Action	Student Action	Evidence
Intro/hook- Teacher will demonstrate fugitive dust by placing multipurpose sand in front of small fan.			
SW be able to explain the purpose of EICP and the field of Biogeotechnical engineering	TW provide students with current research and background information on Biogeotechnical engineering and EICP	SW read together in pairs, annotating the text provided. SW answer the reading comprehension questions.	Annotated text and completed reading comprehension questions

	TW provide students with card stock paper to serve as a draft for research poster.	SW complete a draft of section 1 (explain the problem) using the information provided and knowledge gained from the lecture	Completed draft of section 1 – statement of the problem
ESWBAT compare solutions for soil stabilization and fugitive dust control in Arizona. Students will explain the environmental impact of proposed methods for concrete reduction and fewer dust emissions as well as economic implications of soil stabilization.	TW provide students with soil stabilization and fugitive dust control lab supplies and data collection sheet TW facilitate the completion of the laboratory and support groups in need of assistance TW have students continue to collect data over the next 4 school days TW have students complete the final drafts of their research posters TW have students complete the final version of the research poster	SW complete the lab following directions provided and adhere to lab safety rules SW gather data by completing day 2-5 instructions SW compile the data from all days and begin to complete the research poster SW use Google Slides to complete their research poster	**Evidenced by (Learner Evidence):** ▪ Completed lab report for soil stabilization and fugitive dust control ▪ Comparative analysis poster (1 per group of 4) explaining the problem, proposed solutions, research, lab results, and future applications.

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Soil Stabilization and Fugitive Dust Control Lab

Materials

Pre-mixed EICP solution
(2) Aluminum Containers
Spray Bottle
250ml beaker
Multipurpose sand
Paver brick
Transfer pipette

Procedure

Your goal is to mix a soil sample that will best support a brick standing on end.

1) Using your materials, work with your group to make a mix you think will leave the least indentation from the brick.
2) Record and illustrate your final soil sample makeup in your lab notebook and the amount of polymer used and time it was injected. You don't want to use too much polymer as that would increase the cost! Remember you are trying to come up with a solution that is cost effective.
3) Once your mix is done, gently stand the brick upright in the center of your soil sample. Try not to push the brick down into the soil. Record the amount of Polymer you used in your notebook and calculate the cost (ml used * 125)
4) Let your brick stand overnight. The following day, gently remove the brick and measure the indentation that has been left. Record the depth.
5) Based on the results of your first sample, mix a second sample only this time spray the polymer across the surface of the stand. Let stand overnight again and measure results.
6) On the third day check the strength of your soil against a windy day (the fan) and see how much soil stays in the tray. Record your results.

Questions
Write your answers on a separate sheet of paper.

1. What did you learn about the delivery method of the polymer?
2. If you were to repeat the experiment once more, how would you change your soil mixture?
3. What other variables might affect a soil's effectiveness in holding up a building?
4. Based on what you learned, where might be a good place to build a new high rise in your town?

Name_____ Date_____ Class Period_____

Soil Stabilization and Fugitive Dust Control

What are hydrogels?

The three classical phases of matter on Earth are solid, liquid or gas. Phase transitions occur with sufficient change in pressure and/or temperature. For example, water (liquid) transitions to ice (solid) with a drop in temperature. Gelatin powder, such as Kraft Foods' Jell-O, is a solid. Empty a packet of Jell-O into a mixing bowl and add boiling water. Stir until dissolved and then chill. Now the material in the bowl is neither solid nor liquid nor gas; it's a hydrogel. Like a solid, hydrogels do not flow. Like a liquid, small molecules diffuse through a hydrogel. So what is a hydrogel? In 1926, Dorothy Jordan Lloyd stated that "the colloidal condition, the gel, is one which is easier to recognize than to define". Hydrogels are currently viewed as water insoluble, crosslinked, three-dimensional networks of polymer chains plus water that fills the voids between polymer chains.) The ability of a hydrogel to hold significant amount of water implies that the polymer chains must have at least moderate hydrophilic character. Returning to our discussion of Jell-O, what happened at a molecular scale that resulted in the formation of hydrogel? Collagen protein is extracted from skin, crushed bones, connective tissue and other animal parts, and then is partially hydrolyzed to make gelatin, a mixture of peptides and proteins. When gelatin is dissolved in hot water, the long protein polymer chains move freely in solution. As the solution cools, the motion of the polymer chains slows down. Polymer chains encounter each other and become entangled. As the degree of entanglement increases, water is trapped and immobilized. As a result, the material behaves in some ways like a liquid and other ways like a solid.

EICP soil improvement

EICP or enzyme induced calcium precipitate is a soil improvement technique that falls within the field of biogeotechnical engineering. Biogeotechnical engineering is a relatively new sub-discipline within geotechnical engineering. Biogetoechncial engineering techniques have steadily gained attention from geotechnical engineers within the last few years. Modern construction techniques developed to address practical problems may often cause adverse environmental impacts. EICP methods can help with environmental impact both pre and post construction.

Fugitive Dust

Fugitive dust can impact the environment and cause adverse health side effects. Fugitive dust has caused vehicle accidents due to reduced visibility, caused damage to homes, destroyed landscaping, and most importantly, increased the incidence of respiratory and cardiovascular conditions in the general population (USDA, 2013). Fugitive dust is a significant problem, specifically in Arizona. Over the past few years, construction sites around Maricopa County have been failing their air quality inspections. This accumulation of air quality inspection failures has caused the Environmental Protection Agency (EPA) to take action against the state of Arizona. The EPA fined the state of Arizona millions of dollars due to their lack of effective fugitive dust control. In turn, the state of Arizona is charging construction companies to pay for the state fines acquired from the EPA. In addition to the fines, Arizona is being threatened with a loss of federal highway funds.

This is a substantial issue for Arizona, and that is why they are allocating funds to implement new and effective methods of fugitive dust control. Current practice of fugitive dust control consists of constantly spraying the site with water, or using extremely expensive polymers to reduce erosion. These options work, but they are not cost effective. EICP is an effective, relatively cost effective, and environmentally friendly option for fugitive dust control. With further research it could become the new gold standard for erosion control. Water is considered the current “gold standard” of dust control, but in an arid environment it requires multiple passes over the course of a day to suppress dust. EICP stabilizes fugitive dust in a dry state. This means that our goal is to achieve a detachment velocity similar to that of water when we apply EICP solution to the soil. Detachment velocity is simply the velocity of wind moving over a surface that will cause soil particles to detach from their original surface. Typically the soils that have low detachment velocities are most susceptible to fugitive dust propagation are fine-grained soils. The soil in Arizona tends to be very silty, and that is why fugitive dust is such an issue in this area.

Questions

1) The author uses Jell-O as an example of hydrogels. What state of matter is Jell-O considered?

2) Describe what hydrogels are?

3) What does holding significant amounts of water imply about hyrdrogels?

4) What happens to polymer chains as Jell-O solution starts to cool?

5) Biogeotechnical is not formally defined in the passage. What do you thing biogeotechnical most likely mean?

6) What does EICP help with in the construction field?

7) What is one major contributor to fugitive dust?

8) Explain how fugitive dust is impacting Arizona.

9) What is considered the gold standard of dust control?

10) Explain what is meant by detachment velocity.