Riders of the Storm

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LESSON DETAILS

Subject Area(s): Environmental Mitigation

Focus Grade Level: 8th grade

Grade Level Range: 6th – 9th grade

RESEARCH BACKGROUND

The CBBG (Center for Bio-mediated, Bio-Inspired Geotechnics) at ASU (Arizona State University) studies a variety of ways to use Bio-Geo-Technics (life, Earth, art/skills) to improve environmental pollution issues. CBBG research alters Earth's crust using an enzyme mixture to strengthen and stabilize the first few centimeters of soil. Using EICP (Enzyme Induced Carbonate Precipitation) sand turns to thin sandstone. The goal of using EICP is to minimize dust particles from riding through the air which can impact humans and the environment.

What is the best way to strengthen the soil and develop nature-compatible methods for its use?

Students' tasks focus on learning to sort and then strengthen soil using an enzyme extracted from a plant bean. After a crust of sandstone is formed, using EICP (a plant-based mixture) sprayed on sand particles, we will test the strength of the new crust against wind and water erosion.

LESSON OVERVIEW

Soil crust solidification can be accomplished by spraying bio-mediated solutions to dirt at the ground level. This process turns fine sand into a crust-like sandstone material. Prior to treatment, flying dust particles are harmful to human respiration, increase environment erosion, and are a legally, monitored issue for industries like construction, mines, and dams.

Students will test various kitchen-sourced solutions to strengthen soil crust, and also determine various environments where a soil's crust strength would support natural hazard mitigation.

This unit is designed for four 80 min. class periods. The focus of this exploration is Lesson 3.

This unit utilizes the Engineering Process for Problem Solving: Identify the constraints/criterion, brainstorm solutions to the problem, select the most promising solution, a prototype of your solution, test and evaluate your prototype, iterate improve your prototype, communicate your solution.

Lesson 1: Exploring the Problem and the work of CBBG (Center for Bio-mitigated, Bio-Inspired, Geotechnics) understanding of EICP (Enzyme Induced Carbonate Precipitation) research.

Students will determine how 'dust storms' impact humans, society, and communities.

Students will understand how EICP (Enzyme Induced Carbonate Precipitation) penetrates into soil to strengthen it.

Engineering Processes for Problem Solving: Identify constraints/criterion and brainstorm solutions to the problem.

Question: What bio-mediated mixtures would be effective to create a 1-centimeter soil crust that can be tested for strength against wind and water erosion?

Students will explore the problem flying dust causes, and brainstorm solutions to mitigate dust exposure to human health and in our mainstream environments. Students will understand the research of ASU (Arizona State University) CBBG (Center for Bio-mitigated, Bio-Inspired, Geotechnics) understanding of EICP (Enzyme Induced Carbonate Precipitation) research. Consider the criteria and constraints of fugitive dust and explore variables to explore for testing.

The concept of 'Rider of the Storm' refers to dust particles that get caught in wind and/or water erosion processes, which might seem like mini storms to such small fine particles). Bio-mediated soil is developed by adding a nature-based mixture to soil to toughen its structure without harming the environment.

Important vocabulary (mitigation, criterion, constraint). Density (amount of space between particles) is also important since the space between sand granules is where EICP and other treatments are placed to create a crust on the soil. The student will draw soil granules and highlights the areas where mixtures have the greatest impact.

View (video Haboob) and ask students to discuss and share aloud the impacts associated with dust storms. Dust Storm Video: Time-Lapse Shows Haboob Blanketing Phoenix

Explain overview expectations of this unit to include ways of strengthening soil particles using bio-mediated mixtures to include: household products (as explored in our previous chemistry labs and CBBG's EICP).

Lesson 2: Mixtures for Creating Sand to Sandstone

Students will explore a variety of mixture choices to treat soil (household products, water, EICP).

Students will complete a lab creating the EICP solution components.

Students will discuss and complete a rubric criterion of at least 3 different parameters of measuring treated soil strength against erosion from wind and water.

Engineering Processes for Problem-Solving: Select the Most Promising Solution and Prototype of Your Solution

Review mixtures to improve the strength of sand from wind and water erosion. Create a rubric to guide and score students on effective ways to test and compare treated sand surfaces. Discuss and display products:

Mixture 1 - Obleek (3 beakers of separated products: cornstarch, water, and sand)

Mixture 2 – White Liquid Glue (3 beakers of separated products: white liquid glue (bottle in a beaker), water and sand)

Mixture 3 - Xanthan Gum (3 beakers of separated products: xanthan gum, water and sand)

Mixture 4 - *EICP components are (previously prepared and kept refrigerated)

EICP – 2 beakers (soaked Jack beans (blended and strained through cheesecloth mixed with dried milk in one beaker and the other beaker urea, carbonate with DI water - De-Ionized water). The 2 beakers are separated to prevent the chemical reaction that caused carbonate bubbles. Later it will be mixed and placed in a spray bottle for use within 1-2 minutes after mixing for best results.

Videotape: Demonstrate how to make EICP (soaked beans blended, urea, carbonate, dried milk, De-Ionized water – DI water).

Lab Station 1: Brainstorm/Research - How could soil strength be tested against wind and water erosion?

Describe the quantitative measurements your team will collect to test the soil's crust strength.

Lab Station 2: Students will prepare their team's EICP solution for later use. Share instructional video:

Lesson 3:

Students will choose from a variety of mixture choices and methods to strengthen soil against wind and water erosion using household products, water, EICP.

Students will implement their team's treatment solutions on fine-grained soil surfaces (silicone cupcake molds). Students will perform strength tests in the next lesson after treatment has precipitated and dried (48-72 hours).

Students will finalize their team rubric, and then write the procedures of how to build the 3 different strength tests they are designing.

Lesson 4:

Students will test treated-dried soil surfaces using at least 3 parameters of treated soil strength against erosion from wind and water. (student-designed rubric)

Engineering Processes for Problem Solving: Iterate - Improve your prototype and communicate your current findings and/or solution.

Engineering Processes for Problem-Solving: Test and Evaluate Your Prototype

Overview of a basic experiment outline to describe an experiment that explores the question, research, hypothesis, procedures to build testing platforms and what is collected as data, 3 different data collections, data analysis, conclusions, reflections, and further tests.

Question: What bio-mediated mixtures would be effective to create a 1-centimeter soil crust that can be tested for strength against wind and water erosion?

MATERIALS AND EQUIPMENT

Demo Materials: Enzyme Extraction

2 Beakers

Mixture 1 – soaked and blended 'Jack beans' and non-fat milk powder

Mixture 2 – urea, carbonate calcium, water

Prepared cupcake mold(s) of fine-grain sand

Sprayer for placing blended solution on the sand surface.

Demo Materials: Sorted Soil

Stacking soil sorting pans (Set of 12 grain sizes, prepare for display all pans after sorting soil)

Highlight the finest-grain sand pan.

Highlight prepared EICP-treated pan of fine-grain sand (sandstone crust)

Materials (for 24-28 students, divided in 2 large groups, comprised of 2-3 smaller groups, 3-4 team members)

Lab Station 1: Brainstorm/Research - How could soil strength be tested against wind and water erosion?

Lab Station 2: Students will prepare their teams EICP solution.

Mixture 1 - Obleek (3 beakers of separated products: cornstarch, water and sand)

Mixture 2 – White liquid glue (3 beakers of separated products: white glue (bottle in a beaker), water and sand)

Mixture 3 - Xanthan Gum (3 beakers of separated products: xanthan gum, water and sand)

Mixture 4 - EICP (soaked Jack beans, blended, urea, carbonate, dried milk). *(previously prepared) kept refrigerated in 2 beakers separated (to prevent the chemical reaction, then mixed later in a spray bottle for demonstration. Share instructional video: Demonstrate how to make EICP (soaked beans blended, urea, carbonate, dried milk).

Lab 1: Making Solutions (per Team 4 student members)

Jack Bean Solution

- 50 gm beans (dried Jack beans) *optional - watermelon seeds or soybean x 10 = 500 gm
- 200 ml water
- Blender w/ glass pitcher (2 mins blend)
- Clean cheesecloths
- Soaked beans 24 hours
- 2 Beakers
- Urea
- Calcium Carbonate

Oobleck Solution

- 1/8 cup cornstarch powder
- Water to saturation
- 1/2 cup of saturated fine-grained sand (moist)
- 2 beakers

Glue Solution

- 1/4 cup white liquid glue
- Water to saturation
- 1/2 cup of saturated fine-grained sand
- 2 beakers

Xanthan gum

- ____ Xanthan gum
- Water to saturation
- 1/2 cup sifted fine-grain sand (moist)
- 2 beakers

Lab 2: Testing Equipment Soil Strength (per Team 4 student members)

- a Penetrometer
- a gram weights including 60 - 80 gm (various sizes)
- a small paper/plastic cups 4 -6 oz.

ATTACHMENTS

Worksheet: CER (Claim, Evidence, Reasoning) Question

End CER Worksheet

Worksheet: Vocabulary: Riders of the Stone

Facilitator, Timekeeper, Scribe, and Reporter

Lab 1 and 2 Worksheets

[Dust Storm Video: Time-Lapse Shows Haboob Blanketing Phoenix]

Educational Standards

Earth and Human Activities 8th grade

MS-ESS3-2. Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects.

Chemistry Activities 8th grade

MS-PS1-2. Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred.

Engineering Design Standards 6-8th grade

MS-ETS1-1. 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-ETS1-2 Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

MS-ETS1-3. Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.

MS-ETS1-4. Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

Learning Objectives

Lesson 3:

Students will choose from a variety of mixture choices and methods to strengthen soil against wind and water erosion using household products, water, EICP.

Students will implement their team's treatment solutions on fine-grained soil surfaces (silicone cupcake molds). Students will perform strength tests in the next lesson after treatment has precipitated and dried (48-72 hours).

Students will finalize their team rubric, and then write the procedures of how to build the 3 different strength tests they are designing.

Vocabulary

Mitigate/Bio-Mitigate	Reduce the negative impact of a problem. Use natural products to reduce the negative impact of a problem
Criterion/Constraint	Problem requirements or needs: Problems limitations: i.e. time money

Natural Hazard	Natural phenomenon that might have a negative effect on humans, organisms, or the environment
Well/Poorly sorted soil	Various sizes of rocks and sand 1-2 sizes of rocks or sand

LESSON PROCEDURE

INTRODUCTION/MOTIVATION

Students have been working on a rubric and testing procedures for an experiment using household materials for making sand become sandstone at a depth of 1 centimeter.

Allow students time to complete the hypothesis for their experiment using the warmup handout below. They will keep this worksheet with them and complete the bottom half after the lab.

Warmup Handout: 'Riders of the Storm' CER (Claim, Evidence, Reasoning).

Question: What bio-mediated mixtures would be effective to create a 1-centimeter soil crust that can be tested for strength against wind and water erosion?

Directions: Use the prompt below to write a bold hypothesis statement of which bio-mediated mixture your team has determined will be most effective in creating a 1 cm. soil crust. State your team's evidence and reasoning clearly.

Hypothesis:

The bio-mediated mixture that is most effective to create a 1-centimeter soil crust is _____

(claim)

When it is tested for strength against erosion our observations and research predict that

_____

(evidence - what data do you expect to see)

because _____

(reasoning – why?)

LEARNING ACTIVITIES/STRATEGIES

Once students have completed their hypothesis and had it checked off for completion with the instructor, they may begin the lab work with their team. Each team member has a role as described before: Facilitator, Timekeeper, Scribe, and Reporter

Labwork:

CBBG research focuses on transforming soil to a sedimentary stone. This is done by spraying a special solution on the upper crust made primarily of: Cornstarch, Glue, Xanthan gum, and/or EICP (Enzyme Induced Carbonate Precipitation) are our testing solutions. All are planet-based so they will not harm the soil or environment. It's very effective on fine-grain sand. Carbonate drinks have a gaseous component like bubbles in soda. EICP allows those bubbles to release space and cause precipitation of the sand grains downward.

Question:

What bio-mediated mixtures would be effective to create a 1-centimeter soil crust that can be tested for strength against wind and water erosion?

Hypothesis:

The bio-mediated mixture that is most effective to create a 1-centimeter soil crust is (claim). When it is tested for strength against erosion our observations and research predict (evidence) because (reasoning).

Using the lab work sheet, students will perform 2 Labs today:

Lab 1: Students will choose from a variety of mixture choices and methods to strengthen soil against wind and water erosion using household products, water, EICP (Enzyme Induced Carbonate Precipitation).

Lab 2. Students will finalize their team rubric, and then write the procedures of how to build the 3 different strength tests they are designing.

Closure

Help students bring it all together. Written toward the students.

Students will implement their team's treatment solutions on fine-grained soil surfaces (silicone cupcake molds). Students will perform strength tests in the next lesson after treatment has precipitated and dried (48-72 hours).

Assessment

Formative Assessment

Once teams have completed have their hypothesis reviewed, they may begin the lab work with their team.

Summative Assessment

Student will complete the following in writing: End CER Worksheet

Question: What bio-mediated mixtures would be effective to create a 1-centimeter soil crust that can be tested for strength against wind and water erosion?

Directions: Now that you have some experience with the materials, have discussed more with your team and thought more completely about how the solutions might react to the strength test, rewrite your hypothesis statement in the space below the dots line. Which bio-mediated mixture has your team determined will be most effective in creating a 1 cm. soil crust. State your team's evidence and reasoning clearly.

CONTRIBUTORS

INDIVIDUALS

List the names of any person who participated in the development of this instructional unit (teachers, mentor, lab director, education staff, etc.).

Dr. Edward Kavazanjian - Project Professor

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Anju Kharbanda – team support and Lab partner

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REFERENCES

List citation information for any graphics or copyright material used in the development of this lesson.

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