From Dirty to Clean

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Overview

The purpose of this activity is to showcase various passive options for cleaning watersheds, such as rivers or streams. Passive remediation is a consistent improvement of water quality without the continuous addition of a treatment source. It can be human-made or natural as long as it is able to maintain efficiency once in place. *From Dirty to Clean* will serve as a foundation to introduce passive treatment options and how they work to clean contaminated water. The participants should be given the following scenario: Mine drainage contamination has resulted in a polluted creek (or applicable watershed) in their community. The pollution has resulted in acidic water and high levels of iron contamination. Three stations will be set up to represent 3 treatment options: Limestone (pH), plants (filtration), and bacteria (metal removal). The students will rotate through the stations, identifying the various characteristics of each treatment and how they will impact the effectiveness of the technology. The students will then construct their own remediation system based on the information that they collected from each station. Laminated remediation components will be provided to allow the students to build their system. The order in which the treatment options are placed will determine overall success of the treatment system. Alternatively, this activity can be used at a tabling event where participants can "drop in" and explore one (or all) of the remediation option stations.

Learning Goals

1. To learn about water contamination sources and how they impact ecosystems and human health.
2. To learn about different types of passive remediation options and how they can be combined for optimal performance.
3. To explore how existing resources (i.e. vegetation) can be used to clean contaminated watersheds.

Materials

- Included in the kit:
    - Activity flyer
    - (3) Passive option cards (limestone, bacteria, and plants)
    - Water contamination information sheet
    - pH scale

- (3) Velcro bases and the Velcro treatment options that will be used to build the passive system
- (6) silver spoons for scoping limestone
- (5) 50 ml falcon tubes
- Container of pebble limestone
- (1) bottle of Methyl Orange pH Indicator (0.1%)
- Strainer funnel with plants attached
- (5) Circle filters
- Collection cup with silver handle
- Container of iron hydroxide
- (1) Small and (1) medium bowl
- (50) Magnetic beads
- "Bacteria" pond containers (green water)
- "No Bacteria" pond containers (blue water)

- Not included in the kit:
  - Lemon juice
  - Water
  - (1-2) Water pitchers

Set-up

1. Activity 1: Limestone raises the pH of acidic water.

   a. Make lemon water by mixing the following: 50 ml of water + 2 ml of lemon juice ii. This can be scaled up to account for large crowds.

   b. Pour Lemon water into 1-4 falcon tubes (no more than half full) and put two drops of Methyl Orange Indicator. It should be pink in acidic water.

2. Activity 2: Plants work as a filtration system to remove contaminants.

   a. Fill a 50 ml falcon tube with iron hydroxides to the 5ml line.

   b. Fill the tube with water (to 50 ml line), place the cap on tight, and shake well.

   NOTE: Will be an orange solution and **can stain.**

   c. Place the round filter into the funnel.

   d. Place the funnel into a cup.

3. Activity 3: Bacteria help to remove trace metals.

   a. Pour a cup of water and lay out metal beads.

Procedure

Short Form

The following 3 activities can be performed as individual drop-in activities or 1-3 of the activities can be completed. All of the activities are surrounded by one uniting concept: water remediation using naturally occurring options (i.e. passive remediation).

1. Activity 1: Limestone raises the pH of acidic water

   a. Participants will add a half of a spoon full of limestone powder and swirl.

   b. The color will turn orange indicating a raise in pH.

   c. The pH scale provided allows participants the ability to predict how the pH will change with the addition of limestone, as well as to point out the impacts pH has on fish.
2. Activity 2: Plants work as a filtration system to remove contaminants.

   a. Pour the iron water into the funnel and observe the filtration. Note: Filtration can be slow and may get clogged.

   b. Plants do not completely remove contamination and as such the water will improve, but not be completely clear. The filters can be rinsed and reused throughout the activity.

   c. Participants can discuss how strategic placement of plants may be important due to the clogging that can occur.
3. Activity 3: Bacteria help to remove trace metals (iron, manganese, nickel, lead, etc.).

   a. Place 6-10 colored magnetic beads into a cup of water.

   b. Let the participants pick the number of beads they want to add to the water. This represents the metal contaminants found in the water

   c. Pour the bead/water solution in the “pond container” that has no “bacteria”.

   d. Again, pour the solution back into the original cup and note how many beads remain. All the beads should return to the original cup with no beads remaining in the “no bacteria pond”.

   e. Repeat the experiment but this time pour the bead/water solution into the “bacteria” container and swirl.

   f. Then pour solution back into the original cup and note how many beads remain in the water. All the beads should remain in the “bacteria pond”. This is because the bacteria pull the metals from the solution, making the water safer.

   g. This can be repeated with more or less beads and the participants can discuss how more/less metals can impact the ability for bacteria to remove it.

Definition of Success

Success is met when participants can identify different naturally occurring options for removal of contamination in impacted watersheds. The participants should leave with an understanding that water contamination is a problem across the United States and that there are natural remediation options that can be used to clean contaminated watersheds.

Long Form

As a *classroom activity*, the students will be given a background article before the day of the activity. The article will discuss water contamination and the environmental concerns associated with it. On the day of the activity, the students will rotate through the 3 activities and then develop a passive remediation system based on a given scenario. The long form works in a similar manner where the participants complete the 3 activities and then develop a passive system based on a given scenario.

1. Participants will complete all three drop in activities (described above) and then assemble their own passive remediation system based on a given contamination scenario (scenarios provided below).
   a. This can be repeated with a different contamination scenario.
2. Using the information that the participants learned in the individual activities, participants can discuss the benefits of using multiple remediation options to treat contaminated water.

Definition of Success

Success is obtained when the individual can assemble a passive remediation system. A secondary challenge can be providing the participants with a different contamination scenario.

Modifications and Guiding Questions

<u>Contamination Scenarios:</u> For the long form or classroom activity provide one of the following "contamination scenarios" to the participants.

Contamination Scenario 1: A well that is used for drinking water was contaminated because of nearby fracking. The contaminated well was found to be high in iron and arsenic (both trace metals), while the pH remained neutral.

Contamination Scenario 2: A stream used for recreational fishing and extracurricular activities has become void of all living organisms, including fish, insects, and plants. Upon further investigation, it was discovered that the water was contaminated from an old gold mine and is now highly acidic (<3 pH) and high in trace metals (lead, nickel, and cadmium).

Contamination Scenario 3: The local drinking water source in your community becomes overrun with algae growth and elevated levels of nitrogen, phosphorus, and uranium due to fertilizer runoff. The pH was still neutral.

Contamination Scenario 4: A creek that runs through your backyard turns bright orange, your parents tell you it is because your house is near an old coal mine. The water is orange because of the very high levels of iron and the neutral pH.

Contamination Scenario 5: Surface mining contaminates a local stream and results in the formation of a large pond that didn't once exist. The sign says beware of acid mine drainage and you discover that both the stream and the pond has a low pH (<2) and is high in trace metals (iron, manganese, and aluminum).

<u>Modifications: Short Form</u>

1. Activity 1, Limestone: Addition of more or less limestone to determine how much is needed to raise the pH.
2. Activity 2, Plants: Varying degrees of contamination can be made (1 ml, 5 ml, and 10 ml of iron hydroxide) so that participants can explore how plants filter the different degrees of contamination.
3. Activity 3, Bacteria: The number of magnetic beads (i.e. contamination) added to the water can change (up to 50 beads) to determine if efficiency decreases with higher amounts of contamination.

<u>Modifications: Long Form:</u> The short form modifications can be utilized in the long form activity. Additional "contamination scenarios" can be tested. Limitations can be applied to make construction of passive remediation more realistic to real life obstacles.

1. Limitations can include:
    a. Size limitations where only 1 or 2 passive options can be used.
    b. Multiple of the same passive options can/cannot be used.
    c. Money values can be assigned to the passive options and budget applied.

Guiding Questions: Short Form

1. What sources of water contamination do you think occurs in your area?
2. Do you think all water contamination is visible?
3. What are some examples of water contamination that we cannot see (e.g. metals like lead and arsenic)?
4. Why is the pH of the water important?
5. What would happen if the pH was too low?
6. How can plants be used to remediate water?
7. Why can we not just use plants to clean water?
8. What are bacteria (can you provide an example)?
9. How do the bacteria get in the water?
10. Do you think all bacteria are harmful?

Guiding Questions: Long Form

1. What sources of water contamination do you think occurs in your area?
2. Do you think all water contamination is visible?
3. What are some examples of water contamination that we cannot see (e.g. metals like lead and arsenic)?
4. Why is the pH of the water important?
5. What would happen if the pH was too low?
6. How can plants be used to remediate water?
7. Why can we not just use plants to clean water?
8. What are bacteria (can you provide an example)?
9. How do the bacteria get in the water?
10. Do you think all bacteria are harmful?
11. What are the benefits of passive treatment options?
12. Do all remediation options serve the same purpose (i.e. are they effective at performing the same task)?
13. Do you think that there are limitations in the remediation options to clean the water? (i.e. is there a time where the water is too contaminated or too much time has passed where it stops working)?
14. Does the order in which you place the remediation options matter?
15. How did you determine the best remediation options for each “contamination scenario”?
16. Are there other natural remediation options that can be used to remediate contaminated water?

Further Resources

- Freshwater contamination: https://www.nationalgeographic.com/environment/freshwater/pollution/
- Fracking contamination: https://www.psr.org/wp-content/uploads/2018/09/fracking-and-water- contamination.pdf
- Metal Mining Contamination (Gold Mining for this source): https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5129257/
- Fertilizer Runoff Contamination: https://cen.acs.org/articles/93/web/2015/08/Nitrate-Pollution- Trigger-Uranium-Release.html;
- Coal Mine Contamination:
- https://www.epa.gov/nps/abandoned-mine-drainage
- Information on Acid Mine Drainage Formation:
- https://www.usgs.gov/mission-areas/water-resources/science/mine-drainage?qt-science_center_objects=0#qt-science_center_objects
- Hedin Environmental – Paper Resources on Passive Remediation Systems: http://www.hedinenv.com/papers.html

NGSS Standards

K-ESS2-2 Earth's Systems

Construct an argument supported by evidence for how plants and animals (including humans) can change the environment to meet their needs.

K-ESS3-3 Earth and Human Activity

Communicate solutions that will reduce the impact of humans on the land, water, air, and/or other living things in the local environment.

5-ESS3-1 Earth and Human Activity

Obtain and combine information about ways individual communities use science ideas to protect the Earth's resources and environment.

3-5-ETS1-2 Engineering Design

Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.

[MS-ESS3-3 Earth and Human Activity]

Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.

[HS-LS2-7 Ecosystems: Interactions, Energy, and Dynamics]

Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.