Too Much of a Good Thing?

Objectives
Students will be able to:

Observe
Predict
Analyze

Process Skills:
Predicting
Analyzing

Duration:
60 minutes

Overview

Point source pollution is a common issue that may affect our water sources. Unlike types of pollution where we may not know the source or cause, point source pollution comes from a place that can be traced back to the point of origin such as a particular industry or sewer system. This activity presents a scenario where the students have to analyze well water data to determine the cause of a phosphorus plume in an area that caused a devastating fish kill.

Background

Phosphorus is a key element that is needed for living organisms to function and survive. In soils, it is present as water-soluble dissolved phosphorus and particulate-bound phosphorus. It moves through soil with the help of water from rain or flooding events. Phosphorus can be carried by surface water runoff or by leaching deeper into the soil profile. Gravity aids in this process as water travels from higher to lower elevations. The flow of phosphorus from its original source through groundwater can create a plume, or an area in the soil where concentrated phosphorus becomes present. Eventually, phosphorus will make its way into surface and groundwater sources.

Large concentrations of phosphorus can enter the environment from a variety of sources. The main pollutants are detergents, waste, and fertilizers. Household detergents and soaps that contain phosphates can make their way into rivers and streams when they are not properly managed. Pet waste and sewage also contain high levels of phosphorus that can be environmentally harmful if they are improperly disposed of, or if there are leaks in drainage systems. Livestock farms output large amounts of organic waste that can be carried downstream or leach into soils. Fertilizers are used for agriculture, household lawns, gardens, parks, sporting fields, and more. When the phosphorus from fertilizers is not used by plants, it can be washed away with rainfall or storm water runoff. These examples above are instances of point source pollution, because the source of phosphorus pollution is identifiable. In some cases, a single source for pollution cannot be determined. This is called nonpoint-source pollution.

Because phosphorus is a nutrient, too much phosphorus in water is harmful for aquatic ecosystems because it causes algae and plants to overproduce. This process is called eutrophication. Plants and algae on the surface of the water form a thick layer that blocks fish from receiving dissolved oxygen and submerged plants from receiving sunlight. Underneath the surface, animals and plants will die off.

Materials

Spray bottle
Glass dish

Pink flavored drink powder
Sand
Town Map
Student Data Sheet
Color pencils
Concentration Level Data Set

Engage

Set up a plume demonstration using a glass dish, sand, and pink flavored powdered drink. Add ½-1 inch of sand in the glass dish and then add the powdered drink to the middle of one side of the dish. Do not let anyone know that there is pink powder in the dish.

Flavored powder hidden under soil

Cover powder under soil

Ask the students to predict what will happen if you spray (rain) on the sand. Let them describe permeation, run off, etc. If they mention runoff, ask them what types of substances could be transported by the water. Where do the substances go? Do they stay on top of the ground?

Prop up the dish a couple of inches with a book. Mist the dish for several minutes. Lift the dish so that everyone can see and view the plume underneath.

Mist the dish for several minutes

View of plume from underside of dish

A plume develops as pollutants travel from one point and the dispersion widens as it travels. There are several types of plumes that may affect our environment. One of which is a toxic plume that consists of a pattern of contaminants that develops by the movement of groundwater.

Explore

Provide the following scenario to the students:

You are a scientist that just discovered a rare fish in the local river. NSF just awarded you a one million dollar grant to research this amazing species. Unfortunately before you can continue your study of this rare species of the fish, the news reports a massive fish kill downstream. The local chapter of the Fishkeepers Citizen Science group had been tracking an increase in eutrophication in the area that may have resulted in the fish kill.

When you arrive on the scene you see that the rare fish has been part of the casualties! You must act fast to figure out what happened so you contact the local soil and water conservation agency to test for contaminants. They determined that the fish kill was the result of excess nutrients (phosphorus). What was the main source of these contaminants? Can you help figure it out so that you can save the rare fish species?

Study the map below to design a sampling plan to determine how the excess nutrient (phosphorus) is entering the river. Make observations and predictions of where the contaminant could have originated and begin your investigation.

- Which way would groundwater flow in this town? Notice the higher elevation and mountains in the top right.
- There are abandoned, private, and city wells throughout the community. Instruct the students to analyze the data to determine the source of the excess nutrients in the water.

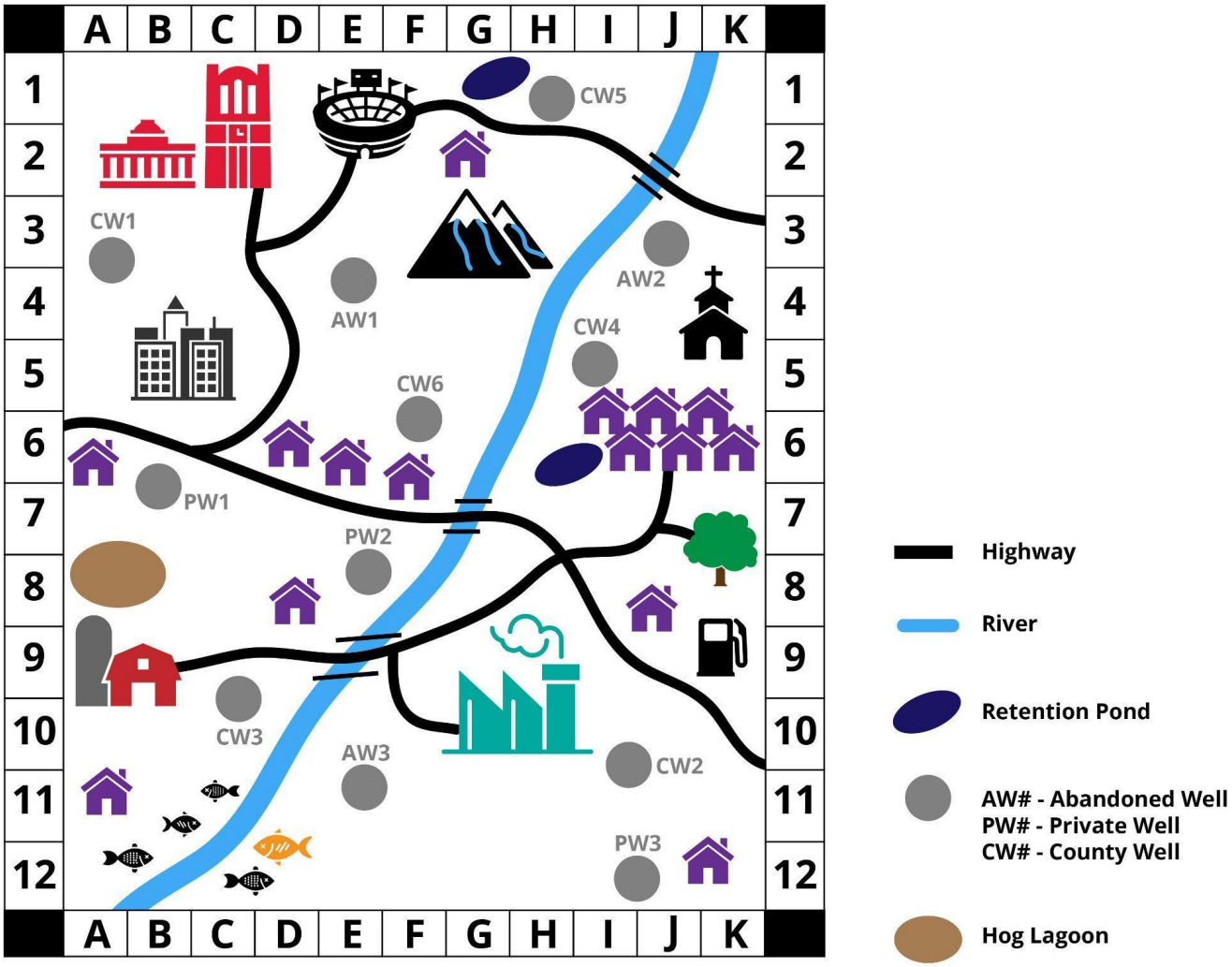
Task 1

Start at the bottom of the map near the fish kill and choose three wells to sample to test your hypothesis. Contact the agency to obtain the results of the water samples for those specific wells (ask your instructor for the concentration levels).

- Record the levels on your data sheet and color code according to low, medium, or high concentrations(For example, red=high, yellow=medium, and green=low or within limits).
- Look at the levels of phosphorus in these three water samples. What does your data suggest?
- If you think you know the source of the contaminant, confer with the soil and water agency (aka the instructor).

Task 2

Select three more wells to sample. Does this additional data confirm or refute your hypothesis? Continue to take samples and confer with the soil and water agency to determine the source of the contaminants.



Explain

Have students discuss their data and where they think the spikes in phosphorus levels originated.

Discuss the sources of phosphorus, levels of phosphorus, nutrient levels, eutrophication and point pollution. What is a plume and how do contaminants travel through soil, surface water, and groundwater?

Natural levels of phosphate usually range from 0.005 to 0.05 mg/L, but many bodies of freshwater are currently experiencing increases of phosphorus and nitrogen from other sources. Phosphorus is not necessarily toxic to living organisms. However, too much phosphorus can lead to increased plant growth and algae and decreased levels of dissolved oxygen. This process of eutrophication can cause algae blooms that may also produce toxins that are dangerous to living organisms, including humans.

In 1986, the Environmental Protection Agency (EPA) established the following recommended criteria for phosphorus: No more than 0.1 mg/L for streams that do not empty into reservoirs; no more than 0.05 mg/L for streams discharging into reservoirs; and no more than 0.024 mg/L for reservoirs.

Extend

What is citizen science?
How can you help your community with conservation of species, water quality, etc.?

Check out this citizen science project called CyanoTRACKER on the SciStarter Website. This project helps the community locate and report algal blooms.

Design your own citizen science project related to sustainability or pollution..

Evaluate

Present citizen science projects

Teacher Key

Instructor Tips:
You may want to extend this investigation with a discussion about the source of contaminants from the following:
Farm, factory, neighborhood, park, gas station, shopping center, and/or the university's sports complex. Remember that eutrophication occurs when a high level of nutrients such as nitrogen or phosphorus leads to dense growth of aquatic vegetation/algae, depleted oxygen levels, and possible toxin exposure.

Remind the students at some point that the higher elevation and mountains are in the top right of the map.

Students will suspect that the source of the pollution will be the hog farm and/or the factory. They will come to you to alert you that it must be the hog lagoon spill from the farm or the factory must have released excessive phosphorus (i.e., fertilizer plant). You will tell them that they have been investigated and have followed all safety protocols. No contaminants have originated from those sources.

After everyone has explored all possible sources of the contaminants and discussed the data, explain that there was a sewage spill at the University that released human wastes (excessive phosphorus and nitrogen) into the groundwater. The toxic plume moved underground passing through the wells in the town, ultimately ending up in the river and causing the fish kill.

Contaminant level range:
Natural levels: 0.005 to 0.05 mg/L
Up to 0.1 mg/L for streams

Well	Concentration of Contaminant (mg/L)	Record the grid coordinates of the well (ex: A12)	Level (High, medium, or low)
AW 1	.300	E4	
AW 2	.002	J3	
AW 3	.200	E11	
PW 1	.100	B6	
PW 2	.040	E8	
PW 3	.005	J12	
CW 1	.500	B4	
CW 2	.009	I11	
CW 3	.190	D10	
CW 4	.007	I5	
CW 5	.001	H2	
CW 6	.170	F6	

Data set

Suggestion: For the efficiency of sharing concentration levels, you may create a foldable so that the students can see only the data for one specific well at a time.

Concentration Levels (mg/L) Data Set

AW 1= .300
AW 2= .002
AW 3= .200
PW 1 = .100
PW 2 = .040
PW 3 = .005
CW 1 = .500
CW 2 = .009
CW 3 = .190
CW 4 = .007
CW 5 = .001
CW 6 = .170

Note: This lesson was adapted from A Grave Mistake, a *Project WET Curriculum and Activity Guide* lesson.The Watercourse and Western Regional Environmental Education Council (WREEC).

Student Data Sheet

Record observations and predictions about what you think caused the fish kill.

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CW 2			
CW 3			
CW 4			
CW 5			
CW 6			

Discussion:

1. What did you initially think was the source of the contaminants and why?
2. Which wells were highly contaminated?
3. Describe how the toxic plume carried the contaminants to the river.
4. Is phosphorus toxic?
5. What is eutrophication and how does it cause a fish kill?