

Who Turned Miller Pond Green? An Evidence Jigsaw

Learning target: I can work with a team to sort evidence, build a model of how nitrogen moved from a field into a pond's living things, and argue from data which source caused the bloom and the fish kill.

Collaborative investigation

About 50 min

Jigsaw

MS-LS2-3 · practice

MS-LS2-4 · practice

collaboration

discussion

data analysis

Name _____

Date _____

Period _____

Directions

Work in home groups of four. Step 1 (expert round, 10 minutes): each member takes one expert set of three cards (Set A: cards 1-3, the setting; Set B: cards 4-6, the measurements; Set C: cards 7-9, the suspects; Set D: cards 10-12, the biology). Meet with the students from other groups who hold the same set and agree on what your three cards prove and what they do not. Step 2 (home round, 20 minutes): return to your group, teach your cards in two minutes each, and complete the group task. Step 3 (challenge, 10 minutes): present your model and verdict to a neighboring group, who will try to find a hole in it. Step 4 (individual, 10 minutes): answer Part C alone. All numbers on the cards are a teaching scenario, not measurements from a real pond.

You will need: Twelve cards per group, cut from the card sheet, One large sheet of paper and markers per group, Group record table, Pencils

Twelve evidence cards (teaching scenario)

1 Card 1: The map

Miller Pond is fed by two creeks. North Creek runs along the edge of a six-hectare cornfield before entering the pond. West Creek runs through a cattle pasture before entering the pond. The farmhouse, with its septic tank, sits 80 m from the pond's south shore. A single outlet stream drains the pond.

2 Card 2: The fertilizer log

April 20: 180 kg of nitrate fertilizer spread on the cornfield. The farm's notes say the forecast that day called for heavy rain within the week. No fertilizer has been applied to the pasture this year.

3 Card 3: The rain gauge

April 1 to May 2: 9 mm of rain in total. May 3 to May 5: 62 mm of rain in three days. May 6 to June 3: 4 mm.

4 Card 4: Nitrate in the water (mg/L)

North Creek: April 25, 0.2; May 6, 7.4; May 20, 1.1; June 3, 0.4. West Creek: April 25, 0.9; May 6, 1.4; May 20, 1.0; June 3, 0.9. Pond: April 25, 0.3; May 6, 4.8; May 20, 1.6; June 3, 0.5.

5 Card 5: Algae cover

Percent of the pond surface covered by green scum, estimated from photographs: April 25, 3 percent; May 12, 15 percent; May 24, 70 percent; June 3, 85 percent. Under the microscope the scum is single-celled green algae, a producer.

6 Card 6: Dissolved oxygen (mg/L)

May 30, 5:30 a.m. (dawn): 2.1. May 30, 3:00 p.m.: 11.8. May 31, 5:30 a.m.: 1.8. For comparison, the pond read 7.9 at dawn on April 25. Bluegill need at least about 5 mg/L to stay healthy.

7 Card 7: The fish

May 30, before sunrise: fourteen dead bluegill floating near the north shore; several live fish gulping at the surface. May 31: nine more dead. No dead fish on April 25 or May 12.

8 Card 8: The pasture

Thirty cattle have grazed the West Creek pasture year-round for six years. Their manure contains nitrogen, mostly as ammonium and organic matter, which sticks to soil and is released slowly. West Creek has read about 1 mg/L of nitrate every spring on record.

9 Card 9: The septic test

On May 15 a technician flushed a harmless dye into the farmhouse septic system and watched the pond's south shore for three days. No dye appeared. A sample from the south shore on May 15 read 1.5 mg/L nitrate, lower than the north shore's 2.2 mg/L that day.

10 Card 10: How algae grow

Algae are producers. They build their bodies from carbon dioxide dissolved in the water, water, and dissolved nutrients, using sunlight. The nutrient most often in short supply in this pond is fixed nitrogen (nitrate and ammonium). When fixed nitrogen rises, algae can double their numbers in a day or two.

11 Card 11: What happens when algae die

Dead algae sink. Bacteria feed on them and break them down, using oxygen through cellular respiration. Decomposition is fastest in warm water. Living algae also use oxygen all night; they make oxygen only when there is light.

12 Card 12: Nitrate versus ammonium

Nitrate dissolves completely in water and does not stick to soil particles, so rain can carry it off a field within hours. Ammonium clings to soil and is released over weeks or months. Nitrate fertilizer spread just before a storm is at high risk of washing away.

Part A: Expert round (one set per person)

1. Your expert set: _____. For each of your three cards, write one sentence: 'Card __ proves _____ but does not prove _____.' Be strict: a card proves only what it measures or states.

Part B: Home group task

- Each expert teaches their three cards in two minutes. Listeners write the card number next to any step of the story it supports.
- On a large sheet, draw a flow model that follows nitrogen from the fertilizer bag to the dead fish. Use boxes for reservoirs (fertilizer, field soil, creek water, pond water, algae bodies, dead algae, bacteria,

pond water again) and arrows for processes (spreading, runoff, uptake by algae, death, decomposition). Write the number of the card that supports each arrow beside it. An arrow with no card is a guess; mark it with a question mark.

- 3. Add a second, shorter chain for oxygen: what made the oxygen and what used it up, with card numbers.
- 4. Complete the suspects table. For each suspect, list the card numbers that point toward it and the card numbers that point away from it.
- 5. Agree on a verdict: which source caused the bloom, and how confident is the group (sure, fairly sure, unsure)? Rank your three strongest cards.
- 6. Prepare a one-minute explanation of the model and the verdict. Every member must be able to give it and to answer a challenge from the neighboring group.

Group record: the suspects (fill in)

Suspect	Cards pointing toward it	Cards pointing away from it	Verdict for this suspect
Cornfield fertilizer by way of North Creek			
Cattle pasture by way of West Creek			
Farmhouse septic system			
The storm by itself (rain and mud with no added nitrogen)			

2. Group answer: State your verdict and your three strongest cards in order. For the strongest card, explain in one sentence why no other suspect can explain it.

3. Group answer: Write the hardest challenge the neighboring group raised and how you answered it with card numbers.

Part C: Individual accountability (complete alone)

4. Explain why the fertilizer did not harm the pond between April 20 and May 2, even though it had already been spread. Use two card numbers.

5. Using Card 4, calculate how much nitrate the pond lost between May 6 and June 3, and how much North Creek lost over the same dates. Then explain where the pond's lost nitrogen went, using Card 5.

6. The fish died at dawn on May 30, almost four weeks after the nitrate arrived and when the nitrate was already low. Using Cards 5, 6 and 11, explain the chain of events that connects nitrate on May 6 to dead fish on May 30, and why dawn was the dangerous hour.

7. The cattle pasture also sends nitrogen toward the pond every year. Using Cards 8 and 12, explain why that nitrogen has never caused a bloom like this one.

Cards are evidence, not conclusions

When you teach your cards, say only what each card shows. Card 4 shows that North Creek's nitrate jumped on May 6; it does not say the fertilizer caused it. Card 2 says fertilizer was spread; it does not say any of it reached the pond. The group's job is to connect cards: Card 2 plus Card 3 plus Card 12 plus Card 4 together make the case. If your group gets stuck on the model, start with the three reservoirs you are surest about (fertilizer bag, pond water, algae) and add the arrows between them first.

Design the test that would settle it

Your verdict rests on a natural experiment that happened once. Design a controlled test the farm could run next spring to confirm or overturn it: name what you would change, what you would keep the same, what you would measure and when, and what result would prove your group wrong. Then explain why a scientist might still prefer the natural experiment's evidence for the question of what actually happened this year.