

Water Quality Tests Explained

Chicago River Classroom Activity

Summary

When doing water quality testing it is important that students understand how each of the eight parameters affects the river. This demonstration can help teachers explain these concepts in a visual way.

Acknowledgements

This activity was developed with the help of Ellen Alde, chemistry teacher at Streamwood High School.

Background

Background on the eight water quality tests (pH, turbidity, nitrates, phosphates, total solids, dissolved oxygen, biological oxygen demand and fecal coliform) are included within the procedure.

Procedure

Take the large beaker, jar or bowl and fill it with water. Explain that this water represents water in the Chicago River.

Though the water quality concepts they will be learning apply to all fresh water bodies, the focus is on the Chicago River so the container will be referred to as “the river”.

Ask the students: What is in this jar?

Explain to the students: Water in the environment is never just pure H₂O. Water has all kinds of things in it naturally: dirt, calcium ions, potassium ions, nutrients such as nitrogen and phosphorous, and organic material. These all impact living things like frogs, fish, insects, microscopic creatures, plants and algae that live lakes, ponds, rivers and wetlands.

Explain: Let’s start by adding some plants to our river. Some plants grow underwater attached to the bottom, or float on top of the water.

Do: Put some plant leaves in the container.

Grade Level: 7th-12th

Duration: 1 class period

Objectives:

1. Students will be able to define all eight water quality parameters.
2. Students will understand the interrelationships between the eight water quality parameters.
3. Students will be able to list at list one source for each of the eight water quality parameters.

Materials:

- ◆ Large clear beaker, jar or bowl (volume about 3 cups)
- ◆ Salt
- ◆ Chocolate sprinkles
- ◆ Glass cleaner
- ◆ Fertilizer
- ◆ Antacid
- ◆ Vinegar
- ◆ pH paper
- ◆ Goldfish crackers
- ◆ Plastic straw
- ◆ Several plant leaves
- ◆ GREEN test kit (optional)
- ◆ 2 plates or flat trays
- ◆ Ping pong balls or other such small and light ball (about 30)
- ◆ 100 ml beaker
- ◆ Small pieces of green plastic that float (ex. cut out of a pop bottle)

Standards:

12B, 13B

Ask: Can you see all of the photosynthetic organisms in water with your naked eye? (*No. There are microscopic algae.*)

Dissolved Solids

Explain: Many substances dissolve in water. In fact, water is known as the “universal solvent” because so many substances can dissolve into it.

Do: Pour some salt in the water and stir it up until it dissolves.

Ask: Where did the salt go? (*It dissolved. When something dissolves in water, it is called water-soluble.*)

Ask: Do you know any other substances that are water-soluble? How about something that is not water-soluble?

Explain: All kinds of substances naturally dissolve in water, such as ions, salts, and nutrients. Substances like oil, gasoline and fats do not dissolve in water.

Do: Pour some window cleaner in the water and stir it up until it dissolves.

Explain: When the students realize that the cleaner dissolves, ask them: When someone pours window cleaner down their bathroom drain, it goes to a sewage treatment plant. A sewage treatment plant can remove everything that floats or sinks in the water as well as some of the nutrients. The treated effluent is then released into the local river or lake.

Ask: Can a treatment plant take the cleaner out of the water before the treated effluent is released into the river? (*No*)

Give the students this example: We live by a river and we want to salt our driveway because it’s icy. The ice melts and the water gets washed into the river bringing the salt with it.

Do: Pour some more salt in the water.

Ask: Can a treatment plant take the salt out? (*Not really*)

Give the students this example: What if your dad had some old weed killer that he wanted to get rid of. He decides to dump it down the utility sink in the basement.

Ask: Can a treatment plant take that bug killer out of the water before the effluent is released into the river? (*Not really*)

Explain: Water treatment plants cannot remove anything that remains dissolved in water. All that dissolved stuff that is in water is called total dissolved solids. A certain amount is natural, but too much is a bad thing and lowers the water quality needed for aquatic organisms.

Dissolved Oxygen

Explain: Not just plants live in the water.

Do: Throw some goldfish crackers and gummy worms into the water.

Ask: So how do fish breathe? Where do they get their oxygen? (*From oxygen gas (O₂) dissolved in the water, NOT from the oxygen atom in H₂O. Only strong beams of radiation can split water molecules.*)

Ask: Where does the dissolved oxygen come from?

Explain: See these plants in here? Plants, like algae, release oxygen when they photosynthesize.

Do: Blow bubbles in the water with the straw.

Continue to Explain: Oxygen also gets added to water when the water moves quickly, causing riffles and rapids to form (thus increasing the surface area of the body of water). This time oxygen gas from the air is being incorporated.

Do: Stir the water with the straw.

Explain: Water heats up in summer and cools down in the winter. Believe it or not, temperature affects the amount of dissolved oxygen (DO) that water can hold.

Do: Take out a two trays or plates (label one “Cold Water” and the other “Warm Water”) and several dozen ping-pong balls. Tell the students that the ping-pong balls represent oxygen molecules.

Explain: Molecules at colder temperatures have less energy – they move around less. Molecules at warmer temperatures have more energy – they move around a lot. To simulate that the cold water tray will be held steady, while the warm water tray will be shaken back and forth.

Do: Choose four students to help you. Ask one to hold the cold water plate as still as they can – representing low energy. Ask another to hold the warm water plate and gently move it side to side. Have the other two students try to stack as many ping-pong balls on the plates as they can.

Do: After a minute or so, have the students count the number of ping-pong balls they are able to reasonably fit onto their plate.

Explain: The movement of the molecules relative to the plate is due to the higher temperature and, hence, higher molecular energy of the oxygen dissolved in the water. As you can see, the warm water is holding less oxygen than the cold water.

pH

Ask: What is pH? (*How acidic or basic something is.*)

Explain: Most living things need water to have a pH of about 7, which is neutral. Anything higher is basic. Anything lower is acidic. Here in our river, the pH is about 7 because many organisms are able to live in it.

Ask: Suppose someone decides to get rid of a bunch of old car batteries by chucking them in the river. After a while, the batteries start to break up and release acid.

Do: Pour about 3 capfuls of vinegar into the “river”.

Ask: What happened to the pH?” (It goes down. It’s too acidic, not good for living things).

Do: Test the water’s pH with GREEN kit or pH paper. It should be 4 or lower.

Explain: How many of you have heard of acid rain? When the rain starts to fall, nitrogen oxides in the air from the burning of fossil fuels dissolve in the droplets. This makes nitric acid, so the droplets coming down are acidic. Here in the Chicago area, we are pretty lucky. The whole region is built on top of limestone, which is calcium carbonate – the same stuff in that is in Tums, Roloids and Alka-Seltzer.

Ask: What do these medicines do? (*Neutralize stomach acid.*)

Do: Add some antacid to the water and allow it to dissolve. Test the pH with GREEN kit or pH paper. It should go up at least 1 unit.

Nutrients

Explain: Every organism needs nutrients such as nitrogen, phosphorous, potassium, calcium, iron, etc. Plants get their nutrients from the water they soak up through their roots. Animals (including people) get their nutrients from eating plants or other animals. Nutrients dissolve in water and can be found naturally in water bodies. Most are products of decomposition. When plants or animals die they decompose and the nutrients in their bodies are released into the water. In addition, when animals urinate and defecate nutrients are added to the water. For a river to thrive there can neither be too little nor too many nutrients.

Explain: Here in our river we have a healthy supply of nutrients. Well, what if this river runs through a golf course? The golfers sure like the grass green. So they fertilize it, and that fertilizer has nitrogen and phosphorous in it because nitrogen and phosphorous are some of the most important nutrients for plants. And oops, it rains! That fertilizer gets washed into the river.

Do: Dump in some fertilizer.

Ask: What’s going to happen to the nitrate and phosphate levels? (*Levels will increase.*)

Do: Test N and P if you have GREEN kit.

Ask: What does it matter if there are too many nutrients? The plants will like it right?

Explain: All of the microscopic algae will go crazy! Use up those nutrients and explode in growth.

Do: Put the green plastic circle on top of the water.

Continue to Explain: This represents the algae exploding in growth. In a pond where water doesn’t move like it does in the river, these algae would block the light to plants at the bottom and these plants would die, thus no longer releasing oxygen. In a river, the huge number of algae will eventually start to die. Now they’re not releasing any more oxygen. Plus, all of that dead stuff is sinking to the bottom and the bacteria will begin to eat it up (decompose it). Bacteria use oxygen up when they decompose. Now there is very little dissolved oxygen in the river.

Ask: What is going to happen to the fish? (*They die.*)

Do: Crumble up the fish crackers and add to the water.

Explain: Now there is even more dead material for the bacteria to decompose and the cycle continues. That's why it's very important to have a healthy level of nutrients in the water. Too much can cause this process, called cultural eutrophication.

Ask: Can you think of any other human sources of excess nutrients? (*Farm animal feces, and untreated and treated sewage.*)

Turbidity

Ask: When you think about a pond, stream or river, is it always crystal clear blue?

Explain: In reality, many are a muddy brown color. There are particles of sediment in water and how cloudy it looks helps tell you how much sediment is in it. The amount of sediment in the water is an index of its turbidity.

Do: Pour some dirt in and stir it up.

Ask: Look at this water. Can we see through it? (*No*). Will the dirt eventually settle to the bottom? (*Yes*) What about if the water is moving like in a river, will it have time to settle? (*No*) It's normal to have some sediment in a river.

Explain: Suppose it rains hard. Water runs off pretty fast because there's a lot of concrete around here where the water can't soak in. When the water pours into the river it pushes the mud from the riverbank in the river. This is called erosion.

Do: Put more dirt in.

Explain: Look, it's awfully cloudy, light can't get through the water very well.

Ask: Why is that a problem? (*Plants cannot photosynthesize without light and oxygen levels are going to decline. Plus, extra sediment can clog the gills of aquatic creatures, make it harder for predators to find prey and buries the small creatures at the bottom of the river. A certain amount of turbidity is natural but too much is bad.*)

Fecal Coliform Bacteria

Explain: Bacteria decompose things. Bacteria come from all sorts of places, the soil, the feces of animals etc. Some are helpful to people, some are harmful to people. There are a special group of bacteria that live in the intestines of warm-blooded animals. These are called fecal coliform bacteria. They live only in the intestines NOT in the stomach, and if a certain type of fecal coliform (*e. coli*) gets in your stomach you can get violently ill. But in your intestines these help to break down food. Now, when an animal (including a person) defecates some of the coliform bacteria comes out with it. The feces from birds and mammals that live in and around the river can get washed into the river.

Do: Throw one or two chocolate sprinkles in the water.

Ask: Do you think these sources of coliform bacteria cause a high level of bacteria in the river? (*Not really, it's pretty diluted because there is not that much feces getting in.*)

Ask: When you go to the bathroom where does the water go? (Into the sewer and to the sewage treatment plant. In Chicago and near north suburbs, the sewage is not disinfected. This means that bacteria are NOT removed before being released into the river. In addition, in the Chicago area south of Dempster, we sometimes have what are called combined sewer overflows. In this area, our sewage and the rainwater flowing into the street drains are connected to the same combined sewer pipes. During a heavy rain, the combined sewer pipes, deep tunnels and the wastewater treatment plants are overwhelmed with the sheer quantity of rain and sewage water. The combined sewer pipes, which contain RAW sewage are then emptied directly into the river without treatment.

Do: Pour a bunch of chocolate sprinkles in the water.

Continue to Explain: When a combined sewer overflow happens that means a whole lot of bacteria are in the river. Some of the bacteria are E. coli and pathogenic. What if you are canoeing on the river and you get some water in your mouth? Some of the pathogenic bacteria could get into your stomach and you could get sick. Plus, those bacteria use up a lot of oxygen, causing dissolved oxygen levels to drop. A little bit of fecal coliform bacteria is okay, but a lot can be trouble.

Biological Oxygen Demand

Explain: You can now see how many of these parameters are related. In freshwater bodies, the most important parameter is dissolved oxygen.

Ask: If we have too much nitrogen and phosphorous, what eventually happens? (*Dissolved oxygen levels will decrease because of cultural eutrophication. All that bacteria decomposing the extra dead plants use up the DO.*)

Ask: If we have a combined sewer overflow, what might happen to the DO? (*It will decrease because the bacteria from the sewage are decomposing the sewage itself. Plus cultural eutrophication can occur because sewage has nutrients in it. Think of how manure is used as fertilizer!*)

Explain: We can actually test for the amount of oxygen used up in a sample of our river water! This can tell us how much decomposition is going on, how much oxygen is used up, and how much oxygen is left over for all the animals to survive on. This is called biological oxygen demand.

Explain: So our river now has dissolved solids, sewage and nutrients in it. Suppose we test the water for dissolved oxygen and get an answer of 20 mg/l (ppm). Now we need to find out how much oxygen would be left after all the bacteria are allowed to decompose.

Do: Fill a test tube with river water. Cover the tube with tin foil.

Explain: We are going to (pretend) to let this tube sit for five days, then we are going to (pretend) to test the DO levels again.

Ask: Why do we cover the tube in tin foil and wait? (*We need to allow the bacteria time to decompose and we want to prevent the plants from producing any new oxygen through photosynthesis.*)

Explain: After five days, suppose the dissolved oxygen level is 4 mg/l.

Ask: So how much oxygen did the bacteria use? (16mg/l, subtract the new reading from the reading five days ago. This is the biological oxygen demand.)

Continue to Explain: Any BOD reading higher than 5 mg/l indicates poor water quality, because that means that there is a lot of decomposition going on and therefore there is little oxygen left over for the animals. Your hypothetical reading is 16 mg/l. This would make sense considering you had fertilizer and sewage spilling into your river.

Conclusion

By testing our river water we can find out how healthy the river is, if it is a good place for plants and animals to grow and people to enjoy. Testing our river water also tells us how good a job we have been doing at keeping our community a safe place for everyone and everything to enjoy.