

5700 HOW CLEAN IS THE WATER

The objective of this demonstration kit is to give the student an understanding of various aspects of water pollution by testing samples of water from the local environment. The kit provides instructions and materials for: a class demonstration; a student; or a student group, to perform the following six tests and four demonstrations:

pH	Acid / Alkaline Demonstration
Phosphates (0 - 50+ ppm, 10 ppm increments)	Phosphates and Algae Demonstration
Chlorides (50 ppm increments)	Chloride Demonstration
Lead (5 ppm)	Particle Settling Demonstration
Oil contamination	
Bacterial contamination	

These tests take about two 45 minute class periods. The bacterial contamination test will take 3 or 4 days to complete. There is enough material in this kit to repeat each test three times, except the bacterial contamination test. The Teacher/Student Manual may be used by a student or student group to perform the tests.

Contents:

Sterile Biplate Petri Dish (1)
Pipet (1)
Test Tubes (2)
Forceps(1)
Vials, empty (2)
Sodium Chloride
Nutrient Agar (0.7 gram)
Fertilizer
Chloride Test Solution (0.14M AgNO_3)
(1 - 30ml bottle)
Clay (1 vial)
Sand (1 vial)
Chloride Test Powder (6 pillows)
Phosphate Test Powder (4 pillows)
Phosphate Color Chart
Lead Test Paper (1 strip)
pH Test Paper (3 strips)
Oil Test Paper (1 strip)

Teacher/Student Manual and Instructions (1)

Additional Materials Required:

Access to Sink
Supply of Hot Water/Heating Source
Test Tube Rack
Scissors
Small Bottle with cap (at least 30ml)
Jars with tops
Collection Containers
Distilled water
Lettuce leaf

HOW CLEAN IS THE WATER #5700**Teacher/Student Manual****INTRODUCTION**

The water around us is vital to our existence. Most people understand the need for clean, safe drinking water. Many of us, however, don't think much about the many different functions of water. Rivers, lakes, and streams serve as a habitat for a variety of living things. We depend more than we realize on the balance of these aquatic organisms. Water is also important for irrigating farmland in many parts of the world. Beside its effects on living things, water is constantly interacting with the physical environment of air, soil, and rocks.

In nature, absolutely pure water is never found. Rain water, which is potentially the purest water in nature, picks up dust and gases from the air. Water in streams and lakes picks up soil materials and the by-products of living things. To fully understand water, we need to deal with the materials it contains.

Humans have contributed a great deal to the material found in water, much of it harmful. Cities, factories, and agricultural operations have dumped millions of tons of waste into our water supplies. You may be familiar with the pictures of "dead" rivers or lakes - bodies of fish floating on oily water, garbage floating up on shore.

While many people know that a problem exists, few really understand what constitutes pollution, where it comes from, and what can be done about it. This activity will help you understand various aspects of water pollution. You will perform tests to measure levels of various pollutants. Throughout the investigations, keep in mind the basic concept of water as a complex mixture of materials with different functions. Try to relate what you learn here to problems of water quality in your area. The most important material used for these experiments is your local water.

WHAT IS IN THE WATER?

Besides water molecules, most water sources contain a variety of other materials. For this discussion, these other materials will be divided into three categories:

- *Dissolved and undissolved chemicals, such as salt, calcium, phosphates, lead or oil
- *Particulate matter, such as clay, silt, or sand particles
- *Living materials, such as algae, fungi, and bacteria

Most "clean" water supplies contain a mixture of all these materials. *Water pollution occurs when a new, harmful material is added to the water, or when the balance of naturally occurring materials is upset.* The first case represents such pollutants as lead and mercury, which are harmful even in very small quantities. The second case includes such things as the buildup of phosphates in the water supply. Phosphates are found in small amounts naturally, and are necessary for the life of many aquatic organisms. However, in the case of an increased amount of phosphates buildup, the balance is upset with often disastrous effects.

As you work through the activities, decide which of the three types of pollutants you are dealing with, and what the origin of that pollutant might be.

Using the kit:

Carefully read the background information section, and all test procedures. When used properly, the materials in this kit are safe. Remember to BE SAFE!

Wash test tubes and pipets after each test and when changing water samples. Use distilled water for the final rinse.

The agar should be prepared at least 3 hours before use in the bacterial contamination experiment. See Testing For Bacterial Pollution section for detailed preparation instructions.

Cut the lead and oil test papers into 6 pieces each.

The indicator zone on the pH test strips is in the center of the strip. The pH test strips may be cut in half, from top to bottom.

If the test results show non-polluted water, don't be disappointed. Environmental legislation has had major impacts on the way businesses, municipalities and individuals treat wastewater.

Collecting the Water Samples:

Using clean containers, collect samples of water from different sources - streams, lakes, rivers, tap, and sewage runoffs; any source that you may think is interesting. Try to pick a variety of samples to provide a more complete picture of water quality in your area.

You may use this kit to completely test three different water samples. Alternatively, you may collect several samples and use only one or two tests on a given sample. For example: phosphate test on runoff water near agricultural sites, or oil test for water collected near an oil changing station. Note that you will need pond water to run the phosphate demonstration. In order to test for oils, you will need water collected from the surface of the body of water being sampled. One method is to fill a test tube by placing it in a horizontal position and lowering it slowly into the water. Do not submerge the tube; fill the tube only about 1/4 full. Quickly turn the mouth of the tube upward to catch as much of the surface water as possible and cap the tube.

TESTING FOR PH

Many chemicals which dissolve in water affect the acidity of the water. Pure distilled water contains no dissolved material, and is considered neutral, neither alkaline nor acidic. Scientists measure the acidity of water in terms of pH. It is a measurement scale used to describe the acidity or alkalinity of the water, (pH is the negative logarithm of the hydrogen ion concentration). The pH scale ranges from very acidic (0) to very basic (14), with 7 considered neutral.

The presence of acidic or alkaline chemicals in drinking water affects the taste of the water. Acidic substances have a sour taste while alkaline substances have a bitter taste. More important than the taste of the water is the effect that pH has on living things in the water. Most organisms enjoy a particular pH level that is most favorable for their growth. Even minor changes in pH can affect the ability of organisms to survive. The pH of water can be changed by materials contained in industrial sewage, by fertilizer runoff from the land, and even by the presence of certain gases in the air. Sulfur dioxide, a major air pollutant, can make rainwater very acidic.

Materials:

Pipet	Aspirin or Soap
2 Test Tubes	Lemon or Vinegar
1 pH Test Strip	

Procedure:

The testing paper provided has been soaked with a mixture of pH sensitive chemicals. The color of these indicator dyes will change with pH.

- Dip a strip of the pH paper into the water to be tested. To assign pH, match the color in the center indicator box with the color scale on the strip.

What effect would large runoffs of soaps and detergents would have on the pH of rivers and lakes?

Demonstration:

- Pipet a few drops of vinegar or lemon juice into one of the test tubes. The test paper can be reused for this. *Was the liquid acidic or alkaline?*
- In the other tube, add a small piece of soap or an aspirin tablet and add a few drops of water to dissolve the material. Test this solution to determine whether it is acidic or alkaline.

Now that you have learned how to use the pH testing scale, test samples of the tap water in your area, as well as water from a stream, river or lake. If the water is more than 1 pH unit away from neutral (7), it is a strong indication of pollution. While variations in pH are normal, large differences indicate a problem.

What effect do you think large runoffs of soaps and detergents would have on the pH of rivers and lakes?

Note: Wash test tubes and pipets after each test and when changing water samples. Use distilled water for the final rinse.

PARTICLE SETTLING TIME

As mentioned above, particulate matter is one constituent of most water sources. The water found in rivers may contain a large amount of small particles (silt, for example) as the rapid velocity of the water continuously stirs these particles. A reservoir contains slow moving water and allows time for some particulate matter to settle out of the water column. However, some very fine particles may never settle out and a process of filtration is necessary to prepare water for safe drinking.

Materials:

Vial of sand	Vial of clay	2 Empty vials
Stopwatch	Distilled or tap water	

Procedure:

- First, observe the particle size of the sand and the clay. Record your observations.
- Fill vials of sand and clay with water.
- Check your watch. Shake vial with sand and water and record the time it takes for the sand to settle (water to become clear).
- Do the same procedure with the vial of clay and water.

How long did the sand require to settle out? How long did it take for the clay to settle out? Which particle would you expect to cause turbidity in a reservoir? What can you say about the size of the individual particles of sand and clay?

- Two empty vials have been provided to try this experiment on other samples you collect.

TESTING FOR PHOSPHATES

The element phosphorous is necessary for all life. In water, the most common forms of phosphorous are the phosphates. These compounds occur in fertilizers, minerals, and in some detergents. If large amounts of phosphates are present because of fertilizer runoff or sewage pollution, excessive growth of algae may occur. This creates an imbalance in the aquatic community and may have serious long range consequences. The rapid growth of algae ("algae blooms" - creating accelerated eutrophication) uses up the dissolved oxygen thus depriving other forms of aquatic animal life of necessary oxygen.

Procedure:

- Pipet 5 ml of water sample into a clean test tube.
- Cut off end of the phosphate test powder pillow and add to the test tube.
- Stopper the test tube and shake 1 minute. A blue or violet color indicates the presence of phosphates.
- Hold the test tube and color chart side by side against a piece of white paper. Match the colors to determine the phosphate concentration in the sample. A reading over 10 ppm indicates a severe pollution problem.

Phosphates and Algae Demonstration:

- Fill two large glass jars 3/4 full of pond water.
- Add the sample of fertilizer to one of the jars and gently swirl to dissolve the fertilizer. (This jar could be tested for phosphate level).
- Set both jars in a sunny location for several weeks with the caps setting loosely on top.
- Look for changes in the color of the two samples.

What can you conclude about the effects of the fertilizer, particularly phosphate levels, on algae growth?

TESTING FOR CHLORIDES

While chlorides are abundant in sea water, fresh water normally contains low levels. The organisms which live in or near fresh water are adapted to these low levels of chloride, and may be harmed by excessive amounts. Chloride concentrations build up as water containing small amounts evaporate, leaving the chlorides behind. Water which flows through underground caverns may dissolve large amounts of salt that is the principle source of chlorides. In addition, salt is used in many cold winter areas to control ice on roads. As much as 1500 pounds of salt per mile of highway may be used during a single heavy storm. This salt flows off the road and contaminates the water supplies and land. In high concentrations, salt is very damaging to metals, such as automobiles, or steel hulled ships in salt water.

Materials:

Chloride Testing Powder Pillows	Packet of Sodium Chloride
Chloride Testing Solution	Plant leaf or Fresh Lettuce leaf
2 Test Tubes	Water samples to be tested
Scissors	

Procedure:

- Pipet 5 ml of the water sample into a test tube.
- Tap one of the chloride testing powder pillows so that the powder settles to one end. Cut open the end of the powder pillow and add its contents to the water.
- Gently swirl the test tube to dissolve the contents.

Note: Read Chloride Test Solution Material Safety Data Sheet!

- Add the chloride testing solution, one drop at a time, swirling gently between each drop. Count the number of drops required to change the color from yellow to orange.
- To determine the chloride concentration in parts per million (ppm), multiply the number of drops by 50. Chloride concentrations of 250 ppm and greater are considered unsafe.

Chloride Demonstrations:

- Pipet two test tubes 2/3 full of water.
- Add the packet of sodium chloride to one test tube and gently swirl the liquid to dissolve the salt.
- Place equal sized pieces of lettuce or other leaves into both test tubes and let them soak for 20-30 minutes.
- Remove the two leaf samples and observe. *What effect did the salt have on the leaves?*
- Clean the test tubes and rinse with distilled water.

Seawater Demonstration:

The sodium chloride concentration in seawater is important to the survival of oceanic animals and plants. Humans cannot drink seawater because of this high concentration of salt, as it acts as a dehydrator to the bodies cells. Due to the content of sodium chloride in seawater of approximately 35,000 ppm, a seawater sample must be diluted prior to testing.

- Pipet 4.5ml of distilled water into a test tube.
- Add 4 drops of the seawater sample to the test tube (1/10 concentration).
- Gently swirl test tube to mix the contents.
- Cut and add the contents of one chloride powder pillow to the test tube. Cover and shake the test tube to dissolve the powder.
- Add the Chloride Test Solution (BE CAREFUL NOT TO SPILL ON SKIN OR CLOTHING) one drop at a time, gently swirling after each addition. Count the number of drops required to change the color from yellow to orange.
- Multiply the number of drops by 500 to get the chloride concentration in ppm.

TESTING FOR LEAD

A number of harmful chemicals, such as mercury, lead and cyanide are used in industry. Paper, paint, insecticides, leather, metal working and other industries use many of these chemicals to help manufacture their products.

When the chemicals have been used, they are often released into water supplies with other waste water such as that used for rinsing, cooling and other processes. These materials then become suspended or dissolved in the water supplies, often for long periods of time. Substances such as mercury and lead are toxic to living things and can cause serious damage to the balance of life in the water. A variety of chemical tests have been developed to deal with the problem of monitoring such hazardous chemicals.

Materials:

Pipet	Lead Testing Paper
Test Tube	Scissors

Procedure:

- Pipet 2-3 drops of water on a piece of the lead testing paper.
- A pink to deep purple-red color indicates the presence of lead at a minimum of 5 ppm. (If you have a positive result, report to your local water quality agency).

Lead often enters the water supplies through old lead water pipes. The lead actually dissolves out of the pipes into the water. Many paints were once made with lead-based pigments. These too can dissolve slowly and enter the water supply. With the remaining pieces of lead testing paper, test other sources for possible lead contamination, such as bits of paint dissolved in a small amount of water.

TESTING FOR OIL

Many people have become concerned recently about oil spills in water. These may be caused by leakage from wells or pipes, damage to tankers, or runoff from streets and factories. Some of the oil floats to the surface of the water and forms a thin film. If you've ever seen a shiny, rainbow colored coating on the water, this was probably oil or some oil based material. In addition to the harmful effects of any poisons dissolved in the oil, oil coatings cut down the amount of oxygen that can dissolve in the water. This can have serious effects on the organisms that live in the water, since they need oxygen to survive.

Materials:

Oil Test Paper Forceps

Procedure:

- Using forceps, dip a piece of oil test paper into the water sample.
- A dark blue or purple color indicates the presence of oil.

TESTING FOR BACTERIAL POLLUTION

Many different microorganisms live in the water. Most of these are harmless and are needed for the balance of life in the water. Occasionally a harmful bacteria can enter the water and multiply. For example, inadequate treatment of sewage can introduce *E.coli* bacteria into drinking water supplies.

Many serious diseases are related to such water borne bacteria.

Materials:

Pipet Sterile Biplate Petri dish
 Water sample Heating Source (hot water bath., Bunsen burner)
 Nutrient Agar Small Bottle (30ml or larger)
 Cellophane tape

Preparation:

- Place the nutrient agar into the glass bottle and add 30 ml of water. Carefully, heat this agar mixture in a hot water bath, or suspend over burner flame, until nutrient agar mix boils. Boiling is necessary to ensure proper solidification of the agar. Use caution as the bottle will be hot, remove from heat source. Label one side of the petri dish as a control, the other your sample. Wash your hands prior to pouring the agar. If the solution has become separated, it may be necessary to shake the bottle. Be sure to have cap tightly in place before shaking and then carefully pour the agar into the petri dish.
- Pour the solution equally into both sections of the biplate petri dish. Work quickly and immediately cover the dish when the agar is poured. Set aside to cool. Do not invert until agar is completely cooled and gelled.
- Thoroughly wash the bottle with hot water and rinse with distilled water. Be sure to wash your hands also.

TESTING FOR BACTERIAL POLLUTION cont.**Procedure:**

- Once the agar has set, or solidified, continue with experiment. Open cover of petri dish just enough to pipet 3 drops of water sample onto section labeled "Sample" of the gelled agar. Do not add anything to section labeled "Control".
- Gently spread the water around using "z" motions back and forth on the agar using the tip of the pipet. (Try not to poke the tip of the pipet into the surface of the agar).
- Immediately cover the petri dish and seal the cover by wrapping the edge with tape.

Do Not Open the Lid of the Dish after this Point!

- Set the dish aside overnight in a warm, dark place(not above 99°F) to allow any bacteria present to grow.
- Examine the plate after a day and again after 2 days.

What do you see on the surface of the agar? Are there any colonies on the control section of the petri dish?

Bacteria usually form as small round colonies that are shiny in appearance. Different colors and textures represent the presence of different types of bacteria. *E.coli* are usually small green colonies with a metallic sheen. Many textbooks contain illustrations of various types of bacterial colony growth to aid in identification.

If you see growth inside the agar, the water used to prepare the agar may have had bacteria in it.

- When you are finished with the bacterial cultures, put the sealed petri dish into boiling water for 20 minutes before disposing of it. This precaution is taken because there may be some rather unpleasant bugs growing on the agar.