

# Finding and Measuring What You Can't See

## A Simple Lesson in Identifying and Quantifying Pollutants

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**Grade Level:**

High School

**Discipline:**

Analytical Chemistry, Pollution

**Objectives:**

1. Find out how scientist measure pollutants in the food we eat and the environment around us.
2. Find out what physical properties are and how scientist use them to pull out one material that they are interested in and leave everything else behind.
3. Find out how to figure out how much of a pollutant is present after you have identified the pollutant.

**Background:**

### Have You Ever Wondered . . .

How do scientist figure out what pollutants are in our environment?

How do scientists check to make sure that any pesticide used in food doesn't contaminate the food itself. Insecticides are sprayed on apple trees to eliminate worms, yet you don't want to eat pesticides.

We use the words "pollutant" and "contaminant" to indicate that something is present where it should not be. Pollutants and contaminants are not necessarily dangerous or harmful, but they could be. It is important to know not only the "identity" but also the "quantity" present. Some pollutants or contaminants present below certain levels pose no hazards. It is the job of scientists to figure out the **identity and the quantity** of contaminants because both pieces of information are needed to determine whether a hazard exists.

Sometimes you can sense the pollutants—seeing, hearing, smelling, tasting or feeling. Some things you smell—like ammonia, vinegar, rotten eggs (Scientists know that these are compounds with specific elements in them.) Sometimes you can tell what it is this way, but not how much is there.

There are some pollutants which we cannot sense at all, yet they are very dangerous, like carbon monoxide produced by cars or lead in drinking water.

To measure how much of a material is present, scientists usually develop a "**standard curve**." This is a relationship based on known amounts of a material (standards or reference materials) and a physical property of the material. The scientist makes the standard or reference material up in the laboratory so that the scientist knows exactly how much of a specific pollutant is present and then measures the physical property. By using this relationship, the scientist can then determine how much is present in an unknown sample, such as in drinking water or in apples from the local supermarket, etc.

Today's activity is a **MODEL** to illustrate how these measurements are made. Although the techniques are simple and the pollutants large and visible, the principles are consistent with how the work is actually done.

***The Experiment:***

We will pretend that pieces of rubber bands and paper clips are pollutants that we must isolate and measure. You will be given a sand sample which has been contaminated with rubber bands and paper clips. It is your job to find out how many rubber bands and how many paper clips are in your group's sand sample.

You will be given all the tools you need to be able to separate the sand mixture into three components—sand, rubber bands, and paper clips. Once separated, you will measure how many rubber bands and paper clips contaminated your group's sand sample.

***Objective:***

Two pollutants have contaminated our play sand—paper clips and rubber bands. Your job is to figure out how many of each pollutant are present. You may not extract the pollutants from the sand with your hands. Once they are out and separated, however, you may pick them up to weigh them.

***Materials:***

- 10 jumbo paper clips
- 10 rubber bands
- 1 bag of sand – the sand must be dry or it will cake in the sieve
- 1 aluminum pan
- 1 sieve or colander
- 1 bar magnet
- 1 triple-beam balance
- 1 table of measurements
- 1 piece of graph paper
- 1 ruler
- 1 pencil

***Procedure:***

1. Study the properties of the sand, paper clips and rubber bands. If they were all mixed together, how would you separate them? (Consider the materials and tools which are available.)
2. Establish a **standard curve** for paper clips.
  - Mass 1, 5, and 10 paper clips
  - Record the masses (data) on the data chart.
  - Graph the masses (data) on the graph paper.
3. Establish a **standard curve** for rubber bands.
  - Mass 1, 5, and 10 rubber bands.
  - Record the masses (data) on the data chart.
  - Graph the masses (data) on the graph paper.
4. Determine the number of paper clips and rubber bands that are contaminating the sand.
  - Obtain an **unknown**.
  - Extract the pollutants (paper clips and rubber bands) without touching them with your hands. (Once they are extracted and separated from each other you may touch them.)
  - Determine **how many** paper clips and rubber bands are contaminating the sand.

**Student Handouts:**

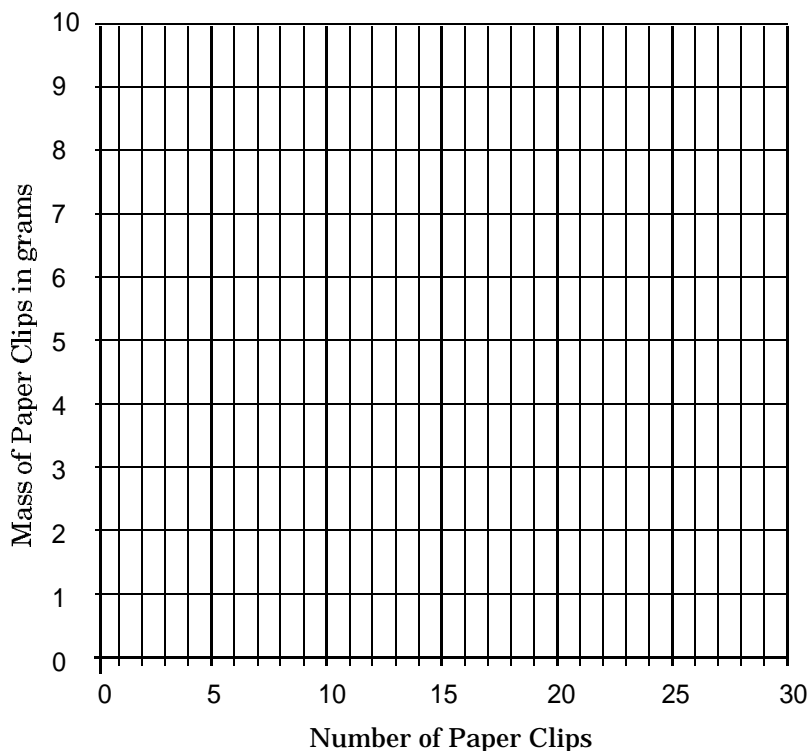
Two pollutants (rubber bands and paper clips) have contaminated our sand. How would you find out how many rubber bands and paper clips are in the sand if you could not sense them directly?

Please work with the following materials: One triple beam balance, 10 rubber bands, 10 paper clips, one plastic bag containing a scoop of sand, one strainer, one aluminum pan, one bar magnet, one piece of graph paper, one ruler, one pencil.

Using this equipment: How would you determine how many rubber bands and paper clips have contaminated your sand sample? Once you have designed your technique for extracting rubber bands and paper clips from the sand and for determining the amount of each present, request an “unknown” (a plastic container of sand contaminated with pieces of rubber bands and paper clips). Separate the rubber bands and paper clips from the sand without touching them and then calculate how many of each was in the sand. (You may touch them once they have been extracted and separated.)

Remember, although you can see the rubber bands and paper clips and, therefore, can count them by eye, most pollutants are not as easily identified. The procedure for measuring “invisible” pollutants still involves isolating them from the environment (air, water, soil) and identifying and quantifying them using standards.

**Standard Curve: Paper Clips**



### Table of Measurements

**Data:**

Number of Rubber Bands	Mass of Rubber Bands (grams)
1	
5	
10	
Unknown	

Our Unknown is Letter\_\_\_\_\_ It contains\_\_\_\_\_ rubber bands (how many?)

**Data:**

Number of Paper Clips	Mass of Paper Clips (grams)
1	
5	
10	
Unknown	

Our Unknown is Letter\_\_\_\_\_ It contains\_\_\_\_\_ paper clips (how many?)

## Notes to the Teacher

A broom and pan should be available for spilled sand.

### **Unknown:**

2-pound deli container filled 3/4 with dry sand  
Size 64 rubber bands, cut into pieces (less than 10)  
(We use W.T. Rogers premium rubber bands.)  
Jumbo paper clips, cut into pieces (less than 10)

Marker to label container  
Key to unknowns  
Scoop for sand

### **Two activities** are presented.

In the **first**, students figure out a technique to use to answer the question. You may want to give your students the activity card in advance so that they can think about it and discuss the problem in advance. Students will design their approach after studying the properties of the rubber bands, paper clips, and sand. They will then test their technique by using it to identify and quantify the the “contaminants” in the unknown. If they fail, it’s back to the drawing board to figure out another approach.... There are two problems here. The first is to design a reliable technique and the second is to identify and quantify the contaminants.

In the **second** activity, more direction is given. Students, however must make the transition from the standard curves to identifying and quantifying the unknowns.

### **Objectives:**

1. To develop a working understanding of standard curves.
2. To develop a working understanding of concentration.
3. To develop a working understanding of “limits of detection.”

### **Secondary Objectives:**

- To stimulate questions about magnetism.
- To stimulate questions about physical properties.
- To stimulate questions about pollutants and procedures for testing for them.
- To help students learn how to use a triple beam balance.

### **Sample Procedure:**

1. Extract rubber bands and paper clips from the sand using the strainer.
2. Separate the paper clips from the rubber bands by attracting the paper clips on the bar magnet.
3. Brush sand particles from the rubber bands and paper clips.
4. To determine the number of rubber bands, mass the pieces and compare the mass to the standard curve for rubber bands.
5. To determine the number of paper clips, mass the pieces and compare the mass to the standard curve for paper clips.