ehp

LESSON:
Getting the Lead Out

Summary:	Students read an article about Environmental Protection Agency (EPA) requirements for community water systems to test drinking water in homes for lead contamination. Then students use water sampling results for lead from four community water systems to determine if they must implement corrective action based on percentile rankings. Finally, students explore the distribution patterns of the water sampling results and the logs of the water sampling results to see if they are normally distributed.
Lesson Type:	Graphic organization and modeling—This lesson has students organize information graphically (e.g., by using figures, graphs, and/or webs) or by creating a model.
***EHP* Article:**	"Taking the Lead and Copper Rule to Task" *EHP Student Edition*, August 2006, p. A276 http://www.ehponline.org/docs/2006/114-5/forum.html#taki
Objectives:	By the end of this lesson, students should be able to:

1. determine the percentile ranking of a group of numbers;
2. compute the logarithms to the base 10 of various numbers;
3. plot frequency bar graphs or histograms of sampling results using numbers and the logs of these numbers;
4. define a lognormal distribution;
5. describe the criteria that community water systems must use for determining if corrective action is needed to address high lead levels found in drinking water; and
6. list the health effects of lead in drinking water.

Class Time:	25 minutes for Part 1 only, 60 minutes for the entire lesson
Grade Level:	9–12
Subjects Addressed:	Environmental Sciences, Chemistry, Physics, Physical Science, General Science, Mathematics

▶ **Prepping the Lesson (15 minutes)**

INSTRUCTIONS:
1. Download the entire August 2006 *EHP Student Edition* at http://www.ehponline.org/science-ed/, or download just the article "Taking the Lead and Copper Rule to Task" at http://www.ehponline.org/docs/2006/114-5/forum.html#taki.
2. Review the Background Information, Instructions, and Student Instructions.
3. Read the article "Taking the Lead and Copper Rule to Task."
4. Decide if you will have students conduct Part 1 only or Parts 1 and 2. If you conduct the whole lesson, decide if students will use computers and spreadsheet software, calculators, or log tables to convert numbers to logarithms to the base 10.
5. Assemble the materials needed for the laboratory activity.
6. Make copies of the *EHP Student Edition* article and the Student Instructions.

MATERIALS
Per Student
• 1 copy of *EHP Student Edition*, August 2006, or 1 copy of the article "Taking the Lead and Copper Rule to Task"
• 1 copy of the Student Instructions

Per Group
• 2 sheets of graph paper
• Computer, calculator, or tables to convert numbers to logarithms to the base 10

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VOCABULARY:

- action level
- frequency distribution
- lognormal distribution
- normal distribution
- parts per billion (ppb)
- percentile
- statistics

BACKGROUND INFORMATION:

Lead is a common environmental neurotoxicant that can lead to serious health problems if ingested in excessive amounts. There is no known safe level of exposure to lead. Infants and children who drink water contaminated with lead over long periods could suffer delays in physical or mental development, slight deficits in attention span, and learning disabilities. Adults could develop kidney problems or high blood pressure. The EPA estimates that 10–20% of human exposure to lead may come from lead in drinking water. Leaded solder was used up to 1986. Lead service lines can also be found in older homes. Lead can leach into drinking water through the corrosion of lead pipes, lead solder joints in the plumbing system, and brass fixtures.

In 1991, the EPA passed the Lead and Copper Rule requiring public water systems to test for lead and copper at the taps in residences. Under the Lead and Copper Rule, public water systems must collect a certain number of 1-liter water samples from frequently used cold water taps in high-risk residences served by the public water system. Samples should always be collected as first-draw samples from a tap where water has stood in the pipes for least six hours. These samples reflect lead that has leached into the water from contact with plumbing inside the house. If 10% of the samples have lead results above the action level of 15 parts per billion (ppb), the public water system must implement corrective action. This corrective action may include corrosion control treatment of the water, water source monitoring, public education, and replacement of lead service lines. To confirm if lead service lines are the source of the contamination, lead service line or second-draw samples may be collected from taps. Water is allowed to run until the water changes temperature, indicating it is now coming from just outside the residence. Another 1-liter sample of water is collected at this point and analyzed for lead content.

There have been concerns about the enforcement of the Lead and Copper Rule, especially after it was found that 73% of tested homes serviced by the Washington, DC, public water system had lead above the action level. The Government Accountability Office (GAO) issued a report critical of the level of enforcement and the number of public water systems meeting the testing requirements.

In order to understand and make valid decisions about environmental monitoring (quantitative) data, it is helpful to be able apply mathematical or statistical methods to summarize and describe the data. One of the easiest ways to describe numeric data of one variable is a frequency distribution. Data are grouped into some category or range, and the frequency or percentage is plotted on a histogram, bar chart, or pie chart showing graphically how the data are distributed. A histogram of environmental monitoring data typically has high-frequency counts at the low range of the numbers and then trails off with a few results at the high end of the range. Because of this skewed distribution, environmental data are harder to interpret and understand compared to normally distributed data, especially when looking at the high numbers. Part 2 of this lesson asks students to make a histogram of lead monitoring results for drinking water showing the typical skewed distribution.

More powerful statistical tools are available for summarizing and describing data if the data are normally distributed. This means the data are evenly distributed around a central point in a uniform pattern forming what is called a bell curve. It turns out that environmental data are typically lognormally distributed, allowing for these more powerful statistical tools to be used if the data are converted to logs. Part 2 of this lesson also has students convert the sampling results to logs and then make a bar graph of the logs, which now shows normally distributed data resulting from the transformation. It is a common practice when analyzing numeric data that are not normally distributed to apply various mathematical transformations to the data to try to make them fit a normal distribution pattern.

RESOURCES:

Environmental Health Perspectives, Environews by Topic page, http://ehp.niehs.nih.gov. Choose Laws/Regulations/Policies, Lead

Drinking Water: EPA Should Strengthen Ongoing Efforts to Ensure That Consumers are Protected from Lead Contamination, GAO Report (GAO-06-148), http://www.gao.gov/new.items/d06148.pdf

Rutgers Cooperative Extension, *Interpreting Drinking Water Quality Analysis: What do the Numbers Mean? (6th Edition)*, http://www.rce.rutgers.edu/pubs/publication.asp?pid=E214

U.S. EPA, Lead in DC drinking water, http://www.epa.gov/dclead/index.htm

U.S. EPA, Lead in drinking water, http://www.epa.gov/safewater/lead/index.html

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▶ Implementing the Lesson

INSTRUCTIONS:

1. Tell students they are going to look at the requirement for community water systems to test for lead contamination in drinking water in homes.
2. Divide students into groups and pass out the materials, Student Instructions including Drinking Water Sampling Results for Lead Worksheet, and a copy of the article "Taking the Lead and Copper Rule to Task." Assign each group a community water system (1 through 4) and have students complete either Part 1 alone or Parts 1 and 2 of the activity.
3. Discuss with students the answers to their questions, the health effects of lead, and why it is important to remove lead from drinking water.

NOTES & HELPFUL HINTS:

- The rank ordering, calculations, and graphing can be easily be done using a spreadsheet program such as Microsoft Excel. This would be an excellent activity to have students use computer spreadsheets if you have access to the computers and software in your classroom. Excel has a data analysis tool available to do histograms using the bin ranges provided in the lesson. Click on Tools, then Data Analysis. If Data Analysis is not visible on the Tools, click on Add-ins, and the Data Analysis tool can be added.
- This activity can be extended by looking at other statistical descriptive parameters such as mean, medium, mode, standard deviation, and variance. Students could also do stem- and leaf- or box- and whisker- plots to get an addition feel for how the data are distributed.

▶ Aligning with Standards

SKILLS USED OR DEVELOPED:

- Classification
- Communication (notetaking—oral, written)
- Comprehension (listening, reading)
- Computation
- Critical thinking and response
- Experimentation (conducting, data analysis, design)
- Graphing and graph reading
- Tables and figures (creating, reading)
- Unit conversions

SPECIFIC CONTENT ADDRESSED:

- Percentiles
- Logarithms
- Normal distributions
- Lognormal distributions
- Interpretation of lead drinking water sampling results
- Environmental health

NATIONAL SCIENCE EDUCATION CONTENT STANDARDS MET:

Unifying Concepts and Processes Standard
- Systems, order, and organization
- Evidence, models, and explanation
- Constance, change, and measurement

Science as Inquiry Standard
- Abilities necessary to do scientific inquiry
- Understanding about scientific inquiry

Science and Technology Standard
- Abilities of technological design
- Understandings about science and technology

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Science in Personal and Social Perspectives Standard
- Personal and community health
- Natural resources
- Environmental quality
- Natural and human-induced hazards
- Science and technology in local, national, and global challenges

History and Nature of Science Standard
- Nature of scientific knowledge

▶ Assessing the Lesson

PART 1

Step 1:   Read the article "Taking the Lead and Copper Rule to Task" and answer the following questions:

a) What is the action level for lead in drinking water?

15 parts per billion (ppb) or 0.015 mg/L

b) The Environmental Protection Agency (EPA) requires community water systems to test water for lead coming out of the taps of homes. The number of samples that must be collected and the frequency with which the samples must be collected varies with the size of the system and the results of previous monitoring. What are the criteria that community water systems must use to determine if their testing results require corrective action?

10% of the testing results must be above the action level of 15 ppb.

Step 2:   Table 1 lists the first-draw drinking water sampling results for lead in homes from four community water systems. Determine if the community water system assigned to your group is above the action level for lead. Use the Drinking Water Sampling Results for Lead Worksheet to make this determination. (Additional instructions are on the Student Instructions.)

a) Are your community water system sampling results above the action level for lead?

See tables for each community water system at the end of this section. If sample #23 ($25 \times 0.9 = 22.5$ and rounded up) is above 15 ppb, the community water system is above the action level.

Community water system 1—No

Community water system 2—No

Community water system 3—Yes

Community water system 4—Yes

b) Why does the EPA use the 90th percentile number to determine if the community water system should take corrective action? Why not just use any single home sampling result above the action level to determine the need for corrective action?

The EPA rule is designed to address broad public health threats to water safety without creating an undue burden for community water systems. Responding to individual sampling results one by one would be overly burdensome and might prevent the community water system from addressing the larger problems. In addition, all sampling results have a natural variation that must be taken into account so that true problems are identified. By selecting the 90th percentile, 10% of the results are above the action level, and the possibility that high results are just the result of natural variation is reduced significantly.

PART 2

Step 3:   One common way to help describe and display numeric data is to create a frequency distribution in the form of a bar graph or histogram. Make a bar graph of the lead sampling results for your community water system showing how the sampling results are distributed. Use the Drinking Water Sampling Results for Lead Worksheet you filled out in Step 2. Column 3 of the worksheet ("Frequency Range for Lead in ppb") lists defined ranges or bins where individual results may fall. From the sampling results for your community water system, determine the total number of samples that falls in each bin and list the number of samples next to each bin in Column 4 ("# of Results in Frequency Range"). Make a bar graph of the results showing the frequency on the y axis and the bin ranges on the x axis. You may label

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bin ranges using the highest number in the bin. Be sure to label the axes and give the graph a title.
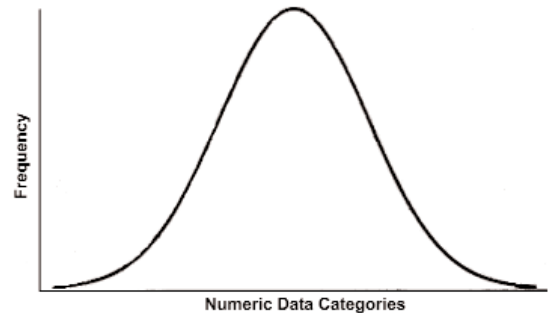
a) Describe the shape of how the sampling results are distributed.

See tables and graphs for each community water system at the end of this assessment section. Community Water Systems 1, 2, and 3 have a high left side that trails off to the right. Community Water System 4 has a high left side that rises to a peak and then trails off to the right of the graph. These shapes are typical of environmental sampling results. There are always a few high outliers.

b) A frequency distribution that allows for the use of many powerful mathematical and statistical methods to analyze, summarize, and describe numeric data is called the normal distribution, or bell curve. An example is shown at right:

Are the lead sampling results you graphed normally distributed? Explain.

The bar graphs showing the frequency distributions for the four different community water systems are not normally distributed since the shapes of the curves are very different from the pictured bell curve. The bar graphs show frequency distributions that are very positively skewed (data bunched together at the lower end of the range).

Step 4: Sometimes it is possible to mathematically transform numeric data so they become normally distributed. This then allows for the use of the many powerful statistical methods available for normally distributed data. Make a second bar graph of the lead sampling results for your community water system showing how the sampling results are distributed if the results are converted to logarithms to the base 10. A logarithm is the power (a) of the number 10 ($10a$) that gives you the equivalent sampling result. For example, the log of 8 is 0.903 or $10^{0.903}$.

Using your Drinking Water Sampling Results for Lead Worksheet, compute the log10 of the sampling results from Column 2 for each result and record the number in Column #5 ("Log10 of Results") to three decimal places. Column 6 ("Frequency Range for Log10 Results") lists defined ranges or bins where individual log10 results may fall. From the log10 results for your community water system, determine the total number of samples that falls in each bin and list that number next to each bin in Column 7 ("# of log10 Results in Frequency Range"). Make a bar graph of the results showing the frequency of the log10 results on the y axis and the bin ranges on the x axis. You may label bin ranges using the highest number in the bin. Be sure to label the axes and give the graph a title.

a) Describe the shape of how the sampling results are distributed.

See tables and graphs for each community water system at the end of this section. Community Water Systems 1, 2, 3 and 4 are all more or less bell-shaped with a high rounded center and even tails on both sides trailing off to lower numbers.

b) Are the logs of the lead sampling results normally distributed? Explain.

The shapes are close to a normal distribution. Any differences from the bell curve would begin to disappear if many more samples were collected. Converting environmental sampling results to logs typically results in a normal distribution.

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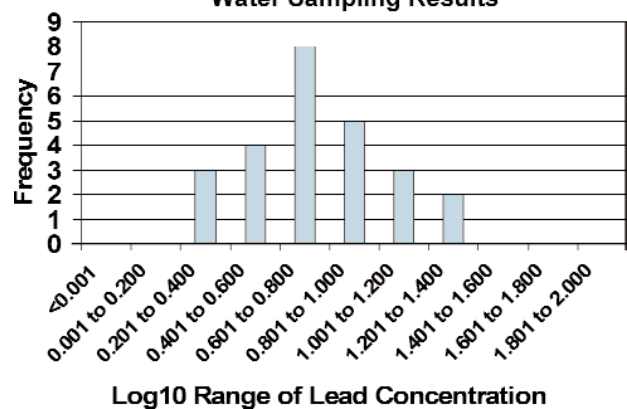| **Community Water System 1 Lead Drinking Water Sampling Results**						
Sample #	Lead Concentration in ppb	Frequency Range for Lead in ppb	# of Results in Frequency Range	Log10 of Results	Frequency Range for Log10 Results	# of log10 Results in Frequency Range
1	2	0 to 5.00	12	0.301	<0.001	0
2	2	5.01 to 10.00	8	0.301	0.001 to 0.2	0
3	2	10.01 to 15.00	3	0.301	0.201 to 0.400	3
4	3	15.01 to 20.00	1	0.477	0.401 to 0.600	4
5	3	20.01 to 25.00	1	0.477	0.601 to 0.800	8
6	3	25.01 to 30.00	0	0.477	0.801 to 1.000	5
7	3	30.01 to 35.00	0	0.477	1.001 to 1.200	3
8	4	35.01 to 40.00	0	0.602	1.201 to 1.400	2
9	4	40.01 to 45.00	0	0.602	1.401 to 1.600	0
10	5	45.01 to 50.00	0	0.699	1.601 to 1.800	0
11	5	50.01 to 55.00	0	0.699	1.801 to 2.000	0
12	5	55.01 to 60.00	0	0.699		
13	6	60.01 to 65.00	0	0.778		
14	6	65.01 to 70.00	0	0.778		
15	6	70.01 to 75.00	0	0.778		
16	7	75.01 to 80.00	0	0.845		
17	7	80.01 to 85.00	0	0.845		
18	8	85.01 to 90.00	0	0.903		
19	9	90.01 to 95.00	0	0.954		
20	9	95.01 to 100.00	0	0.954		
21	11			1.041		
22	14			1.146		
23	15			1.176		
24	18			1.255		
25	23			1.362		

Community Water System 1 Lead Drinking Water Sampling Results

Community Water System 1 Lead Drinking Water Sampling Results

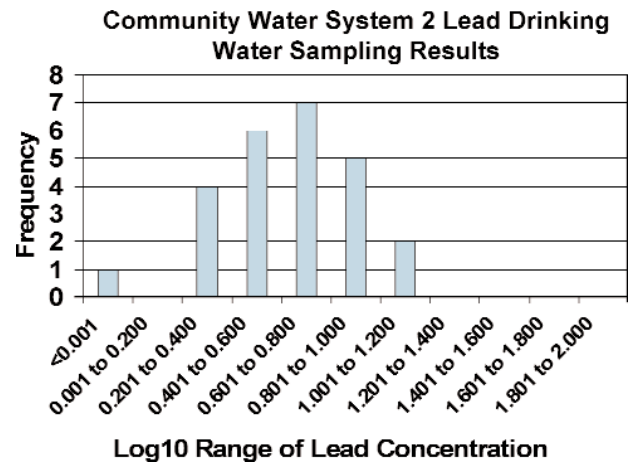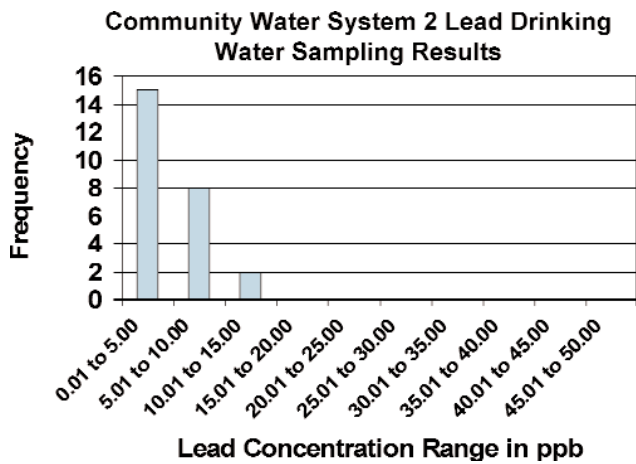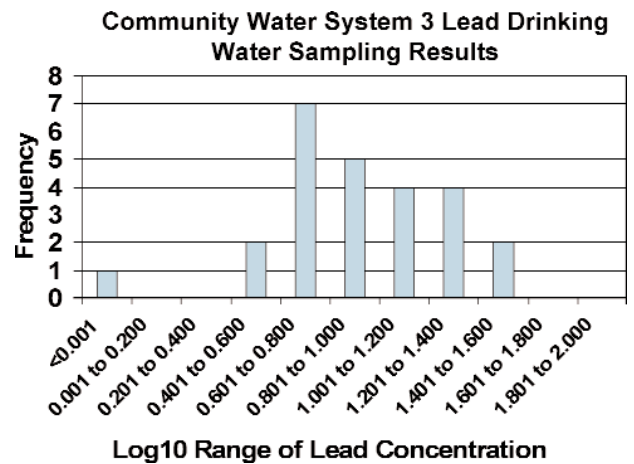|		**Community Water System 2 Lead Drinking Water Sampling Results**				
Sample #	Lead Concentration in ppb	Frequency Range for Lead in ppb	# of Results in Frequency Range	Log10 of Results	Frequency Range for Log10 Results	# of log10 Results in Frequency Range
1	1	0 to 5.00	15	0.000	<0.001	1
2	2	5.01 to 10.00	8	0.301	0.001 to 0.2	0
3	2	10.01 to 15.00	2	0.301	0.201 to 0.400	4
4	2	15.01 to 20.00	0	0.301	0.401 to 0.600	6
5	2	20.01 to 25.00	0	0.301	0.601 to 0.800	7
6	3	25.01 to 30.00	0	0.477	0.801 to 1.000	5
7	3	30.01 to 35.00	0	0.477	1.001 to 1.200	2
8	3	35.01 to 40.00	0	0.477	1.201 to 1.400	0
9	3	40.01 to 45.00	0	0.477	1.401 to 1.600	0
10	3	45.01 to 50.00	0	0.477	1.601 to 1.800	0
11	3	50.01 to 55.00	0	0.477		
12	4	55.01 to 60.00	0	0.602		
13	4	60.01 to 65.00	0	0.602		
14	5	65.01 to 70.00	0	0.699		
15	5	70.01 to 75.00	0	0.699		
16	6	75.01 to 80.00	0	0.778		
17	6	80.01 to 85.00	0	0.778		
18	6	85.01 to 90.00	0	0.778		
19	7	90.01 to 95.00	0	0.845		
20	8	95.01 to 100.00	0	0.903		
21	8			0.903		
22	9			0.954		
23	9			0.954		
24	11			1.041		
25	11			1.041		

Community Water System 2 Lead Drinking Water Sampling Results

Community Water System 2 Lead Drinking Water Sampling Results

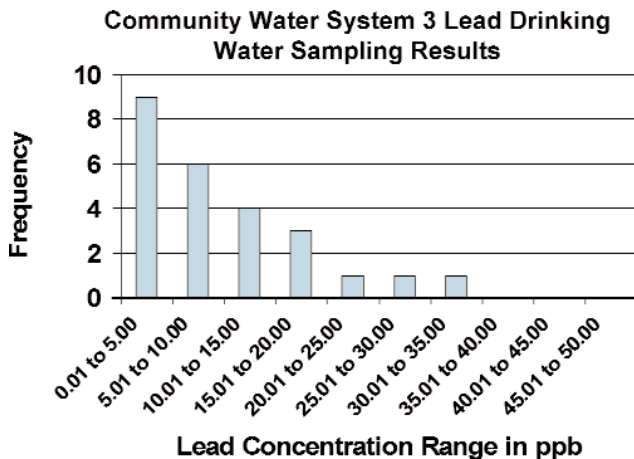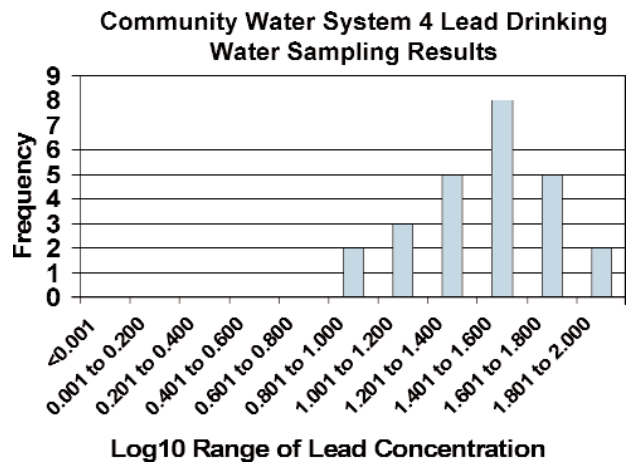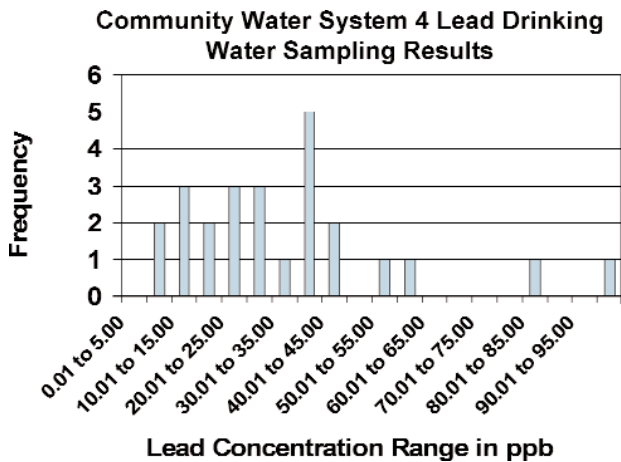| Community Water System 3 Lead Drinking Water Sampling Results						
Sample #	Lead Concentration in ppb	Frequency Range for Lead in ppb	# of Results in Frequency Range	Log10 of Results	Frequency Range for Log10 Results	# of log10 Results in Frequency Range
1	1	0 to 5.00	9	0.000	<0.001	1
2	3	5.01 to 10.00	6	0.477	0.001 to 0.2	0
3	3	10.01 to 15.00	4	0.477	0.201 to 0.400	0
4	4	15.01 to 20.00	3	0.602	0.401 to 0.600	2
5	4	20.01 to 25.00	1	0.602	0.601 to 0.800	7
6	5	25.01 to 30.00	1	0.699	0.801 to 1.000	5
7	5	30.01 to 35.00	1	0.699	1.001 to 1.200	4
8	5	35.01 to 40.00	0	0.699	1.201 to 1.400	4
9	5	40.01 to 45.00	0	0.699	1.401 to 1.600	2
10	6	45.01 to 50.00	0	0.778	1.601 to 1.800	0
11	8	50.01 to 55.00	0	0.903	1.801 to 2.000	0
12	8	55.01 to 60.00	0	0.903		
13	8	60.01 to 65.00	0	0.903		
14	8	65.01 to 70.00	0	0.903		
15	10	70.01 to 75.00	0	1.000		
16	11	75.01 to 80.00	0	1.041		
17	12	80.01 to 85.00	0	1.079		
18	13	85.01 to 90.00	0	1.114		
19	15	90.01 to 95.00	0	1.176		
20	17	95.01 to 100.00	0	1.230		
21	18			1.255		
22	20			1.301		
23	21			1.322		
24	29			1.462		
25	32			1.505		

Community Water System 3 Lead Drinking Water Sampling Results

Community Water System 3 Lead Drinking Water Sampling Results

Sample #	Lead Concentration in ppb	Frequency Range for Lead in ppb	# of Results in Frequency Range	Log10 of Results	Frequency Range for Log10 Results	# of log10 Results in Frequency Range
		Community Water System 4 Lead Drinking Water Sampling Results				
1	7	0 to 5.00	0	0.845	<0.001	0
2	8	5.01 to 10.00	2	0.903	0.001 to 0.2	0
3	12	10.01 to 15.00	3	1.079	0.201 to 0.400	0
4	14	15.01 to 20.00	2	1.146	0.401 to 0.600	0
5	14	20.01 to 25.00	3	1.146	0.601 to 0.800	0
6	17	25.01 to 30.00	3	1.230	0.801 to 1.000	2
7	18	30.01 to 35.00	1	1.255	1.001 to 1.200	3
8	21	35.01 to 40.00	5	1.322	1.201 to 1.400	5
9	21	40.01 to 45.00	2	1.322	1.401 to 1.600	8
10	21	45.01 to 50.00	0	1.322	1.601 to 1.800	5
11	26	50.01 to 55.00	1	1.415	1.801 to 2.000	2
12	28	55.01 to 60.00	1	1.447		
13	30	60.01 to 65.00	0	1.477		
14	33	65.01 to 70.00	0	1.519		
15	36	70.01 to 75.00	0	1.556		
16	38	75.01 to 80.00	0	1.580		
17	39	80.01 to 85.00	1	1.591		
18	39	85.01 to 90.00	0	1.591		
19	40	90.01 to 95.00	0	1.602		
20	43	95.01 to 100.00	1	1.633		
21	44			1.643		
22	53			1.724		
23	60			1.778		
24	84			1.924		
25	98			1.991		

Community Water System 4 Lead Drinking Water Sampling Results

Frequency vs. Lead Concentration Range in ppb

Community Water System 4 Lead Drinking Water Sampling Results

Frequency vs. Log10 Range of Lead Concentration

▶ **Authors and Reviewers**

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Give us your feedback! Send comments about this lesson to ehpscienceed@niehs.nih.gov.

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PART 1

Step 1: Read the article "Taking the Lead and Copper Rule to Task" and answer the following questions:

a) What is the action level for lead in drinking water?

b) The Environmental Protection Agency (EPA) requires community water systems to test water for lead coming out of the taps of homes. The number of samples that must be collected and the frequency with which the samples must be collected varies with the size of the system and the results of previous monitoring. What are the criteria that community water systems must use to determine if their testing results require corrective action?

Step 2: Table 1 on page 13 lists the first-draw drinking water sampling results for lead in homes from four community water systems. Determine if the community water system assigned to your group is above the action level for lead. Use the Drinking Water Sampling Results for Lead Worksheet (page 14) to make this determination by following the steps below:

• Place lead results in ascending order (from lowest to highest value) in Column 2 of the worksheet.
• Multiply the number of samples by 0.9 (90%). Round up this number to the nearest whole number.
• Circle this sample number on the worksheet in Column 1. This is the 90th percentile number for your sampling results. Compare the 90th percentile level to the action level of 15 parts per billion (ppb). If your 90th percentile value is higher than 15 ppb, you have a level that exceeds the EPA allowance.

a) Are your community water system sampling results above the action level for lead?

b) Why does the EPA use the 90th percentile number to determine if the community water system should take corrective action? Why not just use any single home sampling result above the action level to determine the need for corrective action?
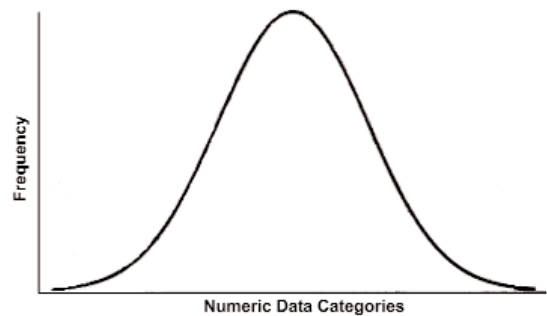
PART 2

Step 3: One common way to help describe and display numeric data is to create a frequency distribution in the form of a bar graph or histogram. Make a bar graph of the lead sampling results for your community water system showing how the sampling results are distributed. Use the Drinking Water Sampling Results for Lead Worksheet you filled out in Step 2. Column 3 of the worksheet ("Frequency Range for Lead in ppb") lists defined ranges or bins where individual results may fall . From the sampling results for your community water system, determine the total number of samples that falls in each bin and list the number of samples next to each bin in Column 4 ("# of Results in Frequency Range"). Make a bar graph of the results showing the frequency on the y axis and the bin ranges on the x axis. You may label bin ranges using the highest number in the bin. Be sure to label the axes and give the graph a title.

a) Describe the shape of how the sampling results are distributed.

b) A frequency distribution that allows for the use of many powerful mathematical and statistical methods to analyze, summarize, and describe numeric data is called the normal distribution, or bell curve. An example is shown at right:

Are the lead sampling results you graphed normally distributed? Explain.

Step 4: Sometimes it is possible to mathematically transform numeric data so they become normally distributed. This then allows for the use of the many powerful statistical methods available for normally distributed data. Make a second bar graph of the lead sampling results for your community water system showing how the sampling results are distributed if the results are converted to logarithms to the base 10. A logarithm is the power (a) of the number 10 (10a) that gives you the equivalent sampling result. For example, the log of 8 is 0.903 or 100.903.

Using your Drinking Water Sampling Results for Lead Worksheet, compute the log10 of the sampling results from Column 2 for each result and record the number in Column 5 ("Log10 of Results") to three decimal places. Column 6 ("Frequency Range for Log10 Results") lists defined ranges or bins where individual log10 results may fall. From the log10 results for your community water system, determine the total number of samples that falls in each bin and list that number next to each bin in Column 7 ("# of log10 Results in Frequency Range"). Make a bar graph of the results showing the frequency of the log10 results on the y axis and the bin ranges on the x axis. You may label bin ranges using the highest number in the bin. Be sure to label the axes and give the graph a title.

a) Describe the shape of how the sampling results are distributed.

b) Are the logs of the lead sampling results normally distributed? Explain.

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Table 1
First-Draw Drinking Water Lead Monitoring Results in ppb

Community Water System 1	Community Water System 2	Community Water System 3	Community Water System 4
2	9	4	26
3	2	21	98
6	6	1	18
5	6	8	30
2	11	18	36
5	3	8	39
11	1	6	21
3	8	11	33
4	4	12	40
9	8	3	12
9	2	5	38
6	5	5	28
23	11	3	60
3	2	17	8
14	3	13	7
4	6	8	21
18	7	15	43
5	5	32	17
2	9	20	14
3	3	8	84
7	3	10	44
15	2	4	14
6	4	5	53
8	3	29	21
7	3	5	39

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Drinking Water Sampling Results for Lead Worksheet Community Water System #___						
1	2	3	4	5	6	7
Sample #	Lead Concentration in ppb	Frequency Range for Lead in ppb	# of Results in Frequency Range	Log10 of Results	Frequency Range for Log10 Results	# of log10 Results in Frequency Range
1		0 to 5.00			<0.001	
2		5.01 to 10.00			0.001 to 0.2	
3		10.01 to 15.00			0.201 to 0.400	
4		15.01 to 20.00			0.401 to 0.600	
5		20.01 to 25.00			0.601 to 0.800	
6		25.01 to 30.00			0.801 to 1.000	
7		30.01 to 35.00			1.001 to 1.200	
8		35.01 to 40.00			1.201 to 1.400	
9		40.01 to 45.00			1.401 to 1.600	
10		45.01 to 50.00			1.601 to 1.800	
11		50.01 to 55.00			1.801 to 2.000	
12		55.01 to 60.00				
13		60.01 to 65.00				
14		65.01 to 70.00				
15		70.01 to 75.00				
16		75.01 to 80.00				
17		80.01 to 85.00				
18		85.01 to 90.00				
19		90.01 to 95.00				
20		95.01 to 100.00				
21						
22						
23						
24						
25						

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