# Pounds of Pollution

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## National Academic Standards:
**Science**
Science as Inquiry
▪ Understandings about scientific inquiry

## Grades: 9-12

## Subject: Science

## Objectives:
1. To calculate the weight of various pollutants.
2. To visualize the amount of air pollution emitted by a car each year.

## Materials:
Many two-liter soda bottles

## Background:

Air pollution is a difficult concept to grasp. We often can't see it! Yet cars emit many different air pollutants. (See box.) Air pollution is often referred to in terms of pounds. You know that air has weight, but how much of a gas is a pound? By displaying the soda bottles and attaching a label that informs passers-by that the bottles represent one pound of carbon dioxide ($CO_2$), the awareness of a school and community can be significantly raised.

## Procedure:
A. Calculate the volume of one pound of whatever air pollutant you are interested in by using the following equation:

$$\frac{454g}{1\ lb} \quad x \quad \frac{1\ mole}{"X"\ g} \quad x \quad \frac{22.4L}{1\ mole} = \text{liters of gas/pound}$$

**Explanation:**
There are 454 grams in a pound. The next step is to find out how many grams of your pollutant are in a mole. This number can be calculated using values from the Periodic Table of the Elements. Add the grams per mole for each compound. For example, one atom of oxygen is 16 grams per mole and carbon dioxide is 12 grams per mole. This totals 44 grams per mole of carbon dioxide molecule ($CO_2$ is two oxygen atoms plus one carbon atom). For your convenience, we have listed the weights of carbon dioxide, carbon monoxide, and nitrogen dioxide - three pollutants given off by cars. Insert these values for "X" depending on the pollutant:

$CO_2$ = 44g
$CO$ = 28g
$NO_2$ = 46g

There are 22.4 liters in a mole. Multiply by this number of liters and you have converted the pound of gas into an equivalent number of liters.

B. Calculate how many two-liter bottles are needed for the display. Use the following equation:

$$\frac{\text{volume of 1 lb of the pollutant}}{2\ liters} = \text{total bottles}$$

For example, if you are dealing with $CO_2$, which you have calculated to be 231 liters per pound, divide 231 by 2. This tells you that you need 115.5 bottles to represent one pound of $CO_2$.

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### A Car Does What?

In one year, a new 2001 model small car, traveling the average 12,513.2 miles per year, getting 28.7 miles to the gallon, using 436 gallons/year, spews into the air we breathe*:

▪ 8,725 lbs of <u>carbon dioxide</u> ($CO_2$)
▪ 193 lbs of <u>carbon monoxide</u> (CO)
▪ 5.7 lbs of <u>hydrocarbons</u>
▪ 18 lbs of <u>nitrogen oxide</u> ($NO_x$)
▪ smaller amounts of benzene, formaldehyde, volatile organic compounds, and other toxic materials.

Larger vehicles, like popular sport utility vehicles (SUVs), can produce **more than twice as much pollution** as a small car!

Note: Cars emit several different **nitrogen oxides**. If you want to demonstrate how much of a particular nitrogen oxide weighs per pound, you would have to make a separate calculation for each kind of nitrogen oxide using their different atomic masses.

*Figures from "Tailpipe Tally," Environmental Defense Fund, on the web at <u>www.edf.org</u>.

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## Answer Key:

Number of two-liter bottles:
    $CO_2$ = 115.5 bottles
    $CO$ = 181.3 bottles
    $NO_2$ = 110.5 bottles
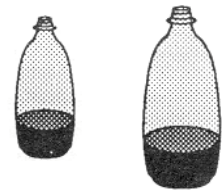
## Student Questions:
1. How many bottles would be needed to represent the hypothetical car's (see box) yearly $CO_2$ and CO emissions?
2. Calculate how many bottles would be needed to represent the amount of CO2 and CO your class members contribute to the atmosphere during one school week. Use the hypothetical car amounts, above.
3. According to Wisconsin DNR calculations, the number of tons of NOx emitted on a hot summer day in southeastern Wisconsin* is about 409. If this amount were made up entirely of NO2, how many soda bottles would this be?

## Student Answers:
1. There are 363 liters per pound of CO, multiplied by 193 lbs emitted by the average car per year equals 70,059 liters.

    There are 231 liters per pound of $CO_2$, multiplied by 8,725 lbs emitted by the average car per year equals 2,015,475 liters.

    $CO$ = 35,029.5 bottles

    $CO_2$ = 1,007,737.5 bottles
2. Answers will vary.
3. Multiply the 409 tons of $NO_x$ emitted, by 2000 lbs in a ton, and you have 818,000 lbs of $NO_x$. There are 221 liters per pound of $NO_2$. Multiply this by 818,000 lbs and you have 180,778,000 liters. This is 90,389,000 soda bottles worth emitted on one summer day in southeastern Wisconsin.

* "Southeastern Wisconsin," above, refers to the following 11 counties: Door, Kenosha, Kewaunee, Manitowoc, Milwaukee, Ozaukee, Racine, Sheboygan, Walworth, Washington, and Waukesha.

## Extension:

The average American contributes 20 tons of $CO_2$ to the atmosphere each year. Have your students use the worksheet "<u>Calculate your CO2 production</u>" to determine what they produce each year.

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*Adapted from Tammie Niffenegger, Port Washington High School, Wisconsin.*