The Cave of Dogs!

Experiment - Behold the Cave of Dogs!

Grades: 5-8
Time: 20 -30 minutes
Subject: Chemistry
Topics: Properties of Gasses

Overview

Get ready for the big show as we simulate our very own Cave of Dogs - fire, dangerous fumes, and thrilling science are about to all come together!

Background

Welcome to the Cave of Dogs - your very own Science Mystery simulation! The Cave of Dogs, located near Naples, Italy was once on the Grand Tour as a tourist attraction over 300 years ago! Dogs and other small animals would pass out upon entering the cave, yet humans were fine. What was going on?

It turns out the cave is located in an active volcanic area and there is a "fumarole" - a volcanic vent that leaks gases, located in the cave. This provides a constant source of carbon dioxide (CO_2) that fills the lower parts of the cave displacing oxygen. In this activity you will get to watch exactly what happens as oxygen is displaced in your very own Cave of Dogs. What do you predict will occur?

Let's explore further with databot™!

CO2 Levels and their Effect	
250-400 PPM	Normal background concentration in outdoor ambient air.
400 - 1,000 PPM	Concentrations typical of occupied indoor spaces with good air exchange.
1,000 - 2,000 PPM	Drowsiness and complaints of poor air.
2,000 - 5,000 PPM	Headaches, sleepiness and stagnant, stale, stuffy air. Poor Concentration, loss of attention, increased heart rate and slight nausea may also be present.
5,000 PPM	Workplace exposure limit in most places.
>40,000 PPM	Exposure may lead to serious oxygen deprivation resulting in permanent brain damage, coma, even death.

Objectives

Understand & Recognize:
- Gases have weight, and different gases are heavier or lighter than others.
- CO2 is:
  - an invisible and odorless gas
  - deadly to animals in concentrated amounts
  - heavier than air
  - varying in levels in the air around us depending on many factors
- A fumarole is a volcanic vent, an opening in the earth's crust, that emits steam and gases.

What You'll Need

Materials to Build Your Cave of Dogs

- IOS or Android smart device with Bluetooth Low Energy (BLE) to connect to databot™
- databot™ + Phypox App installed on your IOS or Android device
- Vase, Jar, or container (Your Cave of Dog)

  In the activity demonstrations we are using an OXO brand, 4.2 liter,storage container that has a push button airlock feature.

- Tea Candles - 3
- Lighter (Long-Handled)
- Blocks - LEGO works well.
- 12" Round Balloon filled with CO2
- Paperclip -1 (to pinch off the balloon)

Your Cave of Dogs can be any container large enough to hold the candles and databot™ A rectangular vase works well as it provides a lot of visibility of the effect. In the experiment video we are using a 4 quart storage container. You can try other types including a shoebox type plastic container that you might have available

Important Terms

Carbon Dioxide (CO2): A colorless, odorless gas naturally present in the air you breathe and

Important Terms (continued)

(CO2 continued) is absorbed by plants in photosynthesis. There would be no animal life or green plants without carbon dioxide. Green plants use energy from the sun plus carbon dioxide and water to produce carbohydrates and oxygen.

Weight: A measurement of the force of gravity applied to an object – it is calculated by multiplying an object's mass by the acceleration of gravity. The weight of an object can vary depending on the gravitational field it is in.

Volume: The amount of space a substance takes up.

Density: An object's mass in a given volume. For example, a 1 cm cube of gold is much denser than a 1 cm cube of balsa wood so the weight of the gold cube is much, much heavier.

Fumarole: An opening in the Earth's crust through which volcanic fumes are emitted.

Prep (5 mins)

Ready for the Cave of Dogs simulation?!

- Gather the materials required for assembling your Cave of Dogs simulation.
- Practice connecting to databot™ with a smart device such as a tablet or smartphone, you will want to be ready to record data when you begin the experiment!
- Use your knowledge of CO2 generation to fill a balloon with CO2. Pinch it off with a clip of some kind so you can release the CO2 when the time comes.
- You may want to even add a cutout of people and dogs to make your cave simulation more realistic and give perspective.
- Review the Important Terms.

Experiment (10 mins)

Set-up:

- Use the QR Code to see the proper set-up for your Cave of Dogs experiment.

Set-up: (continued)

- You can use different types of containers such as a long rectangular vase or a gallon jar. You may need to experiment depending on the type of container as air movement will be different in different shapes.
- The container shown here is an Oxo 4.4 quart storage container.
- Use blocks as spacers to place the three candles at different heights.
- Place your databot™ on the end as shown.
- Leave enough open space on the opposite end of databot™ to "pour" in the CO2 without blowing out the candles.
- Place your cutout stencil of people and animals to give you a perspective on the depth of the CO2.

Lab Procedure

Ready to begin! Let's go!

- *Watch the video using the QR code.*
- Turn on your databot™.
- Light your candles using a long handled lighter. Be careful!
- Connect databot™ to your smart device and begin taking CO2 readings.
- Don't release too quickly as this will blow out the candles, you want to slowly feed the CO2 into the cave as a volcanic fumarole would. Watch what happens.

*Stop your data recording on Phyphox and review the numbers in Phyphox.*

- What are the highest levels recorded? Look at the chart that shows levels of CO2 and their potential danger. Was the cave a hazardous place to be?
- Export your Phyphox file if you are going to conduct further analysis in a spreadsheet or other software.

Reflection: After performing the experiment and watching the candles and the data readings, explain in your own words why the Cave of Dogs is dangerous to small animals like dogs but less dangerous to people.

Ready to Challenge Yourself?

Data Analysis

Export your dataset from Phyphox and open the file in your favorite spreadsheets like Excel, Numbers, or Google Sheets. The "Time Stamp" is recorded in milliseconds (thousandths of a second) relative to your device system time.

CO2 vs. Time (s)
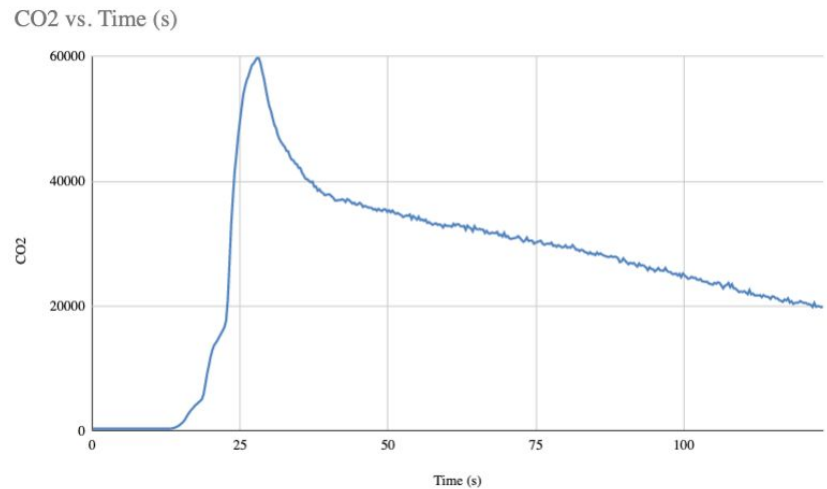
Perform a calculation in your spreadsheet to convert your data to seconds relative to your experiment starting time and generate a chart showing CO_2 levels versus time (t) in seconds. Math on!

You've mastered some great challenges in this Module!

Great job! Now for a new kind of adventure, the next stop is a Collaboration. Learn how to take control through programming. Good luck!

Next Step, Collaboration!

Educator Resources

Prep

- Read through the background information on this module and review PDQ 1 and 2 as they lay the groundwork for this experiment.
- Have CO_2 prepared and in a balloon.
- Practice the Cave of Dogs several times so you understand the dynamics of the experiment. Depending on the container you use and airflow you will find that the behavior of your experiment can vary. A bit of practice and you will be able to do it perfectly.
- Make sure you are proficient with your databot™ and Phyphox. You can use the Enable Remote Control function to display your data collection on a big screen if you have one!
- Read through the additional resources and familiarize yourself with the CO_2 stories that highlight its density. These can be great talking points with your students.

Objectives

Understand and Recognize:
- Gases have weight, and different gases are heavier or lighter than others.
- CO2 is:
    - an invisible and odorless gas
    - deadly to animals in concentrated amounts
    - heavier than air
    - varying in levels in the air around us depending on many factors
- A fumarole is a volcanic vent, an opening in the earth's crust, that emits steam and gases.

NGSS

- 5-PS1-1: Develop a model to describe that matter is made of particles too small to be seen.
- NGSS Practice 4: Analyzing and Interpreting Data
  Excerpt: When possible and feasible, students should use digital tools to analyze and interpret data. Whether analyzing data for the purpose of science or engineering, it is important students present data as evidence to support their conclusion.

Misconceptions

- Air has no weight
- All gases have no weight, they just float around.

Guiding Questions

Why do the candles go out from the bottom up?

- Why do you suppose the cave is more dangerous to animals than people?

Additional Resources:

The Grotta Del Cane (Dog Cave), Naples, Italy

Article, W.R. Halliday; Arrigo Cigna. January 2006

https://www.researchgate.net/publication/290890558_The_Grotta_Del_Cane_Dog_Cave_Naples_Italy

Cave of Dogs

Illinois Library, Rare Book and Manuscript Library

https://www.library.illinois.edu/rbx/2016/12/15/cave-of-the-dogs/

Carbon Dioxide

Wikipedia

https://en.wikipedia.org/wiki/Carbon_dioxide

Carbon Dioxide Stories

This document is highly recommended reading as it provides some great examples of how CO2 and its heavier-than-air quality creates unusual events and circumstances. Great talking points for classroom discussion.

https://www.scienceinschool.org/sites/default/files/teaserMaterial/issue20_CO2_stories.pdf

The Lake Nyos Disaster

One of the CO2 stories is about Lake Nyos in Africa in which over a thousand people and thousands of animals died from a CO2 eruption from the Lake. This is a tragic story but powerfully tells the story of CO2 and how its heavier-than-air nature can be deadly in large doses.

https://en.wikipedia.org/wiki/Lake_Nyos_disaster

This is a good Youtube video on Limnic Eruptions, what caused the Lake Nyos disaster.

https://www.youtube.com/watch?v=o8AonDeS8HY

Another example of conducting the Cave of Dogs experiment, based on the Lake Nyos disaster.

https://www.youtube.com/watch?v=1xuAS9Z1e_4

References:

Fumarole Image by Monika P on Pixabay!

Creative Commons License:

The Cave of Dogs by Robert O. Grover & Team databot™ is licensed under a Creative Commons Attribution 4.0 International License. Permissions beyond the scope of this license may be available at databot.us.com/contact.