

Ocean Acidification: The Other CO₂ problem

Driving Question: How has Ocean Chemistry Changed in the past 25 years?

Activity: Using Hawaii Ocean Time-Series data to graph CO₂ and pH with time

Introduction

Most people think of global climate change as *the* CO₂ problem. But, when human activities put excess CO₂ in the atmosphere, this causes another, related problem: ocean acidification. Here's how it works: Some of the atmospheric CO₂ gets dissolved in the ocean, where it combines with water (H₂O) to form carbonic acid (H₂CO₃). This causes the ocean to become more acidic (lower pH).

How do we know this? Since October 1988, scientists from the Hawaii Ocean Time-series (HOT) program have been making measurements of seawater about once per month. This allows them to track how variables have changed over time. To see this for yourself, make a graph to show that the ocean's CO₂ has increased and its pH has decreased since the HOT program began collecting data. If desired, you can also plot the atmospheric CO₂ data on the same graph.

Materials

- Computer with Microsoft Excel
- Excel data file with two spreadsheets: (1) HOT data of oceanic CO₂ and pH, and (2) NOAA data of atmospheric CO₂ from the Mauna Loa observatory. Download Excel file from:
cmore.soest.hawaii.edu/education/teachers/documents/HOT_and_NOAA_%20data_FINAL.xlsx

Graphing

A) *Create a scatter plot showing how pH and CO₂ data change with time*

1. Create basic graph. Open Excel file and click on the "HOT" spreadsheet tab (lower left corner of the Excel file). Highlight the 3 data columns (date, CO₂ and pH). Click on "Insert" tab and insert a "scatter plot" (scatter with straight lines). Do you see a graph with 2 sets of data that are scrunched together and hard to read? Reformatting the axes will definitely help!
2. Reformat the x-axis. Right click on x-axis and "format axis". Under "Axis options", set the minimum value to 32000, maximum to 41500, and major unit to 365. Under "Alignment", set custom angle to -45 degrees. [What did this accomplish? What do you think the numbers represent?]
3. Create two y-axes (one per data set). Right click on the upper dataset on the graph (CO₂ values). Click on "Format Data Series", "Secondary Axis" then "Close". [What did this accomplish?] Do you see two overlapping data sets (pH and CO₂)? To make it easier to read, we can adjust the y-axis ranges so they don't overlap.
4. Reformat the left y-axis. Right click on the left y-axis and "Format axis". Under "Axis Options", set the minimum value to 8.04, maximum to 8.28, and "Close". [What did this accomplish?]
5. Reformat the right y-axis. Repeat the above step for the right y-axis, but set the minimum to 195 and the maximum value to 410. [What did this accomplish?]
6. Adding trendlines. To add trendlines to the data, right click on the upper data series. Click on "Add Trendline" and select "Linear". Adjust Line Color and Line Style to your liking. Click "OK". Repeat for the other data series.
7. Examine the graph. What do you notice about the two datasets?

B) Plot the atmospheric CO₂ data (if desired).

8. Add data series. To add the atmospheric CO₂ values to the graph right click on the chart and choose "Select Data". Click the "Add" button and type the series name (e.g. Atmospheric CO₂). To add X values click in the box then go to the NOAA worksheet tab (lower left corner of the Excel file) and highlight the dates. Do the same for Y values, but highlight the Atmospheric CO₂ column instead. Click "OK".
9. Examine the graph. You should see now see a third data series of atmospheric CO₂ values added to the graph. How do the trends of the atmospheric and oceanic CO₂ values compare?

C) Add some finishing touches.

10. Change x-axis values to years, for easier reading. [Hint: "Format axis", "Number" and type "yyyy" for "Format Code"]
11. Add axis labels & a title [Hint: "Chart Tools" and "Layout"]
12. What other finishing touches would you like to add?

Questions (partial list; please add your own!)

1. Why do you think the atmospheric data fluctuate in such a regular (saw-toothed) pattern?
2. The oceanic and atmospheric CO₂ both generally increase with time. Why?
3. The oceanic CO₂ and pH data appear to be mirror images of each other. Why?
4. About how much has the atmospheric CO₂ increased from 1988 to 2011?
Increase in ppm: _____ Percentage Increase: _____
5. About how much has the ocean CO₂ increased from 1988 to 2011?
Increase in ppm: _____ Percentage Increase: _____
6. About how much has the ocean pH decreased from 1988 to 2011?
Decrease in pH units: _____ Increase in acidity*: _____
*Note: the pH scale is logarithmic: a decrease from 9.0 to 8.0 equals a 10x increase in acidity.
7. Hypothetically, at some point in the future, suppose the pH of the ocean decreased to 8.0. How much of an increase in acidity would that represent (from 1988)?
8. What could be done to prevent the scenario in the above question from happening?

References

Hawaii Ocean Time-series (HOT) program: <http://hahana.soest.hawaii.edu/hot/>
NOAA Earth System Monitoring Laboratory: http://www.esrl.noaa.gov/gmd/ccgg/trends/#mlo_data