COAL POWER AND ACID RAIN

1. Introduction

Acid rain emerged as a concern in the 1960s with observations of dying lakes and forest damage in northern Europe, the United States, and Canada. Although there has been major progress in controlling acid-forming emissions in some countries, the global threat from acid rain is far from over yet. Acid rain is now emerging as a major problem the developing world, especially in parts of Asia and the Pacific region.
Scientists conclude that the combustion of fossil fuels is the cause of acid rain. In the last decades, an increasing number of power plants supplied with coal have been established in Asia. In this activity **you will work to answer the question**:

Effects of acid rain in the woods of Jizera Mountains, Czech Republic

The Leshan Giant Buddha in China is being slowly destroyed by acid rain.

How can we explain the contribution of coal combustion to acid rain?

To answer this question you will:

- Investigate what acid rain is, and study how can acidic deposition be monitored.
- Explore the chemical composition of coal and the chemical reactions that intervene in its combustion.
- Design and perform an experiment to model coal combustion in the laboratory and its relation with acid rain.
- Evaluate the results obtained and draw conclusions to answer this demand.

2. Acid rain and pH measurements (optional)

What do we know about acid rain?

Acid rain is rain or any other form of precipitation that is unusually acidic, that is, it possesses abnormally low pH. It can have harmful effects on living beings and on infrastructures. The pH is a magnitude that measures the degree of acidity or of basicity. In aqueous solutions, pH = - log $[H_3O^+]$. The pH varies slightly with temperature: at 25 ºC a solution of pH = 7 is neutral, an acid solution has a pH < 7 and a basic solution has a pH > 7.

Cite this work as:
Tortosa, Montserrat (2014). Coal power and acid rain. pp. 1-6.Available at http://comblab.uab.cat

This project has been funded with support from the European Commission. This publication reflects the views only of the author, and the Commission cannot be held responsible for any use which may be made of the information contained therein Project N. 517587-LLP-2011-ES-COMENIUS-CMP

	pH	
Battery Acid	1	Acid
	2	
Acid Rain	3	
	4	
Normal Rain	5	
	6	
Water	7	Neutral
Ocean Water	8	Basic
Liquid drain cleaner	9	
	10	
	11	
	12	
	13	
	14	

Using the above information or other that you consider, answer on you own the next questions,

What is an acid? .....

.....

Can you put examples of acids? .....

.....

What is acid rain? .....

How is acid rain formed? .....

.....

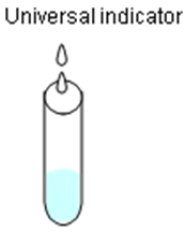
How is acidity measured? .....

.....

Discuss your answers with the whole group in a plenary session

Measuring acidity in the laboratory

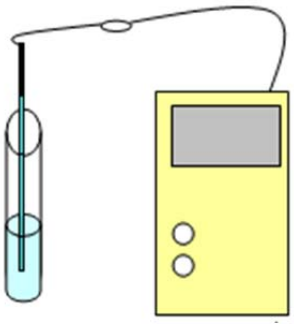
pH can be measured qualitatively using pH indicators (eg: phenolphthalein, methyl orange, universal indicator) that change its color depending on the pH value, and quantitatively using devices as a pH meter of a pH sensor connected to a microcomputer based laboratory equipment. This last methodology allows studying temporal variations of pH.



You have distilled water and 0,01 M solutions of the next compounds. Measure the pH of each liquid using both universal indicator and pH sensor.

Methodology: using universal indicator

- Pour a few mL of each liquid in separates test tubes
- Add one or two drops of universal indicator to each tube
- Observe the change of color, compare it with the scale of color of the indicator, and deduce its pH.



Methodology: using pH sensor and MBL equipment

- Pour a few mL of each liquid in separate test tubes
- Configure adequately your MBL equipment to measure pH
- Introduce pH electrode in each test tube, and measure until pH sensor is stabilized (in can take more than half a minute). Write the result obtained.
- Clean adequately the electrode before being introduced in a new liquid.

Results

	Universal indicator Color	pH	pH sensor
Distilled water			
H_2SO_4 0,01 M			
$NaHCO_3$ 0,01 M			
NaCl 0,01 M			
HNO_3 0,01 M			
NaOH 0,01 M			

Compare the measures obtained with the universal indicator and with pH sensor, in what are they similar? ……..

In what do they differ? ……

Classify these substances as acids, neutrals or bases ……

……

3. What is coal made of? What chemical reactions involve coal combustion?

Coal is a rock composed mainly by carbon, ash, volatile compounds, humidity and sulphur. Carbon is the main component of coal, and the one that determines the energy that can be released by coal combustion. In next tables it is reflected the composition of a coal and the composition of ash. Volatile fraction is mainly composed by hydrocarbons.

Chemical composition of a coal	
% fix Carbon	93.89
% Ash	2.10
% Volatile Organic Compounds	3.01
% moisture	2.94
% Sulphur	1.01

Chemical composition of coal ash fraction

Oxide Component:	Percentage:
SiO_2	10 - 70
Al_2O_3	8 - 38
Fe_2O_3	2 - 50
CaO	0.5 - 30
MgO	0.3 - 8
Na_2O	0.1 - 8
K_2O	0.1 - 3
TiO_2	0.4 - 3.5
SO_3	0.1 - 30

<u>Thinking on coal combustion</u>

Explain using your own words: How can coal be considered chemically, a pure substance or a mixture? ……
……

What is combustion? ……
……

What chemical reactions are involved in the combustion of coal? Can you write them?……..

……

4. Modeling the situation in the laboratory

To answer the main question of this activity (How can we explain the contribution of coal combustion to acid rain?), you should:

a) Choose chemistry substances that can model coal (that is they will be an "artificial" coal)
b) Design an experiment to evaluate how coal contributes to acid rain,
c) Perform the experiment,
d) Evaluate your data and
e) Obtain conclusions.

Modeling coal

What substances do you choose that can act as coal?

……

How the products of the combustion can acidify water and form acid rain? ……..

……

……

How will you monitor if the products of burning coal can produce acid rain? ……..

……

……

Design of experiments and working collaboratively

Explain which experiments have to be performed to know the contribution of each component of coal in acid rain. ……..

……

……..

What coal component do you choose to test its effect on acid rain production? ……

……..

What will you do to avoid the influence of other components? .....

……..

In your opinion, which density will have the products of the reaction, in comparison with the density of the air? ……

……..

How will they behave? ……

……

What will you do so that other variables do not affect/influence your results?

Explain the experiment that you will perform and make a drawing of it

Prediction of results Fill in the next boxes with you predictions

Component ..... Prediction	Component ..... Prediction

What is your general prediction: Why burning coal causes acid rain? ……

……

Evaluating the data obtained

Component_____

Describe the reaction, have you obtained a gas? How do you know it? ..... ……

Is this gas more or less dense than the air? ..... How do you know it? ..... ……

Initial value of pH ..... Final value of pH……

How has been the evolution of pH in the water that has been in contact with the gas? ……

……

How do you interpret pH variation in your experiment? ……..

What chemical reactions and when have been involved in your experiment? ……

……

Component_____

Describe the reaction, have you obtained a gas? How do you know it? ..... ……

Is this gas more or less dense than the air? ..... How do you know it? ..... ……

Initial value of pH ..... Final value of pH……

How has been the evolution of pH in the water that has been in contact with the gas? ……

……

How do you interpret pH variation in your experiment? ……

……

What chemical reactions and when have been involved in your experiment? ……

Show your results

Share your results in a plenary session; write the results obtained by all other groups

Results Fill in the boxes with the results for all components of coal, taking into account the results of all groups of students

Component	Component .....
Component	Component .....

5. Returning to the main question of this activity:

How can we explain the contribution of coal combustion to acid rain? ……..

……

……

Reference:R. Downing, R. Ramankutty, and J. Shah, RINS-ASIA: An Assessment Model for Acid Deposition in Asia (The World Bank, Washington, D.C., 1997), Available at http://www.wri.org/publication/content/8434 (accessed 9th September 2012)