The effect of an acidic environment on Marble structures

**INTRODUCTION**

Acid rain is a term used to describe rain (or other precipitation) which is acidic. Rain which has a pH less than or equal to 5.5 is considered to be acidic. When power stations, factories, houses and cars emit pollution into the air, it contains chemicals known as sulphur dioxide and nitrogen oxides. These chemicals may mix with water in the air to form acids which can be transported long distances by the wind before being deposited in rain. (*Atmosphere, Climate & Environment Information Progamme1)*

Acid rain can have harmful [impacts](http://www.ecoca.ro/meteo/tutorial/Acid_Rain/Younger/Impacts.html) on the environment in many ways. It affects freshwater lakes and the wildlife that depend upon them. It also affects trees by harming leaves and soil, and it damages buildings and outdoor statues made of limestone and marble *(Singh, A. and Agrawal, M.20082).* The damage caused to buildings and statues is the most commonly noticed example of the damage caused by Acid rain (see diagram 1)

Diagram 1

*http://archive.thedailystar.net/beta2/news/sustainer-of-life-or-angel-of-death/*

This investigation will measure the effect of an acidic environment on marble. The acid environment will be created by the use of Hydrochloric Acid, and the building or a statue will be represented by marble chips. Marble chips will be placed in Hydrochloric acid and the rate of the reaction (decomposition of the marble) will be measured by recording the time needed for the loss of 0.4 g of mass. Mass is lost because the reaction between marble chips (CaCO3) and Hydrochloric Acid (HCl) releases Carbon Dioxide (CO2) gas. This is shown in the chemical equation below. The Carbon Dioxide gas bubbles to the surface of the acid and leaves the reaction beaker, causing a loss in mass. If the loss of 0.4 g of mass occurs in a lower time, the production of Carbon Dioxide has occurred at a faster rate. Thus the time for the loss in mass indirectly provides a measure of the rate of the reaction.

CaCO3 + HCl → CaCl2 + H2O + CO2 (gas)

Marble Hydrochloric Acid Calcium Chloride Water Carbon Dioxide

Independent Variable – Concentration of Hydrochloric Acid

Dependent Variable – Time (to lose 0.4 g of mass)

Controlled Variables – Volume of Hydrochloric acid

Temperature of Hydrochloric Acid

Mass of Marble Chips

Size and Shape of the Beaker

Loss in mass (0.4g)

**AIM:**

To measure the effect of various concentrations of Hydrochloric acid on the rate of reaction between the acid and Marble chips (Calcium carbonate).

**HYPOTHESIS:**

The rate of the reaction should increase as the concentration of the acid increases. This should occur because at higher concentrations of acid there are more acid molecules to react with the marble.

**PROCEDURE:**

EQUIPMENT:

* 1 x 100 mL beaker
* 1 x electronic scales
* Container of marble chips
* Hydrochloric acid (1M)
* 1 x 25 mL Measuring Cylinder
* Distilled water
* Watch or timer

METHOD

1. Measure 50 Ml of the Acid (1M) and pour into the Beaker

Beaker (50mL Acid)

Marble Chips

Electronic Balance

DIAGRAM 1

1. Place the beaker on the electronic scales as shown in Diagram 1
2. On the electronic scales, beside the beaker add exactly 4 grams of marble chips.
3. Tare (zero) the scales so that the reading is 0.00 g
4. Pick up the Marble chips and add them (all together to the beaker of Acid. Start the timer at this point.
5. At the three minute mark record the loss in mass of the acid and Marble Chip mixture.
6. Discard this mixture into the waste beaker at the front of the room and rinse and dry the beaker.
7. Repeat steps 1-7 but using different concentrations of Acid - 0.8M, 0.6M, and 0.4M.

**RESULTS:**

The table below records the mass lost from the reaction between hydrochloric acid and the Marble chips after a time period of three minutes.

Table 1: Mass loss after three minutes – Marble chips in Acid

|  |  |
| --- | --- |
| Concentration of Hydrochloric Acid (M) | Mass loss after 3 minutes (g) |
| 1.0 | 0.52 |
| 0.8 | 0.46 |
| 0.6 | 0.20 |
| 0.4 | 0.23 |

These results are graphically represented in a trend line scatter graph shown below

Graph 1: Mass loss in beaker versus acid concentration - Scatter graph with trend line

**ANALYSIS:**

The concentration of the Hydrochloric acid does affect the mass loss of the marble chip and acid mixture. As the concentration of the acid increases so does the loss in mass. At an acid concentration of 0.4M, the mass loss was 0.23g, but at double this concentration (0.8M) the mass loss was 0.46g.

The trend line indicates a linear relationship between Acid concentration and Mass loss. A linear trend line means that changes in the concentration of acid cause a proportional change to the mass lost. The equation describing this relationship is

y = 0.57 x - 0.043

Or mass loss = 0.57 x acid concentration - 0.043

This equation suggests that for every change of acid concentration, there is an increase of 0.57 grams of mass lost over the four minutes. Acid rain generally does not involve changes in concentration of such a large scale and therefore smaller mass losses would be expected when there is an increase in the concentration of acid rain. Never the less, for statues with fine detail, or building which are exposed over a very long time, the increase in mass loss would be significant.

There is large amount of error in the results. Generally speaking, the closer the data points are to the trend line the more consistent the pattern (trend) is in the data, and the lower the error. There are several points in graph 1 which are not close to the trend line. The data points at 0.4M and 1.0M are close to the trend line; however the data points at 0.6M and 0.8M are not.

The data points also indicate that a concentration of 0.6M would cause less mass loss (0.20g) than the lower concentration of 0.4M (0.23g). This result is not logical and contradicts other data points. Therefore these four data points do not form a consistent pattern and contain significant error.

This is supported by the R2 value shown in Graph 1. The R2 value of 0.81 also indicates there is too much error for this data to be considered accurate.

**CONCLUSION**

Higher concentrations of hydrochloric acid cause more mass loss when it reacts with Marble. Thje relationship between acid concentration and mass loss is proportional and can be described by the mathematical equation of

mass loss = 0.57 x acid concentration - 0.043

This relationship suggests that decreasing the concentration of acid rain should have a significant and beneficial ffect in reducing mass loss in marble statues and buildings.

However, this conclusion has to be considered with some caution. The results appear to contain significant error. The data points appear to contradict each other and several are not close to the trend line. This indicates that the patterns formed by the data is not consistent. This type of error is referred to as episodic – single individual episodes of error. Graph 1 indicates that error was made in the 0.6M and 0.8M experiments as these data points are furthest from the trend line.

The reason for this was poor laboratory technique by the person(s) doing the experiment. The error is likely to be either not mixing the concentration of the acid accurately, or not controlling the mass of the Marble chips at exactly 4 g for each experiment. It is recommended that the investigation be repeated with more attention to mixing concentration of the acid and controlling all variables.

Another recommendation would be to perform more experiments - at concentrations of 0.5M, 0.7M, and 0.9M. This would means there are more data points to determine the trend line, and the trend line should therefore be more accurate.

This investigation proved that an increased concentration of Acid will cause a greater mass loss when reacting with Marble. The exact relationship was linear and proportional. There was significant error in the investigation and the error appeared to be caused by poor laboratory techniques. It is logical that higher concentrations of Acid would cause a higher mass loss. However, given the degree of error in the investigation this conclusion is not necessarily accurate and further repeated investigation, is recommended.

**REFERENCES:**

1. Ecoca.ro, (2016). *Introduction to Acid Rain*. [online] Available at: http://www.ecoca.ro/meteo/tutorial/Acid\_Rain/Younger/Acid\_Rain\_Introduction.html [Accessed 10 Feb. 2016].
2. Singh, A. and Agrawal, M. (2008). Acid rain and its ecological consequences. *Journal of Environmental Biology*, [online] 29(1)(January 2008). Available at: http://jeb.co.in/journal\_issues/200801\_jan08/paper\_02.pdf [Accessed 10 Feb. 2016].