Enviropedia Air Pollution Clean Air for Kids

INFORMATION

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What is Acid Rain?

Introduction

Acid rain is a term which describes the acidity of wet and dry deposition. This includes acidity falling as rain, snow, sleet, hail, mist or fog (wet deposition) and the dry deposition of gases and particles.

Sources

Rain water is naturally acidic as a result of carbon dioxide dissolved in water and from volcanic emissions of sulphur. However, it is the chemical conversion of sulphur and nitrogen emissions from power stations, factories, vehicles and homes, where fossil fuels are burnt, that we call acid rain. These waste gases are carried by the wind and can in time be converted into sulphuric and nitric acids, having travelled many hundreds of miles.

Sources of SO_2

Natural sources of sulphur dioxide (SO_2) include release from volcanoes, oceans, biological decay and forest fires. Actual amounts released from natural sources in the world are difficult to quantify; in 1983 the United Nations Environment Programme estimated a figure of between 80 million and 288 million tonnes of sulphur oxides per year. Sulphur dioxide emissions also result from combustion of fossil fuels due to varying amounts of sulphur being present in these fuels. World-wide emissions of SO_2 are thought to be around 69 million tonnes per year (2000) and nitrogen oxides around 24 million tonnes per year (1990).

Levels of SO_2 from combustion sources in the UK have declined in recent decades. Between 1970 and 1999, UK SO_2 emissions fell by 82% due to recession, restructuring of industry, substitution of fuels (e.g. natural gas) and air pollution control technology. Power station emissions fell by 73% over the same period, but the percentage of UK emissions from power stations has actually increased to 65% of the 1999 total compared to 45% of the total in 1970.

Sources of NO_X

Natural sources of nitrogen oxides (NOx) include volcanoes and biological decay. Estimates range between 20 million and 90 million tonnes per year NOx released from natural sources, compared to around 24 million tonnes from human sources world-wide (1990). Nitrogen oxides are produced when fossil fuels are burned. The major sources of NOx in the UK in 1999 were road transport (44%), power stations (21%) and industry (including iron and steel, and refineries) (12%), as shown in Table 1. Emissions of nitrogen oxides from road transport increased during the 1970s and 1980s before decreasing again during the 1990s. For example, in 1970, emissions of NOx from road transport in the UK were 0.769 million tonnes. By 1990 they had risen to over 1.31 million tonnes NOx. Since then, however, emissions from transport have been declining; in 1999 they were 0.714 million tonnes, lower than in 1970. The major sources of SO2 and NOx pollution in the UK are shown below.

Sources of UK Sulphur Dioxide & Nitrogen Oxides, 1999.

SULPHUR DIOXIDE	NITROGEN OXIDES
Domestic 4% Commercial 2%	Domestic 4% Commercial 2%

Road Transport 1% Power Stations 65% Refineries 8% Other Industry 10% Shipping 2% Iron & Steel 4% (total in 1999 = 1.19 million tonnes)	Road Transport 44% Power Stations 21% Refineries 2% Other Industry 9% Shipping 3% Iron & Steel 2% (total in 1999 = 1.61 million tonnes)

The geographical distribution of human emission sources is not even. Nitrogen and sulphur emission sources are heavily concentrated in the northern hemisphere, particularly in Europe and North America. As a result, precipitation is generally acidic in these countries (pH 4.1 to pH 5.1).

Deposition

The distances that pollutant gases travel means that acidification is an international problem. In 1998, for example, the UK received one quarter of its sulphur deposition from other countries whereas, for example, Sweden and Norway both received more than 90% of their sulphur pollution from abroad. Acid pollutants are not necessarily deposited in the same country where they were produced.

Transport of Acidifying Gases

The Chernobyl disaster of 1986 highlighted the way in which air pollutants are carried many hundreds and thousands of kilometres by the wind. The upper winds can move pollutants at a speed of 500km per day. The distance travelled depends upon a number of factors such as wind speed and direction, the height of release into the atmosphere, topography, and the presence or absence of other reactants.

Rainfall Acidity

Rainfall is naturally acidic due to the presence of carbon dioxide in the atmosphere which combines with rainwater to form weak carbonic acid. However, the combustion of fossil fuels produces waste gases such as sulphur dioxide (SO_2), oxides of nitrogen (collectively known as NOx) and to a lesser extent, chloride (Cl). These pollutants can be converted, through a series of complex chemical reactions, into sulphuric acid, nitric acid or hydrochloric acid, increasing the acidity of the rain or other type of precipitation.

Carbon dioxide + Water → Carbonic acid (weak)

Sulphur dioxide + Water → Sulphuric acid

Nitrogen oxides + Water → Nitric acid

The pH Scale

Rainfall acidity is measured in pH units. The pH scale is used to measure the acidity of a solution and ranges from 0 to 14; 0 being the most acid, 7 being neutral and 14 being the most alkaline.

1 2 3 4 5 6 7 8 9 10 11 12 13 14

Acid **Neutral** **Alkali**

The pH scale is logarithmic rather than linear, and so there is a ten-fold increase in acidity with each pH unit, such that rainfall with pH 5 is 10 times more acidic than pH 6, rainfall with pH 4 is 100 times more acidic than pH 6 and rainfall with pH 3 is 1000 times more acidic than pH 6.

Conclusion

Acid rain has been called the environmental issue of the 1980s and it continues to be a problem today. However, acid rain is not a new problem at all. It dates from the middle of the 19th century when a Scottish chemist, Robert Angus Smith, began to study the effect of air pollution in Manchester and used the term 'acid rain' to describe his findings. What is very new is the scale of the problem. In Smith's time, acid rain fell both in towns and cities and downwind from them, but now, the pollution is spread far and wide, within and between nations. It has now become an international problem.