

## **15. Impacts Of Air Pollution & Acid Rain On Vegetation**

### ***Introduction***

"Acid rain" is a general name for many phenomena including acid fog, acid sleet, and acid snow. Although we associate the acid threat with rainy days, acid deposition occurs all the time, even on sunny days.

Sulphur dioxide and nitrogen oxides both combine with water in the atmosphere to create acid rain. Acid rain acidifies the soils and waters where it falls, killing off plants. Many industrial processes produce large quantities of pollutants including sulphur dioxide and nitrous oxide. These are also produced by car engines and are emitted in the exhaust. When sulphur dioxide and nitrous oxide react with water vapour in the atmosphere, acids are produced. The result is what is termed acid rain, which causes serious damage to plants.

In addition, other gaseous pollutants, such as ozone, can also harm vegetation directly.

### ***How Acid Rain Harms Trees***

Acid rain does not usually kill trees directly. Instead, it is more likely to weaken the trees by damaging their leaves, limiting the nutrients available to them, or poisoning them with toxic substances slowly released from the soil. The main atmospheric pollutants



that affect trees are nitrates and sulphates. Forest decline is often the first sign that trees are in trouble due to air pollution.

Scientists believe that acidic water dissolves the nutrients and helpful minerals in the soil and then washes them away before the trees and other plants can use them to grow. At the same time, the acid rain causes the release of toxic substances such as aluminium into the soil. These are very harmful to trees and plants, even if contact is limited. Toxic substances also wash away in the runoff that carries the substances into streams, rivers, and lakes. Fewer of these toxic substances are released when the rainfall is cleaner.

Even if the soil is well buffered, there can be damage from acid rain. Forests in high mountain regions receive additional acid from the acidic clouds and fog that often surround them. These clouds and fog are often more acidic than rainfall. When leaves are frequently bathed in this acid fog, their protective waxy coating can wear away. The loss of the coating damages the leaves and creates brown spots. Leaves turn the energy in sunlight into food for growth. This process is called photosynthesis. When leaves are damaged, they cannot produce enough food energy for the tree to remain healthy.

Once trees are weak, diseases or insects that ultimately kill them can more easily attack them. Weakened trees may also become injured more easily by cold weather.

## ***How Air Pollution Harms Trees***

Whilst acid rain is a major cause of damage to vegetation, air pollutants which can also be harmful directly. These include sulphur dioxide and ozone.

### ***Sulphur Dioxide***

Sulphur dioxide, one of the main components of acid rain, has direct effects on vegetation. Changes in the physical appearance of vegetation are an indication that the plants' metabolism is impaired by the concentration of sulphur dioxide. Harm caused by sulphur

dioxide is first noticeable on the leaves of the plants. For some plants injury can occur within hours or days of being exposed to high levels of sulphur dioxide. It is the leaves in mid-growth that are the most vulnerable, while the older and younger leaves are more resistant. You can see the damage to coniferous needles by observing the extreme colour difference between the green base and the bright orange-red tips.

The effects of sulphur dioxide are influenced by other biological and environmental factors such as plant type, age, sunlight levels, temperature, humidity and the presence of other pollutants (ozone and nitrogen oxides). Thus, even though sulphur dioxide levels may be extremely high, the levels may not affect vegetation because of the surrounding environmental conditions. It is also possible that the plants and soils may temporarily store pollutants. By storing the pollutants they are preventing the pollutants from reacting with other substances in the plants or soil.

### **Ozone**

The effects of ozone on plants have been investigated intensively for almost two decades. Studies made in controlled environment (CE) chambers, glasshouses and in the field, using open-topped chambers, have all contributed to the understanding of the mechanisms underlying ozone effects and their ultimate impact on vegetation. The biochemical mechanisms by which ozone interacts with plants have been intensively studied and, although the relative significance of different initial reactions remains unclear, there is a consensus that the key event in plant responses is oxidative damage to cell membranes. This primary oxidative damage results in the loss of membrane integrity and function, and in turn to inhibition of essential biochemical and physiological processes. A key target is photosynthesis, although ozone may also affect stomatal function and so modify plant responses to other factors, such as drought and elevated carbon dioxide. These changes result in reduced growth and yield in many plants. However, it is clear that

such responses vary in magnitude between species and also between different cultivars within species. The mechanisms by which some species and genotypes are protected from ozone injury are not clear, but may include differences in uptake into the leaf or in the various components of antioxidant metabolism. Ozone may also increase the severity of many fungal diseases, while virus infections reduce the effects of ozone in some plants.

### ***Past and Present Pollution***

Acid deposition and ozone exposure have increased considerably in the past 50 years in Asia, Europe and the US, with many reports of tree/forest decline and increased mortality. In general, the more highly polluted forests have the higher rate of decline and mortality. However, there has been no recent chronic deterioration in the UK of tree condition. Since the early 1990s, peak concentrations of ozone have been falling, whilst the large reduction in sulphur dioxide emissions since the 1970s has provided an opportunity for recovery of many plant species. By 2010, atmospheric sulphur dioxide concentrations in the UK should pose little or no threat to vegetation.

### ***Acidification by Forestry***

While forestry has long been considered to be adversely affected by air pollution and acid rain, recent studies show it to be part of the acidifying process. The rough canopies of mature evergreen forests are efficient scavengers of particulate and gaseous contaminants in polluted air. This results in a more acidic deposition under the forest canopies than in open land. Chemical processes at the roots of trees, evergreens in particular, further acidify the soil and soil water in forest catchments. When the forests are located on poorly buffered soils, these processes can lead to a significant acidification of the run-off water and consequent damage to associated streams and lakes.