Outdoor Acid Air Pollutants

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Outdoor acid air contaminants are mainly generated by human activities and to a much lesser extent by natural sources such as volcanic activity. Acid air pollutants are known to cause acid deposition which damages the environment. Epidemiological studies have also shown that air pollutants have a harmful impact on human health, by increasing total, respiratory and cardiovascular mortality and morbidity. Children and the elderly are particularly vulnerable to the effects of air pollution. The emission limits imposed by some governments have been helpful, but not conclusive.

Outdoor acid air pollutants mainly derive from the combustion of fossil fuels by industrial plants and vehicles. This releases acid gases (sulfur dioxide, nitrogen oxides and carbon dioxide) and particulate matter (PM). It contributes to global warming and the spread of respiratory and cardiovascular diseases.

Keywords: air-quality ; acid-pollutants ; air-acidity ; sulfur-dioxide ; nitrogen-oxides ; carbon-dioxide ; acid-rain ; respiratory-diseases ; cardiovascular-diseases ; allergy.

1. Introduction

Progress and industrialization have led to the increase of acid pollutants in the air. Acid air pollutants proved to be a public health problem in 1952, with 4,000 direct deaths during the Great Smog in London. Public health events and studies conducted in recent decades have increasingly shown that the harmful consequences can be diverse and serious. In the 1970s the governments of some industrialized countries began to limit emissions of acid compounds, such as sulfur dioxide and nitrogen oxides. The quality of the fuels has been considered and various systems have been introduced to improve combustion. Also, alternative energy sources have received a considerable boost. As a result, emissions have steadily decreased, but not enough, and the problem of acid rain is currently still present. The positions of governments around the world are inconsistent, as most persons in charge retain that the limitations are not convenient.

2. Chemical and Toxicological Characteristics

Polluting atmospheric acids damage surface water, buildings, and living organisms, either by direct reactions or through acid rain. Epidemiological studies on acute respiratory effects show that fine particulate matter ($PM_{2.5}$) and gaseous acid pollutants can have a major impact on the airways[1][2][3][4], because of their significant toxic potential. Given their small size, fine particles are able to penetrate deeply and reach the lower respiratory airways[5][6] . Furthermore, as a result of their low polarity and high liposolubility, the gases can spread quickly through biological membranes[5][7] and hence enter cells. Among these gases, NO and O_3 are known to cause nitrosative and oxidative stress, respectively. Recent studies have drawn attention to the health impacts of PM[4][5][6][8][9], NO_2 [2][3][5][8][10][11], and SO_2 [12][13][14].

It is known that PM from anthropogenic sources, such as heating systems, industrial plants, and motor vehicles, is mainly acid, since PM is associated with the anthropogenic acid pollutants NO_2 and SO_2[2][5] [2,5]. In addition, NO_2 and SO_2 can react with water and oxygen to give the corresponding acids: nitric acid (HNO_3), sulphurous acid (H_2SO_3), sulphuric acid (H_2SO_4), and their related acidic salts. The toxicity of acid compounds is mainly due to their ability to release protons (H^+). Both HNO_3 and H_2SO_4 are strong acids, important sources of protons, and therefore are fiercely corrosive. While, at normal temperature and pressure, NO_2 and SO_2 are gases, the corresponding acids HNO_3, H_2SO_3, and H_2SO_4 are liquids, and easily soluble in water. Their acidic salts are water-soluble as well. Therefore, most air acidity is concentrated in the microscopic PM, suspended in the air itself, in the form of both moist solid particles and watery droplets, known as acid aerosols. Notably, for its smaller particle size and its larger specific surface area, $PM_{2.5}$ is richer than PM_{10} in water and acids.

Around the year 1985, interest in the effects of acid aerosols increased as a result of the risk of high exposure levels in the US and Canada. Clinical studies were carried out to assess the toxicity of some atmospheric pollutants. The results showed that:

1. The bronchoconstrictor action of carbachol could be enhanced by acid sulphate aerosols[15][16], even though the sulphate is not itself toxic[16];
2. The biologically active portion of these compounds is H^+ rather than sulphate and the potency is proportional to their acidity[16];
3. Titratable acidity appears to be a more important stimulus to bronchoconstriction than pH[17].

Consistently, it was shown that bronchoconstriction provoked by inhalation of sodium sulphite aerosols was caused by the released gaseous SO_2, or by bisulphite, but not by sulphite[17]. Combined exposures to acidic aerosols and pollutant gases have synergic effects.

The abovementioned PM, HNO_3, H_2SO_3, and H_2SO_4 are the strongest acid components of acid aerosols. In addition, some other weaker acids are present, including carbonic acid, nitrous acid, and hydrogen sulphide, which essentially contribute to titratable acidity. All acids can contribute to the effects of total air acidity by releasing H^+s to different extents.

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