HEALTH IMPACT AND CONTROL OF PARTICLE MATTER

L.W. OLSON AND K. BOISON
Arizona State University
Technology Center
85212 Mesa, Arizona, USA

Summary

Particulate matter (PM), unlike other air pollutants such as carbon monoxide or ozone, is not a single compound. Particles can be either solids or liquids and can vary greatly in size, shape, and chemical composition. The effects of particulate aerosols on human health include damage to the cardiovascular system, aggravation of existing respiratory diseases, and increases in lung cancer mortality. Evidence of increased mortality from exposure to the types of particulate matter associated with traffic, including diesel exhaust, has been established. Children, the elderly, and those with pre-existing conditions such as asthma are particularly susceptible. Regulatory actions initially focused on larger particles, but increasingly they have targeted the smaller PM_{10} and $PM_{2.5}$ fractions. Control strategies for particulate matter must be targeted to a given size fraction and take into account the various origins, both natural and man-made, for each type of particle.

1. Introduction

Particulate matter (PM) is part of the natural environment. It can arise from sources such as sea spray, wind blown dust, volcanic emissions, fungal spores or pollen. Anthropogenic activities also contribute to the atmospheric load of particulate matter through activities such as traffic, mining, construction, agriculture, or power plant emissions. Until fairly recently, the health effects of particulates on humans had not been studied to the same extent as other air pollutants and little attention had been paid specifically to the smaller size particulates (Commission of the European Communities, 2001). However, both toxicological and epidemiological studies have now demonstrated the negative consequences to human health of exposure to particulate matter, even at low concentrations and without apparent threshold. Inhalation of particulate matter has been linked to pulmonary inflammation and injury, cardiovascular impairment, pulmonary hypertension, and increased rates of death. Those at highest risk are the elderly, children, and those with respiratory

P. Nicolopoulou-Stamati et al. (eds), Environmental Health Impacts of Transport and Mobility, 115-125.
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ailments or cardiovascular disease (US EPA, 1996). It is now apparent that regulating and controlling human exposure to particulate matter is essential if the health impacts of air pollution are to be minimized.

This paper will describe different types of airborne particulate matter, their sources and properties, absorbance mechanisms for particles, and evidence of adverse health effects of PM on humans from toxicological and epidemiological studies. The regulatory status for measuring and controlling particulate matter in both Europe and the United States will also be discussed.

2. Classification of particulate matter

The term particulate matter seems to imply a solid, but actually PM can consist of liquid droplets, solids, or solid cores surrounded by liquid. Size is the critical factor for airborne particulate matter since the particles must be small enough to remain suspended in air for a period of days, weeks, or months. Typically, this means they must be less than about 45 μm in diameter. The shapes of the particles and their chemical composition can vary greatly, as can their source (US EPA, 2003a).

Particles can be classified in a number of ways. Primary particulate matter exists in the same chemical form as when it was generated, whereas secondary PM involves condensates of gases or liquids onto the surface of a particle, the coagulation of smaller precursor particles to form larger particles, or oxidation and subsequent reaction of molecules such as sulfur dioxide, nitrogen oxides, or volatile organic compounds (US EPA, 2003a). In Europe, suspended salt particles from evaporation of sea spray, suspended soil particles, and in Mediterranean regions Saharan dust and volcanic emissions are major natural sources of primary particulate matter (Blanchard and Woodcock, 1980; Löye-Pilot *et al.*, 1986; Nicholson, 1988; Haulet *et al.*, 1977; Malinconico, L.L., 1979).

Anthropogenic contributions tend to be more important for secondary particulate matter, especially in urban areas. Photochemical smog, for example, produces a complex soup of organic molecules, few of which were emitted directly from tailpipes. These organic chemicals can be absorbed onto what otherwise might be fairly innocuous naturally occurring dust particulates in the ambient air to create a much more toxic material. Organic compounds have been found to constitute from 10-60% of the dry mass of some particles (Turpin, 1999). Over 18,000 different organic molecules have been found adsorbed onto diesel particles (Salvi and Holgate, 1999). Thus, air pollution from traffic is a major contributor to secondary PM.

Particulate matter can also be categorized by size. Airborne PM can vary in size over five orders of magnitude, from 1 nm to 100 μm (US EPA, 2003a). Accurately determining the distribution of particulate matter over such a range poses significant technical problems and yet is essential for understanding epidemiological data and devising control strategies.