A Novel Method for Determination of Suspended Particulate Matter in the Atmosphere Using Array Antennas

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In many places, atmospheric pollution is a serious public health problem. The respiratory systems of children and the aged are particularly affected; for the most vulnerable, atmospheric pollution can be mortal. Other environmental effects include reduction of the ozone layer (which in turn favours skin cancers), and damage to the fabric of buildings and monuments. The sources of atmospheric pollution include both mobile emitters (mainly motor vehicles, but also livestock) and stationary sources (notably cement works and power stations). The main components of atmospheric pollution are (depending on source) carbon monoxide, carbon dioxide, chlorofluorocarbons (CFCs), heavy metals (mainly lead), ozone, mononitrogen oxides (NO_x), sulphur dioxide, volatile organic compounds (VOCs) and other hazardous air pollutants (HAPs) (generally associated with specific industrial activity), and airborne particulate matter. Each of these components poses a health threat.

For continuous monitoring of environmental airborne particles, three main methods are currently employed. In all three, ambient air is drawn through a filter at a controlled volumetric rate, and the mass of particles caught on the filter in successive short pre-set time intervals is measured and recorded. In this work we propose to develop a novel technique for the measurement and characterization of airborne particulate matter using a microwave antenna.

The theoretical basis of the proposed technique is as follows. In the absence of particulate pollution, the relative dielectric constant of the air is almost unity, but the relative dielectric constant of polluted air must be different from unity, depending on the type and concentration of the polluting particles. As a result, for an antenna of fixed geometry and transmission frequency, the wavelength of the radiation it emits when immersed in polluted air is expected to differ from that of the radiation emitted in clean air. Therefore, in principle, it should be possible to deduce the nature and concentration of pollutant particles from the consequent differences in antenna and/or radiation pattern parameters. A factor that must be taken into account is the possible influence of atmospheric humidity. For example, at a relative humidity of 60% and room temperature (20ºC), the relative permittivity of otherwise unpolluted air is 1.00067.

Apparatus implementing the proposed technique will conceivably be more portable and/or provide greater temporal resolution than currently available equipment for continuous airborne particle monitoring. Such apparatus will therefore facilitate thorough exploration of airborne particulate pollution in any given indoor or outdoor environment. For example, particle monitoring antennas could easily be elevated to any desired height above ground, or could be mounted on an airplane or unmanned aerial vehicle (UAV). It may be noted that a PM-measuring antenna, unlike conventional PM measurement devices, may be of particular utility for measuring very high PM levels such as are attained in industrial emissions at source or in clouds of volcanic ash, where relative permittivity is expected to be significantly greater than unity.

As preliminary results we have examined the sensitivity to pollution of the air-filled waveguide-fed 16-slot linear array that was previously designed (J. A. Rodríguez, F. Ares, E. Moreno, G. Franceschetti. "Design of shunt slot arrays without weak excitations". *Electronics Letters*, Vol. 35, Nº 17, pp. 1396-1397, August 1999). In simulations of the behaviour of this array when operated in an external dielectric medium, alterations of both the power pattern peak and the input admittance were observed when the relative permittivity exceeded 1.01.