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AN EXPERIMENTAL APPROACH TO CORRELATE AIR CONDUTIVITY AND PARTICULATE POLLUTION

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ABSTRACT

The design and development of air-conductivity meter and particulate analyzer is presented in the present paper. Particulate analyzer was used to determine the dust level in air whereas conductivity was measured by means of Gerdien cylinder. A correlation between concentration of particulate matter in air and air conductivity has also been made. The results indicated reduction in electrical conductivity with increasing particulates in air. Therefore, it is concluded that air conductivity can be used as an index for total air pollution.

Keywords: Air Conductivity, Particulate Matters, Gerdien Cylinder, Air Pollution, Cosmic Rays.

1. INTRODUCTION

The sources of air-pollution are many and varied. They derive from the expanding needs of transporting goods, from industrial activities which add a large amount of gaseous and particulate contaminants to the atmosphere[1]. Formation of air pollutants can be used by natural processes or by human activities. Depending upon their origins, pollutants can be classified as biological, chemical or physical. Physical aspects of air pollution include the emission of particulate materials from smoke stacks of industrial establishments, vehicles or incinerators[2]. Carbon particles and fly ash may enter the air in large quantities. Storms crossing over open land areas and even cities may enrich the air with large quantities of particulate matter. Agriculture produces physical pollutants of the atmosphere in the form of plant fibers. Nuclear explosions project particulate matters into the air. Particulate matters scatter and absorb solar radiation and reduce visibility through the atmosphere[3,5]. Effects on urban temperature and other climatic conditions depend on the properties of the particles[4].

In recent years, some experimental and theoretical studies have been done to consider the effect of air pollution on atmospheric conductivity. Retalis et. al.(1991) experimentally studied conductivity and other electrical parameters under the influence of meteorological elements and air pollution in Athens[5]. Paoletti et. al.(1989) investigated the variations of the conductivity of lower atmosphere with the presence of small traces of pollutants(NO_x) under different meteorological conditions[6]. Guo et. al.(1996) determined the air conductivity as an air pollution indicator through correlation analysis[7]. However, Kumar (2000) measured electrical conductivity experimentally under different pollution conditions [8].

Although, the behaviour of air conductivity has been investigated previously but to the author's knowledge, no systematic experimental as well as theoretical study simultaneously has been carried out on the effect of particulate pollution on air conductivity. Therefore, the purpose of this work is to design and develop the instruments for air conductivity and particulate matters. A theoretical estimation has also been done to correlate the air conductivity with the particulate matters present in air.

2. MATERIALS AND METHODS

Two instruments have been designed one for atmospheric conductivity and the other for particulate matters present in air.

2.1 Instrument for air conductivity

Fig. (1) shows the experimental set-up for conductivity measurement. The instrument for the measurement of atmospheric conductivity is based on Gerdien's condenser[9]. It consists of two co-axial cylinders between which air is allowed to flow. When the air is drawn in, the ions of opposite polarity are attracted by the electrodes.

A positive potential applied at the outer electrode makes electrons and negative ions to move towards the central electrode and thereby constituting a current. This results in negative conductivity. Similarly, the negative potential on the outer electrode gives us the positive conductivity. Therefore, by measuring the output current of electrometer amplifier, the positive and negative conductivities can be estimated[8].

2.2 Measurement of particulates concentration

Particulate analyzer has been used to measure the particulate matters present in air. It is based on the principle that when the particles are illuminated by a beam of laser light, the intensity of scattered light varies with size, shape, refractive index and concentration of the particles.

This instrument measures the intensity of the scattered laser beam by aerosols at angles of 45° and 135°. By using the intensities of the scattered laser beams, the concentration of particulates were computed. A simplified diagram of the experimental set-up is shown in Fig. (2). For the present work, a He-Ne laser (6328 Å) was used. With the help of air blower, more particulates were allowed to enter into the cylinder and the out put of the photo detector was recorded on a two strip chart recorder(Omni scribe model 5212-14). The particulate concentration can be calculated by the application of Mie theory of scattering[10].

3. DATA ANALYSIS

By running these two instruments(air conductivity meter and particulate analyzer) simultaneously at a place very close to polluted area(Delhi-Haridwar highway) on a way to Roorkee town, several experimental data were taken to get readings over a wide range of particulate concentrations. In all 24 experimental runs were taken with each run covering six hours in a particular day. Measurements were made at regular intervals of time. By analyzing the experimental data, following relationship has been obtained

between polluted air conductivity (σ_{poll}, in Sm^{-1}) and particulate concentration (C, in per m^3}.

$$\sigma_{poll} = 6.31x10^{-15} \exp(-0.00862\ C) \qquad \text{……..Eq.(a)}$$

4. RESULTS AND DISCUSSION

Equation (a) indicates that the electrical conductivity in air decreases with the increase of particulate pollution. This is in agreement to the fact that the conductivity is reduced chiefly by the increasing particulate concentrations[5]. Manes[1977] found that the average conductivity drops by about 50 percent from 1.6 x 10^{-14} Sm^{-1} in 1966 to about 0.8 x 10^{-14} Sm^{-1} in 1977[9]. This is due to the growth of industrialization and vehicular traffic. Agarwal et. al.(1995) reported conductivity for Hyderabad and Calcutta as 6.89 x 10^{-15} Sm^{-1} and 1.90 x 10^{-15} Sm^{-1} respectively[3]. This is attributed to high particulate concentration of Calcutta due to increased population and heavy industrialization as compared to relatively less industrialization and better ecological balance in and around Hyderabad. Fig. 3 shows a graph between conductivity and particulate concentration.

5. CONCLUSION

The air conductivity is determined by the ions produced by cosmic rays and radioactive emanations near the earth surface. High particulate concentration in lower atmosphere decreases the electrical conductivity. This reduction in air conductivity due to particulate concentration suggests that the atmospheric electrical conductivity can be used as a composite air pollution indicator for detecting total air pollution.

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