F-O-3

# SIZE SEGREGATED PARTICLE REMOVAL EFFICIENCY USING UNIPOLAR IONIZERS FOR COMBUSTION AEROSOLS IN INDOOR ENVIRONMENTS

**B. K. Sapra*, P.S. Kothalkar, A. Khan and Y.S. Mayya**

Environmental Assessment Division
Bhabha Atomic Research Centre, Mumbai – 400 085.
*Email: bsapra@barc.gov.in

**Keywords:** Aerosol, Ionizer, Depletion constants, Mean life time.

## Introduction

It is an established fact that NIGs can be efficiently used for removing aerosol particles and bio-organsisms (**Grabarczyk, 2001; Lee et al. 2004 (a, b**). The mechanisms of particle removal includes particle charging by emitted ions and electromigration from air to wall surfaces (**Mayya et al., 2004**). Particle size has an important role in governing the removal rates. This is because the charge on particles as well as their electromigration velocities are governed by size. In addition, particle-particle interactions also affect removal rates which are size dependent. Hence, for a detailed understanding of ionizer action, it is necessary to study the effects with respect to size groups. In view of this, we conducted systematic studies aimed at determining the change in efficiency of removal of airborne particulates with varying particle size in the presence of an ioniser.

## Methodology

Experiments were carried out in a closed room of volume 47.6 $m^3$, using five negative ion generators placed in the centre of the room at a height of 130 cm from the ground in a circular fashion with needles pointing in all the directions, so as to achieve uniform ion spray. This arrangement is shown in Fig. 1. A nearly uniform ion concentration of about 2,30,000 ions/$cm^3$ within a radial distance of 1.5 m and about 90,000 ions/$cm^3$ at about 2m was measured using Medion Ion analyser. (Background negative ion concentration in the room was found to be about 1000 ions/$cm^3$.) Also, the vertical distribution of ions in the room was recorded within a height of 200 cm from the ground and was found to be more in the upward direction than in the downward with maximum at the front of the ionizer. Ion concentrations were recorded with and without Air conditioner (AC). Interestingly, while the background ions were cleared away rapidly with ventilation, the unipolar ions sprayed into the room using ionizer were unaffected by AC. Combustion aerosols were released in the room using commercially available mosquito coils lit for 15 mins.

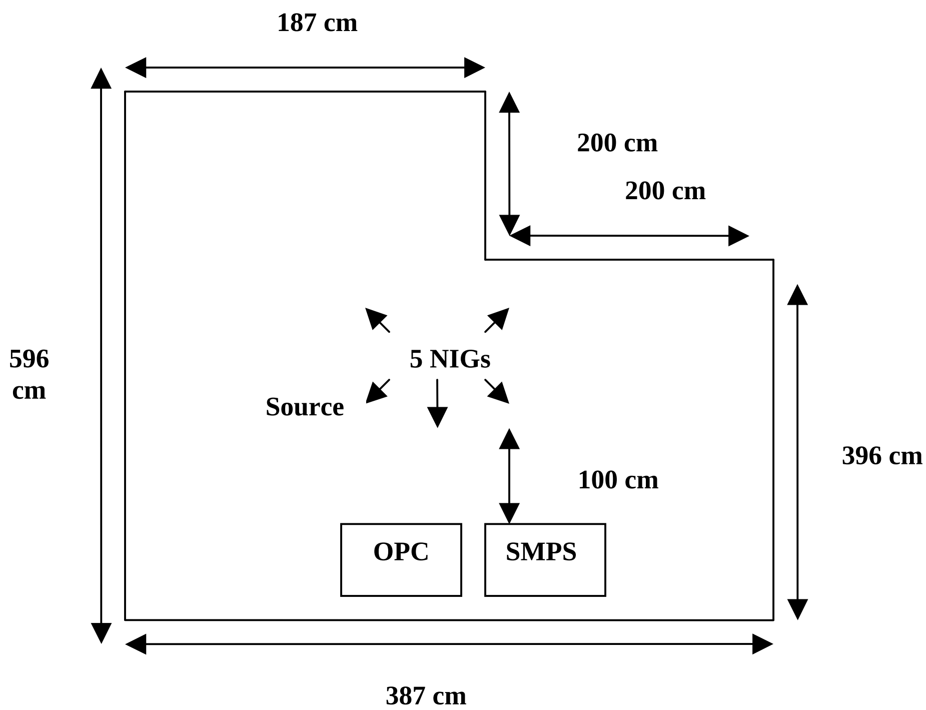



**Fig 1: Schematic of the experimental setup.**

During the burning period a fan was kept on, so as to make the aerosols spread uniformly in the room. After 15 mins, the source was put off and number concentration measurements were recorded using SMPS [Scanning Mobility Particle Sizer (10 nm-800 nm)] and OPC [Optical Particle Counter(0.3-20 µm)] placed at a distance of 1.5 m from the ionizer assembly. Simultaneously, ion concentrations were also recorded.

**Results and Discussions**

From the time since the ioniser was switched on, the negative ion concentration increased from the background level to 2,30,000 ions/cm$^3$ in about 100 min and concurrently, the combustion aerosol (all sizes) concentration began to decrease and dropped to background levels in the same time span (See Fig. 2). The total particle number concentration was recorded by the SMPS for both with and without ionizer operation cases, for the same amount of source (45.97 mg) aerosols released. The depletion in aerosol concentration was faster with the ioniser with an overall aerosol lifetime of 28 mins in contrast to 48 mins for the case without the ionizer, thereby confirming the efficacy of ionizer in total particle removal. The Count Median Diameter reduced from 73 nm to 65.7 nm in the presence of the ionizer while the Geometric Standard Deviation was almost constant at about 2.1.

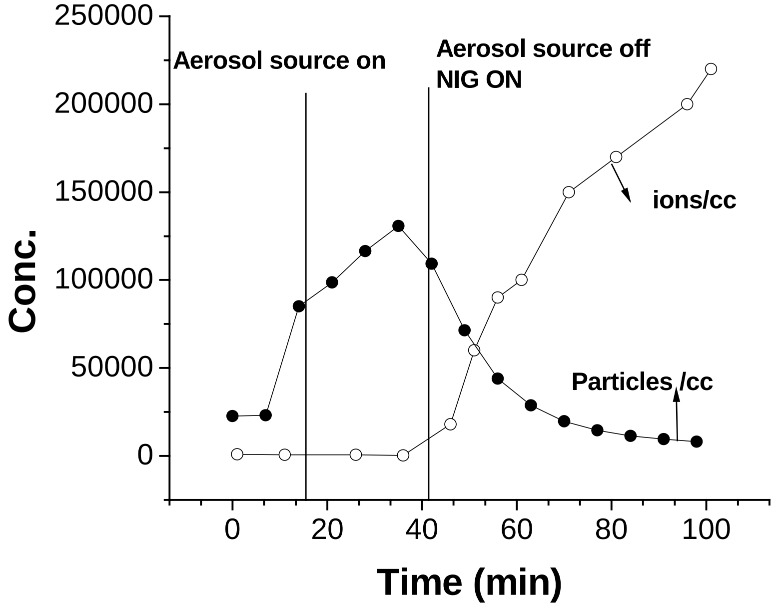
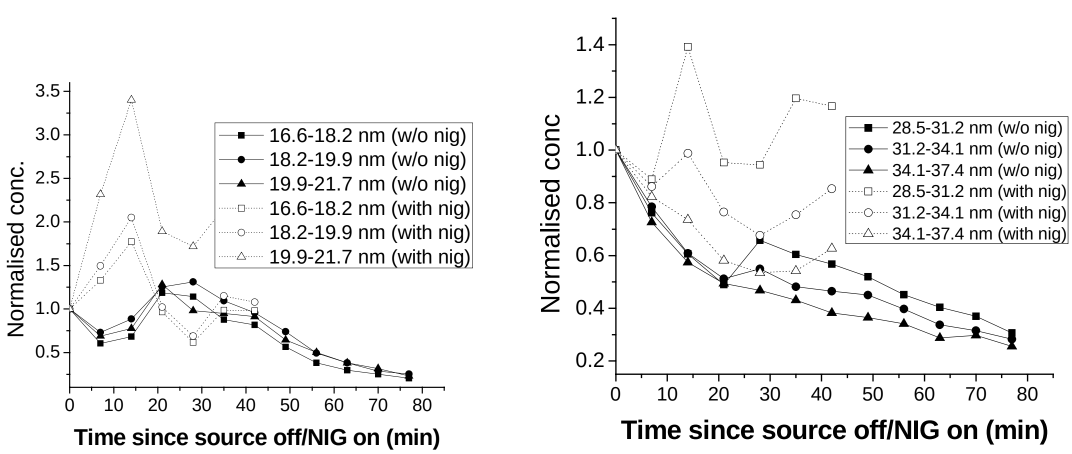
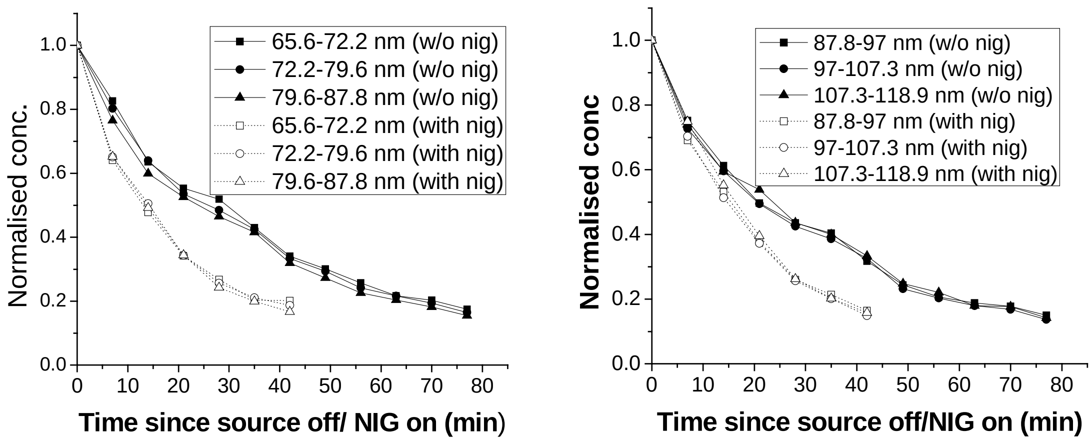



**Fig. 2: Variation of ion and aerosol concentrations with time**

**Size segregated Removal**: The extent of concentration reduction of smoke aerosols was found to vary significantly with particle sizes. In fact, SMPS data showed an increase in the concentration of smaller (<35 nm) particles when the ionizer was switched on. This may be due to the fact that, atmospheric aerosols are mostly in the sizes smaller than 30 nm and with smoke, particles generated are in the sizes greater than about 30 nm. Although both the sizes are being scavenged by the ionizers, the depletion constants are higher for the larger particles which manifests as an increase in the concentration of the smaller particulates. Fig. 3 shows the change in the concentrations with time for varying size groups with and without the ionizer. As may be seen, the critical size is near about 34.1 nm above which size, the ionizer operation clearly decreases the number concentrations.




(a) (b)




(c) (d)

**Fig 3: Particles Concentrations of the various size groups with and without ionisers**

To quantify the depletion of the particulates, mean depletion constants were calculated for various size groups by fitting the normalised concentration to a first order exponential decay. These are plotted for the SMPS size range and the OPC size range in Figs. 4(a) and 4(b) respectively for the cases of with and without ioniser operation. They are found to be higher with ionizer for particle sizes > 34 nm.

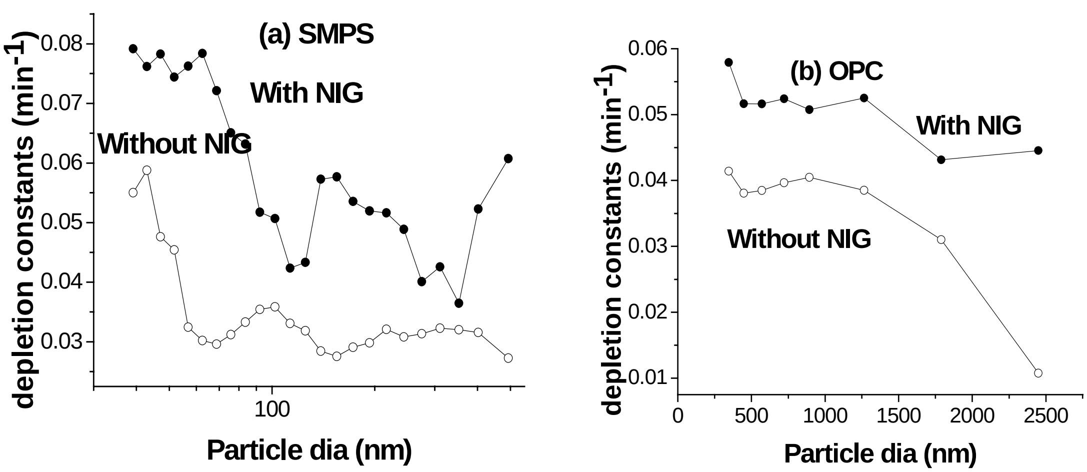



**Fig 4 : Variation of depletion constants with size for cases with and without ionizer as shown by a) SMPS and b) OPC.**

## Conclusions

The study brings out the effectiveness of the operation of ionizers in reducing particle concentrations in indoor environment. For a typical combustion source, sizes below 34 nm seem to be unaffected by ionizer operation while enhanced depletion constants are observed above this size.

**References**


1. Grabarczyk, Z. (2001). Effectiveness of indoor air cleaning with corona ionizers. *Journal of Electrostatics*, 51-52, 278-283.
2. Lee, B. U., Yermakov, M., & Grinshpun, S. A. (2004a). Removal of fine and ultrafine particles from indoor air environments by unipolar ion emission. *Atmospheric Environment*, 38, 4815-4823.
3. Lee, B. U., Yermakov, M., & Grinshpun, S. A. (2004b). Unipolar ion emission enhances respiratory protection against fine and ultrafine particles. *Journal of Aerosol Science*, 35, 1359-1368.
4. Mayya, Y. S., Sapra B. K., Khan, A ., Sunny, F. (2004). Aerosol removal by Unipolar ionization in indoor environments. *Journal of Aerosol Science*, 35, 923-941.