Monitoring Charged Particles in Indoor Air using a Neutral Cluster and Air Ion Spectrometer

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1 Introduction

While there are sources of ions both outdoors and indoors, ventilation systems can introduce as well as remove ions from the air. As a result, indoor ion concentrations are not directly related to air exchange rates in buildings. In this study, we attempt to relate these quantities with the view of understanding how charged particles may be introduced into indoor spaces.

Outdoor air ions are naturally formed by ionization due to cosmic rays and radon in the air. In addition, in built-up areas, there may be several anthropogenic sources such as electrical distribution systems and motor vehicle exhaust. There have been very few studies investigating how these outdoor concentrations may influence indoor spaces. In addition to the introduction of ions from outside, many sources contribute to indoor ion concentrations. These include electrical appliances, cooking and static electricity on carpets and clothing.

2 Methods

In this study, a neutral cluster and air ion spectrometer (NAIS) (Mirme et al, 2007) was used to monitor and compare the charge on aerosol particles between two indoor and outdoor locations. The study was carried out in an air conditioned laboratory on the sixth floor of a building. Air was alternatively sampled from inside the room and out of a window over a period of one month. At times, sampling was carried out over several days from either indoors or outdoors, while at other times, the sampling was quickly alternated between indoors and outdoors at short intervals of about ten minutes each. Data was logged in real time at 10s intervals. The NAIS measures concentrations of both positively and negatively charged particles separately as well as uncharged particles in the air in the size range 0.5 to 42 nm. Following the definition of Horrak et al (2000) we classify small, intermediate and large ions in the size ranges <1.6 nm, 1-6-7.5 nm and >7.5 nm, respectively. Small ions are molecular clusters while intermediate and large ions are generally aerosol particles. The NAIS was programmed to measure ion concentrations in these three size ranges separately.

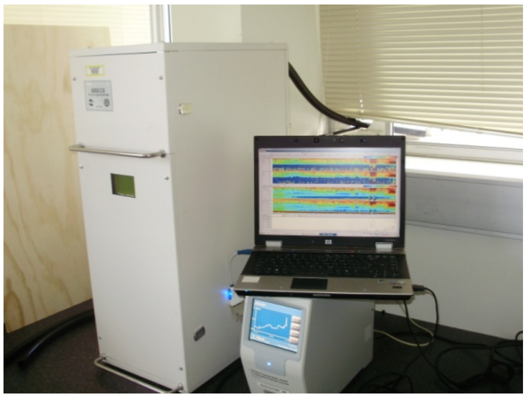

Fig 1: The NAIS in its sampling location in the 6th floor laboratory. Outdoor sampling was carried out through the window at the back.

3 Results and Discussion

In general, when there were no indoor activities, outdoor ion concentrations were higher than indoors. Outdoor small ion concentration showed a diurnal variation with a maximum in the early morning hours, usually attributed to the accumulation of radon in the lower boundary layer. Outdoor intermediate and large ion concentrations generally peaked during mid-day which corresponded to times of maximum particle number concentration. With no indoor activity, indoor ion concentrations were typically one-half of the outdoor concentrations. Fig 2 shows a typical experiment where the air was sampled alternatively from indoors and outdoors for approximately 10 min each.

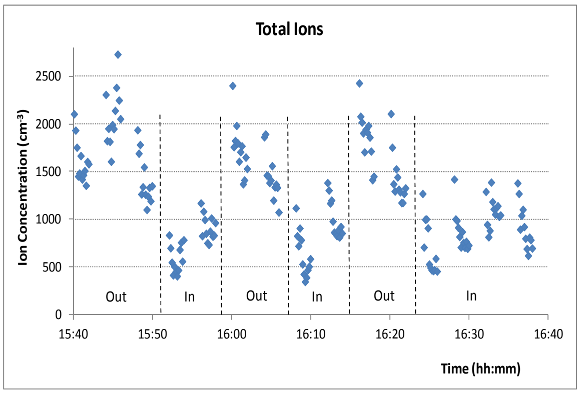

Fig 2: Typical total ion concentrations indoor and outdoor.

These results are classified into the three types of ions according to their size, and summarised in Table 1 below. Clearly, the ion concentration was higher outdoors than indoors. The outdoor small and large ion concentration values were more than twice the indoor values. These differences were tested using the Students t-test and found to be statistically significant at the 95% level of confidence ($p<0.01$).

The results of this study show that the ventilation system in the room removed a large fraction of the ions as air was supplied indoors. In addition to indoor sources of ions, indoor ion concentrations depend on outdoor ion concentration as well as the efficiency of the ventilation system. Hirsikko et al (2007) measured indoor and outdoor ions in an urban environment and found that, while the large ion concentration outdoors was greater than indoors, the small ion concentration indoors was greater than outdoors. Clearly, in this case, there appeared to have been one or more indoor sources of cluster ions.

4 Conclusions

The NAIS enabled us to compare the indoor and outdoor ion and charged particle concentrations in the three different size ranges – small, intermediate and large. In all three ranges, the outdoor concentrations were significantly higher than the indoor values. We conclude that the ventilation system removed over one half of the small and large ions and a substantial proportion of the intermediate ions from the outdoor air when introduced into the building through the air conditioning system.

Indoor ion sources such as electrical appliances and activities such as cooking can generate large numbers of ions. The next stage of this Project will aim at investigating the concentrations and size distributions of ions and charged particles in indoor environments due to various sources and activities.

5 References

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Hirsikko et al. 2007. Indoor and outdoor air ions and aerosol particles in the urban atmosphere of Helsinki: characteristics, sources and formation. Boreal Environ Res. 12, 295-310.

Outdoor	Negative Ions				Positive Ions				Total Ions			
	Small	Int	Large	Total	Small	Int	Large	Total	Small	Int	Large	Total
MEANS	258	105	396	760	369	122	404	896	627	228	801	1655
MEDIANS	252	103	375	734	372	117	363	816	624	220	739	1550
STDEV	50	21	156	160	35	37	185	210	85	58	341	369
STDERR	5	2	16	16	4	4	19	22	9	6	35	38
Indoor	Negative Ions				Positive Ions				Total Ions			
	Small	Int	Large	Total	Small	Int	Large	Total	Small	Int	Large	Total
MEANS	122	65	188	375	194	72	198	464	316	137	385	839
MEDIANS	110	63	192	381	180	54	180	431	290	117	372	812
STDEV	43	14	89	101	65	55	132	187	109	69	221	287
STDERR	4	1	9	10	7	6	14	19	11	7	23	29

Table 1: Summary of the results of the indoor outdoor ion concentration comparison experiment.