Ion Beam Analysis of 3 DRUM Aerosol Sampler Strips

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Since 1991 ANSTO's IBA laboratory has been sampling fine atmospheric particles every Wednesday and Sunday at urban and rural sites around Australia and internationally. Multi-elemental accelerator-based ion beam analysis (IBA) techniques were used to characterise major components and significant trace elements with minimum detectable limits close to and below 1 ng/m^3. Recently we have started testing a 3-DRUM sampling unit kindly obtained from the University of California, Davies (UCD) USA as a potential addition to our conventional aerosol sampling units.

1. Introduction

The 3-DRUM sampling unit utilises a modified rotating Lundgren-Type impactor offering several advantages over our current filtration sampling units. The most important advantage of an impaction system compared with a filtration system is that two key aerosol parameters, size and composition, can be simultaneously determined. The 3-DRUM system also has additional benefits of time resolution and multiple sampling which allows significantly longer unattended operation. We see these as major advantages for potential use in remote sampling locations where sampling site maybe difficult to service regularly. For testing purposes, the 3-DRUM unit was installed at the Liverpool sampling site next to our conventional sampling units to allow a comparative studies of the results (Fig 1 and 2). The unique IBA techniques available at ANSTO were then used to determine the chemical compostion of the fine aerosols collected on each of the 3-DRUM strips between April - July 2009.

The rotating drum impactor system was originally designed by Lundgren in 1967 and is typically characterised by a single rectangular inlet nozzle for each impactor stage. The individual impactor stages consist of a rotating drum instead of a conventional impaction plate and are configured in series which provides cascade-type particle size seperation. The 3-DRUM unit provides aerosol classification and collection into 3 size ranges: 2.5 -1.15µm, 1.15 - 0.34µm, 0.34 – 0.1µm (Fig 3 and 4). It should also be noted that we utilised 5 µm thin Teflon strips rather than Mylar strips which allowed us to analyse for hydrogen in aerosols.

Fig. 1. Liverpool sampling site showing the 3-DRUM test unit (on left) alongside a conventional ASP unit (middle) and a GENT stacked filter unit (on right).

Fig. 2. ANSTO 3-DRUM unit modified from the system provided by UCD.

Fig. 3. 3-DRUM unit schematic and photo showing the 3 drums and stage size fractions

Fig. 4. 3-DRUM strip after aerosol sampling exposure

2. Sample preparation

To apply Ion Beam Analysis on Drum strips the strips has been mounted on separate frames (Fig 5) and scanned with 2 by 5 mm proton beam of 2.6 MeV energy, 3uC charge and 5 nA current in a steps of 1mm. Total of 510 PIXE, 510 PIGE and 510 PESA spectrum were collected in a scan process. Concentrations of 19 elements H, Na, Al, Si, P, Cl, K, Ca, Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, Br and Pb have been determine by IBA analysis techniques. For analysis and alignment of the obtained elemental concentration of aerosols collected from each strip, a new computer program was developed (Fig 6) and the results have been compared with results obtained from the conventional aerosol sampler located side by side with 3 DRUM sampler.

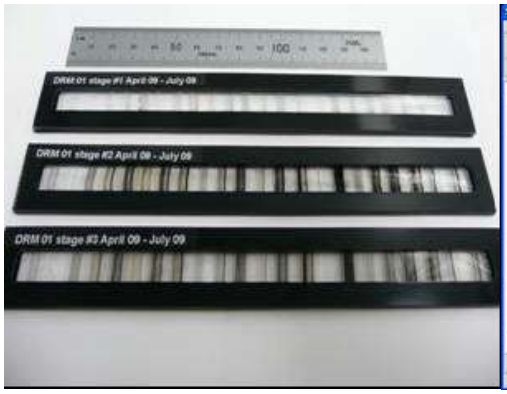


Fig. 5. Strips mounted on frames

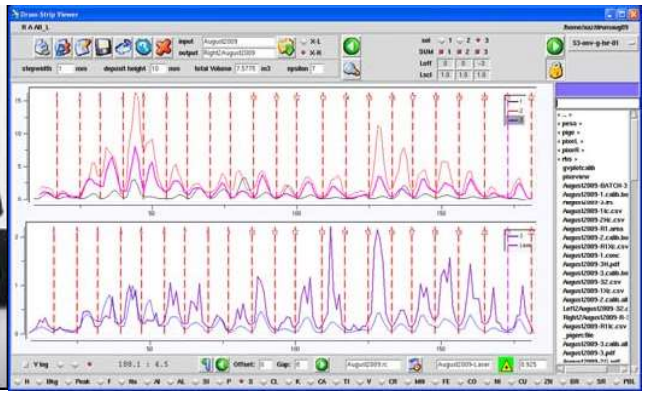


Fig. 6. Interfase of the new computer analysis program

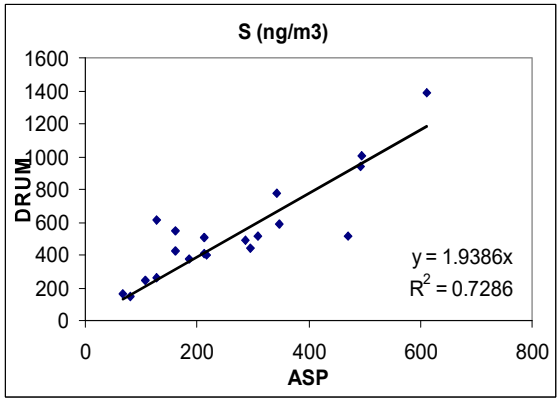
3. Results

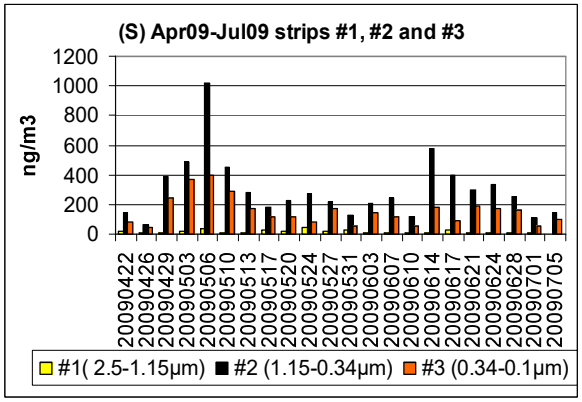
The results plotted in (Fig 7) compare the chemical species sulphur (S) obtained by PIXE, sodium (Na) obtained by PIGE, hydrogen (H) obtained by PESA, black carbon (BC) obtained by laser absorption and potassium (K) obtained by PIXE. It can be seen that the results display excellent correlation between the 3-DRUM unit and the conventional aerosol sampling unit indicating good aerosol sampling by 3-DRUM sampler.

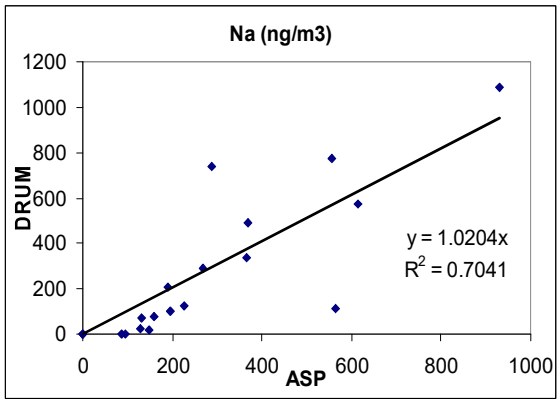
The results ploted in (Fig 8) compare the concentrations of sulphur (S), sodium (Na), hydrogen (H), black carbon (BC) and potassium (K) in aerosols colected on strip #1 (aerosols size range 2.5 -1.15µm), strip #2 (aerosols size range 1.15 - 0.34µm) and strip #3 (aerosol size

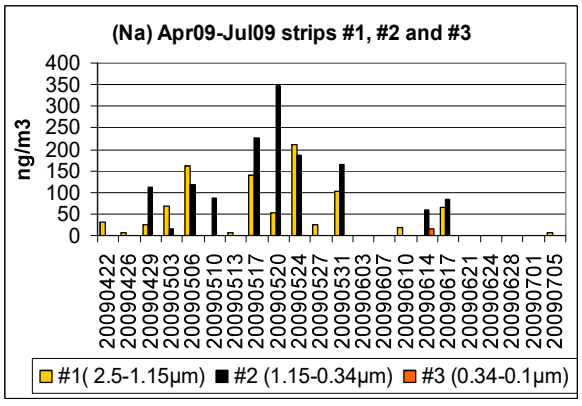
range 0.34 – 0.1µm). It can be seen from plots that S, H, BC and K are present in much higher concentrations in aerosols collected on strips #2 and # 3 than on strip #1 and that Na is in much higher concentrations in aerosols collected on strip #1 and #2 than in aerosols collected on strip #3.

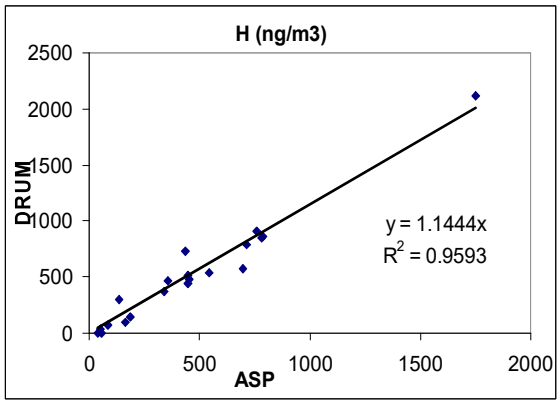
The measurement of Sulphur (S) and Hydrogen (H) is used to determine the levels of ammonium sulphate, $[(NH_4)_2SO_4]$ in the atmosphere. Ammonium sulphate typically originates from sulphur dioxide gas (SO_2) as a result of coal burning, industry and motor vehicle exhausts. Sodium (Na) in the atmosphere is an indicator of sea spray. While especially significant for coastal localities in providing important information on seasonal wind direction variations, it is now known that sea salt is also capable of travelling large distances, for example, a gentle 10km/hr on shore breeze can carry sea spray paticles up to 240km inland in a 24hr period. Black 'sooty' carbon (BC) is mainly the result of motor vehicle and biomass burning. BC is a significant air pollutant and not only a key contributer to reduced visibility in urban area but has also been linked to significant health disorders. Potasium is a good indicator of wood burning and bush fires and can increases by factor of 2-5 between summer winter seasons.

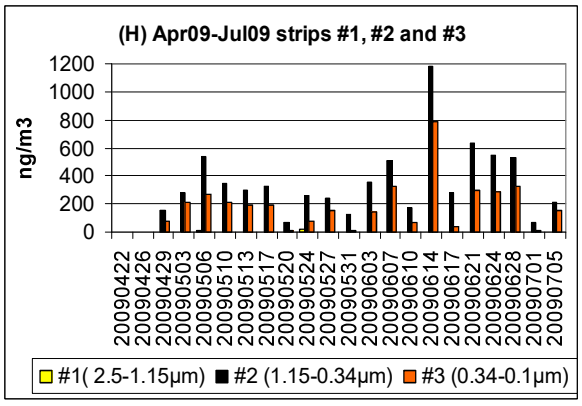


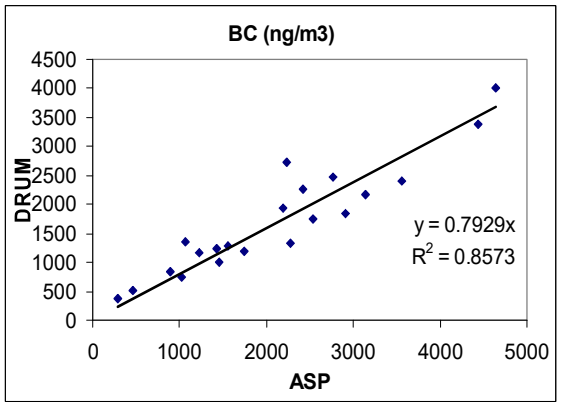


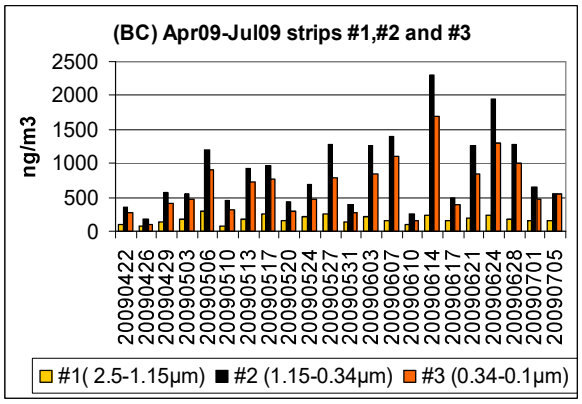


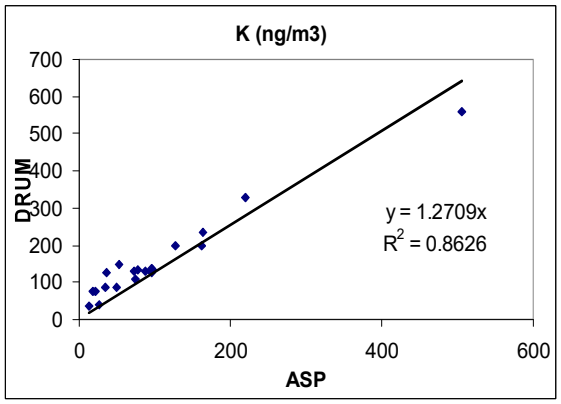












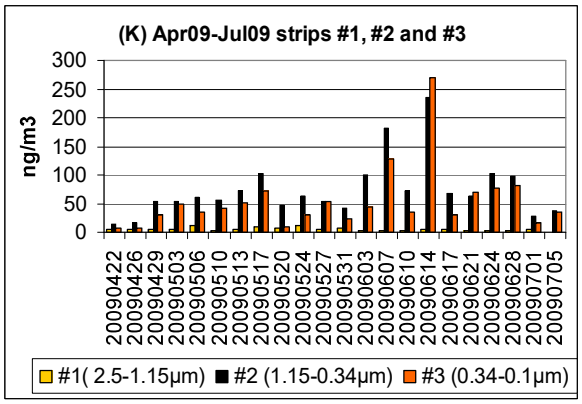


Fig. 7. Plots comparing IBA analysis results of 3-DRUM and ASP unit for Sulphour (S), Sodium (Na), Hydrogen (H), Black carbon (BC) and Potassium (K).

Fig. 8. Plots comparing concentrations of Sulphur (S), Sodium (Na), Hydrogen (H), Black carbon (BC) and Potassium (K) in aerosols collecting on strips #1, #2 and #3.

Acknowledgments

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