

MEGAVOLT ACCELERATOR SYSTEMS FOR ENVIRONMENTAL MONITORING

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Accelerator based ion beam analysis (IBA) techniques have been applied successfully to environmental studies for decades. These megavolt accelerators are ideally suited as the techniques of Particle Induced X-ray Emission (PIXE), Particle Induced Gamma Ray Emission (PIGE), Rutherford Backscattering (RBS), Elastic Recoil Detection and Accelerator Mass Spectrometry (AMS), most commonly used on these machines, all have several key properties in common. They are very sensitive, capable of individual atom or photon counting and they can analysis very small samples, picograms to microgram in just a few minutes of beam time.

PIXE has been used since the mid 1970's to analysis filters obtained to characterise fine particle air pollution. Tens of thousands of such filters have been analysed to date across the globe in Europe, Africa, South America, Middle East and Asia by dozens of laboratories with megavolt accelerators. To date, these methods have been greatly refined. All four IBA techniques of PIXE, PIGE, RBS and ERDA can be run simultaneously to determine over 30 different elements from hydrogen to uranium at concentrations from ng/m^3 to hundreds of $\mu\text{g/m}^3$ of air sampled. The elemental outputs from these methods have been use as input for statistical source apportionment methods such as Positive Matrix Factorisation (PMF) to generate elemental source fingerprints and to then determine the contribution of these fingerprints to the total measured mass of fine particles in the air. This is then taken a step further with the application of hourly wind speed and direction data to pinpoint the location and long-range transport of pollution sources often many hundreds of kilometres away.

The IAEA has run a very successful fine particle characterisation research program for decades across more than 15 countries in Asia from Pakistan in the west to the Philippines in east and Mongolia in the north to New Zealand and Australia in the south. This program has helped national programs understand their air pollution issues and also identified long range pollution transport across national borders.

The technique of PIGE is a fast, sensitive and non-destructive method to determine total fluorine It has been used to determine fluorine down to $\mu\text{g/g}$ levels in Australian coals for export. More recently, total fluorine by PIGE has been applied as a cheap, effective and fast screening method for perfluoroalkyl substances (PFAS) in food wraps, cosmetics and even contaminated ground waters. PFAS are very stable manmade chemicals that have properties that allow them to repel both water and oil and can be toxic in the environment and take a long time to degrade.

AMS is an isotopic method that has the potential to determine isotopic ratios down to 1 part in 10^{15} in microgram samples with a precision approaching $\pm 0.5\%$. It is basically a dating method capable of measuring dates out to around ten half-lives of the isotope being considered. Megavolt accelerators can accelerator almost any isotope in the periodic table. Common isotopes used include ^{14}C (5,730 years), ^{10}Be (1.386M years) and ^{36}Cl (301k years). These three isotopes together span possible dates from the present to over 10M years and have applications in carbon dating for climate change studies, ^{10}Be for soil erosion and formation and ^{36}Cl for ground water studies.

This talk will discuss the application of the IBA methods and show some of the outcomes and success of applying megavolt accelerator systems that use these methods to better understand our environment.