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Air quality data analysis and modelling techniques

Ambient air quality data analyses and receptor techniques are an increasingly important component of effective air quality management. Identifying the types of emission sources, whether they are anthropogenic or the result of naturally occurring events such as forest fires, and their relative contributions to measured air pollution helps identify and quantify the sources that would be most effective to control.

Receptor models provide the theoretical and mathematical framework for quantifying source contributions at that receptor. There are two basic types of receptor models:

1. Sources are known (e.g. Chemical Mass Balance); or
2. Sources are unknown (e.g. Factor Analysis and Positive Matrix Factorization).

In the first type, a regression technique is used to match chemical profiles or “fingerprints” in the measured ambient particulate matter to those in the emissions from potential sources. Chemical Mass Balance (CMB (Chemical Mass Balance)) requires a prior knowledge of major sources and their emission characteristics in the study area. CMB (Chemical Mass Balance) modelling provides a means by which to estimate the percentage contribution of each source to the measured pollutant concentration. These statistical techniques are used for identifying and quantifying the contribution of important emission sources.

The second type requires only ambient measurement data to perform source apportionment. These models rely on the internal variability of the data to determine factor profiles and their contributions to each sample. These factor profiles are related back to specific sources, such as burning or diesel emissions. At a minimum, a hundred or more samples from many locations and/or one location over a long time period are needed for this type of receptor modelling.

At present, receptor models have limited capability to distinguish sources of secondary PM (Particulate Matter) compounds except when combined with elements of source-oriented models and/or other supporting analysis.

Source apportionment (receptor modelling) studies involve the ambient sampling and measurement of atmospheric particles or gases, followed by laboratory analyses to separate and identify the constituents of the samples collected, by their chemical composition. Chemical speciation monitoring helps scientists understand the properties of the airborne pollutants at the receptor site(s) and to identify the emissions sources, including potential sources which are not readily identified in preliminary emissions inventories, such as cooking fires and airborne particles transported over long distances. Additionally, the analyses help quantify the contribution of known emissions sources and can help validate and improve the emissions inventory itself.

Objectives of source apportionment studies can include:

- To quantitatively relate emissions to the characteristics of targeted aerosols at a specific receptor site.
- To evaluate the effectiveness of control strategies over time.

- To improve and validate emission inventories by determining major sources of air pollutants such as particulate matter and other contaminants.
- Strengthening environmental management, particularly at regional and local levels.
- Enhance the linkages between specific emissions sources and ambient air quality.
- Guiding the application of source models.
- Evaluating and improving source model results.
- Providing data to support the reduction of emissions through integrated strategies.

Increasingly, source apportionment analyses are being used as a relatively accurate, rapid, and cost-effective means of identifying and targeting sources and their relative contributions to the total pollution load. This scientific information helps air quality modellers as well as policy- and decision-makers.

The data obtained from source apportionment studies provides policy- and decision-makers with practical tools to identify and quantify different sources of air pollution, increasing their ability to put in place effective policy and regulatory measures and control strategies to reduce air pollution to acceptable levels. Additionally, co-benefits can be realized - for example, source apportionment studies targeting specific air pollutants can also be used to assess climatic impacts, identify clean energy measures and greenhouse gas emission reduction strategies.

Successful application of source apportionment (receptor modeling) methods and support to effective policy- and decision-making depends on the accuracy and relevance of the air quality measurements and the interpretations made by the scientist and air quality manager. Environment Canada’s air quality experts have included source apportionment studies and the improvement of source apportionment techniques and analyses as an integral component of their science and research, constantly seeking the highest quality of data and information.

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