

2.0 AIR QUALITY DISPERSION MODELS

2.1 Definition and Need

A model is simply an imitation of reality. In other words, it is a representation of the important properties of a real phenomenon. It embodies simplifying assumptions to describe a complex system or process.

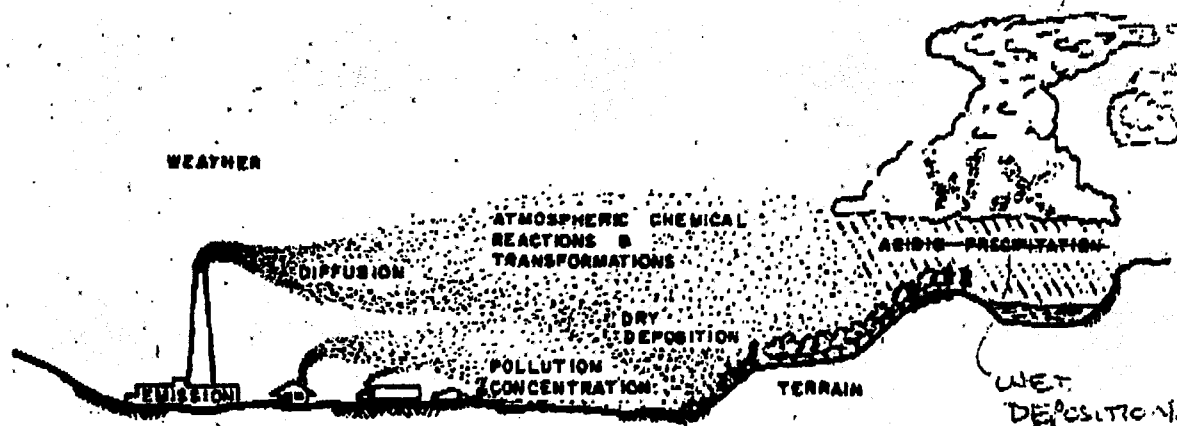
An air quality dispersion model is a mathematical description of pollutant behaviour in the atmosphere. It provides a mathematical cause effect-link between an emission and the resulting air quality impact.

The processes that govern the behaviour of airborne pollutants can be organized into components (transport, diffusion, transformation and deposition) which can be viewed as sub-models that work in concert with one another. To illustrate how these components represent the processes involved, consider a puff of pollutants released into the atmosphere. The puff will be transported by the wind (transport), will spread out due to turbulence (diffusion), can chemically react due to the presence of other species and sunlight (transformation) and will be deposited on the surface due to precipitation, gravitational settling and surface uptake (deposition). The term dispersion relates to the combined effects of all the different components.

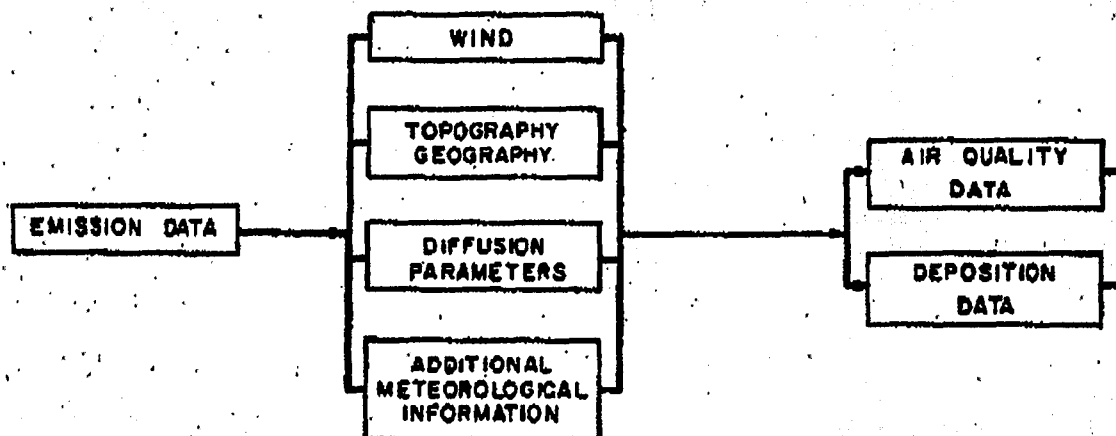
In addition, a dispersion model requires an initial set of conditions before it can be used. Since the behaviour of airborne pollutants are governed largely by atmospheric conditions, then the state of the atmosphere must be described in terms which the model can use. The other inputs involved are source and pollutant characteristics, underlying terrain features and background chemistry. The relationship between reality, model components and inputs is illustrated in Figure 2.1.

Dispersion models have become important tools to assist the decision maker. It is the decision makers responsibility to determine whether a new or existing source will be detrimental to the surrounding air quality, (i.e. if ambient

THE ATMOSPHERE
(reality)



MEASUREMENT
(input data)



MODELS
(simulation)

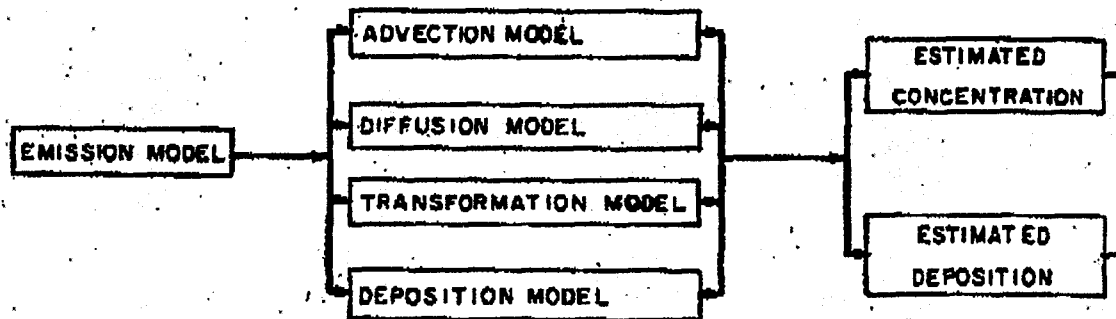


FIGURE 2.1
FLOW SCHEME SHOWING MODULES OR COMPONENTS
OF AN ATMOSPHERIC POLLUTION MODEL
AIR QUALITY DISPERSION

air quality standards are going to be exceeded). Even if the latest in control technology is applied to the source, it is still possible that poor air quality will result. The decision maker must use a method which uses the proposed source emission rate to predict the resulting ambient concentrations. This is where air quality dispersion models have found their niche, since they allow for the exploration of hypothetical situations (different source locations, stack heights, emission rates) and their resulting air quality and/or pollutant deposition. Quantitative answers to "what if" questions provide the foundation for decisions that govern many day-to-day activities. In this way the decision maker can determine whether or not the emissions will have an adverse impact. If required, it allows a scientific justification for a reduction of emissions, or a rejection or relocation of the proposed facility.

There have been some who have not accepted the usefulness of models. In fact many permits issued in British Columbia have not used models in air management decisions. This is contrary to the practice of other regulatory agencies (for example, in Alberta a permit cannot be granted unless model output is submitted). There are basically four reasons for their lack of application. The first is due to an underlying criticism that models involve many assumptions which cannot be substantiated and result in huge errors in prediction. Conceptual ideas and back-of-the-envelope calculations seem to make fewer assumptions and provide just as useful information. No computers or specialized manpower are needed, and there are considerable savings in the short term.

One would respond by pointing out that simple approaches are actually based on rather grand assumptions, which are often not identified or discussed, and which are easily biased by recent events, personal opinion and limited experience. For example, many proposed industrial developments can polarize public opinion (those for vs. those against) and the decision maker can easily be swayed by lobby groups and emotional arguments. Mathematical models show favour to no position and force all assumptions into the open where they can be discussed, challenged, tested and revised. They also force the decision-maker to make a clear separation between technical-scientific factors and socio-economic

issues. Better decisions result from better understanding of all the components. All leading environmental protection agencies do modelling because for many environmental questions there is no other way to get an answer. Even with emission control strategies based on BACT (Best Available Control Technology) or even LAER (Lowest Achievable Emission Rate) there is still a need to assess the impacts since there is no guarantee that ambient air quality standards will be met. *objectives*

A second reason, unique to British Columbia, is related to the decision makers view of the ambient air quality objectives. Since the terrain in B.C. is mountainous it is assumed that exceedences of the ambient air quality standards due to direct plume impingement will always occur. No matter what control technology is employed or conditions put into the permit to minimize air quality impacts, exceedences will happen - so why bother using a model to show the obvious? *objectives*

This fatalistic approach can lead to very poor decisions. It is not known whether an emission will result in an exceedence unless a model is used to verify this assumption. In the case where a model supports the presumption an exceedence will occur, it can also show the magnitude, location and frequency of occurrence of this exceedence. Given the present ambiguity that exists in how the ambient air quality objectives are to be used in British Columbia, this additional information is critical to the information base required for a decision maker. For instance if an exceedence is ten times the ambient air quality objective and it occurs at a hospital site for 20 hours out of the year, very different decisions will be made than for a situation where an exceedence is marginally above the ambient air quality objective and it occurs at a *extensive rock outcropping* gravel-pit for one hour out of a year. Furthermore, if a new facility is planned for an area where there already are a number of sources, what will be the basis for allowing or disallowing this development given the need to account for the contribution due to other sources? Only a model will be able to provide the information so the decision maker can make reasoned judgements.

The third reason is a reliance on monitoring data. That is, since monitoring

provides an actual measure of the contaminant impact, there is no need to do any modelling. The weakness of this argument is evident when one considers that monitors are a measure of air quality at a single point and unless one is extremely lucky, areas of maximum impact will be missed. Hilst (1978) showed that for a large power plant, a monitoring network of 2 stations optimally located would only capture 10% of the total exceedences occurring within 30 km. A model is the only way one can determine the impacts in the gaps between the monitoring locations. In addition, models are the only way to determine the impact for sources which do not yet exist. A healthy air management approach is based on a combination of both monitoring and modelling techniques.

Finally, models are not used because of ignorance of the wide range of situations which they can be applied. One of the goals of this Guideline is to show how these tools can be used so that those involved in air management will have a complete information base from which to make decisions.

2.2 Generic Classes of Models Used in Air Quality Management

Not all models are created equal. The vast array of models used in air quality management can be categorized into different generic classes. These are: Gaussian, numerical, statistical/empirical and physical.

Gaussian models are commonly used by regulators for estimating the impact of non-reactive pollutants. They generally do not require extensive computer resources, input or highly technical expertise. They can be applied in a variety of meteorological, terrain and source settings. They have been in common use for over 25 years and have been the subject of numerous evaluations using actual meteorological and concentration observations.

Numerical models are commonly applied in complex source and meteorology settings (urban situations) and for determining impacts of reactive pollutants. They are numerical solutions to fundamental equations (using finite difference, finite element and splitting techniques) and are typically computer intensive, require detailed input and need special attention by experts. For an excellent review of numerical models used for urban settings, see Seinfeld (1988).

Where's the rest of
the paper ?