THE EXPOSURE COMMITMENT METHOD IN ENVIRONMENTAL
POLLUTANT ASSESSMENT

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Abstract. The exposure commitment method is a time-independent approach to pollutant assessment. The exposure commitment is a measure of the intensity and duration of a pollutant's presence in an environmental reservoir. The method is a particularly convenient means of comparing contributions to intake and exposure from various pathways and in expressing source-receptor relationships. The concepts and definitions of the method are presented and application shown for the transfer of lead and cadmium from general atmospheric sources to man.

1. Introduction

Pollutants are released to the environment from a wide range of industrial, agricultural and natural sources. Although they may cause the most immediate and noticeable effects on man and his resources in the local or regional area of the release, many of the pollutants can become widely dispersed and contribute to low-level, but long-term exposures to the global populations of plants, animals, and man. Assessments of pollutant releases must account for the totality of committed exposure and harm from each release.

The assessment of the consequences of the pollutant release involves description of the sources, the amount and form of the released substance, its transport and behaviour in the environment, the absorption and retention by a receptor organism, and the effects which may be caused. The alternatives to environmental pollutant assessment include time dependent or time independent descriptions of the concentration variations.

The most complete account of the pollutant behaviour is given by the time dependent approach. The amounts of pollutant substance are specified at all points and at all times during the course of the pollutant movement through the environment. Such a comprehensive description requires an extensive set of continuous environmental measurements or, if the system is described by a mathematical model, a correctly formulated compartmental arrangement with accurately specified pathway transfers.

A time independent description of pollutant behaviour can be made on a more limited data base. In this case we are interested in the partitioning of the pollutant amounts in pathway movements and in estimating the amounts which ultimately reach the receptor. The effects can be related directly to the cumulative amounts transferred if a linear relationship can be assumed between exposure and effect. In any case, there is a useful relationship between the cumulative exposure per unit release of the pollutant and the equilibrium concentration for a constant, continuing release.

The exposure commitment method is a time independent approach to environmental pollutant assessment. It has been the basis for the assessment by the United Nations...
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Scientific Committee on the Effects of Atomic Radiation of radionuclide movement through the environment (UNSCEAR 1977). The application to non-radioactive pollutants has been suggested by Butler et al. (1972) and Lindell (1978). The method is being developed and applied at the Monitoring and Assessment Research Centre (MARC) of Chelsea College, University of London (Barry, 1979; O'Brien, 1979; Bennett, 1981). Below are presented the concepts and definitions of the method and the procedures for expressing source-receptor relationships.

2. Concepts and Definitions

When a pollutant is released into the environment, it begins to move along various pathways to man. The fractional amounts which reach man along the various pathways will differ, as will the time course of the exposure. For example, a contaminant in air may be inhaled within a few hours following release to the atmosphere or it may be deposited on soil, absorbed by plants and included in diet in a persistent fashion for years into the future. In a time independent formulation, the cumulative transfers by various pathways can be compared directly.

We are generally interested in the concentrations of the contaminant in subsections or compartments of the environment in which the contaminant is reasonably well mixed. The major reservoirs or compartments are the atmosphere, ocean, soil, lakes and streams, diet and man. It may be useful to make further distinctions, for example, between the troposphere and stratosphere or between the surface and deep ocean. The compartment model must usually be a compromise between a detailed realistic representation of a system and a simplified, manageable version.

The average concentration of a pollutant in a reservoir, which may sometimes be referred to as the level, is the amount of pollutant per unit volume or mass of the reservoir material. Usually the concentration is averaged over the whole volume of the reservoir, but in some cases it may refer to a subregion of the reservoir, for example in the surface soil layer.

Exposure is defined as the time integral of the concentration over a specified time. For a pollutant in compartment $i$, the exposure to time $T$ is

$$E_i(T) = \int_0^T C_i(t) \, dt$$

where $C_i(t)$ is the concentration in the compartment at times prior to $T$. Exposure is, thus, the area under the concentration versus time curve. For periods in which a constant or average concentration is specified, the exposure during the interval is simply the product of the concentration and the time.

When the integral is extended to cover all time, the quantity obtained is the exposure commitment.

$$E_i = \int_0^\infty C_i(t) \, dt$$