ADVECTION – DIFFUSION MODELS

Method Indicator		
Bottom-Up	Hybrid	Top-Down
YES		

Summary of key issues

Issue	**Description**
Description	Such models are intended to make predictions through solution of the so-called advection-diffusion equation, which makes use of probability, time, velocity and the diffusion coefficient with spatial variability, and reflects two transport mechanisms: • Advective (or convective) transport with the mean flow; and • Diffusive transport due to concentrations gradients.
Temporal Applicability	Typically ran over a medium term period (days to months).
Spatial Applicability	Generally limited to small spatial scales, however, can be applied in a course model to extend estuary-wide.
Links with Other Tools	Typically linked with process-based models such as sediment fluxes, hydrodynamic models, water quality and sediment quality
Data Sources	Temperature sources for data setup, salinity, suspended sediment concentrations, contaminants. Contaminant discharge information is required for boundary conditions. Calibration and verification data need to be obtained as well as information regarding mass balance and the displacement of the substance.
Necessary Software Tools / Skills	Hydrodynamic model, which can interface with the advection-dispersion model. Skills needed include an understanding of the hydrodynamics, material released and estuary processes.
Typical Analyses	Consider the fate of material released into the environment.
Limitations	The considered substance is completely mixed over the cross-section, implying that a source/sink term is considered to mix instantaneously over the cross-section; The substance is conservative or subject to a first order reaction (linear decay); Fick's diffusion law applies, i.e. the diffusive transport is proportional to the concentration gradient.
Example Applications	Humber Estuary, Southampton Water, Mersey Estuary

Introduction

Numerical models are important engineering tools when considering the prediction of pollution transport in a body of water. Whatever the nature of a particular pollutant, the mixing process responsible for the distribution of quantities of heat, dissolved gas and solids, and suspended sediment, is shown to consist of a uni-directional movement by turbulent mean flows, called advection, and a three-dimensional spreading action produced by the turbulent flow components, called diffusion. Numerical Advection-Diffusion models are intended to make predictions through solution of the so called advection-diffusion equation (Abbott and Basco, 1989):

$$\frac{\partial p}{\partial t} + u\frac{\partial p}{\partial x} - D\frac{\partial^2 p}{\partial x^2} = 0 \qquad (1)$$

where p is the probability, t is time, u is velocity, x is the spatial coordinate and D is the diffusion coefficient.

In summary, the equation reflects two transport mechanisms:

- Advective (or convective) transport with the mean flow; and
- Diffusive transport due to concentrations gradients.

Typically, the main assumptions underlying the advection-diffusion equation are:

- The considered substance is completely mixed over the cross-section, implying that a source/sink term is considered to mix instantaneously over the cross-section;
- The substance is conservative or subject to a first order reaction (linear decay); and
- Fick's diffusion law applies, i.e. the diffusive transport is proportional to the concentration gradient.

Data requirements
In addition to the data requirements outlined for the hydrodynamic modelling, a large number of measurements are required to ensure the set-up, calibration and validation of a reasonable advection-diffusion model. A list of data requirements is given below:

- Measurements of temperature, salinity, SSC (suspended sediment concentration) and contaminants;
- Boundary conditions;
- Contaminant discharge information;
- Calibration and verification data;
- Mass balance and displacement of substances.

For further information see Ippen (1966); Dyer (1973, 1986); Borthwick *et al*. (1998); CERC (1993); Crank (1975); Fischer *et al.* (1979); McDowell and O'Connor (1977); Sloan and Pender (1998); Niedoroda *et al*. (1995), http://www.pol.ac.uk/coin/nrshrmod.html, and Data Requirements.

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