WATER QUALITY

Method Indicator		
Bottom-Up	Hybrid	Top-Down
YES		

Summary of key issues

Issue	Summary
Description	Water quality modelling represents the advection and dispersion of suspended matter, dissolved oxygen and contaminants. Water quality models can also simulate the biochemical reactions that take place within biological systems such as nitrification and the decay of biological oxygen demand (BOD).
Temporal Applicability	Typically applied to the short to medium-term (single tide up to several months).
Spatial Applicability	Varying from a single point to estuary wide including the open coast.
Links with Other Tools	Water quality modelling can be linked to various tools for the increased understanding of the impacts of water quality on biodiversity, for example.
Data Sources	• Typically, the qualitative models are not hydrodynamic dispersion models and require tidal information to drive the model; • Conservative substances (salinity, chloride, traces); • Decayable substances; • Suspended sediment; • Bacteria; • Heavy Metals; • BOD and COD (biological and chemical oxygen demand); • Algae; • Oxygen; • Temperature; • Nutrients (ammonia, nitrate, phosphate, silicate); • Organic Matter (nitrogen, carbon, phosphorus, silicon).
Necessary Software Tools / Skills	Water quality models (typically linked to a hydrodynamic model); water quality expertise, thorough understanding of chemical processes occurring (e.g. biochemistry, flocculation).
Typical Analyses	The impact of discharge on any water body is dependent upon discharge quantity and the prevailing physical and chemical conditions.
Limitations	Spatial extent of model determined from the knowledge of the location and temporal effect of the discharge. Calibration and validation of a water quality model should reflect the timescales of the parameters in question, tidal and possibly seasonal variability.

Introduction

Water quality modelling solves the equation of advection-diffusion for a predefined computational grid on a wide range of model substances. Overall, water quality models aim to provide the user with information regarding the “condition” of a water body. Typically, water quality models require tidal information to drive the model.

The impact of a discharge on any water body is dependent on a discharge quantity and prevailing physical and chemical conditions. Typically, spatial and temporal conditions for each individual water bodies are highly variable. This is due to tidal and wind currents, bathymetry, fluvial flow. To asses the impact of a discharge it is necessary to predict the duration over which the pollutants may act and the area likely to be effected.

Defining the model

It is essential to define the major issues and variables under consideration at the outset in order to select an appropriate model:

- Model duration; temporal extent of the discharge defines the simulation period which the model simulates processes;
- Model domain; spatial extent of the model determined from knowledge of the location and temporal effect of the discharge;
- Model dimensions; requires the knowledge of the hydrology of the area and behaviour of the pollutants.

These issues then need to be mapped according to the required outputs of each model:

- 1 Dimensional Model, Single scale, e.g. length down an estuary. Typically 1D modelling is undertaken for river networks and estuaries, which are well mixed where longitudinal variation is important;
- 2 Dimensional Model, Two scales, e.g. length and depth of an estuary. Typically, 2D water quality modelling is undertaken for water bodies that are well mixed but have a significant width;
- 3 Dimensional Model, Three scales, e.g. length, width and depth. If width and depth variation are important a 3D dynamic model is required;
- Box Models: simple representations of complex systems that focus on fluxes between boxes and transformations within boxes that are considered relatively homogeneous. In water quality modelling box models can be used in a variety of ways. For example, the simplest box model is the tidal prism model, however, a collection of simple box models can be linked together horizontally and vertically to represent the major features of an estuarine system. They are effective water quality management tools that can incorporate information from measured data or higher order two and three-dimensional models results (Ibrahim, 1996);
- Inverse models: this type of model is able to interpolate objectively between scattered data by making use of a system of governing equations (for example conservation equations for mass and momentum). They require no boundary data, thus they are only useful when only scattered observations rather than boundary data are available. An inverse model needs good data for assimilation (Lam *et al*. 1984; Copeland, 1994; Copeland & Bayne, 1999).

Modelled substances

A wide range of substances can be used within a water quality model, including:

- Conservative substances (salinity, chloride, traces);
- Decayable substances;
- Suspended sediment;
- Temperature;
- Nutrients (ammonia, nitrate, phosphate, silicate);
- Organic Matter (nitrogen, carbon, phosphorus, silicon);

- Oxygen;
- BOD and COD (biological and chemical oxygen demand);
- Algae;
- Bacteria; and
- Heavy Metals.

Water quality models allow the user to specify a wide range of physical, biological, ecological and chemical processes, including:

- Sedimentation and resuspension;
- Re-aeration of oxygen;
- Algae growth and mortality;
- Mineralization of organic substances;
- Denitrification, and
- Adsorption of heavy metals.

Model calibration/validation

Calibration is the process by which the model is adjusted to reproduce the characteristics of the study area for a given set of conditions (STOWA/RIZA, 1999). Water quality calibration consists of concentrations of the modelled substances at points throughout the model area over the period of interest. Seasonal variation may be important for some parameters such as nutrients and chlorophyll. In addition, it is important that all inputs to the model area from e.g. outfalls or rivers are accurately specified.

Model validation demonstrates the accuracy of the model output with a separate, independent dataset. Calibration and validation of a water quality model should reflect the timescales of the parameters in question, tidal and possibly seasonal variability.

More information on model calibration and validation can be found in Data Requirements.

References

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