Eddy Diffusion Modelling - A Tool for Rapid Spatially Resolved Indoor Hazard Assessment

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Mathematical models are used to calculate the exposure of individuals to airborne toxic material in indoor environments to provide advice to protect the warfighter and civilian populations. The models need to be simple when it is not practical to fully survey the environment. In such cases it may not be possible to define the boundary conditions required for more complex techniques such as computational fluid dynamics (CFD) modelling. Another significant advantage of most simple models is the speed with which they can be set up and solved. This means that they can be used when limited time is available. A number of simple modelling techniques are available for predicting the hazard from airborne material in single rooms indoors but most cannot provide a representation of the spatially resolved concentration field. The commonly used well-mixed method assumes that material is instantaneously mixed across a room, but this can massively over/under predict the hazard in large indoor spaces. One model that does provide spatial resolution is the eddy diffusion method. Eddy diffusion models for indoor spaces work by solving a three dimension diffusion model which can account for containment of the transported material by the walls of the room. The single parameter that governs mixing in these models is the eddy diffusion coefficient. Some relationships that enable this coefficient to be predicted have been proposed in the literature, but wider applicability of these has not previously been tested. In this work an automated computational fluid dynamics tool was used to calculate the eddy diffusion coefficient in a range of isothermal, mechanically ventilated rooms. Available models for the diffusion coefficient were then tested and the most applicable was found to be one based on a turbulent kinetic energy balance. This relationship was only appropriate when the characteristic length was set to a dimension of the air supply inlet, instead of the length usually applied, i.e. the room height. The validity of this relationship was further demonstrated using experimental test cases and by applying standard error metrics. This eddy diffusion modelling method we will describe provides more accurate predictions than traditional well-mixed models, and requires far less information and time than CFD methods, enabling it to be used for urgent operational reachback requests.