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A MATHEMATICAL MODEL DEVELOPED TO PREDICT RESIDENTIAL EXPOSURE TO PESTICIDE VAPOURS EMITTED FROM TREATED FIELDS

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Highlights: A mathematical exposure model was developed to assess residents' exposure to pesticide vapours by living nearby the agricultural fields, drawing on the existing established exposure models. The model considers the complex processes of pesticide transfers in the environment, which is useful in supplementing costly and time-consuming field measurements. A validated version can be used as a cost-effective tool in pesticide authorisation and registration process to mitigate pesticide risks in the general public more effectively.

Key words: *resident, pesticide vapour, inhalation, exposure, algorithm, regulatory*

Introduction

In agriculture, pesticides are often heavily applied to kill and control pests and crop diseases. Nevertheless, applied pesticides may be emitted into the atmosphere as pesticide vapours after a spraying activity is completed. The emitted pesticide vapours can be transported to different distances downwind the treated fields, and then get into contact with residents living nearby via respiratory inhalation and indirect dermal contact with pesticide deposits (Wong et al., 2017). Residents typically have no work related to pesticides, but they can be unintentionally exposed to pesticides up to 24 hours per day due to their location, with the highest time-weighted average inhalation exposure to pesticide vapours within 24 hours after spraying and that of default 2 hours of dermal exposure to pesticide deposits in their own lawn (EFSA, 2014). That is, exposure via inhalation route can be more important than dermal route.

Humans' exposure to pesticides via direct and indirect non-dietary routes of exposures (i.e., dermal contact and respiratory inhalation) have been associated with various health effects ranging from acute poisonings to chronic effects. For example, respiratory disorders, coughing, headaches, dizziness, fatigue, reproductive effects and chronic kidney diseases (Sankoh et al, 2016; Elahi et al, 2019). In residents, they can be exposed to pesticides over prolonged period due to the emission of applied pesticides that can occur over several days or weeks after spraying (Scheyer et al., 2007). The inhaled pesticide vapours can be very dangerous because they can be directly dissolved at the lungs' surface and get into the bloodstream (Ogg et al., 2018).

Pesticide exposure is almost always quantified in regulatory risk assessments only. Over time, mathematical exposure models have been evolved as an alternative tool to supplement the limited field data measurements in regulatory risk assessment (Salcedo et al, 2017; Wong & Brown 2020). In a study conducted by Wong et al. (2017), a mathematical exposure model was developed to predict the level of residential exposure to pesticides treated in nearby agricultural fields via both inhalation and indirect dermal exposures. Due to the potential higher risk via inhalation route in residents, we focus on pesticide vapour inhalation in this piece of work.

The developed exposure model for pesticide vapour inhalation consists of three major phases, starting from pesticide emission from treated surfaces (plant and soil surfaces), followed by the atmospheric transport of pesticide vapours at different downwind distances, and lastly the inhalation uptake of pesticide vapours among residents (Figure 1). Four established models were selected to predict residents' exposure to pesticide vapours, namely the Pesticide Emission Assessment at Regional and Local Scales (PEARL; van den Berg & Leistra, 2004) for pesticide emission from plant surface, Pesticide Leaching Model (PELMO; Ferrairi et al, 2005) for pesticide emission from soil surface, Industrial Source Complex Short Term 2 (ISCTCS2; US EPA, 1992) for the transport of pesticide vapours at different downwind distances, and the EFSA Guidance on the assessment of exposure of operators, workers, residents and bystanders in risk assessment for plant protection products (EFSA, 2014) for the systemic inhalation exposure on a daily basis. The present model has a major advantage of its flexibility to predict pesticide exposure at different distances, while other existing models predict the exposure level at fixed downwind distances (e.g., the Bystanders, Residents, Operators and WorkerS Exposure models for plant protection products predicts the exposure at distances between 2 and 20 m only; Butler Ellis et al., 2013), That is, the present model is adjustable for the specific physicochemical properties of pesticide active substances, local environmental factors and different distances.

Exposure predictive models that can describe the actual exposure scenarios are cost-effective tools in regulatory risk assessment. Overall, the present model can be used to monitor pesticide risk in residents, with model validation against field measurements and further improvements are necessary to increase the level of accuracy.