10.1071_ISSN0311-4546EC108p6

A model for **healthy homes**

A model that measures the movement of volatile hydrocarbons through soil and into houses, could help define acceptable levels of soil pollution at old petrol station sites reclaimed for housing.

The 'volatile transport model', being developed by scientists from CSIRO and the Environmental Health Branch of the South Australian Department of Human Services, models the movement of hydrocarbons such as benzene through soil and into houses set on concrete slabs or over crawl spaces. The amount of pollutant occupants of the house are exposed to can then be estimated, and a level of soil pollution that is 'protective of health' determined.

'Our exposure estimates are based on the inhalation rate of a two-and-a-half-year-old child living in an enclosed environment with two adults,' Len Turczynowicz from the Department of Human Services says.

'We then use the transport model to assess how much pollutant would enter the house and, working backwards from an ambient (safe) air standard for the pollutant, determine a soil concentration or 'criterion' that would be protective of health.'

The establishment of such soil criteria could eventually be used by members of the Australian Institute of Petroleum to help redevelop old petrol station sites.

Turczynowicz, in collaboration with Dr Neville Robinson from CSIRO Mathematical and Information Sciences, developed the model by combining mathematical and engineering principles with Australian field data on soil and ventilation characteristics. These field data were obtained from earlier studies conducted by Dr Mike McLaughlin of CSIRO Land and Water, Dr Angelo Delsante from CSIRO Building Construction and Engineering and other researchers.

'The data confer a high degree of reality on the model parameters, which is more than you get with other models,' Robinson says. 'And most importantly, they're applicable to Australian conditions.'

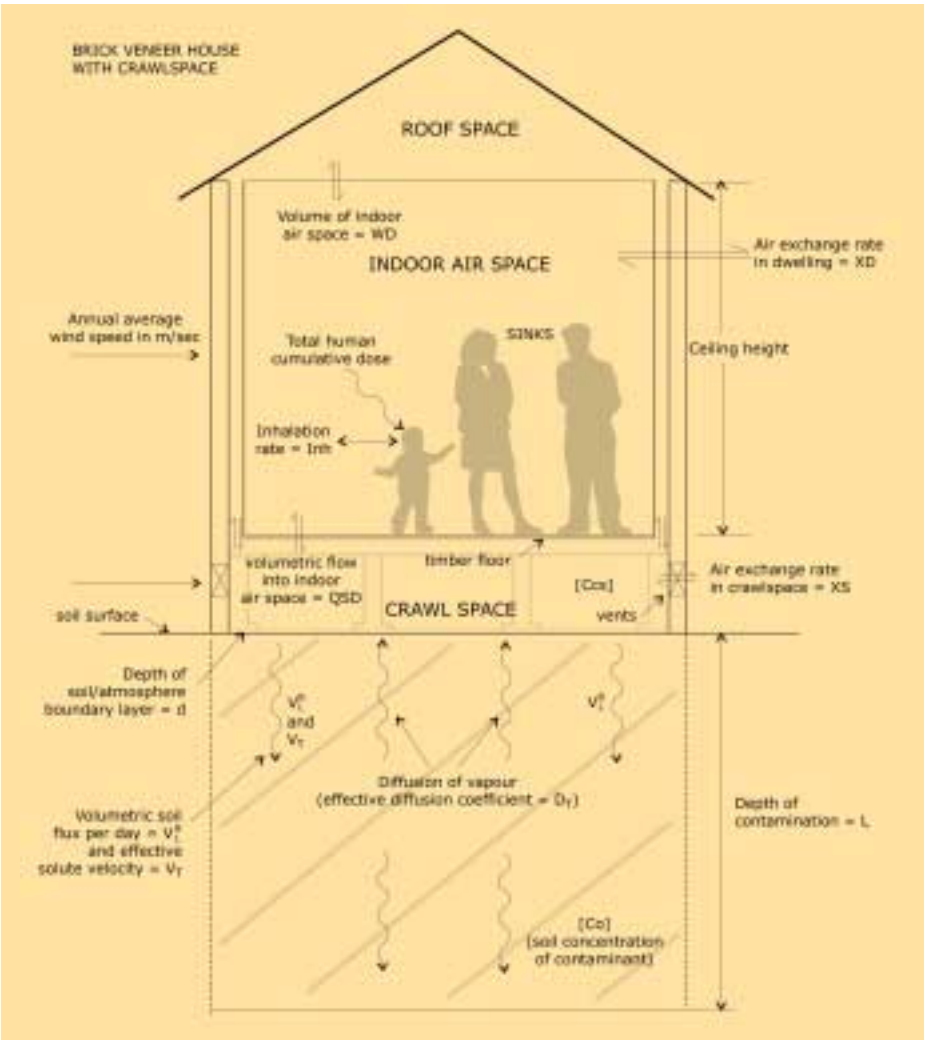
Len Turczynowicz and Neville Robinson.

Currently, soil pollution levels set using US or Dutch models are used by environmental consultants contracted to assess contaminated land. However these models are ultra-conservative and rely on housing characteristics atypical of Australian homes.

'Often the soil criteria generated by these models are so low that site remediation would be costly. Or, they suggest there is a health risk when in reality there isn't,' Turczynowicz says.

'In addition, American and Dutch homes have different ventilation characteristics because they tend to have basements or be two storey structures.'

Australian homes, in contrast, tend to be built with crawl spaces underneath or over concrete slabs. Crawl spaces allow air to move freely beneath the house, and help minimise the amount of volatile hydrocarbons that can infiltrate the house.



The 'volatile transport model' models the movement of volatile hydrocarbons through soil and into typical Australian homes. The dose expected to be received by a 2.5 year old child is then estimated and the level of hydrocarbon that can be safely tolerated is used to determine health-based soil pollutant levels.

This diagram shows some of the parameters that had to be considered when designing the model. They include dwelling characteristics such as indoor air volumes and ventilation rates, soil characteristics and the depth of contamination.

While the model tries to be as realistic as possible, mathematician Dr Neville Robinson, says it is important to maintain an element of simplicity as well.

'The art of modelling is knowing which equations to apply. You don't want them to be so long and complicated that you can't solve anything because you can't get enough data. And you don't want them to be too simple that they fail to reflect the proper maths or physics underlying the situation you're trying to model.'

Concrete slabs, on the other hand, reduce ventilation, allowing more hydrocarbons to permeate upwards into the house.

In fact, one of the key findings during development of the volatile transport model, was that house characteristics have a much greater influence on indoor levels of pollution than soil properties or the physico-chemical properties of the pollutant.

'We conducted a sensitivity analysis on our model – a review of the different parameters that affect the output of the model – and found that parameters relating to house characteristics made the greatest contribution to variation in the indoor pollutant levels,' Turczynowicz says. This means that a single soil pollutant concentration for each type of house can be set.

Although the model has initially focussed on the movement of benzene, Robinson and Turczynowicz will apply it to other volatile compounds such as toluene, ethylbenzene, xylene and total petroleum hydrocarbons (TPHs). Health-based soil criteria could then be set for these pollutants across dwelling types.

The scientists will also fine-tune the model by incorporating additional influences on hydrocarbon transport, such as groundwater movement.

'Housing characteristics are dominant in the sensitivity analysis, so these subsurface factors will be a minor refinement. But they will improve the reality of the model and ensure we have a realistic appraisal of processes that are occurring,' Robinson says.

The final step in the model development process is validation – an evaluation of the model against reality. This is now being undertaken by evaluating the movement of a volatile organic chemical in an established house. As there is a lack of Australian ambient air criteria for various hydrocarbons, validation will use overseas criteria established by the UK Department of Environment (benzene), the World Health Organisation (ethylbenzene, toluene and xylene) and the Total Petroleum Hydrocarbon Criteria Working Group (TPH fractions).

Contact: Dr Neville Robinson (08) 8303 8766, neville.robinson@cmis.csiro.au, Leonid Turczynowicz (08) 8226 7135, len.turczynowicz@dhs.sa.gov.au.

Wendy Pyper

**Ambient air standards are levels of air pollution that are considered to be safe. They are derived from occupational human studies and animal studies. When scientists are trying to assess whether volatile pollutant levels in soil are safe, the levels are compared against the ambient air standard. Australia doesn't have its own ambient air standard, so those developed by expert working parties, WHO and various regulatory bodies are used.*