

## **To the Editor-in-Chief, Journal of Environmental Radioactivity**

Dear Dr Sheppard,

**Comment on “Indoor terrestrial gamma dose rate mapping in France: a case study using two different geostatistical models” by Warnery et al. (J. Environ. Radioact. 2015, 139, 140-148)**

We were interested in the paper by Warnery et al. (Warnery et al. 2015) on estimating doses from naturally occurring gamma rays in residences, particularly now that these dose estimates have been used in the study of Demoury et al. (Demoury et al. 2017) of childhood acute leukaemia in relation to exposure to natural background radiation in France. Broadly, the study of Demoury et al. (2017) did not support the hypothesis that such exposure increases the risk of childhood acute leukaemia, which contrasts with the findings of a generally similar study in Great Britain (Kendall et al. 2013).

Warnery et al. (2015) derived dose estimates in 1 km squares using Ordinary Kriging (OK) and Multi-Colocated CoKriging (MCCK). Warnery et al. (2015) give a mean square error (MSE) of  $407 \text{ (nSv/h)}^2$  for MCCK, but OK gives a very similar MSE of  $409 \text{ (nSv/h)}^2$ . Nevertheless, we were unable to get a clear picture of the uncertainties in the dose rates predicted by the method of Warnery et al. (2015). Warnery et al. (2015) do not seem to have developed a model with a subset of their measurement data and tested it on the remainder. We adopted this approach with British data (Chernyavskiy et al. 2016; Kendall et al. 2016), when it became clear that there was substantial inter-house variation that limited the accuracy with which predictions could be made of indoor gamma dose rates in unmeasured dwellings. It is possible that an underestimation of the uncertainties associated with their predictions could result in over-optimistic predictions of the power of the study of Demoury et al. (2017).

We have some specific concerns about the estimates of Warnery et al. (2015).

Warnery et al. (2015) used a large set of 98,858 indoor gamma-ray dose measurements at 17,420 dentist surgeries and veterinary clinics. There had previously been another large study by Billon et al. (Billon et al. 2005) on the gamma ray exposure of the French population, based on 8737 measurements in private dwellings. The two studies found very different gamma ray mean dose rates (net of the cosmic ray component): Billon et al. (2005), 55 nSv/h; Warnery et al. (2015), 76 nSv/h. The reason for the difference is not apparent.

The two studies used different types of dosimeter: Radio Photo Luminescent Dosimeters (Warnery et al., 2015) and Thermoluminescent Dosimeters (Billon et al., 2005). However, both are well suited to measuring environmental gamma rays (Lee et al. 2009) and this cannot account for so large a discrepancy. Warnery et al. (2015) had a larger database than Billon et al. (2005), but the latter was also large; simple numerical variability can hardly explain the difference.

Warnery et al. (2015) had more complete geographical coverage, presumably of 97 départements in metropolitan France, whereas the study of Billon et al. (2005) covered 59 départements. But if the difference is due to high dose rates in the extra départements then the mean for these 38 must have been about twice that in the original 59. This seems most unlikely and would certainly have merited comment.

Both studies subtracted cosmic ray exposures estimated using the formula of Bouville and Lowder (Bouville and Lowder 1988). Billon et al. (2005) gave data on the cosmic ray estimates, whereas Warnery et al. (2015) did not, but they must have been very similar. The Bouville and Lowder (1988) formula provides estimates for outdoor cosmic rays. Billon et al. (2005) made a universal correction to indoor dose rates using the UNSCEAR factor of 0.8 (UNSCEAR, 2000). In fact, the attenuation will vary from dwelling to dwelling depending on structural conditions, such as how massive they are. The cosmic ray subtraction may have differed between the two studies, and it is unclear whether Warnery et al. (2015) made a correction for shielding in buildings.

An alternative explanation may be that there is a significant difference between mean indoor dose rates in residences (Billon et al., 2005) and in dental/veterinary practices (Warnery et al., 2015). In the absence of data this is speculation, but it would seem to be a possibility. Clearly, such a difference would have implications for the study of Demoury et al. (2017), which used residential indoor gamma ray dose estimates from the study of Warnery et al. (2015).

Warnery et al. (2015) note that the kriging predictions are somewhat less dispersed than the raw measurements, which they remark is an inevitable result of the averaging involved. We wonder if there were any other systematic discrepancies between the predictions and the measurements.

Finally, Warnery et al. (2015) state that “telluric gamma-rays mostly come from the progenies of U-238”. This appears inconsistent with the UNSCEAR rule of thumb that U-238, Th-232 and K-40 contribute roughly equally to indoor gamma dose rates (UNSCEAR 2000). We are not aware of data showing that France differs in this respect.

Yours sincerely  
GM Kendall  
MP Little  
R Wakeford

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