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Selecting passive dosimetry technologies for measuring the external dose of terrestrial wildlife

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ABSTRACT

Dosimeters attached to wild animals can be used to validate regulatory assessment approaches and models for estimating radiation exposure of wild animals. Such measurements are also necessary to ensure that robust dose-effect relationships can be developed from the results of field research programmes. This paper presents the first comprehensive evaluation of the different dosimetry technologies available for specifically measuring the external exposure of wildlife. Guidance is provided on the selection of appropriate passive dosimetry approaches for directly measuring external exposure of terrestrial wildlife under field conditions. The characteristics and performance of four available dosimetry technologies (thermoluminescent dosimeter (TLD), optically stimulated luminescent dosimeter (OSLD), radiophotoluminescent dosimeter (RPLD) and direct ion storage, (DIS)) are reviewed. Dosimeter properties, detection limit and dose range, study organisms and the intended application are variables that need to be considered when selecting a suitable dosimetry technology. Evaluated against these criteria, it is suggested that LiF based and Al_2O_3:C TLDs, OSLD and RPLD could all be used to estimate doses to wildlife. However, only LiF based TLDs have been used to directly measure wildlife doses in field studies to date. DIS is only suitable for comparatively large species (e.g. medium to large mammals), but has the advantage that temporal variation in dose can be recorded. In all cases, dosimeter calibration is required to ensure that the dose measurements reported can be interpreted appropriately for the organisms of interest.

1. Introduction

The need to demonstrate the protection of wildlife from ionising radiation is an increasing requirement of national regulation (e.g. Beresford et al., 2008a; Copplestone, 2012) and is now included in international recommendations (e.g. IAEA, 2006; ICRP, 2008). To meet these needs for radiological assessment, a number of modelling approaches have been developed to estimate absorbed doses received by wildlife (e.g. Johansen et al., 2012; Stark et al., 2015; Vives i Batlle et al., 2011; Vives i Batlle et al., 2016; Yankovich et al., 2010). Estimated dose rates are compared to benchmark (e.g. no-effect) dose rates to judge the level of risk (Andersson et al., 2009).

The assessment approaches developed have to be validated in terms of their estimates of internal and external dose to wildlife, to ensure that the uncertainties are quantified and most importantly that the approaches are demonstrated to be fit-for-purpose (i.e. suitable for use in regulatory applications). Predicted internal dose rates have been compared to those estimated via measured radionuclide activity concentrations in organisms (Beresford et al., 2010; Johansen et al., 2012; Stark et al., 2015; Wood et al., 2009; Yankovich et al., 2010). Gamma dose rate typically dominates external exposure (Vives i Batlle et al., 2007), so validating external gamma dose rate estimates using measurements from dosimeters attached to wild organisms is desirable. However, there have been few such studies to date (e.g. Beresford et al., 2008b; Woodhead, 1973).

As well as allowing validation of dose predictions from assessment models, such dosimetry approaches would also be valuable for measuring doses to wildlife around nuclear facilities (as part of compliance monitoring programmes). In addition, poor dosimetry within field effects studies has increasingly been identified as a limitation in constructing dose-effect relationships for wildlife under field conditions (Beaugelin-Seiller et al., submitted; Beresford and Copplestone, 2011). Application of dosimeters attached to study species would help to address this issue.

It is likely that the different dosimetry technologies available will be suitable for different types of animal, due to variation in animal size, behaviour, habitat and environmental conditions. To ensure that direct measurement of wildlife exposures results in reliable estimates, a

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