Measuring terrestrial wildlife radiation exposure under field conditions

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Overview

1. **Estimation of wild animal radiation exposure**
   - There are a number of models and approaches to estimate radiation exposure of wild animals
   - These models and approaches have to be validated in terms of internal and external dose assessment on wildlife
     - Internal dose rates: compared to measured radionuclide activity concentrations
     - External dose rates: need direct dose measurements of wild organisms in field
2. **Few studies have attempted to measure external dose directly**
3. **<u>No published data on long-term effects combined with direct external dose measurements using appropriate dosimetry technologies under field conditions for mammals or birds</u>**

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Aim

The aim of this study is to develop practical dose measurement technologies for accurately assessing (external) radiation exposure of terrestrial wild mammals and birds.

Objectives

- To define and design specification of appropriate dosimetry measurements
- To investigate the reliability of external dose rate measured from dosimetry technologies
- To assess influence of the orientation of dosimetry technologies on the collars to external dose rate
- To design new environmentally robust methods for mounting passive dosimeters on collars
- To critically evaluate the effectiveness of the developed dosimetry technologies to field application

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Dosimetry Technologies

Passive Dosimeter

The device for recording the radiation accumulated dose received as well as the long term effect of ionising radiation

The dosimetry technologies considered on this research:

- **Luminescence dosimeters**
  - ***Thermoluminescence* (TLD)**
    - ✓ Small sizes with many shapes of material, many kinds of TL material (e.g. LiF, CaF_2, $CaSO_4$, $Li_2B_4O_7$ and Al_2O_3)
    - ✓ Negligible influences from light and moisture, hypersensitivity and low self-dose (e.g. LiF:Mg, Cu, P)
    - X Complicated glow curve and high fading (e.g. CaF_2, $CaSO_4$)
  - ***Optically Stimulated luminescence (OSL)***
    - ✓ High sensitivity, multiple re-analyses
    - X light sensitivity
  - ***Radiophotoluminescence (RPL)***
    - ✓ Repeat reading, insensitive to ambient influences, low fading
    - X Big sizes, a few RPL systems commercially available


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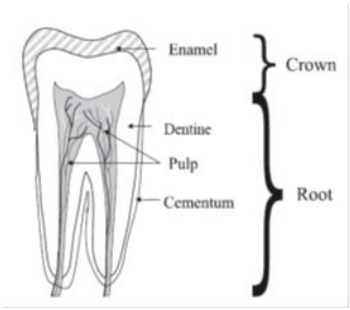
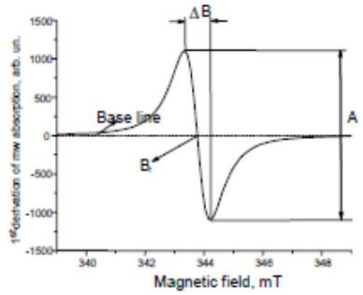
Dosimetry Technologies

The passive dosimetry technologies considered on this research:

- **Direct Ion Storage (DIS)**
  - ✓ Can be used as the active and passive dosimeter, high sensitivity and responsible linearity over a wide energy range
  - X Very sensitive to the temperature
- **Electron paramagnetic resonance (EPR)**
  - ✓ Retrospective dosimetry when the signal is saved in the tooth (enamel) or any calcified tissues
  - X The reconstruction of the individual dose is complicated **f**or bone-seeking radionuclides (e.g. 90Sr)

Instadose 2





Previous studies of dose measurement on wildlife by using passive dosimetry technologies

Author (year)	Dosimetry technologies	Techniques	Animal species
Woodhead[1] (1973)	TLDs	TLDs attachment combine with the Petersen disc tag	Plaice
Halford and Markham[2] (1978)	TLDs	Surgical implantation in subcutaneous	White-footed deer mouse, least chipmunk and ord's kangaroo rat
Rumble and Denison[3] (1986)	TLDs	Ears mounted TLDs	White-footed deer mouse, least chipmunk and ord's kangaroo rat
Chesser et al.[4] (2000)	TLDs	Collars mounted TLDs	Root vole
Khan et al.[5] (2003)	EPR	Teeth enamel of animals	Swiss Webster mice
Khan et al.[6] (2005)	EPR	Teeth enamel of animals	Canine

Remarks:

1. Woodhead, D.S., 1973. The radiation dose received by plaice *(pleuronectes platessa)* from the waste discharged into the north-east Irish Sea from the fule reprocessing plant at windscale. Helath Physics 25, 115-121.
2. Halford, D.K., Markham, O.D., 1978. Radiation Dosimetry of Small Mammals Inhabiting a Liquid Radioactive Waste Disposal Area. Ecology 59, 1047-1054.
3. Rumble, M.A., Denison, S.A., 1986. An Alternative Technique for Attaching Thermoluminescent Dosimeters to Small mammals. Health Physic Society 51, 245-248.
4. Chesser, R.K., Sugg, D.W., Lomakin, M.D., Bussche, R.A.V.D., DeWoody, A.J., Jagoe, C.H., Dallas, C.E., Whicker, F.W., Smith, M.H., Gaschak, S.P., Chizhevsky, I.V., Lyabik, V.V., Buntova, E.G., Holloman, K., Baker, R.J., 2000. Concentrations and dose rate estimates of 134, 137 Cesium and 90 Strontium in small mammals at Chornobyl, Ukraine. Environmental Toxicology and Chemistry 19, 305-312.
5. Khan, R.F.H., Rink, W.J., Boreham, D.R., 2003. Biophysical dose measurement using electron paramagnetic resonance in rodent teeth. Applied Radiation and Isotopes 59, 189-196.
6. Khan, R.F., Pekar, J., Rink, W.J., Boreham, D.R., 2005. Retrospective radiation dosimetry using electron paramagnetic resonance in canine dental enamel. Applied radiation and isotopes : including data, instrumentation and methods for use in agriculture, industry and medicine 62, 173-179.

Previous studies of dose measurement on wildlife by using passive dosimetry technologies

Author (year)	Dosimetry technologies	Techniques	Animal species
Beresford et al.[7] (2008)	TLDs	Collars mounted TLDs	Yellow neck mouse, bank vole and Vole specie
Stark and Pettersson[8] (2008)	TLDs	placed TLDs in Frog phantoms and then placed the phantoms on top soil layer and in the constructed hold	Frog phantoms
Kubota ae al.[9] (2015)	RPLDs, OSLDs	* Place dosimeters on the ground and underground * Embed RPLDs in the non-contaminated wild rodent carcasses and put them on the ground	Wood mouse, small field mice and Japanese grass voles
Fuma et al.[10] (2015)	RPLDs	Placed RPLDs on the ground and on the sediment at the bottom of the pond	Tokoku hynobiid salamander and their larvae

Remarks:

7. Beresford, N.A., Gaschak, S., Barnett, C.L., Howard, B.J., Chizhevsky, I., Strømman, G., Oughton, D.H., Wright, S.M., Maksimenko, A., Copplestone, D., 2008c. Estimating the exposure of small mammals at three sites within the Chernobyl exclusion zone – a test application of the ERICA Tool. Journal of Environmental Radioactivity 99, 1496-1502.
8. Stark, K., Pettersson, H., 2008. External radiation doses from 137Cs to frog phantoms in a wetland area: in situ measurements and dose model calculations. Radiat Environ Biophys 47, 481-489. Steinnes, E., 2007. Radioecology. American Institute of Physics, 23-27.
9. Kubota, Y., Takahashi, H., Watanabe, Y., Fuma, S., Kawaguchi, I., Aoki, M., Kubota, M., Furuhata, Y., Shigemura, Y., Yamada, F., Ishikawa, T., Obara, S., Yoshida, S., 2015. Estimation of absorbed radiation dose rates in wild rodents inhabiting a site severely contaminated by the Fukushima Dai-ichi nuclear power plant accident. J Environ Radioact 142C, 124-131.
10. Fuma, S., Ihara, S., Kawaguchi, I., Ishikawa, T., Watanabe, Y., Kubota, Y., Sato, Y., Takahashi, H., Aono, T., Ishii, N., 2015. Dose rate estimation of the Tohoku hynobiid salamander, Hynobius lichenatus, in Fukushima. Journal of environmental radioactivity 143, 123-134.

Research plan

The first stage:

- **Identify and evaluate current passive dosimetry technologies**
- **The evaluation of the passive technologies will consider two levels of dosimeter performance:**
  - (i) ability to measure down to levels of exposure that equate to screening dose rates
  - (ii) lowest reportable dose rate (suitability for use in field studies on radiation effects)
- **Design schemes in order to aid suitable dosimeter selection for measuring external exposure on different target wild animals under field condition in various scenarios**

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Research plan

The second stage:

- Develop and design new environmentally robust methods for mounting well-chosen passive dosimetry technologies on collars
- Calibrate collars suitable for species likely to be encountered at target testing sites
- Consider the factors of accurate estimation of absorbed doses would cause the most accurate estimation from measurements to whole body absorbed doses

The Third stage:

- Test the methods and techniques developed on terrestrial wild animals in target areas under field condition

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Transfer - Exposure - Effects:

Thank you very much