Biological half-lives for farm livestock which contribute to the human food chain

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Confidence – Coping with uncertainty for improved modelling and decision making in nuclear emergencies

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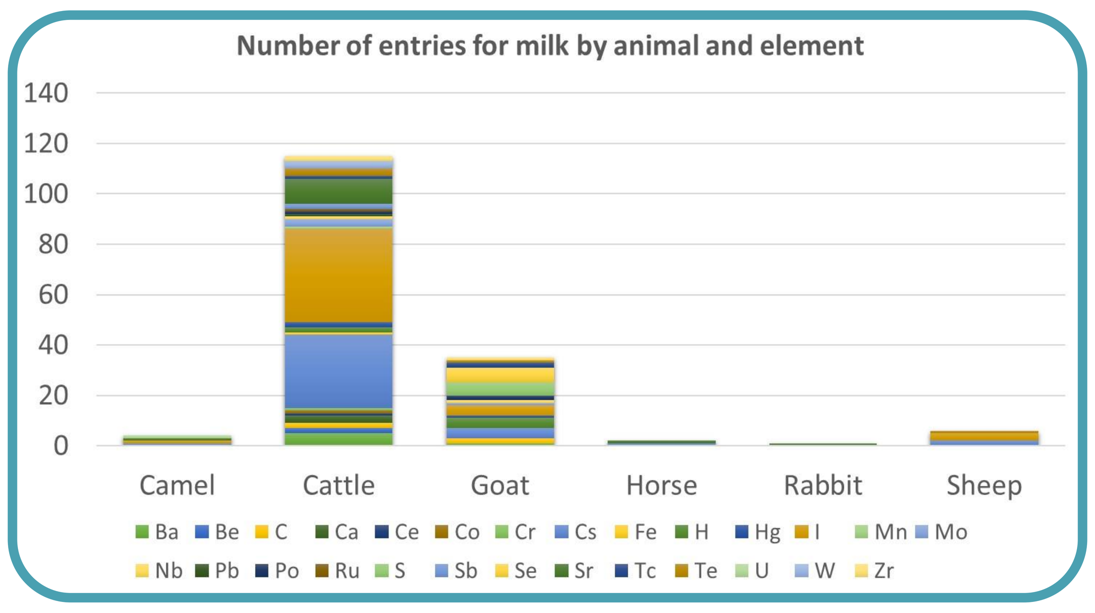
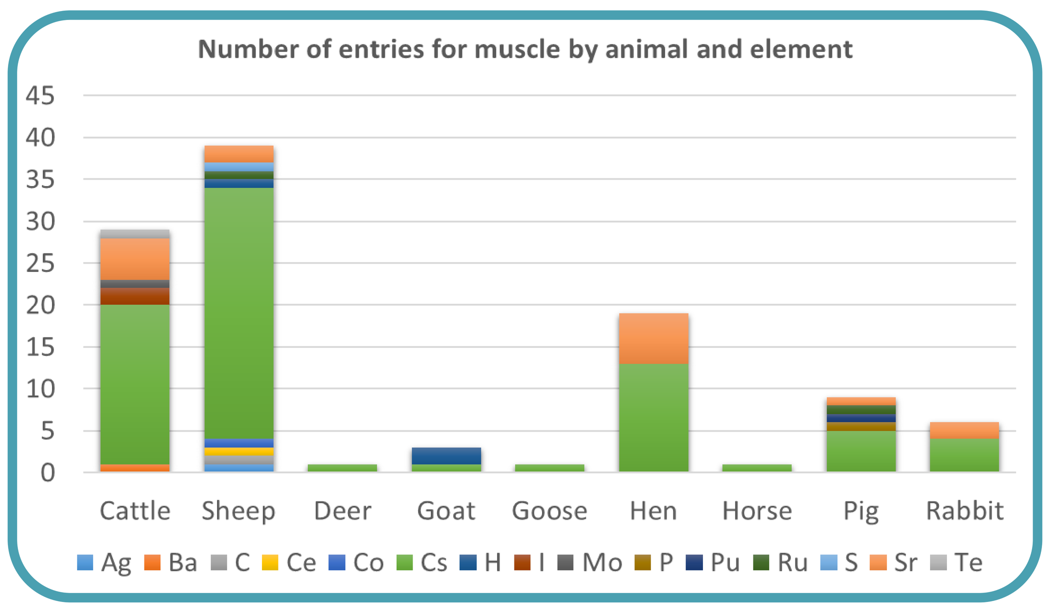




Background

International compilations of radiological data (e.g. IAEA TRS 472) have not collated information on biological half-life values for farm animals. However, many predictive models use this parameter to describe the rate of loss of radionuclides from animal tissues and products.

To address this we have conducted a review of published biological half-life values and compiled the values into a dataset of quality controlled entries.

Dataset description

The dataset comprises almost 650 entries for 32 elements relevant to radiological protection. These encompass 12 animals that are 'farmed' (i.e. cattle, sheep, pigs, goats, deer, geese, hens, ducks, grouse, rabbits, horses and camels).

The majority of the data (~75%) are for tissues used in the human food chain (muscle, liver, kidney), eggs or milk. The remainder are for tissues which are generally not consumed (e.g. bone, thyroid) and excreta.

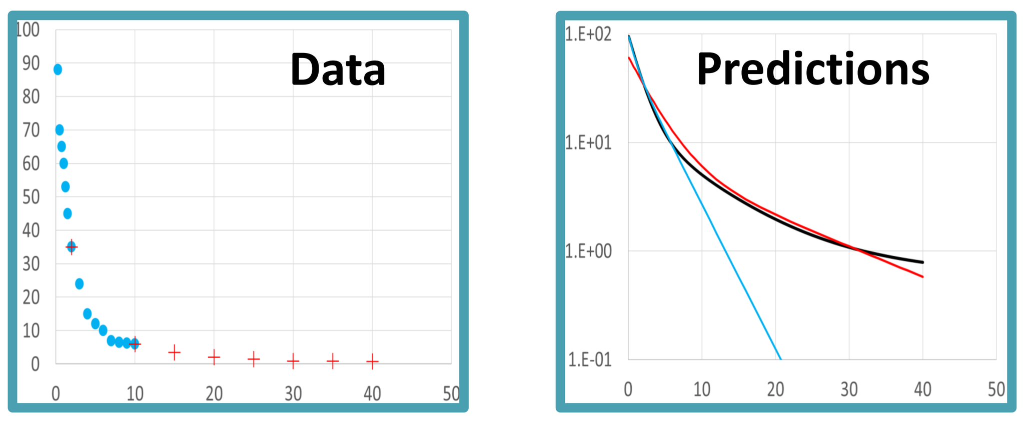
Approximately 60 % of all the entries are for the radioisotopes of caesium, strontium and iodine.

Data overview

Milk: Values for milk represent approximately 30% of all the data; half of these values being for Cs, Sr and I. Almost 70% of the entries for milk are for cow milk with 25% being for goat milk and <1% for sheep milk.

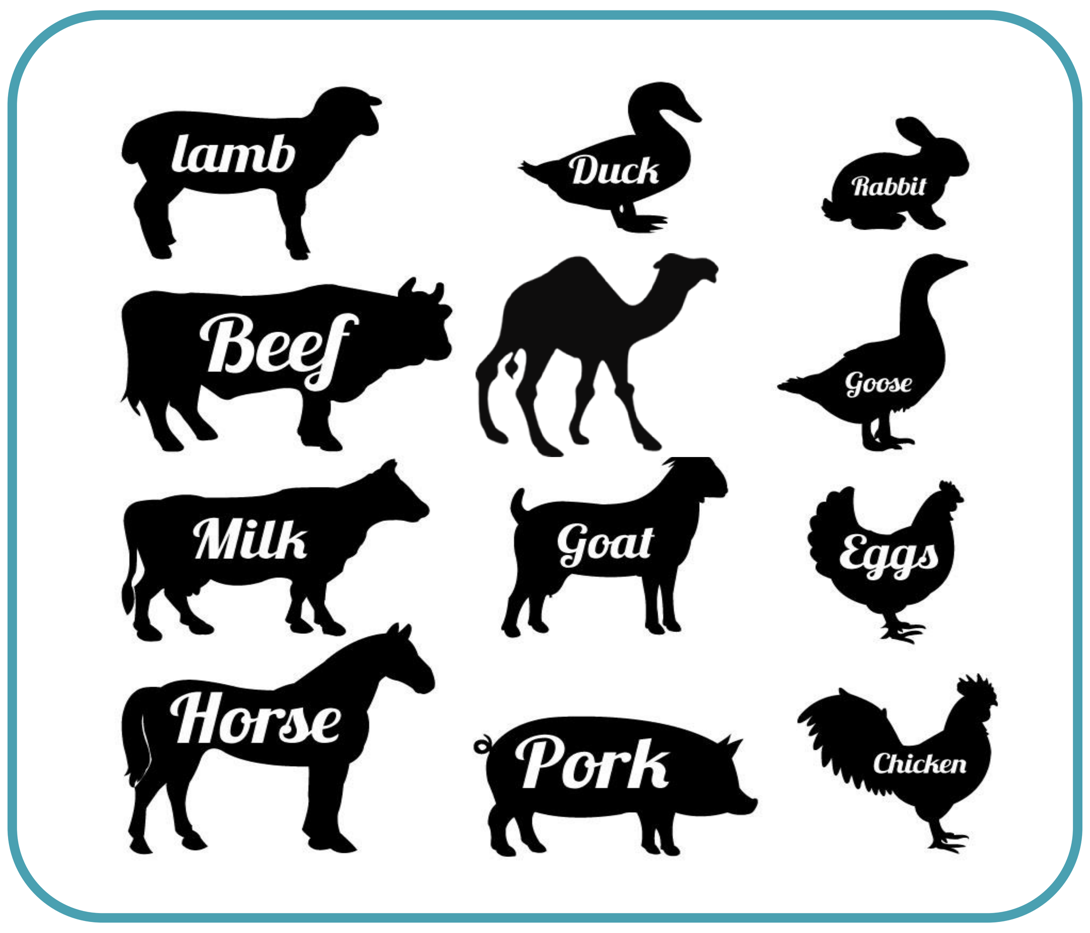
Muscle (meat): Values for muscle comprise approximately 20% of the dataset; the majority of these data (~87%) are for Cs and Sr. Of all the data for meat, data for cattle comprise ~30%, sheep ~32%, hens 19% and pigs 8%.

Eggs: Values for eggs comprise approximately 5% of the dataset with almost half of these being for the whole egg. All data are for hens.



Estimating biological half-life – the effect of data availability (Po in cow milk, Bq/kg)
(based on data from Johnson & Watters, 1972)

Different protocols used in studies can determine the estimated biological half-lives determined from the data. For instance a relatively short study will miss long-term loss components (e.g. blue line). Conversely, with infrequent sampling in the initial phase of a study then the initial rapid changes in activity concentrations may not be well predicted (e.g. red line).



Summarising biological half-life values…

…is not straightforward and care should be taken when analysing the biological half-life values presented within the dataset (see figures above as an example).

This is, in part, because source references often report differing numbers of components of loss (e.g. for Cs in milk between 1 and 5 loss components are reported) which means it is not possible to derive means and associated probability distribution functions (i.e. a degree of interpretation will be required when trying to derive 'best estimates').

For milk, for all elements and species, the majority of loss appears to takes place rapidly with a biological half-life in the range 1-3 days. This likely reflects a relatively rapid change in radionuclide activity concentrations in blood following cessation of a contaminated diet. Longer-term biological half-lives for milk will reflect those in the main storage compartment and are element dependent.

Recommendations

Some initial best estimate recommendations:

Cs cow milk - two components of loss:
1.7 days (80%), 17 days (20%)

I cow milk - single component of loss:
1 day

Cs hen eggs - single component of loss:
yolk 5 days; albumen 3 days

Cs sheep muscle - single component of loss:
lamb 17 days; adult 23 days

Sr adult cattle muscle - two components of loss:
4 days (50%), >200 days (50%)

Cs deer wholebody - two components of loss:
1 day (30%), 15 days (70%)

Data access

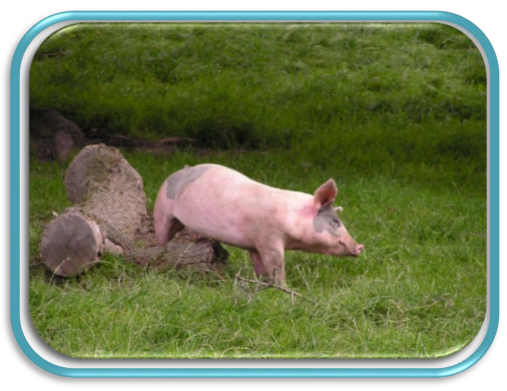
The dataset and a list of all source references has been published as:
https://doi.org/10.5285/d26ea56a-a692-427c-8f5a-a9bb6eb7da6b

The dataset is embargoed until the accompanying paper is published

Allometry (biological scaling)

We have attempted to fit allometric (mass dependent) relationships to the data for the most abundant element-product combinations (e.g. Cs and milk) with the aim of providing extrapolation approaches to predict half-life values for species-element combinations for which we have no data.

However, whilst it looks like allometric relationships may exist, data are insufficient to establish robust models and we were unable to derive a generic relationship across elements (as we have previously done for wildlife).



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