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Improving the quantity, quality and transparency of data used to derive radionuclide transfer parameters for animal products. 1. Goat milk

B.J. Howard*, C. Wells, C.L. Barnett

NERC Centre for Ecology and Hydrology, Lancaster Environment Centre, Library Avenue, Bailrigg, Lancaster LA1 4AP, UK

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ABSTRACT

Under the MODARIA (Modelling and Data for Radiological Impact Assessments Programme of the International Atomic Energy Agency), there has been an initiative to improve the derivation, provenance and transparency of transfer parameter values for radionuclides. The approach taken for animal products is outlined here and the first revised table for goat milk is provided. Data from some references used in TRS 472 were removed and reasons given for removal. Particular efforts were made to improve the number of CR (concentration ratio) values which have some advantages over transfer coefficients. There is little difference in most of the new CR and F_m (transfer coefficient) values for goat milk compared with those in TRS 472. In TRS 472, 21 CR values were reported for goat milk. In the 2015 dataset for goat milk CR values for a further 14 elements are now included. The CR and F_m values for only one element (Co) were removed.

1. Introduction

The transfer coefficient, defined as the equilibrium ratio of the fresh weight activity concentration in milk or meat to the daily dietary radionuclide intake, has been widely adopted as the basis for quantifying transfer to milk (F_m, d l^{-1} or d kg^{-1}) and meat and eggs (F_f, d kg^{-1}) for all radionuclides (Howard et al., 2009a,b).

For many years it was generally accepted that transfer coefficients for smaller animals were higher than those for larger animals, so those for adults are lower than those for smaller livestock. Beresford et al. (2007) and Ng et al. (1982) both suggested that much of this difference was because transfer coefficients incorporate daily dry matter intake (DMI, in kg d^{-1}) which increases with animal size. An alternative approach to quantifying transfer is to remove the dietary intake used in the estimation of F_m or F_f, and simply calculate the concentration ratio (CR) defined as the equilibrium ratio between the radionuclide activity concentration in the animal food product (Bq kg^{-1} fresh weight) divided by the radionuclide activity concentration in the feedstuff ingested (Bq kg^{-1} dry weight). Values for CR were first provided in TRS 472 and are now often reported for animal products.

1.1. TRS 364

The TRS 364 (IAEA, 1994) animal product tables for F_f and F_m were compiled by the end of 1992 and published in 1994. They were prepared initially by Ng who published many extensive reviews of transfer parameter values (Ng et al., 1968, 1977, 1978, 1979a,b; 1982; Ng, 1982). The work was finalized at short notice by Howard and Voigt, who completed the tables by focusing on review data complemented by only a few original source data. The literature used contained no original Russian data values, but instead relied upon values from a limited number of monographs and reviews. The animal product tables in TRS 364 gave 'Expected F_f and F_m' values and ranges. 'Less than' values were included (i.e. values below detection limits) and the type of data was given in footnotes to the tables.

The importance of review sources in TRS 364 is shown in Table 1, which lists the most commonly cited reviews and those sources which were used for at least three elements in the animal products.

The use of review values has some advantages in that they utilise expert guidance from authors who have considerable experience and expertise in compiling and evaluating data such as Ng and Coughtrey. Also, for some reviews, the values are compiled by more than one expert in radionuclide transfer to agricultural animals (e.g. Commission of the EC 1987). Some reviews derive

* Corresponding author.
E-mail address: bjho@ceh.ac.uk (B.J. Howard).

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Table 1
Reviews and sources of data for three or more elements in animal products in TRS 364.

Source	Cow		Sheep		Goat		Pig	Poultry	
	Meat	Milk	Meat	Milk	Meat	Milk	Meat	Eggs	Meat
Review source information									
Coughtrey (1990)	✓	✓	✓	✓		✓	✓	✓	✓
Ng (1982)		✓							
Ng et al. (1982)	✓		✓				✓	✓	✓
Commission of the EC (1987)			✓				✓		✓
Cramp et al. (1990)									✓
Bishop et al. (1989)	✓								
References supplying data for more than three elements in animal products									
Ennis et al. (1988)								✓	✓
Johnson et al. (1988)	✓	✓			✓	✓			
Johnson and Ward (1989)		✓				✓			
Voigt et al. (1988)		✓							
Van Bruwaene et al. (1984)		✓							

values using model predictions based on relevant data to fill gaps (e.g. Thorne, 2003) by extrapolating in a consistent manner (e.g. Balkema series: Coughtrey and Thorne, 1983; Coughtrey et al., 1984 etc.).

However, the use of review values also has some disadvantages, these include:

- Unclear provenance of data with some values now being impossible to verify as they refer to bibliographic numbers in an unobtainable reference system (e.g. Ng et al., 1977)
- Variable or undocumented Quality Control (QC) and/or peer review
- Some reviews cite reviews which cite reviews which ultimately provide transfer parameter values for an element and animal product that were derived. For example, in SRS 19 (IAEA, 2001), the source data for the F_m and F_f values is given as TRS 364 and, if data are not present in TRS 364, it refers to NCRP 123 (1996) as the secondary source of data. NCRP 123 includes citations from Ng et al. (1977, 1982) and Baes et al. (1984) as its source of F_m and F_f data. The latter utilises data from Ng references (1968, 1979a,b) and a theoretical approach based on the elemental variation in soil to plant and plant to milk. Similarly, although some values in Ng references are based on data for the element in both animal product and feed, many values were derived, or extrapolated, using a number of different approaches, some of which are still widely used in current assessments.
- Time, resource and expertise limitations mean that it is common for values taken from reports to be used without checking the validity or acceptability of the method used to derive or extrapolate data.

1.2. *TRS 472*

The F_f, F_m (and CR) values in TRS 472 (IAEA, 2010) were compiled up to 2007 under the EMRAS programme of the IAEA by CEH, IAEA and RIARAE and published in TECDOC 1616 in 2009, and TRS 472 in 2010. The dataset incorporates data for both radionuclides and stable elements. Compared with the TRS 364 data tables, more elements were included and some elements were removed after QC. Most of the values were based on original data, < values were excluded and the majority of review data were removed. Detailed information on the approach taken to derive the tables in TRS 472 and supplementary information can be found in the accompanying TECDOC 1616 (IAEA, 2009) and Howard et al. (2009a,b). In a substantial improvement, TRS 472 included original Russian literature data associated with a series of papers by Fesenko et al. (2007a,b; 2009a,b).

When the data for TRS 472 was collated up to the end of 2007, the primary focus was to report revised F_m and F_f values. The tables reported geometric mean (GM) and geometric standard deviation (GSD) when $n \geq 3$ otherwise the arithmetic mean (AM) was reported together with the minimum, maximum and n. Only values for adult animals were used to calculate F_f (or F_m) as the DMI of an animal varies with live-weight.

CR values were included in the TRS dataset when they were reported in the source data used for the F_m of F_f values for some elements. These CR values were supplemented with values based on stable element concentrations in animal products and feed. For feed, data were collated from agricultural review literature (Church, 1980; NRC 2001, NRC 2005, MAFF 1990, Underwood, 1977). The arithmetic mean of collated literature values of element concentrations in animal products were then divided by that of the feed concentrations to derive CR values. Ng et al. (1978) derived "unassociated" transfer coefficients using separate data sources for the element concentrations in animal products and feed. This approach was used to derive CR values for Se, Na, Zn and P in TRS 472 reported in the CR table (shaded values). Additional literature values for stable element concentrations were also collated for each of the animal products.

The number of F_f and F_m data available increased in TRS 472 compared with TRS 364. However, for many elements the number of data values was <10 and the quality and information for the data from different studies was variable.

2. The need for improvements

The widespread use of the review values discussed above can lead to a situation where new and valuable data are not incorporated into models at regular intervals when it becomes available. Instead, updating tends to follow that of the tables produced by the International Atomic Energy Agency at long intervals often exceeding a decade. Within the MODARIA[1] programme, it was recognized that mechanisms to produce more frequent revisions of transfer parameter tables need to be explored. Any revisions of the datasets needs to be registered so that the version of the data used can be suitably referenced in assessments.

Current problems include the provenance of the data, transparency of changes made and how source data was used and the need for continual data quality checks. Those people carrying out assessments, or using the parameter values in models, need clear

[1] MODARIA http://www-ns.iaea.org/projects/modaria/.