THE EFFECTS OF RIVER FLOODING ON PCDD/F AND PCB LEVELS IN COWS MILK

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Introduction

Cows grazing on pastures that are located near pollution sources may show elevated milk levels of dioxins and PCBs. Pastures located on the floodplains of contaminated rivers are known to have higher soil pollution levels[1]. The mechanism by which this occurs is probably the translocation of contaminated river sediment to pastureland during incidents of flooding. This study was designed to investigate the levels of these contaminants in farms prone to flooding, and determine the direct effect of any such contamination on milk from cattle grazing on the pastureland. The results should enable an evaluation of any potential threat to the food chain caused by river flooding, as well as improve our understanding of the environmental pathways and exposure models in this area. This study is particularly relevant in the light of a recent report[2] on climate change that suggests that the frequency and magnitude of flooding is likely to increase in most regions.

Analytical Methodology

A Geographical Information System (GIS) was used to assist in the identification and selection of suitable river systems in the UK that had a relatively high frequency of overbank floods. Two further selection criteria were that the river systems should pass through cattle grazing areas unprotected by flood alleviation schemes and that they would include potentially ‘contaminated’ (urban and industrial pollution influences) and ‘clean’ (rural) river sections. Flood events were monitored in each area. Three river systems (the Dee, Trent, and Doe Lea/Rother/Don) were chosen on the basis that they provided the best combination of a wide variety of catchment environments with a relatively high density of suitable farms. The Trent and Doe Lea/Rother/Don systems satisfied the criteria for containing potential urban and industrial pollution sources, while the course of the Dee is predominantly rural with no heavy industry close to its banks.

Suitable farms prone to flooding on these river systems were selected and paired with nearby farms not subject to flooding, as controls. As far as possible, flood-prone and control farms were selected that would be expected to experience similar levels of contaminant aerial deposition. Additionally, all selected farms kept herds of Holstein Friesian cows except for one farm that kept Jersey cows.

Analytical methods used for the extraction and analysis of samples have been previously reported.[3] All measurements were UKAS accredited to the ISO 17025 standard. Additionally, BCR reference materials (CRM 350 for PCBs; RM 533 and RM 534 for the PCDD/Fs) were analysed with each sample batch and results of participation in international inter-comparison trials are well documented (laboratory 12[4] and laboratory 1[5]).

Milk samples were collected in three phases in October/November 1998, March 1999 and August 1999. This report presents results for the first two phases.

Results and Discussion

TEQ concentrations from the present study are summarised in Table 1 together with literature values from other studies. The mean value of 3.8 ngTEQ/kg fat for all samples in this study is consistent with previously reported levels for monitoring programmes in the UK. It should be noted however that some of these earlier studies were targeted at areas expected to have higher concentrations. Additionally, some of the samples from these studies were collected several years ago and concentrations have been shown to have declined since then.

Table 1. Mean values for dioxin and PCB TEQ (ng/kg fat) for different studies on milk.

PCDD/F TEQ*	PCB-TEQ non-ortho+ ortho	Total TEQ**	Sampling date	Reference
UK				
4.5	2.7	7.2	1982	Harrison *et al* (1998) [6]
2.0	1.5	3.6	1990	Krokos *et al* (1996) [7]
2.0	1.3	3.3	1992	Harrison *et al* (1998) [6]
1.0	1.8	2.8	1995	MAFF (1997d) [10]
4.6	2.7	7.3	1996	MAFF (1997c) [9]
1.9	1.8	3.7	1997	MAFF (1997c) [9]
2.2	3.6	5.8	1997	MAFF (1997a) [8]
Netherlands				
3.9	4.3	8.2	1991	Traag *et al* (1993) [12]
1.8	2.3	4.1	1993	Hendriks *et al*(1996) [1]
Present study				
2.9	2.4	5.3	1998/1999	Doe Lea/Rother/ Don
2.3	1.4	3.7	1998/1999	Trent
1.2	0.8	2.0	1998/1999	Dee
2.2	1.6	3.8	1998/1999	All samples

* TEQs reported as documented in the literature.
**Total concentrations of dioxins and PCBs may not equal the sum of individual dioxin and PCB values due to rounding.

The mean total TEQ concentration (2.0 ngTEQ/ kg fat) of milk samples collected from farms on the Dee is lower than any of the previous UK studies listed and justifies its choice in this study as a potentially ‘clean’ or control river. Also in keeping with the original premise the total TEQ values for the Trent (3.7 ngTEQ/ kg fat) and the Doe Lea/Rother/Don river systems (5.3 ngTEQ kg/fat) are higher than the Dee. These observations are consistent with the known contamination of the Doe Lea/Rother/ Don river system and the fact that the rivers of this system flow close to major industrial cities such as Sheffield and Rotherham.

The total TEQ values reported for earlier Dutch studies[1,12] are particularly relevant to the current study as they relate to milk samples taken from farms on the Rhine delta which are subject to flooding. It is clear from an inspection of the data that the mean total TEQ value reported by Hendriks[1] (4.1 ngTEQ/kg fat) is in good agreement with data from the present study.

A summary of SWHO-TEQ and SICES 7 PCB data ordered by river system is given in Table 2. There are distinct differences between the three river systems for both SWHO-TEQ as well as S ICES 7 PCB concentrations. Altogether, the general trends for WHO-TEQs and SICES7 PCB concentrations appear very similar. Mean values for flood prone farms in particular show a gradient increasing consistently on going from the rural Dee to the more urban/industrial Trent and Doe Lea/Rother/Don systems (Figure 1), a pattern that was anticipated in the experimental design. Table 2 also shows a general trend for flood prone farms on the urban/industrial rivers to have higher values than control locations, a feature that is not observed for the rural Dee.

Table 2. PCDD/Fs and PCBs in milk - Summary of mean values by River System.

Parameter →	ΣPCDD/F-TEQ µg/kg	Σnon-*ortho*-PCB TEQ µg/kg	Σ*ortho*-PCBs TEQ µg/kg	Total ΣWHO-TEQ µg/kg	ΣICES7 PCBs µg/kg
Dee Control Farms (n=6)					
Range	0.9 – 4.2	0.2 – 0.9	0.2 – 1.2	1.3 – 4.9	1.5 – 17
Mean	1.72	0.41	0.46	2.58	4.62
Dee Flood Prone Farms (n=5)					
Range	0.6 – 1.2	0.3 - 0.8	0.2 – 0.4	1.3 – 1.9	2.0 – 5.3
Mean	0.93	0.5	0.25	1.68	3.15
Trent Control Farms (n=8)					
Range	1.0 – 3.5	0.2 – 1.8	0.2 – 0.4	1.5 – 4.3	1.1 – 6.3
Mean	1.61	0.78	0.31	2.69	3.30
Trent Flood Prone Farms (n=7)					
Range	1.1 – 8.1	0.4 – 3.8	0.2 – 0.9	1.7 – 13	1.9 – 26
Mean	2.85	1.35	0.36	4.56	6.24
Doe Lea/Rother/Don Control Farms (n=5)					
Range	0.7 – 4.5	0.8 – 3.2	0.3 - 0.6	2.0 – 7.0	2.8 – 8.6
Mean	2.07	1.68	0.43	4.18	5.52
Doe Lea/Rother/Don Flood Prone Farms (n=6)					
Range	1.7 – 10	0.9 – 4.4	0.2 – 1.0	2.9 – 14	3.3 – 13
Mean	3.56	2.09	0.46	6.11	6.87

These findings were confirmed by undertaking statistical tests on the WHO-TEQ and SICES7 PCB concentrations for matched pairs of control and flood-prone farms. The results of applying the Wilcoxen matched-pairs signed-ranks test[11] to the WHO-TEQ and SICES7 PCB data over both sampling periods showed significantly higher concentrations for flood prone farms than control sites. However the tests indicated no sufficiently consistent increase or decrease over the two sampling periods of October 1998 and March 1999. This may be due to the fact that during the winter months the cattle would mainly be housed indoors, unexposed to pastureland. Analysis of the samples collected in August 1999 would help clarify any effects of periodic flooding, but the differences between levels from different farm types suggest that if the observed levels are a result of flooding then the effect may be cumulative rather than the impact of individual incidents.

Conclusions

- The comparison of data from paired flooded and control farms indicates significantly higher dioxin and PCB SWHO-TEQ and SICES7 PCB concentrations in milk samples from flood prone locations than control sites.
- Mean SWHO-TEQ and SICES7 PCB concentrations for flood-prone farms on the Doe Lea/ Rother/Don and Trent are approximately twice those found on the Dee. These differences accord with

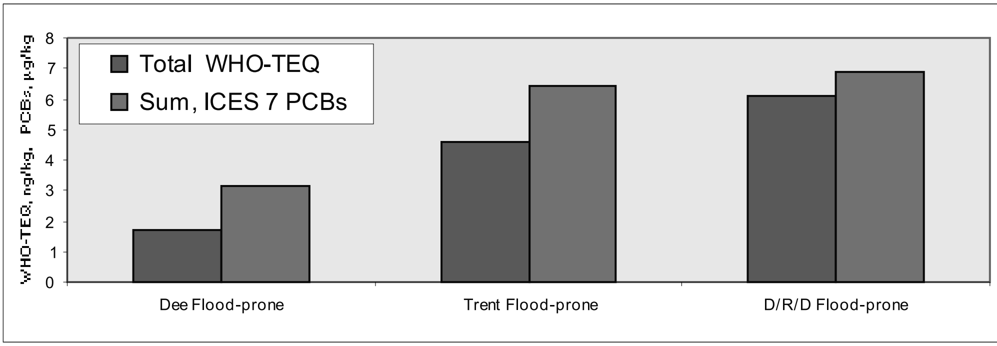

Figure 1. Average contaminant levels (by fat weight) for flood-prone farms

prior expectations, given the relatively rural course of the Dee compared to the urban/industrial areas that other two rivers flow through.

Interpretation in terms of more specific seasonal/periodic variations will be considerably aided when data for the third sampling period becomes available. Additionally, the collection of data on samples of milk for this period as well as analysis of sediments, grass and feed from the farms is necessary to investigate the correlation between analyte levels in these media and the milk samples already studied. In this context, it is hoped that these studies can make a significant contribution to the understanding of the environmental pathways that lead to the translocation of these and other similar contaminants to food for animal and human consumption.

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