PCB and PCDD/DF concentrations in fruit and vegetable samples from urban and rural areas in Wales and England.

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1. Introduction

One of the most intensive investigations of environmental concentrations of PCBs and PCDD/DFs ever undertaken in the United Kingdom has focused on the Panteg district of south Wales[1]. The survey, begun in 1991, was primarily initiated as a result of public concern over the operations of a chemical waste incinerator, located to the south of the town of Pontypool and owned by Rechem International Ltd[2]. Details of the plant and its environs, together with information on industrial activities of the area, both past and present, have been previously described[3].

Results from the main investigation clearly indicated that the operations of the incinerator had resulted in elevated PCB and PCDD/DF soil and air concentrations in a strip of land some 200 metres wide around the eastern boundary of the plant. The data also implied that this contamination originated from one or more common sources and suggested that fugitive rather than stack gas emissions were responsible for the elevated soil and air concentrations observed in the vicinity of the plant[1,4].

In the light of these findings, concern was expressed that fruit and vegetables grown in the residential areas closest to the incinerator might also be contaminated by PCBs and PCDD/DFs[1]. A further study was therefore undertaken to provide data on the levels of PCBs and PCDD/DFs in local produce.

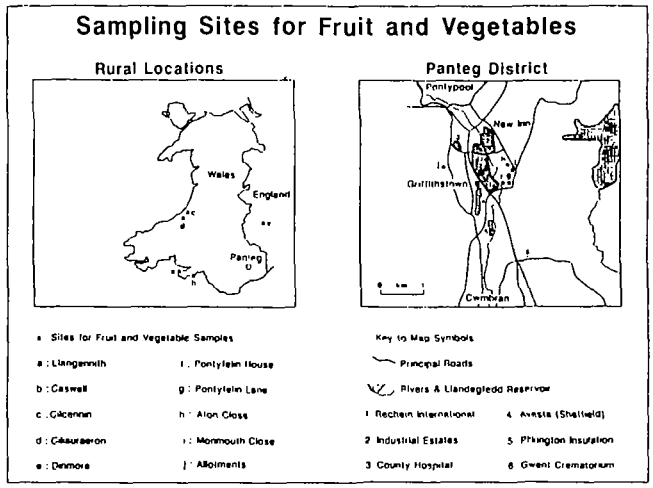
PCB and PCDD/DF foodstuff monitoring programmes have, to date, focused mainly on fatty foods such as dairy products, fish and meat. Relatively few studies have investigated the levels of these contaminants in fruit and vegetables. Of those that have, most of the data relate to composite samples obtained from retail outlets. In such cases, PCB and PCDD/DF concentrations cannot be easily attributed to a particular type of fruit or vegetable, or correlated with specific environmental conditions.

Implementation of the present survey however, involved the determination of both PCBs and PCDD/DFs in fruit and vegetable samples from precisely known urban and rural locations. The resulting data set is, to our knowledge, unique in the literature.

The purpose of this paper is to compare PCB and PCDD/DF concentrations in fruit and vegetables from urban areas with those from rural locations, and thus to assess the implications for human exposure resulting from the consumption of such locally grown produce. All concentrations presented or referred to in this paper are quoted on a fresh mass basis.

2. Methods

Samples of fruit and vegetables (apples, courgettes, lettuces and potatoes) were collected between 7-9 September 1993 from five small-holdings and gardens in the Panteg district and from five similar sources in three rural areas, namely the Gower peninsula (south Wales),Ceredigion district (mid-Wales),and south Herefordshire. The sampling sites in Panteg district were all within a radius of 1.5 km of the Rechem incinerator. The rural sites were in areas devoted to arable farming or fruit and vegetable production. Locations of the sampling sites are shown below:



Sample preparation was carried out centrally at the University of East Anglia using standard procedures. Representative sub-samples, each typically containing at least three individual fruit or vegetables, were distributed to the three laboratories involved in the analysis programme. Samples were analysed for PCB congeners (IUPAC No): 77,81,126,169 (non-ortho);105,114, 118, 123 156, 157, 167, 189 (mono-ortho); 28, 52, 101, 138, 153, 180 (di-ortho); and the seventeen 2,3,7,8-substituted PCDD/DFs.

The performance of each participating laboratory was assessed using an extensive inter-laboratory quality control programme, involving the analysis of standard PCB and PCDD/DF solutions and fruit and vegetable homogenates. Each laboratory was also required to abide by the acceptance criteria and quality control procedures for PCDD/DFs[5] and to similar

standards for PCBs[1]. Full details of sample collection, preparation, and quality control procedures have been reported elsewhere[6].

Fruit and vegetable samples from a number of sites were analysed by more than one laboratory as an integral part of the monitoring programme. For PCBs, there were 30 samples of fresh produce from 22 locations, eight of which (26.7%) were duplicates. In the case of PCDD/DFs the degree of inter-laboratory overlap was less and, of a total of 25 samples processed, only three (12%) were duplicates.

PCB and PCDD/DF data from the individual laboratories were in generally good agreement, although comparison of results was somewhat restricted by the low levels of contaminants found, and variations in limits of detection between the laboratories. To illustrate the former point, 480 (88.9%) of the 540 (30 x 18) PCB congeners were recorded as below 0.1μg/Kg and 232 (54.6%) of 425 (2.5 x 17) PCDD/DF congeners were measured as lower than 0.1ng/Kg. It is also worth noting that congeners 28 and 52 in the PCB analyses were those which most consistently recorded concentrations above 0.1μg/Kg, while for PCDD/DFs it was the hepta and octa congeners that regularly exceeded 0.1ng/Kg. Wherever the concentration of an individual congener was below its respective limit of detection, the latter value was used to calculate the PCB and PCDD/DF concentrations reported in this paper. The levels quoted thus represent the maximum concentrations likely to be present in any particular sample.

3. Results

PCB and PCDD/DF concentrations in the different types of fruit and vegetables are summarised in Tables 1 and 2. Inspection of the data reveals a considerable degree of overlap in both the PCB and the PCDD/DF concentrations between the foodstuffs, and suggests that concentrations in produce such as apples and lettuces that are directly exposed to atmospheric deposition are not, in this case, obviously different to vegetables grown underground.

Table 1: Concentrations (μg/Kg) of PCB congeners in fruit and vegetable samples.

		Σ7 Congeners			Σ18 Congeners		
Fruit/Veg.	No of Samples	Minimum	Median	Maximum	Minimum	Median	Maximum
Apple	9	0.2	0.8	5.9	0.5	1.0	6.6
Courgette	5	0.5	1.3	2.5	0.8	1.5	2.7
Lettuce	9	0.1	0.7	2.0	0.1	1.7	2.3
Potato	7	0.2	0.6	1.1	0.5	1.2	1.8

Table 2: PCDD/DF concentrations (ng/Kg) in fruit and vegetable samples.

		I-TEQ			Total PCDD/DFs		
Fruit/Veg.	No of Samples	Minimum	Median	Maximum	Minimum	Median	Maximum
Apple	8	0.1	0.4	0.9	6	23	44
Courgette	5	0.1	0.3	0.6	5	9	25
Lettuce	5	0.1	0.3	0.3	7	10	17
Potato	7	0.2	0.3	0.5	2	11	25

A comparison of the sum of seven PCB congener concentrations in apples, lettuce and potatoes from urban locations with similar produce from rural sites is given in Table 3. The limited number of samples available at the time of collection precludes a similar comparison for courgettes. The data are presented in the form of stem-and-leaf displays which show the distribution of values in a similar manner to histograms. However, the individual digits of each value are used to construct the display, so the actual concentrations recorded can be readily identified.

Table 3: Stem-and-leaf displays of sum of seven PCB congener concentrations in apple, lettuce and potato samples from urban and rural sites.

Apple		Lettuce		Potato	
Rural	Panteg	Rural	Panteg	Rural	Panteg
0 23478	0 8	0 117	0 227	0 2446	0 67
1 1	1	1 11	1	1 1	
	2 9		2 0		
	3				
	4				
	5 9				

Note: Stem values represent 1μg/Kg, leaf values represent 0.1μg/Kg. The concentrations in apple samples from rural samples are thus 0.2, 0.3, 0.4, 0.7, 0.8 and 1.1μg/Kg.

Table 3 indicates that there was considerable overlap in the PCB concentrations found at urban and rural sites. There were some higher levels in apple and lettuce samples from the Panteg district but, when Mann-Whitney U tests were conducted, no significant differences were found between urban and rural sites at the 95% confidence level. Similar results were also obtained when sums of eighteen PCB congeners were analysed.

Stem-and-leaf displays for total PCDD/DF concentrations are shown in Table 4. Again, substantial overlap between urban and rural sites is evident and no significant differences were found when Mann-Whitney U tests were conducted. Similar trends were also apparent when I-TEQs were examined.

Table 4: Stem-and-leaf displays of total PCDD/DF concentrations in apple, lettuce and potato samples from urban and rural sites.

Apple		Lettuce		Potato	
Rural	Panteg	Rural	Panteg	Rural	Panteg
0 7	0 6	0 79	0	0 277	0 7
1 1	1	1 7	1 00	1 1	2 5
2 15	2 6			2 0	
3	3				
4 4	4 2				

Note: Stem values represent 10ng/Kg, leaf values represent 1ng/Kg. The concentrations in apple samples from rural samples are thus 7, 11, 21, 25 and 44ng/Kg total PCDD/DFs.

4. Discussion

The few previously reported total PCB concentrations in fruit and vegetables suggest that levels are usually below 10 ug/Kg[8,9]. Similar concentrations were obtained in this study. Of the 30 samples analysed, only one had a total PCB concentration in excess of 10 ug/Kg. Median total PCB concentrations for apples, courgettes, lettuce and potatoes were 2.6, 4.3, 2.3 and 2.0 ug/Kg respectively.

PCDD/DF concentrations in fruit and vegetables found in this study ranged from 0.1-0.9 ng TEQ/Kg and from 2.3-44 ng/Kg total PCDD/DF. By comparison, levels reported in existing literature[10,11] are generally somewhat lower, with I-TEQ values usually being below 0.1 ng/Kg and total PCDD/DF values falling in the range 1.0-8.0 ng/Kg. It is worth stressing however, that many of the data in the literature relate to samples obtained from retail outlets that have been subsequently blended into composites and, in some cases, cooked prior to analysis. It is quite conceivable that such additional handling and preparative processes could result in some loss of PCDD/DFs compared to the fresh samples examined in the present study, which were analysed immediately after harvesting.

Owing to the relatively low lipid content of fruit and vegetables and the consequently reduced opportunities for bioaccumulation of PCBs and PCDD/DFs, relatively little attention has been paid, to the level of human exposure to these contaminants from such sources. However, even if absolute concentrations are comparatively low, commonly consumed foods such as apples, potatoes and green vegetables, may still make a substantial contribution to the overall dietary intake of PCBs and PCDD/DFs[10].

The purpose of the final part of this discussion is to consider if, and to what extent, consumption of fruit and vegetables grown in urban locations near the incinerator could result in the residents of the area being exposed to higher levels of PCBs and PCDD/DFs than consumers of similar locally grown produce from rural sites.

Using mean consumption values of apples, lettuce and potatoes of 0.032, 0.0058, and 0.151 Kg/person/day[10,12], and the maximum PCB concentrations from Table 3, the local dietary intake from such sources would be 0.31ug/day for the Panteg district and 0.22ug/day for the rural sites, a difference in the sum of seven congeners of 0.09ug/day. Employing a conversion factor between the sum of seven congeners and total PCBs of 3.3, this is equivalent to a total PCB intake of 1.02 and 0.73ug/day respectively with a difference of total PCB intake of 0.3ug/day. This additional amount represents 3% of the normal dietary intake of PCBs, if the latter is taken as 10ug/day.

Similar calculations for PCDD/DFs based on the data in Table 4 and I-TEQ values, puts the potential increased intake of PCDD/DFs for the Panteg area compared to rural locations, at 10pgTEQ/day, equivalent to about 8% of the estimated average UK intake of 125pg TEQ/day[10].

5. Conclusions

This study demonstrates that PCB and PCDD/DF levels in locally grown fruit and vegetables were low and generally in accord with previous data. Concentrations of such contaminants in

samples exposed to atmospheric deposition were not significantly different to root crops. No statistically significant differences in concentrations between produce grown locally in the residential areas of Panteg district and that from rural sites were found. It should be recognised, however, that the small number of samples involved in some comparisons mitigates against detecting statistically significant differences. Any potentially increased intake of PCBs and PCDD/DFs resulting from the ingestion of apples, lettuce and potatoes was considered unlikely to exceed 3% and 8% of the respective average daily intakes of these contaminants from all food sources.

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