

PCDD/F CONTAMINATION OF THE ENVIRONMENT AT BOLSOVER, U.K.

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Abstract

This paper provides a brief historical context to a "case study" of PCDD/F contamination at Bolsover in the U.K. Several Government agencies, organisations and institutions have been involved in an investigation of PCDD/F contamination in the area and their involvement is briefly described. There is an opportunity to obtain field-based data on PCDD/F persistence in soils.

The study area and PCDD/F monitoring.

The town of Bolsover is situated in Derbyshire, central England. Historically it has been the hub of the North Derbyshire coalfield having many industries in support of, and consequential to its mining past, which include coke manufacture and allied chemical works. The Coalite Chemicals plant, which has been at the centre of this case study, uses coal oil/tar residues formed as by-products from the carbonisation process operated on the adjoining site of its sister company, Coalite Fuels Division.

Since 1991 Bolsover has been the focus of considerable media attention following the discovery of high concentrations of PCDD/Fs in cow's milk and subsequently in soil, herbage, river sediment and animal tissue. However, this is not the first time the area has been associated with dioxins. In 1968 there was an explosion at the Coalite Chemicals factory during the manufacture of 2,4,5-trichlorophenol which released PCDD/Fs. Seventy nine of the exposed workers subsequently exhibited chloracne¹. In addition, further concerns were expressed about potential emissions following a warehouse fire involving PCDD/F precursors in 1986, although from samples analysed at the time, these fears appear to have been largely unfounded.

During 1990 and 1991, as part of a national study into PCDD/F intake in the U.K. diet, the Ministry of Agriculture Fisheries and Food (MAFF) analysed milk from 27 farms in North Derbyshire for PCDD/Fs. Milk from two of the farms near Bolsover was found to have concentrations of PCDD/Fs at 1.8 ng TEQ kg⁻¹, over ten times above the mean concentration of milk from industrial/urban areas (0.12 ng TEQ kg⁻¹ whole product) in Autumn 1990 and Spring 1991. The U.K. threshold concentration for PCDD/Fs in milk is

0.7 ng TEQ kg⁻¹)². Milk from a third farm (used for a suckler herd) was later found to contain 3.4 ng TEQ kg⁻¹ ³ which is believed to be one of the highest recorded concentrations of PCDD/F in milk world-wide. Once discovered, MAFF prohibited the milk from entering the food chain and restricted the movement of livestock from the farm having the highest concentrations of PCDD/Fs in milk and animal tissue.⁴

MAFF also analysed samples of soil and herbage from the affected farms. It was found that most soils had elevated concentrations of selected PCDD/Fs. Concentrations of PCDD/F in the most contaminated of the soils analysed from the Bolsover area were as follows (in ng kg⁻¹ dry weight):- 2,3,7,8-TCDD - 73; total TCDD - 3,750; total PeCDD - 2950; total TEQ - 90 ⁵ A survey of background PCDD/F concentrations in U.K. soils in 1989 reported concentrations of (ng kg⁻¹ dry weight) 2,3,7,8-TCDD - <0.5; total TCDD - 9.4; total PeCDD - 6.6 ⁶ and total TEQ - 6.2 ⁵. The Bolsover soil samples, though not necessarily unique in the U.K. in terms of their TEQ value⁷, were unusual in containing high concentrations of specific congeners and homologues.

The analysis of herbage samples exhibited similar congener profiles. Typically, vegetation at rural U.K. sites has total TCDD homologue concentrations of 7.7 ng kg⁻¹ (dry weight) ⁸. A thistle from one of the affected farms was found to have a total TCDD concentration of 7140 ng kg⁻¹ and grass samples from several fields in the vicinity contained total TCDD concentrations in the range 4000-5000 ng kg⁻¹. As with the soils, 2,3,7,8-TCDD concentrations were comparatively low, typically <7 ng kg⁻¹.⁸

The milk, soil and herbage samples suggested an apparent focus of contamination in the vicinity of both the chemical works and the adjacent carbonisation plant.

Following the discovery of the contamination on the farms, other regulatory agencies began the search for possible sources. Her Majesty's Inspectorate of Pollution (HMIP), responsible for regulating air pollution from both of these plants, monitored emissions from the waste-heat boiler and smoke abatement chimney at the carbonisation plant and from the waste chemicals incinerator (used for the destruction of chlorophenol waste) at the Coalite Chemicals plant. These results are summarised in Table 1. Although the current U.K. and E.U. limit for emissions of PCDD/Fs from new incineration plant is 1.0 ng TEQ m⁻³ with an aim to achieve 0.1 ng TEQ m⁻³, it should be stressed that the incinerator was not in breach of any emission limits in force at that time. Examining the data in Table 1, there is a similarity between the environmental samples and the emissions from the incinerator in that the total TCDD, TCDF and PeCDD homologue concentrations were high in comparison to their respective 2,3,7,8 congeners.

	Smoke Abatement Stack		Waste-Heat Boiler Chimney		Chemical Waste Incinerator-gas		Chemical Waste Incinerator-particulates	
	run 1	run 2	run 1	run 2	run 1	run 2	run 1	run 2
2,3,7,8-TCDD	0.05	<0.01	0.01	<0.01	77	32	35	0.57
Total TCDD	315	7.7	25	3.4	15,000	3,500	3,600	135
1,2,3,7,8-PeCDD	0.11	0.06	0.01	0.04	0.94	0.32	1.2	0.08
Total PeCDD	130	3.5	2.7	0.6	540	1,900	780	117
2,3,7,8-TCDF	0.14	0.05	0.04	1	97	37	2.2	0.25
Total TCDF	19	0.96	2.4	1.8	5,400	2,100	300	40
TEQ	0.15	0.08	0.03	1.21	88.3	36	36.6	0.76

Table 1. Selected PCDD/F concentrations in emissions (concentrations in ng m⁻³)⁹

It should be emphasised that the authors of that report acknowledge that there may be some uncertainties with these results, particularly in respect to discharges over a long period of time, due to only having made two measurements from each emission source.

Analysis of the incinerator feedstock undertaken by HMIP confirmed that substantial quantities of PCDD/F were present in the waste⁹ which suggests that they were formed during manufacture of the chlorinated phenols. Consideration was also given to other potential sources of PCDD/Fs in the area. The M1 motorway, which runs through the affected area, and the high use of coal on open domestic grates (prevalent at the time) can be dismissed as being insignificant having regard to the extent of the contamination found.

Following these findings the Minister for the Environment announced in Parliament in November 1991 that the current emissions from the Coalite incinerator would only account for part of the PCDD/Fs found in the milk and that the company had volunteered to close the incinerator at the end of that month¹⁰. The incinerator has not operated since November 1991.

Further studies undertaken by MAFF since 1991 have shown a dramatic reduction in the TEQ concentrations of PCDD/Fs in milk from the two dairy farms involved, such that they are now typical of urban milk samples^{2,5,8,11} and thus the restrictions on the milk and meat have now been removed.

Whilst HMIP were investigating gaseous emissions from the Coalite works, the National Rivers Authority (NRA) began monitoring for PCDD/Fs in the river Doe Lea which flows through the works and receives liquid effluent from the company's biological effluent treatment plant. Scrubber liquor bleed-off from the incinerator was discharged into the common effluent treatment plant at a rate of 202 ng TEQ s⁻¹⁹ and subsequently discharged, after treatment, into the river.

The NRA found that PCDD/F concentrations in the river sediment (although sparse in nature) were amongst the highest ever reported. It was found that the river sediment contained 2x10⁷ ng kg⁻¹ (dry weight) total PCDD/F (4.5x10⁴ ng TEQ kg⁻¹) downstream of the company's effluent outfall, compared to 2x10³ ng kg⁻¹ total PCDD/F (9 ng TEQ kg⁻¹) upstream¹². PCDD/Fs have been detected at concentrations in the order of 10⁵ ng kg⁻¹ total PCDD/F up to 15 km downstream of Bolsover¹². Again, an interesting feature of the congener profile was the virtual absence of the 2,3,7,8-TCDD congener and the very high concentration of the total TCDD homologue group.

During the four years since the discovery of the PCDD/Fs in milk there has been great concern within the community living in close proximity to the centre of contamination (the nearest dwelling, one of the affected farms, is within 100m and the village of Shuttlewood is within 1km). Many environmental pressure groups have emerged in response to the controversy and criticism has been levelled not only at the suspected source but also at the regulatory agencies.¹³

The North Derbyshire Health Authority have undertaken several epidemiological studies of the residents of the affected area and have concluded that there is no evidence of any abnormal incidence of ill-health in the community^{14,15,16}. Exposure of the general public to

PCDD/Fs is likely to have been low; PCDD/Fs in air and soil are a minor route of exposure in comparison to the food chain¹⁷ and PCDD/Fs in milk on sale locally were found to be at normal background concentrations². Certain members of the families living on the affected farms have been identified as having elevated blood PCDD/F levels from the consumption of their own milk produce, in one case by a factor of 7 above typical concentrations.¹⁸

Recently, reports have emerged on the occupational health aspects of the workforce at the chemical works. A recent study by the Health and Safety Executive found no convincing evidence of an increased mortality risk to workers employed during the period when 2,4,5-TCP was produced at the Coalite plant¹⁹. It has also been reported that in a study of nine workers at the plant, some have elevated blood PCDD/F concentrations, in one case up to 25 times the norm in terms of the TEQ value and 250 times the norm for the 2,3,7,8-TCDD congener²⁰. More recently, work reported from Liverpool University has indicated that blood from some workers at the plant had reduced testosterone and immunoglobulin levels although the researchers acknowledge their work has to undergo the process of a peer review and has yet to be published in the scientific journals²¹.

Conclusion

The rapid drop in milk PCDD/F concentrations to near background levels and their presence in high concentrations on annual and grazed vegetation are indicative of contamination from aerial deposition of fairly recent origin rather than being attributable to the events of, for example, 1968 and 1986.

The contamination of virtually all environmental compartments in the Bolsover area has seen one of the most intensive monitoring exercises for the presence of PCDD/Fs ever undertaken in one locality. Whilst the input of PCDD/Fs into the environment appears to have largely ceased, existing contamination will remain for many years. The soil and river sediment, recognised to be the most important matrices in storing PCDD/Fs, will provide an unprecedented opportunity for long-term field experiments into the environmental fate, persistence and behaviour of these compounds.

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