PCDD/F levels in soil used for urban agriculture in a post industrial city

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Introduction

Urban agriculture can be defined as the production of food and fuel directly for the urban market within or surrounding the boundaries of cities. Urban food growth is central to the existence of many cities around the world[1]. Within urban areas in the UK 'allotment sites' are the oldest and most important public resource dedicated to urban agriculture[2]. Gardeners can grow vegetables and fruit on an individual plot and, on some sites, rear poultry. Allotment gardening is viewed as a health promoting activity through improvements in diet, exercise and mental health[2].

In 1999, allotment gardeners in Newcastle raised concerns after a mixture of bottom- and fly-ash from a refuse derived fuel (RDF) incinerator was applied to local allotment footpaths. These concerns prompted investigations into the levels and homologue profiles of PCDD/F in allotment footpaths and subsequently studies concerning the transfer of PCDD/F to soil, eggs and vegetables[3-5]. The results of these studies have been used to inform the Contaminated Land Strategy at Newcastle City Council required under Part IIA of the UK Environmental Protection Act 1990. A program of human health risk assessments is being undertaken for those allotment sites found to have elevated levels of soil PCDD/F and heavy metals in preliminary studies.

This paper reports findings for soil PCDD/F from the series of investigations so far and discusses the difficulties involved with undertaking robust human health risk assessments on such sites. We present a dataset collected from seven allotment sites from different areas of Newcastle, the characteristics of which are summarised in Table 1.

Table 1: Description of allotment sites.

Site	Ash (tons)	Number of plots	Plot Type
Branxton B	30[a]	13	Vegetable and Poultry
Branxton A		10	Vegetable and Poultry
St Anthony's	10	65	Vegetable and Poultry
Blucher	10	20	Vegetable and Poultry
Westmacott	100	72	Vegetable and Poultry
Fenham Model	150	40	Vegetable
Little Moor	50	144	Vegetable

[a]Ash distributed between Branxton A and Branxton B sites

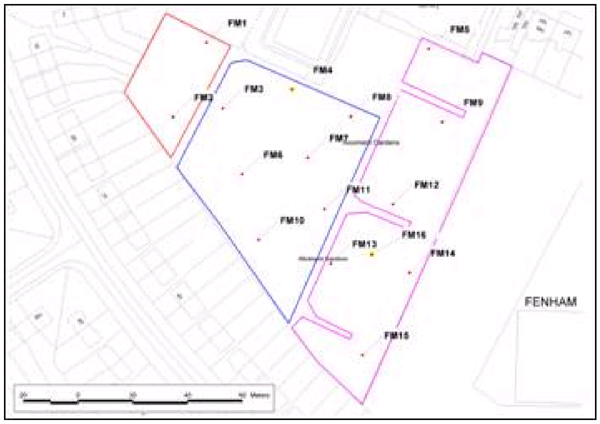
Methods and Materials

Desk top study: The GIS package Arcview 3.1 was used to view and reproduce historic maps for each site for the epochs 1856-1895, 1895-1898, 1916-1920, 1932-1942, 1952-1963, and 1965-1984. Information on the site geology, hydrogeology and hydrology was consulted. A site reconnaissance visit was carried out to establish present day land use and site conditions.

Intrusive Investigations: Systematic random sampling locations were located using the SPLUS spatial statistics and environmental statistics packages (e.g. Figure 1). The number of sampling locations was dependant on cost and the size of each site. In addition, further targeted sampling locations were taken if there was visual evidence of incinerator ash. In each plot, a composite sample of five sub-samples was taken to a depth of 0-30cm.

Sample analysis: Soil samples were analysed by Ergo Laboratories, Germany. Details of the analytical procedure have been outlined previously in Vizard et al[6]. The results were expressed as PCDD/F ng/kg I-TEQ and homologue profiles were produced for each sample.

Figure 1: Randomly selected sampling locations at Fenham Model allotment site.



Results and Discussion

There was considerable variation in the levels of PCDD/F which, over all sites, ranged from 2 to 292 ng/kg I-TEQ (Table 2). The toxic equivalents of soils sampled from Branxton B allotment site were highest (25 to 292 ng/kg I-TEQ, median 48 ng/kg I-TEQ). The lowest PCDD/F levels were recorded in soils from Little Moor allotment site (7 to 52 ng/kg I-TEQ and median 11 ng/kg I-TEQ). In some sites, PCDD/F levels were higher than UK urban background levels which have been reported to range between 4.9 to 87.3 ng/kg I-TEQ[7]. All allotment sites were within the range recorded in a study of PCDD/F levels in the vicinity of Byker incinerator (6 to 1911 ng/kg I-TEQ)[6]. Overall, levels were also similar to those recorded previously on allotment sites in Newcastle (5.5-272ng/kg I-TEQ)[3].

Land use surveys showed that six sites were used as allotment gardens between the years 1921-1936. Allotment gardening at Little Moor site started later between 1936 and 1950's. Only Blucher and Little Moor allotment sites, had former industrial uses, with Blucher being situated on a former colliery yard and Little Moor being the site of several former coal mining 'bell pits'. Five sites are situated in heavily populated areas with nearby main roads, with two, Westmacott and Blucher, being in more semi-rural environments.

Table 2: PCDD/F (ng/kg I-TEQ) in allotment soils.

Branxton B	Branxton A	St Anthony's	Blucher	West-macott	Fenham Model	Little Moor
292	185	121	66	57	89	52
239	148	46	39	37	38	21
190	92	44	38	34	36	18
99	82	42	34	34	28	17
80	58	42	32	25	26	17
50	57	36	32	25	26	13
47	45	35	26	23	18	12
44	45	34	26	23	18	12
38	41	31	18	18	16	12
34	38	28	16	17	13	12
25	36	25	12	13	13	11
25	36	23	11	12	12	11
	33	22	9	10	12	10
		21		10	11	10
		19		9	9	9
		17		5	8	9
		15				8
		2				8
						8
						7

	Branxton B	Branxton A	St Anthony's	Blucher	West-macott	Fenham Model	Little Moor
N	**12**	**13**	**18**	**13**	**16**	**16**	**20**
Median	**48**	**45**	**30**	**26**	**21**	**17**	**11**
Min	**25**	**33**	**2**	**9**	**5**	**8**	**7**
Max	**292**	**185**	**121**	**66**	**57**	**89**	**52**

The results show that soil PCDD/F concentrations at each site can be accounted for, in part, by previous industrial land-use and location within an urban environment. The considerable variability between plots within each site can be accounted for by other human activities.

One such activity known to have taken place at each site is the amendment of footpaths with incinerator ash. At the outset of the investigations, this was anticipated to be the main source of soil PCDD/F contamination on the sites in Newcastle. However, only seven of samples overall were identified as exhibiting an incineration homologue profile typical of the waste combustion process at the RDF incinerator plant. This suggested that there was a wide range of other sources that potentially contributed to the soil PCDD/F load on these allotment sites.

This, to an extent, is likely to be attributable to the activities of individual allotment gardeners. Our findings agree with a recent review by Alloway (2004) which lists potentially PCDD/F contaminating activities on allotments sites as the use of pesticides, wood preservatives, composts, waste dumping and the burning of wastes on bonfires by individual allotment gardeners[8].

There are a number of implications of these findings for human health risk assessments of such sites. Any prediction of PCDD/F contamination across the whole site from information collected from randomly selected plots is inherently problematic. This is in part due to elevated levels in allotment gardens, in line with their urban locations, and the wide range of potential contaminant sources an allotment gardener can introduce to an individual allotment plot. Ideally, sampling should take place on a plot by plot basis to account for the inter-plot variability. However, there are considerable cost implications for local authorities associated with such extensive sampling policies, which could result in fewer allotment sites being investigated.

References

1. Ellis F. and Sunberg J. (1998) *World Development*. 26(2):213-255.

2. Howe J. and Wheeler P. (1999) *Sustainable Development*. 7:13-24.

3. Pless-Mulloli T., Edwards R., Paepke O. and Schilling B. (2000) *Report on the analysis of PCCD/PCDF and heavy metals in footpaths and soil samples related to the Byker incinerator,* University of Newcastle, Newcastle upon Tyne, UK.

4. Pless-Mulloli T., Paepke O. and Schilling B. (2001) *PCDD/PCDF and heavy metals in vegetable samples from Newcastle allotments: assessment of the role of ash from the Byker incinerator*, University of Newcastle, Newcastle upon Tyne, UK.

5. Pless-Mulloli T., Edwards R., Paepke O. and Schilling B. (2001) *Full technical report. PCDD/PCDF and heavy metals in soil and egg samples taken from Newcastle allotments: assessment of the role of the Byker incinerator,* University of Newcastle, Newcastle upon Tyne, UK.

6. Vizard C., Pless-Mulloli T., Rimmer D L., Singleton I., Paepke O., Schilling B. and Air V. (2003) *Soil contamination with PCDD/F and heavy metals in the vicinity of the Byker incinerator in Newcastle*, University of Newcastle, Newcastle upon Tyne, UK.

7. HMIP (1995) *Determination of polychlorinated biphenyls, polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans in UK soils*, HMIP, London, UK.

8. Alloway B J. (2004) *Land Contamination and Reclamation*. 12(3):179-187.