EXECUTIVE SUMMARY PCCD/PCDF AND HEAVY METALS IN SOIL AND EGG SAMPLES FROM NEWCASTLE ALLOTMENTS:

Assessment of the role of ash from the Byker incinerator

(Includes comments from Food Standards Agency, Environment Agency)

EXECUTIVE SUMMARY

REPORT ON THE ANALYSIS OF PCCD/PCDF AND HEAVY METALS IN SOIL AND EGG SAMPLES FROM NEWCASTLE ALLOTMENTS

UNIVERSITY OF NEWCASTLE

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CONTENT

Acknowledgements:

We wish to gratefully acknowledge the help received from Terry Harnen of Newcastle Cityworks during the soil sampling. We are also grateful to Doug Fox and Heather Lamb of Newcastle City Council who collected and documented the egg sampling and to all allotment gardeners who donated their produce for the investigation. Members of the Byker ash steering group provided valuable comments on a previous confidential draft of this document.

FOREWORD FROM THE BYKER ASH STEERING GROUP

This executive summary document outlines the results of an independent investigation into levels of dioxins and heavy metals in samples of soil and eggs from allotments across Newcastle where ash from the Byker Incinerator/Heat Station had been used on footpaths. It includes a commentary from the Environment Agency and Food Standards Agency.

It is expected that the full technical report on the soil and egg samples will be available during February 2001. In the meantime, this executive summary will be shared with allotment gardeners who will be given the opportunity to hear about how these particular results relate to their allotments and to ask any questions they may have.

This executive summary does not seek to be the final answer to public concerns over the use of ash from the incinerator but it provides more information to help us ascertain whether or not there has been any risk to health.

The testing of soil, eggs and vegetables was instigated following the publication last summer of the **Report on the Analysis of PCCD/PCDF and Heavy Metals in Footpaths and Soil Samples Related to the Byker Incinerator.** This independent report, produced by the University of Newcastle upon Tyne showed raised levels of dioxins and some heavy metals in **ash samples** taken from allotment footpaths at a number of locations across the city.

As a response to that report, the Director of Public Health for Newcastle and North Tyneside Health Authority and the Head of Public Health and Environmental Protection for Newcastle City Council issued the following precautionary advice:

- **Children aged two and under should not play in the named allotments in order to avoid contact with the ash.**
- **Eggs and poultry and other animal produce from the named allotments should not be consumed until further notice.**
- **All produce from the named allotments should be thoroughly washed and root vegetables should be peeled before eating.**

At that time it was not possible to say if there had been any risk to public health as a result of the raised levels of dioxins and heavy metals and so Newcastle City Council agreed to a further investigation to examine levels in soil, eggs and vegetables. **The vegetable testing is ongoing and the precautionary advice will remain in place until these results are known.** These are expected in the next few months when a final report will be produced.

Other action at the time included the removal of ash from allotment footpaths and the establishment of a steering group representing the various groups with an interest in this matter.

The group – **Steering Group for Further Investigations in Relation to Ash from the Byker Incinerator/Heat Station -** includes representatives from the

Health Authority, City Council, Byker and Newcastle Waste Group, allotment gardeners, Environment Agency and the University of Newcastle. Their meetings over recent months have often been robust, with divergent opinions expressed and minuted.

In November, with invited experts, they discussed the results of analysis of soil and eggs. They agreed that the commentary from national experts should be included alongside the results of the investigations on soil and eggs and were unanimous in supporting the publication of this full and unamended report. However, individuals and agencies do not necessarily agree with the opinions expressed in different sections of the report.

Pending the results from the vegetable analyses, Newcastle City Council has proposed specific action in relation to poultry kept on allotments that received ash. It is also undertaking further detailed work with the Environment Agency in relation to the possible need for remediation of some allotment sites. Newcastle City Council's actions to date and planned actions are described in section four.

MEMBERS OF BYKER ASH STEERING GROUP

(in alphabetical order)

Val Barton	Allotment gardener and BAN Waste
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SECTION ONE:

UNIVERSITY OF NEWCASTLE

EXECUTIVE SUMMARY: NEWCASTLE UNIVERSITY

REPORT ON THE ANALYSIS OF PCCD/PCDF AND HEAVY METALS IN SOIL AND EGG SAMPLES FROM NEWCASTLE ALLOTMENTS

Assessment of the role of ash from the Byker incinerator

BACKGROUND AND AIMS

In May 2000 the University of Newcastle reported on the investigation into the contamination of footpaths by ash from the Byker incinerator. [1, 2] It contained data of 24 samples taken from 19 allotments, which had received ash from the Byker incinerator. The samples had been analysed for their concentrations of heavy metals and dioxins/furans (PCDD/PCDF). Twenty of these samples had been from footpaths, 16 from allotments, which had received ash (a combination of fly ash and bottom ash), two were from control allotments, and four were from an allotment in the vicinity of the incinerator.

Copper, lead and zinc were found to be major contaminants in the large majority of ash samples. Levels of heavy metals were in the order of magnitude that could be expected in slag (bottom ash) from municipal waste incinerators. 13 out of 16 ash samples showed a characteristic pattern of simultaneous elevated levels of copper, lead and zinc. A massive contamination of ash with dioxins/furans in a large majority of Byker ash samples was also reported. The median of 16 ash samples was 918 ng/kg I-TEQ, values ranged between 11 and 4224 ng/kg. Contamination with PCDD/PCDF was in the order of magnitude that would be expected in fly ash from municipal waste incinerators. A characteristic zigzag shaped pattern of the sums of dioxins and furans was found in 14 out of 16 samples, which had received Byker ash. The Byker ash pattern of PCDD/PCDF contamination contrasts for example with a bell shaped deposition pattern characteristic of deposition from industrial processes such as incinerator emissions.

One of the conclusions of the report was that the contamination of ash samples especially with lead and dioxins/furans required further risk assessment. The report recommended that the likelihood of transfer into soil, animals and vegetables should be assessed in Byker ash allotments.

The present executive summary covers the analysis of soil and of egg samples.

The aims of the investigation were:

1. **To assess whether transfer of heavy metals and dioxins has occurred from ash on footpaths into adjacent soil in allotment gardens (ash to soil transfer)**

2. **To assess whether transfer of dioxins occurred from ash and soil into poultry in allotment gardens (ash/soil to poultry transfer)**

The objectives were to investigate the levels and pattern of contamination with heavy metals and PCDD/PCDF in soil and eggs. The hypothesis for soil was that if contamination had occurred as a result of the deposition of ash a) higher levels of contamination were to be expected closer to the footpaths compared to further away, and b) the pattern of contamination should be similar in ash and soil. The hypothesis for eggs was that if contamination had occurred as a result of the deposition of ash a) higher levels of contamination with PCDD/PCDF were expected in eggs, and b) the pattern of PCDD/PCDF contamination should be similar in ash and eggs.

The results of an investigation of transfer from ash and soil into vegetables will be reported later.

METHODS

Soil: Thirty-two allotments, which had received Byker ash on their footpaths, were included in the soil sampling plus 2 control allotments. In total there were 76 soil samples, 7 of which came from the parallel sampling program of the Environment Agency (19 out of 76 samples have heavy metal data only). 39 samples were from a distance of 30cm from ash paths, 37 samples were from a distance of 150cm from the ash paths. Each 30cm and 150cm pooled sample consisted of between two and nine individual samples, which were pooled to give a representative sample of the location. This sampling strategy allowed the cost to be limited. A sampling strategy covering all allotment areas in detail would have been extremely expensive. However, it needs to be pointed out that hot spots can not be ruled out on the basis of the analyses that were carried out. All soil samples were analysed for heavy metals. All 30cm soil samples were analysed for PCDD/PCDF. If the levels in the 30cm samples were above 40ng/kg I-TEQ the 150cm sample from that allotment was also analysed for PCDD/PCDF.

Eggs: Hen, bantam or duck eggs were provided from 9 allotments, hen eggs from 2 control sites were also included. Forty-four eggs were analysed, 36 in pooled samples of 2 or 3, 8 were single samples. The total number of egg samples was twenty-one.

Analysis: The levels of contamination with heavy metals and PCDD/PCDF were analysed by comparing the measured levels with levels previously reported in ash and by comparing levels in 30cm and 150cm samples. The levels of soil contamination were also compared with published guideline values (see appendix). In order to ascertain the likelihood of any contamination being caused by the deposition of ash patterns of contamination were compared between ash and soil and ash and eggs.

RESULTS AND RECOMMENDATIONS FOR FURTHER ACTION

The results for heavy metals and arsenic in soil are summarised in table 3 in the appendix. In total there were the following number of allotments were recommended for further sampling to assess the need for remediation: arsenic three, cadmium four, chromium none, copper nine, mercury six, nickel none, lead seventeen, zinc seventeen.

Number of allotments recommended for further sampling to assess need for remediation

Arsenic:	3	**Cadmium:**	4
Chromium:	none	**Copper:**	9
Mercury:	6	**Nickel:**	none
Lead:	18	**Zinc:**	17

Table 1 shows the descriptive statistics of ash and soil contamination and the trigger levels for further investigation from the Dutch list. (Detailed data for all individual allotments will be published in the full report, which will be available soon. Sheets with raw data for individual allotments are given to allotment holders today).

There was considerable contamination of soil samples with heavy metals in about half of all allotments sampled. Compared to levels in ash median levels of heavy metal contamination in soil were:

Slightly lower:	for Lead, Zinc and Nickel
Lower:	for Chromium
Much lower:	for Cadmium and Copper
Higher:	Arsenic and Mercury.

None of the soil samples showed the contamination pattern of elevated copper, lead and zinc found in the ash. No clear gradients were observed between 30cm and 150cm samples for any of the heavy metals. Overall, the evidence suggested that sources other than the deposition of Byker ash are likely to be the main source of contamination with heavy metals and arsenic in soil in Newcastle allotments.

Table 1 Descriptive statistics of ash and soil contamination with heavy metals [mg/kg]

	Arsenic	Cadmium	Chromium	Copper	Mercury	Nickel	Lead	Zinc
Dutch list	**20**	**1**	**100**	**50**	**0.5**	**50**	**50**	**200**
Median ash *	**15**	**5.9**	**104**	**610**	**0.20**	**62.0**	**579**	**676**
SOIL								
Minimum 30cm	8	0.3	20	42	0.11	19.6	127	115
Median 30cm	**16**	**1.0**	**35**	**80**	**0.53**	**43.6**	**436**	**375**
Maximum 30cm	53	2.2	72	325	1.37	50.4	2090	971
Minimum 150cm	8	0.3	26	20	0.15	19.7	134	124
Median 150cm	**16**	**0.8**	**37**	**81**	**0.60**	**32.2**	**407**	**418**
Maximum 150cm	53	2.3	82	158	1.99	77.3	1260	754

N for 30cm samples = 38, N for 150cm samples = 37, *Ash medians reported here include all samples measured in stage 1 by the ergo laboratory plus those analysed by aes laboratory. They are therefore slightly different from those medians reported in the stage 1 report, which onlyincluded the ergo results

KEY FINDINGS 1 AND 2: HEAVY METALS IN SOIL

- Considerable soil contamination with heavy metals and arsenic was found in more than half of the allotments in the sampling programme requiring detailed consideration of the necessity for remediation
- No clear link between soil contamination with heavy metals and the deposition of Byker ash was identified. It is likely that other sources than the deposition of ash from the Byker incinerator are the main source of contamination with heavy metals and arsenic

Table 2 shows a summary of the results on the contamination of soil with PCDD/PCDF. The four background samples had concentrations of PCDD/PCDF expected for urban background sites (12ng/kg I-TEQ), those samples with dominant Byker ash pattern in the soil sample had a level of contamination of 53ng/kg I-TEQ on average. A majority of samples from allotments, which had received ash from the Byker incinerator, showed an impact of Byker ash on the pattern of PCDD/PCDF contamination (18/32 allotments, 36/57 samples). However, the Byker influence was combined with evidence of contamination from other sources (compost, deposition) in more than half of those samples showing Byker influence. In eight allotments a gradient in levels between 30cm and 150cm samples indicated a possible influence from Byker ash on footpaths. However this could have happened by chance in some cases.

Table 2 Summary results for PCDD/PCDF in soil

	No.	**Mean I-TEQ in ng/kg**
• All samples	57	38
➔ **All allotments**	**34**	
➔ **Allotments** with Byker ash	**32**	
• 30cm samples	38	41
• 150cm samples	18	33
• Samples with dominant Byker pattern	15	**53**
➔ **Allotments** with dominant Byker pattern	**6**	
• Samples with dominant deposition pattern	4	17
• Control samples	4	**12**
• Samples with Byker plus other pattern	36	41
➔ **Allotments** with Byker plus other pattern	**18**	
• Samples without Byker pattern	18	33
➔ **Allotments** without Byker pattern	**12**	
• Samples above 40ng/kg I-TEQ	13	
		Name of allotments
➔ **Allotments** with at least one sample above 40ng/kg	**9**	**Blucher, Branxton A, Branxton B, Christen Road, Denton Dene, Fenham Nursery, Little Moor, Walkergate 3B, Westmacott Street**
➔ **Allotment** with evidence of gradient in contamination 30cm>150cm	8	**Branxton A, Branxton B, Christen Road, Denton Bank, Denton Dene, Fenham Nursery, Little Moor, Westmacott Street**
➔ **Allotments** with at least one sample near or above 100ng/kg	5	**Branxton A, Branxton B, Fenham Nursery, Little Moor, Walkergate 3B**

KEY FINDINGS 3, 4 AND 5: PCDD/PCDF IN SOIL

- PCDD/PCDF contamination of soil above 40ng/kg I-TEQ was evident in just over one in four of all allotments (9 out of 32), which is the level where avoidance of critical land-use and limitation of agricultural use (unlimited cultivation only of plants with minimum dioxin transfer) is recommended
- A link between contamination of soil with PCDD/PCDF and the deposition of Byker ash was evident in 18 out of 32 allotments
- Five allotments had PCDD/PCDF levels near or above 100ng/kg, which is the level where remediation in playgrounds is recommended in addition to the avoidance of critical land-use and restriction of agricultural use

Table 3 shows a summary of the results for PCDD/PCDF in eggs. Sixteen out of 21 egg samples showed levels of contamination well in excess of barn held supermarket eggs. [3] 17 out of 19 egg samples from allotments, which had received Byker ash showed an influence of ash in the pattern of contamination. There was a clear link between the use of ash within chicken pens (or direct access to ash) and the levels of contamination in eggs. This was evident from the weighted averages, which were higher for those eggs from hens which Byker pattern and direct access to ash (see table 3) and from further graphical analysis not shown here.

Table 3 Summary results for PCDD/PCDF in eggs

	No.	Weighted average I-TEQ in pg/g
• All samples	21	16.4
• Pooled samples (including 2 controls)	13	18.1
• Single egg samples	8	8.8
• Samples from allotments with Byker ash (pooled plus single)	19	17.7
• Samples of eggs with Byker pattern (pooled plus single)	17	22.2
• Samples from allotments with Byker ash where hens had direct access to ash	8	26.1
• Control sample from Hawthorn farm	1	0.2
• Barn held supermarket eggs [3]		<1

Table 4 shows the estimated impact of the consumption of Byker eggs. The impact on the daily intake of PCDD/PCDF was estimated assuming a contemporary background intake for the UK of 70pg ITEQ [3] as calculated by the Food Standards Agency. This is equivalent to a daily intake of 1.0pg/kg body weight ITEQ for a 70kg person (adult) or 2.0pg/kg body weight for a 35kg person (10-year-old child). This compares to a recommended daily intake of 1-4pg/kg body weight. [3, 4]

Eating half a Byker egg per day (this is the UK average egg consumption, a Byker egg is assumed with 30pg/g I-TEQ fat basis) increases the daily intake for a 70kg person to 2.3pg/kg body weight and the daily intake of a 35kg person to 4.6pg/kg body weight. Accordingly the consumption of one Byker egg per day increases the daily intake for a 70kg person to 3.6pg/kg body weight and that of a 35kg person to 7.1pg/kg body weight. An estimate for the overall impact on body burden is also illustrated in table 4. The regular consumption of Byker eggs is likely to have contributed to an elevation of the body burden with PCDD/PCDF in humans to levels similar to the levels in the general population approximately ten years ago.

Table 4 Impact of consumption of Byker eggs on human body burden

Assumptions	Results
• Person weighs 70kg • Fat content of body = 25% = 17.5kg • Background body burden = 15pg/g fat I-TEQ • 1000pg = 1ng • Total body burden = 17.5 x 15 = 263ng • Egg weighs 60gram • Eggs have 30 I-TEQ in pg/g fat • Egg has 10% fat	❖ *Eating 1 Byker egg per day for 100 days (no excretion) adds 18ng to the body burden, total body burden 281ng (263 + 18) = 16 pg/g fat I-TEQ* ❖ *Eating 1 Byker egg per day for 1000 days (no excretion) adds 180ng to the body burden, total body burden 443ng = 25pg/g fat I-TEQ*

KEY FINDINGS 6, 7, 8, and 9: PCDD/PCDF IN EGGS

- 16 out of 21 egg samples had PCDD/PCDF levels well in excess of levels from barn held supermarket eggs
- 17 out of 19 egg samples from allotments, which had received Byker ash showed influence of ash in the pattern of contamination
- There was a clear link between the use of Byker ash within chicken pens and the levels of contamination in eggs
- The regular consumption of Byker eggs is likely to have contributed to an elevation of the body burden of PCDD/PCDF to levels equivalent to those in the general population approximately 10 years ago.

SUMMARY OF KEY FINDINGS

HEAVY METALS IN SOIL

1. Considerable soil contamination with heavy metals and arsenic was found in more than half of the allotments in the sampling programme requiring consideration of remediation
2. No clear link between soil contamination with heavy metals and the deposition of Byker ash was identified. It is likely that other sources than the deposition of ash from the Byker incinerator are the main source of contamination with heavy metals and arsenic.

PCDD/PCDF IN SOIL

3. PCDD/PCDF contamination of soil above 40ng/kg I-TEQ was evident in just over one in four of all allotments (9 out of 32), which is the level where avoidance of critical land-use and limitation of agricultural use (unlimited cultivation only of plants with minimum dioxin transfer) is recommended
4. A link between contamination of soil with PCDD/PCDF and the deposition of Byker ash was evident in 18 out of 32 allotments
5. Five allotments had PCDD/PCDF levels near or above 100ng/kg, which is the level where remediation in playgrounds is recommended in addition to avoidance of critical land-use and restriction of agricultural use

PCDD/PCDF IN EGGS

6. 16 out of 21 egg samples had PCDD/PCDF levels well in excess of levels from barn held supermarket eggs
7. 17 out of 19 egg samples from allotments, which had received Byker ash showed influence of ash in the pattern of contamination
8. There was a clear link between the use of Byker ash within chicken pens and the levels of contamination in eggs
9. The regular consumption of Byker eggs is likely to have contributed to an elevation of the body burden of PCDD/PCDF to levels equivalent to those in the general population approximately 10 years ago

CONCLUSIONS:

1. There was little evidence for a transfer of heavy metals from ash to soil. However, there was considerable contamination in many allotments from other unknown sources requiring consideration of further action.

2.There was evidence for a transfer of dioxins/furans from ash to soil in 18/32 allotments. Levels of contamination were such that limitation of agricultural use should be considered in nine allotments, consideration of remediation is required in five.

3.There was clear evidence for a transfer of dioxins/furans from ash and soil into eggs in the large majority of egg samples. This was particularly the case in sites were hens had access to ash.

SUMMARY OF RECOMMENDATIONS FOR FURTHER ACTION

Table 5 summarises the recommendations for consideration of further sampling to assess the need for remediation or restriction of land use. Twenty-seven allotment sites out of 34 (32 with Byker ash, two controls), which were sampled are listed here. We recommend to develop criteria to prioritise the further sampling, which could include the level of contamination, the occurrence of different contaminants, and the current use of the allotment for vegetable growing, pigeon keeping, chicken keeping etc.

Table 5 Allotments recommended for consideration of further sampling to assess need for remediation or restriction of land-use

	Name of allotment	Contaminant of concern	Additional comment
1	**Armstrong Street**	Zinc	Await vegetable data to assess bio-availability
2	**Blaney Row**	Lead	
3	**Blucher**	PCDD/PCDF	See next page
4	**Branxton A**	Cadmium, Copper, Lead, Zinc, PCDD/PCDF	Highly contaminated sites requiring further investigation, source of contamination likely to be combination of Byker ash and other currently unknown sources.
5	**Branxton B**	Copper, Mercury, Lead, Zinc, PCDD/PCDF	
6	**Brunswick**	Arsenic, Cadmium	
7	**Christon Road**	PCDD/PCDF	See next page
8	**Coxlodge**	Lead	
9	**Denton Bank**	Mercury, PCDD/PCDF	Levels of Hg only just reaching 1mg/kg, await vegetable data to assess bio-availability
10	**Denton Dene**	Mercury	
11	**Fenham Nursery**	PCDD/PCDF	Identify hotspot requiring remediation
12	**Hexham Avenue**	Arsenic, Copper, Lead	Both soil levels of As were just below 40mg/kg. As these were pooled samples levels above 40mg/kg cannot be ruled out
13	**Hulne Terrace**	Zinc	OK for animals such as horses
14	**Iris Brickfield**	Lead, Mercury	Both Hg and Pb only just reached the limits of 1mg/kg and 500mg/kg respectively, await vegetable data to assess bio-availability
15	**Jesmond Premier**	Lead, Zinc	Very high lead levels
16	**Jesmond Vale**	Arsenic, Lead, Zinc	
17	**Keebledale Pigeons**	Lead, Zinc	OK if limited to pigeons
18	**Little Moor**	PCDD/PCDF	
19	**Moorside**	Lead, Zinc	
20	**Nuns Moor**	Copper, Lead, Zinc	Very high lead levels
21	**Oxnam Crescent**	Lead, Mercury, Zinc	Control allotment, very high lead levels
22	**St Michael's A**	Zinc	Await vegetable data to assess bio-availability
23	**Tweed Street**	Arsenic, Cadmium, Copper, Lead, Zinc	Very high lead levels
24	**Walkergate 3A**	Cadmium, Copper, Lead, Zinc	
25	**Walkergate 3B**	Copper, Mercury, Lead, PCDD/PCDF	For PCDD/PCDF see next page
26	**Walkergate Hospital**	Copper, Lead, Zinc	
27	**Westmacott Street**	PCDD/PCDF	See next page
28	**Whinneyfield Road**	Copper, Lead, Zinc	

Table 6 Recommendations for further sampling and restriction of land-use: PCDD/PCDF in soil

Allotments with PCDD/PCDF above 40ng/kg I-TEQ (n=9)
Recommended for avoidance of critical land use and unlimited cultivation only of plants with minimum dioxin transfer

- Currently **with poultry**
  - **Branxton A**
  - **Branxton B**
  - **Denton Dene**
  - **Westmacott Street**
- Currently **without poultry**
  - **Blucher**
  - **Christen Road**
  - **Fenham Nursery**
  - **Little Moor**
  - **Walkergate 3B**

Allotments with PCDD/PCDF near or above 100ng/kg I-TEQ (n=5)
Recommended for further sampling to assess need for remediation

- **Branxton A (pattern B,C)**
- **Branxton B (pattern X,D)**
- **Fenham Nursery (pattern B)**
- **Little Moor (pattern B,C)**
- **Walkergate 3B (pattern B)**

Suggested sampling strategy:
- Individual samples at varying distances from the path at Branxton A, Branxton B and Little Moor to assess the extent of Byker ash impact
- Individual samples at original sampling locations in Fenham Nursery to locate hotspot
- Sampling across allotment in Walkergate 3B to assess the extent of the contamination

B = Byker pattern, C = Compost pattern, X = pattern found in several samples of unknown origin, D = deposition pattern

TABLE 7 Recommendations for further action on eggs

Situation	Allotments	Recommendations
Allotments currently with poultry		
• No serious soil contamination (PCDD/PCDF <40ng/kg)	• Coxlodge • Hulne Terrace • Brunswick	➢ **Removal of ash from all pens**
• Pooled soil samples with PCDD / PCDF between 40-100ng/kg	• Denton Dene • Westmacott Street	➢ **Removal of all ash from pens** ➢ **Restriction of poultry to pens (Avoidance of critical land use)** ➢ **Sample eggs from original hens 6-9 months after removal of ash from pens** ➢ **Or Sample eggs from new hens 6-9 months after they were brought to the plot**
• Pooled soil samples with PCDD / PCDF near of >100ng/kg	• Branxton A • Branxton B	➢ **Removal of ash from pens** ➢ **No poultry for egg production until extent of soil contamination is established** ➢ **Restriction of poultry to pens** ➢ **Sample eggs from original hens 6-9 months after removal of ash from pens** ➢ **Or Sample eggs from new hens 6-9 months after they were brought to the plot**
Allotments currently without poultry with possible soil contamination		
• Soil samples >40ng/kg I-TEQ	• Blucher • Christen Road • Fenham Nursery • Little Moor	➢ **No starting of poultry holding until extent of soil contamination is established** ➢ **Restriction of poultry to pens.**

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ABBREVIATIONS AND GLOSSARY OF TERMS

As	Arsenic
Bioavailability	*Degree to which contaminants are taken up by plants, animals or humans who are exposed*
Body burden	*Total amount of a chemical substance in the human body*
Bottom ash	*Fine material from the bottom of an incinerator*
Byker pattern	*Pattern of contamination with heavy metals and dioxins/furans found in the stage 1 study considered characteristic of contamination related to the deposition of ash on footpath*
Cd	Cadmium
CLEA	Contaminated land exposure assessment; *forthcoming probabalistic exposure model to derive new UK guideline values for heavy metals and dioxins/furans*
Composting pattern	*OCDD dominated pattern of dioxin/furan contamination typical of compost, sewage sludge or pentachlorophenole*
Cr	Chromium
Critical land-use	*Use of given area of land, which could lead to the accumulation of toxic substances in the food chain. For dioxins/furans this is the grazing of cows on or the raising of hens*
Cu	Copper
Deposition pattern	B*ell-shaped pattern of contamination with dioxin/furans characteristic for deposition from chimney stacks*
Dutch list	*Dutch list of guideline values for heavy metals and arsenic to assist risk assessment of contaminated land*
Fly ash	*Fine and ultrafine material collected in incinerator stack by various filter systems*
Hg	Mercury
HpCDD	Heptachlorodibenzodioxins; *Dioxin with seven chlorine atoms*
HpCDF	Heptachlorodibenzofurans; *Furan with seven chlorine atoms*
HxCDD	Hexachlorodibenzodioxins; *Dioxin with six chlorine atoms*
HxCDF	Hexachlorodibenzofurans; *Furan with six chlorine atoms*
ICRCL	Interdepartmental Committee on the Redevelopment of Contaminated Land; *UK body, which set guideline values for heavy metals and arsenic in contaminated land in 1987*
I-TEQ	International Toxicity Equivalents; *summary measure of toxic dioxins/furans*
mg/kg	milligram (10^{-3})g per kilogram; *equivalent to a teaspoon of salt in a bathtub*
ng/kg	nanogram (10^{-9}) g per kilogram, *equivalent to a teaspoon of salt in a small lake, this is the same as pg/g*
OCDD	Octachlorodibenzodioxins, *Dioxin with eight chlorine atoms*
OCDF	Octachlorodibenzofuran, *Furan with eight chlorine atoms*
Pb	Lead
PCDD/PCDF	Polychlorinated Dibenzodioxin/Polychlorinated Dibenzofuran
PeCDD	Pentachlorodibenzodioxin, *Dioxin with five chlorine atoms*
PeCDF	Pentachlorodibenzofuran, *Furan with five chlorine atoms*
Stage 1	*Initial investigation to assess whether ash on footpaths, which had received Byker ash was contaminated with dioxins/furans and heavy metals [1, 2]*
TCDD	Tetrachlorodibenzodioxin, *Dioxin with four chlorine atoms*
TCDF	Tetrachlorodibenzofuran *(Furan with four chlorine atoms)*
TDI	Tolerable daily intake, *level of intake of chemical substances considered acceptable by national bodies or WHO*
Zn	Zinc

APPENDIX

Table 1 Recommended levels of heavy metals in soil with different uses [5, 6] in mg/kg soil (ICRCL in brackets) [7]

	Play-ground	Allotment or garden		Sport field		Park		Agri-culture
Arsenic	20-25	20-40	(10)	35	(40)	40	(40)	40
Cadmium	2-10	1-2	(3)	2	(15)	4	(15)	2
Chromium	50-200	70-100	(600)	150	(1000)	150	(1000)	200
Copper	50	50	(130)	100		200		50
Mercury	0.5-10	2	(1)	0.5	(20)	5	(20)	10
Nickel	40-70	70-80	(70)	100		100		100
Lead	200	200-300	500	200	(2000)	500	(2000)	500
Zinc	300	300	(300)	300		1000		300

[1] The ICRCL list distinguishes between contaminants, which may pose a hazard: Arsenic, Cadmium, Chromium, Lead, Mercury, and those that are phytotoxic (toxic for plants) but not normally hazards to human health: Copper, Nickel, Zinc

Extract from Stage 1 report [1]:

'The recommendations for heavy metals were based upon those in use in the 'Dutch list'. They are trigger values for further risk assessment.

The protocol outlined that recommendations would be for no further action if levels were below the level of the 'Dutch list'. If levels were above these limits we stated that we would recommend a more detailed risk assessment to be conducted which should include consideration of different age groups and activities.

The Dutch list was used for the protocol of this study in the absence of an up to date and scientifically based guidance in the UK. We were aware that legally the Interdepartmental Committee for the Redevelopment of Contaminated Land (ICRCL) guidance was in existence until March 31 2000, but it was considered no longer up to date. New guidance based on a probabilistic contaminated land exposure assessment model (CLEA) has not yet been released, but is expected shortly.

The Dutch list has been criticised for a lack of consideration of the type of use that any soil is put to. Some recent lists of guideline values for heavy metals have included consideration of the specific use of land. Examples for the use of land as playground, allotment or garden, sports fields, parks, and agriculture are shown in the table. The forthcoming CLEA guidelines are also expected to incorporate a suitable for use principle.'

Table 2 Summary results for heavy metals and arsenic in soil

	Number
All samples	76
30cm samples (including 2 controls)	39
150cm samples (including 2 controls)	37
Samples with dominant Byker ash pattern (Copper, Lead, Zinc)	0

ARSENIC	**No.**
Samples above 20mg/kg	26
Samples above 40mg/kg	3
Allotments* with arsenic levels above 40mg/kg recommended for further sampling to assess need for remediation	3
• **Brunswick** • **Jesmond Vale** • **Tweed Street**	

CADMIUM	
Samples above 2mg/kg	6
Allotments* with cadmium levels above 2mg/kg recommended for further sampling to assess need for remediation	4
• **Branxton A** • **Brunswick** • **Tweed Street** • **Walkergate 3A**	

CHROMIUM	
Samples above 100mg/kg	0

COPPER	**No.**
Samples above 50mg/kg	62
Samples above 130mg/kg	18
Allotments* with Copper above 130mg/kg recommended for further sampling to assess need for remediation	9
• **Branxton A** • **Branxton B** • **Hexham Avenue** • **Nuns Moor** • **Tweed Street** • **Walkergate Hospital A** • **Walkergate 3A** • **Walkergate 3B** • **Whinneyfield Road**	

MERCURY	
Samples above 0.5 mg/kg	36
Samples above 1 mg/kg	13
Allotments* with Mercury above 1mg/kg recommended for further sampling to assess need for remediation	6
• **Branxton B** • **Denton Bank** • **Denton Dene** • **Iris Brickfield** • ***Oxnam Crescent (Control)*** • **Walkergate 3B**	

NICKEL	
Samples above 50mg/kg	3
Samples above 70mg/kg	0

LEAD	
Samples above 50mg/kg	76
Samples above 200mg/kg	69
Samples above 500mg/kg	27
Allotments* with lead above 500 mg/kg recommended for further sampling to assess need for remediation	18

- **Blaney Row**
- **Branxton A**
- **Branxton B**
- **Coxlodge**
- **Hexham Avenue**
- **Iris Brickfield**
- **Jesmond Premier**
- **Jesmond Vale**
- **Keebledale Pigeons**
- **Moorside**
- ***Oxnam Crescent (Control)***
- **St Michael's A**
- **Walkergate 3A**
- **Nuns Moor**
- **Walkergate 3B**
- **Tweed Street**
- **Walkergate Hospital A, B**
- **Whinneyfield Road**

ZINC	**No.**
Samples above 200 mg/kg	68
Samples above 300mg/kg	50
Samples above 500mg/kg	26
Allotments with zinc above 500 mg/kg recommended for further sampling to assess need for remediation	17

- **Armstrong Street**
- **Branxton A**
- **Branxton B**
- **Brunswick**
- **Hulne Terrace**
- **Jesmond Premier**
- **Jesmond Vale**
- **Keebledale Pigeons**
- **Nuns Moor**
- ***Oxnam Crescent (Control)***
- **St Michael's A**
- **Walkergate 3A**
- **Moorside**
- **Walkergate 3B**
- **Walkergate Hospital A, B**
- **Tweed Street**
- **Whinneyfield Road**

* The discrepancies between the number of samples above a cut-off levels and the number of allotments above a cut-off level is explained by the fact that in some cases both the 30cm and the 150cm sample had levels above the cut-off, these are only counted once for the number of allotments affected.

Table 3 Recommendations for the assessment of soil contamination by PCDD/PCDF by the joint working group on dioxins in Germany chaired by A. Basler[8]

PCDD / PCDF level	Recommendation
<5ng I-TEQ /kg soil	• Target value
5 - <40ng I-TEQ / kg soil	• Unrestricted cultivation of foodstuffs • Avoidance of critical land use (here poultry keeping)
40 -<100ng I-TEQ / kg soil	• Limitation to defined agricultural and horticultural use • Unlimited cultivation only of plants with minimum dioxin transfer
>100ng I-TEQ / kg soil	• Remediation in playgrounds (sealing, decontamination or soil exchanges)
>1000ng I-TEQ / kg soil	• Remediation in residential areas

Extract from Stage 1 report: [1]

'The protocol outlined that our interpretation of these limits in the local context would be to advise against the holding of poultry if levels were found to be 5-<40ng/kg I-TEQ, and to advice against the consumption of root vegetables if levels were 40-<100ng/kg.

The Basler values are not legally binding thresholds, but are recommended levels for further risk assessment, they have been widely used across Europe to inform decisions on how to deal with areas affected by contamination with PCDD/PCDF.'

SECTIONS TWO TO FOUR CONTAIN SEPARATE ANALYSES CONDUCTED BY THE ENVIRONMENT AGENCY, COMMENTS AND FURTHER ANALYSIS FROM THE FOOD STANDARDS AGENCY, AND AN ACTION PLAN FROM NEWCASTLE CITY COUNCIL.

IT IS IMPORTANT TO NOTE THAT THE VIEWS EXPRESSED IN THESE SECTIONS ARE NOT NECESSARILY THE VIEWS OF THE RESEARCH TEAM.

SECTION TWO:

NATIONAL GROUNDWATER & CONTAMINATED LAND CENTRE
NATIONAL CENTRE FOR RISK ANALYSIS & OPTIONS APPRAISAL

BRIEFING NOTE

INVESTIGATION OF BYKER INCINERATOR ASH DISPOSAL - IDENTIFICATION OF POTENTIAL IMPACT ON HUMAN HEALTH

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Report Reference Number: EA/02/10/02
Date: 6 February 2001

This Briefing Note describes activities that the Environment Agency's National Groundwater & Contaminated Land Centre and the National Centre for Risk Analysis and Options Appraisal have carried out in support of the Environment Agency's North East Region investigation in to the identification of any potential human health impact from the disposal of Byker Incinerator ash in the Newcastle Area to recreational sites such as allotments.

WHO WE ARE

The National Groundwater & Contaminated Land Centre (NGWCLC) is a small team within the Environment Agency that provides technical support to colleagues in our Regions and Areas. We have particular expertise in the investigation and evaluation of land that may have been contaminated by past industrial activities. We also work closely with other National Centres of the Environment Agency, especially the National Centre for Risk Analysis and Options Appraisal (NCRAOA). They have particular expertise in the analysis of a wide variety of risks, including the potential of land contamination to cause harm to human health.

WHAT WAS DONE

We were asked by the Environment Agency's Northumbria Area to review and comment on some site investigation information relating to the use of Byker Incinerator ash at a number of places in the Newcastle area[1]. This information focussed on the levels, or concentrations of dioxins[2] in soil and ash samples taken from a number of recreational areas such as allotments and parks, where Byker Incinerator ash was known to have been deposited in the past. Some areas were included where it was known that no ash had been deposited. These were included so they could be compared with areas where ash had been deposited and could act as normal or 'control sites'.

We were asked to respond to some specific questions about the deposit of Byker Incinerator ash, namely whether:

1) the concentrations of dioxins in the ash deposits at the various sites have had, and continue to pose, a significant risk to human health; and,

2) the use of ash for footpath material would have been allowed on the grounds that it was "fit for purpose" under relevant legislation (Waste Management Licensing Regulations 1994).

These are complex questions and are not simple to answer - there are many areas of uncertainty that need to be acknowledged. The remainder of this Briefing Note describes the:

- methods we used to respond to the two key questions asked;
- results of our investigations;
- areas of uncertainty (where we can not be absolutely certain of the outcome) and the limitations of our work; and,
- summary of our overall findings.

Summary of our Methods

We have used a method called 'site-specific risk assessment' to look at potential risks to human health arising from the use of incinerator ash as footpath material and possible associated land contamination. A risk assessment is a way to make decisions about potential problems such as harm to human health and to look at the chances of that harm happening or not. It is called 'site-specific' risk assessment because each site is looked at separately so you are not trying to compare an allotment with a park for example. Each assessment is based on a picture of which groups of people may be affected (the '*receptors*'), by what (the '*source*') and how they may be affected (the '*pathway*' or how the pollutant gets to the person) – this

[1] Environment Agency Report number B001608, dated 16 August 2000 with additional information from the University of Newcastle reports

[2] Terms used are listed at the end of this note

picture is called a *'conceptual model'*.

Part of a site-specific risk assessment is a process where the substance under investigation like dioxins in this case, the potential receptor groups that could be harmed (for example, allotment holders) and potential ways in which these people could be exposed (for example, ingestion of contaminated soil) are assessed to estimate what amount of dioxin, may be taken in daily by the person. This is called an *exposure assessment*. The result of an exposure assessment is an estimate of how much of the substance has been taken in by, for example an allotment holder. This is called the *estimated daily intake*. Potential receptors such as allotment holders have not been identified individually but the exposure assessment has been carried out making sure that conservative values were selected for things such as number of days spent on the site - these are termed *'exposure characteristics'*. These various combinations of sources of contaminants, exposure pathways and receptor characteristics are called *'exposure scenarios'* and go together to form the conceptual model for the site (a picture of what may be going on at the site).

The exposure assessment part of the site-specific risk assessment was done using a computer-based modelling package called RISC-HUMAN and was undertaken by Land Quality Management Ltd at the University of Nottingham (LQM). RISC-HUMAN allows you to feed in information about each site and build up a 'picture' of that site. For example, if you want to include the consumption of contaminated vegetables as an exposure pathway then you can switch that pathway 'on' in RISC-HUMAN. Once all the necessary information has been put in then RISC-HUMAN calculates the estimated daily intake for each 'receptor' you identified (such as allotment holders) and it is this number which is used to consider the risk to human health that might result from such exposures. This is explained in more detail in the following paragraphs.

An exposure assessment was done for six of the sites under investigation. They were selected by us using our professional judgement on the basis of providing some "worst" (higher dioxin soil and ash concentrations) and "best" (lower dioxin soil and ash concentrations) case scenarios for both allotments and park areas plus a control site. As this was a preliminary look at potential exposures it was more effective to focus on a selection of sites to represent all sites including a control.

The six sites evaluated were: four allotments (Fenham, Little Moor, Blucher, and Christen Road), one park area (Dinnington), and a control (Highbury). The maximum soil concentrations of dioxins were used to estimate exposure that may arise from these sites, using the relevant exposure scenario (i.e. either an allotment or a park scenario).

The National Centre for Risk Analysis and Options Appraisal evaluated these exposure assessments to consider the risk to human health that might result from such exposures. In carrying out the evaluation, the Tolerable Daily Intake (TDI) for dioxins was used. A Tolerable Daily Intake is an estimate of the average daily intake of a contaminant over a *lifetime* without appreciable health risk. The estimated daily intake value from the exposure assessment can be compared to this Tolerable Daily Intake to see if it is bigger or smaller. For dioxins a number of TDIs have been recommended by different organisations which range from 1-10 pg TEQ per kg body weight per day[3].

[3] In 1997, the UK expert advisory Committee on Toxicity of Chemicals in Food, Consumer Products and the Environment (COT) recommended a Tolerable Daily Intake (TDI) for dioxin and dioxin-like PCBs of 10 pg TEQ/kg bw/day. In 1998, the World Health Organisation (WHO) recommended a TDI range of 1-4 pg TEQ/kg bw/day. Most recently, in November 2000, the European Commission's Scientific Committee for Food (SCF) recommended a temporary Tolerable Weekly Intake (tTWI) for dioxins and dioxin-like PCBs of 7 pg TEQ/kg bw/week. The Food Standards Agency has asked COT to review all the most recent data on dioxins and dioxin-like PCBs, including the opinions of the World

The terms 'dioxin and furan' cover a range of different substances that all belong to the 'dioxin family'. They are not all toxic to humans to the same degree and to allow a total concentration value for dioxin to be used (instead of looking at the very large number of individual compounds) a method has been developed which compares the most toxic compound with all the others. In this way the 'TEQ' is a Toxicity Equivalency Quotient is calculated on the basis that the most toxic compound has a toxicity equivalency of 1.0 with others set at relative values of 1, 0.1, 0.001 etc. The way a tolerable daily intake is expressed is in terms of amount of contaminant per kg of body weight per day allows intake values to be compared.

WHAT WE FOUND

Results of the Exposure and Risk Assessment investigations

Measured soil concentrations and estimated daily intakes for the six sites are shown in Table 1.

Table 1: Measured soil dioxin concentrations and estimated daily intakes

Site	Soil concentration* (ng/kg)	Estimated daily intake (pg TEQ/kg bodyweight/day)
Little Moor (allotment)	167	13
Fenham (allotment)	81	6
Blucher (allotment)	69	5
Christen Road(allotment)	18	1
Highbury (control)	11	1
Dinnington (park/recreational area)	321	9

*These are maximum recorded values found and not average values

The exposure scenarios used by LQM were at our request highly conservative. For allotments, exposure pathways included soil ingestion, consumption of contaminated vegetables, inhalation of dust and skin contact with soil. None of the sites looked at here were used to keep poultry. The Food Standards Agency has included a discussion of dioxin contamination of eggs and poultry on other allotment sites in its comments on the main report. .

In reviewing the relative intake contributions from each exposure pathway (for example, consumption of soil, inhalation of dust etc.) it was found that consumption of vegetables appears to have accounted for 94% of the estimated daily intake from the allotments.

For the park scenario, the exposure pathways considered were ingestion of soil, inhalation of dust and dermal contact. Here dioxin levels measured in the footpath (rather than in the soil) were used to model the exposure. These would be expected to be higher than those measured away from the path (as there would be more ash on the path and so more dioxins). Children were selected as the most important receptor at this type of site as the main route of exposure is through soil ingestion. At Dinnington this has been estimated to account for about 77% of the estimated daily intake value of 9 pg/kg body weight/day (Table 1) and represents a worst case scenario as it assumes that all soil ingested will have levels of dioxin as high as in the footpath. However, in reality it is more likely that children will play in different parts of the park, especially in playground areas where it might be expected that levels would be lower.

Health Organisation (WHO) and the EC Scientific Committee on Food (SCF) on what is a tolerable exposure to these chemicals. Working to advice received from the Food Standards Agency, we have compared our exposure assessments to both the current UK and WHO guidelines.

Exposure to soil and ash is not the only source of dioxin intake by those using these sites that must be taken into account by the exposure assessment. In considering the other possible sources, we have used the Food Standards Agency estimated mean dietary intake (MDI) for dioxins of about 4-5 pg/kg bodyweight/day for a child aged up to 6 years old and 1.8 pg/kg bodyweight/day for an adult (published in 2000). This estimate is based on a basket food survey conducted in 1997 that described the average UK diet.

Table 2 presents the estimated daily intakes taken from Table 1 that have been revised to take into account the background exposure to give an 'overall' total exposure. This includes intake from the soil and dust, contaminated vegetables and background intake (non-Byker sources of dioxins).

Table 2 'Total dioxin intake

Site	**Estimated daily intake (including soil etc. plus background exposure) (pg TEQ/kg body weight/day)**	
	UK TDI (10)	**WHO TDI (1-4)**
Little Moor (allotment)	**15***	**15***
Fenham (allotment)	8	**8***
Blucher (allotment)	7	**7***
Christen Road (allotment)	3	3
Highbury (control)	3	3
Dinnington (park/recreational area)	**13-14***	**13-14***

* Note that these estimated daily intakes are higher than the respective tolerable daily intake

In order to assess whether there is likely to be any significant risk to human health arising from using the sites investigated we must as a first step compare the estimated daily intake of dioxins with the corresponding tolerable daily intakes (Table 2). For three of the four allotments examined the estimated daily intakes are less than the UK tolerable daily intake, however the opposite is true for comparison with the WHO TDI. Only Little Moor exceeds both TDIs. At Little Moor, the estimated daily intake exceeds the UK tolerable value by a factor of 1.5 and the WHO value by a factor of 3.75. However, this is only the first step in assessing the risk. Exceeding a tolerable daily intake does not imply that individuals will show any appreciable risk of adverse effects during their lifetime. This is because (i) the tolerable daily intake incorporates a set of uncertainty factors (or safety factors); (ii) the estimated exposure for this site is conservative; for example, as mentioned earlier, washing and peeling vegetables may considerably reduce exposure (from the soil on the vegetables); and (iii) to date individuals have been exposed to these levels for a maximum period of 6 years (the maximum time since the ash was first deposited at any site). Therefore, based on the estimates presented here, the increased daily exposure of dioxins that may result from direct or indirect exposure from the allotments is *unlikely* to lead to any appreciable health risks (over a lifetime exposure period).

Children playing at Dinnington Park may also be exposed to levels above both the UK and WHO values of tolerable daily intake. Again, values used in the exposure assessment for the park are conservative and therefore children may not necessarily be exposed to contamination above the recommended levels. The exposure assessment was made based on measurements taken from the footpath. These are likely to be much higher than those reported in adjacent soil or away from the path. Therefore the estimated daily intake represents a worst case scenario.

Key Limitations and Uncertainties Associated with the Exposure and Risk Assessment

There are a number of important uncertainties in our exposure and risk assessment that must be taken into account when reviewing the outcome of this work. These can be summarised as:

- *Overall sampling strategy* - Any risk assessment is ultimately reliant on the quality and quantity of the underlying data. The actual concentration of dioxins / furans over the area of concern could be higher or lower than that reported by the existing site investigations. We would require further data to increase our confidence in understanding the level and extent of any contamination at these sites. This in combination with a more comprehensive site-specific exposure assessment would increase our confidence in the predicted intakes.

- *Exposure modelling* - We need to be aware of the fact that the reported TEQ levels only account for dioxins and furans. However, dioxin-like PCBs will also contribute towards the overall TEQ and, if these were incorporated into the overall estimated TEQ, we would obviously have a higher daily intake than estimated here. It is not clear how much dioxin-like PCBs there may be in the ash from the Byker Incinerator.

Summary of our Findings

We carried out an exposure and risk assessment for a representative number of sites using the data set that had been provided to us. There are a number of uncertainties that can affect the results of our assessment and these could lead to a larger or smaller risk of exposure. With this in mind, we were careful in selecting the exposure characteristics for our assessment, making it necessarily conservative at this stage.

The data and our assessment can only be described as an *indication* of the likely risks posed by the contamination. Only by further sampling, analysis, and assessment can the confidence in our risk modelling be increased.

Returning to the questions asked of us, whether:

1) the concentrations of dioxins in the ash deposits at the various sites have had, and continue to pose, a significant risk to human health

   There were two parts to our answer:

   (i) The most important consideration is whether there are likely to be any significant effects on human health arising from the deposit of the ash. Based on the assessment of representative sites it is *unlikely* that there are any significant *actual* health effects arising from the deposit of the ash. For two of the sites that we have examined the estimated daily intake appears to exceed both the UK and WHO tolerable daily intake (Little Moor and Dinnington Park). However, this is clearly not the same as saying that effects are *likely* to occur since we have deliberately examined a relatively conservative worst-case scenario (there are also safety factors built into the underlying tolerable daily intake value). We understand that measures have been taken to remove the ash from these sites in which case any possible lifetime exposures will be considerably reduced. Every effort should be made to continue to reduce exposure from contaminated soils at

sites where any contamination remains. In addition, it would be sensible to carry-out some follow-up work on the Little Moor site to confirm the level and extent of contamination across it and the level of exposure for key pathways (e.g. measuring the concentration of contamination in vegetables).

(ii) Is there sufficient evidence for the Environment Agency to decide that there is a *'significant possibility of significant harm'* arising from soil contamination? This phrase is taken from Part IIA of the Environmental Protection Act 1990, the "contaminated land regime". Bearing in mind the uncertainties in assessing the risk of exposure to soil contamination, it is sensible that we should use a test level that takes into account such uncertainty in protecting human health and the environment. Under the "contaminated land regime", this level of *'unacceptable risk'* is therefore much lower than the level at which significant health impacts are *likely* to appear. On the basis of the test that a local authority might apply in deciding whether a piece of land is contaminated land, the result of our study is that two of the sites (Little Moor and Dinnington) would *probably* be considered to be "contaminated land" on the 'more likely than not' basis of any inspection. A further two allotment sites (Fenham and Blucher) exceed the WHO TDI and would therefore require further consideration. If such a decision were made, it would probably result in more detailed risk assessment and site investigation being carried out as part of any action.

2) the use of ash for footpath material would have been allowed on the grounds that it was "fit for purpose" under the legislation (Waste Management Licensing Regulations 1994).

On the grounds of harm to human health, there is some evidence to suggest that if we take a 'precautionary' view to the re-use of the ash on some of the sites concerned that this material is *not* "fit for purpose". It would seem unlikely that depositing the ash would be allowed if the effect of that deposit may make the land "contaminated land" under the legislation. In the context of a new use of land (a change from an allotment for example) the presence of ash and its associated contaminants at concentrations found on Little Moor, Fenham, Blucher, and Dinnington Park, would be likely to need action ('remediation') under any planning permission, prior to the site being considered "suitable for use" as an allotment or park. However, we recommend that further work needs to be carried out to demonstrate this more clearly.

List of terms used in this Briefing Note *(in alphabetical order)*

Dioxins (and furans) – a range of substances that are produced when, for example, materials such as domestic rubbish are burnt.

Estimated daily intake (EDI) – intake of contaminant on a daily basis calculated from an exposure assessment.

Exposure assessment – method of estimating an average daily intake of a substance by looking at the source of the substance, characteristics of the potential human receptor population such as time spent at a place where ash was deposited such as an allotment and potential pathways where the substance could come into contact with human receptors and possibly affect health.

Incinerator ash – when material is burnt in an incinerator, a residue will remain: ash left in the incinerator itself, called 'bottom ash' and ash collected from the chimney, called 'fly ash'. Fly ash generally has higher concentrations of substances such as dioxins than bottom ash. The ash from the Byker Incinerator deposited on allotments etc. is thought to have consisted of bottom and fly ash.

Mean daily intake (MDI) background intake from non-soil sources such as diet

ng/kg – nanogram per kilogram – 1 ng is the same as 1 / 1000000000 of a kilogram

pg/kg – picogram per kilogram – 1 pg is the same as 1 / 1000000000000 of a kilogram

PCBs – Polychlorinated biphenyls – a group of substances used in industry in electrical insulators and in the manufacture of plastics that are toxic and can become concentrated in the bodies of animals (including humans). Along with dioxins PCBs can also be emitted from incinerators and some of them behave in a 'dioxin-like' manner.

RISC-HUMAN – is an exposure assessment model based on the Dutch model C-SOIL, this has been used to calculate the Dutch soil guideline values and is therefore considered to be authoritative (although it clearly has been developed for the Dutch situation). We consider that its conceptual model with some further adaptation is a good fit for the sites investigated here. RISC-HUMAN is not the only model available to assess exposure to humans from land contamination. In assessing such exposures, it is important to compare the conceptual model for the site concerned and the conceptual model that underpins the modelling tool to ensure that there is a close match between them.

Risk – the likelihood of an unpleasant outcome or the probability and the consequences of harm

Risk assessment – a structured process of evaluating a specific risk, such as the risk of harm to human health from dioxin contamination in soil. Part of the process is carrying out an exposure assessment

Sample e.g. soil sample – it is not possible to chemically analyse, for example, all the topsoil from an allotment, so samples of soil are collected to represent conditions at the allotment and it those samples that are analysed by the laboratory

TDI – Tolerable Daily Intake – an estimate of the average daily intake of a contaminant, that can be ingested over a *lifetime* without appreciable health risk

SECTION THREE:

COMMENTS FROM THE FOOD STANDARDS AGENCY

COMMENTS FROM FOOD STANDARDS AGENCY

REPORT ON ANALYSIS OF PCDD/F AND HEAVY METALS IN SOIL AND EGG SAMPLES IN NEWCASTLE ALOTMENSTS: Assessment of the role of ash from the Byker incinerator- BY UNIVERSITY OF NEWCASTLE AND ERGO.

Background

The Food Standards Agency was informed by Newcastle and North Tyneside Health Authority of the preliminary results of the analysis for heavy metals in samples of ash and soil from allotments, which had received ash from the Byker incinerator/heat station plant. These preliminary data indicated elevated levels of metals in paths and allotment soils. As this could result in elevated levels of metals in fruit and vegetables grown in these allotments, we recommended to the health authority that samples of allotment produce should be tested to determine the extent of any such contamination. Elevated levels of dioxins were found in paths on allotment sites and we also recommended that samples of animal products, such as eggs, from these allotments be analysed for dioxins.

On the basis of the information supplied to us about the contamination at these allotments, we advised the following **precautionary** measures:

- allotment holders to wash thoroughly all produce and to peel root vegetables from these allotments before eating them. This would minimise any contamination on the surface of fruit and vegetables.
- no products from animals or birds reared on these allotments should be eaten.

Further information on the analysis of soil for metals and dioxins and egg samples for dioxins are included in the Report by the University of Newcastle and ERGO on Stage 2.3 of the investigations at these allotment sites.

METALS IN ASH AND SOILS
Concentrations of heavy metals (cadmium, copper, chromium, mercury, nickel, lead and zinc) and arsenic have been measured in soil samples from allotments in Newcastle.

The availability of metals in soils for assimilation by plants is in most cases strongly influenced by the pH of the soil and it would be informative to know the pH values in the soil samples tested for heavy metals. Even with pH data it is difficult to make reliable predictions of the metal levels in food crops grown on allotments on the basis of data on metal levels in soils. A large proportion of any contamination of crops by heavy metals will be present as soil or dust on the outer surfaces of the crops.

We will be able to comment in detail on the food safety implications for consumer only when the crop data are available. Until this time, we repeat our advice that allotment holders should, as a precaution, thoroughly wash and where appropriate

peel allotment produce before consumption. This will help to minimise any exposure to these contaminants.

The Report recommends further investigation at sites where one or more results exceeded the guidelines for heavy metals or arsenic in soils given in the so-called 'Dutch list' or in the ICRCL Guideline. The soil data may also be compared with:

- the relevant limits for metals and arsenic in agricultural soils to which sewage sludge has been applied, as given in the Sludge (Use in Agriculture) Regulations 1989 (S.I. [1989] No. 1263) as amended, and
- the guideline values given in the MAFF Code of Good Agricultural Practice for the Protection of Soil (MAFF, 1988).

These limits have been developed to protect soil fertility and the health of plants, animals and humans from contaminants in agricultural soils to which sewage sludge has been applied, but may be considered as generally applicable to agricultural soils. They were reviewed independently by the WRc in 1998.

The relevant values are similar in most cases to those used in the Byker Report and are listed in Table 1 below. On the basis of an assessment of the results from the allotment soils against these values, we have the following comments:

Chromium and nickel
We agree that the results do not suggest these metals are a priority for further investigation.

Copper and zinc
Some soil samples exceeded the relevant limits. However, the limits for these metals were set to protect against toxicity to plants and soil micro-organisms rather than for food safety concerns. These metals may therefore be regarded as having a lower priority than lead, cadmium, mercury and arsenic on food safety grounds. However, it may be sensible to consider them for further investigation as part of the wider investigation into the extent and nature of the contamination and the options for remediation.

Mercury
The limit in the Sludge Regulations and Code is the same as that used in the Report and we support the recommendations that sites at which results exceeded this levels should be investigated further.

Arsenic and cadmium
The soil cadmium results for the allotments are all within the limit value of 3 mg/kg in the Sludge Regulations. The maximum values found for arsenic are only just above the guideline of 50 mg/kg. Arsenic levels above the 50 mg/kg guideline do occur naturally in agricultural soils in some parts of the UK, for example the South West, for geological reasons, and as a result of historic mining activity. These do not however normally result in unacceptable levels of arsenic in crops. These metals could be regarded as a lower priority for further investigation compared with lead and mercury, for which the limits are exceeded to a greater degree. However, because, as the report suggests, the sampling may not have identified hot-spots with higher concentrations, an investigation of cadmium and arsenic at the sites identified in the report would be a sensible **precautionary** measure.

Lead
The report recommends further investigation at those sites at which soil lead concentrations exceeded 500 mg/kg. The guideline value in the Sludge Regulations

and Soil Code is 300 mg/kg, with a recommendation from the WRC Review to reduce this to 200 mg/kg.

Plant uptake of lead is strongly dependent on pH, and is negligible at soil pH over 7. However, soil or dust on the exterior of vegetables can contribute significantly to lead exposures of consumers (although this can be minimised by thoroughly washing and where appropriate peeling produce before consumption). In view of the comments above regarding hot-spots, we recommend that the Group consider further investigation of sites where lead results exceeded 300 mg/kg.

Dioxins in eggs

The Report includes the results of analysis for dioxins in pooled and individual samples of eggs from the Byker allotment and control sites. The samples were not analysed for dioxin-like polychlorinated biphenyls (PCBs). The results were reported using the International Toxic Equivalent (I-TEF) system rather than Toxic Equivalency Factors recommended by the World Health Organization (WHO-TEF), which are becoming more widely used.

When assessing whether the levels of dioxins and PCBs in a food are safe, we compare estimates of the exposure from that food to recommended safety guidelines (for example Tolerable Daily Intakes or Tolerable Weekly Intakes).

In 1997, the expert advisory Committee on Toxicity of Chemicals in Food, Consumer Products and the Environment (COT) recommended a Tolerable Daily Intake (TDI) for dioxin and dioxin-like PCBs of 10 pg TEQ/kg b.w./day. In 1998, the WHO recommended a TDI range of 1-4 pg TEQ/kg b.w./day.

Most recently, in November 2000, the European Commission's Scientific Committee for Food (SCF) recommended a temporary Tolerable Weekly Intake (tTWI) for dioxins and dioxin-like PCBs of 7 pg TEQ/kg bw/week.

The Food Standards Agency has asked the COT to review all the most recent data on dioxins and dioxin-like PCBs, including the opinions of the World Health Organization (WHO) and the EC Scientific Committee on Food (SCF) on what is a tolerable exposure to these chemicals.

The COT review may result in current UK guideline being revised. In the meantime, the COT has considered it appropriate to comment on exposure to dioxins and dioxin-like PCBs in the light of the current UK and WHO guidelines.

There are limited data on the levels of dioxins in eggs generally in the UK. However, the results of these tests show that eggs produced on some of the Byker allotment sites have elevated concentrations of dioxins when compared with other available data. Owing to the small number of eggs sampled at each allotment, it is not possible to discriminate between any potential differences in the concentrations of dioxins in eggs from different sites.

We have used the data provided to estimate the exposure to dioxins of adults and schoolchildren (10-15 years) from consumption of eggs from these allotments. These estimates are based on a number of pessimistic assumptions (see explanation below).

With the exception of Bantam eggs, estimated exposures of average consumers of eggs produced on the allotments do not exceed the current UK Tolerable Daily Intake

(TDI) for dioxins and dioxin-like PCBs (10 pg TEQ /kg bodyweight) or the TDI set more recently by the World Health Organization (1-4 pg TEQ/kg bodyweight).

Again with the exception of Bantam eggs, estimated exposures of consumers eating more than average amounts of eggs (about 1½ eggs per day for adults and about 1 egg per day for schoolchildren) from the allotments also do not exceed the current UK TDI, but could exceed the WHO TDI.

The estimated exposures to dioxins and PCBs from eating the Bantam eggs from the Branxton A site are very pessimistic. For these estimates, it was assumed that all eggs eaten every day are these Bantam eggs. This is unlikely to be the case in practice.

Even if the WHO-TDI is exceeded, this does not imply that adverse effects will occur, rather that there is an erosion of the margin of safety built into this guideline value. Therefore, the concentrations of dioxins in eggs from these allotments are unlikely to pose a risk to health. Nonetheless, our initial precautionary advice should still be followed.

We understand that the poultry on these sites are to be slaughtered as a precautionary measure. We support this action. Poultry should not be re-introduced to the allotments until after remediation has been effected.

Dietary exposure assessment

Our estimates of dietary exposure to dioxins by individuals eating eggs from these allotment sites used:

- data provided by Newcastle and North Tyneside Health Authority for dioxins in samples of eggs from Byker allotment and control sites;
- data on the fat content of these samples; and
- information on the average and above-average consumption of eggs from dietary surveys of adults and schoolchildren (10-15 years)[4][5].

The estimates were also based on a number of pessimistic assumptions. It was assumed that:

- all eggs are consistently obtained from a particular allotment site. This is a conservative assumption, particularly for duck and Bantam eggs, as it is likely that a proportion of the eggs eaten would be from other sources. Separate estimates were made for the exposure from the consumption of eggs from each site.
- all eggs at a single site contained dioxins at the concentration reported for the composite sample from that site. This is considered to be a more realistic assumption than using the maximum level reported in an individual egg. Dioxin concentrations vary between individual egg samples and, over a period of time, an individual is unlikely to be continually exposed to the level of dioxins reported for a single sample. Different types of egg (hen, duck or Bantam) at a site were considered separately.
- dioxin exposure from eating eggs from these allotments is in addition to the estimated average exposure to dioxins and dioxin-like polychlorinated biphenyls

[4] Gregory, J. *et al.* (1990). Dietary and Nutritional survey of British adults. HMSO.
[5] Department of Health. (1989). The Diets of British schoolchildren. *Report on Health and Social Subjects*, **36**. HMSO.

(PCBs) from consumption of the typical UK diet, including exposure from eggs already taken into account in the typical diet data. This is a conservative assumption, as there will be some 'double-counting' of exposure from eggs. Exposure from the diet was based on 1997 Total Diet Study data[6].

- an adult weighs 60kg and schoolchildren aged 10-15 years weigh 43.4 kg.

As some PCBs exhibit a similar mechanism of toxicity to dioxins, these two groups of chemicals are usually considered together. A system of toxic equivalents (TEQs) has been developed to give a pragmatic indication of the toxicity of mixtures of these chemicals in food. Dioxin-like PCBs would be expected to occur in eggs but these samples were not analysed for these chemicals. In a further set of exposure estimates, the PCB contribution to the quantity of dioxin-like chemicals was taken into account by assuming that the contribution of dioxin-like PCBs to the total TEQ of the sample is equal to the contribution by dioxins (see Table 2b). The assumption, which effectively doubles the dioxin concentration in these samples, is considered to be conservative. Elevated concentrations of dioxins could be expected; PCB concentrations in the ash are unlikely to be elevated as the majority would be expected to be destroyed by incineration.

With the exception of consumers of Bantam eggs from the Branxton A site, estimated exposures of average consumers of eggs produced on the allotments do not exceed the current UK Tolerable Daily Intake (TDI) for dioxins and dioxin-like PCBs (10 pg/kg bodyweight), or the TDI set more recently by the World Health Organization (1-4 pg/kg bodyweight). This is the case for both adults and schoolchildren, even when pessimistic assumptions are made about the concentrations of dioxin-like PCBs in these eggs.

Estimated exposures of above-average consumers of eggs will also not exceed the current UK TDI, but could exceed the WHO TDI. This is the case for both adults and schoolchildren, even when pessimistic assumptions are made about the concentrations of dioxin-like PCBs in these eggs. However above-average consumers of Bantam eggs from Branxton A would again exceed both TDIs.

A number of pessimistic assumptions were used in these exposure estimates, some of which are unlikely to occur in practice. For example, it is highly unlikely for an individual to eat only Bantam eggs from the Branxton A site. Even if the WHO-TDI is exceeded this does not imply that adverse effects will occur, rather that there is an erosion of the margin of safety built into this guideline value. Therefore, the concentrations of dioxins in hen and duck eggs from these allotments are unlikely to have posed a risk to health.

[6] Food Standards Agency (2000). Dioxins and PCBs in the UK diet: 1997 Total Diet Study samples. *Food Surveillance Information Sheet 04/00.*

Table 1: Limits for heavy metals and arsenic agricultural soils given in the Sludge (Use in Agriculture Regulations 1989 and the Soil Code

Element	Value (mg/kg)		Outcome of WRc review
Arsenic	50		No revision recommended
Cadmium	3		No revision recommended
Chromium	400		No revision recommended
Copper	80 100 135 200	for pH 5.0 to 5.5 for pH 5.5 to 6.0 for pH 6.0 to 7.0 for pH > 7	135 mg/kg acceptable for all soils from pH 5.0 to 7.0
Lead	300		Recommend reduction of limit to 200 mg/kg to reduce risk of animals offals exceeding legal limits
Mercury	1		No revision recommended
Nickel	50 60 75 110	for pH 5.0 to 5.5 for pH 5.5 to 6.0 for pH 6.0 to 7.0 for pH > 7	75 mg/kg acceptable for all soils from pH 5.0 to 7.0
Zinc	200 300	for pH 5.0 to 7.0 for pH > 7	No revision recommended

Table 2 a Estimated dietary exposure to dioxins and dioxin-like PCBs from consumption of eggs from test sites and the typical UK diet, assuming egg samples do not contain dioxin-like PCBs (pg TEQ/kg b.w./day)

Test site	Hulne Terrace	Bruns-wick	Blaney Row	Cox lodge	St Anthony's		Branx-ton B	Denton Dene	Branx-ton A	Branx-ton A	West-macott Street	Haw-thorn Farm	Pets Corner
	Hen	Hen	Hen	Hen	Duck	Hen	Hen	Hen	Hen	Bantam	Hen	Hen	Hen
Adults													
Estimated exposure from average consumption of eggs + typical exposure from the whole diet	2.5	2.1	1.9	1.8	2.4	2.3	2.4	2.1	2.8	4.4	2.1	1.7	2.5
Estimated exposure from above-average consumption of eggs typical exposure from the whole diet	4.1	2.8	2.3	1.9	3.8	3.5	3.7	2.8	5.0	10.0	2.9	1.7	4.2
Schoolchildren													
Estimated exposure from average consumption of eggs + typical exposure from the whole diet	3.0	2.5	2.3	2.2	2.8	2.7	2.8	2.5	3.3	5.1	2.5	2.1	3.0
Estimated exposure from above-average consumption of eggs typical exposure from the whole diet	4.8	3.4	2.7	2.3	4.4	4.1	4.3	3.4	5.7	11.3	3.5	2.1	4.9

Note: Typical exposure from the whole diet also includes a contribution from the consumption of eggs

Table 2 b Estimated dietary exposure to dioxins and dioxin-like PCBs from consumption of eggs from test sites and the typical UK diet, assuming egg samples contain equal quantities of dioxins and dioxin-like PCBs (pg TEQ/kg b.w./day)

Test site	Hulne Terrace	Bruns-wick	Blaney Row	Cox lodge	St Anthonys		Branx-ton B	Denton Dene	Branx-ton A	Branx-ton A	West-macott Street	Haw-thorn Farm	Pets Corner
	Hen	Hen	Hen	Hen	Duck	Hen	Hen	Hen	Hen	Bantam	Hen	Hen	Hen
Adults													
Estimated exposure from average consumption of eggs + typical exposure from the whole diet	3.3	2.4	2.1	1.8	3.0	2.9	3.0	2.4	3.8	7.0	2.5	1.7	3.3
Estimated exposure from above-average consumption of eggs + typical exposure from the whole diet	6.5	4.0	2.8	2.0	5.8	5.3	5.7	4.0	8.2	18.2	4.2	1.7	6.8
Schoolchildren													
Estimated exposure from average consumption of eggs + typical exposure from the whole diet	3.9	2.9	2.5	2.2	3.6	3.4	3.6	2.9	4.5	8.1	3.0	2.1	3.9
Estimated exposure from above-average consumption of eggs + typical exposure from the whole diet	7.5	4.6	3.4	2.5	6.7	6.1	6.6	4.6	9.4	20.5	4.8	2.1	7.8

Note: Typical exposure from the whole diet also includes a contribution from the consumption of eggs

SECTION FOUR

Newcastle City Council

NEWCASTLE CITY COUNCIL ACTION PLAN

Newcastle City Council

Newcastle City Council Action Plan

Following an independent report published by the University of Newcastle upon Tyne commissioned by Newcastle City Council (N.C.C.) on the analysis of PCCD/PCDF and Heavy Metals in footpaths and soil samples following the deposit of ash from the Byker Incinerator N.C.C. have taken and intend to take the actions as detailed below.

ACTION TO DATE

1. N.C.C. have removed all known ash deposited and undertaken to remove any other subsequently identified.

2. N.C.C. have commissioned an independent report on the Analysis of PCCD/PCDF and Heavy Metals in soil and egg samples following the deposit of ash from the Byker Incinerator. (This report).

3. N.C.C. have commissioned an independent report carried out by Newcastle University into the Transfer of PCCD/PCDF and Heavy Metals from Ash/Soil into vegetables. (Work ongoing to be published shortly).

4. N.C.C. have paid compensation to allotment gardeners who keep poultry following the issue of precautionary advice not to eat eggs and poultry from allotments which had received ash.

FUTURE ACTION

Whilst it is accepted there is a clear link between the presence of PCCD/PCDF in soils on most allotments identified in this report and Byker Ash, it is acknowledged there is no clear link between soil contamination with heavy metals and the deposition of Byker Ash. In recognition of these findings N.C.C. intend to take the following action to ensure gardens are fit for purpose in order to restore confidence in allotment gardening.

1. N.C.C. undertake to ensure allotment gardens are fit for purpose by carrying out assessments of soil contamination on a risk based priority programme in respect of
   a.) PCCD/PCDF
   b.) Heavy Metals

   The assessments will be site specific and advice will be taken from the Director of Public Health for Newcastle and North Tyneside Health Authority, the Environment Agency, and Newcastle University in addition to other expert bodies.

2. N.C.C. undertake in conjunction with Newcastle University to retain some poultry from allotment gardens, in order to monitor the levels of PCCD/PCDF in eggs once the exposure to Byker Ash has ceased.

3. N.C.C. undertake to remove all poultry from sites where ash has been used, to allow 'new poultry' to be introduced on soil suitable for laying birds. Discussion will take place with allotment gardeners who may wish to retain the poultry.

4. N.C.C. undertake to carry out appropriate sampling and analysis at Walker Road allotment. This site did not receive ash but due to its proximity to the Byker Incinerator and following the results of initial sampling further investigation is considered appropriate.