DEALING WITH INDUSTRIAL LEGACY IN THE CONTEXT OF CURRENT LEGISLATION ON CONTAMINATED LAND: THE UK SALTMEADOWS CASE STUDY

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Introduction

In 2003 we reported soil contamination from deposition of an incinerator on the river Tyne which separated the conurbations of Newcastle and Gateshead in the NorthEast of England[1,2]. Whilst no deposition impact was found from the Newcastle incinerator for PCDD/Fs a chance finding on the Gateshead side of the river required further investigation. We reported levels of PCDD/F as mean in South West sector: 487ng/kg I-TEQ, median: 169ng/kg I-TEQ, mean overall: 120, median 32 along with a characteristic furan dominated pattern of congeners. Both Newcastle and Gateshead have a long history of heavy industry along the river Tyne most of which has disappeared during the late 20th Century. Many previous industrial sites have now been converted into light industrial, recreational, and some residential use. Historic maps, trade records, and local knowledge identified an electrolysis process of alkali making operating between the early 1900s and the 1920s to be the likely source of contamination. It was also suggested that potentially contaminated material was left on and near the site when it closed down in 1924. Some movement of material occurred in the 1920s and in the early 1970s. This resulted in contaminated material being spread over an area of approximately 10 hectares along the riverfront. The current land-use of the area is mainly recreational and industrial. There is a school approximately 700metres away and council owned housing at a distance of approximately 500metres. Furthermore there was potential for sediment contamination from washouts and consequently contamination of fish in the tidal river. Overall the scenario presented a highly complex situation with regards to human exposure and risk assessment with a wide range of potential pathways as well as both acute and chronic effects requiring consideration. Soil remediation by 'dig and dump' has greatly decreased in popularity in recent years and is discouraged. The aim of this paper is to describe this complex case study in the context of current UK legislation on contaminated land and requirements for remediation. The objectives were: To establish the horizontal and vertical spread of contamination, to carry out the risk assessment in line with UK contaminated land exposure assessment guidance, and to inform a remediation strategy.

Material and Methods

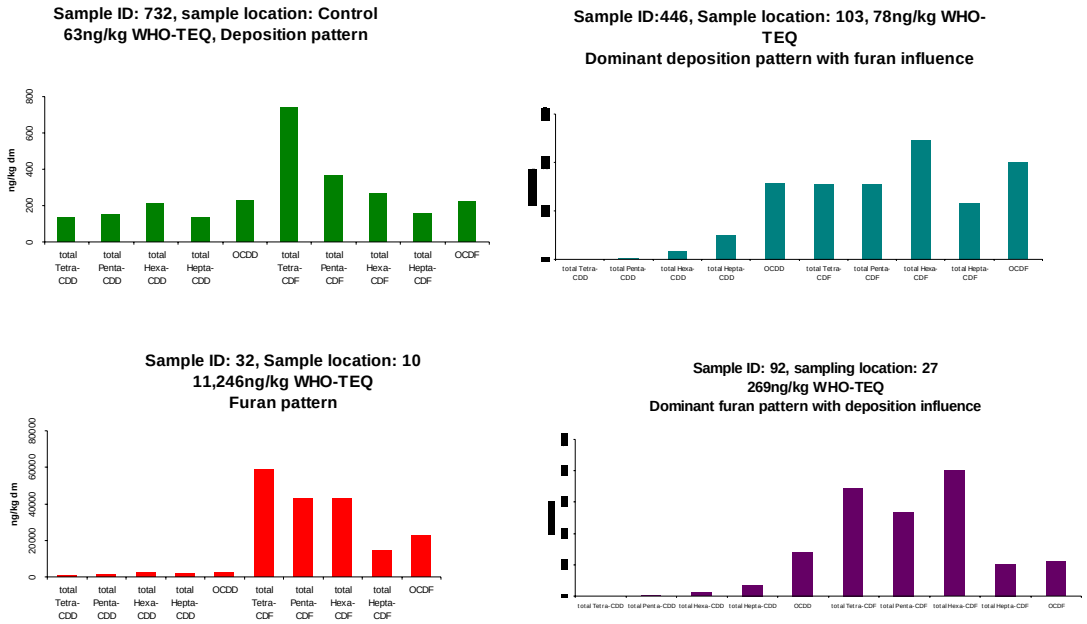
In line with the requirements of the UK guidance sampling points were identified to achieve a grid with a density of 25m. 44 window and borehole samples were collected at varying depths resulting in 50 samples. Surface samples were taken from the top 100mm after clearing of vegetation. All samples were analysed for heavy metals and arsenic (data not presented here). Ninety eight surface samples were selected from the main study site along the river Tyne at random for PCDD/F analysis. Five samples were taken from public open space within a nearby housing estate, six from a nearby school playing field, and six samples each from two control sites without previous industrial use to establish background levels of PCDD/F (cemetery and playing field). The control samples were pooled into a single sample from each site. High resolution GC/MS analysis of PCDD/F was carried out by the ERGO laboratory in Hamburg, Germany.

Congener pattern were identified by two authors (TPM, BS) blinded for the overall level in ng/kg I-TEQ and location of the sample. A furan dominated congener pattern had previously been reported by Rappe et al in 1991 and Ying for the contemporary Chinese alkali industry in 2000[3,4]. Figure 1 shows the main types of congener patterns found in the study: deposition (background), combination of deposition and furan (alkali industry derived) pattern with dominant deposition, furan pattern (alkali industry derived), furan and deposition with dominant furan pattern.

Results and Discussion

Table 1 shows the descriptive statistics of PCDD/F contamination levels by surface congener pattern. Figure 2 displays the data visually on a contemporary map of the site. Table 2 shows the descriptive statistics by congener pattern for the subsurface samples.

Figure 1 Main congener pattern found at Saltmeadows site



We found deposition pattern samples with a near normal distribution and levels typical of post-industrial urban areas in the UK (median 44, mean 55 ng/kg I-TEQ). This pattern was found in only 7% of all surface samples. Samples with a mainly pure furan congener pattern had the highest overall levels (median 2369, mean 873ng/kg I-TEQ) accounting for 63% of all samples analysed. Considering all samples showing influence of furan congeners together over 83% of all surface samples showed impact of the previous alkali industry. 25 out of 98 surface samples had contamination levels of above 1000ng/kg I-TEQ, 3 samples exceeded 10,000ng/kg I-TEQ. For the subsurface samples the median and means of furan influenced samples were broadly in line with those found in the surface samples, however their range was even larger than in the surface samples. Subsurface samples showing deposition congener patterns had lower levels than surface samples (mean and median of 10ng/kg I-TEQ) in line with the expectation. Control samples, samples from the school playing field and the housing estate, which were all not known to have received any contaminated material directly all showed modest overall levels typical of post-industrial urban areas, but nevertheless impact of the furan pattern characteristic of the alkali industry source. We interpret this to mean that fugitive emissions from the material are likely to be the route for such impact.

The distribution of all furan influenced samples was highly skewed with high and low levels in close proximity to each other. We confirmed extensive vertical and horizontal distribution of contaminated material across the site. We consider this likely to be a reflection of at least two phases of movement of material since the 1920s resulting in a near random distribution over much of the site. Industrial installations at the western and eastern end of the site may have limited the area over which material was spread. Overall, the contamination levels on the Saltmeadows are likely to be one of the highest levels of PCDD/F contamination in the UK and Europe. Compared to other sites where contamination of a similar order of magnitude has been detected in the past, the change of land-use combined with the current recreational nature of land-use and the spread across a wide area prior to any knowledge of the material being contaminated with PCDD/F, created a scenario which was likely to challenge any quantitative risk based assessment tool for contaminated land. This is due to the combination of very high levels alongside limited human exposure pathways.

Three sediment samples had levels of 70, 50, and 330ng/kg I-TEQ respectively all of which showed impact of furan congener patterns along with a strong OCDD signal. We interpreted this to indicate some contaminated material from the alkali works had reached the River Tyne alongside evidence of sewage impact.

Table 1 Descriptive statistics by pattern of surface samples

Congener pattern	I-TEQ [ng/kg]			No of samples (%)	
Industrial/recreational area					
	Min-Max	**Median**	**Mean**		
Deposition	6-165	44	55	7	(7.1%)
Deposition and furan with dominant deposition	7 -265	89	74	12	(12.2%)
Furan	49-25507	2369	873	63	(63.2%)
Furan and deposition with dominant furan	78-550	210	270	8	(8.1%)
Furan and OCDD	1065	N/A	N/A	1	
OCDD	9, 41	N/A	N/A	2	
OCDD and furan	78	N/A	N/A	1	
Other	4, 7	N/A	N/A	2	
ALL	4-25507	492	1604	98	(100%)
School playing field (5/6 with furan influence)	29-115	42	58	6	
Housing estate (4/5 with furan influence)	10-87	61	54	5	
Control 1	63 Deposition				
Control 2	37 Deposition and furan				
Previous study SW sector	14-1911	169	487	13	

Table 2 Descriptive statistics by pattern of subsurface samples

Pattern	I-TEQ [ng/kg]			Number of samples (%)	
Industrial/recreational area					
	Min-Max	**Median**	**Mean**		
Deposition	3.4-11	9.6	9.7	5	(10%)
Deposition and furan with dominant deposition	10-49	22	27	3	(6%)
Furan	139-92376	1653	8309	25	(50%)
Furan and deposition with dominant furan	58-348	83	163	3	(6%)
Furan and OCDD	1397	N/A	N/A	1	
OCDD	0.1-24	5	10	3	(6%)
Other	0.1-102	3	16	10	(20%)
ALL	0.1-92376	132	4199	50	(100%)

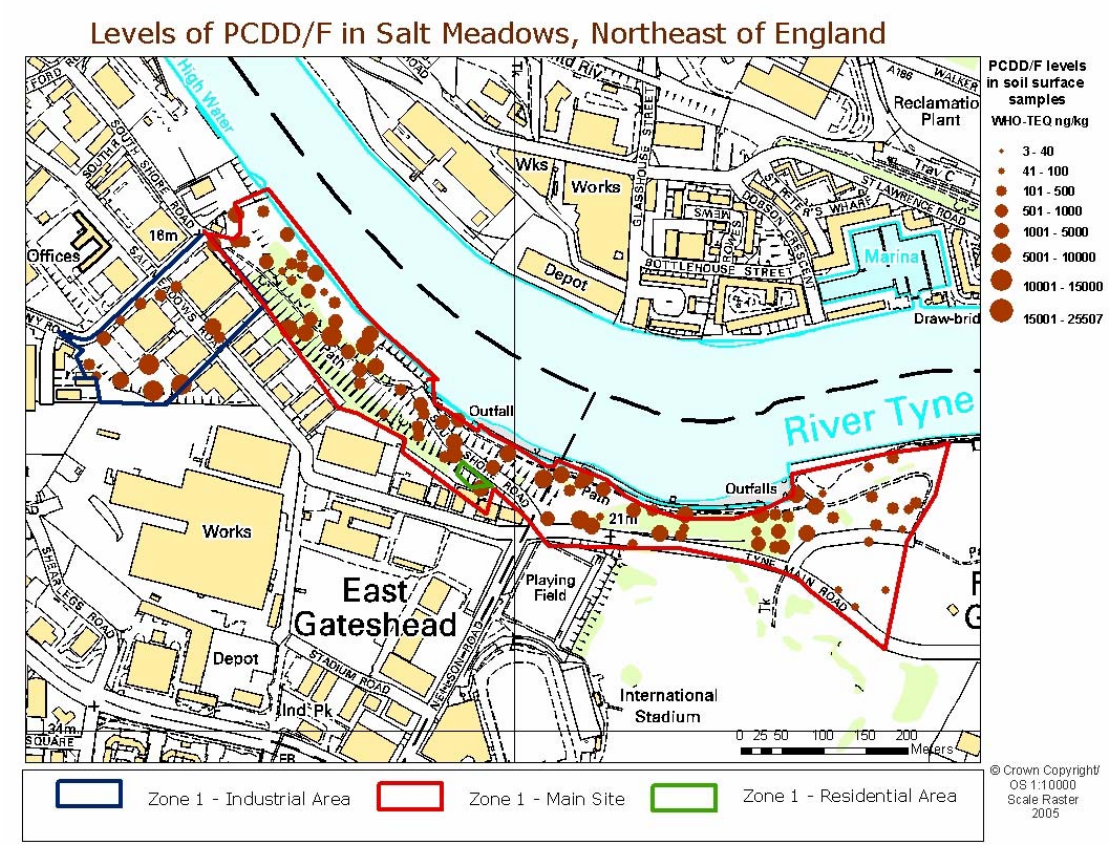
Risk Assessment and Remediation Options

Despite the difficulties of using standard risk assessment tools, they provided some useful guidance in identifying sensitive receptors, key pathways and the frequency of site visits for the assessment of the risk. This in turn facilitated the remedial approach to be targeted at breaking the most relevant source-pathway-receptor linkages. These were very young children ingesting soil.

Most of the site is a steep wooded slope above the river Tyne and contains a nature reserve. Dig-and dump remediation of the site would have posed considerable risk of soil dust emissions and run-off. Combined with the current emphasis on avoiding dig-and-dump remediation, in-situ remediation was considered appropriate for this location. Whilst the recreational use of the site is designed for older children and adults, young children were the considered as most sensitive receptors. Furthermore the apparently immobile nature of the contamination also favoured in situ remediation.

The remediation proposals will exclude people from the majority of the wooded areas whilst at the same time making access safer by providing hard surfacing instead of gravel and mud paths and car-parking areas. An area of short grass will be capped and reinstated for amenity use. An added benefit of this approach is that it will benefit wildlife.

Figure 1 Spatial distribution of surface PCDD/F levels across study area



Conclusions

We conclude that the very specific furan dominated congener pattern was highly useful in determining the extent of contamination across the horizontal and vertical body of soil. The repeated movement of contaminated material created a highly complex pattern of contamination especially in the context of existing risk based assessment tools that form part of UK legislation. We recommend that Local Authorities in areas where electrolysis was used for alkali production should be advised of the findings of this study to enable them to assess risk. This will also enable them to inform developers if necessary and request tests to be carried out prior to development. The current risk based exposure assessment tools such as the UK CLEA need to be improved to reflect more complex exposure scenarios.

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