# Flooding Area And Sediment Contamination Of The River *Mulde*, an *Elbe*-Influx, With PCDD/F And Other Organic Pollutants

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## 1. Objectives

The area of Bitterfeld/Wolfen, a former chemical production center, is generally regarded as heavily contaminated with several organohalogen compounds. Results of a monitoring of this area have been published at DIOXIN'91[1] and DIOXIN'92[2]. Here, sediments of the *Spittelwasser*, which runs into the river *Mulde*, showed PCDD/F contamination up to 3,750 ng TE/kg d.s.. Further investigation focussed on the question of waterborne spreading of PCDD/F and other organohalogen compounds, especially in the flooding areas of the river *Mulde* which after about 30 km enters the stream *Elbe*.

## 2. Approach and methods

The brook *Schachtgraben* served as outlet channel of the chemical industry in the region of Bitterfeld. Its river bed was transposed several times in the past. The *Schachtgraben* flows into the river *Spittelwasser*, which ends in the river *Mulde*. The area covering flooding areas, former and actual river beds and banks of these rivers have been investigated by the authors. 36 sediment and 177 soil samples (partly from deeper soil layers), most of them taken at four theoretical profiles through these rivers, were analyzed for PCDD/F, chlorophenols, chlorobenzenes, HCH (sum), DDX (DDT + metabolites) and other trace contaminants. Eluates of four sediment samples were analyzed for PCDD/F and chlorophenols, too. Sample collection was performed in summer 1992. Ten reset sediment samples from summer 1991 were analyzed, additionally.
PCDD/F analysis followed VDI 3499. Before extraction, the samples are spiked with a mixture of a $^{13}C_{12}$-labelled PCDD- and PCDF-standard per degree of chlori-

nation and with an unlabelled standard for identifying the other organochlorine compounds. Extraction with toluene follows. A smaller part of the raw extract is branched off for chlorophenol detection, while for the larger one clean-up and fractioning by adsorption chromatography on silicagel- and aluminum oxide columns follow. The PCDD/F containing fraction is concentrated and a defined aliquot of the final volume is injected into a GC/MS. Screening analysis and detection of higher chlorinated congeners is performed with a non-polar DB-5 capillary column, isomer specific detection uses a polar capillary column (CP Sil 88), the MS using the MID-mode (multiple ion detection). Quantification is based on standard addition, with a recovery rate of the internal standard of at least 70 %. The chlorophenol containing fraction is cleaned, too. An increase in sensitivity and selectivity is achieved by derivation. Eluate analyses are performed according to DEV S 4. All results refer to dry substance. Calculation of TE PCDD/F according to the German BGA (Bundesgesundheitsamt, Federal Bureau of Health).

### 3. Results

Table 1: Results of soil sample analyses; µg/kg d.s. (n in brackets)

| | ClB (56) | ClP (146) | HCH (157) | DDX (155) | PCB (17) | PAH (18) |
|---|---|---|---|---|---|---|
| min | < 10 | < 10 | < 10 | < 10 | < 10 | 1 |
| max | 21,900 | 9,420 | 1,290,000 | 401,000 | 143 | 4,600 |

Table 2: Results of sediment sample analyses; µg/kg d.s. (n in brackets)

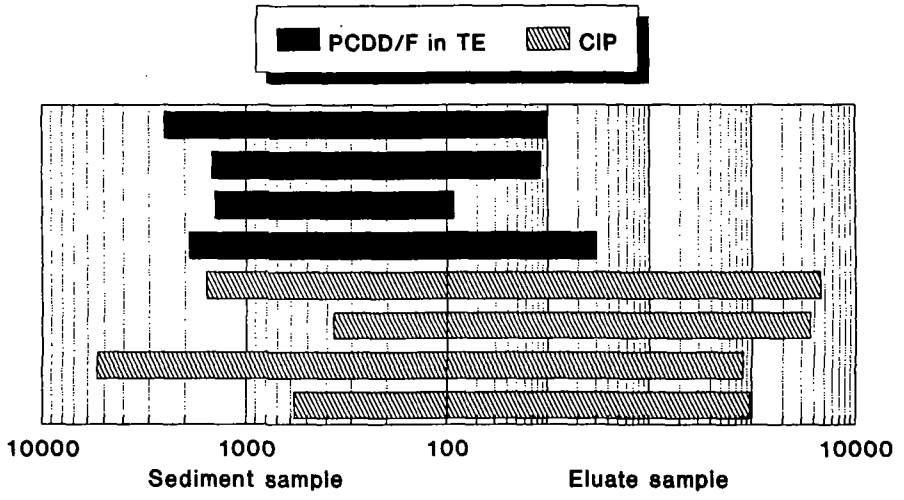
| | ClB (22) | ClP (45) | HCH (38) | DDX (38) | PCB (8) | PAH (6) |
|---|---|---|---|---|---|---|
| min | < 10 | < 10 | < 10 | 30 | 106 | 20 |
| max | 27,300 | 7,500 | 41,500 | 30,800 | 1,920 | 75,900 |

Table 3: Distribution of PCDD/F in soil and sediment samples (ng TE/kg d.s.)

| Soil | n | < 5 | 5 - <10 | 10 - <40 | 40 - <100 | 100-< 1,000 | > 1,000 | > 5,000 | > 10,000 | min | max |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Top | 52 | 3 | 2 | 5 | 9 | 24 | 6 | 3 | - | 1.3 | 8,420 |
| Sub | 21 | 5 | 2 | 2 | 2 | 3 | 3 | 2 | 2 | 1.4 | 203,000 |
| Sed. | 43 | 1 | 1 | 1 | 6 | 23 | 11 | - | 1 | 0.8 | 23,800 |

Table 1 comprises the results of soil and table 2 of sediment samples, table 3 shows the related distribution of PCDD/F. Figure 1 compares organochlorine content in sediment and the respective eluate samples.

Figure 1: Sediment and sediment eluate analyses
PCDD/F in ng TE/kg resp. pg TE/l; CIP in µg/kg resp. ng/l




Lowest rate of PCDD/F elution can be observed in the sediment sample with the highest content of humic substances and organic carbon, while the highest transfer occurs in the sample with the lowest contents of these organic fractions.

**Cross profiles:**
The four cross profiles were

1 southwest to northeast crossing the rivers *Schlangengraben*, *Lobber*, and *Mulde*, about 1 km southeast the City of *Jessnitz*;
2 west to east crossing the river *Spittelwasser* until the banks of the *Mulde*, about 700 m north of the City of *Jessnitz*; here, flooding events and emissions of already shut down and still operating production plants will superpose each other;
3 west to east crossing the river *Mulde*, about 500 m downstream the mouth of the river *Spittelwasser*;
4 southwest to northeast crossing the river *Mulde* between the area of *Dessau-Törten* and the *Scholitzer See* as example for meadows of the river *Mulde* between influx of *Spittelwasser* and mouth of *Mulde* into the river *Elbe*.

**Profile 1** showed always soil values > 40 ng TE/kg, with a decrease in concentration with distance from the river beds; maximum value amounted to > 600 ng TE/kg.
**Profile 2** was located where *Spittelwasser* sediment samples showed > 1,000 ng TE/kg. Soil samples directly from the left bank showed several thousand ng TE/kg (max.: 8,420 ng TE/kg), and a decrease in the flooding area down to > 100 ng TE/kg. Samples taken some 100 m downstream showed high contamination, too, with a maximum of 203,000 ng TE/kg in subsoil layer sample (30 - 60 cm depth). The same soil sample showed a maximum HCH-concentration of 1.3 g/kg and the maximum DDX-concentration with 0.4 g/kg in the second layer. Soil and sediment samples from the upstream area showed a high contamination with these compounds, too.
**Profile 3** showed always soil values > 40 ng TE/kg, with a decrease in concentration with distance from the river bed. Highest soil value of this profile was > 700 ng TE/kg directly at the *Mulde* shore.
**Profile 4** showed > 1,000 ng TE/kg at the *Mulde*-shore with a decrease down to > 100 ng TE/kg with increasing distance to the river.

## 4. Conclusions

The contamination with PCDD/F and other pollutants (HCH, DDX) of sediment and soil in the flooding areas of the rivers *Schachtgraben*, *Spittelwasser*, and *Mulde* reaches partly alarming values. This is even true for samples far away from the suspected emitters (chemical industry at Bitterfeld/Wolfen). Even in the flooding area between *Mulde* and *Elbe*, soil contamination lies often above 100 ng TE/kg. An influence of the contaminated *Mulde* water and sediment can be determined. These results pose hints to a potential pollution of the river *Elbe* by the river *Mulde* - caused by the Bitterfeld industry -, especially by transport of sediment and sediment particles.
Elution tests with sediment samples from the investigated rivers show the risk of re-solving and remobilization of pollutants from river sediments. This poses the risk of re-entry of these substances into the biocycle and of secondary contamination of other sediment and flooding areas, especially of the river *Elbe*.

## 5. References

1 Wilken M, Neugebauer F, Fabarius G, Zeschmar-Lahl B, Jager J. PCDD/ PCDF contamination of different pesticides produced in former GDR. *Poster, presented at DIOXIN'91*, Chapel Hill, N.C., 24.-28.9.1991, see Abstracts: P111, p. 318
2 Wilken M, Cornelsen B, Fabarius G, Zeschmar-Lahl B, Jager J. Soil contamination with PCDD/PCDF and other organohalogen compounds in Bitterfeld/ Wolfen (former GDR). *Poster presented at DIOXIN '92*, 23.-28.9.1992, Tampere (SF)