

# Metal balance in thermal treatment of CCA-contaminated soils

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## Introduction

Chromium, Copper and Arsenic (CCA) are common contaminants in soils affected by wood impregnation operations (Pellerin and Booker 2000; Oremland and Stolz 2003). They also pose a serious threat to the environment and to the health of humans and animals. A common remediation technique for these sites is excavation and land filling of the soil, which causes a lot of transportation and unnecessary negative environmental effects.

Thermal treatment is one of many remediation methods for polluted soil. Directly it cannot remove metalloid impurities from soil, but there was an assumption that the CCA-compounds ends to the fine particle fraction. This particle fraction is removed from the air flow by cyclone- and bagfilters. That way the soil that is coming out of the furnace, should have relatively low CCA-concentrations. One very interesting factor was how to control arsenic volatility during the remediation process (Thurnau and Fournier 1992; Sadiq 1997; Deborah B. Gray 2001). Volatilisation of arsenic also poses serious occupational risk during thermal treatment.

The leaching of the CCA-components before and after the burning tests was also studied. It is one of the most important factors deciding the treatment method of fine particle fraction.

Original purpose was to produce the data in two stages: laboratory tests and field experiments. But difficulties in the process to get the licence for transporting polluted soil from Sweden to Finland, we manage to do only laboratory analysis in time.

## Materials and methods

### *Soil samples*

Soil that has been used in this experiment comes from an old wood impregnation plant in Robertsfors, Sweden.

The soil was dried at room temperature and sieved into different size fractions (<0,125; 0,125-0,250; 0,250-0,500; 0,500-1 mm and a bulk fraction <10 mm) with sieves according to ASTM E11-70 and ISO 3310.

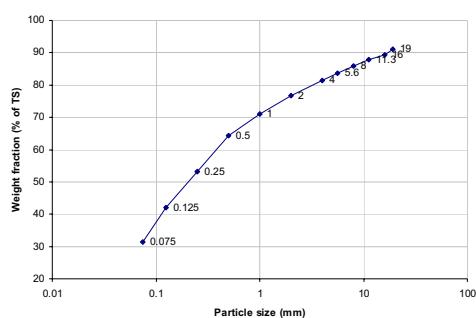
Particle size distribution of the soil was performed according to Swedish standard (SS 02 71 23).

For heat treatment of soil at 800°C for 20 minutes a Carbolite Furnaces CSF 1200 was used. After heat treatment the soil was cooled to room temperature in a desiccator before analysis.

Total element concentration on both untreated and heat treated soil was done by digestion of 1g of soil in 10 ml *aqua Regia* solution using a micro wave digester (Mars 5). Then the solution was analysed by inductively coupled plasma optical emission spectroscopy (ICP-OES, Perkin Elmer Optima 2000 DV).

Leaching tests were performed at a liquid to solid ratio of 10 (L/S 10) according to EN 12457-2 on both untreated and heat treated soil. The samples was shaken for 24 h and then filtered through 45µm nitrocellulose membrane filter. Chemical analysis of elements in leachates was performed by inductively coupled plasma optical emission spectroscopy (Perkin Elmer Optima 2000 DV).

## Results and discussion



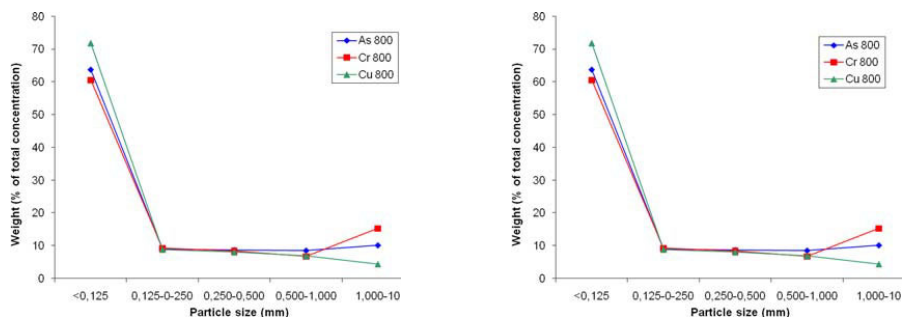
**Figure 1: Sieving curve of the material.**

In the curve can be seen that over 40 % of particles in the sample are smaller than 0.125 mm, which is the size of the particles that goes into filter part of the thermal treatment facility.

The soil sample was sieved into five different size fractions. Chemical analysis results of the different fractions before and after heating tests shows that the main metal concentrations are in the finest

fraction. The distribution of pollutants between different size fractions before and after heating is shown in figure 2. That supports the main presumption, but must be confirmed by the field

experiments.



**Figure 2: Distribution copper, chromium and arsenic in different particle size fractions before (left fig.) and after (right fig.) thermal treatment.**

Leaching tests for the material are also performed before and after heating. Total elemental analysis and analysis results from leachates are presented in table 1.

**Table 1: Total elemental analysis and analysis results of leachates (L/S 10),  $\pm$  SD, n=3.**

	Total concentration			L/S 10			Leaching from total concentration		
	mg kg <sup>-1</sup> dw			mg kg <sup>-1</sup> dw			%		
<b>Untreated</b>	<b>As</b>	<b>Cr</b>	<b>Cu</b>	<b>As</b>	<b>Cr</b>	<b>Cu</b>	<b>As</b>	<b>Cr</b>	<b>Cu</b>
<0,125 mm	352 $\pm$ 7	155 $\pm$ 2	94 $\pm$ 1	0,87 $\pm$ 0,02	0,048 $\pm$ 0,001	0,23 $\pm$ 0,01	0,25	0,03	0,24
0,125-0-250 mm	191 $\pm$ 4	93 $\pm$ 2	49 $\pm$ 1	0,72 $\pm$ 0,02	0,054 $\pm$ 0,002	0,21 $\pm$ 0,01	0,38	0,06	0,43
0,250-0,500 mm	179 $\pm$ 23	93 $\pm$ 15	43 $\pm$ 5	0,84 $\pm$ 0,04	0,068 $\pm$ 0,003	0,22 $\pm$ 0,02	0,47	0,07	0,51
0,500-1 mm	148 $\pm$ 33	82 $\pm$ 22	40 $\pm$ 6	0,83 $\pm$ 0,08	0,058 $\pm$ 0,007	0,17 $\pm$ 0,01	0,56	0,07	0,43
<10 mm	266 $\pm$ 40	123 $\pm$ 30	66 $\pm$ 5	0,97 $\pm$ 0,10	0,040 $\pm$ 0,000	0,19 $\pm$ 0,01	0,37	0,03	0,29
<b>800°C</b>									
<0,125 mm	359 $\pm$ 2	158 $\pm$ 1	76 $\pm$ 1	28,3 $\pm$ 0,4	1,07 $\pm$ 0,08	<	7,86	0,68	0,00
0,125-0-250 mm	187 $\pm$ 3	89 $\pm$ 4	35 $\pm$ 1	28,7 $\pm$ 0,1	0,50 $\pm$ 0,01	0,012 $\pm$ 0,001	15,4	0,56	0,03
0,250-0,500 mm	187 $\pm$ 23	83 $\pm$ 8	33 $\pm$ 2	30,9 $\pm$ 0,8	0,14 $\pm$ 0,00	0,014 $\pm$ 0,001	16,5	0,16	0,04
0,500-1 mm	297 $\pm$ 81	108 $\pm$ 4	45 $\pm$ 3	30,5 $\pm$ 0,7	0,80 $\pm$ 0,09	0,013 $\pm$ 0,002	10,3	0,74	0,03
<10 mm	275 $\pm$ 14	127 $\pm$ 12	52 $\pm$ 4	28,0 $\pm$ 0,7	1,65 $\pm$ 0,24	0,001 $\pm$ 0,000	10,2	1,30	0,00

< Below instrument detection limit

The increasing of leaching of arsenic and chromium is noticeable. There are some possible explanations why this happens. Arsenic and chromium can be found in many forms in former wood preservation sites (Steen Honoré Hansen 1992; Bhattacharya, Mukherjee et al. 2002) and are mostly in the organic material in the soil (bark, woodchips, sawdust). When heating the soil at 800°C the organic matter is incinerated and arsenic is released and chromium form more soluble compounds (Pizzi 1981; Pizzi 1982; Helsen, Van den Bulck et al. 2003).

The assumed evaporation of arsenic was not detected. There are some TGA-experiments which shows that chromium and copper forms arsenates, when CCA-containing lumber waste is heated in the air or nitrogen (A. K. Kercher 2001; Toshimitsu Hata 2004).

## Conclusions

The distribution of copper, chromium and arsenic is biased toward the fine fraction. Thermal treatment affects both the size distribution and mobility of elements. Thus the treatment system offers a potential to concentrate hazardous elements to a small fraction of the total mass. However, the conditions in the laboratory are not the same as those of a large scale treatment facility, and the control of operational conditions are crucial for the success of such strategies. This has to be assessed in full scale operations. The concentrated fraction needs further treatment. Also the purified soil may need amendment in order to stabilise remaining pollutants. The working environment needs attention, especially considering the management of the fine dust particles.

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