Immobilisation of Cu and Cr(VI) leached from MSWI bottom ash using natural systems

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Introduction

The use of bottom ash from MSWI in urban construction, e.g. roads, is common in European countries. However, this may possess a risk to the environment if pollutants, such as heavy metals, are leached out with the percolating water.

Grassed swales or ditches constructed along the roads are usually used for urban storm drainage pollution control (Bäckström, 2002). Also they may serve as a treatment facility for the leachate from the road through retention of metals in the soil and prevention of groundwater pollution. By steering the soil composition (e.g. soil organic matter (SOM) content) high retention of heavy metals can be reached.

Peat could be used as a cover material for the ditches to accumulate metals along the road. It is rich in organic matter and has a high potential accumulation ability of toxic metals (Ho et al., 1995; Ledin et al., 1996; Brown et al., 2000). However, variations of pH can influence the peat retention capacity of heavy metals. Alkaline conditions leads to dissolution of SOM. Soluble organics increase the mobility of metals at elevated pH by forming soluble metal-OM complexes (Stevenson, 1994).

The usage of plants might prove to be useful to prevent desorption of contaminants from the soil, i.e. phytostabilisation may be applied as a complementary remediation technique. Phytostablilization reduces the risk of soil contaminants through the formation of insoluble contaminant species with the help of soil amendments, such as organic material (Berti and Cunningham, 2000).

A laboratory and field experiment were performed (1) to analyse the retention capacity of two substrates: peat and mould towards Cu and Cr(VI) leached from bottom ash; and (2) to determine whether phytostabilisation can be a feasible technique to retain metals in the soil using organic matter as a soil amendment.

Materials and Methods

Soil samples taken from the ditches located along the road built on bottom ashes before and after the vegetation period were analysed for heavy metals to determine the retention capacity of the soil under the influence of plants. Two substrates: peat and mould were used in column test.

The column test was performed using leachate, which was generated from the MSWI bottom ashes according to the standard leaching test (NT ENVIR 002) at a liquid to solid ratio (L/S) of 1, 10, and 100 l/kg (Douar, 2002).

The standard columns (bed height 4 times the internal diameter of the column) were filled with substrate samples and run in duplicates using all three types of leachate. Leachate was added with inflow in the bottom by means of a pump at the flow rate of L/S 10/day. Filtrated (0.45 µm) eluate was stored in the refrigerator until analyzed for Cu and Cr by use of ICP optical emission spectroscopy.

Results and discussion

Figures 1 and 2 illustrate the retention of Cu and Cr(VI) by substrates, respectively.

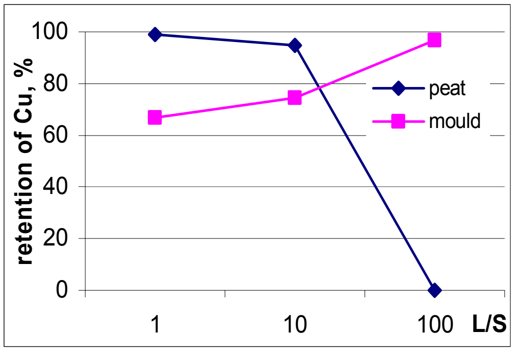

Figure 1 Retention of Cu by substrates using leachate of L/S 1, 10, 100.

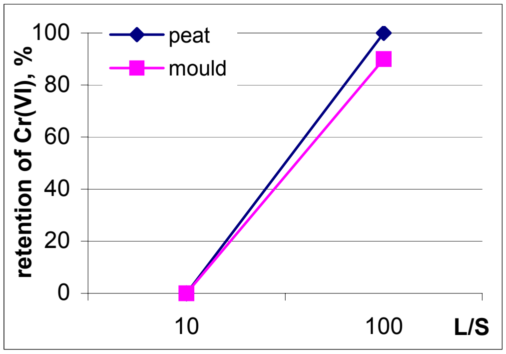

Figure 2 Retention of Cr(VI) by substrates using leachate of L/S 10 and 100.

The increasing concentration of Cu in the leachate decreased the retention capacity of mould from 96.7% to 66.9%, which shows that retention capacity of the mould toward increasing concentrations of Cu is somehow limited.

The contrary effect was observed for the peat: decreasing concentration of Cu decreased the retention of the metal from 99% to zero. This may be due to the high concentrations of Ca (L/S1=661 mg/l; L/S10=585 mg/l; L/S100=63.6 mg/l) in the produced leachate, which is a predominant exchangeable cation in all soils. Also, Ca can have a higher affinity for the exchangeable sites at low initial heavy metal concentrations (Basta and Tabatabai, 1992). The obtained results are in the agreement with those achieved by Duard (2002).

The pH of the leachate was 12.7 for L/S 1, 12.6 for L/S 10, and 11.7 for L/S 100. Such alkaline conditions may increase the substrate pH and thus the solubility of SOM, which seemed to be confirmed by the tarnishing colour of the eluate with the decreasing leachate L/S ratio. Cu can be leached out as a metal-SOM complex (Stevenson, 1994). Conversely, the metal analysis of the eluate from peat did not contain increased Cu concentration indicating that metal-SOM complexes were retained either within column or filter cake. Thus, filtration might be an important factor to retain metal-SOM complexes within soil. Dense root system of plants might serve as a natural filter and minimize the percolation of dissolved metal-SOM complexes. On the other hand, the reduced Cu concentration in the eluate could be due to the precipitation of $Cu(OH)_2$ at high pH.

The increasing Cr(VI) concentration in the leachate decreases retention of the metal by both substrates to zero. However, the results can be speculative, since the Cr(VI) concentration in the leachate was very low (3-5 µg/l) and at L/S 1 no Cr was leached from the ashes. Regardless of the low metal concentration at L/S 1 and 10 Cr was not adsorbed; contrary it was desorbed from both substrates. It has been found that the retention of Cr(VI) decreases with increasing pH (Dean and Tobin, 1999; Guha et al., 2001; Ucun et al., 2002). This is in the agreement with results obtained in our experiment.

Conclusions

The retention capability of peat towards Cu increased with increasing Cu concentration in the leachate and pH despite the dissolution of SOM. Contrary effect was observed for the retention of Cr. However, mould was more effective in retention of low concentrations of Cu than peat. Whether plants can act as a natural filter for the dissolved metal-SOM complexes and help the soil to keep hold of retained metals is the next question to be answered.

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