ABSTRACT: The use of municipal solid waste incineration (MSWI) bottom ash in road construction may possess a risk to the environment due to the release of e.g. salt and heavy metals. In this study, two years of leachate data from a test road built of MSWI bottom ash and crushed rock in northern Sweden were evaluated. It was found that Cu, Cr, Al, Na, and Cl- were leached in higher amounts from the bottom ash, while the release of Zn, Mg, Ba, and Ca was higher from the crushed rock. The difference between ash and crushed rock leachates decreased over time, mainly due to changes in the ash leachate composition. The road pavement reduced the release rate of most pollutants from the bottom ash compared to the release from the uncovered parts of the road, whereas the release of pollutants from the crushed rock was less affected by the presence of a pavement.

KEY WORDS: Roads, construction materials, environmental impacts

1 INTRODUCTION

Roads built with municipal solid waste incineration (MSWI) bottom ash may possess a risk to the environment if pollutants, e.g. salts and heavy metals, are leached out. In order to evaluate the appropriateness of using MSWI bottom ash as a road construction material, a test road was built outside of Umeå in northern Sweden during the summer of 2001. The road includes reference sections built with crushed rock. The aim of this study was to evaluate:

- The quality differences of leachates from MSWI bottom ash and crushed rock used in roads.
- The impact of time and construction design on the leachate quality.

2 METHODS AND MATERIALS

The test road is 320 m long and divided in sections which contain a 0.4 m thick sub-base layer of either MSWI bottom ash or crushed rock. The ash originates from Dåva power plant in Umeå, which is fuelled with MSW and small fractions of sorted industrial wastes such as wood rubber and plastics. The reference material consists of quartz-diorite crushed to a particle size of 0 to 80 mm.
Leachate from each section was collected separately in two lysimeters: one under the road pavement and one positioned mainly under the slope outside of the pavement. Leachates sampled from October 2001 to October 2003 were evaluated using multivariate data analysis (MVDA).

3 RESULTS AND DISCUSSION

The difference in quality of leachates from crushed rock and MSWI bottom ash was found to be significant at the 5% significance level ($\alpha=0.05$). In general, the ash leachate contained higher concentrations of Cu, Cr, Al, Na, and Cl$^-$, while the release of Zn, Mg, Ba, and Ca was higher from the crushed rock. The difference in leaching of Co, Pb, Ni, and SO$_4^{2-}$ from the two materials was not significant ($\alpha=0.05$).

The quality of the leachates was changing considerably over time. A significant ($\alpha=0.05$) difference between leachates from the first sampling season, and the two following years of sampling was found. Most constituents occurred at high concentrations during the first few months of leaching and then rapidly decreased. Such trends were observed for e.g. Cu, Cr, Cl$^-$, Na, and Ca in the ash leachate. Some elements, e.g. Al in ash leachate and Zn in leachate from crushed rock, showed high and largely fluctuating concentrations throughout the two years of sampling. The difference between leachates from MSWI bottom ash and crushed rock decreased over time (Figure 1), mainly due to the decreasing amounts of salts and heavy metals leached out from the ash.

![Figure 1: Principle component (PC) analysis of leachates from the test road.](image)

The majority of leachate was generated in the slopes outside of the road pavement. In the ash layer, the release rates of pollutants were significantly ($\alpha=0.05$) higher from the slopes than from the middle of the road. For example, leachate from the slopes contained 0.05-0.2 g/l of Cl$^-$ after two years of leaching, while concentrations in leachate generated below the pavement ranged from 1 to 2 g/l. Thus, the pavement of the road prevented a rapid wash-out of Cl$^-$ from the ash. No similar observations could be made for leachates from the crushed rock.
Further, ash leachate concentrations of e.g. salts and Zn decreased with increasing liquid-to-
solid ratio, i.e. in leachates from the slopes, which probably is an effect of dilution. In contrast,
Al and Cr showed increased mobility with an increasing degree of material wetting. Possibly, the
increased Al mobility was due to the relatively higher pH found in leachates from the slopes,
while oxidation of the uncovered ash upon contact with air could explain the increased mobility
of Cr.

4 CONCLUSIONS

It was found that pollutant concentrations in leachate from MSWI bottom ash tend to become
comparable, or for some pollutants, even lower than from crushed rock, mainly due to the
variation in the ash leachate composition. In general, Cu, Cr, Al, Na, and Cl were leached in
higher amounts from the bottom ash, while the release of Zn, Mg, Ba, and Ca was higher from
the crushed rock.

The leaching of pollutants from the bottom ash was influenced by the construction design
through the rate of water infiltration and the gas exchange with the atmosphere. Thus, different
utilisation scenarios will lead to different release rates and extents for the same material, which
need to be considered when assessing an intended use of MSWI bottom ash in road construction.

Environmental changes altering pH and redox conditions may affect the release of pollutants
in the future. The magnitude of such processes needs to be estimated and the potential
environmental impacts assessed. For validation, the impacts need to be studied in field, which
requires longer term monitoring data of test roads.

ACKNOWLEDGEMENTS

This work was financially supported by the Swedish Research Council for Environment,
Agricultural Sciences and Spatial Planning, project no. 25.0/2001-0446, Bottom Ash in Road
Construction.