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Resources, Conservation and Recycling 48 (2006) 26–40
Resources Conservation & Recycling
www.elsevier.com/locate/resconrec

Environmental systems analysis of the use of bottom ash from incineration of municipal waste for road construction

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Received 20 September 2004; accepted 17 November 2005
Available online 19 January 2006

Abstract

Bottom ash, originating from municipal solid waste incineration (MSWI), is a potential road construction material. The aim of this study was to describe what differences in resource use and emissions that can be expected if crushed rock in the sub-base of a road in the Stockholm region in Sweden were to be substituted by MSWI bottom ash, taking into account the whole life cycle of the road and including alternative disposal of the bottom ash. An environmental systems analysis approach based on a life cycle perspective was outlined and used in a case study. It was found that the studied alternatives would cause different types of potential environmental impact; whereas, crushed rock in the road's sub-base would lead to larger use of resources, the alternative with MSWI bottom ash in the sub-base leads to a larger contaminant leaching. The results are sensitive to the transport distance for the road material and to conditions affecting the leaching from the road. The differences between energy uses in the two alternatives derive mainly from production of crushed rock and from landfilling of MSWI bottom ash, whereas, the metal emissions occur in the use stage of the road's life cycle.

Keywords: Environmental impact; Disposal; LCA; Waste management; MSWI bottom ash

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doi:10.1016/j.resconrec.2005.11.004

1. Introduction

Swedish environmental objectives call for an increased recycling of resources. One possibility discussed during the last decade is to recycle bottom ash from municipal solid-waste incineration (MSWI) as a road construction material. Previous research on the technical properties of MSWI bottom ash has shown that this material can meet the technical requirements for an unbound sub-base layer in a road (Arm, 2003). In Sweden up to 400,000 tonnes of MSWI bottom ash material are formed annually and disposal of this material is resource consuming. In addition, the space at existing landfills is limited and it is hard to find new suitable areas for waste disposal. Use of bottom ash in road constructions would enable less disposal of bottom ash and at the same time the amounts of rock extracted for road building purposes would be reduced.

Apart from being acceptable from a geotechnical perspective, it has to be proven that the material is environmentally friendly if it is to be used in road constructions. Traditionally, environmental assessments of MSWI bottom ash in constructions have focused on leaching aspects (Olsson, 2005). In particular, the chemical properties and leaching mechanisms of the material has been thoroughly investigated (i.e. Wiles, 1996; Chandler et al., 1997; Fällman, 1997; Meima and Comans, 1999; Meima et al., 2002). In some cases, the potential leaching from the material in field settings (Fällman and Hartlén, 1994), or more specifically, in road constructions (Hartlén et al., 1999; Bruder-Hubscher et al., 2001) has been estimated and frameworks for risk assessments and critical limit definition has also been developed (i.e. Kosson et al., 2002; Apul et al., 2003; Petkovic et al., 2004).

However, while much emphasis has been placed on risks of contaminant leaching, little attention has been paid to other kinds of impact, such as resource use and emissions that do not originate from the road material. To discuss the use of resources and environmental impact from a wider perspective, an environmental systems analysis (ESA) approach may be useful. Such an analysis would provide a tool for strategic environmental assessment (SEA), which is required for strategic decision-making according to EU-directive 2001/42/EG. Roth and Eklund (2003) argue that current leaching tests only forms the first level of environmental assessment for alternative materials and that it should be complemented by the broader system boundaries used in substance flow studies and in life cycle assessments (LCA). This would be particularly important when there is a conflict between different environmental impacts. In another study (Tossavainen and Forssberg, 1999), LCA is also suggested as a method to assess the environmental impact of alternative road construction materials.

There are a few cases where this approach has been used for evaluation of alternative materials in road constructions. In Denmark, a model for LCA of road construction and disposal of MSWI residues has recently been developed (Birgisdottir, 2005). In Finland, Mroueh et al. (2001) used a life cycle perspective to assess the environmental impact from alternative road and earth constructions. They found that the use of by-products as a substitute for natural aggregates could reduce the environmental impact for some impact categories. However, the project did not include MSWI bottom ash. No similar studies have been found that address the utilization of MSWI bottom ash in road constructions for Swedish conditions. For other parts of the waste management system (i.e. the handling