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Soil indicators used in road environmental impact assessments

Agnès Jullien *, Denis François

Laboratoire Central des Ponts et Chaussées, route de Bouaye, BP 4129, Bouguenais Cedex, France

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Abstract

This study has been aimed at proposing a set of specific indicators for the impact assessment of road soils in contact with pavement layers made of industrial byproducts. Two French roads having undergone a 20-year service cycle, one located on a silty surrounding soil and the other on a sandy soil, is studied herein. The pollutant fluxes released by road layers are first determined with respect to a functional unit, according to LCIA protocol. Next, beginning with impact study principles and a local soil state characterization, a reference soil assessment is also performed. Trends in pollutant variations, expressed using road-specific indicators as a function of soil depth, are analyzed and any unexpected maximum values highlighted. A chemical species analysis is then proposed in each local context with respect to the soil type. The capacity of the set of proposed indicators to assess the road's environmental impacts on soils for other sites is discussed in the paper's final section.

Keywords: Soil; Indicator; Road; Impact; MSWI bottom ash; LCI; Heavy metals; Pollution

1. Introduction

Roads play a major role in stimulating society's economic and social progress. Considerable efforts have been undertaken over the years for the purpose of developing a road

* Corresponding author at: Division TGCE-LCPC, Laboratoire Central des Ponts et Chaussées, route de Bouaye, BP 4129, 44341 Bouguenais Cedex, France. Tel.: +33 2 40 84 59 38; fax: +33 2 40 84 59 92.
E-mail address: agnes.jullien@lcpc.fr (A. Jullien).

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infrastructure network featuring a high level of service. In France, recycled aggregates along with industrial byproducts have been used ever since 1980 for road construction with several kinds of pavement layers, for technical investigations or when certain conventional materials are in short supply locally. This trend has accelerated since promulgation of the 1992 law (Law No 92-646, 1992) relative to the decrease in waste disposal volumes. Both natural resource saving and waste reduction have become major requirements when dealing with environmental impacts tied to the use of secondary raw materials for road construction purposes (Michel, 1997).

2. Context and objective

2.1. Conventional road design

In France, road material characteristics, structural design and maintenance operations are defined by means of guidelines or standards (SETRA and LCPC, 1994, 1998, 2000). Roads submitted to heavy traffic loads are usually designed for a 30-year service life (Peyronne and Caroff, 1984). Rigid pavements (cement) and flexible pavements (asphalt) represent the two main kinds of conventional pavements. They are made of natural raw materials, in the majority of circumstances. The deepest layers of the road structure are designed to remain mechanically stable throughout the infrastructure life cycle without maintenance, whereas the upper layers are regularly removed and rebuilt with possible thickness changes.

Natural aggregates are considered to contain very small amounts of pollutants (ADEME, 1996). In most cases, these materials possess physicochemical properties that lead to expecting an absence of any reaction when exposed to water flow through road layers. Hence, leaching properties have not been extensively studied within French road materials. Furthermore, only a few studies on asphalt pavement pollutant release during road operations have been carried out at an international scale (Brandt and de Groot, 2001; Tossavainen and Forssberg, 1999).

2.2. MSWI bottom ash used in road layers

Up until now, the code of practice for road structures has been changing so as to insert the missing guidelines for alternative materials. Mechanical properties, as well as the environmental effects of such products, have been investigated by means of chemical characterization and water or soil assessment. Among the secondary raw materials, municipal solid waste incinerator (MSWI) bottom ash has been used for several decades (Cimpelli et al., 1998; Michel, 1997). Standard tests are commonly performed (e.g. Los Angeles, Micro-Deval, bearing capacity) in order to compare MSWI bottom ash mechanical properties with typical properties required for classification within the standardized reference system for the natural materials (AFNOR, 1992). The specifications for MSWI bottom ash layer thickness are to be determined in accordance with the conventional rules developed for classical materials (SETRA and LCPC, 2000). MSWI bottom ash, which exhibits weak mechanical properties, is used in either the sub-base, subgrade, capping layer or embankment component.