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The creosote content of used railway crossties as compared with European stipulations for hazardous waste

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ABSTRACT

Through the history of railways, wooden crossties impregnated with potentially hazardous creosote tar have supported the rails. With impregnated crossties having a lifespan of approximately 50 years, their creosote content is considered as quite safely stored while in dug-down usage. This situation of relative safety does, however, change into acute risk upon replacement and destruction. Carrying a highly flammable content, creosote crossties discharge a pulse of carcinogenic PAH compounds if burnt as ordinary waste. Safe destruction is therefore required if concentrations exceed a critical limit stipulated by the European Union. Since safe destruction is a process of considerable expense, there is a tendency among financial stakeholders to underestimate the creosote content of used railway crossties. In order to actually test whether concentrations generally exceed the critical limit, a set of used creosote ties was therefore sampled while still situated in the railway embankment. With a standard sum of sixteen PAH compounds used as an expression of their total creosote content, the generic concentration was formally inferred and found to significantly exceed the critical limit. The same applies to the fraction of seven carcinogenic PAH compounds, that alone exceed the stipulated limit for hazardous waste. It was also found that the material of railway embankments, whether or not the crossties were used in switches and/or railway yards, and sample depth within the crosstie, has a significant effect on creosote concentrations. Regardless of the status of these factors, the concentrations significantly exceed the critical limit that defines hazardous waste within the European Union.

1. Introduction

1.1. Study objective

At times when receding oil reserves are being rapidly transformed into hazardous pollution and the end of the petroleum era seems to be at hand, sustainable systems of effective transportation are bound to gain new political momentum. Railway communication is destined for a renaissance, which is a development that needs to be managed with environmental concern. One particular source of environmental threat exerted by a general railway system is the creosote emissions that emanate from the usage of impregnated wooden railway crossties. Large amounts of creosote crossties are installed throughout a typical railway system (as an example, approximately 8.5 million crossties along 15,000 km of Swedish railway), exposing correspondingly large volumes of potentially carcinogenic tar compounds to the environment. Although rendered long by impregnation, wooden crossties have a limited lifespan of approximately 50 years with an average of 180,000 creosote crossties, containing totally 3–7 kt of creosote tar, being annually replaced in Sweden

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only (Larsson and Andersson-Sköld, 2004). Upon replacement, the used crossties should be classified as environmentally hazardous if their total creosote content exceeds the limit concentration of 1000 ppm dry weight (1 g per kg dry weight) stipulated by the European Union (EU) (75/442/EEC, 1975; 91/156/EEC, 1991; 94/67/EEC, 1994).

When railway crossties are inspected for possible replacement, they are typically batch-wise removed from the railway embankment and transported to a depot where they are examined for possible re-use. The creosote content is not at all considered at this stage, it focuses entirely on the physical condition of individual crossties. If they are found to be fit for re-use they are re-installed irrespective of their creosote content, whereas crossties that do not pass the examination are sent for destruction after an eventual period of intermediate deposit. The method for destruction as well as the terms for intermediate deposit do, however, depend strongly on the associated creosote concentration. Crossties considered as hazardous waste require substantially larger resources for deposition and destruction than non-hazardous dittos. In accordance with basic economic law, this might explain the tendency for financial stakeholders to underestimate the creosote content of used railway crossties, and/or to question the toxicity of creosote that has been exposed to evaporation, gravity and biological exposure (e.g.) for decades. It is therefore important to investigate whether a general consensus on the creosote content of railway crossties, used to the brink of replacement, may be based on realistic empirical data. With the total number of crossties examined for possible replacement being very large when counted over a long enough period of time, basing such an investigation on chemical analyses of individual crossties is not a realistic option. In this study, a sample of creosoted crossties has therefore been carefully chosen to represent the generic population of used railway crossties in order to formally infer generic creosote content. If the generic concentration may be proven to exceed the EU-limit upon reasonable levels of significance, individual crossties should be treated as environmentally hazardous (and vice versa). With the sample of crossties chosen to represent factors such as the materials of crossties and railway embankments, and whether or not the crossties were used in switches and/or railway yards, we also test whether these factors affect generic creosote concentration.

1.2. *The creosote content of used railway crossties*

The study of used creosote crossties presented here was conducted by the National Swedish Railway Administration in order to replace large amounts of railway crossties situated along mid-Swedish stretches of typical temperate/boreal landscapes. In order to withstand biological degradation through decades of dug-down usage, wooden crossties are commonly impregnated with creosote tar and should be considered as environmentally harmful if they contain creosote enough to exceed the EU-defined limit of 1000 ppm dry weight. While creosote compounds vary widely with respect to evaporation potential and gravitational exertion (i.e. molecular weight) (Petrowitz and Krüger, 1991; Kohler et al., 2000), their solubility is considered as being generally poor (Hockensmith et al., 1994). Creosote crossties are therefore commonly regarded as releasing potentially harmful substances at rather harmless rates while kept in the railway embankment. This situation of relative safety does, however, change into acute risk when crossties are being replaced and, ultimately, burnt. Carrying a flammable content of creosote tar, they discharge a pulse of carcinogenic PAH compounds upon destruction. The environmental risk associated with creosoted railway crossties is therefore primarily related to the processes of disposal and destruction of used crossties, which sets our study objectives on inferring the creosote content of railway crossties used to the brink of replacement.

Creosote tar is a rather vaguely defined distillation of pit coal that contains approximately 350 different organic substances whereof a majority may be classified as polycyclic aromatic hydrocarbons (PAHs). Among these, many are considered as being carcinogenic which renders the entire complex of creosote tar to be classified as potentially carcinogenic (KIFS, 1994:12). According to the EU directives 75/442/EEC, 91/156/EEC, and 94/67/EEC, which have lead to the Swedish statute regulations of waste, SFS, 2001:1063, any waste that exceeds the critical creosote limit should be regarded as hazardous and dealt with at strict precaution. In compliance with international standards, the Swedish Environmental Protection Agency (SNV) recommends (SNV report 4638, 1996) total creosote concentrations to be targeted with the summed concentration of sixteen specified PAH compounds (PAH_{16} — Table 1) whereof seven are considered to be carcinogenic (PAH_C— Table 1). Since creosote tar varies tremendously with respect to the number and composition of constituent ingredients, and with the EU directives addressing the total content of such an elusive substance, the relation between PAH_{16} and the total creosote concentration is a matter of current debate. Based on an increasing volume of laboratory evidence (SGAB, 2004; Jelnes, 1995), SNV cautiously considers (Christiansson, personal communication) the relatively well defined concentration of PAH_{16} to constitute maximally 15% of the creosote concentration targeted by the EU. The lower limit of what should be considered as a hazardous concentration of PAH_{16} should therefore be set to 15% of the critical concentration stipulated by the EU, which

Table 1 – The PAH compounds constituting PAH_{16} and the carcinogenic fraction PAH_C respectively

PAH_{16} component	PAH_C component
Acenaphtene	
Acenaphtylene	
Antracene	
Benzo(a)antracene	X
Benzo(a)pyrene	X
Benzo(b)fluorantene	X
Benzo(k)fluorantene	X
Benzo(g,h,i)perylene	
Dibenzo(a,h)antracene	X
Phenantrene	
Fluorantene	
Fluorene	
Indeno(1,2,3-cd)pyrene	X
Chrysene	X
Naphthalene	
Pyrene	