Available online at www.sciencedirect.com

SCIENCE DIRECT®

Engineering Geology 77 (2005) 331–338

ENGINEERING GEOLOGY

www.elsevier.com/locate/enggeo

Electrodialytic remediation of CCA-treated waste wood in pilot scale

Anne J. Pedersen[a,*], Iben V. Kristensen[a], Lisbeth M. Ottosen[a], Alexandra B. Ribeiro[b], Arne Villumsen[a]

[a]*Department of Civil Engineering, Technical University of Denmark, Kemitorvet, Building 204, DK-2800 Lyngby, Denmark*
[b]*Departamento de Ciências e Engenharia do Ambiente, Faculdade de Ciências e Tecnologia, Universidade Nova de Lisboa, Quinta da Torre, 2829-516 Caparica, Portugal*

Received 1 June 2003; accepted 1 July 2004
Available online 15 September 2004

Abstract

When chromated copper arsenate (CCA)-treated wood is removed from service and turns into waste, the contents of Cu, Cr and As remain high due to the strong fixation of CCA in the wood. This high content of toxic compounds presents a disposal challenge. Incineration of CCA-treated waste wood is not allowed in Denmark; instead, the wood is to be land-filled until new methods for handling the wood are available. Since the amounts of CCA-treated wood being removed from service is expected to increase in the years to come, the need for finding alternative handling methods is very relevant. In this study, the usefulness of Electrodialytic Remediation was demonstrated for handling of CCA-treated waste wood in pilot scale. The electrodialytic remediation method, which uses a low-level direct current (DC) as the cleaning agent, combines electrokinetic movement of ions in the wood matrix with the principles of electrodialysis. It has previously been shown that it is possible to remove Cu, Cr and As from CCA-treated wood using electrodialytic remediation in laboratory scale, but until now, the method had not been studied in large scale. The pilot-scale plant used in this study was designed to contain up to 2 m^3 wood chips. Six remediation experiments were carried out. In these experiments, the process was up-scaled stepwise by increasing the distance between the electrodes from initially 60 cm to finally 150 cm. The remediation time was varied between 11 and 21 days, and phosphoric acid and/or oxalic acid was used to facilitate the desorption of CCA from the wood. In the most successful of the experiments carried out, the concentration of CCA in the wood was reduced by up to 82% for Cr, 88% for Cu and at least 96% for As.

Keywords: Electrodialytic remediation; CCA-treated wood; Copper; Chromium; Arsenic

* Corresponding author. Tel.: +45 45 25 23 97; fax: +45 45 88 59 35.
E-mail address: ajp@byg.dtu.dk (A.J. Pedersen).

0013-7952/$ - see front matter © 2004 Elsevier B.V. All rights reserved.
doi:10.1016/j.enggeo.2004.07.023

1. Introduction

The wood preservative chromated copper arsenate (CCA), which has been used since the 1950s, is to date the most widely used wood preservative worldwide. It is accepted as one of the most effective treatments for protection of wood against fungi, insects and marine borers. Due to the strong fixation of CCA in the wood, the average lifespan for CCA-treated wood is as long as 20–40 years. However, a concern for the environmental impact of As in CCA preserved wood has led to restrictions in the use of CCA in recent years in many countries (Kristensen et al., 2004). In Denmark, the use of As, and thereby CCA, for wood preservation has been prohibited since 1993 (Miljø and Energiministeriet, 1999). In the U.S., CCA will be forbidden for residential use (e.g., picnic tables and play structures) by 2004, and currently the European Union is proposing to restrict the use of CCA-treated wood to industrial use only (e.g., cooling towers, railway sleepers and electricity and telephone poles) (Kristensen et al., 2004).

Due to the strong fixation of CCA in the wood, the contents of the toxic components Cu, Cr and As remain high when the wood is removed from service and turns into waste. However, while there has been increasing focus on the use of CCA in the past years, only few countries have legislation on the handling of the waste wood. Only two commercial methods for handling of CCA-treated waste wood are available at present: incineration/gasification or disposal by land filling. In the case of incineration, the need for land filling (or additional treatment) remains, as the metals accumulate in highly toxic combustion residues. Other treatment methods, such as chemical and biological extraction (e.g., Clausen and Smith, 1998), are still in the research stage. In some countries, incineration of the wood is recommended, while others recommend land filling. Denmark is one of the few countries with a strict legislation on CCA-treated waste wood. Incineration of CCA-treated wood is not allowed in Denmark. This is primarily due to the risk of release of As into the atmosphere, and the fact that the heavy metals from the wood will be concentrated in the combustion residues. Thus, deposition is the only alternative until new methods that ensure reuse of the resources of the wood, i.e., energy and metals, have been developed. When such a method becomes available, the wood should be collected and treated separately (Miljø and Energiministeriet, 1999).

The amount of CCA-treated wood waste is expected to increase significantly in the years to come. In Denmark alone, it is estimated that 17,000 tons of treated wood was removed from service in 1992; but by 2010, an estimated amount of 100,000 tons is to be removed yearly (Miljø and Energiministeriet, 1999). The same pattern is seen in other European countries and in the U.S. (Solo-Gabriele and Townsend, 2000; Ribeiro et al., 2000). Therefore, there is indeed a need of finding environmentally safe handling methods for this kind of waste. Electrodialytic remediation could be such a method. One advantage of electrodialytic remediation is the potential of reusing the end products—wood and process liquids. At optimised conditions, it is expected that Cu, Cr and As can be removed almost completely from the wood during electrodialytic remediation. Afterwards, the metals can be recovered and possibly reused in new wood preservatives. The remediated wood, which no longer contains hazardous components, may be burned in order to utilise the energy resources, or even reused.

The objective of this present study is to demonstrate the utility of the method electrodialytic remediation for handling of CCA-treated waste wood by using a pilot-scale plant containing up to 2 m^3 wood chips.

2. The principles of electrodialytic remediation

The electrodialytic remediation method, which was originally developed for remediation of heavy metal-polluted soil is developed and patented by researchers at DTU (Ottosen et al., 1997; Ottosen et al., 2000). The method, which uses a low-level direct current as cleaning agent, is a combination of electrokinetic remediation and electrodialysis. The principle of electrodialytic remediation in laboratory scale is shown in Fig. 1.

The polluted medium (e.g., wet soil or wood chips soaked in an aqueous phase) is placed in compartment II. Compartments I and III are electrode compartments containing inert electrodes and circulating electrolyte solutions. The electrode compartments are separated