Bioresource Technology 123 (2012) 92–97

Contents lists available at SciVerse ScienceDirect

Bioresource Technology

journal homepage: www.elsevier.com/locate/biortech

Enhanced desorption of humin-bound phenanthrene by attached phenanthrene-degrading bacteria

Yinping Zhang [a,1], Fang Wang [a,1], Yongrong Bian [a], Fredrick Orori Kengara [b], Chenggang Gu [a], Qiguo Zhao [a], Xin Jiang [a,*]

[a] State Key Laboratory of Soil and Sustainable Agriculture, Institute of Soil Science, Chinese Academy of Sciences, Nanjing 210008, China
[b] Department of Chemistry, Maseno University, Maseno 40105, Kenya

HIGHLIGHTS

- The biodegraded PAHs was significantly higher than the desorbed fraction.
- Bacterial attachment led to enhanced biodegradation of PAHs.
- The interaction between bacteria and humin resulted in increased desorption of PAHs.

ARTICLE INFO

Article history:
Received 17 May 2012
Received in revised form 16 July 2012
Accepted 24 July 2012
Available online 2 August 2012

Keywords:
Polycyclic aromatic hydrocarbons
Biodegradation
Bioavailability
Desorption

ABSTRACT

The objective of the study was to test the hypothesis that the attachment of polycyclic aromatic hydrocarbons (PAHs)-degrading bacteria can promote desorption of PAHs from humin, thereby increasing their bioavailability. Biodegradation of humin-bound phenanthrene (PHE) – a model compound for PAHs – was investigated using two PHE-degrading bacteria, *Sphingobium* sp. PHE3 and *Micrococcus* sp. PHE9, respectively. Sorption data of PHE to humin fitted well into the modified Freundlich equation. Further, a new sorption band appeared at 1262 cm^{-1}, demonstrating intermolecular interactions between PHE and humin. Interestingly, approximately 65.3% of humin-bound PHE was degraded by both strains, although only about 17.8% of PHE could be desorbed from humin by Tenax extraction. Furthermore, both strains grew well in mineral medium and also attached to humin surfaces for substrate uptake. It is proposed that the attached bacteria could possibly consume PHE on the humin via interactions between bacterial surfaces and humin, thereby overcoming the low PHE bioavailability and resulting in enhanced degradation.

1. Introduction

Polycyclic aromatic hydrocarbons (PAHs) are increasingly causing environmental concern due to their toxicity to humans and ecosystems (Quiroz et al., 2009). A major remediation process of PAHs contamination in the environment is microbial degradation (Jacques et al., 2008; Moscoso et al., 2012). Despite the high capability of the introduced microorganisms for metabolizing PAHs, the compounds still persist at significant levels in both freshly contaminated soils/sediments and weathered contaminated sites (Liu et al., 2011; Silva et al., 2009). To some extent, the lack of appreciable microbial degradation has been attributed to the low bioavailability of PAHs in the environment. Therefore, seeking and understanding the mechanisms that influence the biotransformation of PAHs would help to predict their fate in soil/sediment matrices, as well as enable the accurate optimization of bioremediation strategies.

It is well known that the clean-up of PAHs-contaminated sites is mainly dependent on synergistic interactions between the sorption–desorption and biodegradation processes (Gomez-Lahoz and Ortega-Calvo, 2005; Liu et al., 2011). PAHs sorption–desorption processes in soils/sediments can be affected by factors such as humus, minerals and colloid complexes, with humus playing a dominant role. Humus is divided into three fractions: fulvic acid, humic acid and humin. Fulvic acid and humic acid account for only a small fraction of the humus, and usually show a nearly linear partitioning or exhibit nonlinear sorption to PAH molecules (Pan et al., 2007). Both of them are categorized as dissolved organic matter (DOM), which can act as a non-toxic biogenic surfactant or as a natural carrier (Kobayashi et al., 2009; Smith et al., 2009), thereby enhancing bioavailability of PAHs by increasing their apparent solubility or by direct provision of PAHs to bacteria. Humin, in

* Corresponding author. Tel.: +86 25 86881195; fax: +86 25 86881000.
E-mail address: jiangxin@issas.ac.cn (X. Jiang).
[1] These authors contributed equally to this work.

0960-8524/$ - see front matter Crown Copyright © 2012 Published by Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.biortech.2012.07.093