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Novel oxygen-releasing immobilized cell beads for bioremediation of BTEX-contaminated water

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HIGHLIGHTS

- ▶ A novel oxygen-releasing immobilized bead (ORICB) was prepared.
- ▶ The CaO_2-encapsulated oxygen-releasing bead has high oxygen release capacity.
- ▶ The ORICBs-column rapidly and effectively degrades BTEX at HRT of 0.872 day.
- ▶ A high influent BTEX concentration did not markedly inhibit bioremediation.
- ▶ The DGGE profile indicates that the BTEX degrader distributed throughout the column.

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ABSTRACT

Novel oxygen-releasing bead (ORB) and oxygen-releasing immobilized cell bead (ORICB) were prepared. Their oxygen releasing characteristics and effect on degradation of benzene, toluene, ethylbenzene, and xylene (BTEX)-contaminated groundwater were evaluated in a column. ORB prepared by CaO_2-encapsulated freezing had much better oxygen-releasing capacity (0.526 mg O_2 per ORB) than that by the mixing-freezing method. The encapsulated-ORB did not influence groundwater pH. Two BTEX degraders were utilized to prepare the ORICB. The ORICBs-column rapidly (hydraulic retention time: 0.872 day) degraded BTEX after a 2–5 day acclimation period. The BTEX removal increased as flow distances increased. At BTEX concentration of 120 mg L^{-1}, 67% of benzene and 81–90% of TEX were removed. The SEM shows that micropores existed in the ORBs and BTEX degraders were immobilized. The denaturing gradient gel electrophoresis profiles indicate that BTEX degraders were distributed throughout the column. The BTEX concentration of 120 mg L^{-1} markedly altered the structure of the indigenous microbial community.

1. Introduction

Petroleum hydrocarbons contain highly toxic and carcinogenic benzene, toluene, ethylbenzene, and xylene (BTEX). Accidental leakage and spillage of petroleum hydrocarbons from pipelines and fuel–oil storage tanks often contaminate groundwater and may pose health risks to nearby residents (Durmusoglu et al., 2010). Several methods can be used to clean up BTEX in groundwater, including granular activated carbon adsorption, pumping and treating, the *in situ* advanced oxidation process, and air sparging (Farhadian et al., 2008; Tsitonaki et al., 2010). However, the low removal ability or high cost of these techniques often limits their application (Farhadian et al., 2008; Garoma et al., 2008).

Bioremediation is a cost-effective approach for degradation of BTEX-contaminated groundwater because it uses microorganisms to degrade BTEX on site (Farhadian et al., 2008; Juwarkar et al., 2010). However, limited dissolved oxygen (DO) (Da Silva and Corseuil, 2012) and the low density of a degrading population often inhibit bioremediation effectiveness (Farhadian et al., 2008). Aeration below the water table is frequently applied to increase the concentration of DO in groundwater (Farhadian et al., 2008). However, aeration also generates BTEX emissions from groundwater, resulting in air pollution (McGovern et al., 2002).

Calcium peroxide (CaO_2) is often utilized to prepare oxygen-releasing compounds and to increase the DO concentration in groundwater (Khodaveisi et al., 2011; Yeh et al., 2010). However,

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