Experiences of a Large-Scale Application of 1,2-Dichloroethane Degrading Microorganisms for Groundwater Treatment

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1,2-Dichloroethane (DCA) mineralizing microorganisms, enriched and isolated under laboratory conditions, were successfully inoculated into a full-scale groundwater purification plant to treat 5–20 m^3 of water/h at 8–12 °C. The groundwater contained DCA as the single contaminant in the range of 2000–15000 μg/L. It had to be treated to below 10 μg/L. The treatment plant, consisting of two sand filters followed by two granular activated carbon adsorbers, was biologically modified by the inoculation of DCA degraders and the supply of H_2O_2 and nutrients. A total of 5000 kg of activated carbon was consumed during the first month of operation to reach the required DCA levels. This amount decreased as the biological process developed. After 2 years and with the implementation of a rotating biological contactor as an additional process step, the exchange of activated carbon became redundant. The microbial DCA removal was followed by its disappearance, the production of chloride ions, the concomitant reduction of pH, and the requirement for H_2O_2. So far, 1930 kg of DCA has been removed during the 5-year remediation period.

Introduction

The detection of new bacteria and the amount of knowledge collected over the last tens of years of using microorganisms to degrade chlorinated synthetic chemicals is impressing. Initially, the expectations of their degradation potential was high. So far, however, most publications reported their application were related to investigations carried out on laboratory or pilot scales (*1–4*). Reports describing the full-scale application of microorganisms for remediation purposes or groundwater cleanup were usually limited to sites contaminated with naturally produced persistent organic chemicals, such as fuel (*5, 6*). The slow progress in using bacteria to degrade chlorinated compounds could be based to numerous reasons: innovative technologies were not competitive with conventional chemical and/or physical methods; the application of the microorganisms under field conditions simply failed; and additionally, people working in the applied fields were often not scientifically motivated to share their experiences gained from the new technologies.

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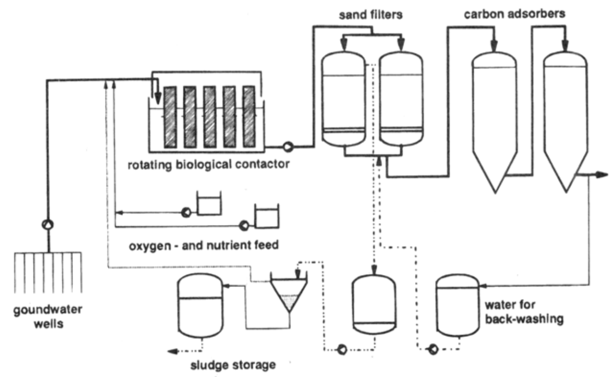

FIGURE 1. Process flow diagram of the groundwater treatment.

In this paper, we present the results of a pump-and-treat groundwater remediation with a successful large-scale application of microorganisms able to degrade 1,2-dichloroethane (DCA). Both aerobic and anaerobic microbial degradation and mineralization of DCA by cultures have been reported by several research groups (*7–11*). Laboratory-scale experiments designed to evaluate the application potential of aerobic strains for groundwater remediations were assessed before the bacteria were inoculated into the reactor (*12, 13*). It was shown that microorganisms could convert DCA to the 100 μg/L range if they were fixed onto suitable surfaces, such as sintered glass or expanded clay. Therefore, it was concluded that the biological degradation process had to be combined with an adsorption process if a target limit of 10 μg/L DCA was to be reached.

The results obtained in the large-scale plant exceeded all expectations since the target limit was met even without the use of activated carbon. We report here about 5 years of experiences gathered at a plant that consisted of conventional treatment steps and was modified so that special microorganisms could develop their full DCA degrading potential. As a result of the biological activity, the exchange of exhausted granular activated carbon became redundant, and thus the process became economically much more interesting.

Materials and Methods

Description of Groundwater Treatment Plant. The groundwater treatment plant was initially designed to treat 20 m^3/h groundwater by a conventional dual media filtration process followed by carbon adsorption. The plant was erected on a platform, which was built on piles over swampy ground, and was covered with a fixed tent. The water was pumped first from the pond and later from the well gallery by individual pumps to two parallel sand filters (Preussag, Hamburg, Germany), each with a volume of 5 m^3. They were followed by two filters filled with granular activated carbon run in series, and each had an empty bed volume of 10 m^3 (Figure 1). The sand filters were backwashed every 2 weeks, and the sludge was collected and thickened in an old storage tank. The supernatant was pumped back to the entrance of the plant while the sediment was disposed of by an authorized disposal

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