World Academy of Science, Engineering and Technology
International Journal of Environmental and Ecological Engineering
Vol:11, No:05, 2017

Biodegradation of Chlorophenol Derivatives Using Macroporous Material

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Abstract : Chlorophenols (CPs) are used as a precursor in the production of higher CPs and dyestuffs, and as a preservative. Contamination by CPs of the ground water is located in the range from 0.15-100mg/L. The EU has set maximum concentration limits for pesticides and their degradation products of 0.1µg/L and 0.5µg/L, respectively. People working in industries which produce textiles, leather products, domestic preservatives, and petrochemicals are most heavily exposed to CPs. The International Agency for Research on Cancers categorized CPs as potential human carcinogens. Existing multistep water purification processes for CPs such as hydrogenation, ion exchange, liquid-liquid extraction, adsorption by activated carbon, forward and inverse osmosis, electrolysis, sonochemistry, UV irradiation, and chemical oxidation are not always cost effective and can cause the formation of even more toxic or mutagenic derivatives. Bioremediation of CPs derivatives utilizing microorganisms results in 60 to 100% decontamination efficiency and the process is more environmentally-friendly compared with existing physico-chemical methods. Microorganisms immobilized onto a substrate show many advantages over free bacteria systems, such as higher biomass density, higher metabolic activity, and resistance to toxic chemicals. They also enable continuous operation, avoiding the requirement for biomass-liquid separation. The immobilized bacteria can be reused several times, which opens the opportunity for developing cost-effective processes for wastewater treatment. In this study, we develop a bioremediation system for CPs based on macroporous materials, which can be efficiently used for wastewater treatment. Conditions for the preparation of the macroporous material from specific bacterial strains (Pseudomonas mendocina and Rhodococcus koreensis) were optimized. The concentration of bacterial cells was kept constant; the difference was only the type of cross-linking agents used e.g. glutaraldehyde, novel polymers, which were utilized at concentrations of 0.5 to 1.5%. SEM images and rheology analysis of the material indicated a monolithic macroporous structure. Phenol was chosen as a model system to optimize the function of the cryogel material and to estimate its enzymatic activity, since it is relatively less toxic and harmful compared to CPs. Several types of macroporous systems comprising live bacteria were prepared. The viability of the cross-linked bacteria was checked using Live/Dead BacLight kit and Laser Scanning Confocal Microscopy, which revealed the presence of viable bacteria with the novel cross-linkers, whereas the control material cross-linked with glutaraldehyde(GA), contained mostly dead cells. The bioreactors based on bacteria were used for phenol degradation in batch mode at an initial concentration of 50mg/L, pH 7.5 and a temperature of 30°C. Bacterial strains cross-linked with GA showed insignificant ability to degrade phenol and for one week only, but a combination of cross-linking agents illustrated higher stability, viability and the possibility to be reused for at least five weeks. Furthermore, conditions for CPs degradation will be optimized, and the chlorophenol degradation rates will be compared to those for phenol. This is a cutting-edge bioremediation approach, which allows the purification of waste water from sustainable compounds without a separation step to remove free planktonic bacteria. Acknowledgments: Dr. Berillo D. A. is very grateful to Individual Fellowship Marie Curie Program for funding of the research.

Keywords : bioremediation, cross-linking agents, cross-linked microbial cell, chlorophenol degradation
Conference Title : ICEWW 2017 : International Conference on Environment, Water and Wetlands
Conference Location : Montreal, Canada
Conference Dates : May 11-12, 2017