

Environmental Assessment of Polybrominated Diphenyl Ethers (PBDEs) Contamination in Indian Municipal Waste Sites and Potential Remediation Using Indigenously Isolated Bacteria

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Abstract:

The present research was the first of its kind attempt to assess the existence, distribution and fate of polybrominated diphenyl ethers (PBDEs) in the soil of municipal waste (MSW) dumping sites and municipal wastewater treatment plant in India. Also, the use of indigenously isolated bacteria for the aerobic degradation of deca-BDE (BDE 209) was elucidated first time in this study.

Initially, the contamination of PBDE congeners in soil samples amassed from MSW dumping sites of India was investigated. Also, the human exposure and health risk through soil intake and dermal contact were evaluated. It was perceived that the soil of analyzed MSW dumping sites was polluted with the PBDEs. The observed PBDE congener profile in the soil samples exhibited the presence of deca and octa BDE technical mixtures in the dumped waste materials leading to contamination of surrounding soil. Significant exposure of PBDEs through soil intake and dermal contact was observed for the workers and people living in the vicinity of the dumping sites. Subsequently, the hazard index was estimated higher in children as compared to the adults. PBDE congeners of primary concern were evaluated to examine the PBDE contamination, dissemination, fate, mass flow, mass load and removal in the municipal wastewater treatment plant located in central India. The concentration of analyzed PBDE congeners was observed in all the samples collected from a different stage of the treatment process. The species BDE 209 and BDE 47 were observed as predominant contaminants. The results of mass loading analysis in the treatment plant exhibited that 77.46 mg/day load of total PBDEs are released via final effluent, while 1297 mg/day concentration is being disposed of at landfill sites in the form of dried sludge.

In the next set of experiments, four novel bacteria having the potential to degrade deca-BDE (BDE 209) and using it as a sole carbon source were indigenously isolated from a PBDE contaminated identified MSW dumping site of India. The bacteria were observed to have similarities with the *Bacillus tequilensis*, *Lysinibacillus capsici*, *Bacillus subtilis* and *Lysinibacillus macrolides* using 16S rRNA gene sequencing. These novel bacterial

strains were named *Bacillus tequilensis* BDE S1, *Lysinibacillus capsici* strain BDE S2, *Bacillus subtilis* strain BDE S3 and *Lysinibacillus macroides* strain BDE S4. Genomic sequences of all the identified strains were submitted to GenBank with the accession numbers MW682831, MZ470736, MZ474476 and MZ474477, respectively. The strain BDE S1, BDE S2, BDE S3 and BDE S4 were found to have 65%, 66%, 60% and 55% BDE 209 degradation efficiency, respectively.

The synergistic effect of different nutritional and environmental conditions on the growth and deca-BDE degradation efficiency of indigenously isolated novel bacteria was assessed. From the results, it was observed that 50 mg/l BDE 209 and 5-10 mg/L glucose concentration, 7.5 pH, 30-40 °C temperature and 10% inoculum size were found optimum for the strain BDE S1, while 50-60 mg/l BDE 209, 10 mg/l glucose, 7.5 pH, temperature range of 35-40 °C and inoculum size of 10% were estimated optimal for strain BDE S2. In the case of strain BDE S3 the suitable combination was found as 50 mg/l BDE 209, 5 mg/l glucose, 7.5-8.0 pH range, 30-40 °C temperature range and 8-10 of inoculum size; however, strain BDE S4 was observed having maximum growth and degradation in 60 mg/l BDE 209, 10 mg/l glucose, pH 7.5, 30 °C temperature and 8-10% inoculum size.