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# ABSTRACTS



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# Simultaneous Biodegradation of Toxic Aromatic Compounds: The Biochemical Incompatibilities, Metabolic Bottlenecks and Their Alleviation

**A.A.M. Kunhi* and H.K. Mononmani,** Department of Food Microbiology, Central Food Technological Research Institute, Mysore 570 013, India.

The biodegradation pathways of most of the aromatic compounds by microorganisms converge at a dihydroxy ring compound such as catechol, protocatechuate, gentisate or their derivates. This key intermediary metabolite is then cleaved by a dioxygenase. Generally, chlorocatechols are cleaved thrugh a modified *ortho*-mode by pyrocatechase II (catechol 1, 2-dioxygenase II) (Reineke and Knackmuss, 1988) whereas *meta*-fission enzymes such as catechol 2, 3-dioxygenase cleave methylcatechols (Babu *et al.*, 1995), though there are several exceptions to these. [Recently, Reineke's group has purified a novel type of chlorocatechol 2, 3-dioxygenese (Kaschabek *et al.*, 1998)]. It is well known that halocatechols are highly inhibitory to the metapyrocatechases (Bartels *et al.*, 1984). Degradation of mixtures of choloro- and methyl- aromatic compounds or other aromatics that are cleaved through different modes thus becomes difficult in natural environments where heterogeneous population of microorganisms possessing both *ortho*- and *meta*-cleavage pathways co-exist. Several natural *meta*-cleaving bacteria can convert haro-aromatics to halo-catechols by their oxidases with broard specificities, but may fail to cleave the halo-catechols, resulting in their accumulation. This metabolic bottleneck not only prevents the mineralization of the chloroaromatic but also inhibits the *meta*-cleaving enzymes of other microbes involved in the degradation of methyl-and other aromatics though *meta*-pathway, resulting in a complete failure of the system. There are also several reports on the inhibition of degradation of a particular compound by the presence of other compounds e.g. inhibition of *p*-nitrobenzoate degradation by benzoate in a pseudomonad (Haller and Finn, 1978). Similarly, degradation of 2, 4, 6-trichlorophenol by *Pseudomonas* sp. TCP114 is inhibited by the presence of 4-chlorophenol and *vice versa* the degradation of 4-chlorophenol by *Arthrobacter* sp. CPR 706 is inhibited by 2, 4, 6-trichlorophenol (Bae *et al.*, 1997).

Often encountered failures of sewage and chemical effluent treatment plants are due to these biochemical incompatibilities and metabolic bottlenecks. To overcome these drawbacks, bacterial strains that can degrade mixtures of aromatic compounds have been developed by applying stringent selection pressure, causing mutations or/and cloning specific genes. German scientists have isolated bacterial strains that can biodegrade mixtures of chloro- and methyl-substituted aromatics, through stringent selection by enrichment of *ortho*-cleaving bacterial strains, with 2-methyllactone as the sole carbon source or by counter selectin of *meta*-cleaving strains using 3-chlorobenzoate (Taeger *et al.*, 1988). Harayama's group has isolated a mutant strain of *Pseudomonas putida* capable of degrading *m*-toluate in the presence of 3-chlorocatechol (Wasserfallen *et al.*, 1991). Spain and co-workers have reported degradation of mixtures of substituted benzens by *Pseudomonas* sp. JS150, a strain possessing multiple ring-fission pathways (Haigler, *et al.*, 1992). A bacterial strain that can degrade 3-chlorobenzoate (3-CBA), 4-CBA, 4-methyl benzoate, 4-chlorophenol and *p*-cresol has been very ingeniously constructed by Rojo *et al.* (1987) by recruiting genes from different sources and assembling them to form an *ortho*-cleavage pathway. Most of these strains, however, were shown to be not very efficient in dealing with higher concentrations of the mixed substrates.

In another approach, using defined mixed cultures of *Pseudomonas* strains, we have demonstrated effective, simultaneous degradation of phenol/cresols and 3-chlorobenzoate mixtures (Babu *et al.*, 1995). A phenol degrading *P. stutzeri* with an *ortho*-pathway was more compatible with the chlorobenzoate-degrader following a modified *ortho*-pathway than the strains possessing *meta*-cleavage pathways (Basheer *et al.*, 1998). A research group in Korea has reported degradation of mixture of 2, 4, 6-trichlorophenol, 4-chlorophenol and phenol by a mixed culture of *Pseudomonas* and *Arthrobacter* strains (Bae *et al.*, 1997). Brunsbach and Reineke (1995) have reported degradation of a mixture of 13 different chhoroaromatics by a 4-membered mixed culture of different *Pseudomonas* spp. In our laboratory, elimination of at least 11 chloro-, nitro-, amino-substituted phenols and other aromatics by an undefined microbial consortium has been demonstrated. It can be concluded that develoment of mixed cultures through judicious selection of microbial cultures and pooling their degradative abilities seems to be the most practical and feasible approach to deal with waste effluents containing mixtures of compounds.

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