

Biodegradation of biphenyl compounds by soil microbiomes

Conceptual

Biphenyls are basically organic compounds which are produced at industrial level as by products. Biphenyls are produced by dealkylation of the toluene. Polychlorinated biphenyl (PCBs) is derivative of biphenyl and used in different applications such as the manufacture of oil condensers, plasticizers, dielectrics, and hydraulic fluids. Along with useful products, there are number of organic pollutants productions which are toxic in nature. Polychlorinated biphenyls are not readily broken down in the environment. PCBs are remaining there for longer periods of the time cycling between air, water and soil. The polychlorinated biphenyls are known to inflict serious impacts on the reproductive, immune, nervous, endocrine systems in animals. The polychlorinated biphenyl are also causing cancer.^{1,2} The microbiomes are ubiquitous in nature and have been reported from extreme environments and well as plant associated. Among microbes from diverse habitats the soil microbiomes play an important role in degradation of PCBs. A number of soil microbiomes have PCBs degrading capability have been isolated and characterized belonging to different genera *Williamsia*, *Trametes*, *Talaromyces*, *Stenotrophomonas*, *Sphingomonas*, *Sphingobium*, *Shigella*, *Rhodococcus*, *Pseudomonas*, *Paenibacillus*, *Ochrobactrum*, *Janthinobacterium*, *Janibacter*, *Bacillus*, *Aspergillus*, *Arthrobacter* and *Achromobacter*. On review of different research it can be concluded that the soil microbiomes degrading polychlorinated biphenyl belongs to phylum *Proteobacteria*, *Firmicutes*, *Basidiomycota*, *Bacteroidetes*, *Ascomycota*, *Actinobacteria* and *Euryarchaeota*.³

The soil microbiomes play a vital role in the degradation of the biphenyls and a basic pathway has been reported in different studies used by bacteria to degrade the biphenyls.⁴⁻¹⁹ The soil microbiomes produced number of numbers of extracellular hydrolytic enzymes which are involved in the degradation of the biphenyls. Bioremediation by soil microbiomes have been investigated extensively during the last few decades. The microbes having capability to degradation is an alternative and less expensive strategy.^{19,20} The culturable useful industrially and agriculturally important microbes are ubiquitous in nature and have been reported from diverse habitats including low temperature,²¹⁻²³ high temperature,^{24,25} hypersaline environments,^{26,27} saline lake,²⁸⁻³⁰ sub-glacial lake,^{31,32} and Drought environments.³³⁻³⁶

There are number of microbes which have been reported to possess the ability to degrade biphenyls including *Sphingomonas* sp., *Ralstonia* sp., *Pseudomonas* sp., *Corynebacterium* sp., *Comamonas* sp., *Burkholderia* sp., *Bacillus* sp., *Alcaligenes* sp., *Acinetobacter* sp., *Achromobacter* sp.,³⁷ *Cupriavidus pauculus*,³⁸ *Hydrogenophaga taeniospiralis*,³⁹ *Paenibacillus* sp.,⁴⁰ *Pseudomonas putida*,⁴¹ *Rhodococcus erythropolis* TA421,⁴² *Rhodococcus globerulus* P6,⁴³ *Rhodococcus jostii*,⁴⁴ *Rhodococcus rhodochrous* K37,⁴⁵ *Rhodococcus* sp. M5,⁴⁶ *Rhodococcus* sp. HA99⁴⁷ and *Enterobacter* sp.⁴⁸ The potential and efficient soil microbiomes has been isolated and characterized to degrades different toxic compounds from diverse sources.

The abundance and distribution of biphenyl compounds degrading microbes have been reported from diverse environment

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niches/habitats such as *Rhodococcus erythropolis* TA421 from termite ecosystem;⁴² *Achromobacter piechaudii* BioC1,⁴⁹ *Bacillus thuringiensis* Bt-NGRA,⁵⁰ *Comamonas testosteroni* TK102,⁵¹ *Cupriavidus pauculus* KF709,³⁸ *Hydrogenophaga* sp. IA3-A,⁵² *Hydrogenophaga taeniospiralis*,³⁹ *Janibacter* sp.,⁵³ *Paenibacillus* sp. KBC101,⁴⁰ *Pseudomonas aeruginosa* KF702,⁵⁴ *Pseudomonas alcaliphila* JAB1,⁵⁵ *Pseudomonas plecoglossicida* 6.1,⁴⁹ *Pseudomonas putida* KF715,⁴¹ *Pseudomonas stutzeri*,⁵⁶ *Pseudomonas toyotomiensis* KF710,⁵⁷ *Rhodococcus pyridinivorans*,⁵⁸ *Rhodococcus ruber* P25,⁵⁹ *Rhodococcus* sp. WB1⁶⁰ and *Sphingobium fuliginis* HC3⁶¹ from rhizospheric and soil ecosystems; *Luteibacter* sp., *Rhodococcus* sp.,⁶² *Talaromyces helices*⁶³ and *Williamsia* sp.⁶² from contaminated soil; *Chitinophaga* sp., *Janthinobacterium* sp., *Pseudomonas* sp., *Shigella* sp. and *Subtercola* sp.⁶⁴ from Cryoconite; *Cupriavidus* sp. SK-4,⁶⁵ *Aquamicrobium* sp. strain SK-2⁶⁶ and *Cupriavidus* sp. SK-3⁶⁷ from sewage sludge; *Doratomyces nanus*, *Doratomyces purpureofuscus*, *Doratomyces verrucisporus*, *Myceliophthora thermophila*, *Phoma eupyrena* and *Thermoascus crustaceus*⁶⁸ from Industrial sites and *Mesorhizobium* sp. ZY1⁶⁹ from legume *Astragalus*.

Biodegradation is a chemical process involving breakdown of materials by bacteria, fungi, or other biological means. Biological degradation of polychlorinated biphenyls is a striking clean-up approach as it is environmentally friendly and worthwhile.⁷⁰ It has been stated that several microorganisms such as bacteria, fungi and yeasts can metabolize Polychlorinated biphenyls (PCBs).^{19,68,71} There have been reports on microbes degrading biphenyl and showing chemotactic response towards 4-chlorobenzoate (4-CBA), benzoate, biphenyl, and polychlorinated biphenyl.⁷²⁻⁷⁴ Fungi are known to utilize a varied range of organic compounds for nutrition and energy generation. In the past few years, use of fungi to clean up the environmental pollutants has gained tremendous importance.^{75,76} Numerous authors have also reported the ability of *P. chrysosporium* to be ubiquitous PAH degraders with the extracellular ligninolytic enzyme system, which includes lignin peroxidase (LiP), manganese peroxidase (MnP), versatile peroxidase (VP), and laccase.⁷⁷⁻⁸⁰ *Phanerochaete chrysosporium* reported to degrade benzo(a)pyrene one of the polycyclic aromatic hydrocarbons (PAHs) significantly.⁸¹

Conclusion

Polychlorinated biphenyls (PCBs) are among the most widely used industrial materials and possess a number of applications but

due to complexity in their structure they are highly recalcitrant and further causes a lot to environmental as well as the health issues. There are number of microbes which have been reported to degrade PCBs and even various studies have taken into consideration the genetic organization of the catabolic genes for the biodegradation of the biphenyls and further, various have studied about the degradation pathways of various microbes. Complex congener mixtures which cannot sometimes be degraded easily by single microbe, consortium can prove versatile in this regard. Thus, microbes bringing about the degradation should be more explored and they will surely prove as novel tool to remove these complex compounds from the environment.

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Conflicts of interest

The author declares there is no conflicts of interest.

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