# Preface

Phenolic compounds such as phenols and their derivatives (*p*-cresol, chlorophenol, nitrophenol, etc.) are essential compounds in the chemical process industries. They are released from various industrial processes like leather manufacturing, textile processing, coal gasification units, petroleum refining, resin synthesis, coconut retting, perfume production, and pharmaceutical industries. Most of these pollutants are phenol-based and classified as a "toxic" pollutant; *p*-cresol, on the other hand, is classified as a **"**very toxic**"** pollutant with a significantly higher toxicity than its isomers. For instance, some bacteria grow well when phenol is the only carbon source, but their growth slows down when *p*-cresol is used as the sole carbon source.

The fact that the wastewater released has not undergone complete treatment makes them considered pervasive environmental contaminants. *p*-Cresol has a priority pollutant classification from the US Environmental Protection Agency. In addition to having a variety of harmful effects on both acute and long-term exposure, some of them are recognized to be carcinogenic, mutagenic, or teratogenic. The detrimental issues around these pollutants spurred the researchers to create environmentally responsible and reasonably priced methods for eliminating these types of hazardous contaminants. Several established physical and chemical techniques exist for degrading the phenols and their derivatives. These consist of the following: solvent extraction, adsorption, flocculation, coagulation, membrane process, ozonation, chemical oxidation, incineration, etc. Nevertheless, the issue with these techniques is that they often result in secondary pollution and are neither economical nor energy-efficient. On the contrary, biodegradation is an eco-friendly and cost-effective method that ensures the complete degradation of a pollutant without having any hazardous by-products.

A significant impediment to this approach is the suppression of *p*-cresol degrading microbial species caused by its toxicity and the resulting poor biodegradability of these toxicants. To address these issues and eliminate these contaminants from wastewater at high concentrations, strong, sustainable technology is needed. Pollutant-degrading microbe immobilization on various support matrices has shown promise for enhancing overall efficiency concerning strong degradation capability resilience to changes in environmental factors. It has been demonstrated in recent decades that distinct bioreactors are essential in breaking down different phenolic compounds. The understudied field for *p*-cresol biodegradation is using continuous packed bed bioreactors. The main objective of this work is the isolation and identification of potential bacterial species from activated sludge for the biodegradation of *p*-cresol. Optimization of various parameters for maximum *p*-cresol biodegradation and integrated photocatalytic and biodegradation process to enhance biodegradation of high concentrations of *p*-cresol and performance evaluation of packed bed biofilm reactor on different loading rates. After that, there was simultaneous removal of *p*-cresol and methylene blue dye and bacterial toxicity assessment of the biodegraded product. Evaluation of phytotoxicity and Chlorophyll content in *Vigna radiata* seeds and leaves, respectively.

The present study is divided into seven chapters. **Chapter 1** contains the introduction of phenolic compounds, treatment technology, and different types of bioreactors. **Chapter 2** deals with a literature review on the biodegradation of phenolic compounds (*p*-cresol, phenol, chlorophenol, nitrophenols, etc.), the research gap, and the objective of the research work. **Chapter 3** describes the batch mode (free cells) operation, including isolation of potential microbial species, microbial growth kinetics studies, optimization of the various parameters using response surface methodology, biodegradation kinetics and phytotoxicity assessment of biodegraded products. **Chapter 4** describes the effect of different environmental parameters on specific growth of microbial study, comparative study of biodegradation of *p*-cresol in batch as well as continuous mode operations, study of possible biodegradation pathway and bacterial toxicity assessment of biodegrade products. **Chapter 5** includes integrating photocatalytic and bioreactors for effectively removing high concentrations of *p*-cresol. **Chapter 6** contains the simultaneous removal of *p*-cresol and methylene blue dye in continuous mode operation. The summary and scope of the future work are described in **Chapter 7.**