



Project Proposal for Ph.D.

Project Details (The research problem must clearly indicate the need for an interdisciplinary approach)	
Project Title	Hydrogel-Immobilized Microbial Systems for Enhanced Dye Decolourization: Mechanistic Insights, Bioreactor Development, and Validation on Effluents from Textile MSMEs
Project Summary (Minimum 500 and maximum 2000 characters)	Overall Summary of the Project: Reactive azo dyes are among the most commonly used dyes in the textile sector. However, their fixation efficiency on the fabric is only 60-70%, which results in the discharge of unbound dyes into the waste stream during dyeing and finishing process. Their recalcitrant and toxic nature arises from complex aromatic structure associated with the reactive groups, making them highly resistant to biodegradation. This poses a critical challenge for Indian textile and allied MSME sector to treat their coloured effluents to meet the prescribed inlet standards of Common Textile Effluent Treatment Plants (CTEPs), leading to regulatory non-compliance and placing additional treatment burden on CTEPs. Microbial consortium-based decolourization approach provides an eco-friendly and efficient solution for their treatment; however, it frequently suffers from biomass washout, poor settleability and stability under fluctuating inlet parameters and less efficient at higher dye concentration (>300 mg/L). Hydrogel Immobilization provide a promising potential solution by offering porous and biocompatible matrix for microbial cell entrapment, higher enzymatic activity in the cell surrounding, and improve resilience under stress condition. The aim of this project proposal is to develop and translate the hydrogen immobilized microbial consortium into an operational lab scale bioreactor. In the first objective, biocompatible hydrogels will be formulated and optimized for porosity, microbial entrapment and structural stability. Further, the study will focus on the comparative assessment between immobilized and suspension consortium for dye decolourization efficiency, microbial kinetics, enzymatic activity and microbial community dynamic with their functional annotations profiling. Afterwards, the study will focus on mechanistic insights by investigating dye-hydrogel interactions, diffusion and mass transfer dynamics, and enzymatic degradation pathways. Finally, an integrated hydrogel-microbial bioreactor will be designed and tested under batch and continuous operation, initially with reactive dye and later with effluents collected from textile MSMEs. This will validate its overall treatment efficiency, stability, and industrial feasibility potential. Objectives: Objective 1: Development of biocompatible hydrogel for microbial immobilization and assessment of its stability. Objective 2: Comparative assessment of microbial growth, dye decolourization efficiency, enzymatic activity, and microbial community dynamics in hydrogel-immobilized versus suspension cultures under reactive dye stress. Objective 3: Investigation of fundamental mechanisms of dye decolourization in hydrogel matrices. Objective 4: Development and validation of a hydrogel-microbial lab-scale bioreactor for treatment of effluents from textile MSMEs

Ph.D. Supervisors* (Supervisor 1 and Supervisor 2 cannot be from the same department of IITD)			
Role	Name of Faculty	Academic Unit in IITD/Institute/University	Email ID (Official)
Supervisor 1*	Prof. Anushree Malik	Centre for Rural Development and Technology, Indian Institute of Technology, Delhi	anushree@rdat.iitd.ac.in
Supervisor 2	Prof. Leena Nebhani	Department of Material Science & Engineering, IIT Delhi	lnebhani@mse.iitd.ac.in

*Supervisor 1 must be from IIT, Delhi.
+All cells in this table are mandatory fields that need to be filled by faculty for consideration of proposal.
§The date of superannuation of supervisors should be at least three years from the date of registration of selected candidates.

Project requirements (Student qualifications, experience required, etc) *The candidate will be shortlisted based on common shortlisting criteria decided by ScRC (SIRe)
• BTech/MTech in Biochemical/ Environmental Engineering/Material Science and Engineering/Biotechnology • Prior experience in wastewater treatment, hydrogel development, or bioreactor operation will be preferred.

Source of fellowship/funding and project number (CSIR/UGC/DBT/ICMR/ICAR/NEET-PG/DST-INSPIRE/IRD/FITT Project details, if any)
Candidate with his/her own fellowship.

Role of Faculty Members involved:	
Supervisor-1	Prof. Anushree Malik (Environmental Science): Development and detailed study of biocompatible hydrogels for microbial immobilization, with focus on dye degradation mechanisms and microbial community dynamics.
Supervisor-2	Prof. Leena Nebhani (Material Science and Engineering): Expert on Hydrogels will guide on selection of appropriate polymers and development of stable gels

Note :-

1. Approval from the respective DRC/CRC/ScRC of your Department/Centre/School will be required for using the "Full-time Institute Assistantship (Category-wise) (FIA)" for selecting the students in SIRe.
2. Declaration:- Faculty members, please ensure that you have at least 3 years of service left before superannuation along with adequate sitting space & lab facilities for the SIRe student.
3. PI/s are also encouraged to submit joint proposals with AIIMS, NII, JNU and institutes with which IITD has an existing MoU. If the Co-PI (Supervisor 2) is from outside IITD, kindly share his/her detailed CV.
4. If a research scholar is to be considered for selection under the project fellowship, then the project should have a minimum of two-year duration remaining.
5. A candidate applying with a valid JRF/INSPIRE/any national level fellowship should have at least two-year validity from the date of joining the Ph.D. program.
6. The third supervisor’s name (if required) can be added only after the formation of Student Research Committee (SRC) subject to a strong recommendation of SRC and subsequent approval from the competent authority.
7. If Institute fellowship is being sought, then DRC approval of the parent department of Supervisor 1 is required at the time of selection.