6

Conclusions and future perspectives

- A total of 54 biosurfactant-producing unique bacterial colonies and 2 fungal colonies were isolated from petroleum oil-logged soil samples collected from 20 locations in Guwahati, Assam.

- The best isolate was screened based on maximum cell density, dry cell biomass, respective protein content, and surface tension reduction potential and was identified as *Klebsiella sp*. strain RGUDBI03 (GenBank accession: ON945613.1) by 16S rDNA gene sequencing method.

- The crude biosurfactant produced by the best isolate was characterized by biochemical tests which showed the presence of amino acid and carbohydrate moieties and was further confirmed by FTIR spectral analysis.

- The bacterial cell-free extract consisting of the crude biosurfactant showed *an* E_{24} index of 36% against diesel oil and could collapse the drop of the oil-supplemented medium on a hydrophobic surface within 45 seconds.

- The Ag NPs and ZnO NPs were synthesized by using the crude bacterial biosurfactant with a one-step method and the NPs were extensively characterized by SEM-EDX, TEM, XRD, FTIR, and DTA-TGA.

- The present work reported a biosurfactant-mediated method for the green synthesis of Ag and ZnO NPs and its implementation for enhancing seed germination along with their probable mode of action.

- The HR-TEM analysis confirmed the synthesis of well-dispersed Ag NPs and ZnO NPs with an average size range of 10-40 and 2-10 nm respectively.

- The Ag NPs and ZnO NPs primed rice (*Oryza sativa*) and chickpea (*Cicer arietinum*) seeds showed enhanced germination % with an optimum dose of 30 mg/L of NPs which also enhanced the seed water uptake, soluble sugar content, and amylase activity.

- The Ag NPs and ZnO NPs showed no cytotoxicity against red blood cells and also exhibited no environmental toxicity when tested on earthworms.

- The nano-treated earthworms demonstrated healthy gut physiology with healthy villi.

- The Ag NPs showed antimicrobial activity against plant pathogens *Ralstonia solanacearum* F1C1 and *Fusarium oxysporum* f. sp. *pisi* (van Hall) Synder & Hansen strain 4814, whereas, ZnO NPs exhibited no antimicrobial activity.

- Thus, the present study gives a complete snapshot of the biosurfactant- mediated green synthesis of Ag NPs and ZnO NPs, its application in enhancing the germination and growth of seeds, their antimicrobial activity against plant pathogens, cytotoxicity, and eco-toxicity assay, which advocates their futuristic potential for a field trial in future.