Understanding the Effect of Mixture of Metal Oxide Nanoparticles to Algae-Bacteria Consortia

ABSTRACT

Due to the excessive use of nanoparticles in various fields since last decade, the concentration of nanoparticles has been increasing rapidly in the aquatic environment. In the aquatic ecosystem symbiotic relation of algae-bacteria consortia can be seen and they are responsible for maintaining the basic functioning of the aquatic ecosystem. Due to the presence of nanoparticles, therefore the possibility of interaction of algae-bacteria consortia with nanoparticles would be increased. Therefore, this research was carried out to understand the effect of metal oxide nanoparticles on algae/algae-bacteria consortia and the impact of nanoparticles on the functioning of algae-bacteria consortia.

The effect of single and mixture of nanoparticles on the algae-bacteria consortia was studied theoretically to understand the interaction mechanism. Algal Species, *Scenedesmus obliquus* and bacterial species *Escherichia coli* were used in the study as test organisms. The metal oxide nanoparticles, ZnO and CuO, were used in single and mixture form at various concentrations (0.1, 1, 10 and 100 mg/L) to understand the effect of the nanoparticles on the consortia. To understand the toxicity mechanism of nanoparticles, the long-term effect of mixture of nanoparticles on algae/algae-bacteria consortia was also evaluated in this study. The effect of time on the stability of media, nanoparticles, and their relation to toxicity to algae was also studied. It was observed that the inhibition time for biomass was observed between 14 days and 21 days at 10 mg/L NPs. At 1 mg/L, the order of toxicity of NPs to algae was found to be: CuO NPs (highest toxicity) > ZnO NPs>ZnO + CuO NPs (least toxicity). During exposure of algae cells to a mixture of NPs at 10 mg/L NP concentration, a smaller value of metal deposition was observed than that during exposure to individual NPs. Antagonistic toxic effects of two NPs on dry cell weight of algae were observed at both concentration levels. The usage of ZnO and CuO NPs is increasing tremendously, and 0.1 mg/L would be more realistic concentration of NPs in the realistic aquatic environment or wastewater.

To understand the toxicity of mixture of nanoparticles on the algae in the realistic scenario,

the wastewater and the pond water was collected and used in the present study. It was observed that at 0.1 mg/L concentration of the mixture of NPs, the reduction in the chlorophyll a content was 13.61 ± 1.34% (OECD media), 28.83 ± 1.85% (wastewater), and 31.81 ± 2.23% (pond water). Values of reduction in biomass were observed to be 42.13 ± 1.38, 39.96 ± 1.03, and 33.10 ± 1.29% for OECD media, wastewater, and pond water, respectively. The overall toxicity trend observed was Wastewater>OECD media>Pond water in single and mixture of nanoparticles. For the consortia studies, 3 algae-bacteria ratios were considered (1:100, 100:1, and 1:1) and effect of observed in single as well as in mixture by analyzing various growth parameters such as Chl a, biomass, lipid, etc. and functioning was observed by observing the nutrient uptake efficiency. It was observed that at environmentally relevant NP concentration (0.1 mg/L), the order of toxicity of NPs to algae-bacteria consortia was found to be: CuO NPs (highest toxicity)>ZnO+CuO NPs>ZnO NPs (least toxicity).

Overall, this study helps in understanding the interaction between algae-bacteria consortia with single and mixture of nanoparticles. This study would help in understanding the effect of NPs on functioning and removal efficiency of algae-bacteria consortia for wastewater treatment and biomass production.

Keywords: *Mixture of nanoparticles; algae-bacteria consortia; long-term effect; toxicity*