Enhancing Algal Bacterial Photobioreactor Efficiency: Nutrient Removal and Cost Analysis Comparison for Light Source Optimization

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Abstract : Algal-Bacterial photobioreactors (ABPBRs) have emerged as a promising technology for sustainable biomass production and wastewater treatment. Nutrient removal is seldom done in sewage treatment plants and large volumes of wastewater which still have nutrients are being discharged and that can lead to eutrophication. That is why ABPBR plays a vital role in wastewater treatment. However, improving the efficiency of ABPBR remains a significant challenge. This study aims to enhance ABPBR efficiency by focusing on two key aspects: nutrient removal and cost-effective optimization of the light source. By integrating nutrient removal and cost analysis for light source optimization, this study proposes practical strategies for improving ABPBR efficiency. To reduce organic carbon and convert ammonia to nitrates, domestic wastewater from a 130 MLD sewage treatment plant (STP) was aerated with a hydraulic retention time (HRT) of 2 days. The treated supernatant had an approximate nitrate and phosphate values of 16 ppm as N and 6 ppm as P, respectively. This supernatant was then fed into the ABPBR, and the removal of nutrients (nitrate as N and phosphate as P) was observed using different colored LED bulbs, namely white, blue, red, yellow, and green. The ABPBR operated with a 9-hour light and 3-hour dark cycle, using only one color of bulbs per cycle. The study found that the white LED bulb, with a photosynthetic photon flux density (PPFD) value of 82.61 µmol.m-2 .sec-1 , exhibited the highest removal efficiency. It achieved a removal rate of 91.56% for nitrate and 86.44% for phosphate, surpassing the other colored bulbs. Conversely, the green LED bulbs showed the lowest removal efficiencies, with 58.08% for nitrate and 47.48% for phosphate at an HRT of 5 days. The quantum PAR (Photosynthetic Active Radiation) meter measured the photosynthetic photon flux density for each colored bulb setting inside the photo chamber, confirming that white LED bulbs operated at a wider wavelength band than the others. Furthermore, a cost comparison was conducted for each colored bulb setting. The study revealed that the white LED bulb had the lowest average cost (Indian Rupee)/light intensity (µmol.m-2 .sec-1) value at 19.40, while the green LED bulbs had the highest average cost (INR)/light intensity (µmol.m-2 .sec-1) value at 115.11. Based on these comparative tests, it was concluded that the white LED bulbs were the most efficient and costeffective light source for an algal photobioreactor. They can be effectively utilized for nutrient removal from secondary treated wastewater which helps in improving the overall wastewater quality before it is discharged back into the environment.

Keywords : algal bacterial photobioreactor, domestic wastewater, nutrient removal, led bulbs
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