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Antibiotic removal in photobioreactor and photogranule reactor: performance and mechanism

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The widespread antibiotics and associated antibiotic resistant genes (ARGs) in the aquatic environment have been recognized as one of the most important emerging pollution problems and pose a growing risk to ecosystems and human life. Our previous study indicated the efficient removal of mixed antibiotics and nutrients from wastewater using fresh microalgae membrane photobioreactors. *Haematococcus pluvialis* achieved the antibiotic removal efficiencies of 53.6-96.3% for 10 mixed antibiotics each initial concentration at 100 µg/L [1].

In the present work, *H. Pluvialis* was co-cultured with the aerobic bacterial granular sludge (BGS) to incubate the microalgal-bacterial granular sludge (ABGS). The BGS and ABGS were applied for eight antibiotic removals using the photo-sequential batch reactors (PSBR). The feed of the PBSRs consisted of synthetic municipal wastewater with hydraulic retention time of 12 h. The operation was conducted for 120 days of 4 stages (30 days per stage), consisting of a pre-antibiotic phase (stage 1) without antibiotics and the antibiotic phases, stages 2, 3 and 4 with 50, 200, and 500 µg L^{-1} antibiotic loads, respectively.

Results showed excellent biomass settleability in the PSBRs with antibiotic concentration at 50 µg/L. Compared to BGS, better stability was noticed in ABGS. Both BGS and ABGS showed excellent performance in terms of COD, nutrient and antibiotic removal under none and 50 µg L^{-1} mixed antibiotics. Elevated antibiotic concentration (200, 500 µg L^{-1}) affected system performance, although the consortium demonstrated better removal of persistent antibiotics (Figure 1). Metagenomic analysis revealed significant fewer ARG and MGE abundance in the consortium reactor, and the particle-association niche and projection pursuit regression model indicated that microalgae may limit gene transfers among phases (biomass and effluent) for MGE and ARG reduction. With in-depth insights into the photogranules microbial ecology under antibiotic stress, our findings highlight the role of microalgae in attenuating antibiotic, and antibiotic resistance genes during wastewater treatment. The proposed ABGS are beneficial for sustainable wastewater treatment.

[1] Kiki C, Ye X, Adyari B, Hu A, Qin D, Yu CP, Sun Q. J. Hazard. Mater., 2022, 434, 128910.