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Integrated phycoremediation and ultrasonic-irradiation treatment (iPUT) for the enhanced removal of pharmaceutical contaminants in wastewater

Mayur B. Kurade [a], Ghulam Mustafa [a,b], Muhammad Tariq Zahid [b], Mukesh Kumar Awasthi [c], Mital Chakankar [d], Katrin Pollmann [d], Moonis Ali Khan [e], Young Kwon Park [f], Soon Woong Chang [g], Woojin Chung [g], Byong-Hun Jeon [a,*]

[a] Department of Earth Resources and Environmental Engineering, Hanyang University, Seoul 04763, Republic of Korea
[b] Department of Zoology, Government College University Lahore, Lahore 54000, Pakistan
[c] College of Natural Resources and Environment, Northwest A&F University, Yangling Shaanxi Province 712100, PR China
[d] Biotechnology Department, Helmholtz Institute Freiberg for Resource Technology, Helmholtz-Zentrum Dresden - Rossendorf (HZDR), Dresden 01328, Germany
[e] Chemistry Department, College of Science, King Saud University, Riyadh 11451, Saudi Arabia
[f] School of Environmental Engineering, University of Seoul, Seoul, 02504, Republic of Korea
[g] Department of Environmental Energy Engineering, Kyonggi University, Suwon 16227, Republic of Korea

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ABSTRACT

Ultrasonication using low frequencies of sound can increase cell organogenesis, which is beneficial for various industrial applications. This study demonstrates a novel approach of integrated phycoremediation and ultrasonication-irradiation treatment (iPUT) used for improving the degradation of sulfonamide antibiotics via a cumulative effect of combined treatments. Variable ultrasonication treatment (UT) (20 %-2 min to 40 %-10 min) was given to a model microalga, *Chlamydomonas mexicana* in two ways, 1) single ultrasonic treatment (SUT) and 2) multiple-intermittent ultrasonic treatments (IUT). The microalgal growth was slightly affected by SUT, while it significantly inhibited by IUT. The removal of sulfacetamide and sulfapyridine was significantly improved by >1.7-fold and >1.95-fold at 20 % of SUT and IUT treatment, respectively, compared to control. In the case of sulfamethazine, the SUT showed maximum removal (33.5 %) at 20 %, whereas IUT could achieve 27.5 % removal at the same ultrasonication conditions compared to 9.5 % removal in control. The IUT accelerated the degradation of sulfamethoxazole and sulfadimethoxine more than SUT showing a 9- fold and 12- fold increase in the removal of sulfamethoxazole and sulfadimethoxine with 20 % and 40 % treatments, respectively. The changes in microalgal cell morphology due to ultrasonication treatment were the main cause of enforced uptake and subsequent degradation of these ECs.

1. Introduction

The presence of emerging pollutants including pharmaceuticals in aquatic reservoirs is becoming a global threat due to their detrimental effects on the aquatic flora and fauna and human health. Pharmaceutical compounds (PCs) are unintentionally released to the surface water and groundwater either directly from their manufacturing units or indirectly through anthropogenic activities such as sewage discharge, hospital waste, landfill leachate, and aquaculture runoff [1–3]. The intermediates of partially degraded PCs with complex structure possess toxicity and persistence [4]. In addition to their mutagenic, carcinogenic, and estrogenic effects, their reactive biological properties can cause detrimental ecological impacts such as inhibition of microbial growth and activities, disintegration of the bacterial nitrification/denitrification process, and decline in the diversity of core microbial communities even at low concentrations (ng L^{-1}) [3,5]. Most importantly, the release of PCs into the environment can develop antibiotic resistance genes, potentially causing antibiotic-resistant bacteria or so-called 'superbugs' [6].

It has been observed that the conventional wastewater treatment systems are not efficient enough to eliminate the emerging contaminants [7,8]. This is related to the low concentrations and high chemical oxygen demands (COD) of these contaminants and their lack of interactions with microbial agents in wastewaters [3,4,6]. Therefore, recent

* Corresponding author at: Department of Earth Resources and Environmental Engineering, Hanyang University, Seoul 133-791, Republic of Korea.
E-mail address: bhjeon@hanyang.ac.kr (B.-H. Jeon).

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