Journal of Cleaner Production 344 (2022) 131121

Contents lists available at ScienceDirect

Journal of Cleaner Production

journal homepage: www.elsevier.com/locate/jclepro

A comprehensive review on the effects of engineered nanoparticles on microalgal treatment of pollutants from wastewater

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ARTICLE INFO

Handling Editor: M.T. Moreira

Keywords:
Nanotoxicity
Dynamics of microbial community
Emerging contaminants
Ecotoxicological responses
Omics analyses

ABSTRACT

Engineered nanoparticles (ENPs) are advanced, high-throughput materials that have revolutionized almost every aspect of human life over the past decade with its numerous commercial applications across the globe. However, these particles have made their way into the environment through various pathways, eliciting unintended environmental consequences, and endangered various ecosystems and human health. Microalgae and their related microbial communities act as one of the key indicators of nano-toxicity, and play essential roles in bioremediation and bioenergy productions. In this review, we analyzed the interactions of nanoparticles with microalgae and the associated microbial communities along with its influence on the remediation capacities of pollutants such as organic pollutants, nitrogen and phosphorus. We also provide a comprehensive insight into the transcriptomics, proteomics and metagenomics of ENPs influenced microalgae and their related microbial communities to identify the in-depth protective and metabolic mechanisms. The information provided herein can extend the understanding of the effect of nanoparticles on environmental processes and might be useful in designing its disposal and treatment strategies.

1. Introduction

The unique transformative properties of engineered nanoparticles (ENPs) have attracted great scientific interests, which are being increasingly used as high-throughput advanced materials in widespread commercial applications such as electronic devices, pharmacology, biomedical devices, paints and cosmetics, biotechnology, energy, magnetic fields, and environmental remediation (Hochella et al., 2019; Xie et al., 2021). According to manufacturers' reports, more than 1300 commercial consumer goods, ranging from cosmetics, paints, food containers, sports goods, biosensors, drug carriers, foam, and catalyst, contain ENPs (Kannan et al., 2020). Large usage of these advanced materials has induced their frequent contamination in environment through numerous channels such as emissions from the manufacturing industry, consumer use of products containing nanomaterials, sewage sludge, wastewater, and incinerators (Fig. 1), causing tremendous adverse effect on ecosystems and human health (Wiesner and Plata, 2012; Xia et al., 2018; Xiong et al., 2020). For example, sunscreens applied during bathing and swimming eventually contaminate surface water due to the break down and dispersal of the nanoparticles contained in them (You et al., 2021; Sendra et al., 2017). Use of personal care products such as facial sprays, skin hydrating mists, hair sprays, disinfectants, and wheel cleaners result in human exposure to ENPs in the size range of 13 nm–20 μm via inhalation, which are then deposited in various regions of the users' respiratory system (Labille et al., 2020). Therefore, ENPs are increasingly recognized as emerging contaminants with extensive ecological impacts because of their nano size, large surface area, and high reactivity with biological systems (Nguyen et al., 2018a,b). There is a growing concern regarding their risks to human health and environment, particularly the hazards that are yet to be

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https://doi.org/10.1016/j.jclepro.2022.131121
Received 18 September 2021; Received in revised form 27 December 2021; Accepted 23 February 2022
Available online 26 February 2022