Assessment of selected emerging contaminants in wastewaters from rural, peri-urban and city areas of Delhi NCR and their microalgal remediation

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ABSTRACT

The objective of the present study was to assess the quality of drain wastewater in sparsely and densely populated different types of human settlements in Delhi NCR, in terms of both conventional and emerging contaminants (ECs) in two summer and two winter seasons and to investigate the potential of microalgal consortium for the removal of emerging contaminants from drain wastewater. Wastewater quality of 12 selected drain in Delhi NCR in different rural, peri-urban and city areas was evaluated in terms physiochemical characteristics – conductivity, TDS, pH, DO, BOD, COD, PO_4, NO_3, NH_4 and coliforms, as well as emerging contaminants - heavy metals and pharmaceutical and personal care products (PPCPs). Drain wastewater characterization was done for the period of two years (December 2016-June 2018) representing two seasons each year: peak winter and peak summer. The concentration of heavy metals at the selected drain sites was below the permissible limits of inland surface water discharge, with zinc and nickel present in highest concentrations. The peri-urban industrial sites were most contaminated with heavy metals. The abundance of PPCPs in drain wastewater and the highly polluted Yamuna river is much higher than the pristine Ganga river sites, indicating the human input of these due to extensive use and disposal. Methyl paraben, diclofenac, triclosan, ranitidine and carbamazepine were the most abundant PPCP contaminants in drain wastewater. However, their concentrations were found to be in pg L^{-1}. The densely populated city and peri-urban drain sites showed the highest contamination with PPCPs. The variety of these PPCPs occurring in wastewater due to non-removal by conventional wastewater treatment systems, may have potential negative effects on the ecosystem. An environment friendly technology is required to remove both conventional and emerging contaminants from wastewater. A potential remediation technology based on microalgal consortium was investigated. For this, a wastewater obtained microalgal consortium from Hauz Khas lake in Delhi, named HL was examined for its emerging contaminant removal ability - heavy metal removal in single and multi-metal solutions; and PPCPs in individual solutions. The results show that under single metal exposure, HL showed better performance (57-98% removal) as compared to multi metal

exposure (14-85% removal). The maximum removal was observed for Zn, Ni and Cu in both type of exposures. The biomass productivity for the consortium increased in both types of heavy metal spiking. For the PPCP removal, it was observed that the consortium was able to tolerate environmentally high concentrations of the selected drugs. The effective concentrations with 50% mortality values for the consortium for estradiol (EST), diclofenac (DCF) and triclosan (TCS) was 16, 8 and 8 mg L^{-1}, respectively. The consortium grew well in EST and DCF spiked media but could not tolerate TCS beyond 5 days. Substantial removal of EST (91.73%), DCF (74.68%) and TCS (78.47%) within the stationary phase of growth was achieved. It was also observed that the removal by microalgal consortium was higher than abiotic degradation in the same time. From the adsorption and bio-degradation experiments, it was concluded that bio-degradation by microalgae was the prominent removal mechanism for the selected PPCPs, and not adsorption. From SEM studies, it was observed that there were morphological deformation, clustering and cell disruption in microalgal cells due to the exposure to the PPCPs. Further, to assess the performance of native microalgal consortium under environmental concentrations of PPCPs, on-site, an LED based photobioreactor system (40L) was developed and fed with raw wastewater from the Barapulla drain in Delhi. PBR performance was assessed for winter and summer season for the removal of both conventional and emerging contaminants. The PBR was able to remove 41.35% COD, 41.28% PO_4 and 100 % NH_4 with an HRT of 4 days. Additionally, 25.67-59.63% removal of heavy metals and 21.93-100% removal of PPCPs was observed in the PBR. Thus, it can be concluded that microalgal-based treatment depicts a promising technology for both conventional and emerging contaminant removal under environmental conditions. The data generated from the mapping study of ECs occurring in the Delhi NCR is an important step towards understanding the scope of the problem of ECs in a highly populous country like India. Mapping of various conventional and emerging contaminants in different types of human settlements had not been previously done. This information can be useful for the regulatory authorities for making guidelines for the continuous discharge of the ECs and for investigating the potential to integrate environment friendly microalgal-based technology as a polishing step in the existing wastewater treatment systems to target and remove the ECs, along with the conventional contaminants.

Supervisors

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