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Advancing Hospital Wastewater Treatment via Continuous Adsorption in a Coiled Flow Inverter Reactor

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ABSTRACT

Hospitals worldwide necessitate substantial water quantities to operate various healthcare facilities efficiently and thus generated wastewater represents a complex matrix of organic pollutants, including pharmaceutical and personal care products (PPCPs) that poses a significant threat to aquatic ecosystems and public health. These substances persist in the environment, accumulate in organisms, and exert toxic effects across biological systems. The prolonged exposure to these compounds even in trace amounts in addition to causing toxicity also results in the growth of antibiotic-resistant bacteria, enhanced risk of cancer, abnormal growth in children, alterations in the immune system, and modifications in reproductive function of humans and aquatic life.

Conventional treatment methods often require a longer processing time along with large space occupancy. To improve the efficiency and cost-effectiveness of hospital wastewater (HWW) treatment, this study explores the application of Coiled Flow Inverter (CFI) for HWW treatment using Graphene Oxide (GO) for the adsorptive removal of triamterene (a model PPCP pollutant) from water. Effects of various parameters including flowrates (10 mg/mL and 135 mg/mL), initial pollutant concentration (1-250 ppm), adsorbent dosage (0.2-2 mg/mL) and pH (2-10) were systematically investigated. The results revealed a maximum adsorption capacity of 822 ± 0.07 mg/g, with approximately 99% removal efficiency achieved across all pH regions. The impact of flow rate on removal efficiency was negligible, and the process was ultra-fast, requiring only 40 seconds compared to the conventional batch process, which takes 5 hours to achieve a similar removal efficiency of ~80%. Finally, adsorptive removal of triamterene in real hospital wastewater samples was tested, achieving a removal efficiency of > 90 % in 1 minute. Adsorption, when combined with novel adsorbents and compact systems, improves PPCP removal by enhancing mixing, reducing adsorption time, space, and cost compared to conventional batch/coulmn adsoprtion.

Key outcomes of this study demonstrated significant reduction of treatment time (x450 times faster), minimal space requirement, and improved mixing efficiency compared to conventional batch adsorption approach, paving way for a new sustainable hospital wastewater treatment in a miniaturized reactor.

KEY WORDS

Hospital wastewater treatment, Adsorption, Coiled Flow Inverter, PPCPs, Sustainability, Graphene Oxide

BIOGRAPHY

Ammara Waheed is a research student at University of Adelaide, specializing in wastewater treatment. Her work focuses on removing pharmaceuticals and personal care products (PPCPs) using continuous adsorption and ozonation based techniques in Coiled Flow Inverter (CFI) reactors. Previously, she lectured at Chemical Engineering Department of University of Wah in Pakistan. She has expertise in the synthesis of advanced materials for environmental remediation, including inverse vulcanized copolymers, graphene-based photocatalysts, and biosorption techniques for heavy metal and pollutant removal from wastewater. Her research aims to develop scalable, cost-effective water purification technologies, shaping the future of environmentally sustainable chemical engineering and innovative wastewater treatment solutions.

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