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Waste Water Treatment by Novel Core-Shell Photocatalytic Materials

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Abstract

Global freshwater scarcity (1) affects roughly 10% of the world's population year-round and exposes an estimated 4 billion people to at least one month of water stress annually, posing significant risks to public health, agriculture, and economic growth. Greywater and secondary effluents from decentralized facilities (hotels, small industry, healthcare) represent an untapped resource that could substantially alleviate water stress through safe reuse, particularly for irrigation and non-potable applications. However, current tertiary treatment technologies for greywater reuse such as reverse osmosis (2) and advanced oxidation are energy-intensive (2–5 kWh/m^3), generate up to 40% brine waste, require complex maintenance, and involve high operational costs, limiting their use in decentralized and off-grid settings. Hereby, we present a set of novel-materials, based on visible light photocatalysis Core-Cell structures, aiming to facilitate a tertiary polishing process for irrigation and non-potable reuse. The photocatalytic stage composed of structurally modified TiO2 core materials (3), decorated by QCDs (Quantum Cabron Dots) (4) has been lab -tested for their photocatalytic efficiency based on the decolorization of methylene blue (MB) dye, under a liquid catalysis process, utilizing both indoor and outdoor (solar) lighting sources. These unique combinational materials are rated as potentially effective candidates that promote photocatalytic processes that can oxidise and mineralise refractory organics and inactivates pathogens; Compared with conventional Reverse Osmosis based tertiary trains, these materials, incorporated in a conventional Compound Parabolic Collector (CPC), followed by an incumbent Capacitive Deionization (CDI) system, may altimetry lead to a unique prototype combinational system process that could enable cost effective off grid and/or solar assisted operation, cut secondary waste generation by >80%, reduce chemical dosing by >90%, and lower energy use by ~30–60%. Socially and economically, such system may improve local water security, in areas such as South European countries with amble sun-light all year round, potentially saving millions of cubic meters of freshwater annually and reducing wastewater nutrient loads that drive eutrophication. Environmentally, this set of materials/system combination aim at advancing circular water use and minimising hazardous secondary wastes.

Keywords: Titanium dioxide (TiO2), carbon dots, photocatalysis, waste water, pollutants degradation