Creating a Sustainable Engineering System for Urban Green Roof Drainage Irrigation via a Two-Way Heavy Metal Removal Mechanism Involving Photocatalytic Reduction and Phytoremediation

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Urban areas will experience benefits ranging from increased local food supply to remediation of heat island effects once urban green roof drainage water is used to irrigate urban agriculture. In this system, it is important to transfer the macronutrients such as nitrates, phosphates, and carbon produced from the green roof soil directly to the designated vegetation while simultaneously reducing the toxic heavy metals that are harmful to plants. In the present work, the toxic heavy metals of Cr(VI), Cd, and Zn were the targets of removal from the acquired green roof drainage samples. The heavy metal concentrations were reduced via a two-way process, specifically, Cr(VI) were reduced by converting them to nontoxic Cr(III) through photocatalytic reduction on the TiO2 filmed nanorod, while Cd and Zn concentrations were reduced via phytoremediation on different species of hyperaccumulator plants. The overall objective of the study was to gauge the effectiveness of this two-way approach for heavy metal removal. For the photocatalytic reduction process, the conversion of Cr(VI) to Cr(III) was accomplished via the transfer of electrons from the dye sensitized zone to the catalysis zone, which made the catalysis zone the anode and thus a source of reduction for Cr(VI). Ultimately, it turned out that the TiO2 nanorod with the Sn3O4 coating showed the highest photoreduction capability due to enhanced electron migrations across the FTO glass substrate. For the phytoremediation step, 4 commonly known hyperaccumulator species (Collards, Arugula, Radish, and Pokeweed) were tested for their abilities in phytoextracting Cd and Zn present in the system. Pokeweed showed the highest tolerance for both which could be attributed to their distinctive physiological characteristics.