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# Vertical Farms on Reused Water: Multifunctional Performance and Food Implications

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In an era of increasing water scarcity, climate change, and rapid urbanization, the expansion of green walls into multifunctional systems that combine water treatment with urban food production is gaining attention alongside rising pressure on agricultural water supplies. Beyond residue transfer, emerging contaminants (ECs) may impair plant health and destabilize the biological functions that underpin vegetated treatment, creating coupled risks for removal efficiency and crop quality. Thus, a pilot scale greywater treatment green wall system planted with edible crops was conducted to (1) assess whether treatment performance is maintained under exposure to ECs mixtures and (2) quantify the uptake, distribution, and potential dietary exposure associated with produce grown in contaminated media under greywater irrigation. A controlled exposure system was established using soil amended with a mixture of 23 antimicrobials and representative trace organic chemicals (TrOCs) at two levels (1 and 10 mg $kg^{-1}$) to simulate soil accumulation that could occur over time from repeated irrigation with greywater containing low level contaminants (<10 µg $L^{-1}$).

The study conducted for 18 weeks using Cos lettuce *(Lactuca sativa)* and cherry tomato *(Solanum lycopersicum)* irrigated with greywater in a green wall configuration under laboratory control and outdoor/nature conditions. Green wall treatment performance remained stable during crop cultivation, with consistent effluent removal of targeted TrOCs and antimicrobials (> 80%), alongside measurable reductions in key nutrients (total dissolved nitrogen: up to 75%, and total phosphorus: 70%). Plant results indicate that ECs were taken up and transported to stems and leaves, reducing plant height (up to 80%), relative growth rate (6.7–18.2%), and chlorophyll content (3.7–16.6%). Oxidative stress was evident from elevated peroxidase activity, increased reactive oxygen species (ROS), and higher lipid peroxidation (malondialdehyde, MDA), with stronger effects at higher contaminant loading. Under high loading, plants did not reach fruiting, while fruiting was delayed at lower loading, suggesting growth inhibition and stress responses occurred before substantial transfer to edible tissues, which appeared limited. These findings improve our understanding of the metabolic responses of green wall crops to ECs stress and how a mixture of antimicrobials and TrOCs may affect the performance of vertical green infrastructure in urban agriculture.