Journal of Environmental Sciences Study Reveals Insights into Passive Water Purification by Constructed Wetlands

Recent article summarizes crucial information and techniques for the practical, full-scale deployment of constructed wetlands for micro-polluted water cleanup

Constructed wetlands can effectively remove pollutants at low concentrations from water, making it safe for release into freshwater bodies. Adding biochar, metal ore waste, and regularly harvesting plants improves their pollutant removal efficacy

BOSTON, MA, UNITED STATES, October 24, 2025 /EINPresswire.com/ -- Constructed wetlands (CWs) effectively remove low concentrations of dissolved carbon, nitrogen, and phosphorus pollutants, and prevent contamination and algal blooms from occurring in freshwater bodies. A team of Chinese researchers have identified factors that affect the removal efficacy of CWs and listed strategies to make CWs more effective. These findings can increase the deployment of CWs across diverse environments.

Micro-polluted water, which is wastewater with low levels of carbon, nitrogen and phosphorus, is emerging as a significant contamination threat to freshwater bodies. Dissolved carbon, nitrogen, and phosphorous in micro-polluted water can accumulate in freshwater lakes and cause algal blooms, increased die-off of fish, and loss of biodiversity. Traditional wastewater treatment plants (WWTPs) cannot efficiently remove dissolved pollutants at low concentrations. In fact, WWTP discharge is actually a source of micro-polluted water. Other major sources include agricultural run-off and polluted rivers carrying untreated sewage.

Constructed wetlands (CWs) are a widely deployed solution to purify micro-polluted water. These systems use a combination of plants, microbes, and soil substrates to mimic the water purification processes seen in natural wetlands. However, experimental small-scale CWs may not accurately replicate how a full-scale CW functions, and studies of full-scale CWs have been

limited.

Understanding the factors that affect the efficiency of full-scale CWs can help improve their efficacy for a variety of environments. To this end, a review of full-scale CWs was conducted by a team of researchers led by Professor Haiming Wu of the School of Environmental Science and Engineering, Shandong University. Their findings were first made available online on 28 March 2025 in the Journal of Environmental Sciences and will be published in Volume 159 of the journal in January 2026.

Describing the purpose of this study, Prof. Wu mentions, "We aimed to identify the characteristics of influent water and their impact on purification performance, design and operational factors influencing CW efficiency, and emerging strategies for enhancing pollutant removal."

Prof. Wu's team first noted that the profile of pollutants varies greatly depending on the source. Agricultural runoff has the highest dissolved carbon / chemical oxygen demand (COD), whereas polluted river water has the highest dissolved total nitrogen, phosphorus and significant levels of heavy metals and pharmaceutical compounds.

Next, they reviewed studies of 78 full-scale CWs, covering a variety of designs, utilizing many kinds of plants and microbes, and designed to treat one or more sources of micro-polluted water. They identified several factors that affect the removal of dissolved pollutants, including:

- Direction of water flow: Horizontally across the CW surface or vertically through substrates
- Rate of water flow: Slower flow allows for more effective removal, but very slow flow increases odor generation
- Rapidly growing plants to absorb pollutants in their growth phase
- Carbon-to-nitrogen ratio in the untreated water
- Electron donors such as manganese in the substrate
- Dissolved oxygen to increase both microbial growth and the removal of heavy metals

"All of these factors can be altered by public utilities to improve the pollutant removal efficacy of their CWs", Prof. Wu explains.

Adding carbon sources (e.g., agricultural by-products, biochar and modified biochar) or inorganic substrates (e.g., natural ores and industrial or mine waste) can enhance the purification performance of CWs for micro-polluted water. Additionally, optimization of hydraulic parameters (e.g., aeration and hydraulic loading), selection of suitable plants, and regular harvesting are also recommended.

Due to their proven efficacy at removing micro-pollution, as well as their relatively low setup and maintenance costs, full-scale CWs are an attractive solution for utilities. However, challenges like the high cost of substrate enhancements and the growing presence of persistent pollutants such

as PFAS (Per- and polyfluoroalkyl substances) remain. Prof. Wu believes that these are ripe areas for future research on improving the removal efficacy and cost effectiveness of CWs.

Other avenues for future research include developing predictive models to optimize factors such as system footprint, substrate selection, plant species, and hydraulic conditions. “These models will enhance our understanding of the complex pollutant removal processes and facilitate more effective CW designs and operations,” says Prof. Wu.

One hopes that future research will keep our freshwater sources safe from contamination.

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Reference
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About Shandong University
First established as the Imperial Shandong University in 1901, Shandong University (SDU) is the second oldest university in China. Spread over seven campuses in Shandong province, the university serves over 41,000 undergraduate and over 24,000 postgraduate students. Over 4,500 faculty members work at SDU, including 21 members of the Chinese Academy of Sciences and Chinese Academy of Engineering. The university is involved in several high-profile national and provincial research projects, and houses over 1,200 international students.
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About Haiming Wu from Shandong University
Haiming Wu is a Professor and PhD supervisor at the School of Environmental Sciences and Engineering at Shandong University. Prof. Wu received his doctorate in environmental engineering in 2014 and has worked at Shandong University since 2020. His areas of research are on wetland management and wastewater treatment, and he has over 120 publications. Prof. Wu received the Science and Technology Progress Award of the Ministry of Education. In addition to his academic work, Prof. Wu is a member of the Expert Committee of the Shandong Environmental Protection Industry Association as well as several national and international environmental sciences organizations.

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