Review Article

Developments and Future Directions in Managing Hydroponic Wastewater: A Comprehensive Review

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ABSTRACT

Wastewater hydroponics offers a sustainable approach to both farming and wastewater treatment, optimizing water usage, enhancing food security, and mitigating environmental pollution. This method utilizes wastewater as a nutrient-rich solution for plant growth, simultaneously treating pollutants and producing valuable crops. Compared to conventional wastewater treatment methods, like constructed wetlands, wastewater hydroponics presents economic advantages by generating high-value produce while requiring less land and water.
This approach plays a crucial role in pollutant removal, nutrient recycling, and sustainable agriculture. Various plant species effectively treat wastewater by removing heavy metals, organic contaminants, and excess nutrients. However, challenges such as nutrient imbalances, system maintenance, and scalability need to be addressed for optimal efficiency. Factors like pH regulation, hydraulic retention time, and appropriate plant species selection also influence treatment effectiveness.
Given the global concerns over water scarcity and food security, wastewater hydroponics is a viable alternative to traditional agriculture and wastewater management. Continued research focusing on system optimization, improved pollutant removal, and integration of renewable energy sources will enhance sustainability. Advancing this technology from experimental research to large-scale applications holds significant potential for environmental conservation and resource-efficient food production.

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Keywords: Wastewater hydroponics, Phytoremediation, Nutrient recycling, Soilless cultivation, Sustainable agriculture.

1. INTRODUCTION

Currently, productivity and eco-friendly sustainability are the primary challenges in conventional farming due to the impacts of climate change. Rising temperatures and extreme weather events intensify threats to soil health, leading to reduced fertility, an increased presence of pathogens and nematodes, unfavorable compaction, and degradation caused by erosion. Conversely, by 2050, the global population is expected to grow to 9–10 billion. With urbanization reducing arable land, food demand will increase, placing additional pressure on water resources. In the coming decades, freshwater availability will be a critical challenge for agriculture, especially in Asia and Africa (Power and Jones 2016). To tackle this issue, advanced methods like hydroponics will be essential, as they:

- Contribute to the conservation of vital resources such as water and soil.
- Assist in adapting to climate change impacts.
- Improve crop yields while maintaining environmental sustainability.

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Soilless cultivation of horticultural crops, commonly called hydroponic systems, involves delivering water and essential nutrients to plants through nutrient solutions, either with or without a growing medium such as clay, rocks, or pebbles (Maucieri et al., 2019) This method of plant cultivation keeps the shoots exposed to air while the roots are submerged in a nutrient-rich solution (Richa et al., 2020) Unlike conventional farming, hydroponics maximizes both horizontal and vertical space, allowing for a higher plant density per unit area. By utilizing vertical farming techniques, it enhances yield and ensures a steady supply of fresh, nutrient-rich produce, particularly in densely populated regions. Hydroponics enables year-round crop production while minimizing environmental impact by reducing pesticide and fertilizer runoff. This method requires significantly less land and water compared to conventional open-field farming Meselmani and Ali (2024). By utilizing advanced greenhouse technologies to regulate key factors essential for plant growth, hydroponic systems maximize resource efficiency, ensuring that water and nutrients are used effectively with little to no harmful waste or residue. Modern large-scale hydroponic farms function within precisely regulated environments, where climate, lighting, and irrigation are meticulously controlled using advanced sensors, web-based platforms, specialized software, and mobile applications (Reza et al., 2025). These technological innovations have significantly enhanced efficiency, driving substantial growth in the hydroponics industry. Between 2021 and 2028, the market is projected to expand rapidly, with an estimated compound annual growth rate (CAGR) of 20.7% over this period (anonymous 2021). Meeting the food demands of a growing population by 2050 is just one of many global challenges. Climate change and environmental pollution remain critical concerns, both ecologically and economically. Hydroponic farming presents a viable alternative to traditional open-field agriculture, helping to address issues such as excessive CO_2 emissions and the depletion of fertile land caused by outdated and unsustainable farming methods.

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In hydroponics, water acts as a major resource and as highlighted in the UN Water Sustainable Development Goal report, nearly 44% of domestic wastewater globally is discharged without undergoing proper treatment (anonymous 2023) Wastewater from households can include a range of pollutants, such as detergents from bathrooms, food residues and oils from kitchens, and waste from toilets. As a result, it may contain pathogens, nutrients, harmful chemicals and organic matter. In response to growing social and environmental concerns, the water industry has increasingly focused on wastewater treatment and reuse (Adewumi and Oguntuase, 2016). Despite these efforts, industrial wastewater remains a challenge, as it often contains high concentrations of persistent organic compounds, inorganic pollutants, and heavy metals, posing risks to environmental health.

Wastewater treatment methods like activated carbon adsorption, biochar, advanced oxidation, biological treatments (e.g., constructed wetlands), and membrane-based systems vary in effectiveness based on wastewater composition. However, high installation and maintenance costs remain a challenge, particularly for biochar and filtration membranes. Additionally, some processes generate by-products that, if not properly managed, can cause secondary pollution. Advanced oxidation methods also require oxidants and catalysts, which may produce additional residues needing careful disposal. Some treatment technologies require strict conditions, making large-scale use challenging. Biofiltration depends on slow-growing microorganisms, while membrane systems need pressure control to prevent clogging or damage. A cost-effective, easy-to-implement solution with economic benefits is essential. Hydroponics, a soil-free method using water-based nutrients, improves resource efficiency, nutrient absorption, and crop yields. Beyond farming, it shows promise in wastewater treatment. Wastewater hydroponics, based on traditional hydroponics, delivers nutrients directly to plants, reducing freshwater and fertilizer use while ensuring steady growth and productivity. In wastewater hydroponics, wastewater replaces conventional nutrient solutions, enabling the treatment of wastewater while producing valuable by-products simultaneously.

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2. WASTEWATER HYDROPONIC PROCEDURE

2.1 Nutrient Solution:

In hydroponic systems, plants receive all essential nutrients through a nutrient solution, except for carbon, hydrogen, and oxygen, which are absorbed from the air. Inorganic fertilizers serve as nutrient sources, while iron is supplied in chelated form to enhance its absorption. Research on plant nutrition in hydroponics has categorized nutrients into three main groups: primary, secondary, and trace (or micro) nutrients, as outlined in Table 1.

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Table 1 : Key nutrients received by plants in hydroponic system

Nutrient Name	Symbol	Absorbed form
Nitrogen	N	NH_4^+, NO_3^{2-}
Phosphorus	P	PO_4^{3-}, HPO_4^{2-}, $H2PO_4^-$
Potassium	K	K^+
Calcium	Ca	Ca^{2+}
Magnesium	Mg	Mg^{2+}
Sulfur	S	SO_4^{2-}
Iron	Fe	Fe^{2+}, Fe^{3+}
Manganese	Mn	Mn^{2+}
Zinc	Zn	Zn^{2+}
Copper	Cu	Cu^{2+}
Molybdenum	Mb	MoO_4^{2-}
Boron	B	BO_3^{2-}, $B_4O_7^{2-}$

Commercially available nutrient solutions use a three-number code to represent the weight percentage of nitrogen (N), phosphorus (P), and potassium (K). For example, an 8-15-36 formula, suitable for tomato cultivation, contains 8% nitrogen, 15% phosphorus, and 36% potassium. For lettuce, an 8-15-16 formulation is typically recommended. In wastewater hydroponics, balancing nutrient levels while ensuring proper pH and electrical conductivity (EC) is challenging, as contaminants must be effectively removed to maintain optimal growing conditions (Reetika et al., 2024).

2.1.1 pH of Hydroponics Nutrient Solutions

An important chemical feature of a nutrient solution is its pH, measured on a scale of 1 to 14, which reflects its alkalinity or acidity. At ambient temperatures, pure water has a pH of 7, which is neutral. Solutions more than pH 7 are basic and those less than pH 7 are acidic. It has been indicated in research that keeping a nutrient solution in the range of pH 5 to 7 is best, as it keeps nutrients in a soluble state and available for uptake by the plant (Lu and Shimamura, 2018).

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If the pH level goes beyond 7, iron (Fe) and dihydrogen phosphate ($H_2PO_4^-$) become less soluble, and calcium (Ca) and magnesium (Mg) precipitates are formed, which cause hindrance to nutrient uptake. Besides that, interactions between different components within the solution restrict the uptake of vital micronutrients like iron, boron, copper, zinc, and manganese. Alternatively, when pH falls below level 5, the uptake of major nutrients such as nitrogen, phosphorus, potassium, calcium, magnesium, and molybdenum is limited.

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When the pH exceeds 7, the solubility of iron (Fe) and dihydrogen phosphate ($H_2PO_4^-$) decreases, leading to the formation of calcium (Ca) and magnesium (Mg) precipitates, which interfere with nutrient absorption. Additionally, chemical interactions within the solution limit the bioavailability of essential micronutrients such as iron, boron, copper, zinc, and manganese. Conversely, when the pH drops below 5, the availability of key macronutrients including nitrogen, phosphorus, potassium, calcium, magnesium, and molybdenum becomes constrained, negatively affecting nutrient uptake.

2.1.2 Electrical Conductivity of Hydroponics Nutrient Solutions

Electrical conductivity (EC) measures the total ion concentration in a solution. A low EC suggests a nutrient deficiency in ionic form, while excessively high EC levels can cause salt stress in plants. (Savvas and Gruda, 2018). Therefore, It is essential to regulate EC within a specific range, as it plays a vital role in influencing plant development and overall crop quality (Sonneveld and Voogt, 2009).

Table 2 depicts the ideal pH and EC range for common vegetable production. In other instances, high levels of some micronutrients, like manganese, have been implicated in causing environmental pollution.

Table 2 Required pH and EC for hydroponic crop (Dunn and Singh, 2016)

Crop	pH	EC (mS/cm)
Asparagus	6 – 6.8	1.5 – 1.8
Basil	5.4 – 6	1 – 1.6
Cabbage	6.5 – 7	2.5 – 3
Celery	6.5	1.8 – 2.4
Egg plant	6	2.5 – 3.5
Ficus	5.5 – 6	1.5 – 2.4
Lettuce	6 – 7	1.2 – 1.8
Okra	6.4	2 – 2.5
Parsley	6 – 6.5	1.9 – 2.2
Rose	5.5 – 6	1.5 – 2.5
Spinach	6 – 7	1.8 – 2.3
Strawberry	6	1.8 – 2.2
Tomato	6 – 6.5	2 – 4

2.1.3 Sterilization of Nutrient solution

Providing a sterile environment is crucial in hydroponic crops to ensure high-quality produce. Maintaining the root zone completely free of contaminants is difficult, though. Wilting of leaves is one symptom of plant disease that results from fungal pathogens such as Fusarium and Verticillium (Son et al., 2022). Root infection due to Pythium and Phytophthora can also be detrimental to plant health. Regrettably, there is no fungicide safe to use in hydroponics without any risks to consumer health.

To ensure sustainability recycling the nutrient solution conserves water and minimizes waste. Setting up a system that best handles natural resources, energy, and cost can prove to be challenging (Kwon et al., 2021). There are a number of ways to prevent infection in hydroponic solutions, as demonstrated in Table 3. With each method possessing different strengths and weaknesses, the use of a combination of techniques might be the best means to keep the nutrient solution clean.

Table 3 Methods of sterilization of nutrient solution (Alsanius and Wohanka, 2019)

Methods		Feature
Chemical Treatment	Ozone Chlorine Hydrogen Peroxide	High levels of organic matter reduce efficiency. A cost-effective method, though its efficiency varies based on multiple factors. Excessive use can be damaging to plant roots if the concentration exceeds 0.05%.
Filtration	Sand Filter	Affordable and simple to use.

	Membrane	Very efficient but requires a high upfront investment and costly maintenance.
Heat Treatment	Pasteurization	Extremely efficient with no formation of precipitates.
Radiation	UV Radiation	Highly efficient with clear solutions and minimal space required.

2.2 Wastewater Hydroponic System

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It would also be helpful to include a paragraph explaining how these systems can be used with treated wastewater (just like with fresh water) or if additional equipment is needed for this purpose.

Hydroponic systems are classified into open and closed systems. In open systems, unused nutrient solutions are not recycled but discarded instead. Closed systems, however, collect and reuse unused nutrients from plant roots, maximizing resource use (Khan et al., 2018). Open system is further classified into deep water culture and floating raft culture, which are beneficial for wastewater hydroponics. The deep-water culture (DWC) method involves suspending plant roots in a nutrient solution with the upper portion of the plant supported by materials like polystyrene, cork, or wood (Velazquez-Gonzalez et al., 2022). This design ensures sufficient oxygen reaches the roots, promoting healthy growth. Often, air pumps and stones are used to further enhance oxygenation. A variation of this is deep water culture, where plants are placed in pots with a growing medium, and the base of the pots is submerged in the nutrient solution. In DWC, some roots remain submerged, while others are exposed to air, facilitating efficient nutrient uptake and oxygen exchange (Dhawi, 2024). DWC is a popular method in hydroponics because of its simplicity and effectiveness. In the floating raft culture system, a nutrient solution is periodically pumped into a growth tray containing plants in water-retaining substrates, providing temporary moisture. Excess solution drains back to the reservoir via gravity-fed tubing for recirculation. Plants are supported by rigid Styrofoam rafts floating on the nutrient solution, allowing significant root exposure to nutrients. Adequate aeration is essential to maintain oxygen levels and prevent root oxygen deficiency (Mai et al., 2023).

Deep water culture is often recommended for commercial hydroponic cultivation of lettuce and leafy greens due to its simplicity, ease of operation, shorter growth cycles, economic viability, high productivity, and superior crop quality. In floating raft hydroponics, plants in containers with a growing medium have their bases submerged in nutrient-rich water, ensuring continuous nutrient absorption and optimal development. Lettuce rafts are considered an economical way to grow herbs and plants in a water container (Majid et al., 2021).

Closed hydroponic systems, also known as continuously flowing solution cultures, use water and fertilizers more efficiently than open systems. The nutrient film technique, where a thin layer of nutrient solution flows over plant roots, is a widely used closed method that ensures efficient nutrient uptake. Studies have shown that hydroponic wastewater recycling in cucumber cultivation can reduce water use by 33% and conserve 59% nitrogen, 25% phosphate, and 55% potassium (Magwaza et al., 2020).

However, a significant challenge in closed systems is the accumulation of salt ions like sodium and chlorine, which can negatively affect plant growth by reducing photosynthesis, transpiration, and overall plant weight. Increased salinity initially impacts root growth, followed by damage to older leaves and significant leaf loss. Cucumber yield can decrease with high Na concentrations, while some plants, like sweet basil, remain unaffected even at elevated salinity levels (Faliagka et al., 2021). Selecting a suitable wastewater hydroponic system depends on whether the effluent quality meets discharge standards, especially for heavy metals and emerging pollutants.

3. HYDROPONIC PLANT MECHANISMS FOR WATER PURIFICATION

Hydroponic wastewater purification relies on phytoremediation, an environmentally friendly and cost-effective technique powered by solar energy, which facilitates the removal of pollutants from various wastewater sources. This process encompasses phytoextraction, phytovolatilization, phytodegradation, and rhizofiltration.

Phytoextraction involves the absorption and translocation of contaminants from soil or water by plant roots. This can be achieved through the use of metal hyperaccumulators or fast-growing plants to ensure the continuous removal of pollutants. The application of specific compounds, such as $(NH_4)_2SO_4$, can further enhance the uptake and mobility of metals within the plants (Chaney, 2018).

Phytomining, a specialized form of phytoextraction, presents significant commercial potential by utilizing plants to absorb and accumulate valuable metals, thereby enabling their extraction from dispersed sources. This method is commonly used in the recovery of nickel from contaminated land. Research conducted by Dinh et al. has explored the effectiveness of phytomining in extracting and enriching precious metals, particularly gold and silver, over the past two decades (Dinh et al., 2022).

Researchers posit that phytomining presents a promising avenue for reclaiming valuable metals from low-grade ores or secondary sources, particularly as reserves diminish. While this technology has been largely applied to contaminated soil, industrial wastewater, and mine wastewater, which often contain notable quantities of precious metals, there is a gap in research regarding the integration of phytomining with hydroponic wastewater treatment systems.

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Moreover, given the increasing prices and industrial demand for rare earth elements in recent years, the potential of phytomining for their extraction remains largely untapped. This approach offers a potentially sustainable and environmentally sound method for recovering REEs from both wastewater and mineral ores (Wang et al., 2019). Currently, research does not specifically address this integration of wastewater hydroponics with phytomining. While the potential of phytomining for extracting rare earth elements is recognized, its application remains largely unexplored despite increasing prices and industrial demand. However, it presents a promising sustainable and environmentally sound approach for recovering REEs from both wastewater and mineral ores. Hydroponic systems can be a promising biotechnology for wastewater treatment. Specifically, using wastewater from aquaponics can provide nutrient-rich water for hydroponic plants (Dang and Li, 2022).

Phytovolatilization is a process where plants absorb contaminants through their roots, transform them into gaseous forms, and release them into the atmosphere via evapotranspiration. This technique has been effectively used to remediate metal pollutants, particularly volatile elements such as mercury and selenium. Selenium, for example, can be converted into dimethyl selenide $[(CH_3)_2Se]$, facilitating its volatilization. Additionally, phytovolatilization has been applied to address groundwater contamination caused by volatile organic compounds like perchloroethylene and trichloroethylene (Zayed et al., 2020).

Rhizosphere filtration is another method primarily employed to decontaminate water by adsorbing or precipitating pollutants onto plant roots or capturing contaminants within the root zone. This approach is often used in wastewater hydroponics for removing heavy metals and radioactive substances. Compared to conventional remediation methods, phytovolatilization provides a cost-effective and passive alternative for pollutant removal. Ecorestoration of polluted aquatic ecosystems through rhizofiltration is a promising technique (Kristanti et al., 2021).

Phytodegradation involves the breakdown of organic pollutants by plants through enzymatic activity, either released from their roots or occurring within plant tissues. During this process, contaminants are absorbed by the roots and transformed into less harmful substances inside the plant. Similar to phytoextraction and phytovolatilization, the effectiveness of phytodegradation depends on the contaminant's solubility and hydrophobic properties being within an appropriate range. Phytodegradation has been successfully applied in the remediation of certain organic pollutants, including chlorinated solvents and herbicides. The phytodegradation of organic compounds can occur inside the plant or within the rhizosphere. Phytoremediation is indeed an emerging technology for cleaning up sites contaminated with hazardous chemicals. It uses plants for the remediation of sites contaminated with inorganic and organic contaminants (Sehrawat et al., 2023).

Chanu and Gupta et al., (2016) found that hydroponically grown water spinach effectively removes lead from wastewater, with roots accumulating higher levels of lead compared to stems and leaves. This suggests that roots play a key role in retaining and limiting the movement of heavy metals within the plant. A similar pattern was observed for copper, where the roots restricted the transfer of the metal to other plant parts.

Furthermore, studies indicate that water spinach can be propagated through fragmentation. This involves cutting uncontaminated plant sections and regenerating them in a clean medium for treating new wastewater batches. After the plants resume growth, any necrotic portions with high contaminant concentrations can be safely discarded, offering a sustainable approach to wastewater remediation. Water lettuce also accumulates lead and copper in the roots (Putra et al., 2015).

Garousi et al., (2016) examined the capacity of hydroponically grown sunflowers to tolerate and accumulate selenium. The study revealed a significant increase in selenium content within the plants as selenium concentrations were raised. Despite a three-week exposure to selenium levels up to 3 ml/L, the plants showed no damage to chlorophyll a and b, which indicates a high tolerance and absorption capacity. Furthermore, the selenium was efficiently transported from the roots to the shoots.

In addition to analyzing a single heavy metal, researchers have also assessed the ability of hydroponic plants to absorb multiple heavy metals simultaneously. Their findings demonstrated that *Helianthus annuus* effectively absorbed arsenic, cadmium, chromium, nickel, and iron, with a notable increase in the accumulation of arsenic and cadmium in the plant tissues. Plants have different strategies to avoid the deleterious effects of heavy metal toxicity. Selenium can also protect plants from abiotic stresses. For example, selenium alleviates cadmium toxicity in sunflower seedlings. Selenium also plays a role in preventing manganese toxicity in sunflower seedlings (Rizwan et al., 2021).

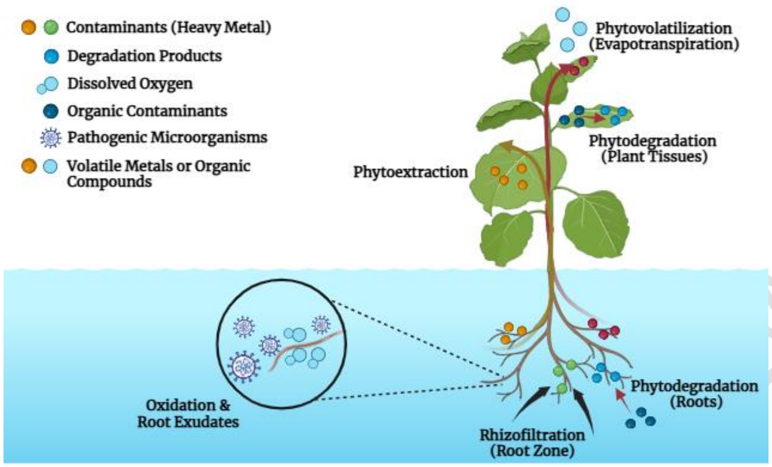

Figure 1: Mechanisms For Water Purification

4. COMPARATIVE ANALYSIS OF WASTEWATER HYDROPONICS AND CONSTRUCTED WETLANDS

Wetland-based treatment systems, such as constructed wetlands, are frequently used for sewage purification. They rely on microbial activity, plant absorption, and substrate filtration. CWs are often favored for wastewater treatment due to their cost-effectiveness and operational stability. By simulating natural wetland ecosystems, CWs integrate physical, chemical, and biological processes to improve water purification. Plants and filtration media are essential to this process. However, wastewater hydroponic systems differ from CWs (Mustafa and Hayder, 2021). Hydroponic systems typically manage low-intensity wastewater in shallow water conditions, whereas CWs are deep-water treatment systems often used for landfill leachate treatment and as a secondary or tertiary stage in wastewater treatment plants.

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Constructed wetlands use various media fillers to remove pollutants through sedimentation, filtration, adsorption, and entrapment. However, the accumulation of contaminants and non-degradable solids can negatively affect system performance over time. Additionally, microbial activity in CWs produces colloidal sludge, which has a high water content and low density. This gradually reduces the porosity of the filter media, obstructing water flow and reducing treatment efficiency and system lifespan. In contrast, wastewater hydroponic systems operate without extensive media filtration, eliminating the risk of clogging. As a result, these systems can maintain a longer operational lifespan with minimal maintenance needs. CWs are a cost-effective method for treating wastewater (Lu et al., 2016).

Hydroponic systems are commonly set up inside greenhouses to shield crops from harsh weather, including extreme temperatures, heavy rain, and strong winds. This controlled environment also offers protection from pests and ensures optimal growing conditions. In contrast, constructed wetlands are typically located outdoors, which means their purification effectiveness can vary with the seasons. Plant dieback during winter can release nutrients, potentially causing secondary pollution (Omondi and Navalia, 2020). The economic viability of hydroponics and constructed wetlands presents a complex picture. While hydroponic systems offer the advantage of cultivating high-value crops, potentially generating substantial revenue, and can be optimized for space using vertical farming, they face challenges due to high initial investment and significant energy consumption (anonymous 2025). In contrast, CWs, while also requiring initial investment and careful site selection, generally have lower energy needs and are simpler to manage (Naja and Volesky, 2011). Furthermore, CWs provide valuable ecological services like habitat creation and flood control, though their direct financial benefits may be less obvious.

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5. CONCLUSION

Wastewater hydroponics presents a sustainable solution by integrating hydroponics and wastewater treatment to optimize water and nutrient use, reduce pollution, and enhance food security. This approach enables year-round crop production with minimal land and water, making it suitable for urban and resource-scarce areas.

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Wastewater hydroponics differs from constructed wetlands in operational efficiency, maintenance, and economic benefits. While constructed wetlands are cost-effective and offer ecological functions like flood control, hydroponic systems produce valuable crops, generating economic returns. Challenges such as nutrient balance, system maintenance, and initial costs must be addressed for scalability.

Further research is needed to enhance pollutant removal, optimize nutrient management, and explore integration with phytoremediation techniques in wastewater hydroponics. As water scarcity and food security concerns increase, advancing wastewater hydroponics through innovation and policy could significantly contribute to sustainable agriculture and environmental conservation.

While hydroponics is promising commercially, research on wastewater hydroponics is limited. Studies show that various plants can treat wastewater from different sources, efficiently removing microorganisms, heavy metals, emerging contaminants, and conventional pollutants. Reported removal rates for pollutants like copper, zinc, total nitrogen, total phosphorus, and COD are substantial.

However, wastewater hydroponics faces challenges related to pH, plant species, light exposure, influent concentration, and hydraulic retention time, affecting system efficiency. The lack of standardized evaluation and technological immaturity, high energy demands, and initial investment costs hinder adoption. Future research should optimize system parameters and integrate renewable energy like solar power to improve cost-effectiveness. Moving research to real-world applications is essential for advancing wastewater hydroponics as a sustainable treatment method.

CONSENT (WHERE EVER APPLICABLE)

No manuscripts will be peer-reviewed if a statement of patient consent is not presented during submission (wherever applicable).
This section is compulsory for medical journals. Other journals may require this section if found suitable. It should provide a statement to confirm that the patient has given their informed consent for the case report to be published. Journal editorial office may ask the copies of the consent documentation at any time.

Authors may use a form from their own institution or SDI Patient Consent Form 1.0. It is preferable that authors should send this form along with the submission. But if already not sent during submission, we may request to see a copy at any stages of pre and post publication.

If the person described in the case report has died, then consent for publication must be collected from their next of kin. If the individual described in the case report is a minor, or unable to provide consent, then consent must be sought from their parents or legal guardians.

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ETHICAL APPROVAL (WHERE EVER APPLICABLE)

The authors and the responsible authorities at the institute/organization where this work has been carried out give their explicit consent to submit and publish the work in JSRR if found suitable

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