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Narrative Review

Aquatic plant-based constructed wetlands for antibiotic resistance mitigation in wastewater: mechanisms and one health implications

Mellyaning Oktaviani Sonya Kirana Sari[1*]

[1] *Biology Department, Faculty of Science and Mathematics, Universitas Diponegoro, Semarang, Indonesia*

*Correspondence: mellyaning16@gmail.com

ABSTRACT

Background: Antibiotic resistance is increasingly driven by the release of antibiotic residues, antibiotic-resistant bacteria (ARB), and antibiotic resistance genes (ARGs) through wastewater. Aquatic plant-based constructed wetlands (CWs) are low-cost, nature-based treatment systems with the potential to mitigate these contaminants. **Objective:** This narrative review evaluates the mechanisms of antibiotic, ARB, and ARG removal in planted CWs, the influence of macrophytes, substrates, and hydraulic design, and their relevance within a One Health framework. **Methods:** A structured search of PubMed, Scopus, and Web of Science was conducted for peer-reviewed English-language literature published from January 2014 to April 2026, supplemented by reference screening. Selected World Health Organization documents were used for policy context. No formal PRISMA process or study-level risk-of-bias assessment was undertaken. **Results:** Reported removal efficiencies ranged from below 30% to over 99%, depending on target contaminants, substrate, system configuration, and operating conditions. Key mechanisms included rhizosphere biodegradation, substrate adsorption, biofilm activity, plant uptake, photodegradation, and physical filtration. Reactive media such as zeolite and biochar often improved removal for selected targets, whereas evidence regarding hydraulic retention time was inconsistent. Persistence or enrichment of some ARG subtypes within substrate and biofilm compartments indicates that CWs do not consistently function as unconditional resistance sinks. **Conclusion:** Planted CWs are promising components of wastewater treatment for AMR mitigation, but performance remains heterogeneous. Standardized monitoring, long-term field studies, biofilm resistome characterization, hybrid treatment evaluation, and stronger One Health integration are needed.

Keywords: constructed wetlands; antibiotic resistance genes; aquatic macrophytes; One Health; wastewater treatment

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1. INTRODUCTION

Antimicrobial resistance (AMR) is regarded by the World Health Organization as one of the most pressing global public health threats of the current decade. Bacterial AMR was associated with an estimated 4.7 million deaths worldwide in 2021 and is projected to contribute to substantially higher mortality by 2050 if current trends continue (GBD 2021 Antimicrobial Resistance Collaborators, 2024). The extensive use of antibiotics in human medicine, veterinary practice, and agriculture has accelerated the emergence and dissemination of antibiotic-resistant bacteria (ARB) and antibiotic resistance genes (ARGs) across environmental compartments (Larsson & Flach, 2022).

Wastewater is a well-recognized pathway for the environmental release of antibiotics, ARB, and ARGs. Municipal and hospital wastewater treatment plants (WWTPs) receive complex mixtures of antibiotic residues, often at sub-inhibitory concentrations that can exert selective pressure on resident microbial communities and promote horizontal gene transfer (HGT) of resistance determinants (Sambaza & Naicker, 2023; Punch et al., 2025). Conventional secondary treatment reduces organic load and pathogen counts but was not designed to eliminate ARGs, and treated effluents frequently still carry resistant organisms into receiving water bodies (Hazra & Durso, 2022).

Constructed wetlands (CWs) have attracted growing research interest as nature-based treatment systems that can also address antibiotic residues and ARGs (Chen et al., 2023; McCorquodale-Bauer et al., 2023). CWs rely on the combined action of aquatic vegetation, substrate materials, and associated microbial communities to remove pollutants from wastewater (Vymazal, 2014). Relative to advanced tertiary technologies such as ozonation or activated carbon filtration, CWs are generally considered a lower-cost and lower-energy alternative capable of substantial pollutant removal, although performance varies considerably across designs and target compounds (Ilyas et al., 2020).

Aquatic macrophytes are central to CW function. Species such as Phragmites australis, Typha latifolia, and Eichhornia crassipes are widely used in CW systems; their root systems provide surfaces for microbial colonization, release oxygen into the rhizosphere, and secrete exudates that can stimulate microbial degradation of organic pollutants (Singh et al., 2024; Riva et al., 2024). The extent to which these plant-mediated processes translate into reduced antibiotic resistance, as opposed to simply reduced antibiotic concentrations, remains an active area of investigation.

The One Health approach recognizes that human, animal, and environmental health are interdependent, and AMR is frequently cited as a paradigm case requiring coordinated action across all three domains (Collignon & McEwen, 2019). The updated WHO Global Action Plan on AMR (2026–2036) calls for environmental interventions, including improved wastewater management, as part of a prevention-first strategy (WHO, 2026). CWs represent one practical intervention at the interface between wastewater discharge and environmental health, although their net contribution depends on whether they function as reliable sinks rather than incidental reservoirs of resistance.

This narrative review synthesizes current evidence on aquatic plant-based CWs for mitigating antibiotic resistance in wastewater, addressing four objectives: (1) to describe the mechanisms by which planted CWs remove antibiotics, ARB, and ARGs; (2) to evaluate the influence of plant species, substrate, and hydraulic design on removal performance; (3) to discuss implications within the One Health framework; and (4) to identify priority directions for future research, including a critical appraisal of the heterogeneity and limitations of the existing evidence base.

2. LITERATURE SEARCH STRATEGY

This narrative review used a structured search of PubMed, Scopus, and Web of Science for peer-reviewed English-language literature published from January 2014 through April 2026. The search combined three thematic axes: (a) constructed wetlands ("constructed wetland," "treatment wetland," "phytoremediation," and "nature-based solution"); (b) antibiotic resistance ("antibiotic resistance gene," "ARG," "antimicrobial resistance," "*resistome*," and "antibiotic-resistant bacteria"); and (c) aquatic vegetation ("macrophyte," "Phragmites," "Typha," "Eichhornia," and "aquatic plant"). Boolean operators (AND/OR) were used to combine terms across axes; a representative search structure was ("constructed wetland*" OR "treatment wetland*" OR phytoremediation) AND ("antibiotic resistance gene*" OR ARG OR "antimicrobial resistance" OR *resistome*) AND (macrophyte* OR Phragmites OR Typha OR Eichhornia), with syntax adapted to each database. Database searches were completed in April 2026. Reference lists of relevant articles were manually screened for additional eligible studies.

Peer-reviewed studies were included if they reported original data or synthesis on the removal of antibiotics, ARB, or ARGs in CW systems with a plant component, or if they provided mechanistic or design context relevant to the review objectives. Conference abstracts, editorials, and other non-peer-reviewed scientific reports were excluded from the evidence synthesis. For the One Health and policy sections, selected authoritative policy documents from the World Health Organization were identified separately through targeted searches and included through May 2026; these documents were used for policy context rather than as evidence of CW treatment performance. Because this was a narrative rather than systematic review, no formal systematic-review protocol, PRISMA flow diagram, or study-level risk-of-bias/quality appraisal was undertaken. The final evidence base included primary experimental studies conducted at laboratory, mesocosm, and field scales, complemented by review articles and selected policy documents.

3. MECHANISMS OF ANTIBIOTIC RESISTANCE MITIGATION IN PLANTED CONSTRUCTED WETLANDS

Removal of antibiotics, ARB, and ARGs in CWs involves multiple, often concurrent, biological, chemical, and physical processes, summarized schematically in Figure 1. Aquatic plants can contribute to several of these processes through root-associated microbial habitats, rhizosphere oxygenation, and direct uptake, but the magnitude and direction of plant effects vary across system designs, target contaminants, and operating conditions.

3.1 Rhizosphere-Mediated Biodegradation

The rhizosphere is typically the most biologically active zone within a CW. The Root exudates, including sugars, amino acids, and organic acids, provide carbon and energy sources for microbial communities colonizing the root surface and surrounding substrate (Riva et al., 2024). Riva et al. (2024) reported that the composition of the root system microbiome, and its associated antibiotic resistance profile, differed measurably between plant species within the same CW receiving primary treated wastewater, indicating that plant identity shapes not only pollutant removal but also the resistome of the rhizosphere itself.

Plant roots also transport oxygen from aerial tissues to the root zone through aerenchyma, creating localized aerobic micro-zones within otherwise anaerobic substrate layers. This redox heterogeneity is thought to support a broader range of microbial metabolic pathways, including both aerobic and anaerobic transformation of antibiotic residues, and is one proposed explanation for improved performance in planted relative to unplanted CWs (McCorquodale-Bauer et al., 2023).

3.2 Substrate Adsorption and Filtration

The substrate or filter medium provides physical surfaces for antibiotic adsorption and for trapping particle-associated ARB and ARGs. Substrate choice measurably affects performance. In a mesocosm-scale hybrid CW planted with Typha latifolia, Alavi et al. (2026) compared gravel, biochar, and zeolite media and reported that zeolite achieved the highest removal for several ARGs (blaCTXM 94.3%, blaOXA 96.2%, dfr1 98.5%, sul1 95.7%, qnrS 99.1%), while biochar performed best for 16S rRNA gene (92.4%) and blaTEM (89.7%); gravel was consistently the least effective medium. Across a broader set of CW studies, reported ARG removal efficiencies range from approximately 14.5% to 100% depending on gene target and system configuration (Chen et al., 2023).

3.3 Biofilm Formation and Microbial Community Dynamics

Biofilms on plant roots, substrate surfaces, and submerged tissues are central to the biological treatment capacity of CWs. These communities are embedded in extracellular polymeric substances that provide a structured environment in which antibiotic degradation, nutrient cycling, and HGT can occur simultaneously (Michaelis & Grohmann, 2023). Competition and predation within biofilms can reduce ARB abundance, but the close physical proximity of diverse bacteria in biofilm matrices also facilitates conjugation, transduction, and transformation, mechanisms that can transfer ARGs between cells (Michaelis & Grohmann, 2023).

This dual character of CW biofilms is illustrated by a ten-year study of an integrated surface-flow CW, in which total targeted ARGs were reduced by 77.8% in winter and 59.5% in summer, yet concentrations of several individual ARG subtypes, including *sul1*, *tetA*, *tetC*, *tetE*, and *qnrS*, increased over the course of treatment (Fang et al., 2017). The higher winter removal (77.8%) compared with summer (59.5%) may reflect reduced hydraulic loading and longer effective retention time during colder months, or seasonal differences in influent ARG concentrations, rather than enhanced biological degradation at lower temperatures. The study did not establish a single causal mechanism for the seasonal difference. Overall, the finding indicates that aggregate removal statistics can mask gene-specific enrichment and underscores that CWs should not be assumed to act as unconditional sinks for resistance determinants.

3.4 Plant Uptake and Phytotransformation

Direct uptake of antibiotics by plant roots is one of several removal pathways and may be less dominant than microbial degradation or substrate sorption for many compounds, although its relative contribution varies with plant species, compound properties, and operating conditions (Ilyas et al., 2020; Chen et al., 2023; Cusumano et al., 2025). Yan et al. (2021) demonstrated that *Eichhornia crassipes* absorbs ciprofloxacin and translocates it toward above-ground tissue, with the extent of migration and transformation differing across plant growth stages. The metabolic fate of absorbed antibiotics within plant tissue remains incompletely characterized.

3.5 Photodegradation and Volatilization

In surface-flow CWs where wastewater is exposed to sunlight, photolytic degradation can contribute to the removal of photosensitive antibiotics such as fluoroquinolones and tetracyclines. Aquatic vegetation influences this pathway indirectly through effects on water depth, turbidity, and shading. Volatilization is generally considered a minor pathway for most antibiotic compounds given their low vapor pressure (Chen et al., 2023).

3.6 Physical Filtration

Physical filtration through the substrate matrix provides an additional removal pathway, particularly for particle-associated ARB and cell-bound ARGs. As wastewater percolates through substrate layers, suspended solids carrying bacteria and extracellular DNA can be retained within pore spaces and intergranular voids. The effectiveness of this mechanism depends on media particle-size distribution, porosity, surface area, and hydraulic loading rate. Media with smaller effective pore spaces can enhance physical retention, while reactive media such as zeolite can additionally provide sorption and ion-exchange capacity; overly restrictive pore structures may increase clogging risk during extended operation. Physical filtration therefore operates alongside the biological and chemical mechanisms described above and contributes to solid-phase retention of resistance determinants within the CW bed (Chen et al., 2023; Alavi et al., 2026). Selected primary-study estimates of antibiotic and ARG removal across different constructed-wetland configurations are summarized in Table 1. Table 2 summarizes the principal mechanisms of antibiotic and ARG removal discussed in Sections 3.1–3.6.

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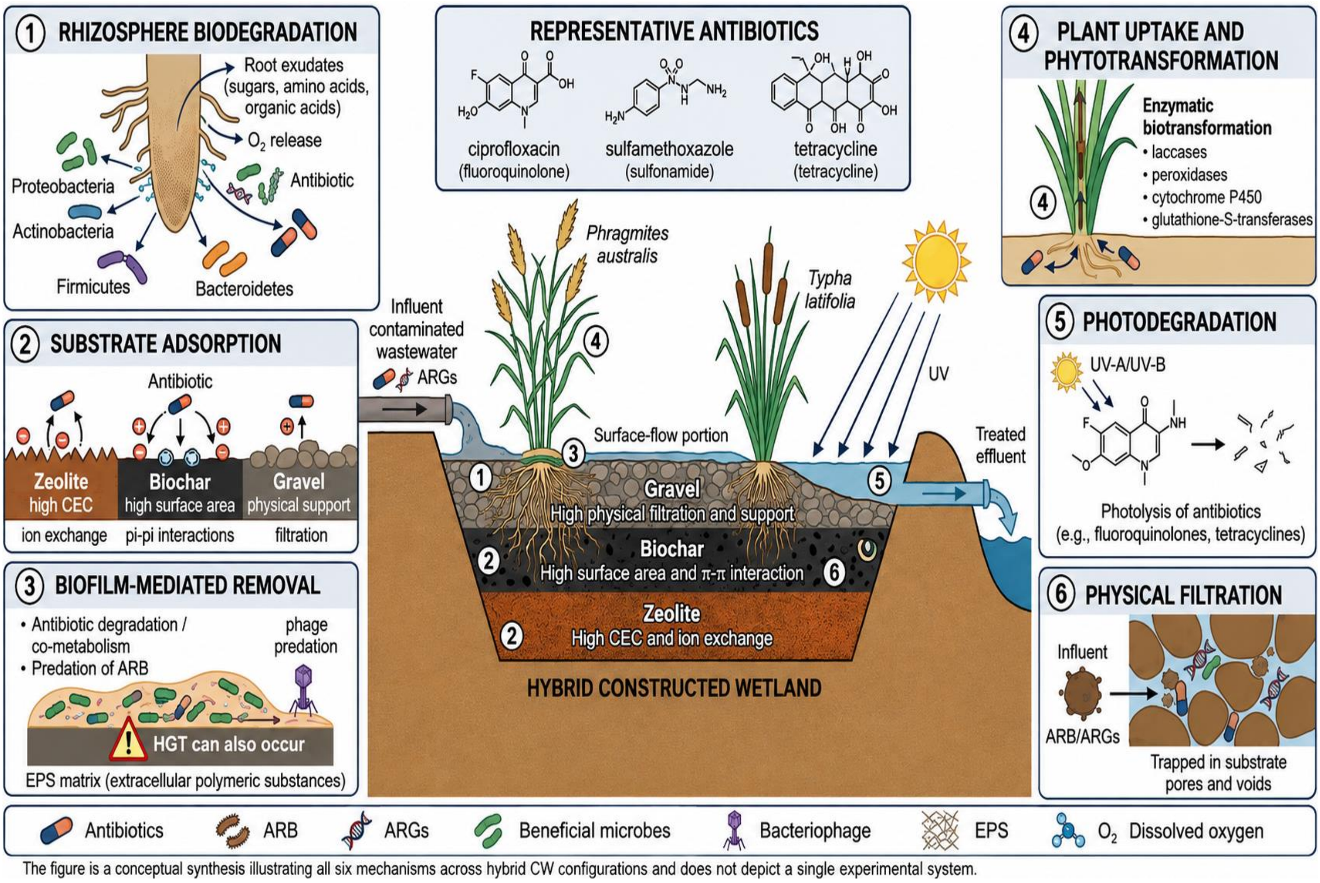

Figure 1. Schematic cross-section of a hybrid constructed wetland illustrating the removal pathways described above: (1) rhizosphere biodegradation; (2) substrate adsorption, contrasting zeolite, biochar, and gravel; (3) biofilm-mediated removal and gene exchange; (4) plant uptake and phytotransformation; (5) photodegradation of photosensitive antibiotics; and (6) physical filtration of particle-associated ARB and ARGs within the substrate matrix. Representative antibiotic structures and selected microbial or enzymatic labels are shown only as conceptualillustrations; they should not be interpreted as universal features of all CWs, as quantitative pathway contributions, or as a depiction of a single experimental system.

Table 1. Selected primary-study reports of antibiotic and antibiotic resistance gene (ARG) removal in constructed wetlands (CWs).

Plant / System	CW Configuration	Target	Reported Removal	Source
Mixed emergent macrophytes, serial polyculture	Horizontal subsurface-flow CW, tuff/gravel substrate	ARGs (intI1, tetM, sul1, ermB, total ARGs)	50.7–97.0% at maturation, depending on ARG and CW configuration	Abou-Kandil et al. (2021)
Typha latifolia	Hybrid subsurface-flow CW; gravel, biochar, or zeolite media	ARGs (qnrS, sul1, dfr1, blaTEM, blaCTXM, blaOXA); antibiotics (ciprofloxacin, cefixime)	ARGs 89.7–99.1% (biochar/zeolite); antibiotics 26.1–100%	Alavi et al. (2026)

Vegetation not specified (full-scale)	Full-scale surface-flow CW, HRT 1 vs 3 days	Antibiotics; ARGs	Antibiotics 28–100%; ARGs 0.8–1.5 log units (HRT effect not significant)	Sabri et al. (2021)
Mixed vegetation, integrated wetland	Integrated surface-flow CW, 10-year operation	Total ARGs (14 genes monitored)	59.5% (summer)–77.8% (winter); several subtypes increased	Fang et al. (2017)

HRT = hydraulic retention time. Values are reported from the cited primary studies; ranges reflect variation across gene or compound targets and system configurations rather than a single point estimate.

Table 2. Principal mechanisms of antibiotic and ARG removal in aquatic plant-based constructed wetlands.

Mechanism	Description	Key Sources
Rhizosphere biodegradation	Microbial degradation stimulated by root exudates and oxygen release; root microbiome composition shapes resistance profile	Riva et al. (2024); McCorquodale-Bauer et al. (2023)
Substrate adsorption	Sorption of antibiotics onto substrate particles (zeolite, biochar, gravel); zeolite and biochar outperform gravel	Alavi et al. (2026); Chen et al. (2023)
Biofilm-mediated removal and exchange	Biofilm communities degrade antibiotics and reduce ARB via competition/predation, but also enable HGT; some ARG subtypes can increase despite overall reduction	Michaelis & Grohmann (2023); Fang et al. (2017)
Plant uptake and phytotransformation	Root absorption and translocation of antibiotics to above-ground tissue; extent varies by growth stage and species	Yan et al. (2021); Cusumano et al. (2025)
Photodegradation	UV-mediated breakdown of photosensitive antibiotics in surface-flow systems	Chen et al. (2023)

4. INFLUENCE OF PLANT SPECIES, SUBSTRATE, AND HYDRAULIC DESIGN ON REMOVAL PERFORMANCE

4.1 Role of Macrophyte Species

Macrophyte species affect CW performance through differences in root architecture, oxygen release, exudate composition, and tolerance to wastewater stress (Singh et al., 2024). Phragmites australis is among the most widely studied CW species, valued for its extensive rhizome system and broad environmental tolerance (Riva et al., 2024). Typha latifolia is also frequently used, including in the hybrid gravel/biochar/zeolite system described by Alavi et al. (2026), and Eichhornia crassipes has been studied for its capacity to absorb and translocate antibiotics such as ciprofloxacin (Yan et al., 2021). Because E. crassipes can become invasive outside its native range, its deployment in open systems requires containment measures.

Serial or mixed plantings have been reported to improve consistency of ARG removal across gene classes compared with single-species systems, plausibly by combining complementary root architectures and recruiting more diverse rhizosphere microbial communities (Abou-Kandil et al., 2021). However, this evidence derives from a limited number of studies, and direct head-to-head comparisons between monoculture and polyculture CWs treating identical wastewater remain scarce.

4.2 Substrate and Hydraulic Configuration

CWs are commonly classified as free-water surface, horizontal subsurface-flow, or vertical subsurface-flow systems, each producing distinct hydrological and redox conditions (Vymazal, 2014). Hybrid systems combining vertical and horizontal flow stages, and systems using reactive substrates such as zeolite or biochar rather than plain gravel, have generally shown improved removal of antibiotics and ARGs (Alavi et al., 2026; Chen et al., 2023).

The role of hydraulic retention time (HRT) is less consistent across the literature than is often assumed. Alavi et al. (2026) found that a longer HRT (7 days versus 3 days) significantly improved removal of qnrS and sul1 genes, but not of 16S rRNA, dfr1, blaCTXM, blaTEM, or blaOXA. By contrast, Sabri et al. (2021), studying full-scale CWs operating at 1-day and 3-day HRT, found that HRT did not significantly influence the removal of either antibiotics or ARGs. These contrasting results suggest that HRT effects may be gene-specific, scale-dependent, or confounded by other design factors, and they caution against generalizing a single optimal retention time across CW types.

4.3 Critical Appraisal of the Evidence Base

Two independent critical reviews of this literature have identified similar limitations. McCorquodale-Bauer et al. (2023) noted that most phytoremediation studies for antibiotics rely on laboratory or mesocosm-scale systems with short observation periods, limiting inference about long-term or field-scale performance. Monsalves et al. (2022), through statistical synthesis of published CW data, likewise found that the influence of design and operational parameters, including configuration, seasonality, and support medium, is difficult to generalize into simple design rules and interpreted the available evidence more conservatively, concluding that CWs alone may not provide consistently optimal ARG removal. Reporting practices also vary: some studies quantify ARGs as absolute gene copy numbers, others as relative abundance normalized to 16S rRNA gene copies, and others as log-unit reductions, complicating direct comparison across the studies summarized in Table 1. Taken together, the evidence supports the premise that planted CWs can reduce antibiotics, ARB, and ARGs under many conditions, but does not yet support precise, transferable design prescriptions or uniformly high removal across ARG targets.

5. ONE HEALTH IMPLICATIONS

The One Health framework connects human, animal, and environmental health, and AMR is commonly cited as an issue that requires coordinated action across all three domains (Collignon & McEwen, 2019). Discharge of inadequately treated wastewater into rivers, lakes, and coastal waters creates exposure pathways through which ARB and ARGs can reach human populations via drinking water sources, recreational water contact, and irrigated crops or aquaculture products (Punch et al., 2025). Figure 2 summarizes these interconnected exposure and treatment pathways and positions the constructed wetland as an intervention point linking the three One Health domains.

CWs can function as a buffer between wastewater discharge points and receiving water bodies, potentially reducing the ARG load entering aquatic ecosystems. This is particularly relevant where centralized treatment infrastructure is limited, since CWs require comparatively low construction and operating costs and can be implemented in a decentralized manner (Hazra & Durso, 2022). Hazra and Durso (2022) summarized reported reductions in antibiotic-resistant bacteria in the order of 2 to 4 log units in CWs. These reductions fall within ranges reported for some conventional treatment systems, although direct cross-study comparison is limited by differences in influent characteristics, treatment stages, target organisms, and reporting methods.

These findings are broadly consistent with the goals of the updated WHO Global Action Plan on AMR (2026–2036), which calls for reduced antimicrobial use in agrifood systems and minimized environmental pollution from resistant microbes as part of a prevention-first, multisectoral strategy (WHO, 2026). At the same time, the evidence reviewed above, particularly the documented persistence and occasional enrichment of specific ARG subtypes within CW biofilm and substrate compartments (Fang et al., 2017), indicates that integrating CWs into One Health AMR strategies requires monitoring programs that track both removal and potential enrichment, so that CWs can be verified to function as net sinks rather than incidental sources of resistance.

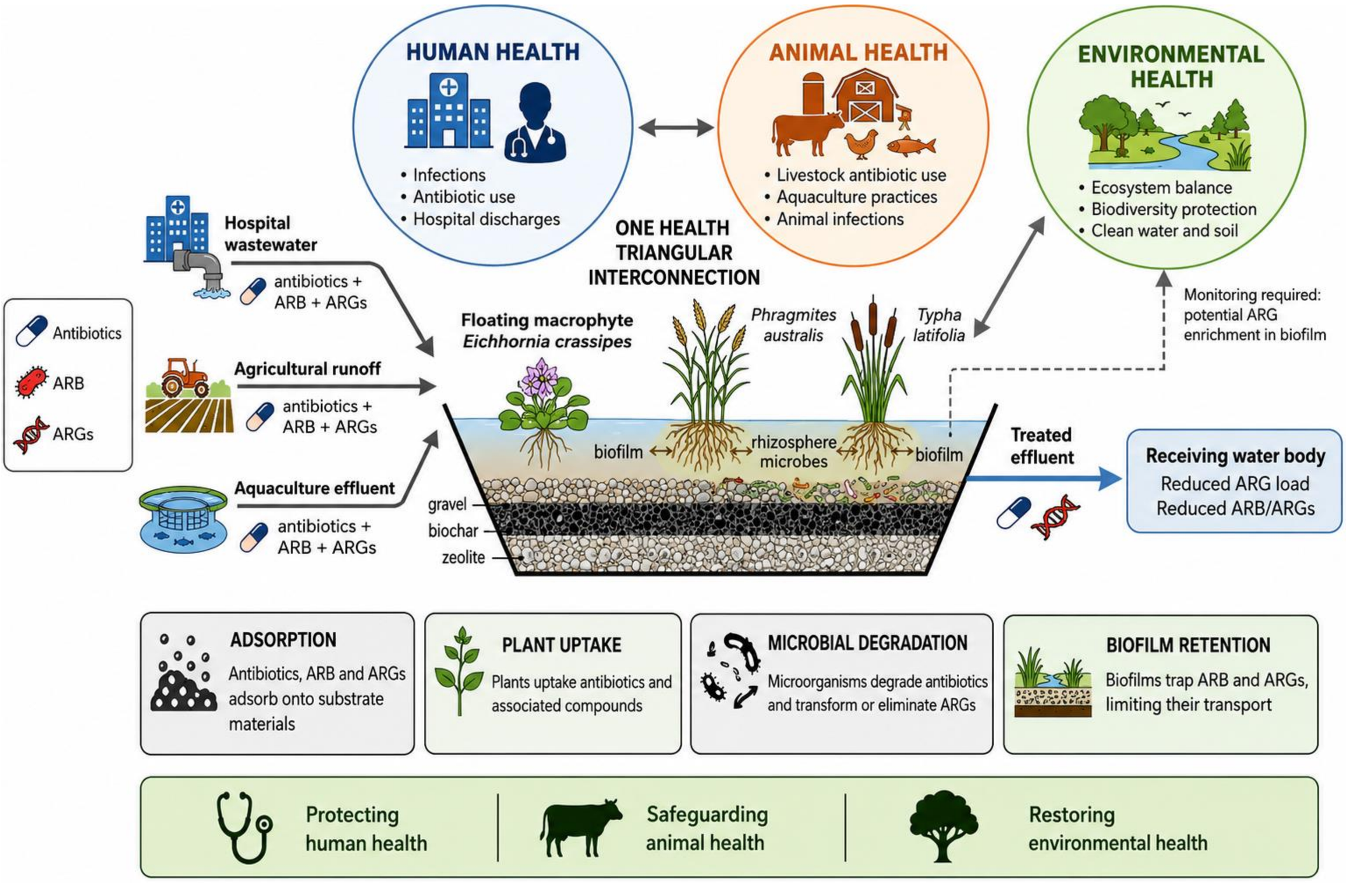

Figure 2. Conceptual overview of the One Health framework for antibiotic resistance mitigation using constructed wetlands (CWs). Hospital wastewater, agricultural runoff, and aquaculture effluent, each carrying antibiotics, antibiotic-resistant bacteria (ARB), and antibiotic resistance genes (ARGs), enter a CW planted with Eichhornia crassipes, Phragmites australis, and Typha latifolia. Adsorption onto substrate (gravel, biochar, zeolite), plant uptake, microbial degradation, and retention within biofilms jointly reduce the ARB and ARG load reaching the receiving water body, thereby supporting human, animal, and environmental health. This diagram is a simplified conceptual illustration of the pathways discussed above and does not represent quantitative removal data from a specific study.

6. FUTURE RESEARCH PRIORITIES

Building on the critical appraisal above, five priorities are proposed to strengthen the evidence base and improve the practical application of CWs for antibiotic resistance mitigation, summarized as a roadmap in Figure 3.

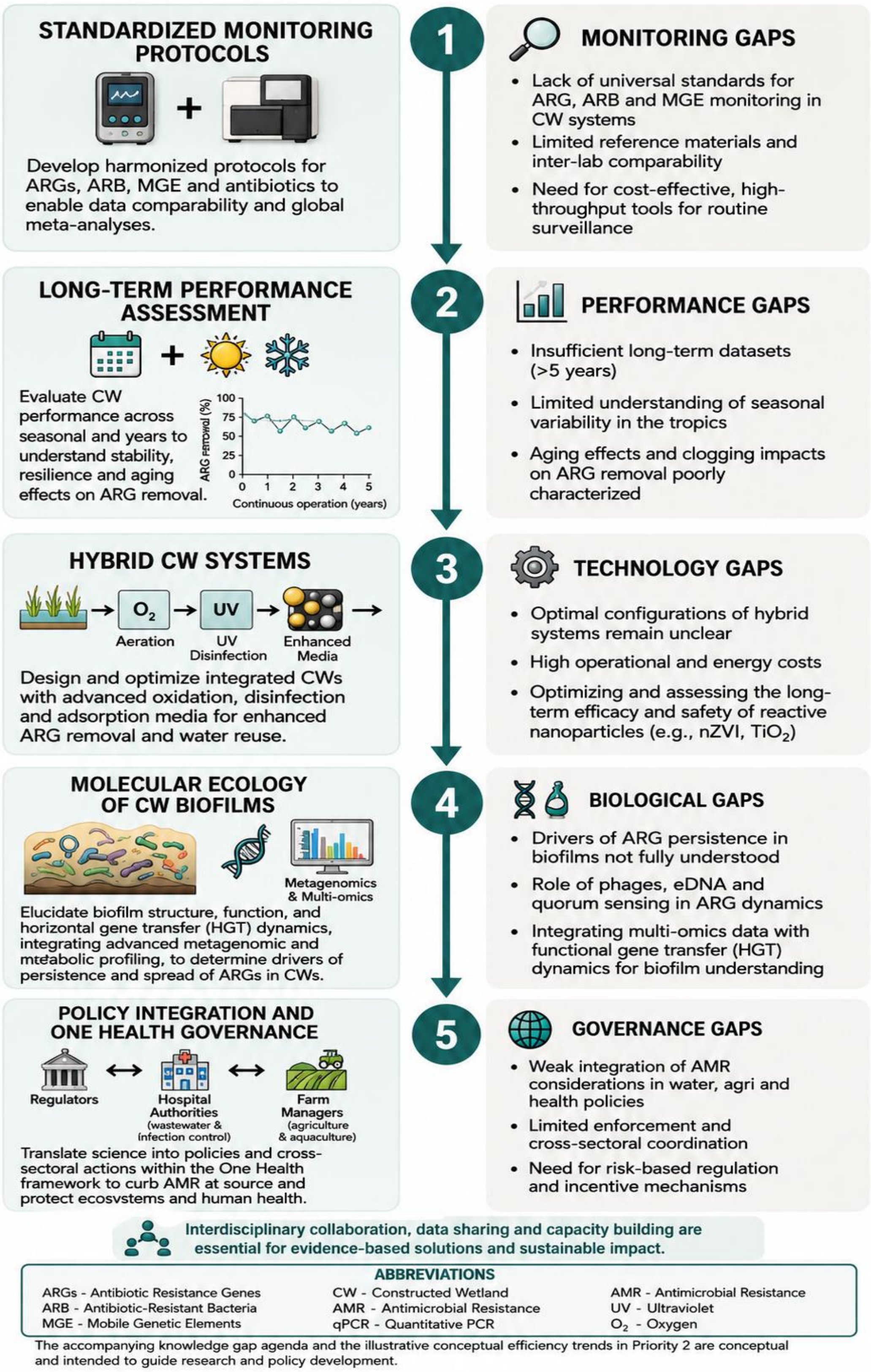

Figure 3. Research roadmap summarizing five priority directions: standardized monitoring protocols, long-term field-scale performance assessment, hybrid CW systems combined with advanced treatment, molecular ecology of CW biofilm resistomes, and integration with One Health policy and governance. The knowledge-gap panels, illustrative performance trends, and any named technology examples are conceptual aids for organizing research questions; they do not represent empirical results, comparative effectiveness estimates, or recommendations derived from a specific dataset.

6.1 Standardized monitoring and reporting protocols

Comparability across studies is limited by inconsistent choices of target ARGs, quantification methods, and reporting metrics. Aligning CW-focused research with standardized surveillance frameworks, such as the Global Antimicrobial Resistance and Use Surveillance System, would facilitate meta-analytical synthesis of removal performance (WHO, 2026; Punch et al., 2025).

6.2 Long-term, field-scale performance data

As McCorquodale-Bauer et al. (2023) observed, much of the existing evidence derives from laboratory or mesocosm-scale systems operated over short periods. Multi-year, field-scale studies are needed to determine whether substrate and biofilm compartments accumulate ARGs over time and whether removal performance is stable across seasons (Fang et al., 2017).

6.3 Hybrid and intensified treatment configurations

Combining CWs with complementary technologies such as ozonation, UV disinfection, or advanced filtration may improve removal relative to a single treatment stage. Comparative field evaluation of hybrid nature-based and advanced treatment trains, together with cost-effectiveness analysis, remains an open priority (Brouwir et al., 2025). Other intensified-treatment examples shown schematically in Figure 3 are included for conceptual orientation only and were not systematically evaluated in this narrative review.

6.4 Molecular ecology of biofilm resistomes

A more detailed understanding of ARG dynamics within CW biofilms, including the relative contributions of horizontal gene transfer, selective pressure, and community assembly, would help resolve why some ARG subtypes persist or increase despite overall reductions. Metagenomic and other molecular approaches that characterize ARGs together with microbial hosts and mobile genetic elements are therefore a priority for future work, particularly where conventional targeted assays cannot resolve the broader *resistome* (Michaelis & Grohmann, 2023). More broadly, metagenomic approaches enable culture-independent access to functional genes from complex environmental microbial communities and have been applied to environmental gene discovery and functional profiling (Prayogo et al., 2020; Prayogo et al., 2023; Setiawan et al., 2025). Recent synthesis also highlights the expanding use of metagenomic and bioinformatic workflows for antimicrobial biosynthetic gene-cluster discovery, while emphasizing the need for experimental validation of computational predictions (Prayogo, 2026).

6.5 Integration with One Health governance

Translating research findings into policy requires closer collaboration between environmental scientists, public health professionals, and regulators. CW-based interventions should be evaluated using indicators connected to human and animal health outcomes, and not only environmental ARG concentrations, and should be considered explicitly within national AMR action plans (Collignon & McEwen, 2019; WHO, 2026).

6.6 Limitations of this review

Several limitations of the present review should be acknowledged. As a narrative rather than systematic review, the literature search, although structured, was not conducted under a registered systematic-review protocol, did not use a PRISMA flow diagram, and did not include formal study-level risk-of-bias or quality appraisal; relevant studies may therefore have been missed. The evidence base is dominated by studies conducted in temperate climates, and generalization to tropical or subtropical regions, where CW applications are increasingly promoted, remains uncertain. The small number of field-scale, long-term studies limits the strength of conclusions regarding operational sustainability. Additionally, heterogeneity in reporting metrics across primary studies, as discussed in Section 4.3, precluded quantitative synthesis or meta-analysis. Future systematic reviews using standardized inclusion criteria, transparent screening procedures, formal quality assessment, and statistical pooling where appropriate would strengthen the conclusions drawn here.

7. CONCLUSION

The evidence reviewed here supports the premise that aquatic plant-based constructed wetlands can meaningfully reduce antibiotics, antibiotic-resistant bacteria, and antibiotic resistance genes in wastewater, through a combination of rhizosphere biodegradation, substrate adsorption, biofilm activity, plant uptake, and photodegradation. This evidence does not yet support the stronger claim that CWs behave as unconditional resistance sinks: several well-documented cases show individual ARG subtypes persisting or increasing in substrate and biofilm compartments even as aggregate removal appears favorable, and reported effects of design parameters such as hydraulic retention time are inconsistent across studies of different scale.

For CWs to be adopted with confidence as a One Health intervention, future work should prioritize five complementary directions: standardized and gene-resolved monitoring, long-term field-scale performance assessment, rigorous evaluation of hybrid treatment configurations, molecular characterization of CW biofilm *resistomes*, and stronger integration with One Health policy and governance. Biofilm *resistome* dynamics should be treated as a design and monitoring consideration rather than an afterthought. If these evidence gaps are addressed, planted constructed wetlands could represent a plausible, low-cost component of integrated wastewater management strategies aligned with global efforts to contain antimicrobial resistance.

DECLARATIONS

Conflict of Interest

The author declares no conflict of interest.

Author Contributions

MOSKS do all work: Conceptualization; Literature search and synthesis; Data curation; Writing – original. The author approved the final manuscript.

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