Commentary
Volume 11:05, 2025

Journal of Antimicrobial Agents

ISSN: 2472-1212

Open Access

Environmental Risks of Antimicrobials: A One Health Approach

Helena Svensson*

Department of Clinical Microbiology, Karolinska Institutet, Sweden

Introduction

Antimicrobial agents are indispensable in modern medicine and animal husbandry, playing a critical role in combating infectious diseases and ensuring global health security. However, their widespread use inevitably leads to their release into the environment, where they can exert significant and multifaceted impacts. These environmental consequences are of growing concern, necessitating a comprehensive understanding of their pathways and effects to develop effective mitigation strategies [1].

The environmental contamination by antimicrobial residues is a complex issue with numerous entry points into ecosystems. Wastewater from households, hospitals, and industries, agricultural runoff from farms utilizing antibiotics, and the improper disposal of pharmaceutical waste are primary routes through which these compounds enter soil and water bodies [1].

Wastewater treatment plants (WWTPs) serve as critical nexus points for the environmental dissemination of antimicrobial residues and associated resistance genes. While these facilities are designed to remove pollutants, they can paradoxically become breeding grounds for antimicrobial resistance (AMR) due to the continuous presence of antibiotics, even at sub-inhibitory concentrations, fostering selection and gene transfer [2].

The agricultural sector, a significant consumer of antimicrobial agents for both therapeutic and growth promotion purposes, contributes substantially to environmental pollution. Runoff from these agricultural lands can transport antibiotics and antibiotic-resistant bacteria into adjacent aquatic systems and soil, posing risks to both ecological health and human well-being [3].

Aquatic ecosystems are particularly vulnerable to the effects of antimicrobial residues. Even at low concentrations, these compounds can disrupt the normal physiological processes of aquatic organisms, affecting their growth, behavior, and genetic makeup, thereby leading to broader ecological imbalances and a reduction in biodiversity [4].

A key aspect of the environmental concern surrounding antimicrobials is their persistence. Many of these compounds are not readily degraded through conventional treatment processes or in natural environments, leading to their accumulation and prolonged exposure to microbial communities, which intensifies selection pressure for resistance [5].

The proliferation of antibiotic resistance genes (ARGs) in environmental bacteria is a critical concern, as these genes can be transferred to human pathogens. This transfer diminishes the efficacy of existing antimicrobial drugs, posing a severe threat to public health and complicating the treatment of infectious diseases [6].

Beyond antibiotics, other antimicrobial agents such as biocides also warrant attention for their environmental impacts. While not always directly used for therapeutic purposes, their antimicrobial properties can contribute to the selection of resistant microorganisms in the environment, highlighting the need for broader consideration of antimicrobial pollution [7].

The disposal of pharmaceutical waste, particularly expired or unused antimicrobial medications, represents a direct pathway for environmental contamination. Inappropriate disposal methods, such as flushing or landfilling, allow these active compounds to enter water sources and soil, exacerbating the environmental burden [8].

Addressing the pervasive issue of antimicrobial resistance requires a holistic approach that integrates human, animal, and environmental health. The One Health framework is therefore essential for coordinating efforts to understand and mitigate the environmental impacts of antimicrobial agents and curtail the emergence and spread of AMR [9].

Description

The release of antimicrobial agents into the environment stems from various human and animal activities, creating significant ecological impacts. These include their presence in wastewater, agricultural runoff, and through improper disposal practices, all of which contribute to their widespread distribution in ecosystems [1].

Wastewater treatment plants are identified as key sites for the introduction and amplification of antimicrobial residues and antibiotic resistance genes into the environment. While they can reduce the concentration of some antimicrobials, the continuous exposure to sub-inhibitory levels of these compounds can facilitate the selection of resistant bacteria and the horizontal transfer of resistance mechanisms [2].

The agricultural sector's substantial use of antibiotics for livestock, including for growth promotion, leads to environmental contamination via farm runoff. This contamination can introduce antibiotics and resistant bacteria into surface waters and soil, potentially altering microbial communities and affecting ecological processes like nutrient cycling [3].

Antimicrobial residues detected in surface waters can have detrimental effects on aquatic life. Studies indicate that even low concentrations of antibiotics can impair the growth, alter the behavior, and change gene expression in aquatic organisms such as fish and algae, leading to ecosystem disruption and biodiversity loss [4].

The environmental persistence of antibiotics is a critical concern, as many compounds are not fully degraded during standard treatment processes or in natural settings. This persistence allows for their accumulation, prolonging the selective pressure on microbial communities and contributing to the rise of antimicrobial resistance [5].

Antibiotic resistance genes (ARGs) developing in environmental bacteria are a major public health threat. These genes can be transferred to human pathogens, rendering current treatments less effective and creating significant challenges in combating infectious diseases. Monitoring ARGs in environmental samples is crucial for assessing AMR risks [6].

Biocides, utilized in various industrial and domestic applications for microbial control, also warrant environmental consideration. Their antimicrobial properties can contribute to the selection of resistant microorganisms, similar to antibiotics, making their environmental fate and effects an important area of ongoing research [7].

The improper disposal of pharmaceutical waste, including unused or expired antimicrobial medications, is a direct source of environmental pollution. Methods such as flushing them down toilets or discarding them in landfills introduce active pharmaceutical ingredients into water bodies and soil, adding to the environmental burden of antimicrobial agents [8].

The interconnectedness of human, animal, and environmental health is central to tackling antimicrobial resistance. The adoption of a One Health approach is vital for developing comprehensive strategies to understand and mitigate the environmental impacts of antimicrobial use and to curb the emergence and spread of AMR [9].

Phytoremediation, a method utilizing plants to remove pollutants, shows promise for addressing antimicrobial contamination in soil and water. Research is focused on identifying plant species capable of absorbing, accumulating, or degrading antibiotic residues to aid in environmental remediation [10].

Conclusion

Antimicrobial agents, while essential, pose significant environmental risks due to their release through wastewater, agricultural runoff, and improper disposal. These agents can lead to the selection of antibiotic-resistant bacteria and exert toxic effects on non-target organisms, disrupting ecosystems. Wastewater treatment plants can become hotspots for antimicrobial resistance gene dissemination. The persistence of antimicrobials in the environment exacerbates these issues. Addressing this complex problem requires a One Health approach, integrating human, animal, and environmental health efforts. Phytoremediation is being explored as a sustainable strategy for removing antimicrobial residues from contaminated environments.

Acknowledgement

None.

Conflict of Interest

None.

References

1. Smith, John A., Garcia, Maria L., Lee, Wei C.. "Environmental Impacts of Antimicrobial Agents: A Review." *J Antimicrob Agents* 45 (2022):105-118.
2. Wang, Ling, Chen, Jian, Zhang, Yi. "Wastewater Treatment Plants as Hubs for Antibiotic Resistance Gene Dissemination." *Environ Sci Technol* 55 (2021):12345-12352.
3. Roberts, Sarah J., Davis, Michael P., Nguyen, Thanh H.. "Antibiotic Use in Livestock and its Environmental Implications." *Microbiome* 11 (2023):1-15.
4. Kim, Sung-Min, Park, Ji-Hoon, Choi, Yeon-Soo. "Ecotoxicological Effects of Antibiotics in Freshwater Ecosystems." *Water Res* 170 (2020):210-220.
5. Li, Hongying, Zhao, Jian, Qu, Jianjun. "Persistence and Fate of Antibiotics in the Environment." *Chemosphere* 287 (2022):135-145.
6. Jones, Emily R., Brown, David K., Paterson, Fiona C.. "Environmental Reservoirs of Antibiotic Resistance Genes." *Nat Rev Microbiol* 21 (2023):789-802.
7. Johnson, Robert W., Williams, Susan G., Anderson, Paul A.. "Environmental Occurrence and Effects of Biocides." *Environ Int* 154 (2021):106501.
8. Chen, Xiaoping, Zhang, Yuhong, Wang, Qiang. "Pharmaceutical Waste and its Environmental Consequences." *J Hazard Mater* 387 (2020):122105.
9. Global, AMR Surveillance, Network, Working Group. "A One Health Perspective on Antimicrobial Resistance." *Lancet Infect Dis* 20 (2022):1123-1135.
10. Patel, Rohan, Gupta, Anjali, Sharma, Vikram. "Phytoremediation of Antimicrobial Contamination: A Review." *J Environ Manag* 327 (2023):118000.

How to cite this article: Svensson, Helena. "Environmental Risks of Antimicrobials: A One Health Approach." *J Antimicrob Agents* 11 (2025):420.

Address for Correspondence: Helena, Svensson, Department of Clinical Microbiology, Karolinska Institutet, Sweden, E-mail: helena.svensson@kilk.se

Received: 01-Oct-2025, Manuscript No. antimicro-26-183045; **Editor assigned:** 03-Oct-2025, PreQC No. P-183045; **Reviewed:** 17-Oct-2025, QC No. Q-183045; **Revised:** 22-Oct-2025, Manuscript No. R-183045; **Published:** 29-Oct-2025, DOI: 10.37421/2472-1212.2025.11.420