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Impact of Wastewater on Antibiotic Resistance Phenomenon

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Abstract

In light of growing concerns about the spread of antibiotic resistance and its consequences for public health, this review article deeply examines the intricate relationship between wastewater contamination and the appearance and spread of antibiotic resistance. Water that has been used and contaminated by different human activities, such as household, industrial, health institutions, and agricultural processes, is referred to as wastewater, which is usually released into the environment and can cause several diseases, including the spreading of antibiotic resistance which is a threat to public health. Antibiotics have been a crucial discovery, saving millions from infectious diseases. On the other hand, their misuse spawn's antibiotic resistance (AR), an enormous threat to global health. This review examines wastewater's important role in supporting AR, underlining how it affects pathogen development and the spread of resistance globally. Wastewater acts as a breeding ground for antibiotic-resistant bacteria (ARBs) and resistance genes (ARGs), causing health concerns to humans and animals. Human actions in several sources, such as hospitals and agriculture, increase the spread of ARBs and ARGs. Wastewater is released into surface waterways, contaminating irrigation systems and household water. Agricultural products are essential for humans, but now agriculture is a standard route for AR transmission.
Furthermore, the review highlighted groundwater and surface water contamination by residual antibiotics. The linked cycle of antibiotic resistance from agriculture to humans and animals shows the need for comprehensive measures. In summary, the review highlights the severe problems of antibiotic resistance (AR) in wastewater and calls for vigilante action against the misuse of antibiotics to maintain antibiotics' long-term effectiveness in maintaining world health.
Keywords: Wastewater, Antibiotic Resistance, Antibiotic, Household Water, water pollution

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Introduction

This study delves into the escalating issue of antibiotic resistance within wastewater, a global issue, clarifying the influence of antibiotic research and treatment development. Antibiotics are one of the most important discoveries that have saved millions of lives from infectious diseases(1). Still, any misuse or overuse of antibiotics can cause side effects and lead to antibiotic resistance (AR), which makes infections harder and impossible to treat(2). (AR) is a significant and severe danger to world health(3). Also, there are dangers to human health associated with (AR), and worries about how antibiotic residues in the environment may contribute to the development and spread of (AR). (4). Especially developing aquatic pollutants that have the potential to encourage the emergence and spread of (AR) in aquatic environments(5). (AR) in these aquatic environments, such as wastewater containing antibiotics, which is a significant environmental hazard(6) Basically, the aim of this article is to show the impact of wastewater on antibiotic resistance because One of the most significant sources of (AR) spread in the environment is wastewater(7). According to some research, many bacteria with antibiotic-resistance genes (ARGs) are found in the wastewater (8). Because wastewaters frequently include antibiotic-resistance genes (ARGs) and antibiotic-resistant bacteria (ARB), which lead to the spread of (AR), it cannot be stopped(9). (ARGs) have been discovered in both the surface and subsurface of water sources, and the number of (ARBs) in aquatic solutions is increasing continuously. It has been long recognized that there is a clear correlation between human activities and the variety quantity of ARBs in the environment(10). So, we can say that most resistant bacteria or resistance genes found in the environment are caused by anthropogenic stresses in aquatic systems that originate from wastewater and trash from several sources, including municipal garbage, hospitals, pharmaceutical manufacturing, farm production, and aquaculture(11). For example, hospital and medical center wastewater can substantially impact soil and aquatic environment pollution and spread infectious illnesses(12). In the hospital wastewater, we have many bacteria and residual antibiotics that can exert selective pressure on the propagation of (ARB)(13).

Antibiotic Resistance

Nowadays, being healthy is essential, and it can be attained with the help of efficient medications such as antibiotics. (14). But because of misuse and overuse, pathogenic microorganisms are becoming more resistant, which is a threat to public health and can cause thousands of deaths. (15). Antibiotics are significant medications commonly used to treat bacterial infections, serving therapeutic and preventive purposes in both human and veterinary healthcare domains. (16). The bacterial resistance mechanism is impressive because bacterial cells are genetically plastic, allowing them to change their genetic code and adapt to altering circumstances. This process can significantly change how bacteria interact with their surroundings in ten minutes or less. (17). Because of this quick development, resistant bacteria are emerging at a rate that is exhausting the world's current supply of potent antibiotics and causing the world health organizations to mark ARB as a significant danger to public health in the 21st- century. (18). According to the latest predictions, nearly all bacteria will develop resistance to almost all antibiotics available within 25 years. By the 21st century, antibiotics are estimated to cause 10 million deaths annually, up from the existing statistic, which exceeds 700,000 every year(19). Also, in 2019 (AR) was estimated to cause 4.95 million human deaths globally. We can mention two impacts of (AR) on public health: limiting treatment options for infectious diseases and higher healthcare costs. For example, antimicrobial drug resistance is expected to cause a global gross domestic product (GDP) loss of not less than 3.4 trillion USD yearly by the end of this century. Losses might account for as much as 4% of the present global (GBD) in 2050, leading to an increase in yearly global health system spending of up to $1 trillion. (20). Antibiotic resistance is a global health crisis affecting large-scale sectors and socioeconomic backgrounds, crossing national and international borders. (21). Given the severity of antibiotic resistance and its dangers to public health, various strategies must be implemented to mitigate its impact, which may include promoting antibiotic stewardship programs, enhancing infection prevention and control measures, investing in the development of new antibiotics and adjunctive therapies, and enacting regulations to oversee the usage of antibiotics in both human and animal healthcare. (22). Lastly, collaborative efforts for combating antibiotic resistance are significant among healthcare professionals, researchers, and the general public to address (AR) effectively. Moreover, the World Health Organization and other international initiatives have heightened the urgency of the fight against antibiotic resistance. These organizations put in a lot of effort to promote appropriate antibiotic use, raise awareness of antibiotic resistance, and support innovative antibiotic research. (23)

Wastewater Irrigation and Household Water Contamination: A Connection for the Spread of Antibiotic-Resistant Bacteria

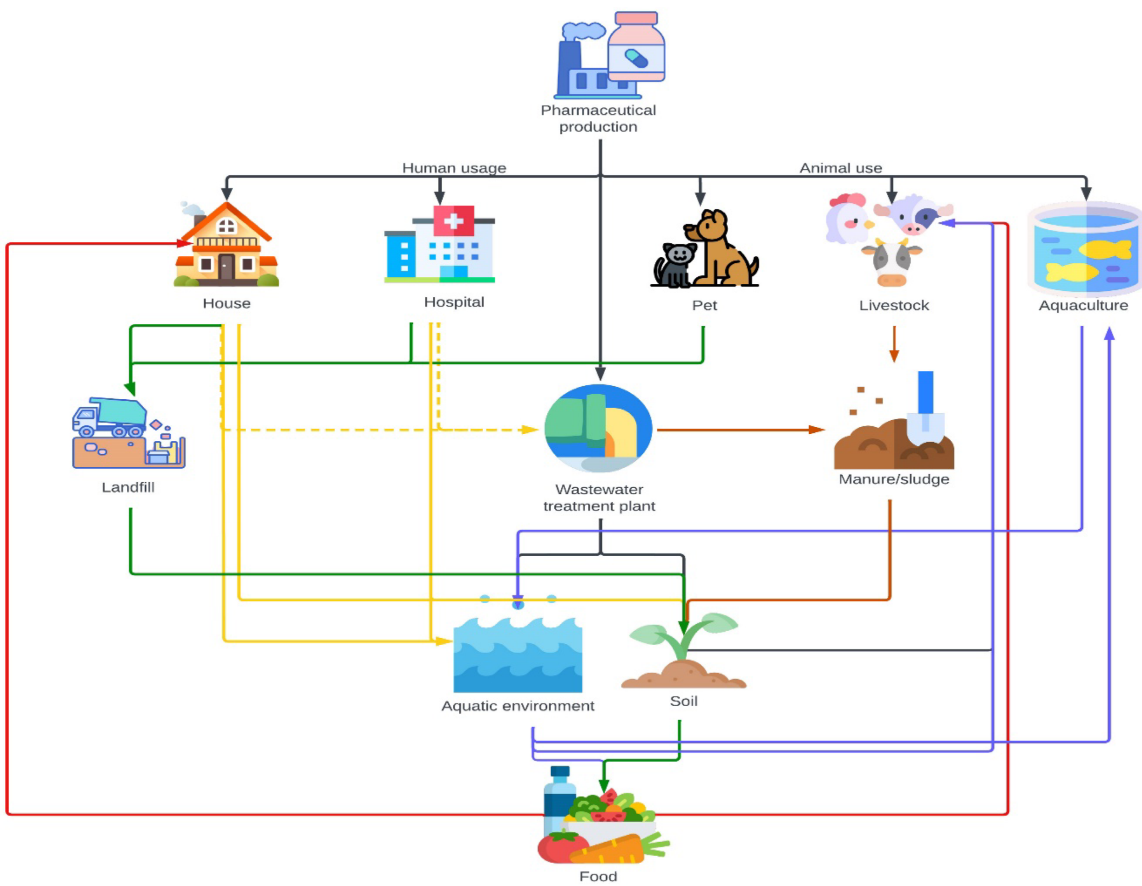
Another serious problem that is spreading (ARB) among people and communities is household water contamination caused by wastewater irrigation. Wastewater irrigation can contaminate household water, which is higher in effect size than the beneficial impact of access to sanitation or personal cleanliness. Practical hurdles are necessary for wastewater irrigation to restrict the spread of bacteria and pathogens into home drinking waters (24). Enormous amounts of untreated wastewater are frequently released into surface waterways (25) and used for irrigation by farms. As a result, wastewater irrigation creates a conduit for reintroducing faecal pathogens, introducing novel pathogens into the population, and contaminating household water. (26) In water, bacteria from different human origins, animals, and environments can mix, and resistance evolves due to promiscuous exchange and shuffling of genes, genetic platforms, and genetic vectors (27).

The Role of Agricultural Practices in Antibiotic Resistance Spread: Wastewater Irrigation Impact on Public Health

Some countries reuse wastewater for irrigation purposes on this subject; agriculture plays an essential role in the spread of (AMR) and transferring ARB to the soil. As we know, this wastewater is frequently used for irrigation worldwide (28). Unorganized and frequently negligent use of wastewater for irrigation poses health dangers to farmers, consumers, and society. (29) The dangerous and severe case is that this wastewater, which contains (AR), promotes the transference of (ARG) between the environment, human, and animal-related bacterial species(30). Humans are exposed to foodborne bacterial infections, including antibiotic-resistant bacteria (ARB) when they consume a variety of fresh leafy and non-leafy vegetables, root vegetables, sprouts, and fruits, AND (31) commonly consumed vegetables are contaminated with (ARB). So, we get to a point that tells us eating these agricultural products can cause animals and humans (ARB) (32).

The Agro-Food Cycle: Antibiotic Resistance Transmission from Food Supply to Human

Antibiotic resistance can occur in animals due to eating agricultural products that contain resistant bacteria and because of overuse and misuse of antibiotics, which are being released into the environment(33). These antibiotics are used in animals for disease prevention and growth promotion (34). Infective diseases are also treated by inhibiting bacterial cell growth. Additionally, it treats diseases in agricultural animals (35). Animals like meat, milk, and eggs are kept for food production. These animals include cattle, buffaloes, camels, horses, rabbits, guinea pigs, bees, sheep, goats, fish, and crustaceans, which are kept for their goods(36). Antimicrobial resistance spreads to people through the food supply and personal contact. So, it is like a cycle that starts with agriculture and food contaminants. It could directly transfer to humans through agricultural products, or when animals eat these contaminant products from farms, they get antibiotic resistance, too(37). When humans use an animal product like meat, it can cause bacterial resistance to be transferred to humans again. International efforts have been made to limit or outright prohibit the use of antimicrobials on both people and animals (38). Furthermore, most sources of antibiotics are wastes from humans, animals, and companies that produce or formulate antibiotics. This figure demonstrates the primary pathways of antibiotics between these sectors and the aquatic environments (39).



Wastewater as a Channel for Antibiotic Resistance: Impact on Groundwater and Surface Water

Groundwater and surface water are essential elements for greater human survival. Due to the leaking of harmful substances, municipal solid waste disposal sites are regarded as a hotspot for groundwater and surface water contamination, both essential for human survival. Freshwater environments are susceptible to contamination by residual antibiotics released through different sources (40). AMR can grow in landfills, spreading ARGs into bacterial strains in the surrounding environment. The general ecosystem, including soil, surface water, groundwater, animals, and public health, are all negatively impacted by this. Antibiotics and toxic organic pollutants are found in landfill leachate, a complex hazardous liquid that could encourage the emergence of ARB and ARGs in the environment (41). During heavy rains, the leachate makes wastewater, which can enter both surface and groundwater and result in pollution. None of these ground and surface waters are safe for human and animal consumption (42). So, we can tell that wastewater is a vehicle for transmitting bacteria that are resistant to antibiotics throughout human and animal species, and it is also a means of introducing resistance genes into natural bacterial ecosystems (43). Antibiotic resistance exists in aquatic environments worldwide, including river water, lake water, seawater, groundwater, wastewater, and drinking water (44). Another way of spreading (AR) is animal waste (45).

Table 1: This table summarizes the complex ways that wastewater supports the development of antibiotic resistance and jeopardizes each environment and public health.

Aspects of Wastewater Impact on Antibiotic Resistance	Summary
Role in AR Transmission	Wastewater is a significant channel for transmitting antibiotic-resistant bacteria (ARB) and antibiotic-resistance genes (ARGs) into the environment.
Presence of ARB and ARGs	Wastewater plenty consists of ARB and ARGs, posing a global risk of spreading antibiotic resistance.
Source of Antibiotic Pollution	Wastewater contributes to the contamination of aquatic environments with residual antibiotics, worsening the issue of antibiotic resistance.
Agricultural Impact	Reused wastewater for irrigation contributes to the spread of ARB and ARGs in agricultural settings, affecting food safety and public health.
Household Water Contamination	Wastewater irrigation can contaminate household water and aid in the spread of antibiotic resistance to communities.
Groundwater and Surface Water Contamination	Residual antibiotics from wastewater can contaminate both surface and groundwater, causing risks to human health and ecosystems.
Impact on Public Health	ARB and ARGs in wastewater pose significant public health risks, requiring complete actions to combat antibiotic resistance.

Wastewater in hospital

Hospitals play an important role in human health and medical research. They aid in complementing many aspects of the health system and providing continual services to deal with the complicated health situations of humans (46). Wastewater in hospitals contains a variety of developing pollutants, including many microorganisms, antibiotic-resistant genes (ARG), antibiotic-resistant bacteria (ARB), persistent viruses, pharmaceutically active chemicals (PhACs), etc. (47). Hospital wastewater contains pollutants that are hazardous to the environment and public health, to the public health by pathogens in wastewater can lead to the spread of infectious diseases if not adequately treated (48). Surface water bodies can accumulate with chemical contaminants and pharmaceutical residues, which can impact aquatic ecosystems and fauna (49). In conclusion, hospital wastewater management is a complex problem that calls for integrated strategies, including sustainable practices, legal compliance, and treatment technology. Healthcare institutions may reduce their environmental effect and safeguard public health by tackling the complicated issues associated with hospital wastewater.

Discussion

Wastewater has an essential role in antibiotic resistance globally by working as a pathway for the emergence of pathogens and being a significant source of antibiotic resistance spread in the environment, which has been a significant danger to world health(50). It should be clear that wastewater contains antibiotic-resistant bacteria (ARB) and antibiotic resistance genes (ARGs), causing the transference of ARG and ARB between humans and animals(51). Resistant bacteria and resistance genes in the environment are caused by human activities like misuse and overuse of antibiotics from various sources, including wastewater(52). After that, we have wastewater irrigation, which leads to household water contamination with antibiotic resistance and creates a conduit for reintroducing pathogens into the population (53). Then, groundwater and surface water are contaminated by residual antibiotics from different sources, and we can look at hospital wastewater, which substantially impacts soil and aquatic environment pollution (52). Antibiotic resistance can transfer from agriculture to humans and animals through contaminated agricultural products, which end up causing antibiotic resistance to both animals and humans (54). But now, there are international efforts to limit and prohibit the use of antibiotics on humans and animals(5). Finally, this review article shows the critical issue of antibiotic resistance (AR) associated with wastewater and its extensive. Antibiotics unquestionably had a revolutionary effect on world health and saved millions of lives from infectious diseases. However, we have to be aware that misuse and overuse of antibiotics present severe risks and lead to the emergence of antibiotic resistance, which consequently produces infections more challenging and often impossible to treat.

Conclusion

In conclusion, Antibiotic resistance is one of the critical problems facing the health sector worldwide. Infection diseases are one of the common disorders of human health caused by the transmission of microbes. In the 19th century, antibiotic medicine was discovered to treat serious infectious diseases. But nowadays, these medication groups have limited effects in killing or inhibiting microbes' activities due to the antibiotic resistance phenomenon. This study shows one of the significant factors that increase this critical phenomenon in the world, wastewater, is that factor leads to the rise of bacteria to golden medicine designed to fight them. The end of this review recommended more research about the role of wastewater in increasing being a pathway for pathogens and a source of antibiotic-resistant bacteria and genes.

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Conflict of interests

None

Authors contribution

All authors contributed to the work's content and modifications. Each author approved the manuscript.

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