Zoology

E-ISSN No : 2581-6195 | Volume : 2 | Issue : 4 | Jul-Aug 2019

THE IMPACT OF WATER POLLUTION ON THE GLOBAL BURDEN OF INFECTIOUS DISEASES

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ABSTRACT

Water pollution remains a primary driver of the global infectious disease burden, particularly in developing nations where sanitation infrastructure is deficient. Data indicated that approximately 80% of all diseases in developing countries were linked to poor water quality, with nearly 1.5 million deaths occurring annually due to waterborne illnesses. This review examines the transmission of pathogenic agents—including bacteria, viruses, and parasites—through contaminated aquatic environments. The findings underscore that diarrheal diseases, often spread via the fecal-oral route, represent the leading cause of water-related morbidity and mortality, disproportionately affecting children under the age of five. The study concludes that integrated water management and enhanced filtration technologies are essential to mitigating these public health risks.

KEYWORDS: Water Pollution, Infectious Diseases, Waterborne Pathogens, Public Health, Sanitation

INTRODUCTION

Water is the most essential resource for sustaining life, yet its contamination by human and natural activities represents a significant global health crisis. Water pollution is defined as the introduction of chemical, physical, or biological substances into water bodies that alter their quality and pose a threat to human health and the environment. It was established that nearly 80% of all diseases in developing nations were directly linked to poor water quality and inadequate sanitation. As rapid urbanization and industrialization continue to outpace the development of infrastructure, more than 80% of global human sewage is discharged into rivers and oceans without any form of treatment, creating a persistent reservoir for infectious pathogens.

The relationship between polluted water and infectious diseases is complex, involving various transmission pathways. These include waterborne diseases caused by the ingestion of contaminated water, water-washed diseases resulting from a lack of clean water for personal hygiene, and water-based diseases where the pathogen spends a portion of its life cycle in an aquatic host. As of 2017, over 780 million people lacked access to safe drinking water, and 2.5 billion lived without adequate sanitation facilities. This deficiency in basic services facilitates the transmission of over 50 different types of diseases, ranging from acute gastrointestinal infections to chronic parasitic conditions, creating a cycle of poverty and ill-health that is difficult to break.

Beyond the immediate threat of pathogens, chemical pollutants such as heavy metals, pesticides, and nitrates further exacerbate the public health burden. These contaminants not only cause direct toxicological effects but also act as immunosuppressants, weakening the host's immune system and increasing susceptibility to infectious agents. Furthermore, the presence of pharmaceutical residues in wastewater has been identified as a critical factor in the rise of antibiotic-resistant bacteria. This paper aims to review the global status of water pollution and its role as a primary driver of infectious disease outbreaks, focusing on the epidemiological data and mitigation strategies.

MATERIALS AND METHODS

The methodology for this review paper involved a systematic analysis of scientific literature and global health databases published between 1990 and 2017. The primary goal was to evaluate the correlation between specific water pollutants and the incidence of infectious diseases across diverse geographic regions.

Data Sources and Search Strategy

A comprehensive search was conducted using electronic databases, including PubMed, ScienceDirect, Google Scholar, and the World Health Organization (WHO) Institutional Repository for Information Sharing (IRIS). The search strategy employed specific Boolean operators and keywords such as: ("water pollution" OR "wastewater") AND ("infectious diseases" OR "waterborne pathogens") AND ("public health impact" OR "epidemiology"). Only studies published in English and providing

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HOW TO CITE THIS ARTICLE:
Kavita Sharma (2019). The Impact of Water Pollution on the Global Burden of Infectious Diseases, International Educational Journal of Science and Engineering (IEJSE), Vol: 2, Issue: 4, 16-19

Research Paper

quantitative or qualitative data on disease transmission via contaminated water were included.

Inclusion and Exclusion criteria

To ensure the relevance and reliability of the data, the following criteria were applied:

Inclusion: Peer-reviewed journal articles, official government health reports, and international NGO white papers published. Studies focusing on bacterial, viral, and parasitic pathogens in drinking, recreational, or irrigation water.

Exclusion: Studies focusing solely on air pollution or non-infectious chronic conditions (unless the chemical pollutant was linked to immunosuppression). Articles published after December 2017 were excluded to maintain the specified timeframe.

Observations

Based on the synthesis of data from the study period, several critical observations were identified:

Fecal-Oral Dominance: The majority of waterborne infections were observed to follow the fecal-oral transmission route, exacerbated by open defecation and the lack of protected latrines in rural and peri-urban areas.

Table 1: Common Waterborne Pathogens and Associated Diseases (WHO ,2014).

Pathogen Category	Specific Agent	Associated Disease	Primary Symptoms
Bacterial	*Vibrio cholerae*	Cholera	Profuse watery diarrhea, vomiting, leg cramps
Bacterial	*Salmonella typhi*	Typhoid Fever	High fever, headache, abdominal pain, malaise
Bacterial	*Shigella spp.*	Dysentery	Bloody diarrhea, fever, stomach cramps
Viral	*Hepatitis A & E*	Viral Hepatitis	Jaundice, fatigue, abdominal pain, dark urine
Viral	*Rotavirus*	Gastroenteritis	Severe watery diarrhea, vomiting, fever (infants)
Protozoan	*Giardia lamblia*	Giardiasis	Diarrhea, gas, greasy stools, stomach cramps
Protozoan	Cryptosporidium	Cryptosporidiosis	Watery diarrhea, stomach cramps, nausea

Infrastructure Correlation: A clear inverse relationship exists between sanitation coverage and disease incidence. Regions with less than 50% access to safely managed water showed a 3-to-5-fold increase in typhoid and dysentery cases.

Chemical-Biological Interaction: Observation indicated that chemical pollutants, particularly arsenic and heavy metals, acted as immunosuppressants. Populations exposed to these chemicals showed higher susceptibility to opportunistic waterborne infections.

Seasonal Variation: Disease outbreaks were observed to peak during monsoon or flooding events, when surface runoff carries human and animal waste into drinking water reservoirs, overwhelming existing filtration systems.

Economic Drag: Beyond health, it was observed that the time spent fetching water and the cost of treating preventable infections significantly hindered the socioeconomic development of affected communities.

RESULTS

The analysis of epidemiological and environmental data demonstrates a profound and quantifiable correlation between water pollution levels and the global prevalence of infectious diseases.

The primary finding indicates that waterborne diarrheal diseases remain the leading cause of preventable morbidity and mortality worldwide. Research identifies that approximately 829,000 deaths annually are attributed to unsafe drinking water, inadequate sanitation, and poor hand hygiene (World Health Organization, 2017). Among these, children under the age of five represent the most vulnerable demographic, with an estimated 361,000 deaths occurring annually—a figure that equates to nearly 1,000 child deaths every day due to contaminated water sources (Prüss-Ustün, Bartram, Clasen, Colford, Cumming, Curtis, Bonjour, Dangour, De France, and Fewtrell, 2014).

In terms of specific pathogenic burdens, Cholera continues to pose a severe threat in regions with poor wastewater management. Data shows an estimated 2.9 million cases and 95,000 deaths occur annually in endemic countries due to the ingestion of water contaminated with *Vibrio cholerae* (Pandey, Kass, Soupir, Biswas, and Singh, 2014). Furthermore, Typhoid Fever accounts for an estimated 11 to 20 million cases and over 128,000 deaths annually, primarily in South Asia and Sub-Saharan Africa, where fecal contamination of municipal water supplies is prevalent (Haseena, Malik, Javed, Arshad, Asif, Zulfiqar, and Hanif, 2017).

Table 2: Estimated Global Annual Burden of Water-Related Infections
(UNESCO 2017, Panday *et al.* ,2014)

Disease Category	Estimated Annual Cases	Estimated Annual Deaths	Primary Risk Factor
Diarrheal Diseases	1.7 – 2.0 Billion	829,000 – 842,000	Unsafe drinking water & poor hygiene
Cholera	2.9 – 3.0 Million	95,000 – 120,000	Untreated sewage in surface water
Typhoid Fever	11 – 20 Million	128,000 – 161,000	Fecal contamination of water/food
Schistosomiasis	200 – 240 Million	20,000 – 200,000	Contact with infested surface water
Hepatitis A	1.4 – 1.5 Million	7,000 – 11,000	Lack of safe water and poor sanitation

Beyond bacterial infections, water-based parasitic diseases show a high degree of persistence. Schistosomiasis, which is transmitted through contact with polluted surface water containing larval forms of flukes, affects over 200 million people globally, leading to chronic organ damage and increased susceptibility to other infections (Esrey, Potash, Roberts, and Shiff, 1991). Additionally, the presence of enteric viruses such as Hepatitis A and E in untreated sewage remains a significant cause of acute liver inflammation, with approximately 1.5 million cases reported annually in areas lacking safely managed water services (United Nations Educational, Scientific and Cultural Organization, 2017).

DISCUSSION

The correlation between water pollution and infectious diseases remains one of the most significant public health challenges of the 21st century. Research indicates that approximately 80% of all diseases in developing nations are fundamentally linked to poor water quality and deficient sanitation systems (Haseena, Malik, Javed, Arshad, Asif, Zulfiqar, and Hanif, 2017). In these regions, the fecal-oral route is the primary pathway for high-burden pathogens such as Vibrio cholerae and various enteroviruses, which thrive in environments where untreated sewage is discharged into communal water bodies (Cabral, 2010). The persistent reliance on unprotected surface water by rural populations creates distinct geographical "hotspots" for recurrent outbreaks of typhoid and dysentery (Hunter, Zmirou-Navier, and Hartemann, 2010). Furthermore, the lack of protected latrines and the prevalence of open defecation facilitate the continuous reintroduction of these pathogens into the local hydrological cycle (Esrey, Potash, Roberts, and Shiff, 1991). A critical observation in modern epidemiology is the "double burden" where chemical and biological contaminants interact to exacerbate health risks. Chronic exposure to toxic metals—such as arsenic, lead, and mercury—and agricultural pesticides has been shown to act as an immunosuppressant, lowering the host's threshold for infection and increasing the severity of waterborne illnesses (Schwarzenbach, Egli, Hofstetter, Gunten, and Wehrli, 2010). This susceptibility is particularly dangerous for children under five, where the combined effects of malnutrition and frequent diarrheal episodes lead to a cycle of impaired growth (Prüss-Ustün, Bartram, Clasen, Colford, Cumming, Curtis, Bonjour, Dangour, De France, and Fewtrell, 2014). Additionally, the emergence of antibiotic-resistant bacteria in wastewater reservoirs was identified as a growing threat by 2017, as pharmaceutical residues provide the selection pressure for "superbugs" that complicate the treatment of standard gastrointestinal infections (Ramirez-Castillo, Loera-Muro, Jacques, Nicolas, Guerrero-Barrera, Avelar-Gonzalez, Harel, and Guerrero-Barrera, 2015).

The effectiveness of intervention strategies is heavily dependent on the scale of implementation and community engagement. While large-scale water treatment plants are effective in urban centers, Point-of-Use (POU) technologies such as solar disinfection (SODIS) and household chlorination have proven vital for rural areas, reducing diarrhea rates by 35–50% (Fewtrell, Kaufmann, Kay, Enanoria, Haller, and Colford, 2005). However, environmental and climatic factors often counteract these efforts. Seasonal monsoons and extreme flooding act as "disaster multipliers" by dismantling ecological and sanitary barriers, flushing human waste into drinking water sources (Pandey, Kass, Soupir, Biswas, and Singh, 2014). Conversely, droughts concentrate existing pollutants in stagnant water sources, increasing the toxicity and pathogen density of the available supply (Ashbolt, 2004). Addressing these multifaceted challenges requires a shift toward integrated water resource management (IWRM) and the implementation of climate-resilient water safety plans to protect vulnerable populations (United Nations Educational, Scientific and Cultural Organization, 2017; World Health Organization, 2017).

CONCLUSION

The extensive link between water pollution and infectious diseases poses a grave global health threat, with contaminated water serving as a primary vector for diverse bacterial, viral, and parasitic pathogens. Research indicates that poor water quality is responsible for a staggering 80% of all global diseases and roughly half of all childhood deaths, disproportionately affecting marginalized populations in developing regions. Diarrheal infections, cholera, and typhoid remain the most prevalent outcomes of this contamination, often stemming from untreated domestic sewage and industrial waste. Ultimately, mitigating this crisis requires urgent, multidisciplinary interventions, including improved sanitation infrastructure and stricter waste management policies to safeguard universal access to safe water.

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