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AEROBIC BACTERIAL AND PHYSICOCHEMICAL FACTORS AFFECTING THE POTABLE WATER

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Abstract
Potable water quality is of utmost importance for safeguarding public health and well-being. Access to safe drinking water is a fundamental human right, and ensuring its microbiological quality is of paramount importance to safeguard public health. The evaluation of aerobic bacterial load concerning physicochemical factors plays a crucial role in determining the suitability and safety of drinking water sources. Ensuring the safety and quality of potable water is of utmost importance for public health. Aerobic bacteria, as one of the primary indicators of water contamination, play a crucial role in assessing water quality. The assessment of microbial contamination in potable water is essential in preventing waterborne diseases and outbreaks. Understanding the impact of physicochemical factors on the proliferation and survival of aerobic bacteria is vital for devising effective water treatment strategies and maintaining water safety standards. This review article aims to comprehensively evaluate the relationship between aerobic bacterial load and various physicochemical factors in potable water. This review synthesizes and critically analyzes existing literature from multiple sources, including research articles, reports, and databases, to investigate the influence of parameters such as temperature, pH, dissolved oxygen, turbidity, and nutrient levels on the growth and survival of aerobic bacteria in potable water. Moreover, the review article highlights the potential sources and routes of microbial contamination and their association with the physicochemical characteristics of water.
Keywords: *Aerobic bacteria, Physicochemical factors, Potable water*

INTRODUCTION

Water is fundamental for maintaining human life, and it should be voluntarily available, safe, and accessible to every individual. Improving access to safe drinking water can advantage to major health benefits. Thus, maximum importance must be given to make sure the greatest possible quality of drinking water (1). In many underdeveloped nations, quick population growth is a big issue that local experts struggle to address effectively. Meeting the fundamental demands of growing populations becomes progressively challenging and one of the most key problems faced is to make sure sustainable access to quality drinking water (2).

Waterborne diseases remain a major worldwide health issue with a shocking number of nearly 4 billion cases of diarrhea reported annually. This aggregates to about 5.7% of the entire worldwide disease burden in the year 2000 (3). The World Health Organization (WHO) expresses that around 80% of diseases in underdeveloped countries are affected by waterborne diseases developing from the utilization of polluted water. Additionally, about 3.1% of deaths can be attributed to the use of unclean and poor-quality drinking water (4), and universally, nearby 785 million people lack access to quality drinking water sources, beside 144 million depending on surface water for drinking, and more than 2 billion people using polluted water contaminated with feces (5).

Regularly observing the physical, chemical, and biological properties of water bodies and drinking water plants is crucial for the well-being of aquatic organisms and community health (6). The health and solidity of an aquatic environment is dependent on the quality of its water, impacted by human behavior, climate, and growing macrophytes. These aspects induce water rotation and the interruption of organic

matter (7). The way people perceive the quality of drinking water is affected by different factors. When dealing with water resources and originating policies, it is important for water managers and policymakers to deliberate these factors. By doing so, they can be well prepared to tackle any probable problems and make sure that their projects or policies have the highest positive impact on water quality and everyone's opinion (8).

Furthermore, drinking water can become polluted with disease-causing microorganisms such as bacteria, viruses and algae from landfills and septic systems, as well as from inappropriate discards of hazardous domestic items, agricultural chemicals, and leakage from underground storage tanks etc (9). This mini review aims to summarize literature published between 2005 and 2024, retrieved from various sources including Google Scholar and PubMed.

FACTORS AFFECTING THE QUALITYN OF DRINKING WATER

The condition of drinking water substantially affects human health, a concern mainly pronounced in underdeveloped nations where it regularly falls short. Drinking water quality has led to the proliferation of waterborne illnesses. This issue of exposure and health research into following the implications of drinking water quality on public health, aiming to induce helpful measures for improving drinking water requirements worldwide [10]. Water should absence smell, taste, color, and cloudiness. It must also lack harmful chemicals, toxins, excessive minerals, organic materials, and have a pH between 6.5 and 8.5. Besides, it must be without pathogens and radioactive elements for safety (9).

Similar to many developing nations around the world, Pakistan is grappling with a significant scarcity of water and growing issues of contamination. Particularly in regions like the drought-stricken parts of Sindh Province, people are currently lacking access to fresh drinking water and are left with no choice but to consume salty water. Meanwhile, in Baluchistan Province, the underground water sources are depleting by about 3.5 meters each year, and they are projected to be completely exhausted within the next 15 years. This combination of falling water resources and escalating demand across various sectors has had a detrimental impact on water quality, leading to a severe problem of water pollution. The safety of water for human consumption is a concern in most of the country's rivers, lakes, and underground aquifers (11). The tap water people drink may have traveled long distances and spent considerable time in the distribution system. It's known that the quality of water might decline after leaving the treatment plant. Several factors, including the decrease of disinfectant, temperature changes, water flow, time spent in the system, and bacterial growth, can contribute to this decline in water quality (12).

MICROBIOLOGICAL CONTAMINATION OF POTABLE WATER

Roughly 1.1 billion people around the world do not have access to safe drinking water, relying on contaminated surface and groundwater sources. Even those with so-called "improved" water sources like household connections or boreholes may face microbial contamination. This leads to serious infectious diseases such as cholera, dysentery, and hepatitis, contributing significantly to global health issues. The lack of safe water disproportionately affects developing countries, causing around 1.6 million annual deaths from diarrheal diseases, primarily among children under five, resulting in multiple episodes of illness each year (13). Good drinking water from treatment plants loses quality as it travels to homes due to the Drinking Water Distribution System (DWDS). The deterioration happens mainly at the pipe inner surface where intricate microbial biofilms play a key role, though not fully comprehended (14).

Water released into the distribution system changes as it flows through pipes, reservoirs, and tanks, with pressure changes and leaks possibly allowing groundwater and contaminants from soil and water to enter. Harmful bacteria, including opportunistic pathogens like *Flavobacterium, Pseudomonas, and Mycobacterium*, can enter and multiply in the pipes, forming biofilms (15). Numerous diseases spread via water contamination, mainly through the fecal-oral pathway. Drinking water-related illnesses claim around 5 million young lives each year and affect approximately one-sixth of the global population (16). Insufficient waste treatment, improper disposal of waste from humans and livestock, industrial emissions, and excessive utilization of limited water sources have led to the presence of microbial and chemical contaminants like bacteria, viruses, heavy metals, nitrates, and salt in water supplies (17). The primary origin of all drinking

water contains a variety of water-dwelling microorganisms, some of which might pose a risk if they find their way into the human body (18).

CHEMICAL CONTAMINANTS OF POTABLE WATER

Water pollution is a result of human activities affecting different water sources like lakes, rivers, and groundwater. Using contaminated water leads to the transmission of waterborne illnesses. In Pakistan, community health research indicates that approximately half of the diseases and 40% of deaths stem from inadequate drinking water quality (19). Several different types of harmful chemicals have been found in tap water. Some of these chemicals, like aluminum, arsenic, disinfection by-products (DBPs), fluoride, lead, nitrate, pesticides, radon, and sulfate, have been linked to potential health risks based on research studies. These contaminants come from both natural sources and human activities, and they can be either inorganic or organic in nature (20).

WATERBORNE PATHOGENS AND DISEASES

Microbes are a major global source of waterborne illnesses, yet chemicals in drinking water, from various sources like spills and treatment processes, are linked to severe health issues like cancer, heart problems, and miscarriages. Contaminants such as disinfection by-products and lead can enter water during treatment or at the tap, causing various negative impacts (21). Long-term diseases like cancer may have connections to various factors such as the presence of harmful chemicals and microorganisms in the water we consume (22). Globally, waterborne microorganisms and the diseases they trigger pose a significant public health issue. Their impact extends beyond the sickness and fatalities they induce, encompassing substantial expenses associated with their avoidance and medical care (23). Microbial pathogens are responsible for waterborne diseases and are closely linked to environmental factors. The risk of infection is influenced by the levels of disease-causing microorganisms present in various water sources like rivers, groundwater, and oceans. These microorganism concentrations change due to factors such as weather, seasons, and the introduction of pathogens from animals and human activities. Additionally, the pathogens' fate and movement within the water cycle also play a significant role in their spread (24). Table 1 provides information about harmful bacteria found in water and the diseases they can cause (25, 26).

Table I. List of some bacteria that are involved in waterborne diseases

Bacteria	Disease	Source	Effects
Campylobacter	Campylobacteriosis	Domestic, wild animal feces	Acute diarrhea
E. coli	Gastroenteritis	Cattle feces	Vomiting and diarrhea
Salmonella typhi	Typhoid fever	Domestic and wild animal feces	High fever, diarrhea, ulceration of small intestine
Salmonella (1,700 serotypes)	Salmonellosis	Domestic and wild animal, human feces	Diarrhea
Shigella	Shigellosis	Infected humans	Bacillary dysentery
Legionella interrogans	Leptospirosis (Weil's disease)	Urine of dogs, livestock, rodents, wild animals	Jaundice, fever
Vibrio Cholerae	Cholera	Sediments, shellfish, asymptomatic human carriers	Extremely heavy diarrhea

Waterborne illnesses are infections that are transmitted through water, with the water serving as a passive transporter for disease-causing microorganisms. The occurrence of these diseases is closely linked to the level of sanitation. Examples of such illnesses include Cholera,

Typhoid, Bacillary dysentery, Infectious hepatitis, Leptospirosis, Giardiasis, and Gastroenteritis, among others (26). Insufficient clean drinking water and proper sanitation lead to diseases like cholera, dysentery, and typhoid, causing millions of deaths yearly, mainly in developing nations. Over 2 million, children under five, die annually due to diarrhea, often caused by infections or a mix of pathogens. Water-related illnesses affect around 250 million people, causing 10 to 20 million global deaths annually. In South

Africa, more than 7 million people lack access to safe drinking water, and approximately 21 million are without basic sanitation, putting them at risk of waterborne diseases (27).

PHYSICOCHEMICAL FACTORS THAT AFFECT THE MICROBIAL GROWTH IN DRINKING WATER

The bacteria and their associated microbiota were found in greater numbers in the initial water flow, which had a cooler temperature. The presence of bacteria was observed in samples with higher HPC (heterotrophic plate count) also known as standard plate count that measures the colonies on plate agar of heterotrophic bacteria and this occurrence showed a negative relationship with elevated temperatures (28). Physical factors like pH, conductivity, and TDS significantly impact the growth of bacterial populations. pH levels within the range of 3 to 10.5 can promote the growth of both harmless and harmful microorganisms. Conductivity measures a liquid's ability to carry an electric current and is closely linked to TDS. TDS indicates the presence of inorganic elements (like salts and minerals) and high TDS can affect taste negatively. TDS concentrations below 10,000 mg/l generally pose no risk to human health. Wells and localized areas with lower TDS and conductivity levels, coupled with higher cloudiness, align with increased bacterial contamination in wells and aquifer zones (29). Microbiological testing included the examination of indicator bacteria like heterotrophic bacteria, total and fecal coliforms. Additionally, key physical factors such as pH, turbidity, and temperature were evaluated. The goal was to determine the safety of both distributed water and water sourced from dams and rivers for drinking and household purposes (27).

CONCLUSION

This review comprehensively investigates the intricate interplay between aerobic bacterial proliferation and survival and various physicochemical parameters such as temperature, pH, dissolved oxygen, turbidity, and nutrient levels. By creating and critically analyzing accessible literature, the association among microbial contamination sources, water characteristics, and the possible risks to human health is discussed. These findings highlight the requirement of formulating effective water treatment approaches and observing strict water safety standards for sustainable supply to the community.

Conflict of interest:

Authors declare no conflict of interest.

Authors' contribution:

MR, MS and SA conceived the idea and designed the research work; RN and MR, Critical analysis; FA Review and methodology; SYAS, FS Proof reading and editing.

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