Pathogenic microorganisms present in contaminated water

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ABSTRACT

Millions of people in the world live without access to good quality water. According to UNICEF (United Nations Children's Fund), less than half of the world's population has access to drinking water. UNICEF data reveal that 35% of the world's population does not have good quality water and 1 (one) in 3 (three) people does not have access to drinking water The inequality of access to water, the lack of investments in basic sanitation and the lack of hygiene conditions result in millions of deaths in the world from waterborne diseases. In Brazil, according to an estimate by the WHO (World Health Organization) is that 15 thousand people die per year from diseases related to the precariousness of basic sanitation (UNICEF, 2019). In view of the context of mortality due to diseases caused by contaminated water, this work aims to present the pathogenic microorganisms present in contaminated water and, through a literature review, describe the diseases, how they manifest themselves from contamination.

Keywords: Sanitation, Contaminated water, Pathogens.

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INTRODUCTION

The relationship between water quality and public health has been a topic of research for decades. Polluted waters are potential environments for the transmission of diseases due to toxic substances accompanied by pathogens. It is inferred that all contaminated water is polluted, but not all polluted water is contaminated (SANTOS, 2023). However, it is essential to differentiate the terms pollution and contamination when discussing water quality.

In the world, more than 1 billion people have problems with access to drinking water and 2.4 billion do not have basic sanitation. Lack of access to good quality water and sanitation results in hundreds of millions of cases of waterborne diseases and more than five million deaths each year. It is estimated that between 10,000 and 20,000 children die from waterborne diseases (IETC 2001; UNESCO, 2003)

Water quality is defined by a conglomerate of factors and indicators that serve to describe its physical and chemical properties, and biological systems, not to mention its main chemical constituents, which compose it (JOÃO, 2020). According to Toledo *et al*. (2002, FLORENTINO 2021 apud; RIOS, 2021), the use of these indicators consists of the use of variables that correlate with the changes that occur in the microbasin, whether of anthropogenic or natural origins. The concept of water quality is relative, since it is based on the objectivity of the user, or the purpose for which the water is intended (PAULOS, 2008, p.28).

Porto (2012, p. 159) considers that the main impacts that interfere with water quality are related to changes in land use and occupation, which has a strong interference in the silting of rivers, deterioration of water quality and waterborne diseases.

The water used in irrigation usually comes from rivers, streams, lakes or wells adjacent to cultivated areas, and the use of public water supply is rare, mainly due to its high cost. As this water collected does not undergo prior treatment, it can become a potential source of contamination for the vegetable to be irrigated (MDLULI; THAMAGA-CHITJA; SCHMIDT, 2013).

Researchers play a crucial role in identifying the pathogenic microorganisms found in contaminated water. Therefore, it is correct to say that his findings are of great importance for the diagnosis and treatment of diseases associated with contaminated water.

THEORETICAL FOUNDATION

Water contamination by microbiological agents represents a significant concern for public health worldwide, including *enterobacteria*, which are found in the human gastrointestinal tract, animal kingdom, water, soil and plants. Its presence in waters contaminated by urban sewage is pointed out as a bioindicator of fecal contamination. Biological indicators are specific to certain types of impact, as numerous species are proven to be sensitive to one type of pollutant but tolerant

to others. However, no indicator is effectively perfect, taking into account a series of factors such as the class of water bodies, water characteristics (fresh, saline water), climate (temperate, tropical) and the economic factor (DUARTE, 2011).

Schistosomiasis mansoni is a waterborne disease transmitted by snails of the genus *Biomphalaria* that are contaminated by *Schistosoma mansoni* larvae when people infected by the parasite throw their waste containing worm eggs into aquatic environments inhabited by these mollusks (BRASIL, 2024).

Viruses and bacteria have very high resistance in the soil and especially in water, they can cause epidemics if they actually reach the underground waterway. According to the World Health Organization – WHO (1998), the typical organisms present in the underground aquifer that cause diseases are *micrococcaceae, streptococc, bacilli* and *enterobacteria*.

Cemeteries can cause environmental pollution in the underground aquifers and soil of the region not only due to the toxicity of *the necroleachate* and the pathogenic microorganisms present (WHO, 1998). The waters affected by *the necroleachate* present microbiological contamination by *heterotrophic bacteria, proteolytic bacteria*, *sulfite-reducing clostridia*, *enterovirus* and *adenovirus*. There is also a large consumption of oxygen, due to biological decomposition and chemical transformations, especially of products with nitrogen, phosphorus, sulfur and others. The graves cause an increase in the amount of mineral salts, increasing the electrical conductivity of these waters. There seems to be an increase in the concentration of the major ions bicarbonate, chloride, sodium and calcium, and of the metals iron, aluminum, lead and zinc and other metals, there is also the presence of *very toxic diamines* that are made up of *putrescine, butanediamine, cadaverine, pentanediamine*, potent poisons for which no efficient antidotes are available. (MATOS, 2001)

The highly relevant research on groundwater contamination by cemeteries in Brazil was conducted by PACHECO *et al.* (1991), which investigated three cemeteries in the cities of São Paulo and Santos. The study found the presence of microorganisms in the water table, including *total coliforms, fecal coliforms, fecal streptococci, clostridia, reducing sulfite clostridia* , among others, originating from the decomposition of bodies buried in the soil. The risk of microbiological contamination associated with the construction of cemeteries in urban areas is considerable. Groundwater is particularly vulnerable to contamination by *viruses* and *bacteria*. Natural springs and shallow wells connected to contaminated aquifers can spread waterborne diseases such as tetanus, gas gangrene, foodborne toxiinfection, tuberculosis, typhoid, paratyphoid fever, *hepatitis A*, among others. The presence of viral contaminant vectors was found in the water table miles away from the cemeteries (LOPES, 2001).

Contamination by petroleum products in groundwater is currently a large-scale problem, which causes impacts on the environment and the health of living beings, especially humans

(RODRÍGUEZ-MARTÍNEZ et. al, 2006). The growing need for spaces suitable for human occupation in densely urbanized areas requires technological advances in remediation processes to obtain effective results for minimizing environmental impacts. When properly applied, bioremediation is highly viable in aquifers in tropical environments. In soil and groundwater, a wide range of bacteria and fungi (*hydrocarbonclastic*) can use *hydrocarbons* as a carbon source for growth or other metabolic functions, producing carbon dioxide and water. In the environment, these microorganisms are the primary agents of the degradation of these organic compounds and the manipulation of the efficiency of this process is the basic principle of effective bioremediation projects, in these processes the bacteria *Pseudomonas stutzeri are identified. Brevundimonas sp. and Pseudomonas sp*. (LIN, 1996).

PATHOGENIC MICROORGANISMS

Coliforms - *Thermotolerant coliforms* are microorganisms capable of fermenting *lactose*, being represented mainly by *Escherichia coli*, and other bacteria. *E. coli* is exclusively of fecal origin, being present in high densities in human, mammalian and bird feces. All coliform bacteria are stained, gram-negative, non-sporulated stems that are associated with the feces of warm-blooded animals and with the soil (CETESB, 2022). Fecal coliforms, when found in water, confirm the discharge of domestic sewage without disinfection (NEITZEL; LINDNER, 2013). According to Derisio (2012), bacteria of the coliform group, such as E. coli, have been the main indicator when talking about contamination of fecal origin, however, their presence does not bring certainty as to the existence of pathogenic organisms, since they will only depend on the feces coming from beings carrying waterborne pathologies, which makes it an indicator of potential contamination. The presence of thermotolerant coliforms in the water is an indicator of pollution with feces of endothermic animals (VALIM, 2006). Among the risks of contamination, there is contact with recreation areas, where a mixture of pathogenic and non-pathogenic microorganisms is found (ALVES, 2007). The indicators generally used include total coliforms, fecal coliforms, *Escherichia coli and Enterococci sp*., as expressed by Tebaldi *et al*. (2018, apud SHIBATA, 2004).

Cyanobacteria **-** are also known as blue-green algae due to the combination of characteristics common to bacteria and algae, in addition, they are also photosynthetic prokaryotic. Most *cyanobacteria* are aerobic photoautotrophic microorganisms, that is, they need water, carbon dioxide, inorganic substances and light for their survival, performing photosynthesis and thus obtaining energy for their own metabolism (NASCIMENTO, 2010).

Regarding *cyanobacterial* blooms, these are the result of interactions between physical, chemical and biotic factors, which lead to an explosive characterization of growth, self-limiting and short-lived microorganisms of one or a few species. In this way, it often produces visible colorations

in water bodies, overcoming a barrier that prevents the penetration of light and, consequently, limits the reproduction and life of other living beings present in that place (GUIMARÃES et al., 2018).

The presence of several genera of *cyanobacteria* that form blooms and produce toxins, known as *cyanotoxins*, is noteworthy, representing a significant source of toxic products of natural origin. Although the exact causes of their production are not yet fully understood, the proliferation of these bacteria, often related to excess nutrients, results in the release of these toxins, which are potentially harmful to health, including as promoters of tumors. Cyanobacterial blooms also cause social, economic, and environmental impacts, affecting the aesthetics of water, its odor, and taste, especially when intended for public supply. In addition, specific genera of *cyanobacteria*, such as *Anabaena, Microcystis and Planktothrix*, with relevance to health and water contamination, are highlighted. In parallel, certain *sporogenic bacteria*, such as *Clostridium* and *Bacillus*, are highlighted as important human pathogens, including species such as C. *botulinum*, C. *perfringens* and B. *anthracis*, the latter feared for its potential as a biological weapon (FIGUEIREDO FILHO *et al*., 2008).

Viruses **-** It should be noted that the current legislation (BRASIL, 2004) indicates the inclusion of research on pathogenic organisms, *enteroviruses* and *Cryptosporidium* sp, as a complement to the analytical routines. Studies point out that viruses in particular can already be found in a large number of groundwater samples and that they are associated with reports of health problems in the community that uses these waters. Therefore, it is considered necessary to routinely evaluate these pathogens, to take fundamental measures for the health of the population, to control these occurrences and also to mitigate the respective compromise of groundwater reserves. (PIRANHA, PACHECO, 2004).

Protozoa **-** It is one of the several pathogenic microorganisms existing in water, with the possibility of contamination. Contamination of water resources by *pathogenic protozoa* has occurred all over the world (NETO *et al*., 2011).

Human contamination occurs when people use or come into contact with contaminated water. The process of water degradation is continuous and increasing due to the discharge of untreated or inadequately treated sewage, feces of wild or farmed animals and industrial effluents. Waterborne diseases, especially those caused by intestinal protozoa, have emerged as one of the main public health challenges (FRANCO, 2007).

Among the *protozoa*, *Giardia lamblia*, also known as *Giardia duodenalis* or *Giardia intestinalis*, a *flagellated protozoan* found throughout the world and commonly identified in fecal examinations, stands out. *Cryptosporidium parvum* also has a major impact on public health, being recognized as one of the leading causes of waterborne diseases in the United States according to the Division of Waterborne and Foodborne Diseases (DDTHA). The transmission of these *protozoa* occurs mainly by ingestion of contaminated water and by contact with aquatic environments

contaminated by feces of infected animals and/or humans. In addition, *Entamoeba histolytica*, responsible for *amoebiasis*, is another *relevant protozoan*, predominantly found in humans and primates (DDTHA, 2023).

Some of the major diseases that can be caused by contaminated standing water or untreated sewage water include:

Hepatitis A **-** is a disease caused by the *virus* of the *Picornavirus* family and can be transmitted through the ingestion of water, food and objects contaminated by the *virus.* This disease is highly contagious characterized by inflammation of the liver and, although it is usually mild, in some cases it can evolve in a severe form and be fatal when left untreated. The symptoms of *hepatitis A* usually appear about 4 weeks after contamination by the virus, with the main indications of *hepatitis A* being dark urine, pale stools, yellowing of the skin and mucous membranes, fever, chills, feeling weak, nausea, loss of appetite and fatigue. (PEREIRA, GONÇALVES, 2003).

Giardiasis **-** is an infection of the digestive system caused by the parasite *Giardia lamblia* whose transmission is made through the consumption of food or water contaminated by feces containing cysts of the parasite, being an infectious disease that can be transmitted between people. The main symptoms indicative of *giardiasis* are abdominal pain, diarrhea, fever, nausea, weakness, and weight loss. (BRAZIL 2024).

Amebiasis **-** or *amoebic dysentery* is an infection caused by *the protozoan Entamoeba histolytica*, which settles in the intestine and prevents the absorption of important nutrients for the body. Transmission happens through the consumption of food or water contaminated by feces containing *mature amoebic cysts*. The main symptoms are abdominal pain, diarrhea, fever and chills, in addition to bloody or mucus feces, in some more severe cases, the disease can develop the invasive form, in which other organs such as the liver, respiratory tract and even brain are infected (CORDEIRO, MACEDO, 2007).

Leptospirosis **-** is a disease caused by a bacterium that can be present in the urine of sewer rats, or other infected animals such as dogs and cats, which penetrates the body through the contact of the excrement of these animals or contaminated water with injured skin or mucous membranes, such as eyes, nose. The main symptoms of are high fever, headache, body ache, loss of appetite, vomiting, diarrhea and chills. (SANTOS, ASSIS, SILVA, ANGELIS, 2012).

Cholera **-** is an intestinal infection caused by the bacterium *Vibrio cholerae* that can contaminate water and food. The main symptoms include severe diarrhea and vomiting, which can lead to severe dehydration (OJEDA RODRIGUEZ and KAHWAJI, 2021).

Ascariasis **(roundworm) -** is a worm caused by the parasite *Ascaris lumbricoides*, develops and multiplies in the intestine. It is transmitted through ingestion of water or food contaminated with

parasite eggs. The main symptoms of ascariasis are abdominal pain, nausea, difficulty in defecating and loss of appetite (INNOCENT, OLIVEIRA and GEHRKE, 2009).

***Typhoid Fever* -** is an infectious disease caused by the bacterium *Salmonella typhi*, and its transmission is through the consumption of water and food contaminated with the parasite. Main symptoms are high fever, vomiting, belly pain, constipation, diarrhea, headache, loss of appetite, weight loss, or red spots on the skin (BRASIL, 2024).

MATERIALS AND METHODS

It is a basic research with a qualitative approach, carried out through bibliographic research in scientific sources in the area addressed in the theme such as books and scientific articles available on digital platforms Google Scholar, CAPES/MEC Journals.

As pointed out by Brizola and Fantin (2017), literature review is the "junction of ideas from different authors on a given topic". Therefore, the literature review is a fundamental instrument to consolidate concepts about pathogenic microorganisms present in contaminated water.

A search was carried out in the CAPES/MEC Periodicals Portal database, with a view to verifying the scientific production on the subject, using the descriptor "contaminated water", "pollution", "microorganism", "diseases" and "Water Resources". For the selection of scientific articles, the following criteria were established: to present information from the article on Viruses, contamination, diseases, microorganisms, and to report the effectiveness of the study regarding the presence of microorganisms in contaminated waters. The procedures were organized as follows: in the first stage of the research, a survey of the articles found with the terms proposed in the previously mentioned database was carried out. Next, the selection of articles published between the years 2019 and 2023 was carried out, in order to ensure the reach of the most recent publications on the subject. Subsequently, a thorough reading of the articles was carried out and a database was composed.

At this time, data from all studies were tabulated with the intention of classifying the variables important for the study, such as the journal of publication and date. Subsequently, the systematization and analysis of the articles was carried out. At this time, the following exclusion criteria were used: 1) duplicate articles; 2) articles that were not available for download; 3) articles that were not directly represented with the research. The results are available in Table 1.

Table 1 - Results of the Literature Analysis

Articles reported by the search on the platform	30
Duplicate articles	1
Articles not available for reading	1
Articles did not present a study on pathogenic microorganisms present in contaminated water	1
Articles that do not have direct representation for the search	1
Total valid articles for analysis	**26**

Source: Author 2024

RESULTS AND DISCUSSIONS

In this last stage, tabulated data on the results of the researched articles were consolidated, thus structuring pathogenic microorganisms present in contaminated water, between the years 2019 and 2023. Thus, Table 2 presents the major infectious agents found in contaminated water worldwide and demonstrates the quantity researched.

Table 2 - Contributions by journal

BACTERIUM	**AS.**
Campylobacter jejuni	01
Escherichia coli	19
Salmonella sorotipo Typhimurium	10
Shigella flexneri	1
Vibrio cholera	2
Yersinia enterocolitica	2
Klebsiella spp	4
Enterococcus spp	3
Staphylococcus aureus	3
Streptococcus spp	3
Legionella pneumophila	3
Clostridium	4
Bacillus	1
HELMINTHS	**AS.**
Ascaris lumbricoides	1
Strongyloides	1
Taenia	1
PROTOZOA	**AS.**
Giárdia lamblia	6
Cryptosporidium spp	3
VIRUS	**AS.**
Adenovirus	0
Enteroviroses	0
Hepatitis A	0
Rotavirus	0

Source: the author

These 18 microorganisms highlighted in the studies encompass only a part of the broader panorama of the research, which also includes other pathogens not mentioned in the table. The fact that *Escherichia coli* was mentioned in 19 of the 26 articles surveyed suggests that it is one of the microorganisms most frequently found in contaminated or polluted waters. The high prevalence of *E. coli* is worrisome, as it is an indicator bacterium of fecal contamination and its presence in water bodies can be an indication of risk to public health. It is important to emphasize that these studies were conducted globally, covering a variety of environments investigated. Among the sites studied are supply wells in rural and urban areas, fountains used for recreation and ornamentation, facilities in the food industry, dental offices, as well as natural water bodies, such as lakes and streams. This diversity of supply sources analyzed reflects the importance of a comprehensive approach in assessing water quality and identifying potential public health risks. Importantly, although the reviewed studies did not record the presence of *viruses*, this absence should not be underestimated.

The lack of virus detection is relevant and may indicate the need for further investigations or the implementation of preventive measures to prevent the spread of these pathogens, given their importance in public health and the environment.

CONCLUSION

This study conducted a literature review from 2019 to 2024 seeking the most recent contributions regarding pathogenic microorganisms present in water. In this context, a search was carried out on the CAPES/MEC Journal Portal, and 26 studies were identified, after inclusion and exclusion procedures were established. Overall, this research highlights the important role of researchers in advancing scientific knowledge about the microorganisms found in water. The results indicate that the contamination, for the most part, is the result of population growth and land occupation, which exert a significant influence on the degradation of the quality of both surface and groundwater. Considering the various routes of transmission of diseases related to contaminated water, it is essential to adopt simple measures to prevent contagion, as emphasized by Santos (2023). These include practices such as washing hands and food thoroughly, consuming only filtered or boiled water, avoiding the use of inappropriate places for the disposal of bodily waste, keeping containers that can accumulate water covered, ensuring proper sealing of the water tank, avoiding the disposal of garbage in aquatic environments and inappropriate places, as well as avoiding the consumption of water from floods and places whose water quality is not known. Such measures are within everyone's reach, regardless of government intervention, as is the case with basic sanitation.

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