"Giardia and Cryptosporidium" removal technologies in water supply systems: a systematic literature review

Tecnologias de remoção de "Giardia e Cryptosporidium" em sistemas de abastecimento de água: uma revisão sistemática de literatura

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ABSTRACT

Water treatment plants must have processes that ensure that the water supplied to the population meets the physical, chemical and biological parameters of the Ministry of Health and ensuring compliance with the recommended limits will provide increased safety in terms of the absence of bacteria, viruses and protozoa. present in the water. Water contamination after treatment by giardia and Cryptosporidium occurs in developed and developing countries, and one of the causes is the resistance of these protozoa to traditional standards of disinfection by chlorination. In this sense, the present article aims to gather information on giardia and Cryptosporidium removal technologies in water supply systems using systematic literature mapping (MSL). Thus, the research used the Science Direct database (Elsevier) with a time frame covering the period from 2016 to 2021. The keywords used were “giardia and Cryptosporidium, water treatment, removal. The research identified 58 studies that, after applying the exclusion criteria, 22.41% of the articles were selected for the first stage, and after the second stage, 5.17% of the total. Research has shown that there are treatment processes for removing “giardia and Cryptosporidium”, such as coagulation/filtration, reverse osmosis, micro or ultrafiltration, advanced UV-based oxidation, etc. and simpler processes such as using slow filtration. Many times, a set of these processes must be used so that the removal can take place in the proper way and that, with this, the potability of the water is guaranteed.

Keywords: quality of life, basic sanitation, techniques.

RESUMO

As estações de tratamento de água devem possuir processos que garantam que a água fornecida à população atendam aos parâmetros físicos, químicos e biológicos do Ministério da Saúde e garantindo o atendimento dos limites recomendados, proporcionará aumento da segurança quanto a ausência de bactérias, vírus e protozoários presentes na água. As contaminações de águas após o tratamento por giárdia e Cryptosporidium ocorrem em países desenvolvidos e em desenvolvimento, sendo que uma das causas é a resistência desses protozoários aos padrões tradicionais de desinfecção por cloração. Nesse sentido, o presente artigo tem como objetivo reunir informações sobre tecnologias de remoção de giárdia e Cryptosporidium em sistemas de abastecimento de água utilizando o mapeamento sistemático de literatura (MSL). Assim, a pesquisa utilizou a base de dados Science Direct (Elsevier) com recorte temporal compreendendo o período de 2016 a 2021. As palavras chaves utilizadas foram “giardia and Cryptosporidium, water treatment, removal. A pesquisa identificou 58 estudos que, após aplicação dos critérios de exclusão 22,41 % dos artigos foram selecionados para a primeira etapa, e após a segunda etapa, 5,17% em relação ao total. A pesquisa demonstrou que existem processos de tratamento para remoção de “giardia e Cryptosporidium”, como por exemplo, coagulação/ filtração, osmose reversa, micro ou ultrafiltração, oxidação avançada baseado em UV, etc e processos mais simples como utilização de filtração lenta. Muitas das vezes devem ser utilizados um conjunto destes processos para que a remoção possa ocorrer da forma adequada e que com isso seja garantido a potabilidade da água.

Palavras-chave: qualidade de vida, saneamento básico, técnicas.

1 INTRODUCTION

Giardiasis and cryptosporidiosis are parasitic diseases caused by protozoa giardia duodenalis, also called giardia lamblia or giardia intestinalis, and cryptosporidium respectively. These diseases are among the leading causes of human gastroenteritis worldwide. Both parasites are disseminated by water transmission and have similar forms of transmission, and the main risk factors for infection are trips abroad, contact with drinking water, activities in the field, or transmission from person to person (HUNTER et al., 2004; KABORE et al., 2010). These protozoa are transmitted through human or animal feces that have found their way to drinking water or food (SOPWITH et al. 2005).

Fecal contamination of water sources represents a health risk to the drinking water-consuming population from Estações de Tratamento de Água (ETA) [Water Treatment Plants] that use surface water sources for water supply. Gourdand and Cryptosporidium are protozoa that provide great risks, as they are excreted in high densities, survive for long periods remaining infectious in the environment (RAZZOLINI et al. 2016).

These pathogenic protozoa giardia and Cryptosporidium are an example of organisms that can be found in contaminated waters. These protozoa are resistant to the standard chlorination disinfection process performed by the Estações de Tratamento de Água (ETA) [Water Treatment Plants] and are infectious in low doses (RAZZOLINI et al. 2016). The obstacle is even greater when it comes of Cryptosporidium due to its small size and compression capacity of its membrane providing greater resistance due to the treatment and its removal.

According to Atlas Esgotos, prepared by the Agência Nacional de Águas (ANA) [National Water Agency] in partnership with the Secretaria Nacional de Saneamento (National Sanitation Secretariat), in Brazil, 45% of wastewater is currently untreated, and 18% have sewage collected and untreated and still 27% do not have sewage collection nor treatment. As a result, raw sewage in many cities is directed to bodies of water, contaminating several springs.

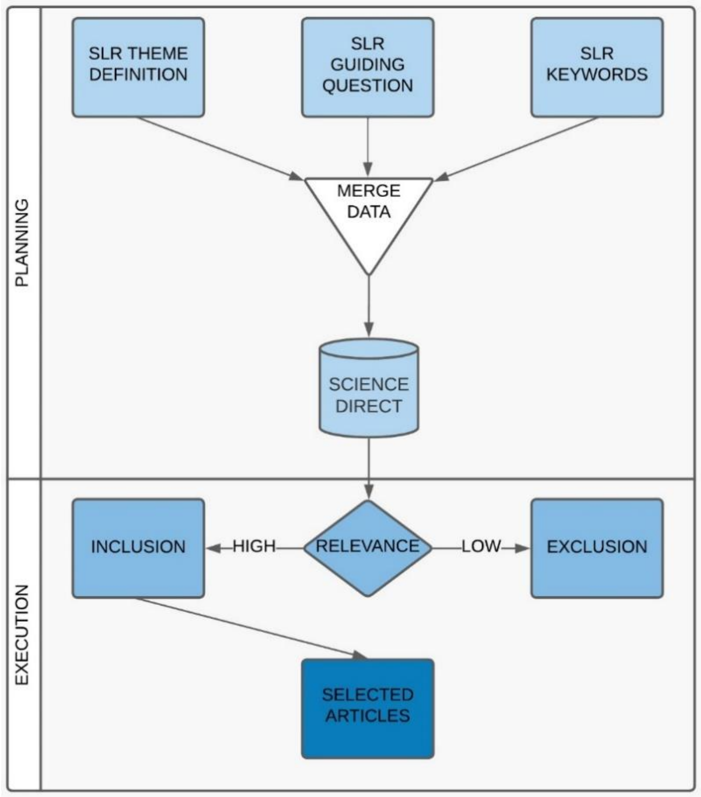
Protozoa pose risks to human health when water treatment plants are unable to remove them. One example was the 1993 outbreak of water-flow cryptosporidiosis in Milwaukee (U.S. – United States), where about 403,000 residents became ill after an inadequate removal of Cryptosporidium oocysts at one of the two water treatment plants in the city, caused by an ineffective filtration process (KENZIE MAC et al. 1994) and, causing approximately millions in medical costs and investment losses (CORSO et al. 2003).

Another example was the Walkerton incident in Canada, where 2,300 people became seriously ill and seven died from exposure to microbe-contaminated drinking water in May 2000 (HRUDEY et al. 2003). In this context, the present study seeks to identify giardia and Cryptosporidium removal technologies in water for human supply.

2 MATERIAL E METHODS

The methodology adopted is a systematic review of the literature on studies and technologies for the removal of giardia and Cryptosporidium in water supply systems in several countries. After choosing the theme, the defined research question was as follows: "Which studies address giardia and Cryptosporidium removal technologies in water supply systems?" The steps of the adopted protocol are presented in the flowchart in Figure 1.

Figure 1: SLR Protocol



Fonte: Autores (2022)

After choosing the theme and question, the following keywords were selected: "giardia and Cryptosporidium" "water treatment" " removal". The sources had to be available on the web, preferably in the scientific database of the subject. A search was carried out on Google Scholar with the keywords and during the search procedure, it was found that the most common and subsequently selected database would be Science Direct.

Initially, a preliminary selection of articles was carried out based on the following criteria: For the elaboration of the protocol, the guiding question of the research was defined "Which studies address technologies for the removal of giardia and

Cryptosporidium in Water Supply Systems?" and the respective keywords: giardia and Cryptosporidium, and water treatment, and removal.

After conducting a preliminary search on Google Scholar, it was found that the database with the highest number of potential studies was Science Direct (Elsevier).

Next, the inclusion and exclusion criteria of the articles to be selected in English were defined. The first stage comprised the analysis of the titles and abstracts of the articles found. The following inclusion criteria were defined:

Applied research articles that investigated the presence of giardia and Cryptosporidium in Water Supply Systems.

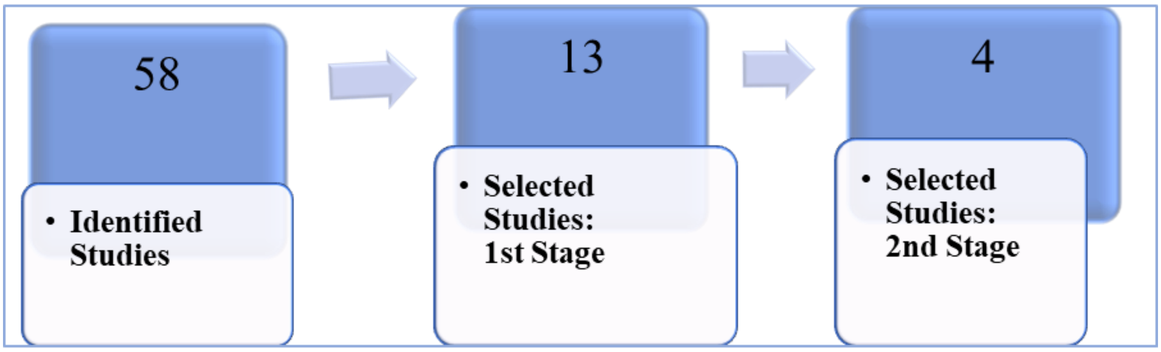
Articles addressing giardia and Cryptosporidium removal technologies in Water Supply Systems.

Articles concerning the efficiency of giardia and Cryptosporidium removal technologies in Water Supply Systems.

The exclusion criteria were: articles that do not address giardia and Cryptosporidium removal technologies in Water Supply Systems and articles that did not address the study of the efficiency of the water treatment process.

Figure 2 shows the number of 58 identified studies. After reading the title and abstract, 13 articles were selected. Among the selected articles, a complete reading of the studies was carried out, applying the inclusion and exclusion criteria. Finally, in the second phase, 4 articles were selected for analysis.

Figure 2: Studies selected based on the Inclusion Criteria



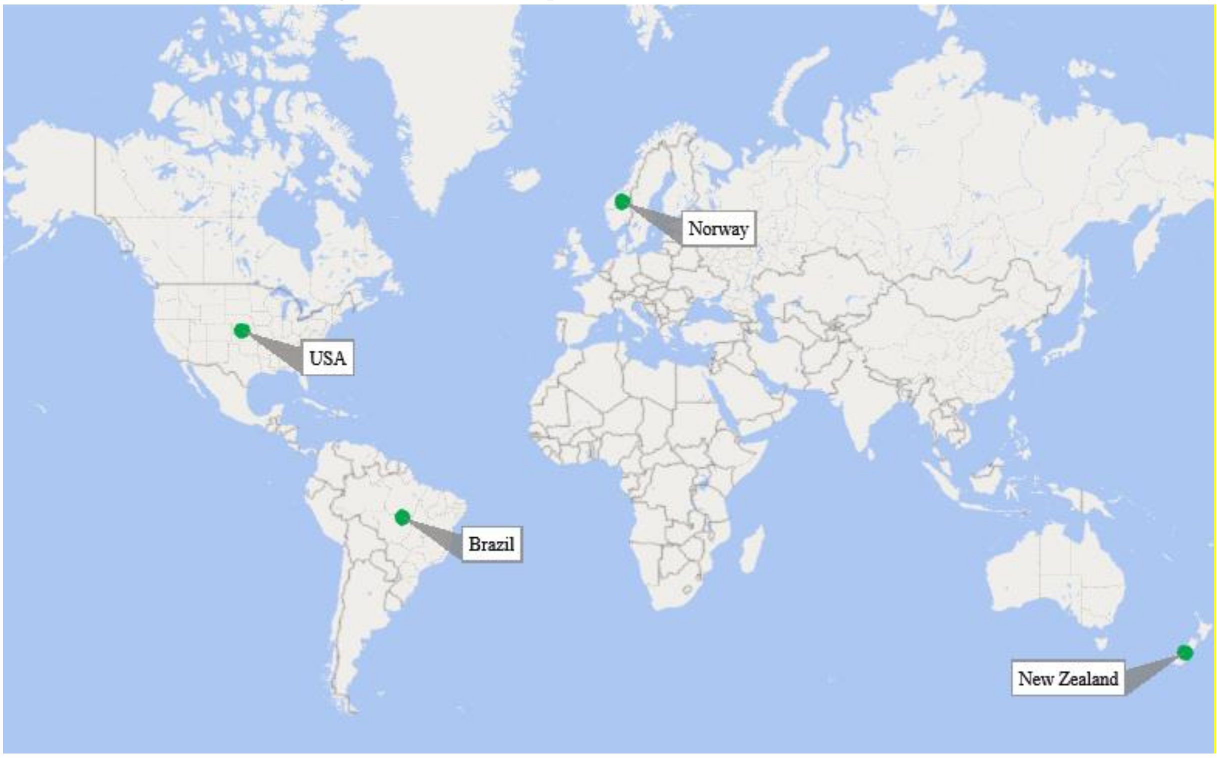
Fonte: Autores (2022)

The following procedure comprised the analysis of the articles selected for information, extraction, and discussion of the results.

3 RESULTS AND DISCUSSIONS

Figure 3 shows the geographic location of the 4 studies that were selected in the systematic review.

Figure 3: Location of publications on continents



Fonte: Autores (2022)

The systematic mapping of literature presented studies located in three continents, America, Europe, and Oceania. In the American continent, the research that presented technologies for the removal of “giardia and Cryptosporidium” in water supply systems that are currently used was carried out in the United States and Brazil. On the European continent, the study came from Norway, and the one from Oceania came from New Zealand.

A brief description on the technologies for removing "giardia and Cryptosporidium" in water supply systems that are currently used will be carried out, from the studies selected in the article, to demonstrate that there are several technologies that can be used, and the best alternative to be adopted will depend on an analysis of the characteristics of the raw water, the treatment station, the available resources, etc.

ROBERTSON et al (2021) explained that although Norway is among one of the richest nations in the world, on several occasions in recent decades there have been contamination of the drinking water supply, resulting in an outbreak of parasitic diseases and the need to implement boiling water recommendations. Most treatment stations have updated their treatments to be effective against parasites, such as "giardia and Cryptosporidium". Many treatment stations in the country currently have effective technologies for removing these parasites, within these, there is the use of disinfection by ultraviolet rays, coagulation / filtration and use of membranes in the filtration process.

ANDREOLI and SABOGAL-PAZ (2020) explains that water treatment is still a challenge for rural communities, so that untreated groundwater consumption is still common. The study developed slow sand filters with intermittent and continuous flow, followed by disinfection with sodium hypochlorite to treat groundwater with Escherichia coli, Giardia and Cryptosporidium. The weekly introduction of river water was tested as a filter ripening agent and this procedure provided a reduction in ripening time by approximately 80 days. The treatment performed with the use of disinfection of filtered water improved the quality of the water and inactivated the protozoa. The costs and simple operation of these filters are a alternative technology that can be used in rural communities around the world.

PECSON et al. (2017) used an advanced water treatment using ozone (O3), biological activated carbon (BAC), micro or ultrafiltration (MF/UF), reverse osmosis (RO) and an advanced UV-based oxidation process. This treatment was tested over a one-year period at the Pure Water Demonstration Facility located at the North City Water Recovery Plant (NCWRP) in San Diego, California. The treatment technology for direct portable reuse (DPR) has demonstrated reliable control of pathogens to meet or exceed the risk targets used by the US, WHO, Australia, and other countries. Therefore, by providing protection equal to or greater than conventional sources of drinking water, DPR should be considered a viable alternative to complement the existing water supply.

PHIRI et al. 2020 showed that while modern water treatment largely eliminates the potential risk of contaminated waterways, recent outbreaks of drinking water contamination in New Zealand demonstrate that water supply system managers need to consider land use management in watersheds, when protected with predominantly native vegetation, is certainly a strategy that is used effectively in countries such as New Zealand, Australia, and the United States, as they have limited agricultural intensity and the use of riparian vegetation has contributed to reducing pathogens in water courses.

A study that presents interesting information related to Giardia and Cryptosporidium will be discussed below.

GASSIE. et al. 2016 conducted a study in which he set up a net-zero water treatment facility, based on advanced oxidation, which served an apartment occupied by four people. The processes of the reported unit consisted of septic tank, membrane bioreactor (MBR), aluminum electrocoagulation (EC), flocculation, vacuum ultrafiltration, peroxone or UV-hydrogen peroxide advanced oxidation, chlorine disinfection, and point-of-use granular activated carbon (GAC) filtration. The water system was monitored, continuously or three times a day, for routine water quality parameters, minerals, Cryptosporidium, Giardia, etc. All 115 drinking water standards with the exception of bromate were met in this phase. Viruses and protozoa were not detected in the treated water, except for the measurement of copies of the adenovirus genome, which were attributed to the accumulation of inactive genetic material in hydraulic dead zones.

The other text that presents information related to the treatment of "giardia and Cryptosporidium" in water supply systems that are currently used will be presented below and although it is not in the research articles of the systematic review, it was selected because its content is relevant.

THE BASIC SANITATION RESEARCH PROGRAM et al. 1999, demonstrates that slow filtration has been used in water treatment since the early nineteenth century and has been shown to be an effective treatment system, when properly designed, for the correct situations. It is a treatment process that does not use coagulant, works with low filtration rates, and uses fine granulometry.

One of the advantages of this treatment is the high efficiency in the removal of bacteria, viruses, and cysts from giardia. Table 01 below, extracted from the research, "Treatment of water supply by filtration in multiple stages" of the Sanitation Program, shows the removal values presented by some authors.

Table 01: Removal of Microorganisms in slow filters according to several researchers

Microorganism	Percentage of removal (%)(*)	Author
Total Coliforms	> 99	Bellamy et al.(1985)
Virus (Poliovirus 1)	98,25-99,99	Poynter and Slade (1997)(**)
Giardia cysts	>98	Bellamy et al. (1985)
Cryptosporidium oocysts	>99,9	Timms et al. (1995)
Schistosoma Cercariae	100	Galvis et al. (1997)

(*) Values obtained in studies conducted on a pilot scale.
(**) apud Wheeler et al. (1988).

The efficiency of slow filters in removing microorganisms depends on the filtration rate (removal decreases with increased rate), temperature (higher temperatures result in higher removals), thickness of the filter medium, sizes of sand grains, etc. (PROSAB et al. 1999)

4 CONCLUSIONS

Water contamination by "giardia and Cryptosporidium" is a social and health problem that occurs worldwide in developed and developing countries. In view of this scenario, this article aimed to analyze the removal technologies of "giardia and Cryptosporidium" in water supply systems that are currently used, in the period from 2016 to 2021.

It was observed that there are technologies for the removal of giardia and Cryptosporidium, among which are cited advanced treatment processes alone and / or combined as coagulation / filtration, reverse osmosis, micro or ultrafiltration, advanced oxidation based on UV, etc. and simpler processes such as the use of slow filtration. The choice of the most appropriate treatment will depend on the characteristics of the raw water and the resources available for implantation and operation of the treatment.

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