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Scientific articles

Contaminación microbiológica en agua potable de localidades rurales en el municipio de Ahome, Sinaloa, México

Microbiological contamination in drinking water in rural locations in the municipality of Ahome, Sinaloa, Mexico

Contaminação microbiológica em água potável de localidades rurais do município de Ahome, Sinaloa, México

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Resumen

Las poblaciones rurales del municipio de Ahome, Sinaloa, presentan cierta prevalencia de enfermedades relacionadas con problemas gastrointestinales, razón que motivó la realización de este estudio, para determinar la calidad microbiológica del agua potable, como uno de los posibles factores diseminadores de patógenos. Se evaluó la calidad sanitaria del agua potable proveniente de la llave, mediante la detección de microorganismos indicadores (coliformes fecales termotolerantes) y la concentración de cloro, en 15 comunidades rurales en el municipio de Ahome, Sinaloa. Las bacterias coliformes fecales termotolerantes se aislaron y detectaron por el método de filtración por membrana. El 80 % de las comunidades rurales mostraron resultados positivos para coliformes fecales termotolerantes (1- 250 UFC mL^{-1}) en muestras de agua de la llave del patio, aunque no fue posible identificar a *Escherichia coli*. Con base en de los resultados, se evidencia la necesidad de contar con mecanismos de control de calidad y saneamiento del agua más eficientes en las zonas rurales consideradas en este estudio, ya que el proceso de cloración no es efectivo y, por lo tanto, es necesario que se intensifique la vigilancia en las redes de distribución de agua, para disminuir la incidencia de enfermedades relacionadas con patógenos en agua para consumo humano.

Palabras clave: agua potable; coliformes fecales; calidad de agua, población rural.

Abstract

The rural populations of the municipality of Ahome, Sinaloa, have a certain prevalence of diseases related to gastrointestinal problems, which is why this study was carried out to determine the microbiological quality of drinking water, as one of the possible factors that spread pathogens. The sanitary quality of drinking water from the tap was evaluated by detecting indicator microorganisms (thermotolerant fecal coliforms) and chlorine concentration in 15 rural communities in the municipality of Ahome, Sinaloa. Thermotolerant fecal coliform bacteria were isolated and detected by the membrane filtration method. 80% of rural communities showed positive results for thermotolerant fecal coliforms (1- 250 CFU mL-1) in patio tap water samples, although it was not possible to identify Escherichia coli. Based on the results, the need to have more efficient water quality control and sanitation mechanisms in the rural areas considered in this study is evident, since the chlorination process is not effective and, therefore, in It is necessary to intensify surveillance in water distribution networks to reduce the incidence of diseases related to pathogens in water for human consumption.

Keywords: drinking water; fecal coliforms; water quality, rural population.

Resumo

As populações rurais do município de Ahome, Sinaloa, apresentam certa prevalência de doenças relacionadas a problemas gastrointestinais, razão pela qual este estudo foi realizado para determinar a qualidade microbiológica da água potável, como um dos possíveis fatores de disseminação de patógenos. A qualidade sanitária da água potável da torneira foi avaliada através da detecção de microrganismos indicadores (coliformes fecais termotolerantes) e concentração de cloro em 15 comunidades rurais do município de Ahome, Sinaloa. Bactérias coliformes fecais termotolerantes foram isoladas e detectadas pelo método de filtração por membrana. 80% das comunidades rurais apresentaram resultados positivos para coliformes fecais termotolerantes (1-250 UFC mL-1) em amostras de água de torneira de pátio, embora não tenha sido possível identificar Escherichia coli. Com base nos resultados, fica evidente a necessidade de mecanismos mais eficientes de controle da qualidade da água e de saneamento nas áreas rurais consideradas neste estudo, uma vez que o processo de cloração não é eficaz e, portanto, é necessário intensificar a vigilância na distribuição de água redes para reduzir a incidência de doenças relacionadas com agentes patogénicos na água para consumo humano.

Palavras-chave: água potável; coliformes fecais; qualidade da água, população rural.

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Introduction

The UN World Water Development Report states that more than 2 billion people in the world do not have access to basic water and sanitation services, due to discrimination based on gender, religious belief or social status (UN, 2019). This organization recognizes that access to drinking water and sanitation is a human right that must be sufficient, healthy and acceptable, considering the most vulnerable and marginalized (WHO, 2022). Thus, access to water sources with adequate quality and availability for human supply is an issue of vital importance for both authorities and society in general (Fernández- Cirelli , 2012), since it is not replaceable by other natural means. It is a resource that abounds in nature and is what sustains all life on planet Earth (Fernández- Cirelli , 2012; Pedrozo, 2020). According to Contruvo *et al.* (2004) water for human consumption is considered an excellent vehicle for the dissemination of intestinal pathogenic microorganisms, so it is necessary to analyze and control water sanitation systems periodically in order to evaluate its parameters and thus, guarantee quality for human consumption. Drinking water is used for multiple domestic purposes, for personal hygiene, washing food and watering plants. Therefore, it is essential to guarantee the health and well-being of the population by monitoring this type of water, which helps reduce the spread of infectious diseases, both in humans and wildlife (Mora *et al* . , 2012).

The transmission of diseases such as cholera, dysentery, hepatitis A, typhoid fever and poliomyelitis are related to contaminated water and sanitation. If purification treatments are insufficient or managed inappropriately, the population will be exposed to health risks (WHO, 2022). In Mexico, enteric diseases are the fifth cause of mortality (3.18% of all deaths) in children under five years of age. In the central and northern states of the country, studies have been carried out on biological and chemical contamination of water in domestic water intakes and according to the results, fecal coliforms and fecal enterococci were present (Rodríguez *et al.* , 2020; Olivas *et al.* , 2013). On the other hand, the contamination of water bodies originates from the discharge of domestic and industrial waste without pretreatment, as well as from the lack of maintenance of sewage systems, which significantly influences the presence of microorganisms in the final drinking water (Larrea - Murrell). *et a l . , 2013* ; Venegas *et al* . , 2014). The effects on the health of the population are directly related to the consumption of water, which has not been carefully monitored and which generates alterations in the organoleptic, physical, chemical and microbiological characteristics. It is of great importance to identify the pathogenic and non-pathogenic microbial agents present in the water to define possible microbiological indicators of water quality, which are basically organisms that have a behavior similar to pathogenic microorganisms (Ríos-Tobón, 2017). To determine the microbiological quality of water, bacterial indicators of fecal contamination are used (Alba *et al.* , 2013; Mejía *et al.* , 2021) such as *Bacillus cereus , Clostridium botulinum and Listeria monocytogenes , Escherichia coli and Salmonella spp.* (Alba *et al* . , 2013).

In Mexico, there is legislation that regulates water purification systems for human consumption, which includes the determination of total coliform bacteria and *E. coli* or fecal coliforms, as well as the presence of thermotolerant organisms, in 100 mL water samples, said microorganisms must be absent in the water (NOM-127-SSA1-2021; NOM-179-SSA1-

2020). In the municipality of Ahome, fresh water supply sources are contaminated by the illegal discharge of wastewater, by animal excrement into water channels and by the use of wastewater for agricultural irrigation, causing contamination of irrigated soil that, by drag, reaches surface water currents, mainly during rainy seasons. In addition, when it filters, there is a risk of contaminating aquifers. For the above reasons, it was considered important to investigate some of the factors associated with the presence of pathogens in the municipality of Ahome, such as those legislated by the water quality standard (NOM-179-SSA-2020), particularly in the microbiological quality of water for domestic use in 15 rural communities in Ahome, Sinaloa. This in order to identify and quantify the presence of residual chlorine and determine the presence of thermotolerant fecal coliform bacteria as indicators of the sanitary quality of the water.

Materials and methods

The research work was carried out in the municipality of Ahome, in the north of the state of Sinaloa, from which 15 highly vulnerable rural localities were selected with a population of between 400 and 1,500 inhabitants, where water samples were obtained from home intakes and The bacteriological quality was evaluated. The rural populations sampled were Bachomobampo #1 (BA), Bachomobampo # 2 (BC), Flores Magón (FM), Jitzmuri (JI), Guacaporito (GU), Matacahui (MA), El Refugio (EF), Leyva Solano (LS), San Miguel (SM), Choacahui (CH), El Porvenir (EP), Macapul (MC), Bagojo (BG), March 18 (DM) and Las Brisas (LB) (Figure 1).

The study period ran from March to July 2023. A triplicate of 100 mL of water samples was taken for the detection of fecal coliforms and *Escherichia coli. coli* , the samples were taken in faucets located in the courtyard of the homes. The faucet mouth was disinfected with 96% alcohol and flamed, the faucet was opened and allowed to run for 3 minutes, then the samples were placed in sterile bacteriological bags brand Nasco ® (Figure 2). Once the samples were collected in the different communities, they were taken inside a polystyrene cooler and kept at a temperature between 4 and 8 °C , avoiding contamination, without exceeding more than 6 hours their transfer for analysis, in accordance with the provisions of NOM-230-SSA1-2002. The processing of the samples was carried out at the facilities of the Autonomous University of the West, Los Mochis Regional Unit . The measurement of chlorine in the samples was carried out *on site* before taking the water sample, using a residual chlorine test kit brand Pentair ®. For the determination of chlorine, a 0.13%

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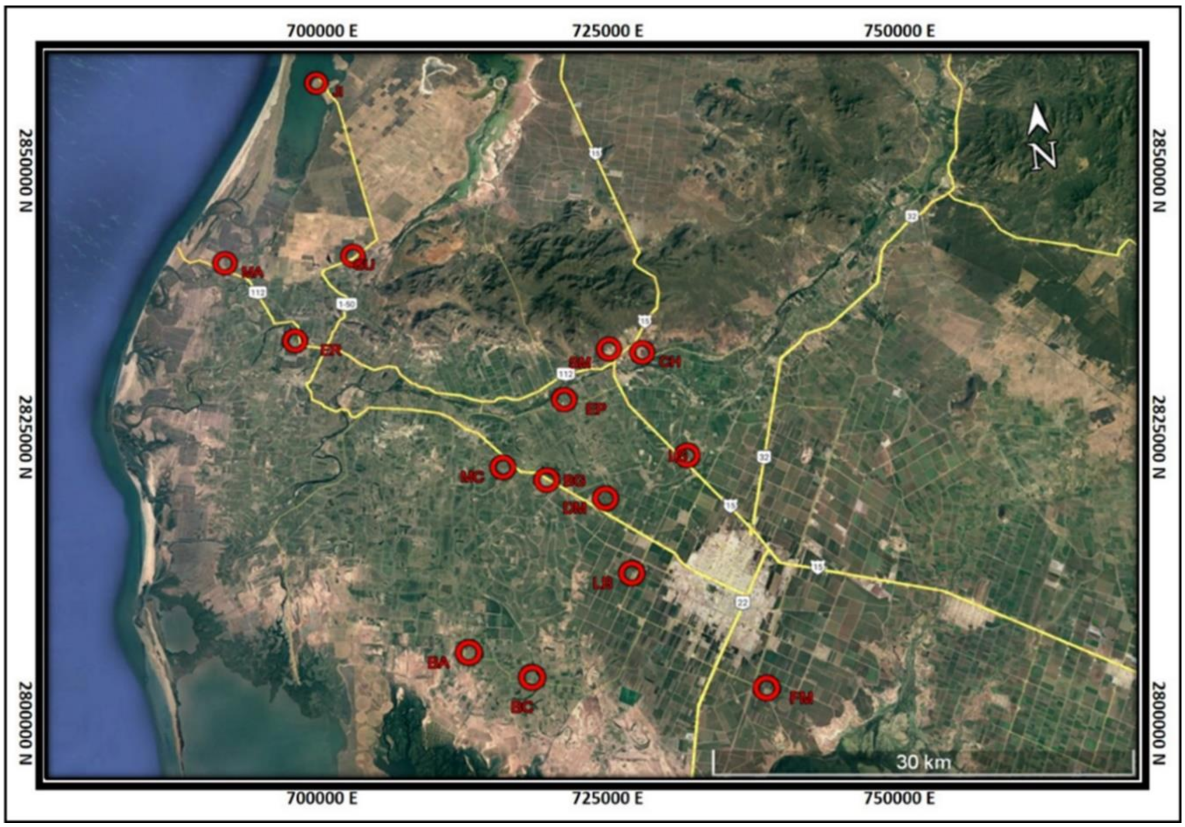
orthotolidine solution with 5.14% hydrochloric acid was used . The detection and counting of thermotolerant fecal coliform bacteria in the studied populations was carried out using a total of 45 samples in triplicate, in accordance with the provisions of NOM-230-SSA1-2002. Three samples were taken in each community. In all samples, residual chlorine was inactivated by adding 0.1 mL of 3% sodium thiosulfate.

Figure 1. Location of the rural populations sampled in the municipality of Ahome, Sinaloa, Bachomobampo 1 (BA), Bachomobampo 2 (BC), Flores Magón (FM), Jitzmuri (JI), Guacaporito (GU), Matacahui (MA), El Refugio (EF), Leyva Solano (LS), San Miguel (SM), Choacahui (CH), El Porvenir (EP), Macapul (MC), Bagojo (BG), March 18 (DM), and Las Brisas (LB) (Google Earth , 2023).



Source: Own elaboration

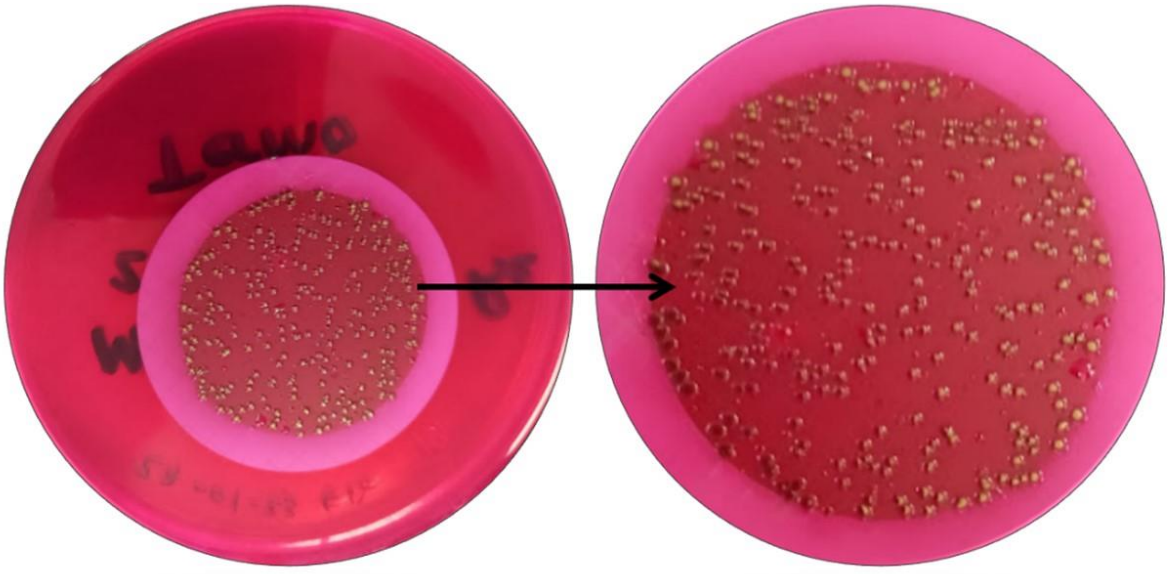
In the analysis of the samples, the membrane filtration method was used. For this, each 100 mL sample was passed through a sterile Millipore brand cellulose membrane filter, with a pore size of 0.45 µm and a diameter of 6 cm, with a grid, using a vacuum pump (Olivas *et al.*, 2013); The membrane was separated and placed in a Petri dish of the same diameter, with Agar Endo culture medium (Merck® brand) and incubated at a temperature of 44 ºC ± 0.5, for 24 to 48 hours in an incubator (Yamato® IC403CR).

Figure 2. Sampling of tap water in rural communities in the municipality of Ahome, Sinaloa.

Source: Own elaboration

After incubation, all dark red bacterial colonies with a metallic green sheen, belonging to thermotolerant fecal coliforms, were identified and quantified in a bacteria counter (Felisa® FE 500) (Figure 3). Bacterial colony counts were recorded for each site, and averages were obtained from the three samples analyzed for the rural community. The reference parameters to determine the microbiological quality that were used in this research are those established by the Mexican Official Standard NOM-127-SSA1-2021, Water for human use and consumption. Permissible limits of water quality.

Figure 3. Identification and quantification of dark red bacterial colonies with a metallic green sheen, belonging to thermotolerant fecal coliforms.

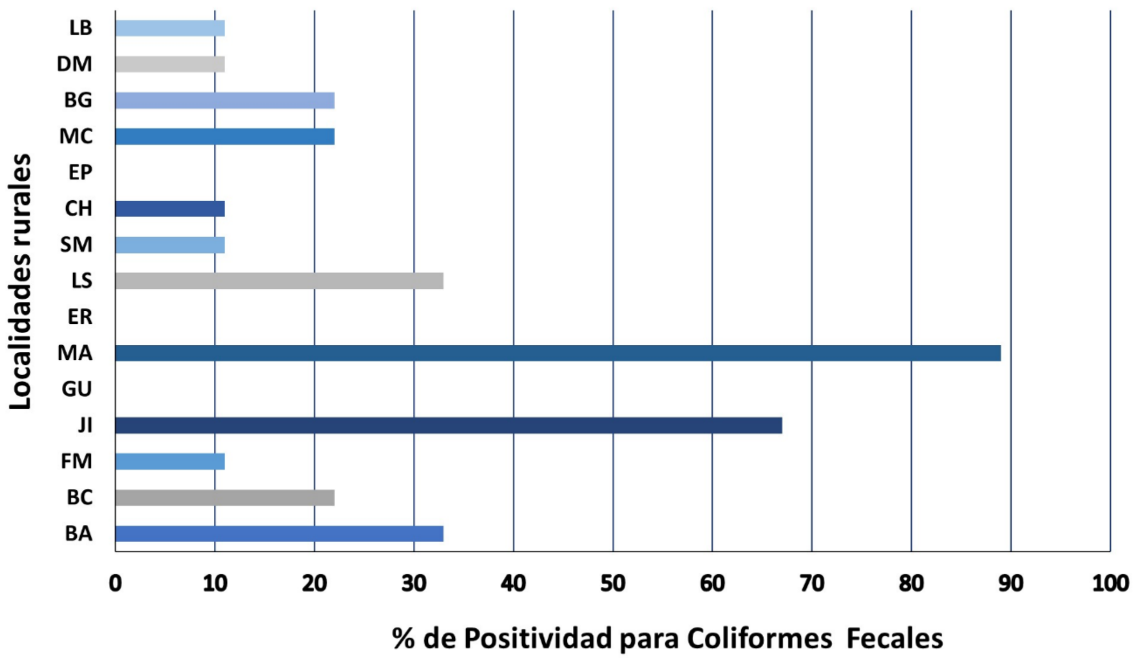


Source: Own elaboration

Results

80% of the rural populations sampled and analyzed presented positive results for the detection and counting of thermotolerant fecal coliforms, that is, in 12 of 15 ejido communities, and only in the towns of Guacaporito , El Refugio, and El Porvenir were there negative results for the detection of these microorganisms, which is attributable to the fact that water chlorination is more effective in these localities since it was greater than 1.0 mg L^{-1} . The average percentage of samples with positive results for thermotolerant microorganisms varied from 0 to 89% within each locality (Figure 4). Of the 135 total samples analyzed, 104 presented a negative result for thermotolerant fecal coliforms and the remaining 31 were positive. Of the total number of samples that tested positive, 24 samples were able to contain between 1 and 100 CFU/100 mL^{-1} , one had 132 CFU/100 mL^{-1} , and six were uncountable. Of the 31 samples that tested positive for thermotolerant fecal coliforms, 17 did not test positive for residual free chlorine, and in the remaining 14, residual free chlorine was quantified between 0.1 and 2.0 mg L^{-1} . In the 104 samples in which fecal coliforms were not identified, residual free chlorine could be quantified in 72 of them, with values ranging from 0.3 to 2.0 mg L^{-1} , while in the remaining 32 it was not detectable.

Figure 4. Percentage positivity for fecal coliforms in the populations sampled in the municipality of Ahome, Sinaloa, during March-June 2023. Bachomobampo # 1 (BA), Bachomobampo # 2 (BC), Flores Magón (FM), Jitzmuri (JI), Guacaporito (GU), Matacahui (MA), El Refugio (EF), Leyva Solano (LS), San Miguel (SM), Choa cahui (CH), El Porvenir (EP), Macapul (MC), Bagojo (BG), March 18 (DM) and Las Brisas (LB).



Source: Own elaboration

Discussion

The presence of thermotolerant fecal coliform bacteria in drinking water in rural communities in the municipality of Ahome, shows an alert for bacteriological contamination, without having identified its origin; the variation between 11% and 89% of the positivity percentage within the localities, is evidence that the contamination was not constant in the different sampling dates or in the different rural communities of Ahome. However, the existence of failures in the dosage of chlorine in rural drinking water systems was evident, in addition, lack of maintenance of storage tanks and the distribution network. The identification of thermotolerant fecal microorganisms in tap water is a health alert that must be addressed, for this it is necessary to improve the quality controls of drinking water, for this purpose it is necessary to increase health surveillance in the distribution networks of each community, improve the dosage of chlorination and train those responsible in municipal drinking water processes.

It is important to continue studies on the viability of coliform bacteria and the effectiveness of chlorine, since these are related to enteric diseases; Mexican water legislation indicates that the required residual chlorine dose must be between 0.2 to 1.5 mg L-1 to guarantee water health (NOM-179-SSA1-2020). However, the World Health Organization (WHO) mentions that the permissible limit of chlorine must be a minimum of 2 to 3 mg L-1, and a maximum of 5 mg L-1 (WHO, 2022; Fewtrell and Bartram, 2001; Cotruvo *et al.*, 2004). Considering the WHO residual chlorine levels, this criterion is not met in the municipality of Ahome. There is a latent risk that the presence of a pathogen present in the water infects the population of a region, reflecting the contamination of the environment of the same area, as may be the case in this case, due to the use of wastewater in agricultural irrigation, cattle excrement in water channels, use of latrines and septic tanks in the communities studied (Flores *et al.* , 2011).

Conclusions

In rural water treatment systems in the municipality of Ahome, Sinaloa, chlorination of domestic water is not effective in most of the studied localities, since it was detected that 80% of the populations presented contamination by thermotolerant fecal coliforms. It was not possible to identify *E. coli* in the water samples from the tap of rural homes, however, positive results were presented for thermotolerant fecal coliform bacteria, which indicates fecal contamination and little effectiveness in the chlorination carried out by the municipality **.** In both the water samples that presented positive and negative results, the residual chlorine was null or in lower quantities than that indicated by Mexican legislation and WHO. In the future, research should include the analysis of water samples from supply sources such as agricultural irrigation canals, to determine if the pathogens come from the aquifer or are contaminated during the distribution network in each community.

Further studies will help to determine the sources of the bacteria identified in this research, as well as to promote the dissemination of the results at different levels of government, especially at the municipal level, to demonstrate the need for the development and implementation of efficient measures in water purification systems for domestic use in rural populations. Municipal agencies must also ensure that their water purification systems comply with construction and operation regulations. In this way, any source of fecal contamination that could be affecting sanitation systems can be identified and the correction of the problem can be facilitated (NOM-003-CNA-1996; NOM-004-CNA-1996).

Future lines of research

The results shown in this research show the risk of the population to enteric diseases, due to microbiological contamination by thermotolerant fecal coliforms in drinking water in rural communities in the municipality of Ahome, Sinaloa. However, there were important aspects that were not included in this research that constitute future lines of research within this field of knowledge. Therefore, it is important to continue with studies that allow identifying the possible sources of water contamination, particularly with the distribution networks of drinking water in the communities and in the sources of supply, such as agricultural irrigation canals and wells based on the Mexican Official Standard NOM-179-SSA1-2020. In addition, carry out research regarding the training of the personnel responsible for rural water treatment plants to know the level of training to fulfill that function. In this way, the necessary corrective measures can be taken so that the population can have drinking water that meets the quality standards for consumption.

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