

Water stored in cisterns of vulnerable communities in the region of Mato Grande/Rio Grande do Norte: Quality analysis and proposals for viable social technologies.

Água armazenada em cisternas de comunidades vulneráveis da região do Mato Grande/Rio Grande do Norte: Análises de qualidade e propostas de tecnologias sociais viáveis.

Agua almacenada en cisternas en comunidades vulnerables de la región de Mato Grande/Rio Grande do Norte: Análisis de calidad y propuestas de tecnologías sociales viables.

Received: 05/05/2022 | Reviewed: 05/14/2022 | Accept: 05/20/2022 | Published: 05/26/2022

Leandro Silva Costa

ORCID: <https://orcid.org/0000-0002-9651-2048>

Federal Institution of Education, Science and Technology of Rio Grande do Norte, Brazil

E-mail: Leandro.costa@ifrn.edu.br

Saulo Gregory Carneiro Fonseca

ORCID: <https://orcid.org/0000-0002-3979-6099>

Federal Institution of Education, Science and Technology of Rio Grande do Norte, Brazil

E-mail: saulo.carneiro@ifrn.edu.br

Lorena Antunes Silva

ORCID: <https://orcid.org/0000-0001-5006-2160>

Federal Institution of Education, Science and Technology of Rio Grande do Norte, Brazil

E-mail: lorena.antunes.124@ufrn.edu.br

Leandro Constantino Silva

ORCID: <https://orcid.org/0000-0001-8470-2277>

Federal Institution of Education, Science and Technology of Rio Grande do Norte, Brazil

E-mail: leandro.constantino.125@ufrn.edu.br

Anderson Santos de Lima Silva

ORCID: <https://orcid.org/0000-0002-5957-3693>

Federal Institution of Education, Science and Technology of Rio Grande do Norte, Brazil

E-mail: andersonsadelisi9@gmail.com

Angelina Maria Lima Araújo

ORCID: <https://orcid.org/0000-0002-3095-7415>

Federal Institution of Education, Science and Technology of Rio Grande do Norte, Brazil

E-mail: angelina1999araujo@gmail.com

Abstract

This article aims to assess the quality of water stored in cisterns, particularly in houses in the Mato Grande Region, an area in Rio Grande do Norte, Brazil, which has benefited from social government programs. Firstly, a survey was applied to the local population to collect information about the stored water (origin, uses, and treatment methods performed). Subsequently, water samples were collected to perform microbiological analyses. The results show that water is primarily used for many purposes, including drinking. Also, all samples were contaminated by *Escherichia coli*, a fecal coliform bacterium responsible for many diseases and health problems. These findings suggest the urgent need for public policies and investment in technologies, education, and social development to prevent the proliferation of pathogens in the reservoirs. In addition, the article discusses the most viable alternatives to ensure potable water consumption in disadvantaged populations: the development and large-scale implementation of low-cost intervention methodologies, for example, Social Technologies (TS), that are currently discussed in Brazil by different sectors. Through these actions, a plausible solution is being demonstrated to assist with social needs and, as a result, allow the effective reduction of the social exclusion of individuals in complete alignment with the different pillars of sustainable development established by the United Nations Organization (UN).

Keywords: Cisterns; Water quality; Analyses; Social technologies.

Resumo

Este artigo visa avaliar a qualidade da água armazenada em cisternas, particularmente em casas na Região de Mato Grande, uma área no Rio Grande do Norte, Brasil, que tem se beneficiado de programas sociais governamentais. Em primeiro lugar, uma pesquisa foi aplicada à população local para coletar informações sobre a água armazenada (origem, usos e métodos de tratamento realizados). Em seguida, foram coletadas amostras de água para a realização de análises microbiológicas. Os resultados mostram que a água é usada principalmente para muitos fins, inclusive para beber. Além disso, todas as amostras foram contaminadas por *Escherichia coli*, uma bactéria fecal coliforme

responsável por muitas doenças e problemas de saúde. Estas descobertas sugerem a necessidade urgente de políticas públicas e investimento em tecnologias, educação e desenvolvimento social para prevenir a proliferação de patógenos nos reservatórios. Além disso, o artigo discute as alternativas mais viáveis para garantir o consumo de água potável em populações desfavorecidas: o desenvolvimento e implementação em larga escala de metodologias de intervenção de baixo custo, por exemplo, Tecnologias Sociais (TS), que são atualmente discutidas no Brasil por diferentes setores. Através destas ações, está sendo demonstrada uma solução plausível para auxiliar nas necessidades sociais e, como resultado, permitir a redução efetiva da exclusão social dos indivíduos em total alinhamento com os diferentes pilares do desenvolvimento sustentável estabelecidos pela Organização das Nações Unidas (ONU).

Palavras-chave: Cisternas; Qualidade da água; Análises; Tecnologias sociais.

Resumen

Este artículo tiene como objetivo evaluar la calidad del agua almacenada en cisternas, en particular en las casas de la región de Mato Grande, una zona de Rio Grande do Norte, Brasil, que se ha beneficiado de los programas sociales del gobierno. En primer lugar, se aplicó una consulta a la población local para recoger información sobre el agua almacenada (origen, usos y métodos de tratamiento realizados). Posteriormente, se recogieron muestras de agua para realizar análisis microbiológicos. Los resultados muestran que el agua se utiliza principalmente para muchos fines, incluido el de beber. Además, todas las muestras estaban contaminadas por *Escherichia coli*, una bacteria coliforme fecal responsable de muchas enfermedades y problemas de salud. Estos resultados sugieren la necesidad urgente de políticas públicas e inversión en tecnologías, educación y desarrollo social para prevenir la proliferación de patógenos en los depósitos. Además, el artículo discute las alternativas más viables para asegurar el consumo de agua potable en las poblaciones desfavorecidas: el desarrollo y la implementación a gran escala de metodologías de intervención de bajo costo, por ejemplo, las Tecnologías Sociales (TS), que actualmente se discuten en Brasil por diferentes sectores. A través de estas acciones, se está demostrando una solución plausible para ayudar a las necesidades sociales y, como resultado, permitir la reducción efectiva de la exclusión social de los individuos en completa alineación con los diferentes pilares del desarrollo sostenible establecidos por la Organización de las Naciones Unidas (ONU).

Palabras clave: Cisternas; Calidad del agua; Análisis; Tecnologías sociales.

1. Introduction

Water is a vital substance for the development of life on the planet. Indeed, a unique and essential natural asset to all aspects of human society, starting with ensuring the subsistence of biological, geological, and chemical cycles that promote stability to ecosystems. Also, water is a resource of symbolic and cultural value for various communities, such as a critical factor in producing goods in the industrial and agricultural sector and promoting health and social development (Gomes, 2011).

According to Nunes et al. (2009), although the vast volume of water found on the terrestrial planet, about 97% is in the oceans, as a salty liquid. In other words, most water resource is unsuitable for human consumption. Of the remaining 3%, more than half is concentrated in glaciers and icebergs, leaving only a fraction of less than 1% distributed in lakes, the atmosphere, and soils. Finally, less than 0.4% corresponds to water suitable for human consumption.

According to data from the Brazilian Ministry of the Environment (BME), despite this global scenario of the scarcity of potable water, the national territory occupies an advantageous position in terms of freshwater reserves, being one of the largest in the world, with more than one million and one hundred thousand square kilometers. However, its distribution is not regular in the whole country (Brazil, 2021). An example of this is that in the Brazilian Semi-arid Region, located in the country Northeast, the problem of water scarcity is still recurrent, as most rivers are intermittent; in other words, they remain dry for most of the year, and people do not have access to safe water (Victral et al., 2020; Araújo, 2011).

Due to these recurrent rainfall irregularities and insufficient access to safe water in Brazilian Semiarid, a kind of reservoir named cisterns is being largely used to capture, store and conserve rainwater. The cisterns are considered one of the most accessible and low-cost alternatives that governmental and non-governmental entities have found to provide water storage and consumption during dry periods (Rocha et al., 2021; Extender et al., 2016).

In the early 2000s, federal and private institutions financed several programs to implement cisterns in Brazilian rural areas for human consumption and agricultural purposes. The Articulation for the Brazilian Semi-arid (ASA, acronymous in

Portuguese), a network formed by more than three thousand civil society organizations, began, in 2000, to implement several partnerships aimed at building cisterns to capture rainwater for families living in the semi-arid region of Brazil. In this context, in 2003, the Federal Government implemented the One Million Cisterns Program (P1MC, acronymous in Portuguese), whose objective was the installation of 750,000 cisterns from July 2011 to December 2014. Of these total cisterns, 450,000 were concrete cisterns, and 300,000 were polyethylene cisterns, benefiting thousands of families.

Several studies have shown the positive impact of this policy of dissemination and construction of cisterns, especially the contribution to the quality of life and social inclusion of people living in situations of socioeconomic vulnerability. However, these approaches demand more extensive actions to monitor and ensure water quality intended for human consumption (Gomes, 2020; Gomes & Heller, 2016).

According to Amorim and Porto (2001), many factors affect the quality of rainwater collection and storage on cisterns, such as atmospheric pollution, type of reservoir, materials used in its construction, and inadequate cistern maintenance. Also, there are water quality problems related to transportation since tank trucks are widely used in Brazil, many without a guaranteed origin. This context generates an excellent purpose for society, government, and institutions to discuss and establish policies that ensure an adequate standard of water potability for safe consumption.

In this regard, several legislations have been enacted over the last few decades in Brazil to regulate the acceptable standards of quality and potability of water used for human consumption. These include law no. 518, of March 25, 2004, and No. 2.914, of December 12, 2011, published by the National Council for the Environment (CONAMA), and the law No. 888, of May 4, 2021, issued by the Brazilian Ministry of Health. This last one ensures in article 4 that "All water intended for human consumption from an individual alternative water supply solution is subject to water quality surveillance."

The concern with the regulation of procedures for control and surveillance of the water quality for human consumption and its potability standard is relevant. It appears as a matter of interest to public health since the inadequate treatment of this resource may lead to the manifestation of many waterborne diseases, such as diarrhea and intestinal parasites, which mainly affect children and the elderly, impacting the population's quality of life (Silva, 2012; Gomes, 2014).

Among the populations affected by this problem, the most damaged are those in a situation of socioeconomic vulnerability, such as the population of the Mato Grande region, an area located in the state of Rio Grande do Norte. The Mato Grande/RN region is frequently impacted by rainfall instability, water shortages, and the absence of public policies that collaborate with the regular water supply in the residences.

Due to these vulnerability conditions, the Mato Grande region was contemplated in the Water for All Program, a part of the P1MC program, whose objective was to guarantee a fundamental right for families residing in the Brazilian Semi-arid a quality drinking water (Brazil, 2011). As part of the activities foreseen in the Program, cisterns were built to supply water for subsistence activities. However, even recognizing the importance of this policy to guarantee the dignity of the local population, little has been done to ensure the quality of water for human consumption.

Therefore, concerned with public health and the quality of life of families that depend on this alternative mechanism of collecting and storing water for consumption, this work aims to contribute to this problem by proposing feasible solutions for the Brazilian Semi-arid context. Thus, the main objective is to assess the quality of water stored in cisterns, particularly in houses in the Mato Grande Region, an area in Rio Grande do Norte, Brazil, which has benefited from social government programs. In this regard, a survey was applied to the local population to collect information about the origin of the water supply and the alternatives used to manage the quality of water stored in cisterns in municipalities belonging to the Mato Grande/RN. Also, to investigate the microbiological conditions and possible contamination, water samples were collected and tested for fecal coliforms presence.

2. Methodology

According to Koche (2016), this research can be considered exploratory and descriptive because it sought a more comprehensive understanding of the problem presented and the consequent discussion for the proposal of appropriate solutions to solve the underlying issues. The approach adopted was quali-quantitative, whose research location was the Mato Grande region located in the semi-arid region of Rio Grande do Norte, Brazil.

2.1 Study area and municipalities mapping

The fifteen municipalities that comprise the Mato Grande/RN Region are Bento Fernandes, Caiçara do Norte, Ceará-Mirim, Jandaíra, João Câmara, Maxaranguape, Pedra Grande, Poço Branco, Pureza, Rio do Fogo, São Bento do Norte, São Miguel do Gostoso, Taipu, Touros and Parazinho. These cities are in the Northeastern Litoral microregion of the state of Rio Grande do Norte, Brazil.

Thus, aiming to select the municipalities for this study, a search was conducted on the towns that were benefited from the Water for All Program through the Ministry of National Integration website. This information was made available through a digital file, and according to it, of the fifteen municipalities from the Mato Grande region, only three were not benefited from the Program (Ceará-Mirim, Maxaranguape, and Rio do Fogo) and were immediately discarded for this study. Therefore, among these twelve cities covered by the Program were considered those with the highest levels of economic vulnerability and the lowest social development index. According to this criteria, three towns were selected for this study: Pureza, Taipu, and Poço Branco.

Pureza

According to IDEMA (2008), the town of Pureza/RN is located in the geographic coordinates Lat. 5° 28' 01" South and Long. 35° 33' 22" West, limited to the North with the municipality of Touros, to the East with Maxaranguape and Rio do Fogo, to the South with Taipu, Poço Branco and João Câmara and West with Touros and João Câmara. With an area of 504.3 km², equivalent to 0.96% of the state surface, and 9,451 inhabitants.

Taipu

The municipality of Taipu/RN, in turn, is in the geographic coordinates Lat. 5° 37' 18" South and Long. 35° 35' 48" West, limited to the North with the municipality of Pureza, to the East with São Gonçalo do Amarante, to the South with Ielmo Marinho and West with Poço Branco. It has an area of 352.82 km², equivalent to 0.66% of the state surface, and a population of 12,398 inhabitants (IDEMA, 2008).

Poço Branco

The municipality of Poço Branco/RN is in the geographic coordinates Lat. 5° 37' 22" South and Long. 35° 39' 46" West, limited to the North with the municipality of Pureza, to the East with Taipu, to the South with Bento Fernandes and West with João Câmara and Bento Fernandes. It covers an area of 230.37 km², equivalent to 0.44% of the state surface, and a population of 15,280 inhabitants.

2.2 Qualitative survey regarding water stored in cisterns

A survey was carried out in twenty-seven cisterns of the selected towns between 03/06/2018 and 03/07/2018. The objective of this action was to perform a descriptive study with a qualitative approach regarding the water stored in the

reservoirs of the districts belonging to Pureza, Poço Branco, and Taipu. Residents of all houses with cisterns were contacted. The heads of households or guardians were invited to participate in the project voluntarily. A semi-structured questionnaire was applied to those heads of families willing to contribute to the research. This questionnaire approached questions that sought to gather important information about the origin of the water stored in the cisterns, how to use this resource and if this undergoes some treatment to ensure its quality.

2.3. Quality analysis of the water collected

Water Samples collection

The water samples were collected in 27 cisterns, 9 in Pureza, 9 in Poço Branco, and 9 in Taipu. All samples were collected in triplicate. The collection of samples is one of the most relevant steps in water quality analysis. Because of this, it is essential that sampling be performed with prudence and technique to prevent any reasons that cause contamination.

The water samples were collected according to the guidelines of the “Practical Manual of Water Analysis” provided by FUNASA (Brazilian National Health Foundation), in which the materials to be used are highlighted, as well as the correct way to carry out the collection procedure. Sterile collection vials with a capacity of 60ml were used. And the process took place by washing hands with soap and water; collecting the water sample; filling it with at least 3/4 of its volume; capping the vial, identifying it, noting the address, time, and name of the owner; marking the vial with the sample number corresponding to the collection point; filling it in the water sample identification form; placing the sample vial in the Styrofoam box with ice; sealing, identifying and sending the box to the laboratory. The time of collection and completion of the examination did not exceed 24 hours (Brazil, 2013).

Microbiological parameters

The samples were collected in sterile 250ml glass vials containing 0.2 ml of sodium thiosulfate solution being transported in an isothermal container, with ice, to the Laboratory of the Federal Institute of Rio Grande do Norte – Macau Campus. Then, the samples were submitted to analyze the presence/absence of *Escherichia coli*. To proceed with the analysis, asepsis was first performed with 70% alcohol on the bench where the analyses were performed. And throughout the procedure, the Bunsen burner flame was lit for aseptic handling of the samples.

The method used for analysis was the chromogenic substrate. This method allows the simultaneous determination of total coliforms and the presence/absence of bacteria of the genus *Escherichia coli*. The procedure took place in two stages: The first stage called the presumptive test, occurred when 100 ml of the sample collected from the cisterns was inserted into a respective tube made up of lactose broth using the test tube. The tubes were incubated in an oven at 35°C for 24-48 hours, with a screening of the media that fermented, and as a result, they changed color. Therefore, this change in color in the tube indicates the presence of some bacteria in the coliform group and means that the presumptive test was positive, and the next stage should be followed. In case of a negative result of color change, the test result is considered negative.

In the confirmatory test's second stage, the tubes that came out positive for lactated broth were transported to the tubes composed of bright green bile lactose broth (C.L.V.B.B.) 2%. Soon after, the solutions were taken to the incubator, where they remained for 48 hours. This test makes it possible to confirm the presence of the *Escherichia coli* bacteria in the water samples from the formation of gas and change in color.

It is important to emphasize that the sensitivity of the tests considers the parameters established by the Ministry of Health. The water is classified as potable from the microbiological bias. At the same time, there are no total and thermotolerant coliforms (*Escherichia Coli*) in 100 ml of the drinking water sample. Fecal coliforms or thermotolerant coliforms are bacteria capable of developing and fermenting lactose with gas production at 44°C in 24 hours. The main species within this group is

Escherichia coli. *E. Coli* differs from other coliforms by having the enzymes β -galactosidase and β -glucuronidase.

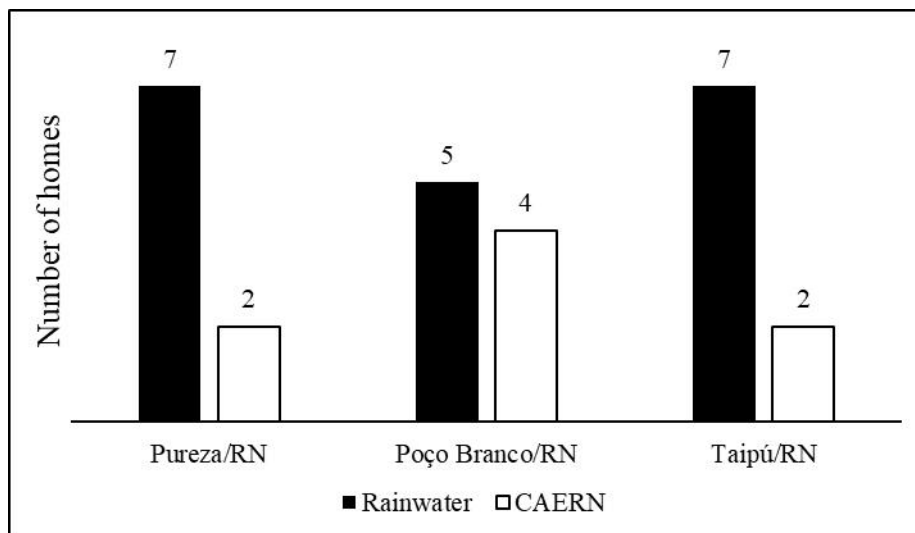
This microbiological assessment of water plays an essential role because of the variety of pathogenic microorganisms, mostly of fecal origin, present in water (Brazil, 2013).

According to the Practical Manual of FUNASA, the reason for choosing this group of bacteria as an indicator of water contamination is its presence in the feces of warm-blooded animals, including humans. So, fecal coliform presence in water directly relates to the degree of fecal contamination. Also, they are easily detectable and quantifiable by simple and economically viable techniques in any water; they have a longer lifespan in water than pathogenic intestinal bacteria, as they are less demanding in nutritional terms, in addition to being unable to multiply in the aquatic environment; are more resistant to the action of disinfecting agents than pathogenic germs.

3. Results and Discussion

During the visit to the communities of Pureza, Poço Branco, and Taipu and after invitations to the residents to participate in the research, twenty-seven homes were selected, nine from each chosen town. Then, the questionnaires were applied. According to the qualitative survey described in the methods section, the cisterns were supplied in two different manners, from Water and Sewage Company (named CAERN) and by the direct rainwater collection, as explained above in Figure 1.

Figure 1 - Ways of supplying the cisterns of Mato Grande/RN.



Source: Authors (2021).

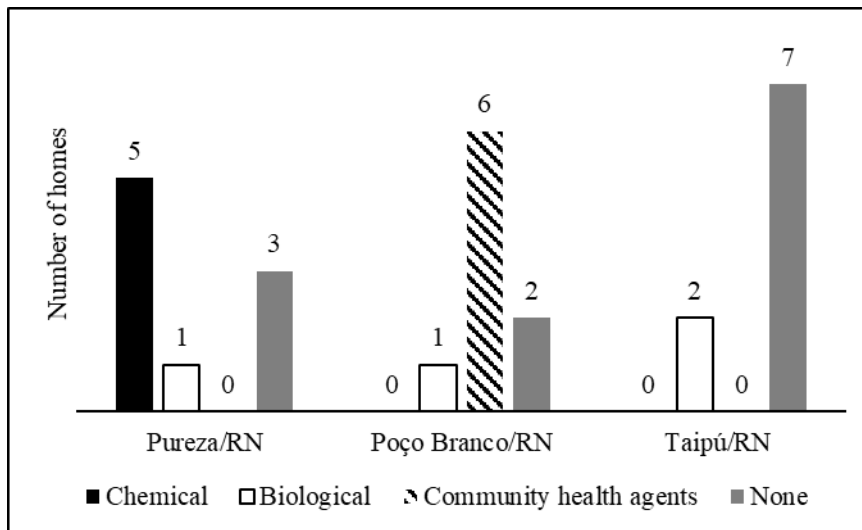
Most families in the study area benefited from rainwater, and this finding can be explained by the fact that the districts are located in areas close to the coast of the state of Rio Grande do Norte, where rainfall occurs preferentially in the summer and a period of the fall season (December to June). On the other hand, a few cisterns are supplied with potable water provided by CAERN. However, according to residents, due to these residences' historical irregular water supply throughout the year, all citizens have reported the necessity to store water to guarantee basic subsistence activities, especially in the drier months.

Regardless of the source, the water collected is stored for up to six months. This requires the population to be careful with the appropriate treatment and guarantee the quality of the water they consume. According to the information collected, most cisterns did not undergo any treatment or control, while in other homes, at least one form of chemical or biological control was used (Figure 2). This high number of cisterns in which no treatment is performed is a highly worrying reality. It

exposes the need to establish intervention priorities by the government.

For those cisterns in which residents reported performing some chemical treatment, sulfur appears to be the primary chemical mechanism used for water purification, especially those in cisterns supplied with rainwater. Interestingly, the use of sulfur in cisterns is concentrated in the municipality of Pureza/RN. The resident population reported that it is a hereditary practice and that there is no prior guidance from a healthcare professional.

Figure 2 – Water treatment methods performed in cisterns of Mato Grande/RN.



Source: Authors (2021).

Despite this population's indiscriminate use of sulfur without any scientific proof, it is essential to highlight that this method has a reasonable basis. This chemical element reduces the nitrate concentration in water as it is a strong oxidant that allows the decomposition of biochemical and organic agents present. However, although sulfur itself is not harmful to health when within safe limits, the association of sulfur with hydrogen sulfide (H₂S), generated in an anaerobic environment (when there is no oxygen), and highly polluted reservoirs, causes several harmful effects on the human body. The products of this reaction affect the respiratory and ocular mucous membranes causing severe irritation and compromising the individual's health (Valadares et al., 2013). Therefore, more regular monitoring of these actions by the government and public institutions is vital.

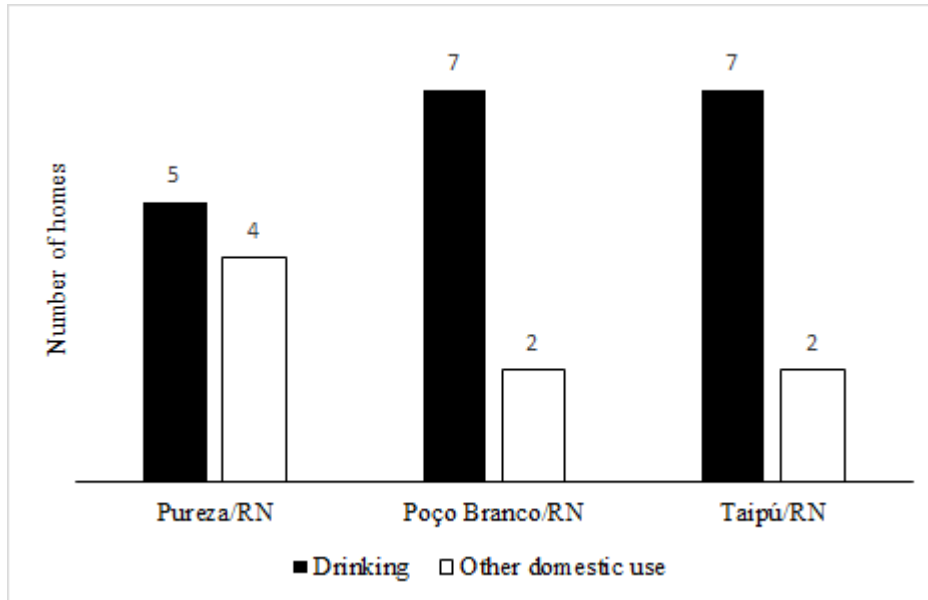
Still, in all municipalities, the use of piaba (*Astyanax Bimaculatus*) was observed, as it is a larval-eating fish. According to the residents, this treatment practice is intended to restrict the proliferation of larvae in the cisterns. In most of these reservoirs, there is no concern about sealing all the existing passages, thus allowing the entry of insects. An example is the *Aedes aegypti* mosquito, which transmits dengue. In addition, although Poço Branco is the only city that has visits from Community Health Agents, they do not visit monthly. According to residents, the last time these professionals visited their homes to treat the water and clean the cistern was about four months ago.

Regarding the utilities attributed to water in the studied residences, as shown in Figure 3, some families reported that the water is mainly used for basic human subsistence tasks such as cooking, bathing, washing dishes, and clothes. However, the most alarming fact is that most of the population uses water to drink, which makes them more exposed to contamination by microorganisms and, consequently, to several diseases that cause damage to their health. Also, it is essential to point out that according to the population, even the cisterns supplied by water from CAERN have a rancid taste for being extremely chlorinated. This condition causes a change in the routine of the residents, who, despite their economic vulnerability, are still

obliged to pay money to purchase mineral water for drinking.

Once again, the results highlight the absence of the government and the urgency to move forward with implementing public policies and participatory education actions for the members of the communities involved to monitor and ensure the quality of the water consumed by the local population.

Figure 3 – Main utilities attributed to water stored in cisterns of Mato Grande/RN.



Source: Authors (2021).

3.1 Microbiological analysis

Concerning microbiological analyses, in Brazil, according to the Ministry of Health, water is potable when total and thermotolerant coliforms (*Escherichia Coli*) in 100 ml of water sample for consumption are absent.

However, terrifyingly, in all samples from the municipalities where the microbiological analyses were carried out, total coliforms and *Escherichia Coli* bacteria were confirmed through presumptive and confirmatory tests, respectively, where the color change and gas formation were visualized.

This situation could be easily explained and was expected. According to the qualitative survey carried out in this study, most cisterns are supplied by rainwater. Pathogens in the water also occur due to the increase of warm-blooded animals' excrement (birds and mammals) and waste that is led into the cistern through the "spouts." (Amaral et al., 2003). Also, no periodic cleaning is carried out on the roof. The same occurs for the channel that takes the water from the roof to the interior of the reservoir. In addition, regarding the forms of treatment, there are many cisterns where no type of treatment is carried out aiming at water quality in all districts.

Therefore, this combination of factors contributes to the extensive existence of water contamination and, consequently, the worsening of health problems. So, it is essential to focus on several measures such as sealing the reservoirs and periodic cleaning to ensure that the water is free from pathogenic microorganisms.

Interestingly, the cisterns supplied by CAERN also presented irregular microbiological parameters. This situation can be explained because the local companies have not treated this water according to the established standards. Hence, this water is not always safe, thus increasing the probability of people contracting waterborne diseases, which, besides the health issue, brings some social and economic problems (Santana, 2012).

3.2 Social technologies and possible solutions to ensure cistern water quality standards

Recognizing that access to potable water is a fundamental right for the whole exercise of life and that only a portion of this resource is available for human consumption, several institutions and researchers have been debating and establishing the responsibilities of different sectors of society in the regulation and implementation of public policies aimed at ensuring universal access to this resource (Soares & Signor, 2021; Lima & Granziera, 2018).

Within this context, the United Nations, in its General Assembly on July 28, 2010, recognized access to clean and safe water as a fundamental human right (Resolution no. 64/292). In September 2015, among the Sustainable Development Goals (SDGs), established in article 6, the "commitment to ensuring the availability and sustainable management of water and sanitation for everyone in an equitable manner" (General Assembly UN, 2015). Thus, attributing greater responsibility to governments in promoting policies that improve the quality of life for people under susceptible socioeconomic circumstances.

Accordingly, and due to the worrying data presented in this work regarding the quality of water consumed by the studied population, this section seeks to offer viable solutions and strategies committed to guaranteeing the quality of the water consumed and, consequently, to protecting the health of the local population, emphasizing studies aimed at the development of low-cost and quickly disseminated technologies.

Thus, within the observed reality in which the residents live, the absence of permanent policies for the water supply, and no control and surveillance of the quality of this resource, some essential measures are envisaged to be exercised. Among these, public institutions and governments must assume their responsibilities in guaranteeing the population's right to access water. This guarantee must be provided by implementing and strengthening policies to control and monitor water quality in cisterns through Community Health Agents. In addition, it should ensure the engagement and effective participation of the population, especially the most disadvantaged, in the planning and management of this common good (Dagnino, 2014; Estender et al., 2016; Gomes, 2016).

We understand here that science and research institutions must be active in identifying the population's needs and point out possible solutions to the problems found, assisting in educational activities, and encouraging the participation of local communities in this debate. But the most significantly responsible for recognizing inequalities in access to potable water and developing policies for its resolution is the government. Supporting the understanding of the intrinsic role of the government in facing this problem and guaranteeing the human dignity of its population, some authors have been bringing important arguments and theoretical foundations to the discussion. It is recognized that public entities must establish access to clean and safe water as a management priority (Dagnino, 2016).

The focus must be on the equal and permanent supply of water to the population, the investment in studies to develop water treatment and reuse technologies, the development of policies for control and surveillance of water quality and education, and the awareness and population engagement.

In addition to the urgent and necessary presence of the state in the communities studied, one of the most viable alternatives to guarantee the consumption of clean and safe water is the development and large-scale implementation of low-cost intervention methodologies. For example, different sectors currently discuss Social Technologies (TS) in Brazil (Social Technology Institute ITS, 2004).

A plausible solution is being demonstrated to assist social needs through these actions. These technologies can be understood as a set of techniques, transforming methodologies, developed and applied in interaction with the population and appropriated by it, representing solutions for social inclusion and improvement of living conditions (Social Technology Institute ITS, 2004). TS arises in a context where social institutions are concerned with the progressive socioeconomic inequality and the current segregationist policy regarding science and technology in the country, leading to a propensity to create opportunities for the privatization of knowledge (Dagnino, 2014).

In addition, these Social Technologies are, for the most part, directed towards the production of a collective rather than a marketing nature, in line with the numerous socioeconomic scenarios that encompass society, intending to provide conniving resolutions to the problems of each location (Dagnino, 2014).

In this context, plate cisterns are successful examples of Social Technologies that make up the actions of public policies for human supply, mitigating the effects of drought in the semi-arid region, especially in the areas affected by the socioeconomic vulnerability of the Mato Grande/RN Region.

However, as already justified, there is currently an emerging need for methodologies that provide safety standards for the population that consumes the water stored in these reservoirs. Above all are low-cost technologies, simple to apply and that the people of interest can appropriate their knowledge.

Therefore, numerous proposals emphasize this concept and can be easily reproduced in the communities studied when resorting to the literature. For example, in 2017, the Federal University of Pernambuco developed an automatic device called DesviUFPE (UFPE). The production material is accessible, consisting of PVC pipes connected to PVC chutes and the pipe through which the water will travel to the cistern. The purpose is to promote the diversion of the first rainwater so that the impurities coming through the roof and chutes present in the water do not enter the cisterns (Araújo, 2017).

The clay filter, an old water treatment practice, also stands out. This technology has proven efficient in filtering solid materials, reducing the incidence of pathogens, and purifying water used for human consumption. The operating principle is based on gravity. Water passes through a candle containing an outer layer of porous ceramic on its upper part and substrates of charcoal and colloidal silver, products with bactericidal potential, on its lower part.

Another exciting technology is the SODIS (Solar Water Purification) technique, developed at the State University of Campinas (UNICAMP) and uses solar energy to disinfect water. The product uses an available natural resource, the sun. It is perfectly applicable in vulnerable regions regarding infrastructure and financial resources. It is unnecessary to dose chemical products, and there is no cost as discarded commercial materials can be reused, such as clear PET bottles and black ink. The tests proved the efficiency of the technology in terms of inactivating bacteria, viruses, algae, fungi, and protozoa.

In the meantime, based on the results obtained from the microbiological analysis and concerned with the population's public health, the research group that this work is part of has proposed the development of a Social Technology called a "sustainable ozone generator." This project is under development, considering that some variables must be improved, for example, the time in the ozonation process and the amount of ozone generated. However, preliminary tests (data not yet published) have confirmed the generator's efficiency in producing ozone gas, an oxidative substance with high bactericidal potential and widely used in water purification and the elimination of E.coli. Even more important is that this device can be produced using easily accessible and low added value electronic scrap (with a total value of approximately US\$ 5.00). Also, it is accessible for large-scale application in the treatment of water from cisterns found in housing in vulnerable regions and with few financial resources.

It is noticeable that these technologies represent a considerable advance in the country, both through the organizations that implement them, aiming at the propagation of concepts and practices and the capacity to build these through popular initiatives and their reapplication throughout the national territory. Following this reasoning, the actions mentioned above are intended to prevent the proliferation of pathogenic agents in the water that may endanger the family health that inhabit the communities under study. Considering that the residents of the Mato Grande/RN Region use this water for drinking and cooking, it is essential to highlight that the presence of E. Coli causes diseases such as diarrhea, hepatitis A, typhoid, paratyphoid fever, cholera, and parasites. In other words, it is causing a severe public health problem that directly affects these populations that live at the mercy of socioeconomic vulnerability. It is also worth noting that implementing at least one of these technologies in Mato Grande/RN communities would be fundamental as a public policy to face cistern water contamination by

fecal coliforms and reduce health and social problems. Finally, it could ensure the role of the government in guaranteeing sustainable management and universal access to water and sanitation for all in an equitable manner and contributing to the global reach of the UN sustainable development goals, particularly the goals 3 (Health and welfare), 6 (Potable water and sanitation) and 10 (reduction of inequalities).

4. Final Considerations

From all the above, it is evident that there is a lack of guidance on the conservation and correct management of water, especially in socially vulnerable communities in the northeastern semi-arid region that historically coexist with severe problems of access to safe water. The government must develop more effective water management policies committed to the search for a fairer distribution of resources, thus promoting the improvement of the human conditions of its beneficiaries and social inclusion.

In addition, guaranteeing decent access to safe water also involves respect for cultural diversity and recognizing the people involved as social actors and political subjects who must have appropriate knowledge on this issue. It would create a demand for education and awareness-raising proposals to guarantee people's effective participation in the planning and execution of public policies.

Moreover, specifically for the communities studied in the municipalities of Pureza, Poço Branco, and Taipu, it is imperative to propose policies that guarantee access to potable water while preventing the proliferation of pathogens in the reservoirs. However, more than methods that help in prevention, frequent monitoring of the government and public institutions is essential, based on Community Health Agents within communities and performing routine microbiological analyses to guarantee the quality of water consumed by the population.

Finally, it seems imperative for the governments and non-governmental organizations to invest in public policies to guarantee the population's right to potable water. Also, researchers and universities should contribute to the development, adaptation, and implementation of low-cost social technologies to solve the local problems and needs of these most vulnerable populations. Thus, we can consider that these presented measures and the appropriate involvement of the society in this debate can effectively reduce social exclusion and inequalities in complete alignment with the pillars established by the United Nations (UN).

References

- Água no mundo. Agência Nacional de Águas e Saneamento Básico (ANA). <https://www.gov.br/ana/pt-br/acao-a-informacao/acoes-e-programas/cooperacao-internacional/agua-no-mundo>
- Amaral, L. A., Nader Filho, A., Rossi Junior, O. D., Ferreira, F. L. A., & Barros, L. S. S. (2003). Água de consumo humano como fator de risco à saúde em propriedades rurais. *Revista de saúde pública*, 37(4), 510–514. <https://doi.org/10.1590/s0034-89102003000400017>
- Amorim, M. C. C.; & Porto, E. R. (2001) Avaliação da Qualidade Bacteriológica das Águas de Cisternas: Estudo de Caso no Município de Petrolina -PE. Anais do 3º Simpósio Brasileiro de Captação de Água de Chuva no Semi-Árido.
- Araújo, L. F. (2017). DESVIUFPE como barreira sanitária para melhoria da qualidade de água de chuva em zona rural: Determinação de deposição seca e melhoria de desempenho. 2017. 74 f. Dissertação (Mestrado) - Curso de Engenharia Civil, Universidade Federal de Pernambuco, Caruaru. <https://www.ufpe.br/documents/39810/1355139/Luttemberg.pdf/e9e6c342-907f-48bd-86c5-677d92e0fcca>
- Araújo, S.M.S. (2011). A região semiárida do Nordeste do Brasil: Questões Ambientais e Possibilidades de uso Sustentável dos Recursos. *Rios Eletrônica - Revista Científica da FASETE*, 5(5), 89–98. https://www.unirios.edu.br/revistarios/media/revistas/2011/5/a_regiao_semiarida_do_nordeste_do_brasil.pdf
- Brazil. (2011). Conselho Nacional de Meio Ambiente. Portaria nº 2.914, de 12 de dezembro de 2011 [National Environment Council. Ordinance No. 2,914, of December 12, 2011]. Brasília, 2011. https://bvsmms.saude.gov.br/bvs/saudelegis/gm/2011/prt2914_12_12_2011.html
- Brazil. (2011). Ministério do Desenvolvimento Social. Decreto 7535 de 26 de julho de 2011. http://www.planalto.gov.br/ccivil_03/_ato2011-2014/2011/decreto/d7535.htm

- Brazil. (2013). Fundação Nacional de Saúde. Manual prático de análise de água / Fundação Nacional de Saúde (4a ed.), Funasa. 150 p. http://www.funasa.gov.br/site/wp-content/files_mf/manual_pratico_de_analise_de_agua_2.pdf.
- Brazil. (2021). Portaria nº 888, de 04 de maio de 2021. <https://www.in.gov.br/en/web/dou/-/portaria-gm/ms-n-888-de-4-de-maio-de-2021-318461562>
- Dagnino, R. (2014). Mais insumos metodológicos para a análise, a pesquisa e o desenvolvimento de Tecnologia Social. In *Tecnologia Social: contribuições conceituais e metodológicas* (p. 153–184). EDUEPB.] EDUEPB.
- Estender, A. C., Volpi, A. Botta, G. M. S., & D'elia, R. (2016). A construção de cisternas como elemento de desenvolvimento sustentável: o caso de Exu/PE. *Encontro Internacional Sobre Gestão Empresarial e Meio Ambiente*, 1-15. <http://engemausp.submissao.com.br/18/anais/arquivos/183.pdf>
- General Assembly UN. (2015). "Sustainable Development Goals (SDGs)." New York. <http://www.un.org/en/universal-declaration-human-rights/>
- Gomes, F. D. C. (2020). Study of physical-chemical characteristics and water quality with a well sample and a cistern sample. *Research, Society and Development*, 9(6), e17963227. <https://doi.org/10.33448/rsd-v9i6.3227>.
- Gomes, M. A. F. (2012). Água: sem ela seremos o planeta Marte de amanhã. <https://www.infoteca.cnptia.embrapa.br/handle/doc/921047>.
- Gomes, U. A. F., & Heller, L. (2016). Acesso à água proporcionado pelo Programa de Formação e Mobilização Social para Convivência com o Semiárido: Um Milhão de Cisternas Rurais: combate à seca ou ruptura da vulnerabilidade? *Engenharia sanitária e ambiental*, 21(3), 623–633. <https://doi.org/10.1590/s1413-41522016128417>
- Gomes, U., Domènech, L., Pena, J., Heller, L., & Palmier, L. (2014). A Captação de Água de Chuva no Brasil: Novos Aportes a Partir de um Olhar Internacional. *RBRH*, 19(1), 7–16. <https://doi.org/10.21168/rbrh.v19n1.p7-16>
- IDEMA. (2008). Instituto de Desenvolvimento Econômico e Meio Ambiente do Rio Grande do Norte, Perfil do Município. <http://www.idema.rn.gov.br/Conteudo.asp?TRAN=PASTAC&TARG=875&ACT=&PAGE=&PARM=&LBL>
- Köche, J. C. (2016). Fundamentos de metodologia científica. Editora Vozes.
- Lima, M. I. L. S. D., & Granziera, M. L. M. (2019). Direito humano à água e a perspectiva econômica para a sustentabilidade hídrica. *Revista do Conselho Nacional do Ministério Público*, 7, 13–36. <https://doi.org/10.36662/revistadocnmp.i7.100>
- Nunes, L., Fernandes, J., Cardoso, J., Parente, J., Almeida, & P., Bettencourt, T. (2009). Disponibilidade de água doce no planeta: Existe água doce suficiente para satisfazer as necessidades do planeta? Trabalho de Graduação (Graduação em Engenharia) – Faculdade de Engenharia Universidade do Porto, FEUP [Graduation Work (Graduate in Engineering) – Engineering University, Universidade do Porto, FEUP]. Portugal. <https://docplayer.com.br/4064318-Disponibilidade-de-agua-doce-no-planeta-existe-agua-doce-suficiente-para-satisfazer-as-necessidades-do-planeta.html>
- Rocha, G. A. da, Malaquias, J. D. F., Cardoso, W. M., Moura, R. W. M. D., & Monte-Mor, R. C. D. A. (2021). Importância da formação e preservação das tecnologias sociais de captação e armazenamento de água de chuva para as famílias do sertão e para os biomas do semiárido. *Revista Multidisciplinar De Educação E Meio Ambiente*, 2(3), 89. <https://doi.org/10.51189/rema/1773>
- Santana, J. (2012). Qualidade da Água das Escolas Municipais de Igarassu - PE. 2012. 22 f. Monografia (Especialização) – Fundação Oswaldo Cruz, Especialização em Gestão de Sistemas e Serviços de Saúde [Monograph (Specialization) – Fundação Oswaldo Cruz, Specialization in Health Systems and Services Management]. <http://bases.bireme.br/cgi-bin/wxislind.exe/iah/online/?IsisScript=iah/iah.xis&src=google&base=LILACS&lang=p&nextAction=lnk&exprSearch=720657&indexSearch=ID>
- Silva, C. V. da, Heller, L., & Carneiro, M. (2012). Cisternas para armazenamento de água de chuva e efeito na diarreia infantil: um estudo na área rural do semiárido de Minas Gerais. *Engenharia sanitária e ambiental*, 17(4), 393–400. <https://doi.org/10.1590/s1413-41522012000400006>
- Soares, S. C., & Signor, A. (2021). How much Water an asset for all: Interfaces development and sustainability. *Research, Society and Development*, 10(9), e1310917728. <https://doi.org/10.33448/rsd-v10i9.17728>.
- Social Technology Institute ITS (2004). "Social technology in Brazil." São Paulo. <http://itsbrasil.org.br/conheca/tecnologia-social/>
- Valadares, M. C., Oliveira, D. F. L., Sousa, P.S., & Sales, J. M. (2013). As reações do elemento enxofre no organismo humano. In: Congresso Brasileiro de Química – CBQ, 53, 2013, Rio de Janeiro, RJ. Anais (on-line) Rio de Janeiro: ABQ, 2013. <http://www.abq.org.br/cbq/2013/trabalhos/6/3613-15382.html> Put space between one reference and another.
- Victral, D. M., Grossi, L. B., Ramos, A. M., & Gontijo, H. M. (2020). Economic sustainability of water supply public policy in Brazil semiarid regions. *Research, Society and Development*, 9(6), e65963435. <https://doi.org/10.33448/rsd-v9i6.3435>.