REVIEW
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Quality of water for human consumption in Brazil: Integrative literature review

Qualidade da água para consumo humano no Brasil: revisão integrativa da literatura

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ABSTRACT

Introduction: Access to water in sufficient quantity and quality, compatible with the potability standard established in the legislation, is a fundamental human right. The lack of universal access, as well as basic sanitation, generates social and economic impacts. **Objective:** To identify in the scientific literature what has been shown about the quality of water intended for human consumption, distributed collectively in Brazil. **Method:** Integrative literature review carried out with 28 studies selected from the Virtual Health Library (VHL) and Portal of Journals of the Coordination for the Improvement of Higher Education Personnel (CAPES) from August to September 2019. Results presented descriptively and in the form of tables and figures. **Results:** Two categories were obtained: 1. Environmental factors that interfere in the water quality - nonconformities as to what was recommended were related to anthropic actions in the environment; 2. Water quality regarding to potability standard and surveillance - there were similarities between microbiological parameters, fluoridation, turbidity. **Conclusions:** Few studies have been found on surveillance of the water quality intended for human consumption, especially with an approach to action in Brazilian states and municipalities and these reflect difficulties in complying with some parameters recommended by the legislation regarding water quality.

KEYWORDS: Water Supply; Water Quality; Public Health Surveillance

RESUMO

Introdução: O acesso à água em quantidade e qualidade suficientes, compatíveis com o padrão de potabilidade estabelecido na legislação é um direito humano fundamental. A carência de universalização desse acesso, bem como de saneamento básico gera impactos sociais e econômicos. **Objetivo:** Identificar na literatura científica o que tem sido evidenciado sobre qualidade da água destinada ao consumo humano, distribuída coletivamente no Brasil. **Método:** Revisão integrativa da literatura realizada com 28 estudos selecionados na Biblioteca Virtual em Saúde (BVS) e Portal de Periódicos da Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES) no período de agosto a setembro de 2019. Resultados apresentados descritivamente e apresentados em forma de tabelas e figuras. **Resultados:** Foram obtidas duas categorias: 1. Fatores ambientais que interferem na qualidade da água - inconformidades quanto ao preconizado se relacionaram às ações antrópicas no meio ambiente; 2. Qualidade da água quanto ao padrão de potabilidade e vigilância - houve semelhanças entre os parâmetros microbiológicos, fluoretação e turbidez. **Conclusões:** Foram encontrados poucos estudos sobre vigilância da qualidade da água destinada ao consumo humano, especialmente com abordagem sobre atuação nos estados e municípios brasileiros e estes refletem dificuldades no cumprimento de alguns parâmetros recomendados pela legislação referente a qualidade da água.

PALAVRAS-CHAVE: Abastecimento de Água; Qualidade da Água; Vigilância em Saúde Pública

INTRODUCTION

Access to potable water, safe, free from the risks of diseases related to its use, in sufficient quantity for consumption, cooking, and personal hygiene is a fundamental human right[1,2,3,4,5]. However, access to potable water and sanitation worldwide, managed securely, is not universally available. The World Health Organization estimates that 2.1 billion people, that is, one in three people in the world, lack potable water services and this number doubles to 4.2 billion who do not have sewage. This reality is accentuated in communities in conditions of social and rural vulnerability[6].

Faced with this situation, the United Nations (UN) 2030 agenda proposes 17 Sustainable Development Goals (SDGs), which seek, through the eradication of all forms of poverty, to achieve human rights in balance with the three dimensions of sustainable development: economic growth, social inclusion, and environmental protection. Thus, in order to bring the issue of water and sanitation to the center of the discussion, the sixth objective was created, which aims to ensure the availability, sustainable management of water and sanitation for all, with goals to achieve guarantee to the universal access to safe potable water[6,7,8].

Results from the National Household Sample Survey (PNAD)[9] showed that 97.2% of the Brazilian population used safely managed potable water services in 2017. However, this high percentage is probably due to the fact that the quality of the water distributed and the intermittence in supplies, a reality experienced by many municipalities, especially in the Northeast, due to water scarcity[8]. In the calculation of the indicator for Brazil, only sources with internal plumbing to households were considered as "safe", since, in that same year, 85.7% of the Brazilian population was supplied by the public network and 12.0% by alternative sources, artesian well, water table, or spring[8,9].

Regarding the quality of water distributed in Brazil, the Consolidation Ordinance of the Ministry of Health No. 5, of September 28, 2017, Annex XX, provides for the potability standards of water intended for human consumption, since all water distributed collectively, through a water supply system (WSS) or collective alternative solution (CAS), must be subject to control and surveillance of water quality[10].

According to the legislation in force regarding the forms of water supply, WSS for human consumption is defined as the installations composed of a set of civil works, materials, and equipment, from the catchment area to the building connections, intended for the collective production and supply of potable water, through a distribution network. CAS, on the other hand, is defined as a collective supply modality for the supply of potable water, originating from underground or surface catchment, with or without channeling and without a distribution network[10].

The information generated by the control and surveillance of water and the registration of forms of supply are registered in the Drinking Water Quality Surveillance Information System (SISAGUA)[2,11].Such information is used in the management of health risks associated with water supply and subsidizes the performance of the National Drinking Water Quality Surveillance Program (VIGIAGUA), which consists of a set of actions continuously adopted by public health authorities covering municipalities, states, and the Union, with a view to guaranteeing the population's access to water in sufficient quantity and quality, compatible with the potability standard established in the legislation. In addition to these, it covers the structuring of public policies in the area of sanitation, the characterization of the quality of the water consumed by the Brazilian population, and the prevention of waterborne diseases[2,11].

Several diseases can result from the consumption of inappropriate water for humans, both of viral origin, such as: hepatitis E, hepatitis A, Rotavirus, enterovirus, norovirus, and of bacterial origin, such as: *Vibrio, Campylobacter, Escherichia coli* O157, *Salmonella, Shigella* and protozoa: *Giardia, Cryptosporidium, Toxoplasma gondii, Entamoeba*, which can reach the population through outbreaks or singly[12]. Human exposure to risk can occur throughout the lifetime of water consumption, however, there are different sensitivities between these stages. Those with the higher risk of acquiring waterborne diseases are children, immunocompromised, malnourished, and elderly people, especially when living in unsanitary conditions[12].

The lack of universalization of basic sanitation generates social and economic impacts resulting from: illness, removal of people from their work activities, decrease in productivity, promotion of serious regional inequalities, devaluation of real estate capital, public and private expenses with the treatment of infected people[13,14]. It was found that in 2009, companies spent R$ 547 million in compensation for non-worked hours of employees who had to be absent due to gastrointestinal infections. In this sense, universal access to sanitation would reduce hospitalizations by 25% and mortality by 65%, that is, 1,277 lives would be saved in that period[13].

In 2013, there were an estimated 14.982 million cases of sick leave due to diarrhea or vomiting in the country throughout the year, equivalent to an incidence rate of 74.7 cases per thousand inhabitants, which resulted in the occurrence of 49.763 million days of absence from routine activities over a year and 353.5 thousand hospitalizations for infectious gastrointestinal diseases[14].

In Brazil as a whole, despite advances in access to piped water, in 2016, 33.4 million Brazilians did not have access to treated water in their homes, which corresponded to 16.7% of the population. In the period from 2004 to 2016, the benefits from investments in basic sanitation reached R$ 590.732 billion across the country and the costs in the period totaled R$ 389.188 billion, which demonstrates the economic viability of investments in this sector[14].

Given the social impact of the lack of access to drinking water and the previously exposed, the objective of this study is to identify in the scientific literature what has been evidenced about the quality of water intended for human consumption, collectively distributed in Brazil.

In the search for subsidies to achieve the proposed objective, an integrative review of the national literature was developed, guided by the question: what has been evidenced in the scientific literature about the quality of water intended for human consumption, collectively distributed in Brazil?

METHOD

This is an integrative literature review, operationalized from the following steps: identification of the topic and construction of the research question, sampling, data collection (extraction of information), critical evaluation of pre-selected and selected studies, categorization and integration of evidence through the synthesis matrix, presentation of the synthesis of the knowledge produced[15,16,17,18].

After structuring the research question, a query was made to the Health Sciences Descriptors (DeCS), from the Virtual Health Library (VHL), to establish the search strategy in the databases. For the research, the VHL and the Journal Portal of the Coordination for the Improvement of Higher Education Personnel (CAPES) were used, through the website www.periodicos.capes.gov.br. The following associated descriptors were used: "*qualidade da água para consumo humano*" (water quality for human consumption) AND "*sistema de abastecimento*" (supply system).

Regarding the period of publication researched, the publication of the Potable Water Ordinance for Human Consumption, Ordinance No. 2,914, of December 12, 2011, revoked by the Consolidation Ordinance of the Ministry of Health No. 5/2017 - Annex XX[10], but without changing the content. Thus, studies published in the last ten years were selected and the search for studies for review was carried out in the last fortnight of August and in the first fortnight of September 2019.

The inclusion criteria established were articles whose theme answered the guiding question: "What has been evidenced in the scientific literature about the quality of water intended for human consumption, collectively distributed in Brazil?", available in full, in Portuguese, English, and Spanish. Were excluded studies that evaluated only raw water from surface springs; articles that reported on the Potable Water Ordinance, prior to the current content, Ministry of Health Ordinance No. 518, of March 25, 2004[19]; articles published in events; dissertations; documentary and quantitative research with unrepresentative samples; studies that addressed operational indicators of the supply systems (taxation, water meters, and losses in the network); researches that evaluated the presence of substances in the water, not expressed in the potability standard of the current legislation and also bibliographic and systematic reviews.

The search on the CAPES Journal Portal resulted in 575 articles. A preliminary selection was made after reading the titles and/or abstracts, applying the selection criteria listed, which totaled 55 articles for full reading and, of these, 24 remained in the research. The search for articles in the VHL totaled 61 articles, of which 13 were selected for full reading and, later, four remained in the search. In summary, 28 articles were analyzed, as shown in Figure 1.

The extraction of information contained in the articles was performed with an instrument that included the following items: title, year of publication, objective, method (place of study, sampling, research instruments, analyzed parameters), results, conclusion/limitations. These data supported the results of the review, presented in a descriptive way and presented in the form of tables and figures.

RESULTS AND DISCUSSION

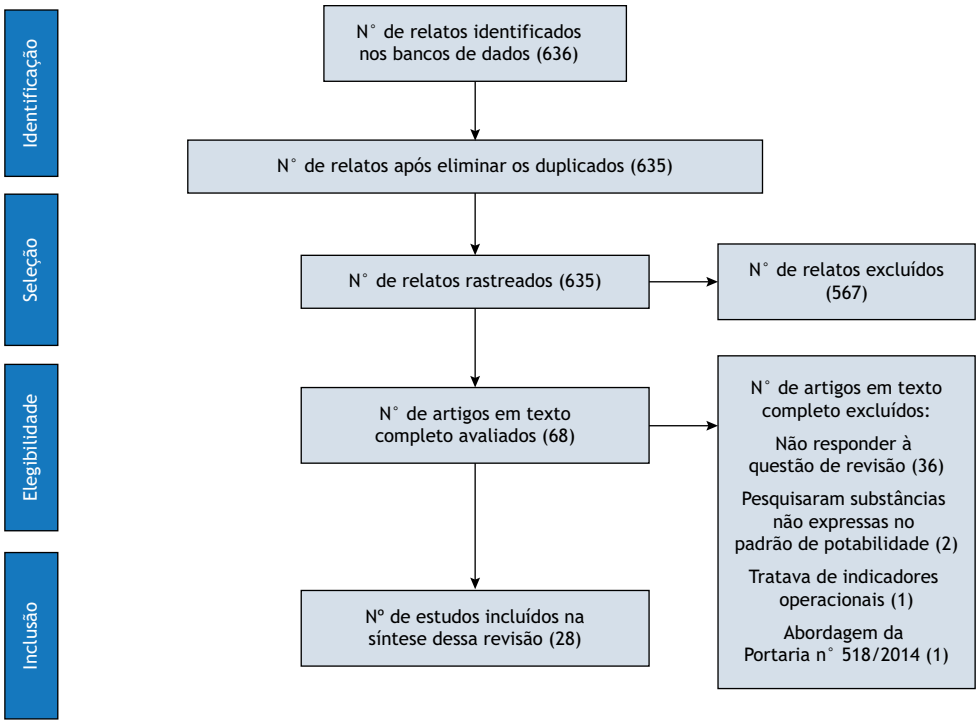
From the careful reading of the 68 articles found in the two databases, 28 studies were selected that contributed to the identification of the quality of water intended for human consumption, distributed in Brazil, in different forms of supply and used collectively.

Of the selected publications, four (14.3%) were from the state of São Paulo, three (10.7%) from Minas Gerais, three (10.7%) from Ceará, three (10.7%) from Pará, two (7.1%) from Rio Grande do Sul, and two (7.1%) from Alagoas. As for the other articles, only one study was selected in Amazonas, Bahia, Espírito Santo, Goiás, Maranhão, Paraná, Pernambuco, Rio de Janeiro, Rio Grande do Norte, Santa Catarina, and a study that addressed the 27 Brazilian capitals. The fact that most of the research was carried out in the state of São Paulo is probably due to the population density, lack of safety and control[36] in the quality of water that remains in some regions of the state[38], a consequence of the lack of treatment and for having been the precursor of legal issues related to water potability[31,41].

Regarding the journals in which the articles are published, seven (25.0%) were published in Ambiente & Água, six (21.4%) in Ciência & Saúde Coletiva, two (7.1%) in Revista Brasileira em Promoção da Saúde and the others in other journals, as can be seen in Table 1.

As for the period of publication of the articles, it can be seen in Figure 2 that the largest number of them occurred in 2015 (25.0%), 2018 and 2016 (17.9% each), and in 2017 (14.3%), respectively Regarding the methodological approach, three (10.7%) selected studies are qualitative, three (10.7%) are quantitative-qualitative, and the majority (22 – 78.6%) are quantitative.

Still, regarding the years in which the researches were published, it was observed that, just as Brazil has experienced in recent years advances in the channeling of distributed water[8,9,14], there was an increase in the number of studies that addressed water quality from 2015, most of them



Source: Adapted from Preferred Reporting Items for Systematic Reviews and Meta-Analyses, 2020.

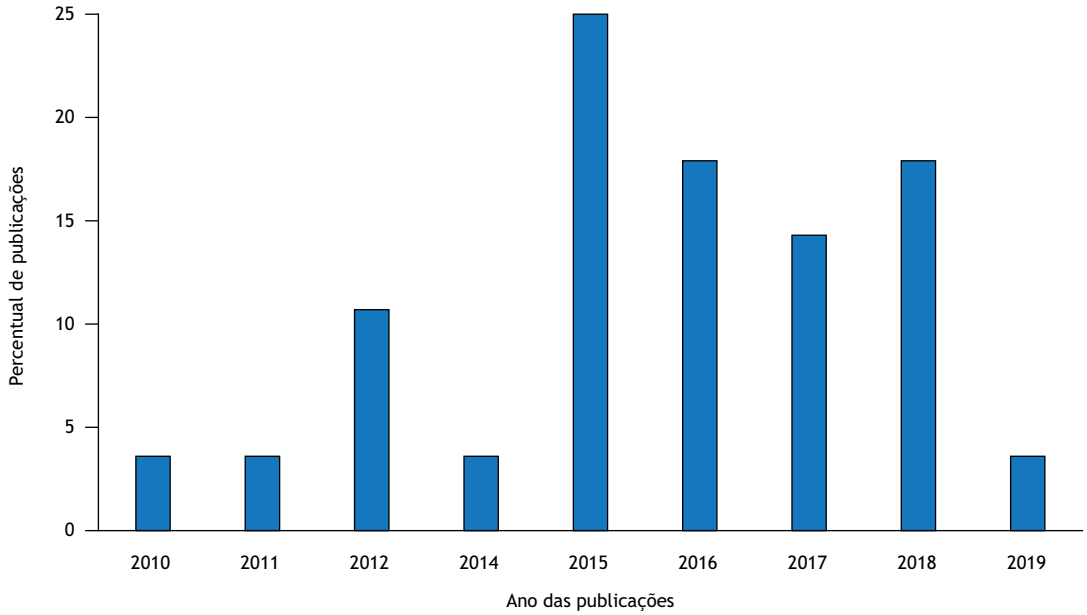
Figure 1. Flowchart of the process of identification, selection, and inclusion of articles that made up the review. Ijuí (RS), Brazil, 2019.

Table 1. Journals in which the articles that were part of the review were published. Ijuí, RS, Brazil, 2019.

Periodical	Number of published articles (%)
Revista Ambiente & Água - An Interdisciplinary Journal of Applied Science	7 (25.0%)
Ciência & Saúde Coletiva	6 (21.4%)
Revista Brasileira em Promoção da Saúde	2 (7.1%)
Acta Biomedica Brasiliensia	1 (3.6%)
Ambiente & Sociedade	1 (3.6%)
Brazilian Dental Journal	1 (3.6%)
Brazilian Journal of Biosystems Engineering	1 (3.6%)
Caminhos de Geografia	1 (3.6%)
Connexio - Revista Eletrônica da Escola de Gestão e Negócios	1 (3.6%)
Engenharia Sanitária e Ambiental	1 (3.6%)
Holos	1 (3.6%)
Revista Eletrônica de Gestão e Tecnologias Ambientais - GESTA	1 (3.6%)
Revista Thema	1 (3.6%)
Revista Sul-Brasileira de Odontologia - RSBO	1 (3.6%)
Saúde e Sociedade	1 (3.6%)
Water Environment Research	1 (3.6%)
Total	28 (100.0%)

Source: Elaborated by the authors, 2020.

with a quantitative approach, and that analyzed the legal parameters[21,22,24,26,27,28,33,34, 35,36,37,39,40,41]. From the studies analyzed, it is clear the need for research that evaluates water quality over time[33] and that considers regional differences, in particular, related to climate, temperature. and precipitation[36].



Source: Elaborated by the authors, 2020.

Figure 2. Percentage of analyzed articles referring to the quality of water intended for human consumption, collectively distributed in Brazil, published each year. Ijuí (RS), Brazil, 2019.

The selected studies were systematized into two categories: 1. Environmental factors that affect water quality: ten (35.7%) articles; 2. Water quality in terms of potability standard and surveillance of its quality: 18 (64.3%) articles. These publications will be presented below.

1. Environmental factors that affect water quality

In this category, studies were analyzed whose results showed, from the quality of the water found, the anthropic action on surface and underground springs and consequences on the standard of potability. Table 2 presents a summary matrix of the characteristics of the selected studies, according to objectives, methodology, and main results.

Most of the analyzed studies investigated raw water from underground springs[21,23,24,25,26,27,28]. It was chosen to select them due to the legal requirements for the treatment of water from this source of capture for human consumption. This treatment modality, according to Consolidation Ordinance No. 5/2017, concerning the control and surveillance of the quality of water for human consumption and its potability standard, comprises exclusively disinfection, which can be performed through chlorination, chloramination, or the application of chlorine dioxide[10].

The article, with code 2, in Table 2, which aimed to carry out a taxonomic survey of cyanobacteria and determine the concentration of cyanotoxins in the Jucazinho and Carpina reservoirs, located in the Agreste and Zona da Mata Norte of the state of Pernambuco[21], was selected, regardless of having used raw water from surface springs, due to the difficulty of removing cyanotoxins in the process of treating water intended for human consumption and the neuro, hepatotoxic, and nephrotoxic potential of its consumption.

The analysis of the articles allowed us to identify that there are similarities in the origin of the nonconformities of the findings, all related to human actions in the environment, arising from the lack of basic sanitation, which includes a sanitary sewage system, effluent treatment, solid waste collection, need to adapt black pits to septic tanks; lack of natural protection of watershed areas; cemeteries built without foreseeing environmental conditions, such as: previous study with observance of topographic, hydrogeological, lithological, and structural characteristics, as recommended in the legislation; contamination by pesticides; laboratory insufficiency and weakened performance in water quality surveillance in monitoring human exposure to chemical residues, in particular, pesticides[20,21,22,23,24,25,26,27,28,29].

From this scenario, the need to increase water quality surveillance actions is evident, in order to monitor the environmental impact of human actions related to the use of pesticides[23], inadequate management of sewage and garbage[20,21,22,23,24,25,27,29], adequacy of cemeteries[26,28] and expansion of inspections at Water Treatment Stations[20]. In addition to these, it is considered necessary to reinforce intersectoral actions[38], involving the different instances of the Public Power, responsible for the environment, urban planning, agriculture, sanitation, and health, educational institutions and the population, since investments in these areas are cost effective[14]. Regarding the environmental impact on the quality of water intended for human consumption, it is clear that there is a need for studies that monitor the actions developed to improve basic sanitation, cost-effectiveness indicators, achievement of goals, and surveillance actions for the quality of water.

Table 2. Synthesis matrix of articles classified in category 1 according to objectives, methodologies, and main results. Ijuí (RS), Brazil, 2019.

Code	Objective	Methodology	Main results
1	Analyze the water quality of the water catchment point in the Chumucuí River, according to the legal parameters. Identify the main factors that affect the physical and chemical characteristics and the content of thermotolerant coliforms in water[20].	Water samples were collected, biochemical parameters analyzed, and interviews were conducted with employees to obtain information on water treatment and distribution.	River water belongs to Class 2. There is a need for conventional treatment for human consumption, which does not occur in practice due to the precarious water treatment system in the city. It is essential to restructure the Water Treatment Station and expand the distribution of drinking water in the municipality, since the network only serves part of the urban area.
2	Carry out a taxonomic survey of cyanobacteria and determine the concentration of cyanotoxins in the Jucazinho and Carpina reservoirs, located in Agreste and Zona da Mata Norte in the state of Pernambuco[21].	Collected monthly water samples.	Occurrence of cyanobacterial blooms, producing cyanotoxins in water samples; greater amount in periods of lower rainfall. Cyanotoxins in both reservoirs below recommended values. The importance of implementing flowering control in the reservoirs was observed.
3	Investigate the occurrence of oocysts of *Cryptosporidium* spp. and cysts of *Giardia* spp.; verify the microbiological, physical-chemical quality and relate them to the possible presence of these protozoa in samples of raw water intended for public supply in Blumenau (SC)[22].	Raw water collections in water treatment plants in Blumenau with microbiological and physical-chemical analyses.	It was observed in the 67 samples the presence of cysts of *Giardia* spp. (23.19% of the samples) and oocysts of *Cryptosporidium* spp. (7.24% of the samples). All samples showed contamination by *Escherichia coli* and 11.76% showed raw water turbidity values above the recommended. In the analyzes of the turbidity of the treated water, 23.52% presented values above the recommended.
4	To carry out an analysis of the correlation between the management and use of water resources with the expansion of agribusiness and its effects on environmental and human contamination, pointing out challenges for the SUS in the context of monitoring pesticides in water for human consumption[23].	Multiparadigmatic qualitative approach, case study applied in an agribusiness expansion area in the semi-arid region of Ceará. Water analysis and pesticide contamination assessment was performed.	Much of the groundwater resources are exploited by agribusiness, their access is prioritized for agribusiness in Ceará, to the detriment of a large part of the population. As a result, pesticide contamination of surface and deep waters poses challenges for the surveillance of their control in water for human consumption.
5	To carry out a diagnosis of the quality of the water supplied to the school community of 22 rural schools, located in four municipalities in the Central Region of the state of Rio Grande do Sul[24].	Study in 22 rural schools, supplied by underground springs. Water collection was carried out with analysis of human activities related to agriculture and microbiological and biochemical parameters.	There are problems of contamination by total coliforms and/or by *Escherichia coli* in the waters of the tubular wells from nine schools studied. In 50%, the pH of the water is below 6. The color of a sample was higher than that provided for in Ordinance No. 2,914/2011. The other parameters of all samples were within the limits established by the legislation.
6	To evaluate the concentration of nitrate ion in groundwater sources that supply the Nova Parnamirim neighborhood of the city of Parnamirim (RN)[25].	Evaluation of nitrate ion concentration in tubular wells from raw water control reports.	It was observed that, of the 13 researched tubular wells, six (46.15%) presented values of nitrate ions above those established by Ordinance No. 2,914/2011. Contamination probably from chemical compounds related to contamination by domestic effluents.
7	Evaluate the quality of water in shallow wells and cisterns around the Campo Santo cemetery in Salvador (BA), including those used for human consumption, using as a basis parameters expressed in legislation and specific indicators of contamination by necroslurry[26].	Eighteen water samples were collected (dry and rainy season) and biochemical and microbiological parameters were analyzed.	The results of microbiological and physicochemical analyzes suggest contamination by necroslurry.
8	Perform seasonal monitoring of water quality from tubular wells in the rural community "Cinturão verde" in São Luís (MA) and identify probable sources of soil and groundwater contamination, resulting from the absence of adequate means of sanitation[27].	Descriptive and exploratory study, with the collection of 16 water samples in four artesian wells in São Luís (MA). Collections performed in periods of dry/rainy transition and analyzed biochemical and microbiological parameters.	Nonconformities regarding the presence of total coliforms, whose absence in all wells occurred only in the rainy season. In the parasitological analysis, the presence of nematode larvae (filaroid type) was detected in a water sample from a well located in a predominantly residential area, during the dry period. It was observed the importance of the process of disinfection and filtration of water for consumption, since the samples were submitted to treatment. The precariousness of basic sanitation services was observed.

Continues

Continuation

9	To carry out a study on the vulnerability to groundwater contamination of the Municipality of Nova Palma (RS), using the GOD system (G = Degree of well confinement, O = occurrence of penetrated lithological cover strata and D = static level or water level), combined with the use of geotechnologies. Map the contaminating points[28].	Analysis of 36 underground tubular water wells in the municipality of Nova Palma. The vulnerability class to which the aquifer belongs was evaluated.	Of the 36 wells, 8% of the abstractions are located in an area of insignificant vulnerability class; 15%, low; 31%, average; 31% high, and 15% extreme. Potential contamination points: seven cemeteries, two gas stations, sewage disposal (all concentrated in the urban area); close to the aquifer recharge zone, riverside areas used for the cultivation of irrigated rice, where fertilizers are used, in addition to pesticides. Need for constant follow-up and monitoring to protect groundwater catchment.
10	To analyze and understand the relationship between water and health in rural communities in the Igarapé Cumaru watershed, northeast of Pará[29].	Quali-quantitative approach. The collection and treatment of water for human consumption in two communities was evaluated.	Both communities have sanitation problems. Farmers (67% - São José and 72% - Cumaru) stated that the drinking water is of good quality. In Cumaru, 26% considered the quality to be partial. They associated quality with dry and rainy periods: change in color, smell, and taste. Most dispense with treatment, and all do not use water treatment. Giardiasis, amoebiasis, and verminoses occur more frequently in the rainy season.

Source: Elaborated by the authors, 2020.

2. Water quality in terms of potability standard and surveillance of its quality

Eighteen (64.3%) studies were selected that analyzed the potability of water intended for human consumption and that addressed the consequences of lack of potability and water quality surveillance actions.

Table 3 shows information from selected studies that discuss water potability, location, analyzed parameters, and results, organized in chronological order.

Regarding the data contained in Table 3, the following stand out among the analyzed chemical substances: fluoride, present in eight studies[30,31,33,35,36,39,40,41], the microbiological parameter, analyzed in six[32,34,36,37,38,41], followed by turbidity in five studies[32,33,36,37,41]. Probably, these parameters were the most analyzed because they are defined as basic indicators of water quality[47]. Fluoride, for its meaning of health[16,43] due to deficiency or excess, and the others for collaborating in the microbiological quality of water[44]. Such aspects are analyzed monthly by VIGIAGUA in all municipalities and the number of samples is determined based on the population range[46].

From the research results, explained in Table 3, nonconformities regarding the potability of water were verified in relation to all parameters. For a better understanding of the reader in relation to the specifications of the Consolidation Ordinance No. 5 regarding the parameters of potability of water and the maximum permitted value (VMP) of each one, for water for human consumption and comparison with the results of the parameters found in the selected studies, a synthesis of the aforementioned parameters and their VMP presented in the aforementioned Ordinance was carried out, explained in Table 4.

As for fluoride, in seven studies that evaluated it, the samples were below the minimum recommended by legislation[42] which is 0.6 mg/L of fluoride for supply systems[31,30,33,36,39,40,41]. Values above the VMP 1.5mg/L[10], which appeared less frequently, were reported in five studies[31,30,33,39,41]. It should be noted that artificial fluoridation is not mandatory in CAS[42], because, in this form of supply, fluoride must be monitored according to its natural presence, according to findings by Medeiros et al.[35], in which the fluoride levels were within the VMP[10].

The fluoride concentration in two analyzed studies evidences the consequences of its lack of control[16,43]. One of them refers to the prevalence of fluorosis in 362 elementary school children in the municipality of Campo do Tenente (PR)[16]. Also in this study, it was observed that the average fluoride concentration in public supply was 1.7 mg/L. Another study evaluated the relationship between socioeconomic conditions and the National Public Policy for Fluoridation of water supplies with the oral health of the 12-year-old population in Brazilian capitals and it was found that the absence of caries in a portion of the population was justified by economic and socio-sanitary indicators, whose magnitude of each variable was adjusted for the presence of fluoridation in the water supply[43]. On the other hand, when socio-sanitary conditions were not associated with tooth loss, together with economic deprivation and water fluoridation, they explained the variability of tooth loss in this portion of the population[43]. The authors point out that, in 2005, 50% of the Brazilian population residing in the capitals had fluoridated water and precisely socioeconomically less favored regions had the lowest share of fluoridation.

Regarding the microbiological pattern of the analyzed water, it was evidenced that all studies showed percentages of samples unsuitable for human consumption, with the presence of *E. and total coliforms with 100.00%, 75.00%, 9.00%, 62.50%*[20], 39.00%[21] and 4.31% increase in the incidence of these in the rainy season[32], in contradiction to what is recommended in the legislation (Table 4). In this sense, one of the studies measured the impact of the water supply system and sanitation on diarrheal diseases in children under five years[44]. In that study, when calculating the global burden of diarrhea, the authors observed that the fraction referring to the water supply and sanitation system was 83.0% and reduced to 78.3% in places with 100% sanitation coverage, in Minas Gerais.

Table 3. Characterization of the analyzed studies regarding the potability of water for human consumption. Ijuí, RS, Brazil, 2019.

	Article title	State	Parameters analyzed and main results	Year
1	Heterocontrol of fluoridation of public water supply in the municipality of Jaguaribara, Ceará, Brazil[30]	Ceará	Chemical: Fluoride (44.4% of samples subfluoridated, 8.3% superfluoridated).	2012
2	*Fluoride Concentration in Public Water Supply: 72 Months of Analysis*[31]	São Paulo	Chemical: Fluoride (20.6% of samples subfluoridated, 0.7% superfluoridated).	2013
3	Occurrence of *Escherichia coli* in water sources and consumption points in a rural community[32]	Alagoas	Microbiological: total coliforms (present in all samples) and *Escherichia coli* (present in all samples); Organoleptic: turbidity (only two samples were below 5 uT) and color (only five samples were below 15 uH).	2014
4	Microbial analysis and fluoride content added to water supply in a state in Northeast Brazil[33]	Alagoas	Chemical: Fluoride (83.9% of samples subfluoridated); Microbiological: total coliforms (present in all samples); *Escherichia coli* (20% of samples with presence).	2015
5	*Chemical and microbiological analysis of public-school water in Uberaba Municipality*[34]	Minas Gerais	Disinfectant: Free residual chlorine (50% of samples below 0.2 mgL^{-1}); Microbiological: total and thermotolerant coliforms (present in 50% of the samples); Chemical: Analysis of metals: lead (Pb) (7.8% above VMP), chromium (Cr) (45.3% above VMP), copper (Cu) (3.1% above the MPV), and cadmium (Cd) (51.5% above the MPV); Organoleptic: manganese (Mn) (12.5% above VMP).	2015
6	Assessment of drinking water quality by riverside communities in areas exposed to urban and industrial pollutants in the municipalities of Abaetetuba and Barcarena in the state of Pará, Brazil[35]	Pará	Physicochemical: pH (acid samples between 6.0 to 9.5), Chloride (VMP), Fluoride (VMP), N-Nitrate (10 to 25 times above the VMP); Organoleptic: Hardness (VMP), Total Dissolved Solids (VMP).	2016
7	Quality of public water supply in the municipality of Jaboticabal, SP[36]	São Paulo	Disinfectant: free residual chlorine (VMP); Physicochemical: fluorides (mean from 0.6 to 1.5 mg/L^{-1}), pH (ranged from 5.9 to 7.9); Microbiological: total coliforms (4 to 43% of the samples outside the potability standard), *Escherichia coli* (ranged from 4 to 9% outside the potability standard), mesophilic bacteria (absence in all samples); Organoleptic: turbidity (after treatment all samples inside the VMP), apparent color (after treatment all samples inside the VMP).	2016
8	Analysis of water potability of fountains in two neighborhoods in the city of Fortaleza, Ceará[37]	Ceará	Physicochemical: pH (37.5% of acidic samples), total alkalinity (VMP); chlorides (VMP), sodium (VMP), potassium (VMP), nitrite (VMP), nitrate (35% of samples above the VMP), conductivity (VMP); Microbiological: *Escherichia coli* (present in 62.5% of the samples); Organoleptic (all within VMP): color, turbidity, hardness, calcium, magnesium, ammonia, iron, sulfate, and total dissolved solids.	2017
9	Microbiological assessment of water consumed by a rural population in Ilha Solteira – São Paulo[38]	São Paulo	Microbiological: total coliforms (present in all samples) and *Escherichia coli* (presence varied between 2%, 5%, and 11% depending on the location); Physical: pH (ranged from 5.1 to 8.6), electrical conductivity (ranged from 19.7 to 303.0 $\mu S.cm^{-1}$); Organoleptic: turbidity (ranged from 0 to 16 uT).	2017
10	Heterocontrol of fluoridation of public water supply in cities of the state of Goiás, Brazil[39]	Goiás	Chemical: Fluoride (61.0% of subfluoridated and 0.6 superfluoridated samples).	2018
11	*Quality of the water fluoridation and municipal-level indicators in a Brazilian metropolitan region*[40]	Espírito Santo	Chemical: Fluoride (68.1 and 81.4% of samples showed optimal fluoride levels in two criteria).	2018
12	*Physicochemical and microbiological quality of the public water supply in 38 cities from the midwest region of the State of São Paulo, Brazil*[41]	São Paulo	Disinfectant: free residual chlorine (2.7% of samples below 0.2 mgL^{-1}); Physicochemical: pH (3.8% below 6 and 3.2% above 9.5), fluoride (24.6% below 0.6mgL^{-1}, 9.7% above 0.8 mgL^{-1}), nitrate (0.3% above 10mgL^{-1}); Microbiological: total coliforms (present in 4.31% of the samples) and *Escherichia coli* (present in 0.35% of the samples); Organoleptic: apparent color (13,2% above the VMP), turbidity (21.1% above the VMP).	2019

Source: Elaborated by the authors, 2020.

It is noteworthy that, given the lack of access to the supply system, the population often chooses to consume water from alternative sources, such as shallow wells[45]. Research in a municipality in the Zona da Mata Mineira identified that the reasons stem from the sanitary condition, that is, the absence of a water supply system. They also reported chlorine as a derogatory factor, associated with taste and smell. The authors also observed that the affection towards well water combined with the security of having their own, clean, and good quality water at home reinforced the participants' defense of drinking water without adequate treatment.

Still in relation to the microbiological pattern, the results of this review point to the cleaning of domestic reservoirs as a measure to control changes in this pattern[32,36,38] and guidance to the population regarding correct cleaning[36], greater control in the disinfection process during treatment[34,41] especially in rainy periods, and reduction of turbidity to increase the efficiency of chlorine action[36,37].

Table 4. Summary of the specifications of Consolidation Ordinance No. 5, of September 28, 2017, for water for human consumption. Ijuí (RS), Brazil, 2019.

Parameter	Maximum permitted value (VMP)
Total coliforms	Absence in 100 mL (at treatment exit)
Escherichia coli	Absence in 100 mL
Inorganic chemical substances	Fluoride - 1.5 mg/L; Lead - 0.01 mg/L; Chromium - 0.05 mg/L; Copper - 2 mg/L; Cadmium - 0.005 mg/L; Nitrate - 10 mg/L; Nitrite - 1 mg/L
Organic chemical substances	Vinyl Chloride - 2 µg/L
Disinfectants and secondary products	Free residual chlorine - 5 mg/L
Organoleptic standard	Chloride - 250 mg/L; Hardness - 500 mg/L; Iron - 0.3 mg/L; Taste and odor - intensity 6; Ammonia - 1.5 mg/L; Iron - 0.3 mg/L; Manganese - 0.1 mg/L; Sodium - 200 mg/L; Total dissolved solids - 1,000 mg/L; Sulfate - 250 mg/L
pH	6 - 9
Color	15 uH (Hazen unit)
Turbidity	1.0 uT (turbidity units) in 95% of samples (groundwater disinfection)

Source: Elaborated by the authors, 2020.

The minimum distance required between catchment sources from groundwater and rudimentary cesspools, monitoring of the quality of water distributed in rural areas, intersectoral actions with universities, public authorities, and rural population to provide treatment and greater control in the distribution system[41].

As for the disinfectant, the legislation[10] provides that all water supplied collectively must undergo a disinfection or chlorination process, with the obligation to maintain at least 0.2 mg/L of free residual chlorine in the distribution system. All studies that showed changes in the microbiological pattern had problems related to disinfection, which make the water unfit for human consumption[22,24,27,32,34,36,37,38,41]. Another important factor refers to the change in turbidity, as levels above the VMP[32,41] act as a shelter for pathogenic organisms, protecting them from the action of the disinfectant agent[47].

As for the other chemical substances, the analyzed studies showed the presence of copper, cadmium, chromium, manganese, lead[34], and N-Nitrate[35,37,41] above the VMP by the legislation[10]. It recommends that those responsible for the quality control of water from WSS or CAS, supplied by surface or underground springs, collect biannual samples of raw water for such substances, including pesticides, disinfectants, and secondary disinfection products, in order to assess risk to human health, followed by the adoption of immediate measures in the face of changes in concentrations presented[10]. Failures in this biannual control were expressed in the results of two studies that analyzed these substances in public supply systems[34,41] and two studies that evaluated them in CAS[35,37].

The quality of water intended for human consumption and the consequences of lack of potability are directly related to the monitoring and surveillance of water quality[31,40,41,44]. Thus, Guerra and Silva[46], in the state of Rio de Janeiro, identified the percentage of compliance with the municipal sampling plan for the analysis of free residual chlorine, turbidity, total coliforms, and *E. coli*, during the year 2014. The researchers stated that there was a gradual evolution of the analyses, with 96% of compliance with the sampling plan, an increase in the presence of coliforms over the years, which may indicate operational problems in the treatment or maintenance and conservation of the distribution system. The authors complement, by stating that geographic barriers and municipal economic weaknesses reflect on the performance of some municipalities in the surveillance of water quality, among them: difficulties in carrying out analyses, acquiring equipment, turnover of municipal servers responsible for this work and operational related to adequate physical space, computer, internet, and vehicle.

From the analysis of the selected articles, it appears that there are some nonconformities in the parameters of quality and potability of the water distributed in Brazil with the current legislation. The analysis also favored knowledge about the importance of control and surveillance of water intended for human consumption, however, the lack of investigations that address these actions drew attention. In addition, difficulties in implementing and structuring VIGIAGUA in the various Brazilian states and municipalities were observed, as mentioned by Guerra e Silva[46] in a study carried out in Rio de Janeiro (2018) and Palmeira et al.[41], who evaluated the results of the VIGIAGUA sampling plan in 38 cities in the Midwest of São Paulo.

CONCLUSIONS

This review study made it possible to deepen knowledge about the quality of the water provided collectively, in the forms of national supply. It elucidated the social consequences of the lack of access to potable water, difficulties that persist in the control of basic parameters, fluoridation, turbidity, *E. coli*, coliforms and free residual chlorine; semiannual controls, which include analysis of chemical substances, in the different forms of capture: underground and surface springs; and in the higher incidence of rainfall.

The importance of VIGIAGUA's actions is highlighted, allied to the operational and structural difficulties of the development of this Program by the municipalities. It is evaluated that intersectoral actions are necessary and require the union of directed

efforts, from the promotion of adequate treatment of the forms of supply to permanent health education, through approaches that focus on the importance of consuming treated water and cleaning domestic reservoirs for maintaining health and preventing damage that is often irreparable.

Em síntese, encontraram-se poucos estudos sobre a vigilância da qualidade da água destinada ao consumo humano, o que requer o desenvolvimento de mais pesquisas nessa área que abordem a atuação dos programas de vigilância nos diversos estados e municípios brasileiros.

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Author's Contributions

Bárta RL – Conception, planning (study design), acquisition, analysis, data interpretation, and writing of the work. Silva JAG – Conception, planning (study design), analysis, data interpretation, and writing of the work. Daronco CR, Pretto C – Conception, acquisition, analysis, data interpretation, and writing of the work. Stumm EMF, Colet CF – Conception, planning (study design), data interpretation, and writing of the work. All authors approved the final version of the work.

Conflict of Interests

The authors inform that there is no potential conflict of interest with peers and institutions, politicians, or financial in this study.