Revista Brasileira de Ciências Ambientais
Brazilian Journal of Environmental Sciences

Water quality of public springs and population perception in Pinheiral, RJ, Brazil

Qualidade da água das minas de acesso público e percepção da população do município de Pinheiral/RJ, Brasil

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ABSTRACT

The consumption of spring water contributes to meeting population demands and is essential in the context of water scarcity, as well as the proper maintenance of human well-being and environmental sustainability. Given the importance of information availability for the adoption of effective water resource management actions, this study aimed to analyse the water quality of public springs in the municipality of Pinheiral, RJ, based on potability standards and the perception of the local population. Water potability was determined through the analysis of the following parameters: pH, turbidity, colour, total Mn, total Fe, NO_3^-, and thermotolerant coliforms, in water samples collected at four time points: summer (March 2021), autumn (June 2021), winter (September 2021), and spring (December 2021). To capture the perception of spring users, interviews were conducted using a questionnaire consisting of closed-ended questions. The results showed that all five springs evaluated failed to comply with legislative standards in at least one sampling period and for at least one of the following parameters: pH, turbidity, colour, total Mn, total Fe, NO_3^-, and thermotolerant coliforms. Regarding consumption, 83% of respondents reported consuming spring water, motivated by their perception of good water quality and favourable organoleptic characteristics. This perception of quality leads to the non-adoption of hygiene practices during water collection, storage, and consumption. Out of the overall survey respondents, 28.1% reported that they do not wash the container where they collect the water, and 30.2% wash it only with water. Regarding consumption practices, none of the respondents reported boiling the water, and only 45.8% reported always filtering it prior to consumption. Based on the study results, it can be concluded that water from the analysed springs does not meet the limits established by potability standards and may therefore pose health risks to consumers.

Keywords: water springs; potability standards; consumption habits.

RESUMO

O consumo de água de minas contribui para o atendimento das demandas da população, sendo essencial em um cenário de escassez hídrica e busca da manutenção do bem-estar humano e sustentabilidade ambiental. Entendendo-se a importância da disponibilidade de informações para a adoção de ações efetivas de gestão dos recursos hídricos, este trabalho teve como objetivo analisar a qualidade da água de cinco minas de acesso público do município de Pinheiral/RJ, por meio dos padrões de potabilidade e percepção da população local. A potabilidade da água foi determinada com a análise dos parâmetros pH, turbidez, cor, Mn total, Fe total, NO_3^- e coliformes termotolerantes em amostras de água coletadas em quatro períodos: verão (março/21), outono (junho/21), inverno (setembro/21) e primavera (dezembro/21). Para a captação da percepção dos usuários das minas, foram realizadas entrevistas com a aplicação de questionário com perguntas fechadas. Os resultados mostraram que as cinco minas avaliadas se encontram em desacordo com o estabelecido na legislação em pelo menos uma das coletas e parâmetros analisados. Quanto ao consumo, tem-se que 83% dos respondentes consomem água das minas, havendo a percepção de boa qualidade desta e sendo suas características organolépticas uma motivação para o consumo. A percepção de qualidade faz com que não sejam adotadas práticas de higiene adequadas na coleta, no armazenamento e no consumo. Do total de entrevistados, 28,1% informaram que não lavam o recipiente onde coletam a água, e 30,2% lavam somente com água. Com relação ao consumo, 100% dos entrevistados não fervem a água, e apenas 45,8% sempre a filtram antes do consumo. Considerando-se os resultados do estudo, pode-se concluir que as águas das minas não estão atendendo aos limites estabelecidos pelos parâmetros de potabilidade, podendo assim trazer riscos à saúde dos consumidores.

Palavras-chave: nascente; padrões de potabilidade; hábitos de consumo.

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Conflicts of interest: the authors declare no conflicts of interest.

Funding: Fundação Carlos Chagas Filho de Amparo à Pesquisa do Estado do Rio de Janeiro (FAPERJ; process no. E-26/210.065/2021) and PROPPI/UFF (FOPESQ 2021).

Received on: 01/09/2025. Accepted on: 12/23/2025.

https://doi.org/10.5327/Z2176-94782421

Introduction

Access to safe and clean drinking water is essential for human health, as well as for economic and social development. Currently, approximately 25% of the world's major cities face water scarcity. Global water demand is expected to increase 55% by 2050 (Schlamovitz and Becker, 2021).

In this context, reducing waste and using available water resources efficiently (surface water and groundwater) should be key water resource management goals pursued by public authorities, civil society, and users. The United Nations, through its Sustainable Development Goals (SDGs), highlights the importance of addressing water scarcity for the maintenance of human well-being, environmental sustainability, and conflict resolution (United Nations, 2015).

In Brazil, water potability standards are established by Ordinance No. 888 of the Ministry of Health (GM/MS), dated 4 May 2021, which defines procedures for the control and monitoring of water quality for human consumption and its potability standard and defines the responsibilities and competences of public health authorities (Brazil, 2021).

Springs, also referred to as water sources (Piroli, 2022), are formed through natural groundwater outcrops and involve complex interactions between groundwater, surface water, and the aquatic–terrestrial environment (Thapa et al., 2020), thus representing an alternative source of water supply for the population (Chauhan et al., 2020; Dendup et al., 2022).

The rapid and increasing urbanization, industrialization, and agricultural activities, mainly in developing countries, generate direct pressure on springs, altering their composition and natural balance (Singh et al., 2023). Thus, its consumption may pose risks to the health of the local users, requiring public authorities to take actions aimed at assessing water quality standards, as well as the perceptions of users and practices related to its use.

The social perception of water quality results from a complex interaction between several factors, including organoleptic characteristics, perception of risk, chemical and microbiological quality of tap water, previous experiences, presence of children at the home, consumer information level, and trust in water treatment supply companies (Doria, 2010).

Thus, the assessment and monitoring of water quality form the basis for effective water resource management, enabling their proper characterisation and an understanding of their specific characteristics. Regarding groundwater, there is no national standardised monitoring network; in general, the main sources of information are sporadic and originate from studies conducted at universities or prepared by state water resource agencies (ANA, 2020).

Given the importance of water consumption for a population or community, several studies have been conducted to provide data on water quality and to guide intervention actions, when necessary, to ensure the conservation of water reservoirs, so that the consumption does not cause harm to the health of its consumers (Moreira and Condé, 2015; Saana et al., 2016; Rezende et al., 2023). Rezende et al. (2023), evaluating the water quality in eight tubular wells in the city of Uberaba-MG, found values above the permitted limits for the parameters colour, COD, total phosphorus, iron, cadmium, lead, nickel, manganese, and chromium, mainly during the dry season. Chauhan et al. (2020), in a study on the potability of the water from different sources in a village associated with the health status of the population, showed that all physical-chemical parameters were within the limits established by the law, however, there was contamination by coliforms in all the locations analysed. Dendup et al. (2022), evaluating the water quality in springs used for human consumption in the locality of Kanglung (Bhutan), found levels of turbidity and thermotolerant coliforms above the limits established for local potability standards, suggesting the need to boil the water before consumption.

In the municipality of Pinheiral, RJ, spring water consumption accounts for a significant portion of the population's water use, however there is a lack of scientific data analysing the quality of these sources and the perception of their quality by the local population. The municipality, which had 24,298 inhabitants in 2022 (IBGE, 2023), despite having 89.8% of its population served by the water supply system and 90% by sewage treatment services, had a supply system that recorded a distribution loss rate of approximately 67% in 2021 (SNIS, 2023), thereby impairing the quality of service provided to consumers. In addition, when sewage is collected, it is not treated, leading to contamination of the water resources that supply the analysed area and other neighbouring municipalities, including both surface water and groundwater. Therefore, understanding the water quality of publicly accessible springs used for direct consumption, as well as the perception of the population regarding this practice, can support informed decision-making to prevent potential public health impacts arising from the consumption of untreated water.

In order to recognize the importance of information availability for effective water resource management, the maintenance of human well-being, and environmental sustainability, this study aimed to analyse the water quality of publicly accessible springs in the municipality of Pinheiral, RJ, based on potability standards and the perception of the local population.

Materials and Methods

Study area

The study was conducted in the municipality of Pinheiral, located in the Médio Paraíba region, State of Rio de Janeiro, Brazil, at a latitude of 22°31′12″ S and a longitude of 43°59′48″ W, at an altitude of 375 m. It borders the municipalities of Volta Redonda, Piraí and Barra do Piraí, with an approximate area of 76.53 km².

Five publicly accessible water springs are located in the municipality of Pinheiral, which were analysed in this study (Figure 1).

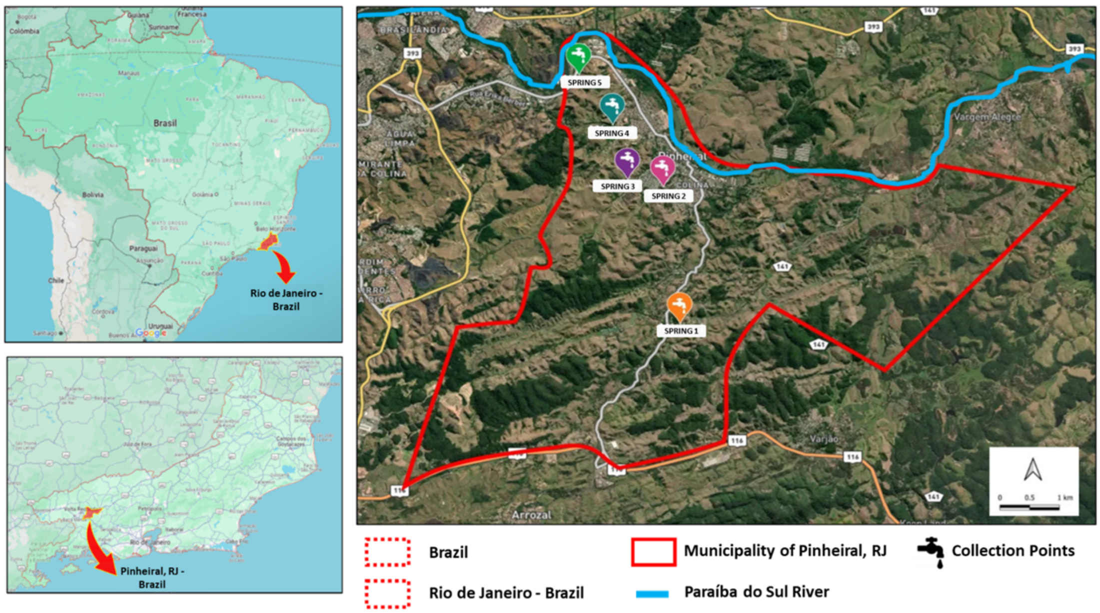

Figure 1 – Location of the publicly accessible springs in the municipality of Pinheiral, RJ.
Source: Prepared based on Google Earth (2022).

The springs are located in urban or rural areas and exhibit specific characteristics, identified through on-site observations, that may contribute to changes in water quality (Table 1).

Analysis of potability parameters of spring water

Water collection and analysis were carried out in accordance with Standard Methods (APHA, 2012). Water samples were collected from the springs during summer (March 2021), autumn (June 2021), winter (September 2021), and spring (December 2021), on days with no rainfall in the 72 hours prior to collection. Five samples were collected from each spring for each parameter analysed, using sanitised plastic bottles. To prevent external contamination, prior to sample collection at springs 1 and 4, the water was allowed to run from the tap for approximately three minutes. Samples from springs 2, 3, and 5 were collected directly at the site, as the water had been flowing continuously. After collection, the bottles were immediately transported to the laboratory and kept refrigerated until the analysis began. To assess the water quality of the springs, several potability parameters established in Ordinance No. 888 of the Ministry of Health (GM/MS), dated 4 May 2021 (Brazil, 2021), were analysed, including pH, nitrate, total Fe, total Mn, turbidity, colour, and thermotolerant coliforms.

For pH and NO_3^- analyses, five samples were collected from each spring using 500 mL plastic bottles. pH analysis was performed immediately after collection by direct measurement using a pH meter. NO_3^- concentrations were determined by ion chromatography using a Metrohm 940 Professional IC Vario system equipped with a C4 column and an eluent solution containing 2.5% sulphuric acid and calcium carbonate. Prior to the analysis, the samples were filtered through 0.45 µm Millipore membranes. Standard NO_3^- solutions were prepared by dilution of a 1,000 mg L^{-1} certified standard solution.

For total Fe and total Mn analyses, five samples were collected from each spring in 500 mL plastic bottles and acidified with nitric acid (HNO_3) at a ratio of 0.75 mL of acid per 500 mL of water sample. Concentrations were determined by atomic absorption spectroscopy (Varian 55B SpectrAA). Standard solutions of Fe and Mn were prepared by dilution of a 1,000 mg L^{-1} certified standard solution.

Turbidity and colour were determined by direct measurement using a turbidimeter and a colorimeter, respectively, both previously calibrated.

For thermotolerant coliforms, the Multiple Tube Method was employed, based on the determination of the "most probable number" of microorganisms.

The values of each parameter were calculated as the mean of five replicates±standard deviation. These means were then compared with the potability limits established in Ordinance GM/MS No. 888, of 4 May 2021 (Brazil, 2021).

Profile characteristics and consumption habits of spring water users and assessment of the perception of the consumers regarding water quality

Consumer perception was assessed using a structured questionnaire comprising 23 closed questions, designed to identify spring users, understanding their consumption practices and assessing their opinions on the water provided by the spring waters and the local public supply network. The study was submitted to and approved by the Research Ethics Committee (CEP) of the University Centre of Volta Redonda — UNIFOA/Oswaldo Aranha Foundation (Opinion No. 4.571.796).

Table 1 – Location and main characteristics of publicly accessible water sources in the municipality of Pinheiral, RJ, based on on-site observations.

Spring water	Area	Characteristics
1 Bambuzal	Rural	The spring is surrounded by residences and pasture areas upstream.
2 Barraquinha	Urban	The spring is located in an alley and is surrounded by residences and commercial properties. Upstream of the spring lies the municipal cemetery.
3 Palmeiras	Rural	Water flows continuously from a long pipe originating on a hillside. Upstream of the spring, there are areas of animal grazing and illegal waste disposal.
4 Vale do Sol	Urban	The spring is located near residences, with a strip of trees separating it from the houses.
5 Três Poços	Urban	The spring is located near residences, businesses, and industries. Water shortages are observed at the spring in specific times of the year.

The questionnaires were administered between July 2021 and March 2022 and were conducted in two stages: The first sought to determine the number of spring users, while the second aimed to understand the perception of the consumers regarding the local spring water.

In the first stage, the sample size was calculated using Cochran (1953) (Equation 1).

$$n = \frac{\frac{Z^2pq}{e^2}}{1 + \frac{1}{N}\left(\frac{Z^2pq}{e^2} - 1\right)} \quad (1)$$

Where:
N: population (22,719 inhabitants);
n: sample size;
p: true probability of the event (0.5);
q: 1 - *p*;
e: sampling error: 10% (0.1);
Z: confidence level (95%).

The sample comprised 96 inhabitants. Since there is no information on the proportion of spring water consumers by neighbourhood, the sampling was based on the proportion of individuals interviewed during the most recent Demographic Census conducted by IBGE in 2010; subsequently, the number of questionnaires administered per neighbourhood was established, after which the streets were selected to initiate data collection and households were randomly chosen for interview.

Out of the 96 residents interviewed in this first stage, 76 were spring water users (79%). In order to reach the total of 96 spring water consumers, a second stage of the interviewing process was conducted, in which 20 area residents were questioned; these individuals were identified through referrals from consumers already previously included in the study.

In order to meet the objectives, descriptive statistics (frequency) were calculated for the tabulated data, and graphs were used to improve visualisation and the analysis of the results. The comments and opinions expressed by the respondents were recorded, subsequently analysed, and included in the discussion of the study. The data obtained were tabulated and processed using Excel and the Statistical Package for the Social Sciences (SPSS), version 20.0.

Results and Discussion

Analysis of the potability parameters of spring waters

According to Ordinance GM/MS No. 888/2021 (Brazil, 2021), which recommends a pH range of 6.0 to 9.5 for water intended for human consumption, spring 3 had a pH below 6 at all sampling times (Figure 2A). The pH of the spring waters was higher during the summer sampling period (March) compared with other periods, except for spring 1 (Figure 2A). Elevated pH values during the rainy season may occur due to the reduced influence of contamination when the body of water has a greater volume (Juárez et al., 2015).

According to the turbidity limit of 5.0 uT for drinking water (Brazil, 2021), spring 5 showed higher values during the summer sampling period, with a mean of 10.8 uT (Figure 2B). During autumn, spring 1 also showed turbidity above the recommended level (15.0 uT). Turbidity is an important physical parameter as it helps to determine whether groundwater is influenced by surface water (Barakat et al., 2018). Thus, it may be indicative of a potential health risk, often associated with the presence of microorganisms transported along with soil particles (WHO, 2017). Dendup et al. (2022) also found turbidity levels above the limits established by potability standards in one of the springs studied in the locality of Kanglung, Bhutan; which was attributed to the input of soil and organic matter from surface runoff during storm events.

Water colour showed the same pattern of variation as turbidity (Figure 2C), with spring 5 during the summer sampling period (60 uH) and spring 1 in the autumn (35 uH) showing values above the recommended organoleptic standard for drinking water (15.0 uH) (Brazil, 2021). The colour of the water may originate from organic matter, such as humic substances and tannins, as well as metals, including iron and manganese, in addition to heavily coloured industrial residues (Brazil, 2013). As spring 5 showed high levels of manganese and iron (Figure 2), it is possible that the results observed came from an excess of these metals in the water.

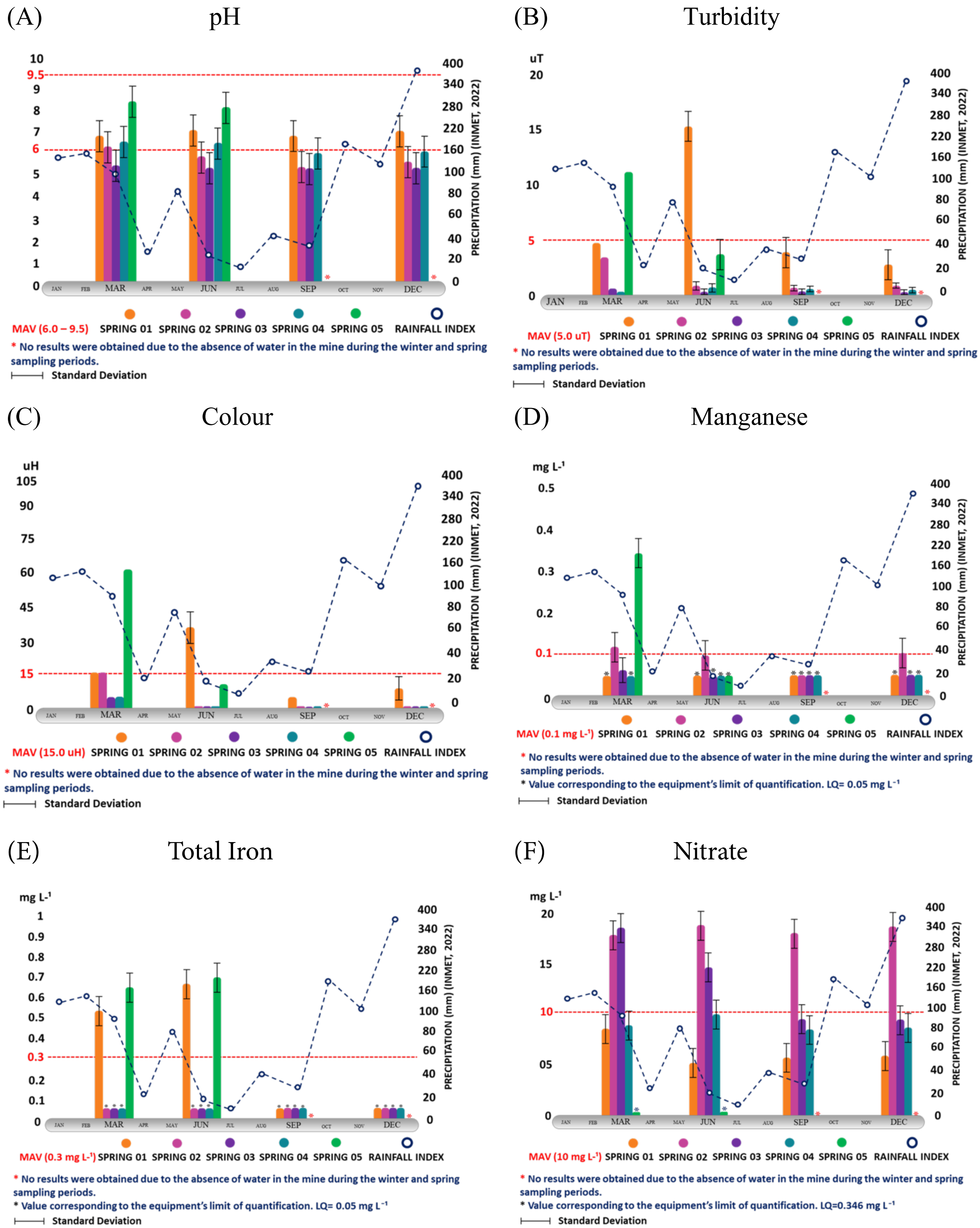

Figure 2 – Seasonal variation of physical and chemical parameters of publicly accessible springs in the municipality of Pinheiral, RJ.
Each value corresponds to the mean of five replicates±standard deviation; MAV: maximum allowed value (Brazil, 2021).

Regarding the total manganese (Figure 2D), springs 2 (0.13 mg L^{-1}) and 5 (0.39 mg L^{-1}) showed concentrations above the recommended level (up to 0.1 mg L^{-1}) during the summer sampling period. Spring 2, in addition to being surrounded by residential areas, is close to the municipal cemetery, located upstream. Ezenwa et al. (2023), when evaluating contaminants in groundwater near cemeteries in Nigeria, found high concentrations of metals, including manganese, and recommended that residents living near these areas seek an alternative source of drinking water. Neckel et al. (2021) emphasize that high concentrations of metals, such as copper, zinc, iron, manganese, lead, chromium, cadmium and nickel, in cemeteries can contaminate neighbouring residential areas.

All springs showed satisfactory results for total manganese in the autumn, winter, and spring samplings (Figure 2D), which may be associated with lower rainfall during these seasons, minimising the transport of the metal through the soil and, consequently, reducing the levels observed in the spring waters.

Total iron concentrations (Figure 2E) in springs 1 and 5 during the summer and autumn samplings were above the permitted level (up to 0.3 mg L^{-1}). According to Patni et al. (2020), water-rock interaction may explain the high iron values in water samples. Iron is also added to groundwater through the leaching of organic residues and plant debris from the surface (Karangoda and Nanayakkara, 2023).

Regarding nitrate (Figure 2F), spring 2 showed concentrations above the permitted level (up to 10.0 mg L^{-1}) in all samplings. In the summer and autumn samplings, spring 3 also showed unsatisfactory results. In general, pure groundwater rarely exhibits high nitrate concentrations; therefore, elevated levels indicate pollution (García et al., 2021).

Amanatidou et al. (2007) found high concentrations of nitrate in drinking water supply sources in the Kozani area, in Western Macedonia, and associated this contamination with agricultural activities. According to Santos et al. (2015), nitrate is one of the parameters that indicates alteration or contamination of water by necrochorume.

High concentrations of nitrate correlated with the presence of thermotolerant coliforms, as observed in spring 2 (Figure 2F and Table 2), indicate that the nitrate may have originated from faecal contamination (García et al., 2021), especially since the spring is surrounded by residences and is also located near the municipal cemetery. Although spring 3 did not present thermotolerant coliforms (Table 2), it is likely that the high nitrate level occurred due to contamination by sewage and domestic waste, given the proximity of the spring to residences and the irregular disposal of waste. Elevated nitrate levels are more commonly observed during the rainy season due to the contribution of rainfall, as nitrate dynamics can be altered by human activities and seasonal variation (Ming et al., 2020).

Escherichia coli is the main representative of the thermotolerant coliform group and indicates contamination by faeces from homeothermic animals. Its presence renders water unfit for consumption, as it reflects a faecal contamination load that deteriorates microbiological quality and poses a health risk if consumed directly without proper disinfection (Jesus et al., 2023). With the exception of spring 3, the presence of thermotolerant coliforms was identified in all springs in at least one of the sampling stations. Spring 2, where the presence of thermotolerant coliforms was detected in all analysed samples, is surrounded by residences. In addition, the infiltration of necrochorume from the nearby cemetery can also be a source of bacterial contamination, including E. coli (Rezende et al., 2023).

The presence of residences upstream from the springs, associated with the irregular discharge of domestic sewage, generates a contamination load that was evidenced in the analyses carried out, particularly during periods of lower rainfall. In some springs, the concern is even greater, as there is also the presence of animal excrement (springs 1 and 3), irregular disposal of solid waste (spring 3), and necrochorume due to proximity to the cemetery (spring 2).

Similar results were observed by Chauhan et al. (2020), who reported contamination in water sources used for human consumption with thermotolerant coliforms in a mountainous village in Uttarakhand, India, linking this contamination to the lack of adequate basic sanitation. Dendup et al. (2022) found concentrations of thermotolerant coliforms in a water source near a residential area in Kanglung, Trashigang, Bhutan, associating this contamination with domestic sewage.

Profile of residents, consumption habits and perception of water quality in springs, according to the interviewees

Most respondents are female, aged 58 years or older, and have attended high school (completed or not). It can also be observed that only 9.5% of respondents live alone, and the largest group (26.2%) lives with one other person (Table 3).

Regarding the water supplied by the public supply network, out of the 116 respondents, 77 (66.4%) reported no problems with water shortages in their homes, while 39 (33.6%) reported experiencing these issues, occurring at least once a month (2.6%), once a week (46.0%), or occasionally (51.4%).

Table 2 – Assessment of the presence of thermotolerant coliforms in the waters of public spring in the municipality of Pinheiral-RJ.

Seasons	Spring 1	Spring 2	Spring 3	Spring 4	Spring 5
Summer	Present(1)	Present	Absent	Absent	Absent
Autumn	Absent(1)	Present	Absent	Absent	Present
Winter	Present	Present	Absent	Absent	(2)
Spring	Present	Present	Absent	Present	(2)

(1) The result "present" for thermotolerant coliforms indicates the presence of *Escherichia coli* bacteria in a 100 mL water sample, whereas "absent" indicates that the bacteria were not identified in the same sample volume in any of the five repetitions of each collection; (2) No result was obtained due to the lack of water in the spring during the winter and spring collections.

Table 3 – Profile of respondents.

	%		%
Sex		**Education Level**	
Female	60.3	No schooling	4.3
Male	39.7	Incomplete Elementary School	33.6
Age		Complete Elementary School	12.1
18-27	10.3	Incomplete High School	1.7
28-37	7.8	Complete High School	40.5
38-47	19	Incomplete Higher Education	1.7
48-57	15.5	Complete Higher Education	6
58 or older	47.4		
Residents in the residence			
One	9.5		
Two	26.7		
Three	23.3		
Four	21.6		
Five or more	19		

As for the local perception of the water supplied by the public supply network, it can be observed that the organoleptic characteristics of the water are decisive in consumers' choices. References to chlorine as a negative characteristic of the treated water supplied by the public network were mentioned by 31 respondents, indicating that consumers believe that high-quality water should be free of odour and taste. Expressions such as "too much chlorine," "chlorine taste," "very strong chlorine taste" and "strong chlorine smell" were attributed to water supplied by the network.

Aversion to chlorine has also been observed in other studies (Wright et al., 2018; Delpla et al., 2020), indicating that the taste and/or smell of chlorine in water can influence consumption.

Regarding quality, 53.4% of all respondents considered the water supplied by the public water supply network to be poor. Expressions such as "bad taste," "unfit for drinking and cooking," "bad for drinking," "unpleasant odour," "strong smell," "bad smell," "stains clothes," "causes itching," "very poor quality" and "poor pressure" were attributed to the water. References to "cloudy water," "yellow water," "dirty water," "rust-coloured water" or "muddy water" were reported by 20 respondents.

Considering that the organoleptic characteristics of water are crucial factors behind consumer decisions, it is essential that water supply companies take these factors into account when planning and managing water services, as poor performance in these areas generates distrust in the service quality and, consequently, to social risks for the population, who may opt for alternative water sources (Rego et al., 2020).

The next question addressed whether respondents consumed water from springs and, if so, from which one. Out of the 116 respondents, 96 reported consuming spring water (82.7%), with 36 consuming the water from private springs and 60 from publicly accessible springs. The distribution of consumers across the springs was uneven, as only one consumer reported using spring 1 to collect water, whereas 26 consumed water from spring 4. Springs 2 and 3 were sources of water collection for 16 and 17 consumers, respectively.

The springs considered private were located on private properties without public access and were the source of water consumption for 37.5% of the respondents. It is noteworthy that there is no control over the condition of these springs or their water quality by either the owners or public authorities.

Out of the 96 users, 92 (95.8%) considered the spring water suitable for consumption. One respondent considered the spring water unsuitable for consumption but reported having previously consumed water from spring 3 and stated that he did not know why he considered the water unsuitable for consumption. Three respondents stated that they did not know whether the spring water was suitable for consumption but consumed it regardless.

The respondents also answered questions about their consumption habits (Table 4).

In general, it is observed that consumers frequently obtain water from springs without adopting adequate hygiene practices related to the water and the containers used for storage, representing a significant risk of contamination. According to the results, more than 80% of those interviewed keep the water in the same plastic bottles in which it was collected. According to Gomes et al. (2022), storage in plastic bottles is adequate due to the easiness of cleaning. However, these bottles should be protected from the light to avoid temperature increases and the growth of microorganisms. In addition, the authors highlight the importance of hygiene practices during the storage and consumption of water in order to avoid contamination.

Another important point concerns the use of spring water alone for cleaning, which is not recommended, as water of inadequate quality results in ineffective washing. The lack of proper cleaning of the containers consequently poses a risk to those who consume the stored water, especially in the case of springs with more critical water quality. None of the respondents mentioned boiling the water before consumption, justifying it by stating that boiling gives the water an unpleasant taste. This perception of a change in taste has already been cited in other studies, such as that of Martínez et al. (2014). In addition, 49% of consumers never filter the water before consumption, justifying it by stating that there is no need for filtration as the spring water is of good quality.

Regarding colour, two interviewees reported that the water from spring 2 "sometimes turns brownish," and one interviewee stated that the water from spring 3 "turns brown when it rains." As for the taste, the terms "brackish" and "mineral" were attributed to the private springs. No smell was attributed to the spring water.

Table 4 – Consumption habits.

	%		%
How often do you fetch water from the spring?		**Do you boil spring water before drinking it?**	
Every day	29.2	Always	0
Once a week	37.5	Sometimes	0
Twice a month	16.7	Never	100
When needed	16.7		
How do you wash the containers used to collect the water?		**Do you filter the spring water before drinking it?**	
Only with water	30.2	Always	45.8
Water and detergent	26	Sometimes	5.2
Water, detergent and bleach	15.6	Never	49
Not washed	28.1	**Does the water from the spring water have colour?**	
How do you store water?		Yes	3.1
In plastic bottles	82.3	No	96.9
In buckets	2.1	**Does the water from the spring have a smell?**	
In reservoirs	15.6	Yes	0
		No	100
		Does the water from the spring have a taste?	
		Yes	2.1
		No	97.9

Subsequently, the interviewees were asked whether they considered the spring water suitable for consumption. Of the 96 interviewees, 92 considered the spring water suitable for human consumption. One interviewee considered the spring water unsuitable for consumption and mentioned having consumed water from spring 3, however he was unable to explain why they considered the water unsuitable. Three interviewees stated that they were unaware whether the spring water was suitable for consumption, despite being users of the springs.

The users were then asked about the purpose of the spring water in their homes. Most respondents use the water exclusively for drinking (40%), followed by those who use it for direct consumption and food preparation (40.6%), and those who use it for drinking, food preparation, and hygiene practices (13.5%). Through the interviewing process, it became clear that spring water is used to meet needs directly associated with the health of the local population, indicating its importance in maintaining overall well-being.

When asked about their motivation for consuming spring water, 81.3% reported that they do so because they believe it is of better quality than the water supplied by the municipal water supply system. The remaining respondents (18.7%) reported consuming spring water due to perceived quality, habit, and/or the absence of cost. It is noteworthy that only one respondent stated that their motivation was the free availability of the water.

It is observed that perception of water quality by the consumers does not correspond to the results of the water analyses, as all evaluated springs presented unsatisfactory indices in at least one of the collected samples (Figure 2 and Table 2). This divergence between expected and observed quality is concerning, as it gives consumers a false sense of security, leading them to disregard safe practices such as boiling and filtering before consuming spring water.

Adequate washing practices were reported more frequently by respondents aged 38–47, among whom approximately 30% reported washing containers with water, detergent, and bleach. Older respondents (48 years or older) reported either not washing the containers (33%) or washing them with only water (29%). Among the younger group (18–27 years old), the habit of not washing containers was not observed; however, 75% reported washing them using only water.

No respondent mentioned boiling the water before consumption, justifying it by stating that the boiling process gives the water an unpleasant taste. In a study conducted in Chaco, Argentina (Martínez et al., 2014), boiling was also cited as responsible for altering the taste of water, making it less pleasant to consume.

When considering education levels and washing practices, it was found that more than 70% of respondents with no schooling, incomplete primary education, or complete primary education wash containers with only water or do not wash them at all. Among respondents with complete secondary education, more than 52% wash containers with water and detergent also use bleach in the washing process. Among respondents with complete higher education, more than 83% stated that they wash containers with water and detergent, also using bleach when sanitizing them.

In addition to properly sanitizing the storage containers at the spring, it is important that the water be filtered or boiled to maintain its quality and potability. The responses showed that, among individuals with no schooling, all stated that they never filter the water. Among respondents with complete secondary education, more than 44% reported that they always filter the water, while among those with incomplete or complete higher education, all stated that they filter the water before consumption.

In view of these results, it can be stated that as the level of education of the respondents increases, greater care is taken with the water. Brito et al. (2021), in a study analysing the perceptions of residents of the historic village of Caraíva, in Porto Seguro, Bahia, concluded that education was the most important factor influencing the concern about water quality and the potential risk of consuming water unfit for human health. The authors also indicated that other water sources and practices are adopted to minimise such risks, such as the purchase of mineral water, the consumption of water from shallow wells, springs, and piped water, in addition to filtering water obtained from alternative sources at home.

According to Tramontina and Carniatto (2019), the level of education also tends to directly influence environmental actions towards preservation; the higher the level of education, the greater the level of knowledge and environmental awareness of the individual.

It is important to emphasise that, in addition to formal education, public authorities can act in other ways to raise public awareness. The development of public policies that demonstrate the importance of environmental education is fundamental to creating a new mindset regarding the problems faced by society (Camara et al., 2019).

Sanitary education should also be developed outside schools, encompassing all social groups. Educational actions on health and hygiene, waterborne diseases, and ecosystem conservation should also be developed for the community through ongoing programmes and initiatives implemented by Health Units, Health Surveillance services, and the Department of the Environment.

It is necessary for the population to understand that the determining factor for water quality is environmental preservation (Silva et al., 2024), especially in the vicinity of water bodies, and, from this understanding, to develop awareness that they, as members of the community, are also part of the environmental conservation process.

Conclusions

The five water sources evaluated presented at least one parameter that did not comply with current legislation in at least one of the collected and analysed samples: pH, turbidity, colour, total Mn, total Fe, NO_3^-, and thermotolerant coliforms. The time of collection influenced the water quality of the sources, and variations in rainfall could cause changes in water parameters, highlighting the need for periodic evaluation of the water quality.

Regarding the perception of the population, it can be stated that there is confidence in the water quality of the sources, which means that preventive measures are not adopted during consumption. Organoleptic characteristics are decisive in the choices by the consumers, who mainly associate the absence of odour and taste with water that is suitable for consumption.

It is recommended that water potability analyses be conducted regularly and that public policies for the conservation of water sources be implemented to protect the population from the risks associated with the consumption of contaminated water. Additionally, awareness campaigns should be carried out to educate the public regarding the risks of water contamination, its health impacts, and the importance of adopting proper hygiene practices in water collection, storage, and disinfection.

Authors' Contributions

Ribeiro, L. M.: conceptualization; data curation; formal analysis; investigation; methodology; validation; writing – original draft. **Paiva**, R. F. P. S.: conceptualization; formal analysis; methodology; supervision; validation; writing – review & editing. **Santos**, F. S.: formal analysis; funding; methodology; project administration; supervision; validation; writing – review & editing.

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