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WATER QUALITY OF THE DISTRIBUTION SYSTEMS OF THE MUNICIPALITIES OF AFONSO CLÁUDIO, BREJETUBA AND IBATIBA, ESPÍRITO SANTO, BRAZIL

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ABSTRACT

The control of the quality of the water to be consumed by the population is an extremely important activity, the water treatment process presents as a necessary condition for the adequacy of the quality established by the norm, therefore, the control of diseases. The objective of the study is to evaluate and compare the water quality of the distribution network of the Water Supply Systems (SAAs), of the Surveillance Program of the Quality of Water for Human Consumption (VIGIÁGUA) with the data of the Espírito Santo Basic Sanitation Company (CESAN) in the municipalities of Afonso Cláudio, Brejetuba and Ibatiba. The study is a descriptive research, with a quantitative approach that involves an analysis of secondary data on drinking water quality, obtained from the https://www.gov.br and https://www.cesan.com.br sites in the period from 2017 to 2022. For the parameters free residual chlorine, turbidity, total coliforms and Escherichia coli, it is observed that the numbers of samples outside the VIGIÁGUA standard are higher than those of the provider (CESAN) for
the free residual chlorine parameter, as for turbidity in a context of comparison, it is found that annually the VIGIÁGUA sampling presented non-standard results in 2022 and that of the provider CESAN are within the standards established in all the years studied.
When analyzing the data for the parameter Total coliforms, practically every year there was the presence of total coliforms in the samples taken, but for the E. coli parameter it is possible to see that only in 2022 in the data provided by the provider CESAN was there a

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presence in the municipalities of Brejetuba and Ibatiba. From the analysis of the data, it is found that there are some non-conformities in the parameters of quality and potability of the water distributed in the municipalities with the 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.

Keywords: VIGIÁGUA. CESAN. Water Quality. Public Supply. Water Supply Systems.

INTRODUCTION

Waterborne microorganisms have fecal-oral contamination as their main route of contamination, being disseminated in the water from its contamination with untreated or inadequately treated sewage. Thus, the control of the quality of the water to be consumed by the population is an extremely important activity (TORTORA, 2017). The water treatment process is a necessary condition for the adequacy of the quality established by the standard, therefore, the control of diseases (BRASIL, 2006). The actions of surveillance and control of the quality established by current legislation, and, therefore, fundamental to the control of diseases of water for human consumption, are implemented in the Health Surveillance sector (BRASIL, 2004).

The Surveillance Program for the Quality of Water for Human Consumption (VIGIAGUA), since its foundation in Brazil by the Ministry of Health, has been building several goals and objectives based on strategic actions, aiming to ensure the development of actions for monitoring the quality of water for human consumption by states and municipalities (BRASIL, 2006). Environmental health surveillance related to the quality of water for human consumption should ensure health benefits, guaranteeing the population access to water in quantity and quality. In view of the above, it is important to carry out studies on the coverage of the Quality of Water for Human Consumption (VIGIÁGUA) in the municipalities to effectively ensure the quality of the water supplied to the population.

According to Fontes et al. (2019), the inclusion of water quality data in the Water Quality Surveillance Information System (SISÁGUA) is a fundamental condition for achieving the objectives of VIGIÁGUA, such as systematically monitoring monitoring, informing the population about water quality, health risks and its management, promote health education, social mobilization and define action strategies.

On the other hand, there is also the monitoring of providers. The main company responsible for the water supply in Espirito Santo is Companhia Espirito Santense de Saneamento básico (CESAN), a mixed-capital company, privately held and has the State of Espírito Santo as the majority shareholder. Of the 78 municipalities in Espírito Santo, CESAN has a contract with 53 for the provision of water collection, treatment and distribution, collection and treatment services

METHODOLOGY

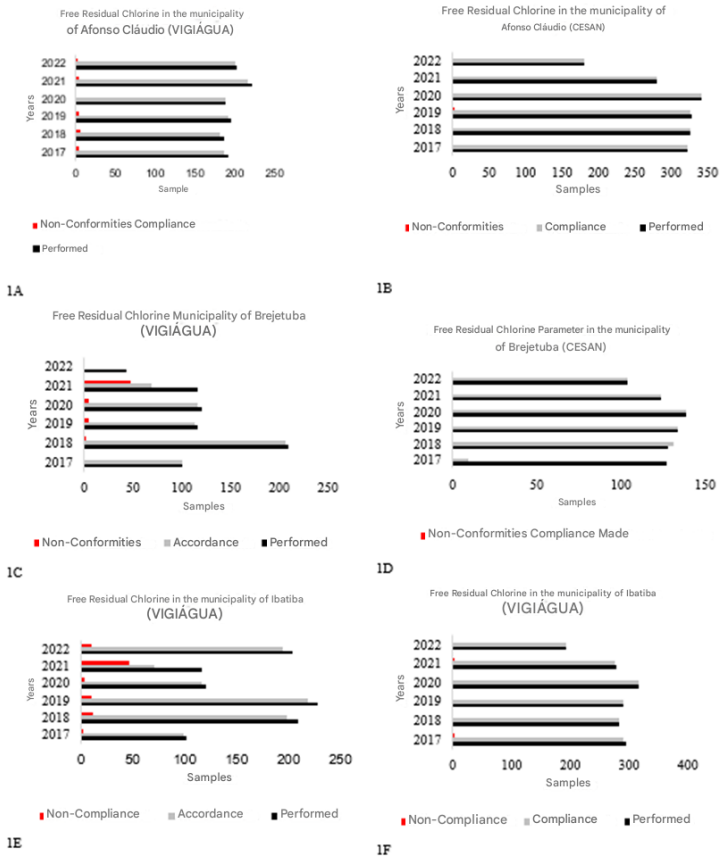
The study is a descriptive research, with a quantitative approach that involves an analysis of secondary data on drinking water quality, obtained in the https://dados.gov.br/dados/busca?termo=sisagua and

https://informacoes.cesan.com.br/servicos/minha-agua/qualidade-da-agua/ in the period from 2017 to 2022. The study was carried out in three municipalities in the south of Espírito Santo, because they have characteristics of small cities, the same provider responsible for water supply, and similar demographic characteristics, namely Afonso Cláudio, Brejetuba and Ibatiba.

For data analysis, electronic spreadsheets were used, which were worked on, to extract the data of interest. They were downloaded per year studied, from 2017 to 2022. And within the spreadsheets of each year, the target municipalities of the study were selected. The data from the provider CESAN were downloaded and edited in electronic spreadsheets to obtain the results. It is important to note that SISÁGUA also receives data from the Collective Supply Systems (SAC) and that environmental or health surveillance monitors them as well as in the water supply system. The Individual Water Supply Systems (SAI) are monitored by surveillance through collections carried out by the VIGIÁGUA program. The present study will not evaluate quantitative data from the SAC and SAI.

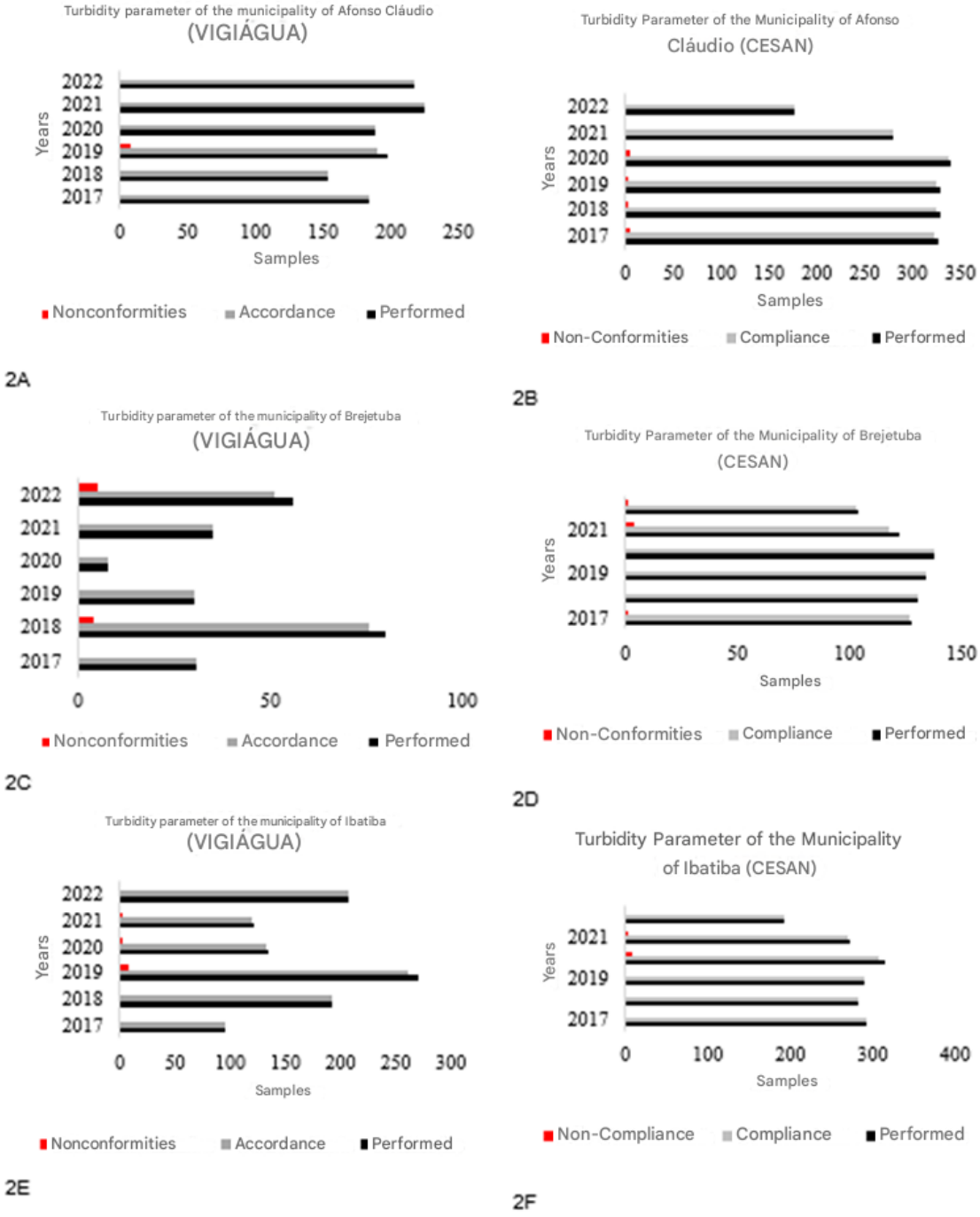
RESULTS

Figure 1 – Results of the compliance of water samples collected in the public supply network in the municipalities of Afonso Cláudio (1st) and (1B), Brejetuba (1C) and (1D) and Ibatiba (1E) and (1F), in the years 2017 to 2022, for the Free Residual Chlorine parameter of the VIGIÁGUA program and the CESAN Provider.



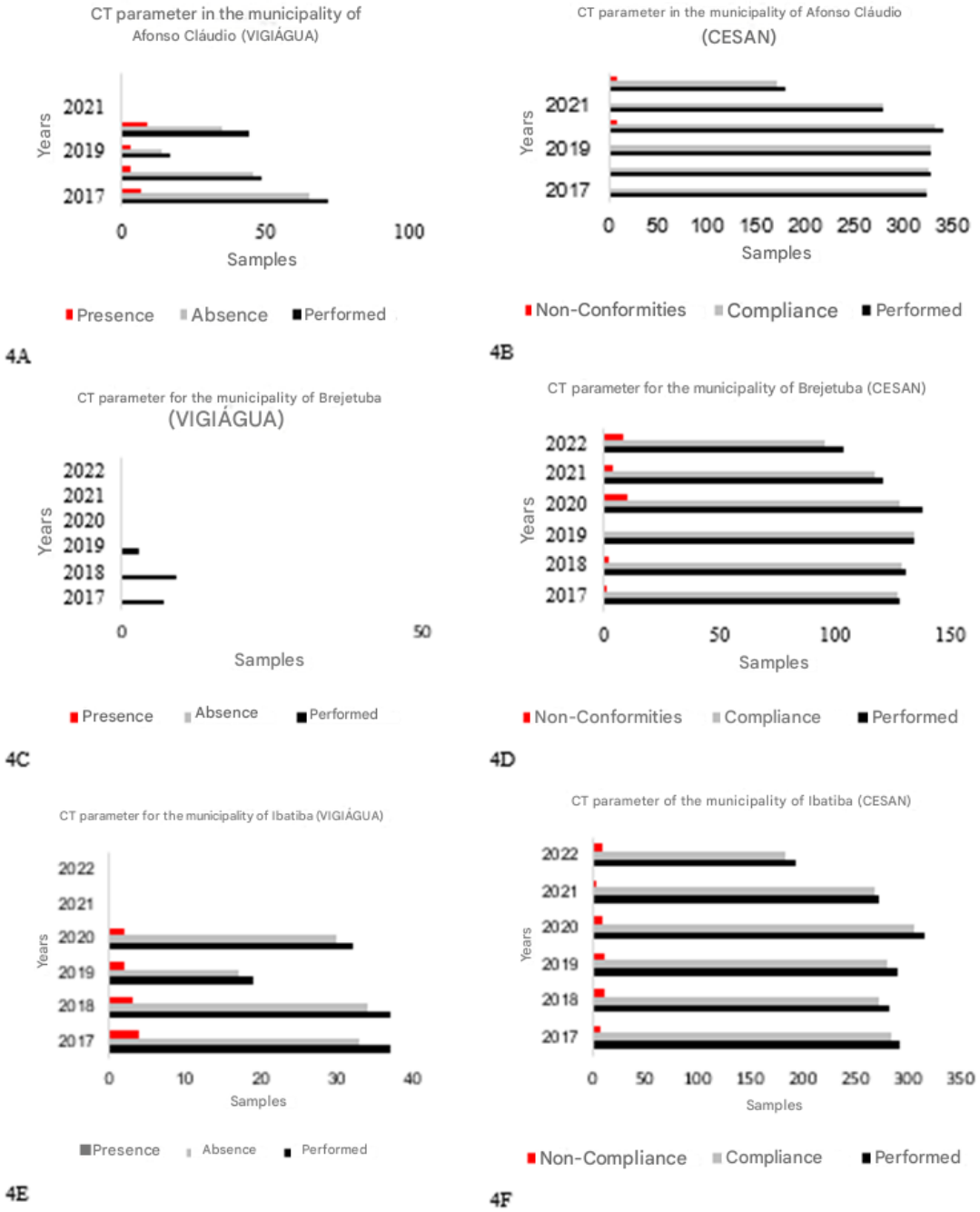
Source: The Author, 2023.

Figure 2 - Results of the compliance of the water samples collected in the public supply network in the municipalities of Afonso Cláudio (2A) and (2B), Brejetuba (2C) and (2D) and Ibatiba (2E) and (2F), in the years 2017 to 2022, for the turbidity parameter of the VIGIÁGUA Prestadora CESAN program.



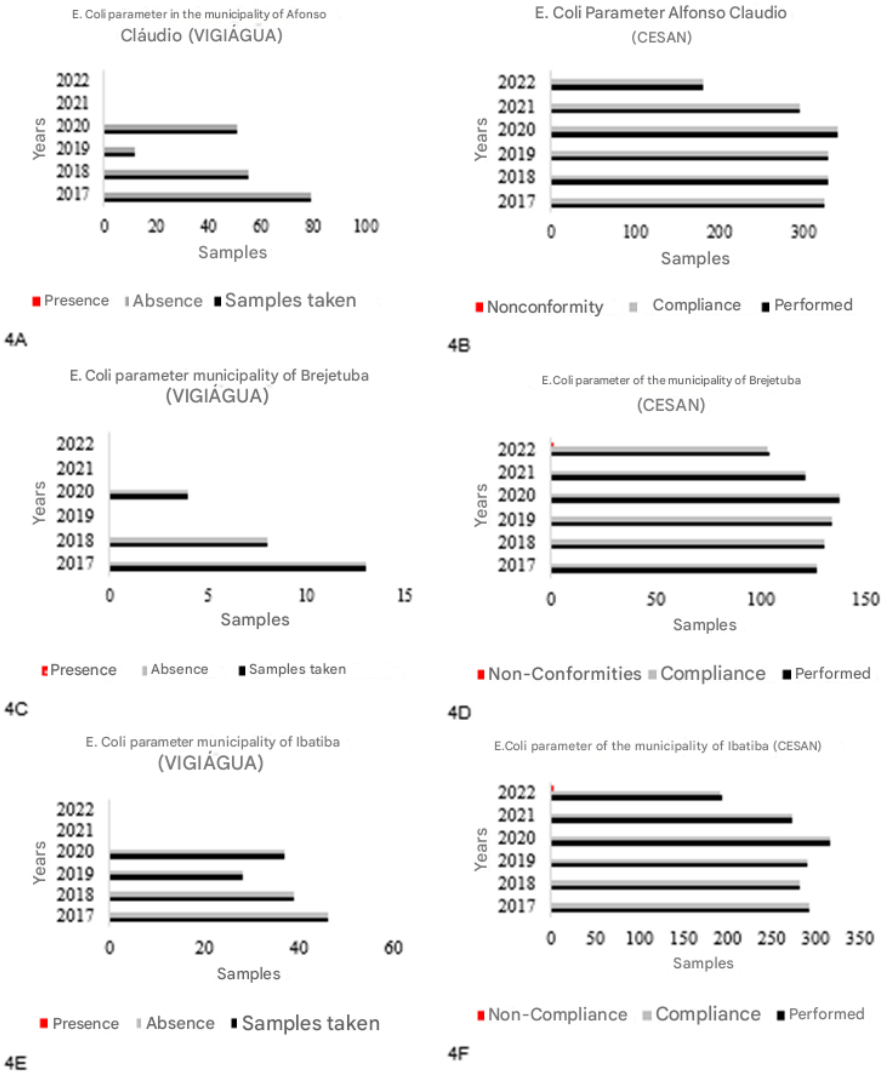
Source: The Author, 2023.

Figure 3 - Results of the compliance of the water samples collected in the public supply network in the municipalities of Afonso Cláudio (4A) and (4B) Brejetuba (4C) and (4D) Ibatiba (4E) and (4F), in the years 2017 to 2022, for the Total Coliforms (TC) parameter of the VIGIÁGUA Prestadora CESAN program.



Source: The Author, 2023.

Figure 4 - Results of the compliance of the water samples collected in the public supply network in the municipalities of Afonso Cláudio (4A) and (5B), Brejetuba (5C) and (5D) and Ibatiba (5E) and (5F), in the years 2017 to 2022, for the *E. Coli parameter* of the VIGIÁGUA Prestadora CESAN program.



Source: The Author, 2023.

DISCUSSION

It is observed in Figures 1A, 1C and 1E, that, in all the years sampled, the three municipalities presented samples outside the standard required by Ordinance No. 888/2021 (BRASIL, 2021), with non-compliance rates ranging from 2.09% to 2.67% for Afonso Cláudio, 0.95 to 58.97% for Brejetuba and 1.98 to 67.70% for Ibatiba, respectively.

According to Ordinance No. 888/2021 (BRASIL, 2021), in the distribution system, the minimum concentration of free residual chlorine (CRL) established for the potability standard is 0.20 mg/L and the minimum residual present in the water throughout the distribution network cannot exceed 2.00 mg/L.

This ordinance also recommends that points located in vulnerable stretches of the distribution system such as network ends, pressure drop points, places affected by maneuvers, subject to intermittent supply and reservoirs, may present problems with low

CRL (BRASIL, 2021). When looking at the results of the analyses for the years 2021 in the municipalities of Brejetuba and Ibatiba, Figures 1C and 1E show a high percentage of samples in non-compliance. It is important to emphasize that values above can cause rejection by the population due to the manifestation of taste and odor in the water and, consequently, the search for unsafe alternative sources (BRASIL, 2016), while values below can indicate failures in the disinfection process and the need for secondary chlorination points due to the extension of the distribution network. According to Costa et al., (2015), studies point to reasons that allow substances to enter the system, such as repairs and connections in pipes, old cast iron pipes, cleaning and maintenance of the system, and the quality of raw water. In addition to the CRL due to the reaction with substances, other factors also reduce it, such as the time of detention in reservoirs, the number of network branching points and the speed of flow.

From the point of view of the monitoring of the provider CESAN, in Figures 1B and 1D it is possible to observe that all samples did not present irregularities, while in Figure 1F, it is observed that in the municipality of Ibatiba in 2017 1.36% and in 2021 0.71%, presented non-conformities. In Figures 1A, 1C, 1E and Figures 1B, 1D, 1F it is observed that the numbers of samples outside the standard of the VIGIÁGUA program are higher than those of the provider CESAN. It should be noted that the monitoring carried out by the VIGIÁGUA program, the days of collection are not known to the water providers of the municipalities, which suggests that the providers on the days of monitoring the sampling plan of the same, can maintain a more effective control of the CRL in their distribution network.

When comparing the monitoring of the respective municipalities studied, it is observed that all of them have non-conformities for VIGIÁGUA, while in the monitoring carried out by CESAN only in the municipality of Ibatiba presented results outside the standard required by Ordinance No. 888/2021 (BRASIL, 2021).

As for the turbidity parameter, Figure 2A shows that in 2019 alone, 4.04% of the samples presented results outside the standard established by Ordinance No. 888/2021 (BRASIL, 2021). Figure 3C shows that turbidity in 2018 presented 5.00% of the annual samples and in 2022 8.92% of the samples analyzed by the VIGIÁGUA program presented unsatisfactory results, the change in turbidity, due to levels above 5 uT act as a shelter for pathogenic organisms, protecting them from the action of the disinfectant agent (BRASIL, 2016), which can bring other non-conformities in the distribution network for other associated parameters. Thus, the turbidity pattern is a component of the microbiological pattern of water potability, as high turbidity values, at the same time, indicate inefficiency of

filtration in the removal of microorganisms and reduce the guarantee of efficiency of disinfection in the distribution network (SOUZA, 2010). Turbidity, by itself, does not characterize pollution in water (SOUZA, 2010), but in treated water, turbidity assumes the function of a sanitary indicator and not merely an aesthetic one, being also an indicator of control of the efficiency of disinfection, in the understanding that suspended particles can protect microorganisms from action (COSTA et al., 2015). Figure 3E shows that the results vary between 2.45% and 2.96% of the samples with unsatisfactory results. According to Ordinance No. 888/2021 (BRASIL, 2021), the established limit is 5.0 uT at any point in the distribution network, but a maximum of 5% of the samples collected in the year may present irregularities (BRASIL, 2016).

When analyzing the monitoring carried out by CESAN, it is observed in Figure 2B that there was only a variation from 0.96% to 2.28% of the samples presented a percentage outside the standard of 5 uT, considering that the limit established by the ordinance and 5% of the samples analyzed, they are acceptable. It can also be seen in Figure 2C, that there is a variation from 2.46% to 2.96% and in Figure 2F the samples presented the same characteristics as the other municipalities, with a variation of 0.34% to 3.29%.

When analyzing in the context of comparison between the collections carried out by the VIGIÁGUA program and by the provider CESAN, it is found that annually the sampling plans of VIGIAGUA presented non-standard results in the year 2022 and that of the provider CESAN is within the standards established by Ordinance No. 888/2021 (BRASIL, 2021).

In relation to the municipalities studied, it was understood that all municipalities in the study series presented non-standard results in at least one year.

In this sense, it is important to emphasize that high turbidity can hinder the disinfection process, as the particles related to this indicator can protect microorganisms from the action of the disinfectant.

In the analyses for total coliforms for the period from 2017 to 2022, it is possible to observe in Figure 3A that in the years 2017 to 2020, there was the presence of total coliforms in the samples collected, in Figure 3C, it is observed that there were no samples with the presence of coliforms and in Figure 3E, it is verified that 2017 and 2020 there was the presence of coliforms in the entire series studied, It is observed that in the years 2021 and 2022 there were no data in the gov.br database in all the municipalities studied.

For Samples carried out by CESAN, in Figure 3B, it is observed that only in the years 2020 and 2022, there was the presence of total coliforms in the samples collected for those years. The presence of total coliforms in the analyzed samples must be evaluated by

environmental surveillance in the sampling context as it is an indicator parameter of the integrity of the distribution system (BRASIL, 2021).

The presence of total coliforms is not a favorable indication of fecal contamination, as this group includes several genera and species of bacteria, under normal conditions, coliforms are not, by themselves, pathogenic, but some strains or the proliferation of these microorganisms can cause diseases (BETTEGA et al., 2006).

The coliform group is divided into total coliforms and thermotolerant or fecal coliforms (MACÊDO, 2002). Total coliforms (TC) and thermotolerant coliforms are the most commonly used indicators of contamination to monitor the sanitary quality of water. Microbiological analyses will indicate the presence or absence of total coliforms and fecal coliforms, which may or may not be pathogenic (BETTEGA et al., 2006).

In water quality control, when samples with positive results for total coliforms are detected, even in presumptive tests, corrective actions must be taken and new samples must be collected on immediately successive days until they reveal satisfactory results.

In view of the above, the public sectors responsible for the management of VIGIÁGUA, if they identify in their monitoring samples with the presence of E. *Coli*, they must request clarification from the provider responsible for the distribution systems as soon as possible, through the letter, and carry out a new collection on site, after the measures taken, if it is necessary to even request that the water supply be interrupted until the problem is solved (BRASIL, 2021). By observing Figures 3A, 3C, 3E and 3B, 3D, 3F, it was understood that in the municipality of Brejetuba there was no presence of total coliforms in the analyzed samples, however it is possible to understand in Figure 3C that there is no monitoring in that municipality, but for the data from the provider CESAN, the monitoring is complied with and the presence of total coliforms in the samples is observed. When analyzing the data from the VIGIÁGUA program in comparison with data from the provider CESAN, practically every year there was the presence of total coliforms in the samples performed.

As for *E. coli,* it is possible to understand in Figures 4A, 4C, 4E and 4B, 4D, 4F, that only in 2022 in the data made available by the provider CESAN there is the presence of *E. coli,* in the municipalities of Brejetuba and Ibatiba. The etiological agent most frequently isolated in cases of waterborne diseases in humans and in different animal species is *E. Coli* (PIEPER and PLESTSCH, 2014).

According to the provider CESAN (2023), when any analytical result is outside the standard established by Ordinance No. 888/2021 annex XX (BRASIL, 2021), the provider takes the following measures, the quality control laboratory immediately communicates the

company's operational sector, where network discharges are made, that is, through existing records in the distribution network, The water is allowed to run to clean the pipe, there is the occurrence of any interference near the point where the sample was collected with unsatisfactory results, new samples are collected and analyzed to verify if the procedures have given results, measures are taken until the quality of the water is restored.

Drinking water must comply with microbiological standards, and water for human consumption must be free of E. coli, treated water at the treatment outlet must be free of total coliforms, the distribution system must be free of *E. coli* and in collective alternative systems or solutions that supply less than 20,000 inhabitants, only one sample, among the samples examined in the month, may present a positive result, while in the case of SAAs that supply 20,000 inhabitants or more, there is an absence in 100 mL in 95% of the samples examined in the month (BRASIL, 2011).

From the analysis of the selected data, it is found that there are some non-conformities in the parameters of quality and potability of the water distributed in the municipalities 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, the difficulties in implementing and structuring VIGIÁGUA in the municipalities were found, as referred to by Guerra (2018) in a study carried out in Rio de Janeiro and by Palmeira et. al (2019), which evaluated the results of the VIGIÁGUA sampling plan of 38 cities in the Midwest of São Paulo. In Brazil, there is a growing concern about the quality of water supply, especially with the aspect of surveillance, in view of the risks to the population represented by microbiological and chemical contaminants. There is also a concern with the aesthetic aspects related to the consumption of waters, especially those related to the taste of these waters, which leads to an increasing consumption of bottled waters, both mineral and desalinated waters.

Data released by the Ministry of Health state that for every R$ 1.00 (one real) invested in the basic sanitation sector, R$ 4.00 (four reais) is saved in curative medicine (BRASIL, 2006). Thus, it is important that the public authorities and societies together develop actions so that good quality water reaches each family, controlling the diseases that afflict humanity.

CONCLUSION

This study made it possible to deepen knowledge about the quality of the water supplied collectively, in the form of water supply, showed that there are difficulties in

controlling the basic parameters, free residual chlorine, turbidity and total coliforms and *E. coli.* However, although the results indicate an improvement in water quality in some municipalities, it is important to emphasize that high turbidity values should always be understood as a threat, especially when referenced by the occurrence of total coliforms and *E. coli*. The need, made explicit in Ordinance No. 888/2021, for drinking water quality surveillance services to carry out a systematic and permanent risk assessment of each water supply system is an important challenge to the health sector.

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