

**WATER CONTAMINATION ASSOCIATED WITH THE USE OF RUDIMENTARY
SEPTIC PITS: STATISTICAL ANALYSIS OF WATER QUALITY DATA IN
ITIQUEIRA-MT (2019–2023)**

**CONTAMINAÇÃO HÍDRICA ASSOCIADA AO USO DE FOSSAS
RUDIMENTARES: ANÁLISE ESTATÍSTICA DE DADOS DE QUALIDADE DA
ÁGUA EM ITIQUEIRA-MT (2019–2023)**

**CONTAMINACIÓN HÍDRICA ASOCIADA AL USO DE FOSAS RUDIMENTARIAS:
ANÁLISIS ESTADÍSTICO DE DATOS DE CALIDAD DEL AGUA EN ITIQUEIRA-
MT (2019–2023)**

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ABSTRACT

This study analyzes the impacts of rudimentary cesspit use on the quality of water intended for human consumption in the municipality of Itiquira–MT, based on data collected by environmental surveillance between 2019 and 2023. A total of 547 water sample results were evaluated, considering the parameters free residual chlorine, turbidity, pH, total coliforms, and *Escherichia coli*. Data were statistically processed using Jamovi software, allowing identification of temporal and spatial contamination patterns. Results indicated a recurrent presence of *E. coli*, peaking in 2021 (24.6% of samples). It is concluded that rudimentary cesspits significantly contribute to water contamination, reinforcing the need for public sanitation policies and preventive actions.

Keywords: Basic Sanitation. Water Contamination. *Escherichia Coli*. Statistical Analysis. Public Health.

RESUMO

Este estudo analisa os impactos do uso de fossas rudimentares na qualidade da água destinada ao consumo humano no município de Itiquira–MT, com base em dados coletados pela vigilância ambiental entre 2019 e 2023. Foram avaliados 547 resultados de amostras de água, considerando os parâmetros cloro residual livre, turbidez, pH, coliformes totais e *Escherichia coli*. Os dados foram tratados estatisticamente no software Jamovi, permitindo identificar padrões temporais e espaciais de contaminação. Os resultados indicaram presença recorrente de *E. coli*, com pico em 2021 (24,6% das amostras). Conclui-se que as fossas rudimentares contribuem significativamente para a contaminação hídrica, reforçando a necessidade de políticas públicas de saneamento e ações preventivas.

Palavras-chave: Saneamento Básico. Contaminação da Água. *Escherichia Coli*. Análise Estatística. Saúde Pública.

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RESUMEN

Este estudio analiza los impactos del uso de fosas rudimentarias en la calidad del agua destinada al consumo humano en el municipio de Itiquira–MT, con base en datos recolectados por la vigilancia ambiental entre 2019 y 2023. Se evaluaron 547 resultados de muestras de agua, considerando los parámetros de cloro residual libre, turbidez, pH, coliformes totales y *Escherichia coli*. Los datos fueron tratados estadísticamente en el software Jamovi, lo que permitió identificar patrones temporales y espaciales de contaminación. Los resultados indicaron la presencia recurrente de *E. coli*, con un pico en 2021 (24,6% de las muestras). Se concluye que las fosas rudimentarias contribuyen significativamente a la contaminación hídrica, lo que refuerza la necesidad de políticas públicas de saneamiento y acciones preventivas.

Palabras clave: Saneamiento Básico. Contaminación del Agua. *Escherichia Coli*. Análisis Estadístico. Salud Pública.

1 INTRODUCTION

Basic sanitation is essential for public health, especially in small municipalities with deficient infrastructure. In Itiquira-MT, the absence of a sewage system with treatment results in the predominant use of rudimentary cesspools. This scenario favors the infiltration of contaminants into the soil, aquifers and the drinking water distribution system to the population, representing a risk of waterborne diseases. The objective of this article is to analyze water quality monitoring data in the municipality between 2019 and 2023 and relate the results to the presence of rudimentary cesspools.

2 METHODOLOGY

The study is characterized as quantitative and descriptive, using secondary data from the environmental surveillance of the municipality of Itiquira-MT. Between 2019 and 2023, 547 water samples collected in 12 neighborhoods and in the district of Ouro Branco do Sul were analyzed. The parameters evaluated were:

- Free Residual Chlorine (CRL);
- Turbidity (TU);
- pH;
- Total Coliforms (TC);
- *Escherichia coli* (EC).

The data were processed in the Jamovi software to calculate descriptive statistics and frequencies, with presentation of results in tables and graphs that allowed the evaluation of the conformity of the results achieved with the goals proposed by the Municipal Plan for Basic Sanitation and Sustainable Development Goal 6 - SDG 6.

3 RESULTS

The Municipal Basic Sanitation Plan (PMSB) of Itiquira-MT is a fundamental instrument for the planning and management of sanitation services in the municipality, covering water supply, sanitary sewage, solid waste management and urban drainage. Established by Municipal Law No. 994, of November 13, 2017, the PMSB aims to ensure the protection of public health and the healthiness of the urban and rural environment.

Water Supply (SAA): The Water Supply System in Itiquira faces challenges related to infrastructure and municipal management. The research by Vasconcelos (2018) highlights

the need for investments to ensure the quality and regularity of the supply of drinking water to the population.

However, the absence of an efficient basic sanitation system in Itiquira – MT causes some problems such as: wastewater running on the streets, in the rainwater galleries, in addition to the fact that rudimentary cesspools are often installed on the sidewalks and close to the water supply networks, representing a direct risk to public health and the environment. The contamination of the water table, associated with the inadequate construction of these cesspools, compromises urban springs and rivers, putting at risk not only the supply of drinking water, but also the biodiversity and environmental balance of the region.

3.1 DISTRIBUTION OF SAMPLES

The number of samples varied annually, with a peak in 2019 and 2023 (119) and a lower volume in 2022 (89). The spatial distribution covered all neighborhoods and catchment points, as shown in table 01 below.

Table 1

Number of samples analysed for CE and TC (2019–2023)

Neighborhoods	Real estate	Samples 2019	Samples 2020	Samples 2021	Samples 2022	Samples 2023	Samples Total
Itiquira (Centro) – B1	1493	56	32	24	19	20	151
Ouro Branco do Sul – B2	1323	00	16	29	20	34	99
Jd. Planalto – B3	509	12	11	07	09	08	47
Stº Antônio – B4	235	14	07	15	10	15	61
Poxoréo – B5	205	09	10	13	11	15	58
Goiás – B6	138	07	09	13	08	14	51
Arco Ires I – B7	82	05	02	02	04	07	20
Jd Natal – B8	75	00	04	01	02	03	10
Arc Ires II – B9	52	05	02	04	02	01	14
Coohab Apoená – B10	49	06	08	03	02	02	24
Villa I – B11	164	00	00	00	02	00	02

João de Barros – B12	57	05	07	01	0	00	13
TOTAL	4.325	119	108	112	89	119	547

Source: Prepared by the author (2024).

The neighborhood with the highest representativeness (chart 01) was the Center (Itiquira – B1), with a total of 151 samples, corresponding to approximately 27.6% of the total. Next are the neighborhoods of Ouro Branco do Sul (B2) with 59 samples, and Santo Antônio (B4) with 61 samples. Other neighborhoods such as Poxoréo (B5) and Goiás (B6) also presented significant amounts of samples, totaling 58 and 51 analyses, respectively.

The samples analyzed (Environmental Surveillance 2019 – 2023) comply with the national guideline of the sampling plan – basic parameters that include the information system for monitoring the quality of water for human consumption, which is responsible for carrying out a minimum quantity of ten monthly samples of each parameter (total coliforms, *Escherichia coli*, free residual chlorine, turbidity and pH), in addition to five monthly fluoride samples, which will not be analyzed in this work because the municipal agency does not perform analysis for this parameter.

3.2 PHYSICOCHEMICAL AND MICROBIOLOGICAL PARAMETERS

The analysis of the results of biological tests is essential to ensure the quality of water intended for human consumption, as it allows the presence of microorganisms and substances potentially harmful to health to be assessed. This evaluation plays a crucial role in several aspects, such as the detection of microbiological contamination, as biological assays identify bacteria, viruses, protozoa, and other pathogenic microorganisms that can cause diseases such as gastroenteritis, hepatitis A, and cholera. The presence of fecal coliforms, for example, indicates contamination by sewage and the need for corrective measures.

The analysis revealed that, despite pH and turbidity values often within the standards, the detection of coliforms and *E. coli* was recurrent.

- ✓ Free residual chlorine: fluctuations associated with operational failures in chlorination.
- ✓ Turbidity: occasional increases in rainy periods.
- ✓ pH: variation within the recommended range, with few exceptions.
- ✓ Total Coliforms: significant presence at several points.
- ✓ *E. coli*: highest incidence in 2021.
- ✓ Tables 01 to 15: Descriptive statistics and frequencies (2019 to 2023)

Frequent analyses allow you to quickly identify the source of contaminants, enabling effective corrective actions to protect water resources. Table 1 below presents the descriptive statistics for three variables: CRL, TU and PH. In addition, the Shapiro-Wilk normality test was performed, whose results (W statistic and p-value) are also indicated, with the exception of the variable TU, for which it was not possible to calculate the test, resulting in "NaN" values.

Analyzing table 2 based on the description of the data for the N (number of cases), the TU was the one with the highest number of cases with 93 values not omitted, while the pH had 91 followed by the CRL with 81, however, all the values presented by the variable (TU) were 0 (zero) which may mean that in this period the water was completely transparent, that is, it did not contain suspended particles detectable by the measuring instrument. Another relevant data in this table, regarding the minimum and maximum values, is noteworthy that the pH variable obtained results lower than 6 (six).

Table 2
Descriptive Statistics, 2019

	N	Silent	Average	Median	Standard deviation	Minimum	Maximum	Shapiro-Wilk	
								W	p
CRL	81	75	0.671	0.610	0.371	0.160	1.99	0.884	<.001
YOU	93	63	0.000	0.000	0.000	0.000	0.00	Nan	Nan
ph	91	65	6.435	6.550	0.752	2.120	7.78	0.832	<.001

Source: Data organized by the author and analyzed in the Jamovi software (2024).

The frequency table in Jamovi is an important tool in data analysis, as it organizes and summarizes categorical or discrete variables, showing the distribution of data in terms of frequency. Overall, this table is essential to better understand the data and is an initial step in many exploratory statistical analyses. Thus, tables 3 and 3 of frequency will be presented below, referring to the variables of total coliforms (TC) and Escherichia coli (EC).

Table 3

CT A and P frequencies, 2019

CT	Counts	% of Total	Cumulative %
The	109	91.6 %	91.6 %
P	10	8.4 %	100.0 %

Source: Data organized by the author and analyzed in the Jamovi software (2024).

Table 4 of total coliform frequencies indicates the frequency distribution for two identified groups: "A" for absence and "P" for the presence of pathogenic bacteria in the water samples collected in 2019 in the municipality studied. Group "A" has 109 counts, representing 91.6% of the total. Group "P" has 10 counts, representing 8.4% of the total.

Table 4

EC A and P frequencies, 2019

EC	Counts	% of Total	Cumulative %
The	116	97.5 %	97.5 %
P	3	2.5 %	100.0 %

Source: Data organized by the author and analyzed in the Jamovi software (2024).

In the analysis of table 4 of frequency presented for *Escherichia coli* cases, there is a predominance of absence (A): the overwhelming majority of the cases analyzed correspond to the absence of *E. coli*, with 116 occurrences, representing 97.5% of the total. This demonstrates that the presence of this bacterium is rare in the dataset. Only 3 cases (or 2.5%) have the presence of *E. coli*, indicating that this condition is uncommon. The accumulated frequency reaches 100% after adding the two values (A and P), which confirms the completeness of the data.

Considering that the biological analysis of water is an indispensable tool for the management of water quality, ensuring that the water consumed is safe, promoting public health and contributing to the sustainability of natural resources. Table 5 will be presented below with the descriptive statistics of the results of the biological trials for the year 2020.

Table 5

Descriptive Statistics, 2020

	N	Silent	Average	Median	Standard deviation	Minimum	Maximum	Shapiro-Wilk	
								W	p
CRL	49	61	0.734	0.2000	1.070	0.0500	2.80	0.596	<.001
YOU	90	20	0.228	0.0400	0.381	0.0000	1.50	0.652	<.001
ph	80	30	6.470	6.3950	0.739	2.9000	7.80	0.886	<.001

Source: Data organized by the author and analyzed in the Jamovi software (2024).

The analysis of Table 5, which presents descriptive statistics for the variables free residual chlorine (CRL), turbidity (TU) and pH, provides important information on the quality of water for human consumption. Main points can be highlighted such as: free residual chlorine (CRL): average: 0.734 mg/L, with a median of 0.2 mg/L; standard deviation: 1.070, indicating high variation in chlorine levels; minimum and maximum values: 0.05 mg/L to 2.80 mg/L; Shapiro-Wilk $p < 0.001$ indicates that the distribution is not normal. The high standard deviation suggests instability in the levels of residual chlorine, which can compromise the safety of the water consumed, as chlorine is important to ensure proper disinfection.

As for turbidity (TU), the average is 0.228, with a median of 0.04; standard deviation: 0.381, reflecting moderate variations; minimum and maximum values: the NTU at 1.50; and Shapiro-Wilk $p < 0.001$ shows that the distribution is also not normal. High turbidity values may indicate the presence of suspended particles that protect pathogenic microorganisms, compromising water quality.

The average pH was 6.470, with a median of 6.395; standard deviation: 0.739, indicating smaller variations in comparison with the other variables; minimum and maximum values: 2.90 to 7.80; and Shapiro-Wilk $p < 0.001$ points to a non-normal distribution. The average pH is within the recommended by Brazilian legislation (between 6 and 9.5), but the minimum value (2.90) is extremely acidic and may indicate a serious problem in some samples.

Table 6 shows the frequencies of total coliforms (TC) in samples of water intended for human consumption, highlighting two categories: A (Absent) and P (Present). The detection of total coliforms is an essential parameter for the evaluation of water quality, since their presence can indicate failures in the treatment processes or contamination during distribution.

Table 6

CT A and P frequencies, 2020

CT	Counts	% of Total	Cumulative %
The	74	69.8 %	69.8 %
P	32	30.2 %	100.0 %

Source: Data organized by the author and analyzed in the Jamovi software (2024).

When analyzing table 6, the absence of Total Coliforms (A) represents 74 counts (69.8% of the total). Indicates that most of the monitored samples are within the desired standards for drinking water. As for the presence of Total Coliforms (P), it corresponds to 32 counts (30.2% of the total). This percentage suggests a significant concern, since approximately one third of the samples have microbiological contamination, indicating potential risks to human health. Table 06 of the frequency of absence and presence of the *E. coli* variable for the year 2020 will be presented below.

Based on table 7, it can be highlighted that, in the absence of *E. coli* (A), there were 101 counts (93.5% of the total). This high percentage indicates that most water samples conform to microbiological quality standards, without the presence of *E. coli*. The presence of *E. coli* (P) had only 7 counts (6.5% of the total). Although this percentage is small, the presence of *E. coli* is a critical indicator of fecal contamination and poses a significant risk to public health, even in small amounts.

Table 7

EC A and P frequencies, 2020

EC	Counts	% of Total	Cumulative %
The	101	93.5 %	93.5 %
P	7	6.5 %	100.0 %

Source: Data organized by the author and analyzed in the Jamovi software (2024).

Based on the idea that the analysis of the results of biological tests is crucial for monitoring the quality of water intended for human consumption, as they allow the identification of the presence of pathogenic microorganisms, such as bacteria (*Escherichia coli*), which can cause diseases. Table 8 will be shown below with the descriptive statistics of the free residual chlorine, turbidity and pH variables referring to the results of the samples collected in 2021.

Table 8

Descriptive Statistics, 2021

	N	Silent	Average	Median	Standard deviation	Minimum	Maximum	Shapiro-Wilk	
								W	p
CRL	151	8	0.7113	0.2900	0.8984	0.0000	3.000	0.708	<.001
YOU	157	2	0.0843	0.0400	0.0908	0.0400	0.780	0.533	<.001
ph	149	10	7.4854	7.4000	0.9673	0.4300	8.800	0.822	<.001

Source: Data organized by the author and analyzed in the Jamovi software (2024).

Analyzing the main relevance of Table 8 on the quality of water used for human consumption, observe the following points: the mean free residual chlorine (CRL) was 0.7113 mg/L, with a standard deviation of 0.8984, the amplitude ranged from 0 mg/L (minimum) to 3 mg/L (maximum), and the Shapiro-Wilk normality test indicates that the CRL data do not follow a normal distribution. High variability may suggest inconsistencies in water monitoring or treatment. The value 0 may indicate the absence of disinfection in some points; the turbidity (TU) had a mean of 0.0843, with a standard deviation of 0.0908, the amplitude ranged from 0.04 to 0.78 and the Shapiro-Wilk test, indicating the absence of normal distribution. Turbidity was at low levels (within the recommended limits), but variability may be relevant to identify episodes of temporary increase in suspended solids; as for pH, the mean was 7.4854, standard deviation of 0.9673, the amplitude ranged from 4.3 to 8.8 and the Shapiro-Wilk test, indicating absence of normality.

Although the average value is close to the ideal (between 6.5 and 8.5 according to quality standards), the minimum value (4.3) suggests episodes of extreme acidity, which can compromise the quality of the water and the safety of consumption. The non-normality of the distributions indicates the need to use nonparametric statistical methods for subsequent analyses. Values outside the acceptable standards for free residual chlorine and pH can indicate problems in the water treatment system or failures in monitoring. The high variability in some measurements suggests the need for more rigorous investigation and control to ensure the consistency and safety of the water supply.

Table 08 shows the frequencies of total coliforms, with (A) indicating the absence and (P) the presence of bacterial indicators.

Table 9

CT A and P frequencies, 2021

CT	Counts	% of Total	Cumulative %
The	66	57.9 %	57.9 %
P	48	42.1 %	100.0 %

Source: Data organized by the author and analyzed in the Jamovi software (2024).

The analysis of Table 9 reveals important data on the presence of total coliforms (TC) in samples of water intended for human consumption, where: the absence contains 66 cases, representing 57.9% of the total, did not present total coliforms; and the presence appears with 48, corresponding to 42.1%, detected the presence of total coliforms.

Regarding the relevance of the data regarding water quality, the striking fact that 42.1% of the samples presented total coliforms is worrisome, indicating a potential risk to public health, since the presence of these microorganisms may indicate evidence of fecal contamination.

In the distribution, most samples are within acceptable standards (57.9% with absence of TC), but the percentage of contamination is still significant. In monitoring, the data reinforce the need to intensify corrective and preventive measures, such as water disinfection and maintenance of supply systems, to ensure the safety of the water consumed.

Table 10 represents the frequencies of *E. coli* resulting from the analysis of the results of biological tests carried out in 2021, which aimed to monitor the quality of water used for human consumption.

Table 10

EC Frequencies, 2021

EC	Counts	% of Total	Cumulative %
The	86	75.4 %	75.4 %
P	28	24.6 %	100.0 %

Source: Data organized by the author and analyzed in the Jamovi software (2024).

Analyzing table 10, the following relevant points are shown for the monitoring of the quality of water for human consumption: as for the absence (A) of *E. coli*, it is recorded in 86 samples, which represents 75.4% of the total. This indicates that most of the water samples analyzed are free of the presence of this bacterium, which suggests generally safe conditions for human consumption; in the presence (P) of *E. coli* was detected in 28 samples, corresponding to 24.6% of the total. This percentage is worrisome, as it indicates a significant amount of contaminated samples, representing a risk to public health.

Table 11 presents the descriptive statistics of the free residual chlorine, turbidity, and pH variables for the year 2022.

Table 11
Descriptive Statistics, 2022

								Shapiro-Wilk	
	N	Silent	Average	Median	Standard deviation	Minimum	Maximum	W	p
CRL	87	2	1.4291	1.3800	0.57789	0.3500	2.8000	0.965	0.018
YOU	89	0	0.0506	0.0500	0.00921	0.0400	0.0800	0.848	<.001
PH	89	0	7.5034	7.5000	0.50485	6.3000	8.8000	0.991	0.821

Source: Data organized by the author and analyzed in the Jamovi software (2024).

Based on table 11, which presents the essential descriptive statistics for monitoring the quality of water used for human consumption, analyzing the variables free residual chlorine (CR), turbidity (TU) and pH. Being able to highlight the main relevant points such as:

1 - The free residual chlorine (CR) had a mean of 1.429 mg/L, a median of 1.38 mg/L, a standard deviation of 0.5778 mg/L, a minimum and maximum of 0.35 mg/L to 2.80 mg/L, and the Shapiro-Wilk normality test: $W = 0.96$, $p = 0.01$. Based on the data, the average concentration of residual chlorine is within the recommended standards for water disinfection (usually between 0.2 and 2.0 mg/L). High variability (standard deviation of 0.5778) may indicate fluctuations in disinfection levels over time. The p -value < 0.05 in the Shapiro-Wilk test suggests that the data do not follow a normal distribution.

2 - In turbidity (TU) the mean was 0.056 mg/L, the median 0.050 mg/L, the standard deviation: 0.0092 mg/L, the minimum and maximum: 0.04 mg/L to 0.08 mg/L, Shapiro-Wilk normality test: $W = 0.84$, " p " < 0.001 . It can be interpreted that the average turbidity is well

below the maximum limit allowed for human consumption (usually ≤ 5 , according to WHO and Brazilian standards). The low standard deviation indicates little variation in the data, suggesting a good stability in the water quality in terms of turbidity. The Shapiro-Wilk test indicates that the data do not follow a normal distribution ($p < 0.001$).

3 - In pH, the mean was 7.503, the median 7.50, the standard deviation 0.5048, the minimum and maximum 6.30 to 8.80, and the Shapiro-Wilk normality test $W = 0.99$, $p = 0.82$. This indicates that the average pH value is within the recommended range for drinking water (usually between 6.5 and 8.5). The moderate standard deviation suggests a variation within acceptable limits. The Shapiro-Wilk test shows that the data follow a normal distribution ($p > 0.05$).

Thus, residual chlorine and turbidity showed a non-normal distribution, while pH followed a normal distribution. The average values of chlorine, turbidity and pH are within the recommended standards for human consumption. The greater variation in chlorine levels may indicate the need for more rigorous monitoring to ensure efficiency in disinfection. The turbidity remains low and stable, suggesting a good efficiency in water treatment and the pH is well balanced, with no worrying variations. These results indicate that water quality is within acceptable standards, but continuous monitoring of residual chlorine may be necessary to avoid excessive variations in disinfection.

Table 12 below shows the frequency of total coliforms with results (A) for absence and (P) for the presence of bacteria, with the quantities and percentages referring to the results of biological tests for the year 2022.

Table 12

CT A and P frequencies, 2022

CT	Counts	% of Total	Cumulative %
The	74	83.1 %	83.1 %
P	15	16.9 %	100.0 %

Source: Data organized by the author and analyzed in the Jamovi software (2024).

By analyzing table 12 of total coliform (TC) frequencies in water samples collected in the municipality of Itiquira-MT in 2022. The data indicate that, of the 89 samples analyzed, 74 (83.1%) showed absence of total coliforms (A), while 15 (16.9%) showed presence (P).

Table 13 shows the frequencies of *Escherichia coli* with results (A) for absence and (P) for the presence of bacteria, with the quantities and percentages referring to the results of the biological tests for the year 2022.

Table 13

EC A and P frequencies, 2022

EC	Counts	% of Total	Cumulative %
The	88	98.9 %	98.9 %
P	1	1.1 %	100.0 %

Source: Data organized by the author and analyzed in the Jamovi software (2024).

Table 13 presents the frequencies of *Escherichia coli* (EC) in water samples collected in the municipality of Itiquira-MT in 2022. The data indicate that, of the 89 samples analyzed, 88 (98.9%) showed absence of *E. coli* (A), while only 1 sample (1.1%) showed presence (P).

Table 14 presents the descriptive statistics of the variables free residual chlorine, turbidity and pH referring to the results of the biological tests for the year 2023, fundamental parameters for the evaluation of the quality of water for human consumption.

Table 14 shows the descriptive statistics of the variables free residual chlorine (CRL), turbidity (TU) and pH in the monitoring of the quality of water for human consumption in the municipality of Itiquira-MT, based on 119 samples collected in 2023.

Table 14

Descriptive Statistics, 2023

								Shapiro-Wilk	
	N	Silent	Average	Median	Standard deviation	Minimum	Maximum	W	p
CRL	119	0	1.7570	1.8900	0.6368	0.2100	2.800	0.952	<.001
YOU	119	0	0.0629	0.0500	0.0550	0.0400	0.580	0.307	<.001
ph	119	0	7.7311	7.7000	0.6665	6.7000	8.900	0.910	<.001

Source: Data organized by the author and analyzed in the Jamovi software (2024).

Analyzing the free residual chlorine (CRL) variables: the mean was 1.757 mg/L, median 1.890 mg/L, standard deviation 0.6368 mg/L, minimum 0.210 mg/L, maximum 2.800 mg/L and the normality test (Shapiro-Wilk): $W = 0.952$, " p " < 0.001. In this case, the CRL is within the recommended standards for drinking water disinfection (0.2 to 2.0 mg/L, according to Ordinance GM/MS No. 888/2021). However, there is significant variation in the values and the distribution is not normal ($p < 0.001$); turbidity (TU) had a mean of 0.0629, a median of 0.0500, a standard deviation of 0.0550, a maximum of 0.580, and a normal test (Shapiro-Wilk): $W = 0.307$, $p < 0.001$. Therefore, the average turbidity is well below the upper limit of 5.0 for human consumption. Low variability indicates that the water is being well treated in relation to the removal of suspended particles. However, the data does not follow a normal distribution; and finally, the pH had a mean of 7.7311, the median 7.7000, the standard deviation 0.6665, the minimum 6.7000, the maximum 8.9000 and the normality test (Shapiro-Wilk): $W = 0.910$, " p " < 0.001. Showing that the average pH is within the recommended range (6.0 to 9.5). The distribution shows slight variation, but with values within acceptable limits for consumption.

The parameters analyzed indicate that the water quality in Itiquira-MT in 2023 is within the standards required for human consumption. Free residual chlorine varies, but remains within limits. Turbidity is low, suggesting good efficiency in water treatment. The pH is within the recommended levels. None of the variables follows a normal distribution, according to the Shapiro-Wilk test.

Table 15 presents the total coliform frequencies referring to the results of biological tests for the year 2023.

The analysis of Table 15 of Total Coliform Frequencies reveals important information about the microbiological quality of water in the municipality of Itiquira-MT in 2023. The main points to be highlighted are:

Table 15

CT A and P frequencies, 2023

CT	Counts	% of Total	Cumulative %
The	90	75.6 %	75.6 %
P	29	24.4 %	100.0 %

Source: Data organized by the author and analyzed in the Jamovi software (2024).

1. Predominance of Absence of Contamination: category "A" (Absence of total coliforms) was identified in 90 samples, representing 75.6% of the total. This indicates that most of the samples analyzed met the quality standards required for drinking water.

2. Presence of Contamination in Part of the Samples: category "P" (Presence of total coliforms) was found in 29 reports, corresponding to 24.4% of the total. This percentage may be worrisome, as it indicates that almost a quarter of the samples showed microbiological contamination.

3. Accumulated Percentage: the accumulated percentage of 100% confirms that all samples were classified between the two categories mentioned, with no intermediate values.

4. Relevance to Public Health and Sanitation: the fact that 24.4% of the samples had total coliforms may indicate treatment failures or contamination in certain areas of the municipality. This outcome may require corrective measures, such as inspecting supply sources, improving chlorination, or maintaining distribution networks.

Table 15

EC A and P frequencies, 2023

EC	Counts	% of Total	Cumulative %
The	118	99.2 %	99.2 %
P	1	0.8 %	100.0 %

Source: Data organized by the author and analyzed in the Jamovi software (2024).

Table 16 presents the distribution of the frequencies of absence (A) and presence (P) of the bacterium *Escherichia coli* (*E. coli*) in the year 2023, indicating the number of occurrences, the percentage in relation to the total, and the accumulated percentage obtained from the data analysis.

The analysis of Table 16 of *Escherichia coli* (EC) Frequencies provides essential information on the microbiological quality of water in the municipality of Itiquira-MT in 2023. The main points to be highlighted are:

1. *Low Presence of E. coli Contamination*: category "A" (Absence of *E. coli*) was identified in 118 samples, corresponding to 99.2% of the total. This data indicates that the vast majority of the samples analyzed meet the standards of potability, suggesting good sanitary conditions of the water.

2. *Only 1 sample showed contamination*: category "P" (Presence of *E. coli*) was found in only 1 sample, representing 0.8% of the total. This result is positive, as the presence of *E. coli* is directly associated with fecal contamination, which can pose risks to public health.

3. *Cumulative Percentage*: the cumulative percentage of 100% confirms that all samples were classified as absent or present of *E. coli*, with no intermediate variations.

4. *Relevance to Public Health and Water Quality*: the fact that almost all samples are free of *E. coli* suggests that the water treatment and distribution system in Itiquira-MT is working properly. However, the detection of a contaminated sample indicates that there may be isolated sources of contamination, which requires attention to avoid risks of outbreaks.

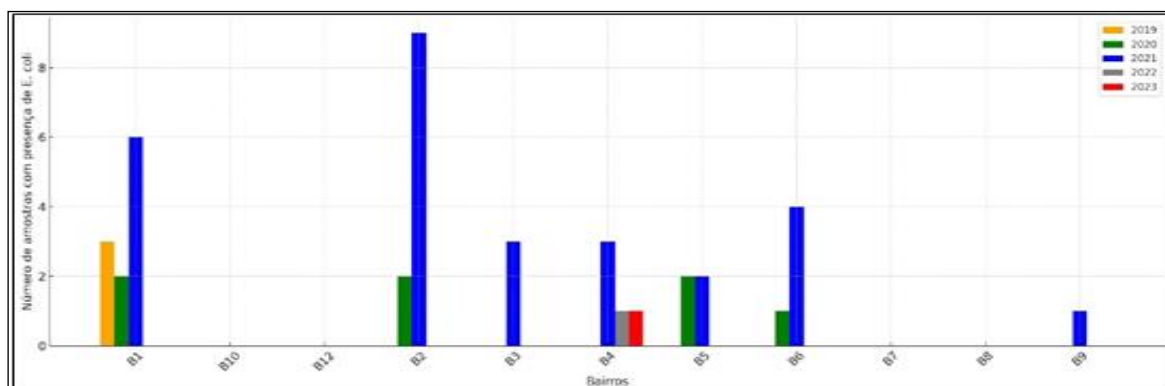
3.3 TEMPORAL TRENDS

In order to understand the temporal and spatial distribution of microbiological contamination of water intended for human consumption, Graph 01 was prepared, which presents the consolidated data regarding the presence of the *Escherichia coli* bacterium in the neighborhoods of the municipality of Itiquira-MT, in the period from 2019 to 2023. The choice of this variable is due to the fact that *E. coli* is widely recognized as an indicator of recent fecal contamination, whose presence in water samples represents a potential risk to public health.

Figure 1 allows the comparative visualization between the different years and neighborhoods, facilitating the identification of critical areas and the recurrence of cases, thus constituting a fundamental tool for environmental diagnosis and the formulation of health control and prevention strategies.

Figure 1

Temporal and spatial distribution of E. coli contamination from 2019 to 2023



Prepared by the author (2025).

Based on Graph 01, the analysis of the presence of *Escherichia coli* in the water samples collected in the neighborhoods of the municipality of Itiquira-MT, in the period from 2019 to 2023, shows significant variations in its spatial and temporal occurrence. In 2019, only neighborhood B1 had positive cases, while in 2020, the expansion of contamination was observed to neighborhoods B2, B5 and B6. The year 2021 concentrated the highest number of records, with emphasis on neighborhoods B2 ($n = 9$) and B1 ($n = 6$), demonstrating a worsening in the quality of the water distributed. In the years 2022 and 2023, although there was a reduction in occurrences, the identification of consecutive cases in the B4 neighborhood indicates the possibility of a persistent focus of contamination.

In view of this scenario, it is recommended to intensify microbiological monitoring, inspect the supply infrastructure and adopt corrective measures in places with recurrence, in order to ensure the potability of water and the protection of public health, according to the parameters established by current legislation.

The recurrence of *E. coli* and total coliforms, even with acceptable levels of chlorine in some cases, indicates post-treatment contamination, probably associated with infiltration from black pits located near pipes and wells. Studies by Fagundes & Andrade (2005) and FUNASA (2013) corroborate the relationship between rudimentary systems and the degradation of water quality.

4 CONCLUSION

Analysis of the results of biological assays demonstrates a significant variation in the detection of *Escherichia coli* (*E. coli*) over the years. In 2019 and 2020, the incidence was relatively low, with rates of 2.52% (3/119) and 6.48% (7/108), respectively. However, in

2021, a significant increase was observed, with 28 cases in 114 samples, representing a rate of 24.56%, which may indicate an outbreak or an environmental factor favorable to contamination and data (Annex) from the Epidemiological Surveillance of the municipality studied, points out that there were 195 cases of acute diarrheal disease notified during this year that may be directly related to the increase in *E. coli* in the samples of water used for human consumption. In subsequent years, there was a sharp drop, with only 1 case in 89 samples analyzed in 2022 (1.12%) and 1 case in 119 results in 2023 (0.84%).

This trend suggests that after the 2021 peak, corrective measures may have been successfully implemented, resulting in reduced contamination in the following years. According to the water and sewage department, the possible causes of the 2021 increase are associated with network ruptures and irregularities between the sewage system (rudimentary cesspool) and the water system, as many residents do not obey the necessary distance, however, it was evident in the result of the analysis that there was an inefficiency in water treatment, Specifically chlorination, in which some samples showed zero results, which may contribute to the increase of the aforementioned bacterium, but improvements in the water supply network and in the treatment system ensured the reduction of cases of presence of the aforementioned bacterium in subsequent years.

The results show that the use of rudimentary cesspools in Itiquira-MT is directly related to the microbiological contamination of the water. It is recommended:

- Gradual replacement by septic tanks or sewage system.
- Continuous and georeferenced monitoring of supply sources.
- Strict supervision regarding the minimum distance between cesspools and wells.
- Educational actions with the community.

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