Asia Pacific Academy of Science Pte. Ltd.

Advances in Analytic Science 2025, 6(1), 3804.
https://doi.org/10.54517/aas3804

Article

Assessment of the drinking water quality in the municipality of Vinto-Cochabamba-Bolivia

Abdiel Adriazola Muriel*, Vanessa Nancy Toro Coca, Abigail Condori Mamani, Raquel Orellana Guevara, Moria Villca Chuquichambi

Universidad Adventista de Bolivia, Cochabamba 528, Bolivia
*** Corresponding author:** Abdiel Adriazola Muriel, abdiel.adriazola@uab.edu.bo

CITATION

Adriazola Muriel A, Toro Coca VN, Condori Mamani A, et al. Assessment of the drinking water quality in the municipality of Vinto-Cochabamba-Bolivia. Advances in Analytic Science. 2025; 6(1): 3804. https://doi.org/10.54517/aas3804

ARTICLE INFO

Received: 5 January 2025
Accepted: 17 February 2025
Available online: 24 February 2025

Abstract: Since coliform bacteria can raise the risk of infectious diseases in the most susceptible groups, their presence in water poses a possible concern to public health. When the physicochemical and microbiological quality of the water is uncertain, the situation becomes more complex. This study aims to assess the drinking water quality in three Territorial Base Organizations (TBOs) of the Municipality of Vinto-Cochabamba as well as the link between the TBOs and the microbiological parameters. According to Bolivian Standard 512 (NB 512), laboratory analyses of 30 samples collected from various residences (10 samples per TBO) demonstrate compliance with the upper limits of allowable values for physicochemical parameters (pH, conductivity, alkalinity, and hardness). The microbiological parameters were subjected to chi-square analysis, showing enough evidence to confirm with 95% confidence that the results of total and heat-resistant coliforms do not depend on the TBO ($p = 0.36$). By comparing the results of household water consumption with those of water supplied, it can be hypothesized that contamination of microbiological origin occurs either in the distribution pipes, household tanks, and/or the water use practices of each household. Of the 30 samples analyzed, only 11 met the maximum permissible limit for total coliforms, whereas 25 of the 30 samples met the maximum permissible limit for total coliforms.

Keywords: water; quality; coliforms; pollution; heat resistant

1. Introduction

According to Gioda [1], in his work “Brief history of water”, humanity has considered water to be an unchangeable element for millennia. When the world was essentially rural, water was not an economic good, as it was available at no cost or at a very low cost.

This situation is no longer entirely commonplace. Currently, the norm is for private and/or public services to transport water to end consumers’ homes using distribution networks and/or pipes. Similarly, both distributors and consumers often have little knowledge about the quality of the water they consume.

Reyes et al. [2] consider environmental pollution to be one of the most important problems affecting society in the 21st century as a result of an exponential increase in the loss of air quality, water resources, and soil available for agricultural activities. Drinking water is essential to health, and its availability is a basic human right. Around the world, efforts are constantly being made to improve its availability, distribution, and, above all, its quality [3].

Pérez et al. [4] and Vildozo et al. [5] agree that water quality is one of the most important factors for human well-being, health, and development. It is necessary to classify water based on purity and contamination through the evaluation of physicochemical characteristics such as pH, conductivity, alkalinity, hardness, and microbiological evaluation, using indicator organisms such as total and fecal coliform bacteria.

The main risks to human health associated with the consumption of contaminated water are microbiological in nature, as they are responsible for 80% of all infectious diseases and more than a third of deaths in developing countries. Microbiologically contaminated water causes acute diarrheal diseases (ADDs) [5–7].

In this regard, many studies have been conducted to determine the quality of water for human consumption, including a study by Pérez et al. [4], who performed a comparative analysis of Water Quality Indices. Applied to the Ranchería River, La Guajira. Peer consistency was analyzed using Spearman's correlation coefficient and the root mean square error. The results show that there is better correlation and fewer deviations in the case of raw indices. The research concludes that the water from the Ranchería River should not be used for direct contact without prior treatment and, before human consumption, requires purification processes, especially rigorous disinfection. This is due to the high concentrations of coliform organisms that favor the presence of diseases in human health. As can be seen, the analysis of water pollution is important for the community, especially for the establishment of measures to improve its quality.

The article published by Pérez-López [8], "Quality control of water for human consumption in the Western Region of Costa Rica", showed very favorable results, as the water samples comply with the current regulations in that country regarding water quality. It should be noted that the alkalinity parameters of two regions, San Ramón and San Carlos, exceed the permitted parameters, so necessary actions will have to be taken in these cases, although this parameter is not covered by the current regulations in that country.

Studies on water quality have not been limited to the international level; there are also studies conducted at the national level, such as those by Vildozo et al. [5], who conducted research on the preliminary diagnosis of the bacteriological quality of water for human consumption and the evaluation of priority corrective measures in the municipality of Poopó (Oruro, Bolivia). Bacteriological monitoring revealed the presence of total coliforms in 82% of the samples and thermotolerant coliforms in 48%. In conclusion, greater intervention is required to eliminate bacterial contamination, considering that rural communities self-manage water resources and are highly exposed to health risks that affect the quality of life of the population.

In a study on the microbiological quality of water in the town of Fortaleza del Suroeste in Cochabamba, eight samples were randomly taken from the taps of 4 homes. The first 4 samples were taken in April 2013, and the next 4 in May 2017. The results show that the water quality is poor. Pseudomonas aeruginosa, total mesophilic bacteria, and total coliform bacteria were found. These results do not meet the minimum requirements established by Bolivian Standard NB 512, as they exceed the maximum permissible limits for microbiological evaluation [3].

This is not only a problem in large capital cities but also a problem in developing cities, such as the municipality of Vinto, Bolivia.

Vinto, the fourth municipal section of the province of Quillacollo, is located 17 km from the city of Cochabamba and only 4 km from Quillacollo. The basic sanitation department of the municipality of Vinto is responsible for providing water services to the municipality's population, including households within our service area. Distribution is carried out through a water supply system consisting of deep wells, which are extracted by submersible pumps that in some cases feed into an elevated tank and in others directly into the systems of the municipal drinking water service provider (EPSA). Subsequently, the water distribution manager distributes the water every other day to the different Territorial Base Organizations (TBOs) (Autonomous Municipal Government of Vinto).

However, since water is sourced from different deep wells, it is difficult to determine the quality of the water consumed in the municipality of Vinto. Therefore, the Adventist University of Bolivia, in its commitment to its community, conducted this study to assess the current state of drinking water quality in three TBOs and the relationship between microbiological parameters and the TBOs. It is essential to monitor aspects such as potability, the presence of fecal coliforms, alkalinity, conductivity, hardness, and pH, as contaminants come from different human practices that affect water quality and, therefore, all activities and organisms that depend on it.

2. Methodology

This research is a descriptive, quantitative, cross-sectional, non-experimental study conducted between September and October 2022. The study was carried out in three TBOs in the municipality of Vinto (Campos Verdes, Alto Mirador, and Lazarte), from which 10 samples were collected per TBO. For the collection of samples, non-probabilistic and systematic sampling was carried out. The samples were transferred to the Microbiology Laboratory of the Biochemistry Department of the Adventist University of Bolivia, where physicochemical parameters (pH, conductivity, alkalinity, and hardness) and microbiological parameters (total coliforms and thermoresistant coliforms) were evaluated.

2.1. Sample collection

Samples were collected in accordance with Bolivian Standard NB 496:2016 (Drinking water - Sampling, Second revision) [9], in accordance with subsection 7.1, which describes the sampling procedure for microbiological parameters, and subsection 7.2 for physicochemical parameters.

Samples for physicochemical and microbiological parameters were taken from the first taps in the homes (previously flamed for 10 s) and placed in sterile glass bottles of 250 and 500 mL, respectively. The samples taken were identified and transported, maintaining the cold chain. Both the microbiological and physicochemical samples were processed within 2 h of collection.

2.2. Physicochemical analysis

The pH was determined in accordance with Bolivian Standard NB 31001:2014 (electrometric method) [10] using the HANNA HI 2210 potentiometer; conductivity was determined in accordance with NB 31011:2016 [11] using the ELE International conductivity meter; alkalinity by titration using the HI3811 kit (Hanna Instruments alkalinity test kit) [12]; hardness by titration using the HI3812 kit (Hanna Instruments hardness test kit) [13].

2.3. Microbiological analysis

The identification and counting of total and thermoresistant coliforms was carried out in accordance with Bolivian Standard NB 31006:2009 (Drinking water - Identification and enumeration of total coliform bacteria, heat-resistant coliforms, and escherichia coli - Most probable number method) [14].

For each sample, the presumptive test was performed in 15 tubes containing 10 mL of lauril tryptose broth (LTB) with inverted Durham tubes (5 tubes with double LTB concentration and 10 tubes with single concentration). 10 mL of the sample was inoculated into each tube with double LTB concentration, 1 mL of the sample into each of the 5 tubes with single LTB, and 0.1 mL of the sample into each of the remaining 5 single LTB tubes. All tubes were incubated at 35 °C ± 0.5 °C for 24 to 48 h ± 3 h. This was followed by confirmatory testing of the positive tubes (greater than or equal to 10% gas in the Durham tubes) by inoculation in brilliant green bile lactose broth (BGBLB) and incubation at 48 h for total coliforms and *E. coli* (EC) in a water bath at 44.5 °C ± 0.2 °C for 24 h for heat-resistant coliforms. All culture media were from the Liofilchem® brand. The results were interpreted according to compliance or non-compliance with the permissible limits of Bolivian Standard NB 512:2016 (Drinking water - Requirements) [15] (see **Table 1**).

Table 1. Results of the physical, chemical, and microbiological analysis of the water at TBO Campos Verdes.

Parameter	**Maximum permissible limits***	**Sample size**									
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
pH	6.5–9.0	7.28	7.46	7.22	7.2	7.25	7.09	7.57	7.63	7.48	6.95
Conductivity (µS)	1500	363	385	401	427	331	428	395	383	375	469
Alkalinity (mg/L $CaCO_3$)	370	158	132	105	132	108	138	129	117	123	132
Hardness (mg/L $CaCO_3$)	500	145.5	177	135	180	135	144	162	132	177	201
Total coliforms NMP/100 mL	< 2 NMP/100 mL	4	22	1600	4	4	< 2	4	2	4	< 2
Thermotolerant coliforms NMP/100 mL	< 2 NMP/100 mL	< 2	< 2	4	< 2	< 2	< 2	< 2	< 2	< 2	< 2

* *NB 512.*

2.4. Statistical analysis

The differences in microbiological parameters were subjected to qualitative statistical analysis using the chi-square statistical design in the SPSS v.25 statistical program to determine the dependence of variables. A $p < 0.05$ was considered to indicate significant differences.

3. Results

The following tables show the results of the parameters analyzed and their relationship with the maximum limit established by Bolivian Standard NB 512.

Table 1 shows that the 10 samples analyzed comply with the physicochemical parameters (pH, conductivity, alkalinity, and hardness). The microbiological analysis of total coliforms and thermoresistant coliforms shows deviations from the maximum permissible limit. 8 of the 10 samples in the study are outside the maximum permissible limits for total coliforms, and one of the 10 samples in the study is outside the maximum permissible limits for thermoresistant coliforms.

Table 2 shows that the 10 samples analyzed comply with the physicochemical parameters (pH, conductivity, alkalinity, and hardness). The microbiological analysis of total coliforms and thermoresistant coliforms shows deviations from the maximum permissible limit. 6 of the 10 samples in the study are outside the maximum permissible limits for total coliforms, and 3 of the 10 samples in the study are outside the maximum permissible limits for thermoresistant coliforms. As an additional analysis, the water from the tank that supplies the entire TBO was also analyzed, resulting in compliance with all maximum permissible limits for the parameters evaluated (the latter was not included as part of the statistical analysis).

Table 2. Results of the physicochemical and microbiological analysis of water from the Alto Mirador TBO.

Parameter	**Maximum permissible limits***	**Sample size**										**Tank**
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	
pH	6.5–9.0	7.22	7.2	7.33	7.67	8.27	7.75	7.26	7.78	7.49	7.71	**7.4**
Conductivity (µS)	1500	410	398	321	345	447	410	426	422	410	412	**328**
Alkalinity (mg/L $CaCO_3$)	370	150	141	114	144	138	144	150	144	147	135	**129**
Hardness (mg/L $CaCO_3$)	500	186	168	141	117	192	171	186	183	165	180	**120**
Total coliforms NMP/100 mL	< 2 NMP/100 mL	80	< 2	< 2	1600	2	< 2	140	300	< 2	240	**< 2**
Thermotolerant coliforms NMP/100 mL	< 2 NMP/100 mL	< 2	< 2	< 2	14	< 2	< 2	8	< 2	< 2	34	**< 2**

* *NB 512.*

Table 3 shows that the 10 samples analyzed comply with the physicochemical parameters (pH, conductivity, alkalinity, and hardness). The microbiological analysis of total coliforms and thermoresistant coliforms shows deviations from the maximum permissible limit. 5 of the 10 samples in the study are outside the maximum permissible limits for total coliforms, and one of the 10 samples in the study is outside the maximum permissible limits for thermoresistant coliforms.

Table 3. Results of the physicochemical and microbiological analysis of water from the Lazarte TBO.

Parameter	**Maximum permissible limits***	**Sample size**									
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
pH	6.5–9.0	7.25	7.2	7.22	7.98	7.36	7.16	7.04	6.86	7.29	7.49
Conductivity (µS)	1500	245	237	241	298	216	220	225	296	236	224
Alkalinity (mg/L $CaCO_3$)	370	135	141	150	120	135	165	135	135	150	117
Hardness (mg/L $CaCO_3$)	500	126	153	126	181	135	147	120	177	150	126
Total coliforms NMP/100 mL	< 2 NMP/100 mL	< 2	2	70	< 2	4	< 2	27	< 2	< 2	2
Thermotolerant coliforms NMP/100 mL	< 2 NMP/100 mL	< 2	< 2	4	< 2	< 2	<2	< 2	< 2	< 2	< 2

* *NB 512.*

Since the microbiological parameters (total coliforms, thermoresistant coliforms) showed deviations from the maximum permissible limit, they were subjected to chi-square statistical analysis. **Table 4** shows the number of samples and their compliance with the maximum permissible limits for the total coliforms parameter, with their chi-square statistical analysis in **Table 5**.

Table 4. Microbiological evaluation of total coliforms.

TBOs	**Compliance with maximum permissible limits**		**Total**
	Yes	**No**	
Campos Verdes	2 (20%)	8 (80%)	10 (100%)
Alto Mirador	4 (40%)	6 (60%)	10 (100%)
Lazarte	5 (50%)	5 (50%)	10 (100%)
Total	**11**	**19**	**30**

Table 5. Chi-square tests for total coliforms - TBOs.

	Valor	**df**	**Asymptotic significance (bilateral)**
Pearson's Chi-square	2.010*	2	0.366
Likelihood ratio	2.098	2	0.350
Linear by linear association	1.873	1	0.171
Number of valid cases	30		

* 3 boxes (50.0%) have expected a count less than 5. The minimum expected count is 3.67.

Table 4 shows compliance with the maximum permissible limits for total coliforms for the different TBOs. In Campos Verdes, 20% comply with the maximum permissible limits, and 80% do not comply with the maximum permissible limits. In Alto Mirador, 40% comply with the maximum permissible limits and 60% do not comply with the maximum permissible limits, and in Lazarte, 50% comply with the maximum permissible limits and 50% do not comply with the maximum permissible limits.

The results of the chi-square variable dependence analysis are presented in **Table 5**. These are established with an $\alpha = 0.05$ (95% confidence) for the hypotheses:

H0: The presence of total coliforms is independent of TBO (p-value > α, the null hypothesis is accepted).

H1: The presence of total coliforms is dependent on TBO (p-value < α, the alternative hypothesis is accepted).

Since the p-value (0.366) is greater than the significance level (0.05), the null hypothesis (H0) is accepted and the alternative hypothesis (H1) is rejected. There is sufficient evidence to conclude that the total coliform results do not depend on the TBO.

Table 6 shows the number of samples and their compliance with the maximum permissible limits for the thermoresistant coliforms parameter, with its chi-square statistical analysis in **Table 7**.

Table 6. Microbiological evaluation of heat-resistant coliforms.

TBOs	**Compliance with maximum permissible limits**		**Total**
	Yes	**No**	
Campos Verdes	9 (90%)	1 (10%)	10 (100%)
Alto Mirador	7 (70%)	3 (30%)	10 (100%)
Lazarte	9 (90%)	1 (10%)	10 (100%)
Total	**25**	**5**	**30**

Table 7. Chi-square tests for heat-resistant coliforms—TBOs.

	Valor	**df**	**Asymptotic significance (bilateral)**
Pearson's Chi-square	1.920*	2	0.383
Likelihood ratio	1.813	2	0.404
Linear by linear association	0.000	1	1.000
Number of valid cases	30		

* 3 boxes (50.0%) have expected a count less than 5. The minimum expected count is 1.67.

Table 6 shows compliance with the maximum permissible limits for thermoresistant coliforms for the different TBOs. In Campos Verde, 90% comply with the maximum permissible limits and 10% do not comply with the maximum permissible limits; in Alto Mirador, 70% comply with the maximum permissible limits and 30% do not comply with the maximum permissible limits; and in Lazarte, 90% comply with the maximum permissible limits and 10% do not comply with the maximum permissible limits.

The results of the chi-square variable dependence analysis are presented in **Table 7**. These are established with an $\alpha = 0.05$ (95% confidence) for the hypotheses:

H0: The presence of thermoresistant coliforms is independent of the TBO (p-value > α, the null hypothesis is accepted).

H1: The presence of thermoresistant coliforms is dependent on TBO (p-value < α, the alternative hypothesis is accepted).

Since the p-value (0.383) is greater than the significance level (0.05), the null hypothesis (H0) is accepted and the alternative hypothesis (H1) is rejected. There is sufficient evidence to conclude that the results for thermoresistant coliforms do not depend on the TBO.

4. Discussion

The tests analyzed drinking water samples from different TBOs in the municipality of Vinto (Campos Verdes, Alto Mirador, and Lazarte). Depending on the source of the water, the analyses showed different results. The purpose of the study was to establish whether the results of the analyses were in accordance with the requirements of Bolivian Standard NB 512:2016 (Drinking water - Requirements, Fifth Revision) and whether these results depended on the TBO.

The chi-square statistical analysis shows independence between the TBOs, and the results of the microbiological parameters reveal the presence of both total and thermoresistant coliforms, in greater or lesser proportions and with a marked difference between one household and another. It is tempting to relate the quality of drinking water to the quality of the water supply. However, analysis of the Alto Mirador TBO's main reservoir tank, where the water supply is received, shows that it complies with the maximum permissible parameters analyzed. Similarly, Choque Aguilar and Quispe Quisbert [3], in their article "Assessment of the risk of contamination and the quality of drinking water in self-managed wells in the central district of the municipality of Vinto, Cochabamba - Bolivia," present the results of the water analysis at the wellhead of the TBO Campos Verdes, where they conclude that the physical-chemical parameters analyzed comply with the permissible limits of NB 512, as well as the microbiological parameter of total coliforms, concluding that the water supplied at the TBO Campos Verdes is suitable for human consumption.

The discrepancy between the water supplied and the water consumed in the households included in the study suggests that microbiological contamination (total and thermoresistant coliforms) occurs either in the households, the household tanks, or the distribution pipes. This speculation is reinforced by Cobacho et al. [16] and Gómez Sellés et al. [17], who state that supply through tanks is a potential source of water contamination, in addition to other serious drawbacks.

The statement by the above authors has a deeper meaning with regard to cross-contamination, especially given the particularity of sample 3 in **Table 1**, where the result of 1600 total coliforms MPN/100 mL and 4 thermoresistant coliforms MPN/100 mL corresponds to a facility with a domestic tank and two water connections (one from the TBO's main network and the other from its own well). The study does not include an independent analysis of these connections, as both are connected to the domestic tank for subsequent consumption. However, sample 3 in **Table 1** is the only one of the 10 households that shows a very high presence of total coliforms compared to the rest of the households, as well as the presence of thermoresistant coliforms.

Although this study provides evidence that the water supplies of the Campos Verdes and Alto Mirador TBOs meet the established requirements for total coliforms and thermoresistant coliforms, this does not imply that all water supplies are in the same situation. The study by Barreto Bogado [18] conducted in the San Vicente neighborhood of the city of Pilar, Paraguay, shows that in a single neighborhood there can be different sources of supply, with and without treatment, and different microbiological qualities, where most of the sources of supply correspond to groundwater wells that may be more or less exposed to the presence of total and thermoresistant coliforms. The study by Gwimbi [19], conducted in the community of Manonyane, Lesotho, attributes the effects of total and thermoresistant coliform contamination to poor protection of water sources, poor sanitation and low levels of hygiene practices, and a lack of monitoring and awareness of healthcare. The protection of the water sources supplying the Campos Verdes TBO is also addressed by Choque Aguilar and Quispe Quisbert [20], who attribute a low level of contamination risk to it.

This study opens the door to further research on hygiene conditions in domestic tanks, distribution networks, and water sources in the different TBOs in the municipality of Vinto.

5. Conclusions

The drinking water from the three TBOs in the study (Campos Verdes, Alto Mirador, and Lazarte) complies with the physical-chemical parameters (pH, conductivity, alkalinity, and hardness), but not with the microbiological parameters (total coliforms and thermoresistant coliforms).

There is no correlation between the results of the parameters analyzed and the TBOs where the samples were taken, so the quality of drinking water cannot be linked to the TBO.

Microbiological contamination (total and thermoresistant coliforms) of drinking water cannot be linked to the quality of the water supply, given that there is evidence in two of the three TBOs that the water supply complies with the maximum permissible limits (NB 512) for the parameters of pH, conductivity, alkalinity, hardness, and total and thermoresistant coliforms. It can be speculated that microbiological contamination occurs either in the distribution pipes, household tanks, and/or water use practices in each household.

Author contributions: Conceptualization, AAM, VNTC, ACM, ROG and MVC; methodology, AAM and VNTC; validation: AAM and VNTC; formal analysis, AAM, VNTC, ACM, ROG and MVC; investigation, AAM, VNTC, ACM, ROG and MVC; resources, AAM and VNTC; writing—original draft preparation, AAM, VNTC, ACM, ROG and MVC; writing—review and editing, AAM, VNTC, ACM, ROG and MVC. All authors have read and agreed to the published version of the manuscript.

Acknowledgments: The authors thank the Autonomous Municipal Government of Vinto and the Adventist University of Bolivia for their support in developing this research.

Conflict of interest: The authors declare no conflict of interest.

References

1. Gioda A. Brief history of water (Spanish). La Naturaleza y sus Recursos. 1999; 35(1): 42–48.
2. Reyes YC, Vergara I, Torres O, et al. Heavy metals contamination: Implications for health and food safety (Spanish). Revista Ingeniería, Investigación y Desarrollo. 2016; 16(2): 66–77.
3. Cossio Andia E, Choque Soto N. Prospective study of the microbiological quality of water consumed by the population of Fortaleza - Cochabamba (Spanish). Cimel. 2019; 24(1): 44–88.
4. Pérez JI, Nardini AG, Galindo AA. Comparative analysis of water quality indices applied to the Ranchería River, La Guajira-Colombia (Spanish). Informacion Tecnologica. 2018; 29(3): 47–58. doi: 10.4067/S0718-07642018000300047
5. Vildozo LH, Peredo Ramírez Y, Vargas Elío F. Preliminary diagnostic of bacteriologic water quality of human consumption and corrective measures priority assessment in the municipality of Poopó (Oruro, Bolivia) (Spanish). Acta Nova. 2020; 9(4): 483–503.
6. Ramos Parra Y, Pinilla Roncancio M. Water quality for human consumption in rural supply systems in Boyacá, Colombia. An infrastructural analysis (Spanish). Un Análisis Infraestructural. Revista EIA. 2020; 17(34): 219–233. doi: 10.24050/reia.v17i34.1378
7. Rodríguez SC, Asmundis CL, Ayala MT, Arzú OR. Presence of microbiological indicators in water for human consumption in San Cosme (Corrientes, Argentina) (Spanish). Revista Veterinaria. 2018; 29(1): 9–12. doi: 10.30972/vet.2912779
8. Pérez-López E. Quality control of drinking water in the western region of Costa Rica (Spanish). Revista Tecnología En Marcha. 2016; 29(3): 3–14. doi: 10.18845/tm.v29i3.2884
9. Ibnorca. NB 496:2016 Drinking water - Sampling, Second review (Spanish). Bolivia; 2016.

10. Ibnorca. NB 31001:2014 (Drinking water - Determination of pH (hydrogen potential) - Electrometric method), Second review (Spanish). Bolivia; 2014.
11. Ibnorca. NB 31011:2016 (Drinking water- Determination of conductivity) (Spanish). Bolivia; 2016.
12. Hanna Instruments. HI3811 Alkalinity Test Kit Instruction Manual (Spanish). Available online: https://cdn.hannacolombia.com/hannacdn/support/manual/2012/10/20140707112234-manual-hi-3811.pdf (accessed on 3 January 2025).
13. Hanna Instruments. Instruction Manual HI 3812 Hardness Tester (Spanish). Available online: https://cdn.hannacolombia.com/hannacdn/support/manual/2019/09/Manual_HI3812.pdf (accessed on 3 January 2025).
14. Ibnorca. NB 31006:2009 (Drinking water - Identification and enumeration of total coliform bacteria, heat-resistant coliforms, and escherichia coli - Most probable number method) (Spanish). Bolivia; 2009.
15. Ibnorca. NB 512:2016 (Drinking water - Requirements) (Spanish). Bolivia; 2016
16. Cobacho R, Arregui F, Cabrera E, Cabrera E Jr. Private water storage tanks: Evaluating their inefficiencies. Water Practice and Technology. 2008; 3(1): 1–8. doi: 10.2166/wpt.2008.025
17. Gómez Sellés E, Cabrera Marcet E, Soriano Olivares J, Balaguer Garrigos M. Sustainable Water Management and Use of Domestic Cisterns: An Incompatible Binomial (Spanish). In: Proceedings of the 4th Conference on Water Engineering; 20–23 October 2015; Córdoba, Spain. pp. 859–868.
18. Barreto Bogado A. Determination of the variability of water quality for human consumption. Case: Bº San Vicente of the city of Pilar (in Spanish). Ciencia Latina Revista Científica Multidisciplinar. 2022; 6(3): 3239–3250. doi: 10.37811/cl_rcm.v6i3.2458
19. Gwimbi P. The microbial quality of drinking water in Manonyane Community: Maseru District (Lesotho). African Health Sciences. 2011; 11(3): 474–480.
20. Choque Aguilar MR, Quispe Quisbert LA. Evaluation of the risk of contamination and the quality of water for human consumption in self-managed wells in the central district of the municipality of Vinto, Cochabamba - Bolivia (Spanish). Ciencia Latina Revista Científica Multidisciplinar. 2023; 7(4): 4966–4981. doi: 10.37811/cl_rcm.v7i4.7325