

## Comparative study of the physicochemical and microbiological parameters of two artesian wells in the community of San Pedro, Frontera, Centla, Tabasco

### Estudio comparativo de los parámetros fisicoquímicos y microbiológicos de dos pozos artesianos en la comunidad de San Pedro, Frontera, Centla, Tabasco

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#### Abstract

The scarcity, mismanagement and poor quality of water resources are alarming; Some data shows the lack of the resource, more than two billion people lack access to drinking water services; more than four and a half billion people lack access to sanitation services; Nearly half a million children under the age of five die each year as a result of water-related diseases (Vivot, E. *et al.*, 2012). To know the water conditions of the wells of the community of San Pedro, Centla, Tabasco, samples of fecal and total coliform water were taken, as well as physicochemical analysis: hardness, pH, chlorides, turbidity, sedimentable solids, color, nitrogen from nitrates, odor, of which those that exceeded the maximum permissible limits based on the criteria of NOM-127-SSA1-1994 were: chlorides, turbidity and fecal coliforms, the data identified outside the norm were analyzed in the program MINITAB to determine the trend of the data, the dispersion and if there is a relationship between the data, as well as data projections based on the confidence levels of 0.05 and 0.10%. It was observed in the results that the fecal coliforms show uniformity of the data from both wells, in both wells a normality of the data is observed although well 2 has an elevation of the LMP based on the norm, for turbidity a difference was also observed. normality and uniformity of the data from both wells. Concluding that the data have a tendency to increase in general. Containment and prevention strategies are established for the analyzed parameters.

**Fecal coliforms, Total coliforms, Chlorides in water, Water quality**

#### Resumen

La escasez, mala gestión y mala calidad del recurso hídrico son alarmantes; Algunos datos muestran la falta del recurso, más de dos mil millones de personas carecen de acceso a servicios de agua potable; más de cuatro mil millones y medio de personas carecen de acceso a servicios de saneamiento; cerca de medio millón de niños y niñas menores de cinco años mueren cada año a consecuencia de enfermedades relacionadas con el agua (Vivot, E. *et al.*, 2012). Para conocer las condiciones de las aguas de los pozos de la comunidad de San Pedro, Centla, Tabasco, se tomaron muestras de aguas de coliformes fecales y totales, así como análisis fisicoquímicos: dureza, pH, cloruros, turbidez, sólidos sedimentables, color, nitrógeno de nitratos, olor, de los cuales los que rebasaron los límites máximos permisibles en base a los criterios de la NOM-127-SSA1-1994 fueron: cloruros, turbidez y coliformes fecales, los datos identificados fuera de norma se analizaron en el programa MINITAB para determinar la tendencia de los datos, la dispersión y si existe relación entre los datos, así como proyecciones de datos en base a los niveles de confianza de 0.05 y 0.10 %. Se observó en los resultados que los coliformes fecales muestran uniformidad de los datos de ambos pozos, en ambos pozos se observa una normalidad de los datos, aunque el pozo 2 tiene una elevación de los LMP en base a la norma, para turbidez también se observó una normalidad y uniformidad de los datos de ambos pozos. Concluyendo que los datos tienen una tendencia a incrementar de forma general. Se establecen estrategias de contención y prevención de los parámetros analizados.

**Coliformes fecales, Coliformes totales, Cloruros en agua, Calidad del agua**

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## Introduction

Water is considered to be the universal solvent, given its characteristics and properties that is related to its molecular structure, which allows it to easily dissolve ionic compounds and polar compounds and solubilize others of lipidic character. This distinctive feature gives water a great importance, since it can have diverse applications; without forgetting that it is an essential element for the maintenance of life on the planet, as mentioned by (Pérez-López, 2016, pp. 4-6). Therefore, and for all of the above it is important to know the ideal conditions of the vital liquid for this it is necessary to rely on what establishes the Mexican environmental regulations that based on the use or final disposal of water, the standards to know the maximum permissible limits of the ideal parameters are; NOM-001-SEMARNAT-1996 and NOM-002-SEMARNAT-1996 and we consider of utmost importance the NOM-127-SEMARNAT- 2021, it is necessary to establish guidelines and guidelines that allow us to evaluate with greater certainty and efficiency the quality of water sampled with the firm purpose of having water available for human domestic use.

There are many studies carried out on surface water bodies or groundwater where the water quality of these bodies of water is evaluated, observing high levels of contamination (Lozada, P. *et al.*, 2010), contaminated water has a great impact on both health and the environment. According to Morell and Hernández (2000), high concentrations of chlorides, nitrates and heavy metals, as well as physicochemical parameters, high levels of contamination limit the viability of the liquid and increase its toxicity, so the study of contamination, the measurement of its effects and the control of its evolution and are aspects of utmost importance. It is essential to monitor aspects such as potability, the presence of fecal coliforms, free chlorine, alkalinity, the amount of suspended solids, conductivity and hardness, since the aforementioned contaminants come from different human practices that affect its quality and, therefore, all the activities and organisms that depend on the vital liquid.

The objective of this work is to evaluate the quality of water under certain physicochemical parameters identified with greater significance that allow identifying the feasibility and viability of water consumption in two water wells in the community of San Pedro, Frontera, Centla, Tabasco, which are the only water supplies for this community and therefore are of utmost importance to know the water conditions and thus in turn know if the water complies with the corresponding regulations.

## Problem statement

La Barra de San Pedro, Frontera, Centla, Tabasco is a community of 517 inhabitants, with a distance of two kilometers from the sea, in this community there is a strong problem of water shortage for human consumption, derived from the water problem the inhabitants of the community made two artesian wells with the purpose of supplying water for consumption, It is worth mentioning that other artesian wells have been drilled without obtaining favorable results because of the proximity to the sea, the wells show a large amount of salts that are found in the water of deep wells, the purpose of knowing the quality of the water of these wells is because the inhabitants use these waters for their basic daily services.

The analyses carried out for this study were chlorides, hardness, turbidity, nitrogen, pH, fecal coliforms and total coliforms, since these parameters allow us to know the condition of the water and the consideration of its use for human activities, using the applicable environmental regulations.

It is worth mentioning that the availability of fresh water is decreasing worldwide; 1.2 billion inhabitants do not have access to a safe drinking water source. Diseases caused by contaminated water kill more than 4 million children per year and 20% of all freshwater aquatic species are extinct or in danger of disappearing (Martínez-Romero *et al.*, 2009).

## Objectives

### General objective

To evaluate the water quality of two artesian wells in the community of San Pedro, Frontera Centla, Tabasco under the corresponding regulations.

### Specific objectives

- Perform physicochemical analysis (hardness, turbidity and pH) of water from two artesian wells in the community of San Pedro, Frontera, Centla, Tabasco.
- To perform microbiological analysis (fecal coliforms and total coliforms) of water from two artesian wells in the community of San Pedro, Frontera, Centla, Tabasco.
- Statistical analysis of physicochemical and microbiological data to determine the trend in the quality of water for human consumption during 1 year in the town of San Pedro, Centla, Tabasco.

## Methodology

### a) Description of the sampling site

The community Barra de San Pedro is located in the Municipality Centla of the State of Tabasco Mexico and is located at the GPS coordinates: Longitude (dec): -92.469722 Latitude (dec): 18.643333 at 10 masl (Figure 1).

The total population of Barra de San Pedro is 384 people, of which 200 are male and 184 are female. The citizens are divided into 158 minors and 226 adults, of which 12 are over 60 years old.

In Barra de San Pedro there are a total of 89 households, of these 89 dwellings, 6 have dirt floors and about 23 consist of only one room. 86 of all homes have sanitary facilities, 0 are connected to public utilities, 89 have access to electricity.

Of the population aged 15 years and older, 0 have no schooling, 131 have incomplete schooling, 66 have a basic schooling and 26 have a high schooling. 66 have basic schooling and 26 have post-basic education.

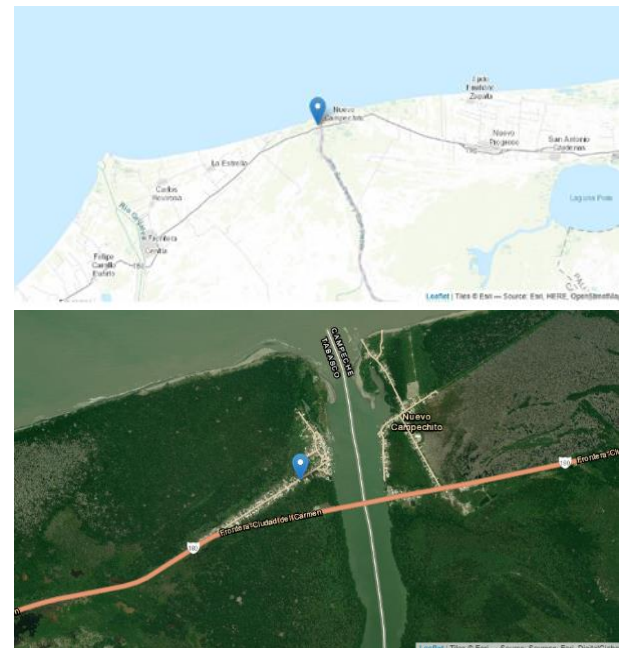


Figure 1 Micro-location of the sampling points

### a) Design and implementation of the sampling plan

The methodological design was established with the objective of evaluating the quality of water in relation to its quality, for human consumption, to which the inhabitants of the San Pedro community in Centla, Tabasco, have access, during 1 year (2021). Through field visits, two sampling points were selected to diagnose the quality of the water used by the community for domestic use, these points are artesian wells, one of which is located in a private home and the other is of common use of the community, this one is located at the edge of one of the main streets of the community. This selection was based on the fact that they are the only freshwater options available (Table 1). Samples were taken from the two wells, naming them Well 1 (at the river bank) and Well 2 (located at the entrance of the community). Water sampling of the artesian water supply wells was conducted during the year 2021. At each sampling point, the following field parameters were determined: temperature, pH, electrical conductivity, water color, odor, and transparency in order to determine the characteristics of the groundwater at the time of sampling; the concentration of residual chlorine was also determined to determine if it complied with the Mexican Official Standard NOM 127-SSA1-1994. The laboratory parameters were turbidity, settleable solids, total hardness, calcium hardness, nitrate nitrogen, chlorides, total coliforms, and fecal coliforms (Table 2).

Sampling point	Geographical location	Description
Well 1	N 18° 38'23.2" WO 92°28'28.7"	River bank well
Well 2	N 18°38'35.8" WO 92°28'08.9"	Well housing

Table 1 Location of sampling points

Water well 1		Location	river bank	MEXICAN ENVIRONMENTAL STANDARD (ANALYSIS METHOD)	
ON-SITE PARAMETER	MEASUREMENT UNITS	ANALYSIS RESULT	DATE OF ANALYSIS	ANALYSIS	STANDARD (ANALYSIS METHOD)
Sampling time	NA		11:05	25/03/2021	NA
Water color	NA	Transparente		25/03/2021	NA
Smell of water	NA	NO		25/03/2021	NA
Transparency	cm		60	25/03/2021	NA
Water bubbles	NA	NO		25/03/2021	NA
Water temperature	°C		29	25/03/2021	NMX-AA-007-SCFI-2013
Environmental temperature	°C		37	25/03/2021	NA
pH	0 a 14 U-pH	7.44		25/03/2021	NMX-AA-008-SCFI-2016
Water film	NA	NO		25/03/2021	NA
Floating matter	NA	NO		25/03/2021	NMX-AA-006-SCFI-2010
Conductivity	µmhos/cm		1067	26/03/2021	NMX-AA-093-SCFI-2000
Dissolved oxygen	mg/L	NA		25/03/2021	NMX-AA-012-SCFI-2001
LABORATORY PARAMETER		MEASUREMENT UNITS	ANALYSIS RESULT	DATE OF ANALYSIS	ENVIRONMENTAL STANDARD (ANALYSIS METHOD)
Water color	U Pt-Co		5	25/03/2021	NMX-AA-045-SCFI-2001
Turbidity	UNT	3.2		25/03/2021	NMX-AA-038-SCFI-2001
Settleable solids	mL/L	0.1		25/03/2021	NMX-AA-004-SCFI-2013
Total hardness	mg/L CaCO <sub>3</sub>	331.24		26/03/2021	NMX-AA-072-SCFI-2001
Calcium hardness	mg/L CaCO <sub>3</sub>	291.85		26/03/2021	NMX-AA-072-SCFI-2001
Nitrate nitrogen (NO <sub>3</sub> )	mg/L	0.96		26/03/2021	NMX-AA-079-SCFI-2001
Chlorides	mg/L	497.36		26/03/2021	NMX-AA-073-SCFI-2001
Total coliforms	NMP/100 mL	< 2		25/03/2021	NMX-AA-042-SCFI-2015
Fecal coliforms	NMP/100 mL	< 2		25/03/2021	NMX-AA-042-SCFI-2016
Water well 2		Location	Entrance to the town	MEXICAN ENVIRONMENTAL STANDARD (ANALYSIS METHOD)	
ON-SITE PARAMETER	MEASUREMENT UNITS	ANALYSIS RESULT	DATE OF ANALYSIS	ANALYSIS	STANDARD (ANALYSIS METHOD)
Sampling time	NA		11:50	25/03/2021	NA
Water color	NA	Transparente		25/03/2021	NA
Smell of water	NA	NO		25/03/2021	NA
Transparency	cm		60	25/03/2021	NA
Water bubbles	NA	NO		25/03/2021	NA
Water temperature	°C		28	25/03/2021	NMX-AA-007-SCFI-2013
Environmental temperature	°C		42	25/03/2021	NA
pH	0 a 14 U-pH	8.13		25/03/2021	NMX-AA-008-SCFI-2016
Water film	NA	NO		25/03/2021	NA
Floating matter	NA	NO		25/03/2021	NMX-AA-006-SCFI-2010
Conductivity	µmhos/cm		457	26/03/2021	NMX-AA-093-SCFI-2000
Dissolved oxygen	mg/L	5.11		25/03/2021	NMX-AA-012-SCFI-2001
ON-SITE PARAMETER		MEASUREMENT UNITS	ANALYSIS RESULT	DATE OF ANALYSIS	ENVIRONMENTAL STANDARD (ANALYSIS METHOD)
Water color	U Pt-Co		5	25/03/2021	NMX-AA-045-SCFI-2001
Turbidity	UNT	0.82		25/03/2021	NMX-AA-038-SCFI-2001
Settleable solids	mL/L	NA		25/03/2021	NMX-AA-004-SCFI-2013
Total hardness	mg/L CaCO <sub>3</sub>	177.18		26/03/2021	NMX-AA-072-SCFI-2001
Calcium hardness	mg/L CaCO <sub>3</sub>	155.23		26/03/2021	NMX-AA-072-SCFI-2001
Nitrate nitrogen (NO <sub>3</sub> ) (NO <sub>3</sub> )	mg/L	3.55		26/03/2021	NMX-AA-079-SCFI-2001
Chlorides	mg/L	244		26/03/2021	NMX-AA-073-SCFI-2001
Total coliforms	NMP/100 mL	< 2		25/03/2021	NMX-AA-042-SCFI-2015
Fecal coliforms	NMP/100 mL	< 2		25/03/2021	NMX-AA-042-SCFI-2016

Figure 2 Field and laboratory parameters taken at the sampling points

Comparison of maximum permissible limits with respect to NOM-127-SSA1-1994			
Permissible limits of bacteriological characteristics			
Characteristics	Results water well 1	Results water well 2	Permissible limits
Total coliforms	< 2 NMP/100 mL	< 2 NMP/100 mL	2 NMP/100 mL
Fecal coliforms	< 2 NMP/100 mL	< 2 NMP/100 mL	Not detectable NMP/100 ml
Permissible limits of physical and organoleptic characteristics			
Water color	5 U Pt-Co	5 U Pt-Co	20 units of true color on the cobalt platinum scale (U Pt-Co)
Olor	No (imperceptible)	No (imperceptible)	Pleasant (Those that are tolerable for the majority of consumers will be accepted, as long as they are not the result of objectionable conditions from a biological or chemical point of view.)
Turbiedad	3.2	0.82	5 nephelometric turbidity units (UTN)
Permissible limits of chemical characteristics			
Chlorides (Cl <sup>-</sup> )	497.36 mg/L	244 mg/L	250 mg/L
Total hardness (CaCO <sub>3</sub> )	331.24 mg/L CaCO <sub>3</sub>	155.23 mg/L CaCO <sub>3</sub>	500 mg/L CaCO <sub>3</sub>
Nitrogen from nitrates	0.96 mg/L	3.55 mg/L	10 mg/L
pH (pH units)	7.44	8.13	6.5-8.5

Table 2 Parameters exceeding the maximum permissible limits of NOM 127-SSA1-1994

b) Determination of physical-chemical and microbiological parameters

The methodology for both water sampling and laboratory analysis was that recommended by the Mexican Standard, as shown in Figure 1, in accordance with the requirements of current regulations. Microbiological analysis was performed using the most probable number method in multiple tubes, as proposed by Mexican Standard NMX-AA-042-SCFI-2015.

c) Statistical analysis of the data

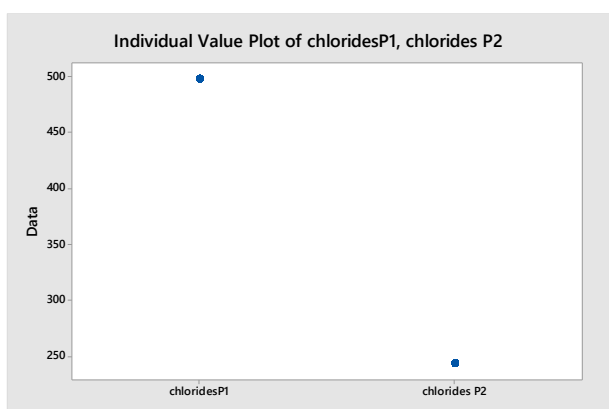
Regression analysis, analysis of variance, as well as Durbin-Watson statistics were determined, obtaining the normality of the data with the Anderson-Darling and Kolmogórov-Smirnov tests, which were applied to the parameters that exceeded the permissible limits with respect to NOM 127-SSA1-1994 (Chlorides, turbidity and fecal coliforms). This process was performed using Minitab software version 18.

Results

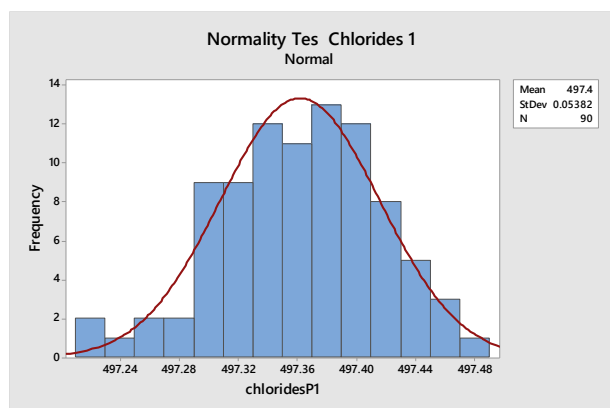
The results shown are for the parameters that exceeded the maximum permissible limits of NOM 127-SSA1-1994 (Table 2).

**a) Chlorides**

As shown in Table 2, chlorides are elevated under NOM-127-SSA and the statistical analysis compares chloride concentrations in water samples from the two wells monitored in 2021, in which it is observed that artesian well 1 located near the river was the one that presented the highest concentration of the pollutant under study; it is worth mentioning this connected to the sea, therefore according to (Pérez-López, 2016, pp. 3-14), the water is assumed to have a high chloride content, since such water (Graphic 1).

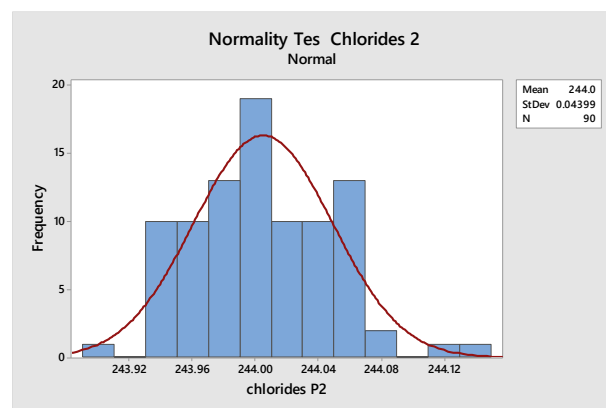


**Graphic 1** Comparison of Well 1 and Well 2 data sets for the physicochemical parameter Chlorides



**Graphic 2** Normality of chloride data for well 1

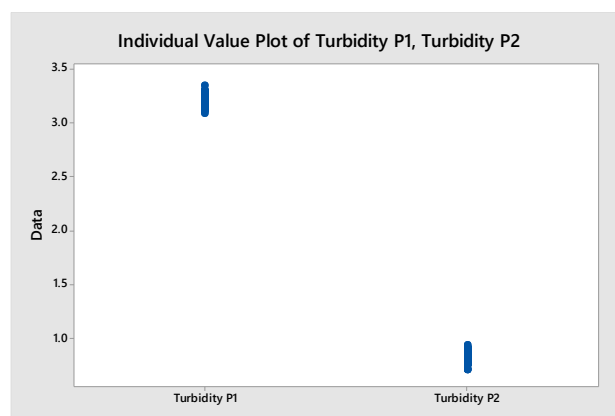
Within the normal range, it is observed that the chloride content is high, which supports the assumption that the proximity of the river mouth to the sea is the factor influencing the high chloride content.



**Graphic 3** Normality of chloride data for well 2

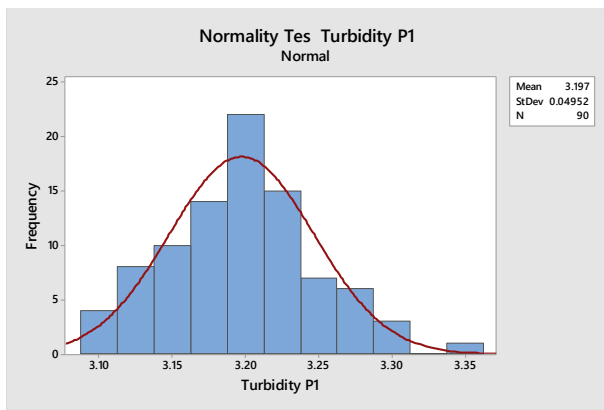
Within the normal range, it is observed that the chloride content is low, this supports the assumption that the remoteness of the river mouth from the sea is the factor influencing the low chloride content.

a) Turbidity. Higher turbidity is observed in well 1, due to the fact that the well does not have the optimal conditions to protect the water from the elements, since it is without a cover, allowing the fall of leaves and other materials with organic matter content and the process of decomposition of organic matter generates suspended solids that are directly related to turbidity and color (Graphs 4, 5 and 6).

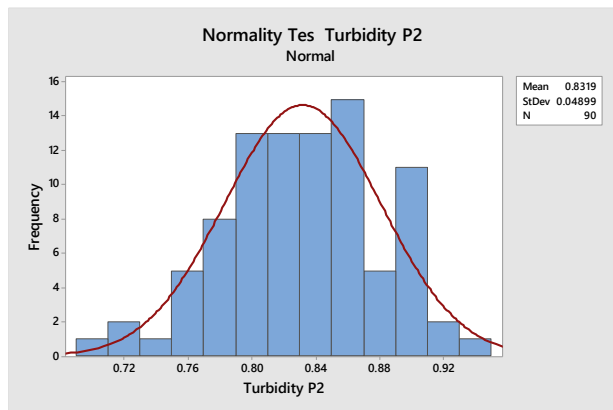


**Graphic 4** Comparison of Well 1 and Well 2 data sets for the physicochemical parameter Turbidity





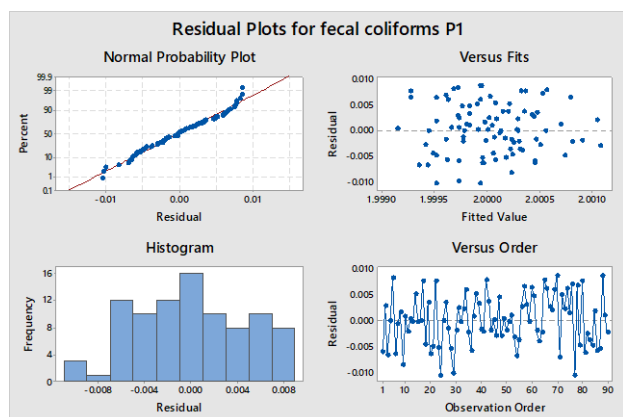
**Graphic 5** Normality analysis of turbidity data for well 1



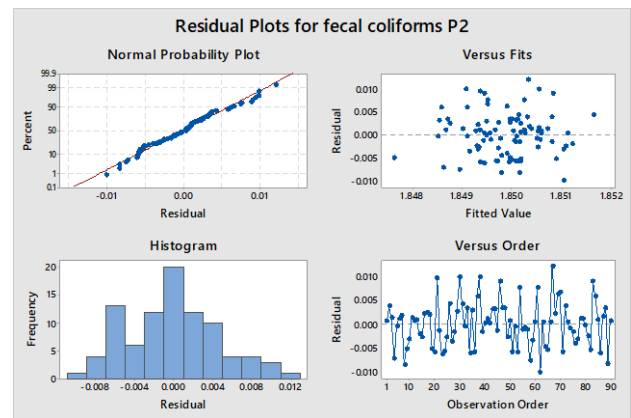
**Graphic 6** Normality analysis of well turbidity data. 2

**b) Fecal coliforms**

Organisms that live in human feces are observed, which are not allowed by the standard, which must be treated with chlorination in both wells to allow the water to be fit for human consumption.



**Graphic 7** Statistical analysis of the fecal coliform parameter of the well 1



**Graphic 8** Statistical analysis of the fecal coliform parameter of the well 2

**Conclusion**

Based on the sampling design, which was established as an annual monitoring of the 2 wells, which were focused on the parameters that exceeded Mexican regulations. Therefore, it is concluded that the water used by the community is not suitable for human consumption, with emphasis on NOM-127-SSA1-1994, in addition to the fact that these parameters are negatively altered due to some external factors such as the proximity to a river with connectivity to the sea and the hygienic conditions of the wells.

**Recommendations**

Based on the data obtained during 1 year of monitoring physicochemical parameters, it is recommended that the community dose the wells with chlorine to eliminate fecal coliforms that are affecting the gastrointestinal health of the population.

If another community well is built in the future, it should be far from the mouth of the well, as this would help mitigate health problems, in addition to complying with Mexican water quality standards.

**References**

DOF, NOM-127-SSA1-1994, Salud ambiental. Agua para uso y consumo humano. Límites permisibles de calidad y tratamientos que debe someterse el agua para su potabilización.

Alejandra Saray Cáceres, T. A. (2020). Análisis geoestadístico de los parámetros fisicoquímicos de los pozos profundos ubicados en el área urbana del municipio de Tunja, para los años 2015-2019. Universidad de los Andes.

Pérez-López, E. (2016). Control de calidad en aguas para consumo humano en la región occidental de Costa Rica. *Revista Tecnología en marcha*, 29(3), 3-14.

Vivot, E. P., Sanchez, C. I., Kieffer, L. A., Prosperí, C. H., Gieco, A. M., Dragan, A. N., ... & Guerra, E. W. (2012). Análisis de algunos parámetros físico-químicos y biológicos del agua en dos estaciones climáticas en el arroyo de la Ensenada, Diamante, Entre Ríos.

Lozada, P. T., Vélez, C. H. C., Escobar, J. C., Vidal, A. P., & Patiño, P. (2010). Aplicación de índices de calidad de agua-ICA orientados al uso de la fuente para consumo humano. *Ingeniería e Investigación*, 30(3), 86-95.